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NOVEMBER 2016 | VOLUME 15, ISSUE 04 | BOEING.COM/FRONTIERS

Frontiers

Growth engine

Boeing expands its Propulsion Systems expertise

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Cover: Before a GE90 engine reaches 777 final assembly, quality inspector Kiem Tran records serial numbers. BOB FERGUSON | BOEING

Photo: (Far right) Mechanic Beth Phelps measures drilled holes for a proper fit on an inlet inner barrel at Propulsion South Carolina, in Ladson. BOB FERGUSON | BOEING


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The stories behind the ads in this issue.

This ad was created to demonstrate Boeing's appreciation and gratitude to veterans and will run in *The Washington Post* and *The Seattle Times* on Nov. 11, which is Veterans Day in the U.S. The campaign also will feature national TV support on *Meet the Press*.

Part of the "A Better Way to Fly" campaign, this ad is from a series showcasing the many ways Boeing airplanes and services enable opportunity and success for customers around the world. The ads are running in trade publications and online.

In support of Boeing's U.S. Air Force trainer replacement bid, this ad debuted the brand-new Boeing T-X. The aircraft is part of a complete advanced pilot training system designed specifically for the Air Force training mission.

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The value of change

From the factory floor to the office, even the simplest actions by employees can help make Boeing more competitive

Kevin Schemm
Senior vice president
Supply Chain Management
Finance & Business Operations

Chief financial officer
Boeing Commercial Airplanes

PHOTOS BY MARIAN LOCKHART

In this Q&A with *Frontiers*, Kevin Schemm, senior vice president of Supply Chain Management, Finance & Business Operations, and chief financial officer of Commercial Airplanes, talks about changes underway to win in the market, fund growth and operate as a healthy business.

How has the market changed over your career?

When I started with the company as an engineer on the defense side in Wichita, Kan., the culture of "value for the money" was pretty straightforward. Over that time, a lot has changed but some things have remained the same. Then, as now, our customers expect the most for their money. What's different today is that for the first time we're competing head to head in every one of our market segments and facing multiple competitors that are using aggressive pricing to win orders.

What is Boeing, in particular Commercial Airplanes, doing to be more competitive?

If you were to ask our customers, they would tell you Boeing products and services are known for their performance, quality and reliability—and we will make sure that doesn't change. We'll continue to innovate and draw on the ingenuity of our people and global partners. But we're expanding the way we think about innovation. It's not just about what's on the airplane—just as important is how we put the airplanes together. And it starts with getting engineering designs right the first time, with the focus on producibility and cost.

Apart from design, when I talk with our employees the focus increasingly is about how we're adapting and modernizing our production system, our supply chain and even our office processes to eliminate waste and inefficiencies. We will use those savings to self-fund our product development and be even more competitive in the market.

Describe some of the changes that are happening in the factory.

We have a number of initiatives underway to boost productivity and efficiency across our business. Some of this work is aimed at the fundamentals, such as ensuring first-time quality or designing cost out of parts. But we're also doing new things such as using data analytics to better understand our production operations and pinpoint where quality errors are costing us money. This level of visibility has reduced rework, which is one of the biggest drivers of cost. Being able

to nail it the first time, in terms of quality, really helps with affordability and being competitive.

How is Boeing working with suppliers?

We're spending more time with suppliers because we see their cost structure as our cost structure. With a backlog of nearly 5,700 airplanes at Commercial Airplanes and two-thirds of every airplane's cost coming through the supply chain, we have a big opportunity to reduce costs by working smarter with our suppliers. That's the idea behind Partnering for Success, our enterprise effort to work with suppliers to reduce costs and provide the highest-quality products.

And our supplier relationships continue to deepen. A great example is how we've worked to increase production efficiency on the 787 program. We're now down to looking at what we can do minute by minute to improve flow of the production system. We share what we've learned with our supplier partners so they can make similar changes and become more competitive.

Is Partnering for Success a long-term effort?

It has to be, because our customers will continue to expect more for less. We must keep looking for ways to trim costs and be more efficient. Partnering for Success is much more than simply reviewing supplier contracts for better terms. We don't ask our suppliers to do anything we wouldn't do ourselves. Our spirit of working together and embedding teams with suppliers is vital to driving quality and stability.

This year, we've extended this work through our "boots on the ground" initiative that involves engineering, finance, operations and Lean+ teams relocating to supplier sites for one year. Over that time, our people work with our supplier partners to capture even more productivity, capability and savings. We have more work to do, but the early results are very encouraging. And as our supplier relationships grow, we will be better able to work with them on development of new processes and technology that we can both use. The future payoff is when those things are implemented and we begin to see better quality and efficiency stemming from them.

What about process changes?

A lot of it involves streamlining processes that drive cost. Earlier this year, we changed when we pay large suppliers to the way most businesses do it. Change isn't easy, and we continue to work with those suppliers through the transition. We're also managing our inventory better. For example, we've created better processes to understand what raw materials and parts are needed to run the business most efficiently. We're also bundling parts orders across programs to take advantage of bulk discounts. These efforts support our ability to generate cash and to manage it effectively, which is fundamental to running a healthy business.

How can employees help?

Every employee plays a part in making Boeing more competitive, and often the simplest things can make a big difference. From using Lean+ to improve productivity and flow, to driving first-time quality in the office and factory to reduce rework, everyone can create value while providing the most innovative yet affordable products. That's our responsibility as individuals. And by working together with our supplier partners, we can capture significant opportunities and successfully address the market forces affecting our industry.

That winning mindset and our 100 years of successfully adapting to new challenges will extend our leadership position going forward. ●


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Our commitment to innovation and your success are inseparable. By maintaining a focus on continually improving every aspect of airplane performance, we're dedicated to helping you achieve your goals year after year. Whether it's efficiency, reliability, environmental performance, passenger comfort and more, you can be certain our dedication to innovation will ensure Boeing airplanes deliver exceptional value today and tomorrow. That's a better way to fly.

