

Frontiers

Incubator of innovation

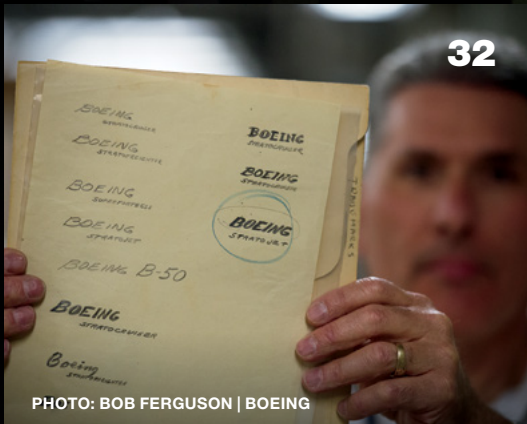
Across the enterprise,
Phantom Works employees
push the creative envelope



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Cover: Sibó Chou, an engineer with Boeing's Phantom Works, uses a motion suit to move in tandem with his virtual avatar in the Immersive Development Center in St. Louis. BOB FERGUSON | BOEING

Photo: Process engineers Scott Seddon, left, and Ryan Dognaux inspect a 3-D representation of an aircraft cockpit in the Immersive Development Center's holographic cave. BOB FERGUSON | BOEING

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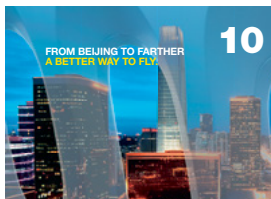
The stories behind the ads in this issue.



This ad is part of a new campaign featuring Super Hornet as the strike fighter the U.S. Navy depends on in combat. It is running in domestic publications.



To celebrate Boeing and Aviation Week Network both turning 100 next year, Boeing is making it possible for *Aviation Week & Space Technology* to digitally archive more than 500,000 articles, photographs and ads—and allow unprecedented access to the past, present and future of aerospace history.



“A Better Way to Fly” is the latest in a series of ads showcasing the many ways Boeing airplanes and services enable opportunity and success for customers. The ads are running in trade publications and online.



This ad is the third of four that will launch in India as a part of Boeing’s “Together. Building the Future” advertising campaign. It highlights the industrial partnership between Boeing and India’s Dynamatic in manufacturing key parts for the Chinook helicopter.

FSC LOGO

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The fighter they send to the front.

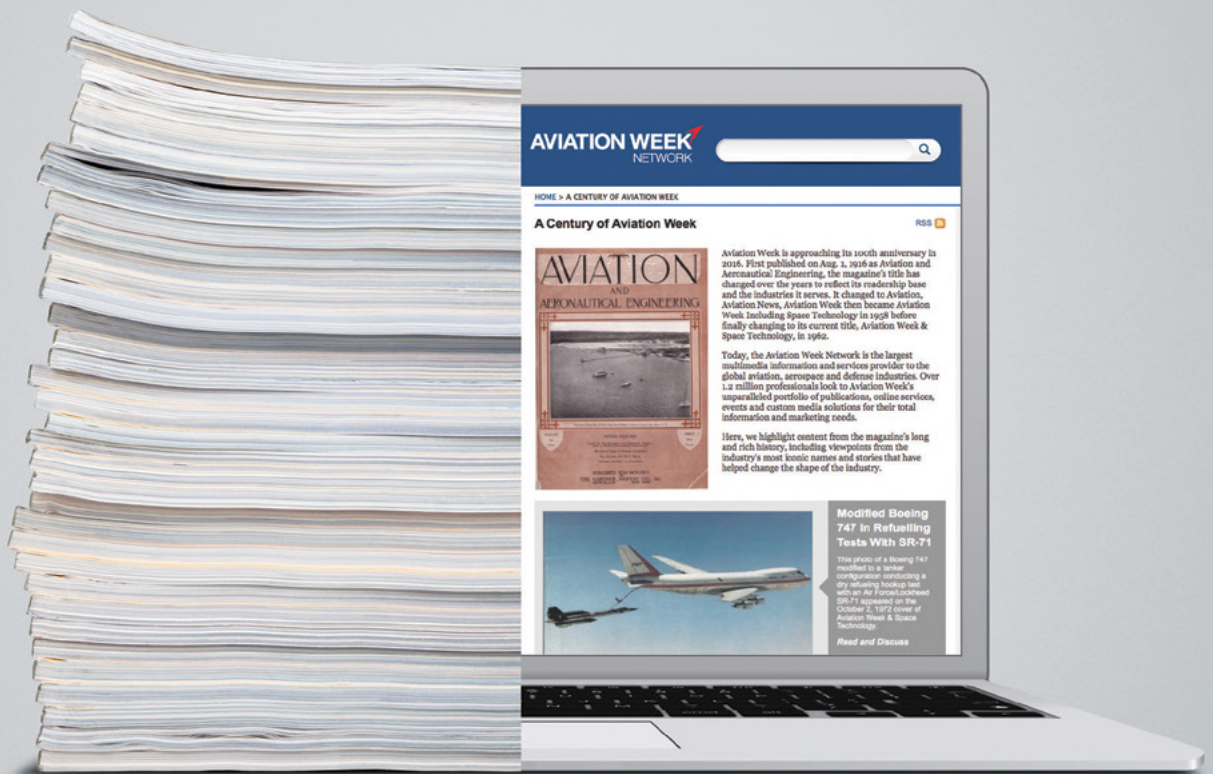
In ongoing military operations around the globe, the Super Hornet is the fighter forces depend upon in combat. Fully networked with integrated sensors and weapons, it delivers a full range of missions from close air support to air combat and interdiction. The Super Hornet also sets a new standard of availability, maintainability and cost per flight hour—providing the U.S. Navy with combat-proven, dominant aircraft today and for generations to come.

F/A-18E/F SUPER HORNET



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It can be done

Boeing must nurture good ideas and remove barriers to innovation

At Boeing, we have long taken great pride in solving seemingly impossible challenges. Perhaps we were destined to be that kind of company. Consider that our founder, William E. Boeing, recognized that the amazing technological and industrial innovations just coming to the fore in the early 1900s were nothing short of revolutionary, so much so that he declared, “it behooves no one to dismiss any novel idea with the statement, ‘it can’t be done.’”

As we move ahead in our centennial year, many of the markets in which we operate present us with new challenges that will be among the biggest we’ll ever have faced. While continuing to succeed in the many tried-and-true things that we have done since Bill Boeing’s time, we must also now do something else: Change our own paradigm for game-changing innovation.

We are in a disruptive business environment—at Boeing Defense, Space & Security, large franchise government programs are scarce. Along with the large defense “primes”

that have been our traditional competitors, we also now compete and partner with well-funded upstart players in information solutions, satellites, space launch, human spaceflight and space exploration. And there’s nothing to stop these “new space” or Silicon Valley players from moving into other markets.

The meteoric rise of these upstarts and tech giants has captured the imaginations of everyday consumers and won the admiration of many of our traditional customers. These new players have achieved tremendous success providing products and capabilities their customers did not initially know they wanted or needed.