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THE POWER WITHIN

Boeing expands Propulsion Systems to bring design and build expertise in-house

BY DAN RALEY | PHOTOS BY BOB FERGUSON

A GE90 engine, the largest in service in the aviation world, hangs from an overhead boom at the Propulsion Systems Division factory in Everett, Wash. For two and a half days, Boeing mechanics crowd around this imposing piece of machinery and install component parts. Once complete, it moves by oversized forklift to the 777 jetliner assembly line next door. Within minutes, another engine arrives to start the process again.

This same rhythm and processes occur in nearby Renton as the Propulsion team prepares CFM56 engines for installation on the 737. It turns out 84 engines per month, one every four hours.

On the opposite side of the country, Boeing technicians manufacture inlets, or nacelle front-leading edge, at Propulsion South Carolina in Ladson, outside of Charleston. When at full rate in 2018, the new facility will produce an inlet every two hours for the 737 MAX—while drilling 18,000 fastener holes per day.

"There's a lot going on under the hood," said Charlie Hix, Propulsion South Carolina director.

From coast to coast, Boeing is pursuing ambitious schedules and expanding operations in propulsion, an area that consists of the engine, fan cowl, inlet, pylon, strut and thrust reverser, all parts either tucked inside or connected to a shell-like nacelle. In short, everything beneath the wing of a large commercial jetliner in flight. There's also the related fuel systems and the auxiliary power unit, an additional jet-engine power source found in the tail of the airplane.

Propulsion accounts for 40 percent of the maintenance cost of an airplane over its lifetime, according to Nicole Piasecki, Propulsion Systems Division vice president and general manager.

"As we look to the future, I expect propulsion systems and fuels to play only a bigger role in terms of the total technology that goes on an airplane toward life-cycle performance," she said.

With new commercial airplane models headed to the factory, Boeing has brought propulsion-related design and build work in-house in

Photo: The GE90 engine powers the 777 and is the largest in service in the aviation world.

Photos: (Clockwise from top right) Engine mechanic Vince Daggs adjusts an engine plumbing system on a 777 engine; assemblies mechanic Debbie Branlund readies a fan cowl support beam for engine installation in Everett, Wash.; engine mechanic James Fletcher, working from a circular ladder, installs support brackets for tubing and electrical wiring to a 777 engine while Andrew Hackett, seated, installs an air-pressure system in Everett.

recent years for greater control of cost and airplane performance, all of which will benefit airline customers, Piasecki said.

Aftermarket opportunities and growing support services are other driving forces behind this move, according to Boeing leaders. The company has added engineers with industry propulsion expertise to its ranks and created the Ladson facility in South Carolina with propulsion development in mind. Engineers there make up almost half of the nearly 300-person workforce. They work in areas such as core engineering, systems engineering and production engineering.

"We haven't done this sort of design work at Boeing for several decades, especially in the nacelle structure," said Aleks Radic, a propulsion core engineering manager at the South Carolina site. "You can see the level of enthusiasm and motivation in all of the engineers. It's really exciting to bring that talent and skill back into Boeing."

In Everett, the propulsion factory offers engine build-up and strut production lines for the 747, 767 and

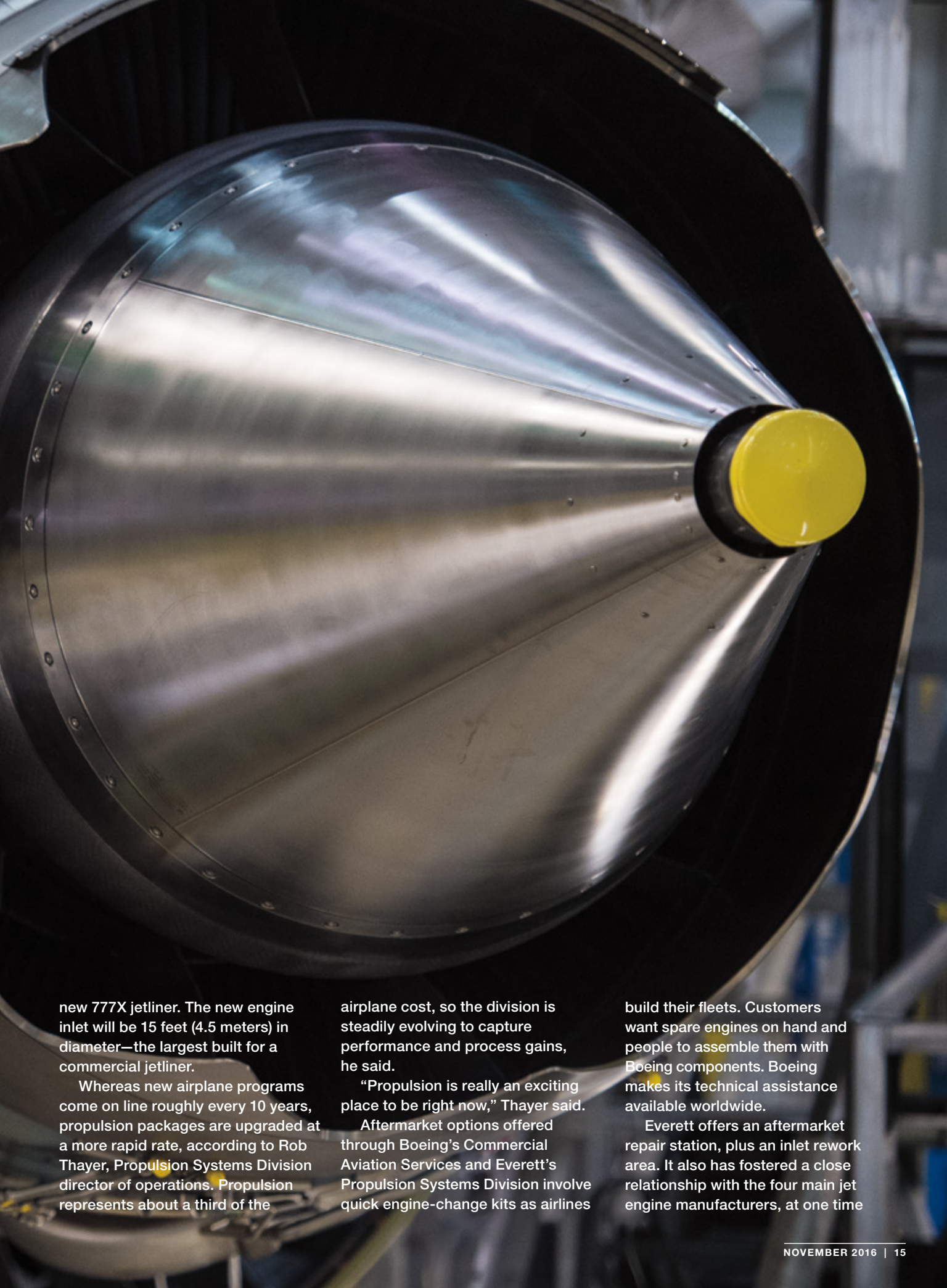
Photo: Mechanics such as Mike Bennett in Everett, Wash., install components on core engines for the 777, 767 and 747 programs.

777. Struts, parts that connect the engines to the wings, roll in on mobile tool platforms and can be rotated during assembly similar to a rotisserie, enabling easier employee work access. Kits with pre-assembled parts and neatly organized tools help employees work more safely and efficiently. Bar charts on computer screens track different jobs in real time.

In a far corner, massive 777 engines arrive in pairs, wrapped in blue, vacuum-sealed shipping bags. They fit snugly into side-by-side work bays, suspended in air by extra-strength cables. Mechanics use scissor lifts, curved ladders and step stools to access work areas. They install fire-detection and anti-icing devices, generators, brackets, ducting, tubing, pumps and wire bundles. Crew members who prepare the GE90 for airplane assembly realize the significance of it all.

"Every once in a while I stand back and look at the engine and sigh—it's impressive," mechanic James Fletcher said.

Everett employees currently are preparing a workspace to accommodate an even bigger engine, the GE9X, which will power the



new 777X jetliner. The new engine inlet will be 15 feet (4.5 meters) in diameter—the largest built for a commercial jetliner.

Whereas new airplane programs come on line roughly every 10 years, propulsion packages are upgraded at a more rapid rate, according to Rob Thayer, Propulsion Systems Division director of operations. Propulsion represents about a third of the airplane cost, so the division is steadily evolving to capture performance and process gains, he said.

"Propulsion is really an exciting place to be right now," Thayer said.

Aftermarket options offered through Boeing's Commercial Aviation Services and Everett's Propulsion Systems Division involve quick engine-change kits as airlines build their fleets. Customers want spare engines on hand and people to assemble them with Boeing components. Boeing makes its technical assistance available worldwide.

Everett offers an aftermarket repair station, plus an inlet rework area. It also has fostered a close relationship with the four main jet engine manufacturers, at one time

bringing them together in a supply chain summit to lay out expectations.

"We deal with the engine companies to ensure the highest-quality delivered engine," said Rich Dickson, Propulsion Systems Division material management leader. "We build relationships that are personal and professional."

Propulsion employees are cross-trained to handle a variety of tasks on different airplane models. They are ready to leave the factory and respond at any time to a customer's immediate needs.

Debbie Branlund is an assemblies mechanic in Everett who works near GE90 engine assembly. She prepares the fan cowl support beam, which involves tubes, pumps and hydraulics. She previously worked on airplane engines, generators and emergency power units. Three years ago, she was part of a Boeing team sent to San Antonio to assist a customer in tearing down a 747 engine that needed refurbishment. She thrives in this atmosphere.

"We're a tightknit family here," Branlund said. "We have a lot on our shoulders. There's a lot at stake to do the job right."

There's plenty of cooperation within the Boeing Propulsion Systems Division sites, which also include Bellevue, Wash., Cincinnati and the Southern California area. Shannon Green is a supply chain analyst who orders and schedules parts in Puget Sound. She has visited Propulsion South Carolina on five occasions, attended workshops and shared her experiences and data to help her Boeing counterparts there prepare for the accelerated delivery rates of the 737 MAX inlet.

"It's best-practice sharing and the leveraging of knowledge to prevent problems," Green said. "It's a masterpiece that all comes together."

Propulsion South Carolina operates from a 225,000-square-foot (20,900-square-meter) building that opened last year. It is located 10 miles (16 kilometers) north of Boeing's North Charleston factory, where employees assemble the 787 Dreamliner.

Manually operated production lines churn out 737 MAX inlets that consist of parts called the lip skin, bulkhead and inner barrel, held together by fasteners, rings and T-chords.

Assembly mechanic Pamela Param, who previously worked on the Dreamliner, drilled the ceremonial first hole on Propulsion South Carolina's inlet production line last year. All of her peers crowded around and shared in the milestone.

"It was a big deal," she said. "It also was a lot of pressure. Everybody was watching."

Hix, the site leader, has drilled inlet holes as well. He worked on the Propulsion South Carolina production line for a week alongside his employees to experience what they go through. He had his hands on nearly two-dozen inlets. He left his cellphone in his office and did everything the others were required to do, took work breaks along with everyone and attended their meetings.