And even as our customers continue to value the mission understanding, reliability and assurance we can provide—thanks to our years of expertise performing well on large and technically complex programs—they’re also looking to us to do things differently. While delivering mission success with our historic “products,” they also want us to act like the more nimble, less risk-averse players with whom we now compete. They want new ideas, quick responses to change in dynamic markets and innovative, “art-of-the-deal” business arrangements.

Our colleagues at Commercial Airplanes face similar challenges.

What can you do to help?

We must envision and anticipate

customer needs rather than waiting for them to tell us their requirements. We need to widen our focus beyond winning and executing programs and shine a stronger spotlight on making amazing products, ones that do not end up as obsolete because they met decades-old assumptions or needs. In the future we will need to provide even more product leadership—in platforms, systems, hardware, software or product-enabled services—and on operational excellence.

Finally, we must accelerate all efforts aimed at removing barriers to innovation. New space and Silicon Valley companies enable innovation partly through decentralization, which empowers individuals, and they rely on powerful strategic principles that everyone understands. We will need to adhere to our strategic principles and create new business models that allow us to pivot more quickly, operate more affordably, enter into new kinds of deals and tolerate more risk. We also must continue to do a better job fostering, nurturing and developing new ideas. This can only happen if each of us makes a promise to ourselves to never again hear a wild idea and say, “it can’t be done.”

Our company’s ability to grow, sustain and create great jobs, and remain the world leader in aerospace, depends on it. ■

PHOTO: PAUL PINNER | BOEING

SNAPSHOT

Dream big

Boeing employees maneuver a new autoclave around a Dreamlifter at Boeing South Carolina last month during a two-hour trip from its on-site assembly area to the Aftbody building. It's where employees use the site's original autoclave to manufacture composite aft-fuselage barrels for 787 Dreamliners.

Boeing is expanding the building to accommodate the new and bigger autoclave, which weighs 1 million pounds (463,600 kilograms) and measures 120 feet long by 32 feet wide (37 meters by 10 meters). It was transported on a specialized self-drive trailer with 21 axles and 336 tires.

After sanding and painting the autoclave, employees will configure it with internal components, then ready it with special testing for 787 production next year. PHOTO: ALAN MARTS | BOEING



QUOTABLES

“I wonder who the crazy ones are now.”

—Chris Browne, chief operating officer of Germany-based TUI Group, who in 2005 was told she was “crazy” for placing orders for a Boeing airplane still in development—the 787. The leisure travel company, which owns six airlines in Europe, now has 13 787-8s and just ordered its first 787-9. Brown said passengers are booking travel just so they can fly on the 787. *Boeing News Now*, Aug. 11

“Never have we had the ability to attack the electronic spectrum the way this airplane will do.”

—Air Marshal Geoff Brown, former chief of the Royal Australian Air Force, at the delivery ceremony in St. Louis for the first of 12 Boeing EA-18G Growlers for Australia, the only country other than the U.S. to operate the advanced electronic warfare aircraft. *Flightglobal*, July 29

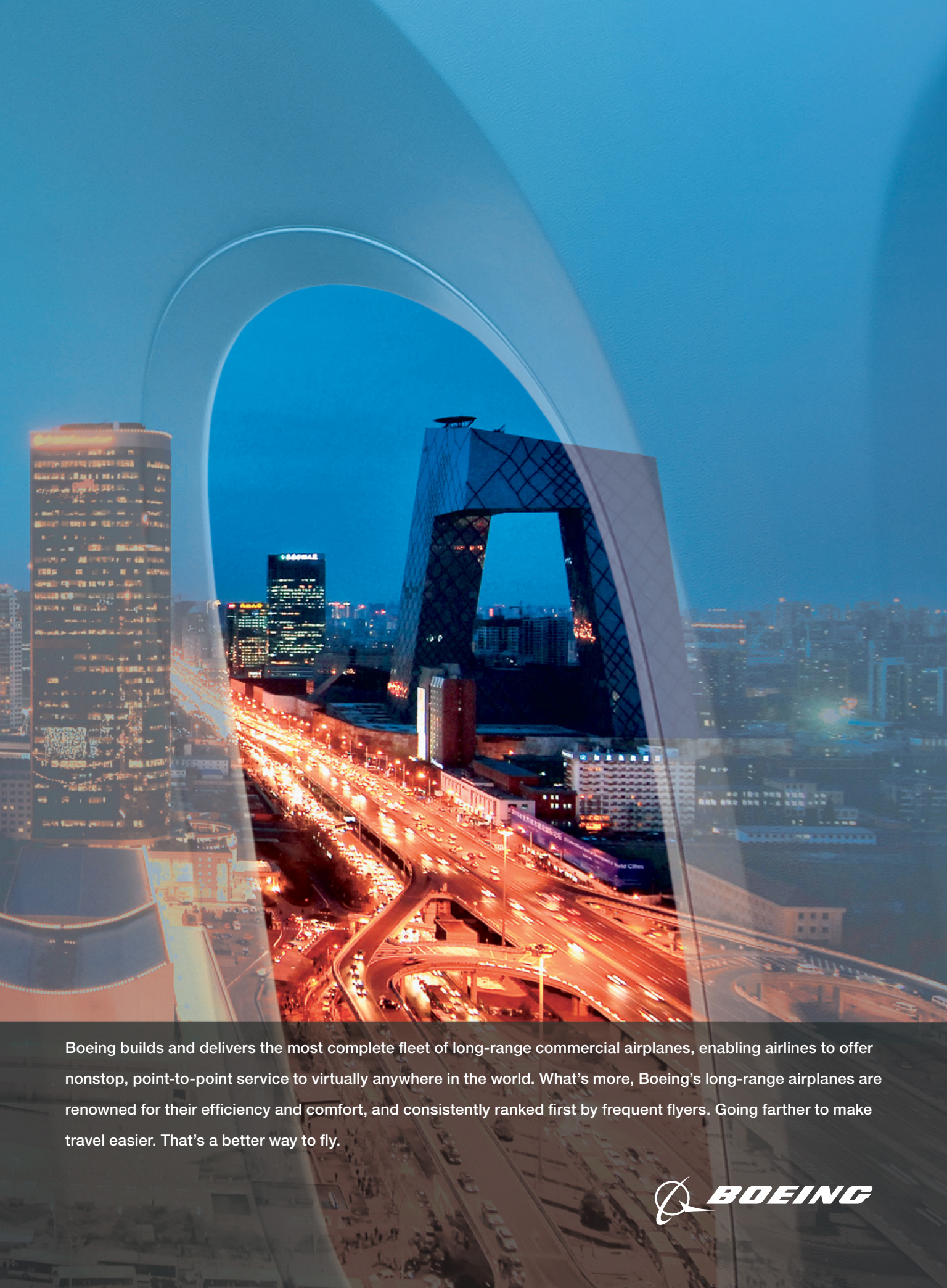
“My kids got to be on first-name basis with (astronauts).”