Roshen Thomas is a Propulsion South Carolina quality inspector who has encountered airplane propulsion parts from various perspectives. He once worked as a mechanic for Pratt & Whitney on jet-fighter engines in

Photos: (Far left) Propulsion South Carolina, in Ladson, plans to produce a 737 MAX inlet every two hours by 2018. (Above) Mechanic Pamela Param drills holes and inserts fasteners on the inlet inner barrel.

Photos: (Clockwise from top right) Mechanics Debra Coleman, left, and Keith Logan prepare a 737 MAX inlet inner barrel for drilling in South Carolina; mechanic Jeff Fields adjusts a wiring bundle beneath a 777 engine in Everett, Wash.; engine mechanic Robert Kee installs a fire detector on a 777 in Everett.

Columbus, Ohio. His job now is to examine inlets, sending them back for rework if they don't fit properly. Building engines was interesting, but Thomas finds his quality role to be equally demanding.

"Everything is important here," he said. "Cars can pull over on the side of the road when they have a problem—you can't do that when you're 30,000 feet up in the air."

The 737 MAX inlet is Propulsion South Carolina's first product line, but the team's goal is to someday develop and build an entire nacelle for an airplane model.

"Our focus is on design for manufacturability and cost … and we work closely with our propulsion suppliers to achieve the best total cost," said Chuck Marano, 777X engineering manager. "That's the vision." ●

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10 things employees might not know about Russia

BY DAN RALEY

It has 146 million inhabitants and spans one-seventh of the planet's landmass. Twelve different seas wash up against its coastline. Nine time zones intersect it.

For Russia, connecting everyone within these far-reaching borders but also beyond them is a sizable need.

For two and a half decades, Boeing has played an important role in advancing air travel from Moscow to Siberia and the outside world, supplying Russia and the nearby Commonwealth of Independent States, or CIS, with more than 400 commercial airplanes operated by 54 airlines.

On a recent day at Boeing Field near Seattle, for example, a newly built orange, blue and silver Aeroflot 737-800 taxied to the runway to begin the long journey to Russia, but not before passing freshly painted jetliners awaiting delivery to Turkmenistan Airlines and Belavia Belarusian Airlines.

This busy exchange could be repeated over and over as future demand strains to keep up with projected growth for the region—Russia and its neighbors are expected to add 1,170 new airplanes valued at $140 billion to their respective commercial fleets over the next two decades, according to the Boeing *Current Market Outlook*.

Airplane sales, however, are only part of a Boeing-Russia affinity. The two share in space exploration, aviation engineering, information technology, titanium parts production and new alloys development, a design center, a flight training center, and more. They have formed an international partnership as diverse as any.

"Russia obviously has a great deal of resources—human resources, a strong suite of natural resources and great technology," said Marc Allen, Boeing International president. "It's got a sizable economy that continues to generate sustained airplane demand. And it has been an important global player in aerospace productivity, helping us lower costs and win the market competition.

"It has taken us a lot of study and real investment over the past two decades to build our productivity model in Russia. Today, it is a model we are replicating in other environments, as we build capability and presence to remain the most competitive aerospace company in the industry."

Following are 10 things Boeing employees might not know about Russia and the aerospace ecosystem to which it is home.

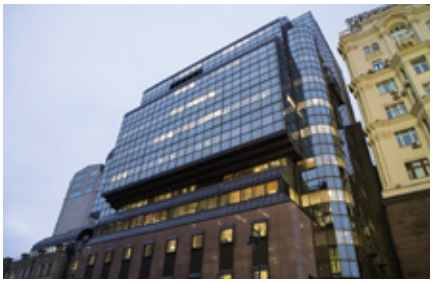
1 Russia gave world travel a boost by opening its polar routes.

Since 2000, Russia has allowed outside airlines to use its airspace, enabling international flights to cross its polar region—which greatly reduces travel time between major hubs in Asia and the United States and Canada. Passengers previously had to stop in Europe or Japan to reach those destinations.

As part of this, Boeing surveyed the sparsely populated Siberian region, identifying Russian airfields there that qualified as suitable alternative airports.

The availability of the Russian polar routes also has proved essential for the sale of Boeing's 777 Longer Range and Extended Range models, 787 Dreamliner, and the coming 777X, according to Sergey Kravchenko, Boeing Russia/CIS president.

"The opening of the polar routes has played a critical role in our global business," Kravchenko said.



2 Russia and the CIS represent an emerging airplane market.

Growing international traffic (expected to rise 4.8 percent annually) and an aging fleet in need of near 50 percent replacement will create demand for 1,170 new airplanes in the region over the next two decades, Boeing *Current Market Outlook* projects.

Single-aisle jetliners will make up a majority of those orders, with 737 options having proved themselves in the region's harsh weather, said Marty Bentrott, Commercial Airplanes vice president for sales in the Middle East, Russia and Central Asia.

"The Next-Generation 737 has been terrific in terms of performance, for operating in cold weather," Bentrott said. "Several airlines are already counted on to take the MAX—that will be the dominant airplane of choice."

3 The Boeing Design Center in Moscow helps provide Boeing with 24-hour engineering.

Boeing places a high value on aerospace experience and innovation and has enlisted a team of 1,200 local engineers to work on Boeing airplanes.

These engineers have shared in hundreds of projects involving the 737, 747, 767, 777 and 787, both passenger jets and freighters, and they currently are designing fuselage structures as well as leading and trailing wing edges for the 777X.

Boeing Commercial Airplanes performs design work in the U.S. and Russia, making engineers available at all times over multiple time zones.

"To move with the sun… is a critical feature of being a global operating company," Allen said.

4 Russia provides 35 percent of the titanium used by Boeing Commercial Airplanes.

For nearly two decades, VSMPO-AVISMA has supplied Boeing with titanium for the manufacture of airplane parts. As the world's largest producer of titanium, it produces forgings for all Boeing jetliner models.

In 2009, Boeing and VSMPO opened a joint venture, Ural Boeing Manufacturing, for the rough machining of titanium forgings that now benefit the 737, 777 and 787 programs.

"VSMPO provides good quality and excellent economics for all titanium parts that we supply," Kravchenko said. "We are very proud of the Ural Boeing Manufacturing joint venture, which soon will have almost 10 years of flawless operation."

Photos: (Far left) The colorful domes of St. Basil's Cathedral in Moscow are illuminated in the night sky. BOEING (Above and top right) Boeing Design Center employees Sergey Sorokin, left, and Ekaterina Yankevich discuss a project; the Design Center in Moscow manages 1,200 engineers. ASSOCIATED PRESS (Bottom right) Russia supplies 35 percent of the titanium used by Boeing. BOEING

5 Boeing recently opened a flight training and research center in Moscow.

Boeing and Russia unveiled a new flight training center in June. Boeing estimates that the region will require 22,000 new commercial airline pilots and 26,000 new technicians over the next two decades.

The center provides aspiring pilots with training on 737 and 777 simulators, a digital aviation team to work on solutions in a variety of areas, and an outlet for customers to interact with service personnel.

"The training facility is a significant investment in the future of the transportation industry in the CIS region and it really differentiates us from the competition," Kravchenko said.

The site also offers a research center, which will focus on civil aviation projects in cooperation with Russian universities and organizations. The center will work on solutions in aviation science, flight safety, metallurgy, and the development of assemblies and components.

6 Russia and the U.S. are longtime space partners.

The Apollo-Soyuz Test Project, which involved the docking of American and Russian spacecraft in 1975, marked the beginning of a longtime space collaboration between the countries.

For a decade and a half, the two have shared with others in the operation of the International Space Station, now certified to continue through 2028. For the past five years, astronauts and cosmonauts have traveled together to and from the orbiting spacecraft.

"The space station is an engineering marvel that has enabled us to build relationships around the world—a prime example being our relationship with Russia," said John Elbon, vice president and general manager, Space Exploration. "We will leverage these relationships as we continue our journey back to the moon and on to and Mars."

7 Aircraft manufacturing is an important Russian industry, accounting for 355,000 jobs.

Russia is known for its high-profile aircraft, notably the Sukhoi-35 and MiG-29, and is continuously seeking ways to innovate with commercial airplanes, such as the Sukhoi Superjet 100, according to Alexander Basyuk, Commercial Airplanes sales director for Russia.

As a part of the Boeing strategy to support market access in Russia, Boeing assisted with development of the Superjet. This regional airplane that seats up to 90 passengers flew for the first time in 2008, after Boeing consulted on marketing, design, certification and testing.

8 The Dreamliner was created with assistance from Russia.

Engineers with Boeing Russia played a big role in the development of the 787 Dreamliner, with 400 engineers there dedicated to the airplane at the outset and later responsible for fuel-cell drawings and design work on wing pylon and engine strut supports.

"We can proudly say the Dreamliner's nose was designed in Russia, or at least part of it was," Kravchenko said lightheartedly.

Even today, each 787, while largely constructed of carbon-fiber material, requires 22 tons (20 metric tons) of Russian-mined titanium for its airframe.

9 Russia is well-represented in the Boeing workforce worldwide.

In its 25-year association, Russia has provided a pipeline of talent for Boeing—people who have joined several organizations across the company, Kravchenko said.

"They were hired in Russia and trained in Russia, but they now work in Seattle, Dubai, Amsterdam and Shanghai," Kravchenko said. "This success with our global talent from Russia may be the most important success, because it shows the globalization of The Boeing Company."

10 Russia has an aviation history more than a century old.

While the Wright brothers were responsible for building and flying the world's first airplane in the U.S. during the early 1900s, Russian naval officer Alexander Mozhaysky was working on a monoplane design as far back as 1876.

Historians have long debated whether Mozhaysky was able to successfully fly his invention.

"It's a matter of national pride," Basyuk said, referring to Mozhaysky's overall work. ●

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Photos and illustration: (Far left, clockwise from left) Russia and the U.S. are space station partners. NASA Aircraft manufacturing accounts for more than 350,000 Russian jobs; Russians have shared in hundreds of Boeing airplane projects. (Above, clockwise from left) An artist's concept of the 787-10—some 400 Russian engineers worked on the 787; the Boeing flight training and research center in Russia offers 777 and 737 simulator training; Aeroflot is one of 400 Russian and CIS airlines operating Boeing jets; UTair Aviation's fleet consists primarily of Boeing airplanes. BOEING

Extended vision

Digital upgrades expand capabilities for AWACS aircraft

BY DAN RALEY | PHOTOS BY BOB FERGUSON

On the southern edge of Boeing Field in Seattle, an Airborne Warning and Control System aircraft, commonly known as AWACS, is receiving a makeover.

A stream of Boeing engineers, technicians and others approach and leave the flight line as the surveillance airplane's most distinguishable feature—a huge disc-shaped radar dome mounted over the rear fuselage—rotates continuously.

The task at hand is to upgrade flight-deck systems for this E-3 Sentry military derivative of the 707, a commercial transport widely credited with ushering in the jet age during the 1960s and '70s.

Boeing engineers such as Dan Seely view themselves as time travelers of sorts, administering to a decades-old airframe. They've dug deep into the company archives, found original designs and relearned earlier systems.

They are replacing gauges and sensors manufactured as far back as the 1940s with the latest in full-color digital display systems.

"When you go through modifications to this extent, it feels like you're making a new airplane," Seely said.

Boeing will upgrade one AWACS each for the U.S. Air Force and NATO, which, in turn, will modify its collective fleet of nearly three dozen surveillance airplanes.