—Carole Eitzen, who worked as a graphic artist at NASA Johnson Space Center supporting the Apollo program in the years leading up to the moon landings. Read her story, and those of other employees, industry colleagues and enthusiasts, on Boeing’s centennial story sharing website at boeing.com/our-stories.





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DAY OF DISCOVER

'Above and Beyond' exhibit inspires young imaginations—and a few career choices

BY DAN RALEY | PHOTOS BY BOB FERGUSON

Oblivious to people standing all around him, Aydan Blakeley was on his knees, arms on a low-slung rail, eyes riveted straight ahead. The grade-schooler from Pennsylvania was inside the Smithsonian's National Air and Space Museum in Washington, D.C.,

specifically in the middle of the new "Above and Beyond" touring exhibit.

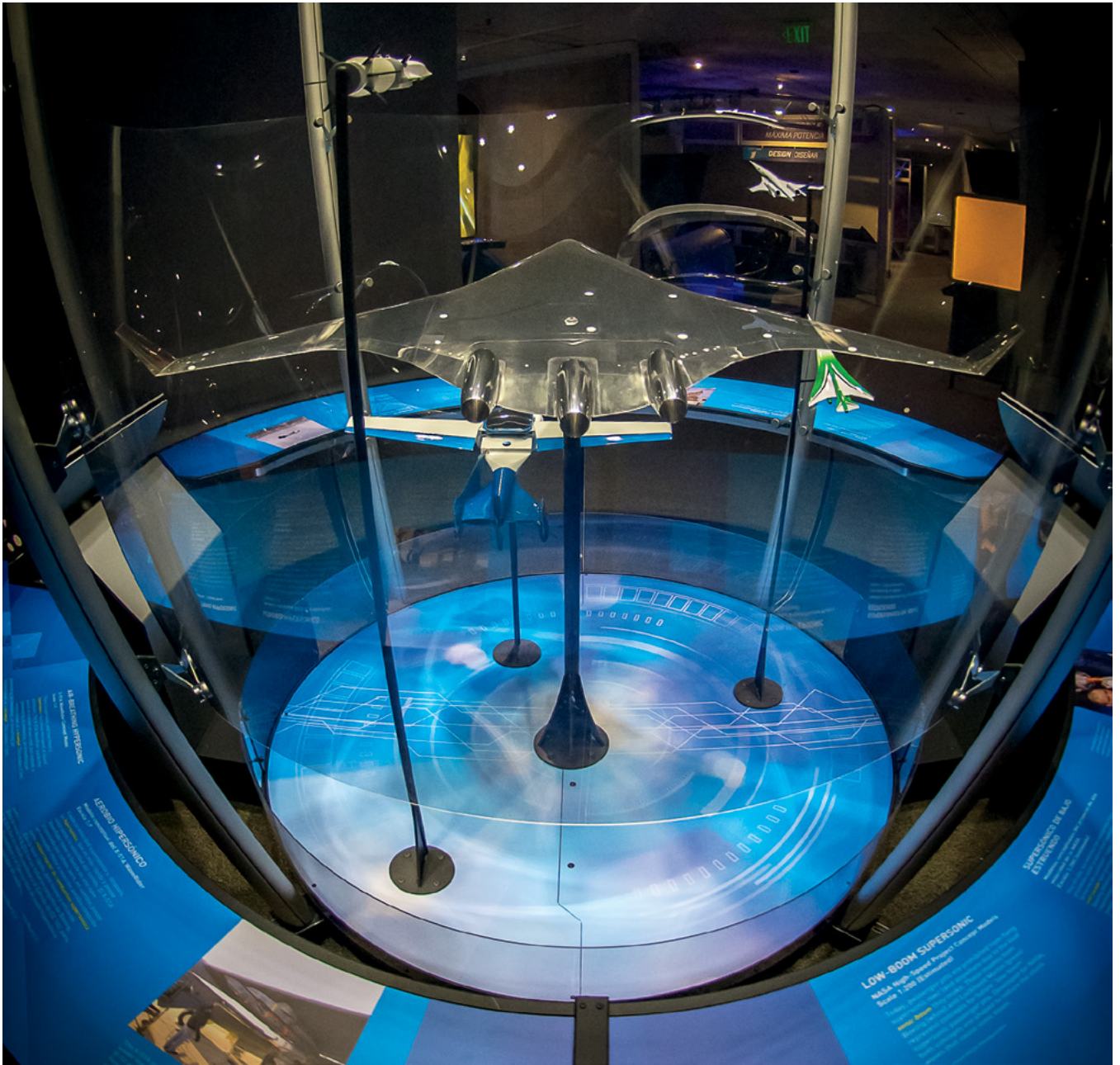
For the longest time, Blakeley, dressed in a T-shirt, shorts and sneakers, was transfixed by an interactive station called the International Space Elevator, which by video means transported him through the different layers of Earth's

Photo: Paul Frank, right, and his son, Aidan, guests of Boeing on Family Day, share in the wonderment of the Above and Beyond exhibit in Washington, D.C.



ERY





atmosphere and well beyond. His grandfather, Marty Gierke, a Boeing brand reputation specialist in Arlington, Va., was always close by. The youngster's thoughts, however, were a million miles away.

"I saw outer space," Blakeley said in all seriousness when asked what had commanded his full attention.

And in his next breath, without any prompting, as if there were no turning back, he added, "I want to be an astronaut."

Blakeley and his grandparents were one of dozens of employee-related groups who took part in Boeing Family

Day, touring the Above and Beyond exhibit in the nation's capital shortly after it opened in early August. It's unclear how many other young minds were made up that afternoon regarding career choices. It's certain a lot of thought-provoking activity took place.

Above and Beyond, underwritten by Boeing, is produced by Evergreen Exhibitions, in collaboration with NASA and the Smithsonian's National Air and Space Museum. The exhibit will remain at the museum until next January, when it will move to St. Louis.

"The exhibition is aimed at inspiring the next generation of pilots,

engineers, astronauts, scientists and innovators, the imagination of all who will advance aerospace into the next century," said Jenna McMullin, director of Boeing's centennial planning.

By all accounts, Above and Beyond, which consists of 20 interactive stations, simulations or historic touchstones,

Photos: (Above) A wind-tunnel model of Boeing's Blended Wing Body in the Above and Beyond exhibit. (Right) Autymn Webb, left, a Boeing office administrator in Arlington, Va., and her niece Mainyana Tarver fly a mock airplane they designed in the Full Throttle exhibit station.





covers 5,000 square feet (460 square meters), and will be put on display in several locations throughout the United States and world, did exactly what it was supposed to do: Inspire discovery and wonderment in the next generation with its hands-on approach.

This unique interaction represents the next concept in museum fare, according to Laura Lott, president and CEO of the American Alliance of Museums, an exhibit visitor and

Photo: Exhibit visitors simulate flight at the interactive Spread Your Wings station.