This will keep the E-3s operating for two or three more decades, said Jon Hunsberger, program manager for DRAGON—or Diminishing Manufacturing Sources Replacement of Avionics for Global Operations

Photo: An E-3 Sentry AWACS aircraft, a military derivative of the 707, receives a digital flight-deck upgrade at Boeing Field in Seattle.

Photos: (From left) Test director Terry Aas, left, confers with test pilot Mark Mitchell in the renovated flight deck of an AWACS jet; a new digital flight deck offers five display screens; the radar dome atop an AWACS jet is 30 feet (9.1 meters) in diameter and mounted 11 feet (3.4 meters) above the rear fuselage.

and Navigation.

Seely, a shipside support liaison, restores cars for a hobby. He's doing much of the same with the AWACS aircraft, which he's found to be extremely well-constructed and durable.

"I'm so impressed with the original craftsmanship of these aircraft—they were built to last," Seely said. "With the amount of things we've been able to touch, fix and investigate, I learn something new every single day. It's interesting and exciting. They're superb aircraft."

The 707 jetliner first entered commercial service with Pan American Airlines in 1958, and a military derivative served as an AWACS aircraft for the U.S. Air Force starting in 1977. The final 707 came off the Boeing production line in 1992.

Seely's grandfather, Donald, was part of the Boeing crew that installed the first AWACS radar dome on the plane and he's passed down tools that he designed and used on the job to his grandson.

The E-3 Sentry acts as a flying air traffic controller that provides surveillance, communications and battle command for military forces in the U.S., United Kingdom, France and Saudi Arabia, plus the NATO fleet based in Germany. Japan operates an AWACS variant, the E-767, while Australia, Turkey and Korea use the E-7A Airborne Early Warning & Control, a military derivative of the 737 that offers similar capabilities.

The E-3 Sentry previously received mission computing and mission radar improvements. The latest flight-deck changes, according to Hunsberger, help satisfy mandates by the Federal Aviation Administration and similar agencies overseas that the surveillance jets use the same safety features and operating practices as commercial airliners in controlled airspace and transoceanic airways; the upgrades also help resolve the increasing challenge of hard-to-find and out-of-production spare parts.

"These systems are 35 to 40 years old," Hunsberger said. "The industry, the technology and suppliers have moved on. It's like VHS or eight-track tape decks—do you still have them?"

Engineers have been focused on making sure the new AWACS equipment can co-exist with the original. They had to prove that the installation of new digital computer systems, which involves converting the flight deck into a five-screen "glass," or digital, cockpit, wouldn't interfere with the surveillance mission. Something as basic as airplane cooling ducts required upgrades to accommodate the new computers. Engineers have had to troubleshoot to find solutions that facilitate the crossover of past and present equipment, Hunsberger said.

"This system is very unique to AWACS, maybe to all avionics engineers," the program manager said. "If you have a problem, you have to understand the basic design. There is no framework here to understand it; it takes researching old data and drawings. Other people would intuitively know it, but they're gone. I look at some of the engineering data—and it's older than I am."

One of the most notable changes to the E-3 Sentry jet is the addition of an Automatic Dependent Surveillance Broadcast-Out system, which alerts other aircraft of the plane's position when training or in-transit and

ensures it can land at any suitable airport in the world, Hunsberger said. New weather radar, radio altimeters, antennas and a global positioning system also have been added.

Boeing will conduct flight tests on the modified Air Force and NATO aircraft through the end of next year before returning them to their owners. The remaining AWACS planes will receive enhanced flight-deck systems installations at Tinker Air Force Base in Oklahoma City and at Manching Flugplatz in Manching, Germany. Military personnel will make the changes on the other American-based AWACS. Airbus Defence and Space Military Aircraft Center, in Manching, which contracts with NATO to perform repair and maintenance services, will update the aircraft in Europe under Boeing oversight—indeed, a second NATO AWACS is already undergoing modifications.

An AWACS aircraft is readily identifiable by its black and gray dome, which measures 30 feet (9.1 meters) in diameter, is 6 feet (1.8 meters) thick and is mounted 11 feet (3.4 meters) above the fuselage on two struts.

Although an aircraft carrying a dome can't maneuver during flight as fast as one that flies without, any other effects from surveillance equipment standing tall on the back of the fuselage are minimal, said Boeing test pilot Mark Mitchell.

"It's aerodynamic; the air goes over the top of it," Mitchell said of the dome. "When landing the airplane, you don't know it is back there. It's very transparent" to the flight crew.

What's different overall with the AWACS, compared with a more modern aircraft, is it requires more precise control when touching down and more instrument checks before departing, the veteran test pilot said.

"It's a good flying airplane," Mitchell said. "It's been a workhorse for a long time. It makes me feel young again."

Gragg Hart has been involved with the AWACS for more than three decades—nearly the life of the unique military aircraft. He served as an Air Force navigator for 14 years, logging 5,000 hours. He's been a Boeing avionics systems engineer for 19 years, providing upgrades and solutions for the plane.

"I have had the bittersweet task of eliminating my position—the navigator—on the aircraft," he noted.

The E-3 Sentry typically operates with 18 to 20 people on board, comprising the flight crew, a surveillance team and a weapons group. A dozen people sit in rows filled with computer consoles, interpreting radar data and consulting with commanders, turning the main cabin into an office-like atmosphere. At the rear of the aircraft are bunk beds for rest breaks.

Hart compares the AWACS aircraft to a B-52 bomber, as a resilient Boeing-built aircraft that ultimately may reach 100 years of service. It is unmatched for conflict resolution—for providing local and theater decision-makers key situational and tactical information—in spite of its advancing years, he said.