A NEW TWIST

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UN NUEVO GIRO

Los avós hacen maniobras de
precisión al despegar las alas con
sus patitas. ¿Cuál secreto es
en los avós también podrían
hacerlo?

Los avós hacen maniobras de
precisión al despegar las alas con
sus patitas. ¿Cuál secreto es
en los avós también podrían
hacerlo?



spouse to a Boeing employee.

“This is the extreme high end of high technology and it’s really a test case,” Lott said. “At museums, you go to look and read a lot; here, you get engaged. Museums are watching to see how it works. It’s a different kind of trend in the museum world. It makes sense—museums keeping up with what’s happening in the rest of our lives.”

By far, Above and Beyond’s most popular exhibit offering was Full Throttle, a simulator station that enables participants to design and pilot an airplane. A standing touch screen is used to accomplish the former task;

a flight-deck seat and accompanying controls are responsible for the latter. On Boeing Family Day, the station carried long lines at all times.

A teenage Britney Gonzalez, whose father, Miguel, is a Boeing Human Resources director for government operations, intends to be an engineer someday. Full Throttle helped steer her more in that direction.

“I’m definitely not going to be a pilot, but it was meaningful to fly a plane, especially after picking out your plane and deciding what to do so it flies,” she said.

Added her father: “I thought this would

be a very good experience for her.”

Boeing aerospace engineer Kim Kolb and his wife, Maggie, watched approvingly as their teenage daughter, Julia, and young son, Joe, took their turns at the busy Full Throttle station. A week earlier, Julia had expressed a strong desire to be a writer, but now it was an engineer, following her design and flight exhibit experience, according to her mother.

“It takes you straight up and you get to spot things along the way—it’s real,” Julia said enthusiastically of the simulator. “There’s a space port in it and I’d like to see that happen in



the future. I'm a physical learner and this was something that got its point across very well."

Ryan Chambers asked his mother, Kristen, a Boeing staff analyst, rather pointedly if he was going to be subjected to words and pictures once more on this particular museum visit. The third-grader was pleased to learn there was much more to the Above and Beyond exhibit, especially in the Full Throttle station.

"I liked it because you could design your own plane and color it a different color," Ryan said. "It was also really cool because you could go at supersonic speed."

His mother noted he "likes to build and he's curious about how things are made—this was perfect for him."

Exhibit visitors initially are greeted by an interactive station far lighter in tone, but similarly popular: Spread Your Wings. Individuals step on circular prompts and their movements are mimicked by birds on a video screen in front of them. They can flap, fly, dive, turn right and turn left.

Steve Rice, Boeing director of political mobilization, his wife, Robin, and grade-school-age sons Zach and Dylan each shared in the three-minute feathered flight. It had them passing over

water and around trees, rock walls and mountainous terrain. It had them smiling.

"The flying game was fun," Zach said. "You get to imagine that you are flying like a bird."

The Above and Beyond exhibit also offers interactive sites that allow participants to choose a planet, moon or asteroid to move to and explore, remove space junk from Earth's

Photo: Caroline Koysza, left, and her mom, Catherine, find great fascination with one of the 20 Above and Beyond stations. Dad and husband David Koysza is regional counsel for Boeing in Arlington, Va.





atmosphere, engage in wind-tunnel testing, and compare the weight of metal and composite airplane parts. Models of spacecraft and satellites and an actual jet-pack are among the items featured in display cases.

At the same time young Aydan Blakeley was contemplating his future as a space traveler, an actual NASA astronaut, Randy Bresnik, was one floor directly below him and the new Boeing exhibit, on stage regaling a Smithsonian audience with his experiences in orbit. He acknowledged that an interactive approach brought by an elaborate exhibit such as Above and Beyond was a logical way to spawn the next astronauts.

“My 9-year-old son designs and

builds things,” Bresnik said. “Anything that puts that into reality, such as participating in a simulator, is a good thing.” **100**

DANIEL.W.RALEY@BOEING.COM

For more on the Above and Beyond exhibit, and where and when it will be displayed, visit boeing.com/boeing100.

Photos: (Left) NASA astronaut Randy Bresnik responds to a question from a young audience member at the Smithsonian’s National Air and Space Museum. (Above) Andrew Adamson, foreground left, a facilities analyst for Boeing Site Services in Arlington, Va., and his daughter, Ava, give their full attention to an exhibit station while Adamson’s son, Jack, left, tries his hand at another.



Spirit of innovation

Phantom Works employees are encouraged to be independent thinkers and to take risks

BY DAN RALEY

Inside a huge Boeing shop in St. Louis, an aircraft structure that hasn't been identified to the public is suspended above the floor and surrounded by a wooden platform, enabling engineers to examine it from every angle. The room is quiet except for the steady hum of overhead fans. Employees inside the building must pass through

three locked doors to enter. Towering blue curtains hang at each end, providing an added layer of security.

In another complex is the year-old Immersive Development Center, located behind a door covered with cloud images, on a floor where all other entryways are generic and unmarked.

The room consists of a wall-size display screen, holographic 3-D "cave," virtual-reality mock-ups, real-time digital humans and collaborative workstations. Multiple locks keep it secure.

In a nearby building is the Virtual Warfare Center, which operates as described—people play out war game



vation

scenarios here. Outcomes are not revealed. The glass-covered facility is as restricted as any at Boeing.

“We counted 60 stars in here at one time,” said program manager Mike Lahm, referring to officers’ rankings.

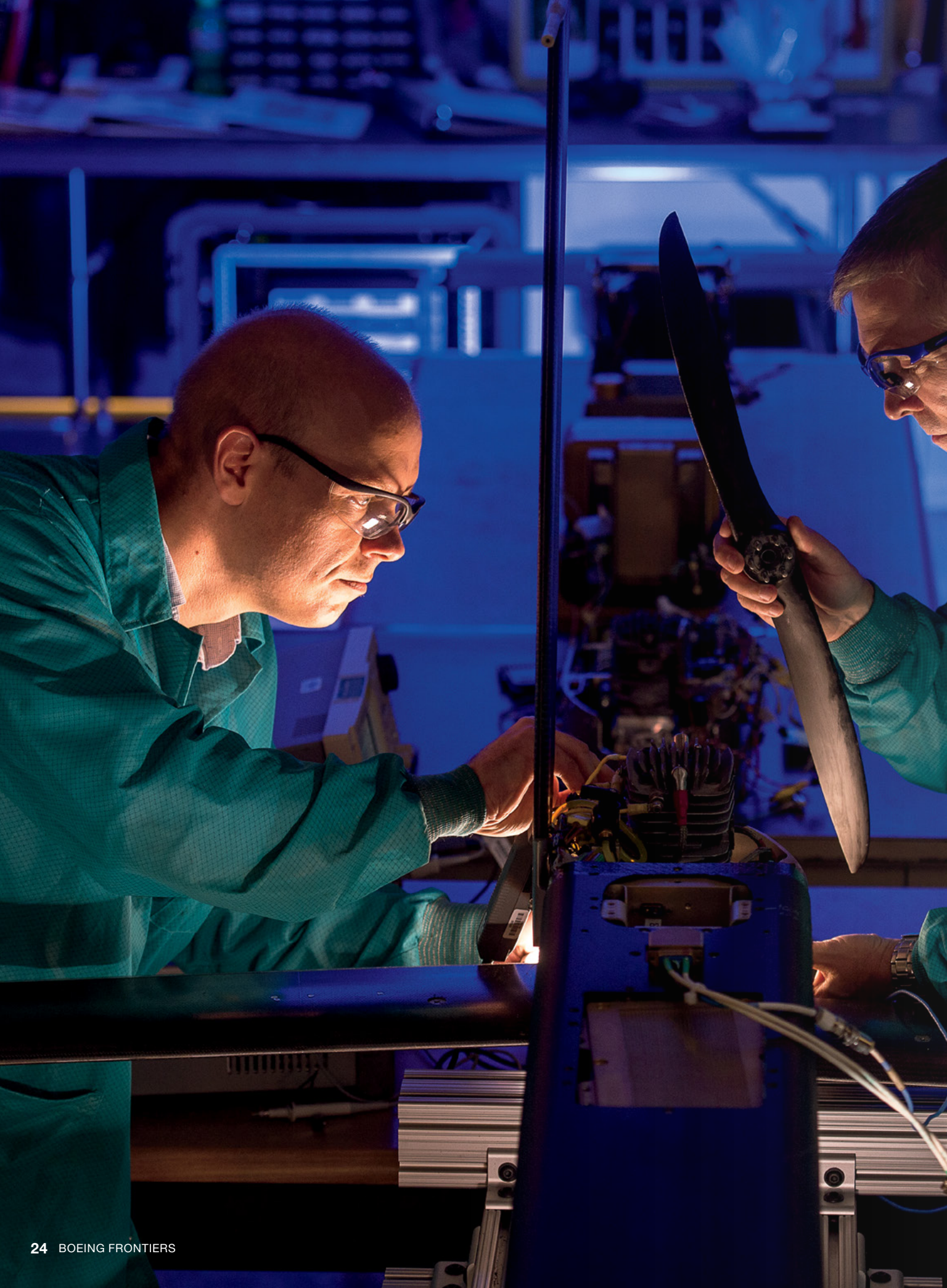
All of this falls under the auspices of Phantom Works, Boeing’s highly progressive and well-shielded research and development arm, an organization centrally headquartered at the northern end of Lambert–St. Louis International Airport amid the background noise of departing and arriving jetliners.

Phantom Works, part of Boeing Defense, Space & Security, also occupies a sprawling site in Huntington

Beach, Calif., with several smaller operations located across the United States, as well as internationally.

Created more than two decades ago by Boeing heritage company McDonnell Douglas, Phantom Works has evolved into more of an incubator for innovation that stretches across company programs and involves a wider range of product lines than before. Military aircraft, unmanned

Photo: Phantom Works engineer Sibon Chou uses a motion suit to perform research in the Immersive Development Center in St. Louis with Bob Olshan’s assistance. BOB FERGUSON | BOEING





aircraft, satellites, unmanned underwater vehicles, space exploration and now commercial airplanes have benefited from Phantom Works employees urged to push creative limits.

“We have an opportunity every day to create the future. We look into our crystal ball and discern where we should go,” explained Darryl Davis, Phantom Works president. “It is our job to develop and nurture the technology that will make our solutions real. It puts us so far ahead of our customers and competition.”

Phantom Works has created an environment for employees where risk-taking is encouraged, say senior leaders and engineers.

“We aren’t limited to ideas here,” Davis said, “but ideas across the enterprise. One plus one equals 11, and when we work across the Boeing enterprise, we can make that happen.”

With a name that suggests something covert or supernatural—it was derived from the McDonnell Douglas F-4 Phantom fighter, produced during Cold War times—Phantom Works carries a public mystique that conjures up mystery and intrigue.

However, Phantom Works employees say they operate in privacy, rather than secrecy, and for ample reason. They do this at the customers’ request. They do this to maintain a competitive edge. And they do this to keep people safe and adversaries continually guessing.

“The bottom line is to protect the country and its allies,” said Amy

Williams, a Virtual Warfare Center operations analyst. “There’s a strong sense of doing the job right. To know the work we do can affect people’s lives gives us a different way of looking at it.”

While the tan, corrugated buildings in St. Louis that house the cutting-edge activity are unmarked on the outside, this is no hidden operation. Street signs readily point to the main Phantom Works site.

There’s also been a concentrated effort to brand and showcase newer Phantom Works products in an obvious manner—Phantom Ray, Phantom Eye, Phantom Badger, Phantom Swift and Phantom Phoenix.

“We are a fast-paced cadre of innovators with a high tolerance for risk, hellbent on bending the laws of physics,” said Gary Fitzmire, vice president, Advanced Boeing Military Aircraft. “We view ‘it can’t be done’ as a challenge. The warfighter relies on our innovation, and we want to give them every advantage possible.”

Phantom Works likewise has made a big push to share its discoveries and technologies, encouraging collaborations with other company

Photos: (Left) Engineers Jon Gettinger, left, and Tom Rice work on Dominator, a Phantom Works unmanned aircraft system that will be used for surveillance, in St. Charles, Mo. (Above) Phantom Eye, a hydrogen-powered unmanned aircraft system, was created by Phantom Works for surveillance and intelligence-gathering missions. BOB FERGUSON | BOEING

programs that extend well beyond its staple defense projects and exploit the “One Boeing” concept.

Two years ago, Phantom Works and Boeing Commercial Airplanes learned that each was working on ways to eliminate assembly drilling and shims, or gap-fillers, used in jetliner assembly.

“Once we both realized we were working on the same thing, it became a synchronizing act,” said Fred Swanstrom, manufacturing engineer for Advanced Developmental Composites, from his Seattle-based office.

The breakthrough solutions will be used in production of the 737 MAX and 777X, as well as for future defense aircraft, creating wide-ranging benefits. The aim was to lower manufacturing costs, and this was a step toward that end.

The magic of this Boeing collaboration? Separate entities with markedly different methods came together on their own and found middle ground in making significant advances, with the possibility of much more to come.

“We took a conservative approach; the approach they took was not,” Swanstrom pointed out. “We are now melding the two together in a one-company approach. Phantom Works revealed what is possible. We’ve just scratched the surface of what we can do.”

The Immersive Development Center in St. Louis was responsible for a similar collaboration with

Commercial Airplanes. The 737 team approached Phantom Works with a production issue. Everyone linked up in the Immersive Development Center through a remote connection, using a bank of overhead cameras and virtual technology featuring a digital human. Phantom Works presented three scenarios over two hours, and one was successfully tested. Previously, this sort of problem-solving would have taken two weeks to complete.

In California, Phantom Works is working on Talon HATE, a communications system that can link various platforms during combat missions. Phantom Works shares in this project with six other Boeing divisions—almost everyone except Commercial Airplanes.