"It's an aging aircraft, that's true, but everything ages," Hart said. "We've got the talent in the seats and at the air bases, and at Boeing, to keep them flying." ●

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Corps education

Employees share how lessons learned during military service have helped them at Boeing

BY KATE EVERSON

When then–Lt. Col. James Osowski, U.S. Army Reserve, was a production manager on the Long Beach, Calif., C-17 line in 2001, a colleague asked him if he found it ironic that he was building an airplane that could take him to war someday.

As he deployed to Iraq nine years later on the second of three tours with the Army, he asked the crew chief what the fuselage number was on the C-17 he was about to board. Sure enough, it was one he had helped build.

"It was pride; it was excitement—everything about it, knowing that I built it and that it was carrying these other people and me," said Osowski, who served 12 years in the U.S. Marine Corps, 19 years in the Army and, as a program quality engineer in Huntington Beach, Calif., still serves in the Army Reserve. He said it made him realize "Everything we do affects everything we do."

The same could be said for each of the 21,000 self-identified veterans who apply lessons they

learned during military service to their current jobs at Boeing. What they've done while wearing a uniform influences what they do while wearing a Boeing badge.

Florent Groberg, Boeing's director of veteran outreach, said the most important lesson he learned was to put aside rank, ego and pride and seek help from those with more experience, regardless of the chain.

"I learned this in 2010 when I got to Afghanistan as a platoon leader," he said. "These gentlemen had been in combat for four months, and here I came, brand-new in the Army and expected to lead all 24 in combat."

Groberg sought support from his second-in-command, who told him to learn about the team's combat history and observe their communication methods and relationships with nearby village elders. For a week he immersed himself in learning from the team.

He used the same method after the attack that earned him the Medal of Honor, the highest commendation for valor in combat. On Aug. 8, 2012, Groberg tackled a suicide bomber about to ambush his platoon, sustaining substantial damage to his left leg. He said the injury left him feeling like he had lost his identity, so he went out and talked to other wounded soldiers, regardless of rank, about how they had overcome emotional trauma to find new passions.

"After I found an opportunity to talk to a quadruple amputee who literally changed my life in 15 minutes, I made sure I utilized all the skills and traits I had learned in the military to be successful as a civilian," Groberg said.

After working with LinkedIn to help veterans transition to civilian jobs, he started in September at Boeing's Government Operations site in Arlington, Va., where he is responsible for developing Boeing's support of military veterans and their families. His first order of business: Learning from those around him.

"You learn something from someone every day," Groberg said.

On the following pages are the stories of six other Boeing employees who share lessons from their military service to mark the U.S. Veterans Day holiday in November, known as Remembrance Day and Armistice Day in other countries. Just as they learned from their service, their fellow employees can learn from them. ●

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PHOTO ILLUSTRATION: CASS WEAVER | BOEING; UNIFORM: BOB FERGUSON | BOEING; MEDAL OF HONOR: SHUTTERSTOCK

BRANCH:
U.S. Air Force

LOCATION:
St. Louis

TEAM:
Shared Services Group

PHOTO: BOB FERGUSON | BOEING

Michael Gay

Frequency Management analyst

After an 18-hour shift, Michael Gay just wanted some shut-eye. Instead, he had his eyes opened.

The U.S. Air Force senior noncommissioned officer had finally nodded off when someone started banging at the door. There stood one of the youngest troops under his purview—sweat-soaked and carrying all of the group's gear and sensitive paperwork.

"I don't know why, but my first response was to laugh," said Gay, now a Frequency Management analyst for Boeing's Site Services Group in St. Louis. "The face he was making was priceless. I'm 6 feet 2 inches and not a small guy, but this airman was much larger and scared to death."

Gay's laughter was cut short by an explosion that shook his trailer. That was when he realized the airman was looking to him for help. As bunker commander, Gay took immediate action by getting his subordinates to safety and running through checklists until they received the all-clear from security forces.

In the end, the night's emergency was false alarm—a distant munitions accident. But its effect on Gay would last beyond that night.

He learned not only that a leader's reaction during crises has implications on everyone else's response but also that leadership means being accountable for people's well-being. Most important, he recognized his own strength for performing under stress, an ability he continues to draw on at Boeing when coordinating with business partners who rely on him to respond quickly and accurately to challenges.

"We all wonder how we would react in a real emergency, and now I know for myself," Gay said. "I went straight to work as my training had taught me. I'm still trying to keep the nervous laughter to a minimum, though." ●

Shandra Jackson

787 industrial engineer

BRANCH:
U.S. Navy

LOCATION:
Everett, Wash.

TEAM:
Commercial Airplanes

Of the five options selected for Shandra Jackson through the military job placement test she took in high school, "aviation electrician" sounded the most interesting. But transitioning into the role and U.S. Navy lifestyle itself didn't have a smooth takeoff. It would take getting used to—and good at—being flexible. She had gone from living with her family in Spokane, Wash., to attending boot camp in Great Lakes, Ill., and deployments out of ports in San Diego and Norfolk, Va., on unfamiliar ships. Every assignment varied by repair and aircraft.

"I thought if I resisted change, it wasn't going to happen," said Jackson, now a 787 program industrial engineer in Everett, Wash. "But there was nothing I could do about it. Trying to lead with a positive attitude when there's nothing in your control is the one thing you can do for yourself."

Once she became more accepting and positive toward shifting tasks and locations, Jackson said work became easier, in part because her team was more willing to work with her.

"Instead of banging your head against the job for eight hours, someone shows you how to do it in four," she said. "Nobody wants to give you feedback or insight if you come across negative all the time."

Jackson continues to use this insight as an industrial engineer who helps with Lean processes, scheduling jobs and assessing the way mechanics work on myriad parts of the 787. She said her experience not only helps her relate to the mechanical engineers whom she supports, but it also informs her approach to getting them what they need, as many of them have exhibited the same resistance she once had. Luckily, she knows how to approach that challenge, too.

"I let them know that I have hands-on mechanical experience, and having that bridge to relate helps build trust," she said. "I definitely don't say, 'This is what you should do.' I say, 'Here's an idea. What do you think of it?' It helps us see where the other is coming from and gets us on a path to a solution together." ●

PHOTO: BOB FERGUSON | BOEING

BRANCH:
U.S. Marine Corps

LOCATION:
Seattle

TEAM:
Boeing Test & Evaluation

Alexandra Earl

Product data management specialist

U.S. Army ammunition specialist Alexandra Earl was finishing a 24-hour shift at a supply point in Miesau, Germany, when her noncommissioned officer in charge informed her that not only was a first lieutenant of the 172nd Airborne going to be there within the hour to do an inventory of all ammunition, but that she would be the one walking him through. Her noncommissioned officer then left to go home.

"I learned on that day that no matter how upset you may be because something was dumped on you, as long as you take a step back and know that there is a much bigger picture to what you are doing, someone will in fact notice," said Earl, now a product data management specialist for the Chinook Release Group in Philadelphia.

She spent the next 10 hours with the lieutenant conducting inventory and talking about their families. Earl's husband had just been deployed, and the lieutenant's wife was about to have their first child.

A week later, the lieutenant surprised Earl during another 24-hour shift. He had brought a picture of his newborn son and something else—a General B.B. Bell 4 Star coin. The lieutenant explained that his brigade had been given five coins to pass out to the best of their soldiers. Earl was the only one outside the group receiving one for ensuring the soldiers had what they needed.

"Even if I didn't get that thank you, I knew that because of me the soldiers going into Iraq were able to defend themselves and others," she said. "I knew that my 24-hour-plus day of working is nothing compared to what the soldiers being shot at go through."

Fast-forward to Earl's first job at Boeing, where within a month of joining the Oklahoma City site's Organizational Delegated Authority she had to prepare for an audit despite being new to the position. Her experience in Germany helped her overcome her trepidation and complete the job, a lesson she carried with her when she moved east to Pennsylvania.

"That situation played in my head every day I went to work to get that audit ready," Earl said. "I knew that no matter how bad it might seem, the mission had to get done." ●

PHOTO: FRED TROILO | BOEING

Felipe Colon

Technical design engineer

For U.S. Marine Corps member Felipe Colon, the dinner was in the details.

When Colon had to sign for the bulk meals provided to Marines during a monthlong exercise, he received a manifest but no food. The supplier assured him the order was on its way, but that wasn't good enough for the then–lance corporal from the 3rd Air/Naval Gunfire Company.

A trip to the warehouse confirmed Colon's suspicions: The meals were still undelivered, and the order didn't match the count he had provided. Had he not checked, the Marines he supported would have left with only half the food they needed for the mission. He said that it had happened before—troops would raise money and collect food wherever they could get it to make up for the shortage—but under his watch, it wasn't going to happen again.

"In boot camp we were taught to question and investigate anything out of the ordinary or suspicious," he said. "Everything has to be accounted for, and then you are taught to inspect it. You carry that through life."

And that's just what Colon has done over his 17-year career at Boeing. His current job as a technical design engineer at Boeing's Integrated Airplane Systems Lab in Seattle involves tracking drawings and parts, and verifying bills of materials.

"I got to really understand that what we were doing over there was a matter of life and death," Colon said. "Almost like Boeing: If we're missing a part or something on a plane, we're carrying lives. If I hadn't learned that, I wouldn't really appreciate what I actually do here, what I build—the importance for me and for the company." ●

PHOTO: BOB FERGUSON | BOEING

BRANCH:
U.S. Army

LOCATION:
Philadelphia

TEAM:
Defense, Space & Security

BRANCH:
U.S. Marine Corps

LOCATION:
Huntington Beach, Calif.

TEAM:
Defense, Space & Security

Casey Fox

Manager, Recovery and Modification Services

Growing up on the Fort Berthold Indian Reservation in North Dakota, Casey Fox was raised to revere members of the military. Not only was his stepfather a former U.S. Marine and grandfather a World War II veteran, but his tribe, the Arikara, holds members of the military in high regard by awarding them the right to carry the U.S. flag and eagle staff—their tribe's equivalent of the Stars and Stripes—during powwows.

So when it came time to decide what to do with his life, Fox chose the U.S. Marine Corps. As an F/A-18 avionics technician there, he learned the benefits of working with diversely skilled teams, a lesson that would come in handy in his current role as a C-17 Recovery and Modification Services manager in Huntington Beach, Calif.

One of Fox's jobs in the Corps was to service departing and returning jets on an aircraft carrier at night. Working quickly in low visibility, everyone on the flight deck was responsible for performing a task distinguished only by the color of their shirt or protective headset.

"Some wore red, white, yellow, brown, green, but each one of those shirts represented a different job or skill set associated to safely ensuring the aircraft not only launched but also was recovered when it came back to the carrier," Fox said. "It didn't matter what upbringing, race, background, beliefs or special interests we brought to work every day. Our priority was to support the aircraft, and we took that to heart."

That appreciation and reliance on diverse skill sets has followed Fox throughout his career, from the military through nine management positions he's had since starting as an avionics technical writer at Boeing heritage company McDonnell Douglas. In September he returned from an extended absence to find that his team had independently solved a number of issues that arose.

"It was like they fed off each other and finished each other's sentences as they explained the solution for the situation they avoided," he said. "It made me smile because they didn't need me to work the situation. I don't take credit for that. It's just something you would hope your team is able to do. Having said that, I'm going to take more vacation." ●

PHOTO: BOB FERGUSON | BOEING

BREAKING THE NORM

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