“We’re using the best of Boeing, and we’re doing more of that now than ever before,” said Geoff Orias, chief engineer for Advanced Network & Space Systems in Huntington Beach. “Before, it was stove-piped and people did their own thing. With less defense funding, you have to overcome that challenge. You have to work together. You can’t afford to just work on your

Photos: (Below) Phantom Ray was developed to further advance unmanned aircraft systems technology. BOEING (Right) Brian Carbrey, Immersive Development technical lead, uses a variety of digital resources to innovate and solve problems. BOB FERGUSON | BOEING





own and not use what's out there.”

In yet another One Boeing collaboration, Insitu worked with Phantom Works and Boeing Research & Technology to come up with a fuel cell for the ScanEagle unmanned aircraft, enabling it to fly longer and quieter. Engineers tested the new motor system successfully in May in Oregon after a couple of years of development.

Phantom Works employees say they are roundly encouraged to be independent thinkers and take risks, creating a spirit of innovation that invigorates the organization throughout. Williams, an operations analyst for less than a year, makes models and simulations used in the Virtual Warfare Center in St. Louis.

“I get to fly around and generate data for them,” she said. “I get to help test out the bugs. What I like most about it is that the people I get to work with are smart and critical, and I enjoy that very much.”

John Aughey, a research engineer who has worked for Phantom Works for three of his 18 years at Boeing, looks for technology that he can experiment with in the Virtual Warfare Center. He's worked on quadcopter technology in collaboration with the National Geospatial and Intelligence Agency and St. Louis University. A quadcopter is an unmanned aircraft that flies using four rotors.

Aughey said he feels liberated in how he's able to do his job and come up with fresh ideas. He credits Phantom Works leadership with giving him the freedom to create.

“You have to get out of the confines of these four walls,” he said. “If I'm put in a box and told to innovate in here, it's not going to happen. I need to get out and see things from a different point of view.”

Also in St. Louis, the Immersive Development Center employees are pushing the creative envelope. The center is unique for its holographic 3-D cave, a 10-foot-by-10-foot (3-meter-by-3-meter) area in which an engine prototype can be projected as if floating in air, enabling a customer to manually remove parts while waving a wand and wearing 3-D glasses. A U.S.

Air Force leader was so taken by the technology that he lay on his back to get a closer and longer look at it.

“To the customer, it's real powerful,” said Brian Carbrey, Immersive Development technical lead. “We can immerse them. On a scale of one to 10, it's a 12. We're trying to get out in front of the competitors. We protect this room. This is a differentiator.”

In the nearby Virtual Warfare Center, pilots and other military personnel participate in battle engagements made as realistic as possible. Phantom Works customers experience a simulated, futuristic warfare environment and use this time to determine future needs and technology gaps. Products are created that might not be put in use for several decades.

“This group is at the forefront of the BDS business,” said Lahm, program manager. “You have to understand the customer to understand the need. We're working way beyond where they thought they could go.”

Jacob Irwin, a Phantom Works project engineer for three years, has worked on several projects in St. Louis, among them Phantom Badger. It's a military vehicle so compact it can fit into a V-22 Osprey tiltrotor aircraft. It has the ability to move troops and payloads into battle more efficiently than any comparable competitive product, making it appealing to defense customers, Irwin said.

“It's one of those things that's out there that really embodies what Phantom Works does,” Irwin said of creating a vehicle rather than an aircraft. “I got to drive it and it's very cool.”

In a final assembly and test facility in nearby St. Charles, Mo., Chief Engineer Jon Gettinger leads a team of engineers and technicians from Phantom Works, BDS, Boeing Test & Evaluation, and Engineering, Operations & Technology on the Dominator unmanned aircraft system. It will be used for surveillance and can

Photo: In Huntington Beach, Calif., Julianne Choy displays the Echo Ranger, an unmanned underwater vehicle. Choy, a mechanical engineer, is working on autonomous technology for Phantom Works, pursuing new ways to explore the ocean. BOB FERGUSON | BOEING





The Phantom knows

BY JOANNA LEATH

The earliest mentions of Phantom Works started with the F-4 Phantom II, a supersonic, advanced jet fighter, produced from 1958 to 1985. Herman Barkey, the “father” of the F-4, started a special projects team, called the Phantom Works, that anticipated future needs and created advanced technologies for the F-4. Some wanted to emulate Barkey’s idea on a grander scale, but the idea was not immediately adopted. The Phantom name became a whisper in the dark world.

By 1991, several contract losses led to the formation of an advanced technology organization that closely mirrored Barkey’s Phantom Works, called the New Aircraft Products Division. This group was created to compete in the evolving environment being dominated by Lockheed’s Advanced Development Company, also known as Skunk Works.

After several name changes and years of the Phantom name appearing inside the company, the organization officially became known as the Phantom Works in 1996, paying homage to McDonnell Douglas’ legacy of engineering excellence.

While the group creates intrigue for its “black” projects and vehicles that look like they belong in a science-fiction movie, Phantom Works was created for more than proprietary programs.

“We’ve always been about more than black stuff ... Sure, it was a place to put the black stuff, but the goal was to consolidate research and development and find synergy between people doing like things,” said Jim Sinnett, former senior vice president and general manager, Phantom Works. “And together we reinvented how Boeing achieves new business.”

Part of the reinvention is anticipating and preparing for technology gaps and needs that will not be required for several decades.

“Our originators were making investments 25 years ago that are going to help us win competitions today,” said Gary Fitzmire, vice president of Advanced Boeing Military Aircraft. “And we are looking that far ahead now.” ■

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launch from the air, sea or ground. When dropping out of an aircraft, Dominator will unfold from a compact configuration and fly off to perform a mission.

Built from existing weapons and unmanned aircraft hardware and software, Dominator will have an endurance many times greater than smaller competing air-launched unmanned aircraft, Gettinger said. It is capable of carrying small weapons and has a potential for multiple uses and fates.

“Once we’ve demonstrated the air launch technologies maturity, it opens up just about anything you want to do with it,” Gettinger said.

Tracey Espero heads a 35-person team in Huntington Beach that is responsible for software for the Vision-based, Electro-optical Sensor Tracking Assembly (VESTA), which will autonomously guide Boeing’s new CST-100 spacecraft into the docking ring of the International Space Station. She holds up a thick black part that will hold a camera used during operation.

“I love when you get to build things and you go from PowerPoint to production and you actually see it fly,” Espero said. “Usually it’s cutting-edge and brand-new. It’s exhilarating to see something work like that.”

Phantom Works, for all of its high-security facilities and measures, might remain a mystery to a lot of

people, yet the curtain is getting lifted more and more these days. When it’s not a matter of national security or competitive sensitivities, products are being shared publicly and celebrated.

The X-51A WaveRider, which was developed to test technology needed for hypersonic flight, is an example. In 2013, the WaveRider broke the record for duration of hypersonic flight. It was no secret.

Within two days of that flight, a YouTube video of the accomplishment was posted.

“That was a first; I had never seen that in my career,” said Orias, the chief engineer for Advanced Network & Space Systems in Huntington Beach. “It was so wonderful to pull up the video and show my family, ‘Here’s what I do.’ Great things used to come out of a quiet organization. We’re now a lot more public in what we’re doing.” ■

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Photos: (Left) Members of Phantom Works Ventures, part of the organization’s strategy team in St. Louis, discuss future growth opportunities that go outside Boeing’s current portfolio. (Below) Tracey Espero, Autonomous Space Capabilities manager, displays an animated image of the CST-100 preparing to dock with the International Space Station. BOB FERGUSON | BOEING



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TREA

TROC

	PASSENGER OR PUPIL	MACHINE	NATURE OF FLIGHT	TIME IN AIR			WEATHER DIRECTION & VELOCITY WIND
				HOURS	MIN	SEC.	
artin	none	B. & W. No 1	TESTING	30	-	-	N. 15 M.P.H.
	C.W. LATTA	"	"	25	-	-	N. "
	none	"	"	35	-	-	S. 20 "
	C.W. LATTA	"	"	45	-	-	" "
	none	"	"	38	-	-	CALM
	L.L. LOCKER	"	SCHOOLING	1	3	✓	"
	"	"	"	15	✓	✓	S.S.W. 25
	"	"	"	15	✓	✓	" 15
	"	"	"	20	✓	✓	" 25
	none	"	FLW FOR PHOTO-GRAPHER.	40	✓	✓	" 25
	L.L. LOCKER	"	INSTRUCTING	15	-	-	" 15
	none	"	TESTING	20	-	-	S.W.
	"	"	"	15	-	-	"
	"	"	"	20	-	-	"
	"	"	"	30	-	-	CALM
	MR. PASSENGER	"	"	20	-	-	"

OVERSURE



CONDITIONS	CONSUMPTION GAS	ALTITUDE
FAIR	6 GAL	2500
POOR	"	3000
POOR	6"	1800
GOOD	7" 3/4	2200
"	6" 1/2	2000
"	4" 1/4	-
FAIR	11 1/2	1 GAL 2500
GOOD	3	1/4 250
POOR	"	" 1000
FAIR	4"	1/4 1500
BAD	6 1/2	3/4 800
GOOD	3	1/4 50
"	4	1/4 30
"	3	1/4 30
"	4	" 15
"	6	1/2 3
"	4	1/4 700
"	4	1/4 700
VERY BAD	2	1/8 600
GOOD	5	1/4 700

REMARKS.
EXTREME DIFFICULTY IN MAINTAINING LATERAL STABILITY DUE TO UNNECESSARY ANGLE OF LEFT WING DECREASED ANGLE OF LEFT WING 3'. NOTICABLE DIFFERENCE IN LATERAL STABILITY. VERY "PUFFY" MACHINE SLOW TO "GET OFF", ALSO SLOW CLIMBING. POCKETY CONDITION OF AIR, BOTHERSOME. TWO COMPLETE CIRCEES OF SMITH BLD'G BANKE TO APPROX 45°. SPIRAL WITHOUT MOTOR FROM 2000 CLOUDS LOW ROCKER ARM. NOTICABLE IMPROVEMENT. LOCKER MA SHOWING GOOD CO IN ACTUALLY FLY INTERVALS. CONT S" GIVEN LAKE, EXCEPT NE TAIL HEAVY AFTER GET PM. NECESSITAT TO TEST L FLEW 50 PER WITH AIR PU MOTOR. IN L NG ABILITY. SUMED IN GETTING R. AIR PUMP AND TROUBLE WH NG QUITE NO AS WELL AS G ABILITY NIT IDITION OF AIR WASHINGTON, OF F MESSRS, FOL COURSE. TWO AT OT TAKEN URSE. VIBRATIO TO LAKE UNION
Martin

Boeing's vast archives safeguard the past, provide a guide to the future

BY DAN RALEY | PHOTOS BY BOB FERGUSON

In a locked and chilled room, 4 million photographs and negatives are stored in cabinets alongside 16 mm motion-picture film kept in stacked silver canisters. It's one of the largest collections of its kind anywhere. Among the countless airplane, factory and employee images are a dozen from a 1946 photo shoot of a teenage model doing promotional work inside a Douglas DC-6—someone later known as actress Marilyn Monroe. In yet another room are a pair of

Photo: Among the oldest artifacts in the Boeing Archives are a logbook and photos of the B&W, a seaplane built by Bill Boeing, which preceded the formation of his airplane-making company.



aviation mechanic's coveralls, preserved from the 1920s; a Charles Lindbergh autograph from 1927, written shortly after his landmark trans-Atlantic flight; Rosie the Riveter patches and badges, awarded during World War II; Boeing CEO William Allen's personal 747 hard hat; groundbreaking engineer Ed Wells' slide rule; a 1969 program signed by Apollo 11 astronauts Neil Armstrong, Buzz Aldrin and Mike Collins, within a month of the moon landing; and the first Boeing novelty item sold, a 1933 lamp featuring a mini-replica of the first modern airliner, model 247.

All are part of the Boeing Archives, kept in a huge basement in Bellevue, Wash. Rows and rows of manuscripts, contracts, artifacts, engineering drawings, models, photographs, motion-picture films and more are spread across multiple rooms. Together, these items tell the century-old story of Boeing and its heritage companies in every manner—creatively, visually, legally, chronologically.

Experts come from all over the world to visit a place that is temperature-controlled and secure as a bank vault. Boeing engineers regularly comb through documents to learn what their predecessors knew. Airlines can see their histories and tradition unwind, some dating back to the 1930s. These visitors can sit in William Allen's leather office chair.

"Our main competitor doesn't have this," said Mike Lombardi, Boeing senior historian and archivist since 1994.

Boeing also maintains sizable archive collections in Huntington Beach, Calif., and in St. Louis, housing materials from heritage companies Douglas, Hughes and North American at the former and McDonnell, McDonnell Douglas and Hughes at the latter.

The Bellevue site, however, is by far the largest and most unusual. Covering 17,000 square feet (1,600 square meters), the archive occupies a space originally constructed by Boeing to hold computer servers and test labs.

The floor sits on a foundation separate from the rest of the building, resting on springs, to reduce vibration. It held up well during a powerful 2000 earthquake that struck the Seattle area.

"We felt the floor bounce, but not shake," Lombardi said. "Nothing fell. It was amazing."

There is much to protect and preserve. Records involving Boeing and heritage company mergers, acquisitions and divestitures are among the most valuable and sensitive materials filed away. The law department is a frequent archive user, relying on these past records to settle disputes, and save the company considerable cost, Lombardi said.

Twenty aisles fill the main Bellevue archive area, including a couple of rows set aside for aircraft models. Among them are countless replicas of planes that were designed but never came to fruition, among them a 737 with engines on the back, similar to a DC-9; a double-decker 747; and an Internal Husky, a unique-looking cargo



plane that would have hauled shipping containers and pulled up directly to a loading dock.

Sarah Musi, an aeronautical engineer who works on 777 wings, is a regular visitor to the Bellevue archive. She's interested in the age-old paperwork on file. She does company-supported research that is shared with her colleagues. She has become a valued source on Boeing production.

"Before, I was just an engineer doing various projects," Musi said. "Now people associate me with this work. People ask me about manufacturing processes done in the past. I can look them up."

Retired Boeing employees view

Photos: (Left) The James S. McDonnell Prologue Room is an air and space history exhibit in St. Louis that portrays milestone events in aerospace and is supported by Boeing Archives. (Below) Mike Lombardi, who grew up in Renton, Wash., hearing Boeing jet engines rev in the night, has been the company's senior archivist for two decades.





the archive as such a necessity that they work there as volunteers. John Fredrickson, onetime senior manager for payroll timekeeping and a 36-year Boeing employee, spends two days per week in Bellevue. He wears cotton gloves and organizes photos, negatives and other materials that involve heritage company North American Aviation.

"It's kind of like a big jigsaw puzzle," Fredrickson said. "Your goal is to preserve the collection."

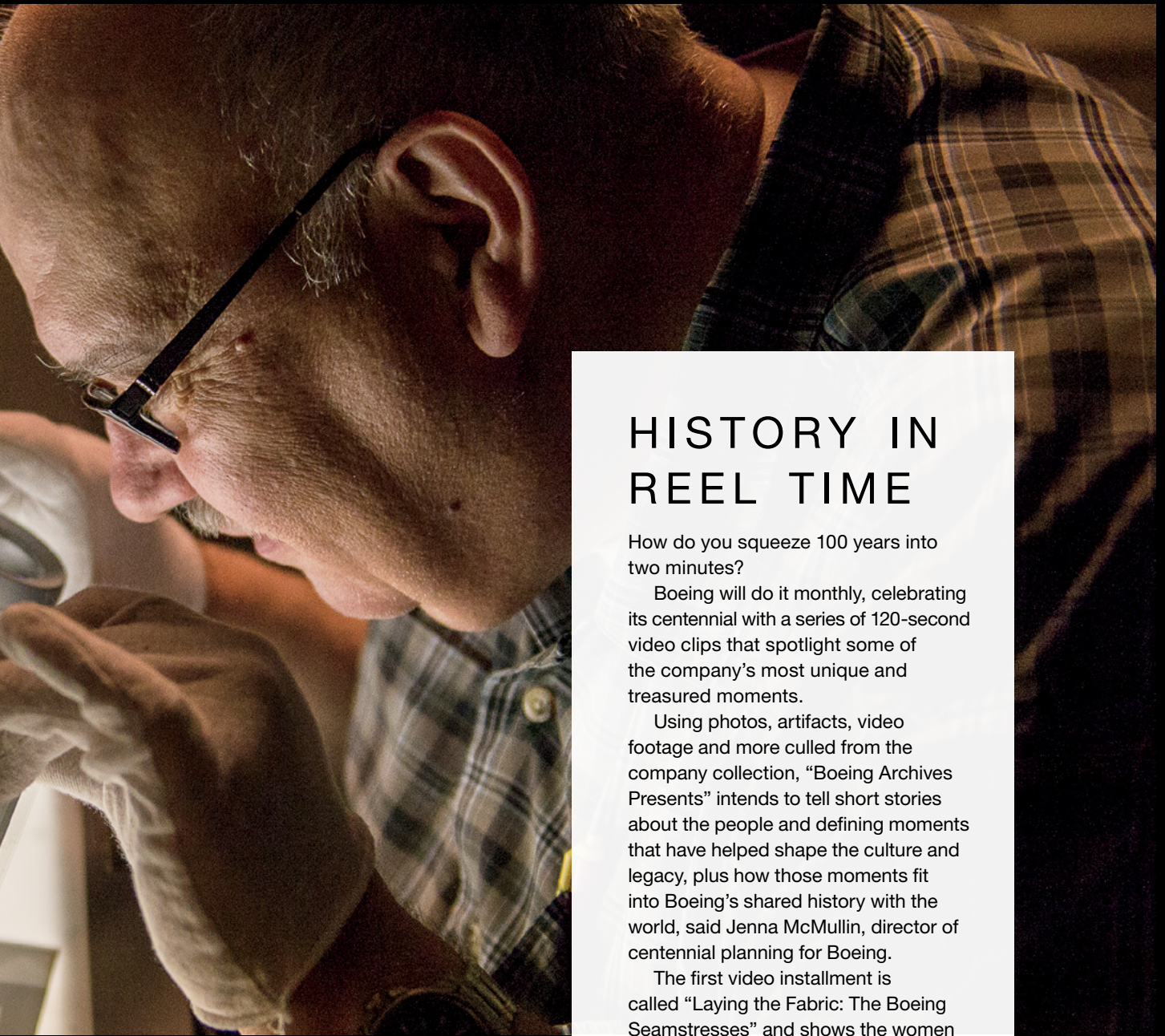
In California, Pat McGinnis, a company historian since 1994, oversees an archive that covers nearly 7,300 square feet (680 square meters) in a single-story

building and holds 2.5 million photo negatives and slides, 300-plus models, and 300-plus aviation manuals. It also has drawings and brochures on file for each heritage aircraft built.

McGinnis counts heritage company

Photos: (Above) John Fredrickson, retired Boeing payroll senior manager, works two days a week as an archive volunteer in Bellevue, identifying and filing photographs. (Right) The Boeing Archives collection fills up 20 aisles of shelves and cabinets in Bellevue in a centralized, environment-controlled room protected against fire, security and earthquake threats.





HISTORY IN REEL TIME

How do you squeeze 100 years into two minutes?

Boeing will do it monthly, celebrating its centennial with a series of 120-second video clips that spotlight some of the company's most unique and treasured moments.

Using photos, artifacts, video footage and more culled from the company collection, "Boeing Archives Presents" intends to tell short stories about the people and defining moments that have helped shape the culture and legacy, plus how those moments fit into Boeing's shared history with the world, said Jenna McMullin, director of centennial planning for Boeing.

The first video installment is called "Laying the Fabric: The Boeing Seamstresses" and shows the women who once sewed together canvas airplane wings and were some of the company's original employees.

The videos are not just product-based. They'll also demonstrate what the company did to influence culture at the time, become involved with the community, and do business in general. The videos describe lessons learned and values formed.

Boeing will unveil a new video each month leading up to the centennial, McMullin said.

Boeing historians will select and help verify the subject matter, and the videos will appear on Boeing's centennial website. To see more, visit boeing.com/100. **100**





founder Donald Douglas' logbook, or personal journal, which was first created when he was a young boy and is filled with airplane designs and magazine clippings, as her favorite archive entry.

In St. Louis, Henry Brownlee supervises an archive that covers nearly 3,800 square feet (350 square meters) in a basement that's filled with 1.3 million photos and negatives, more than 200 models and 200 paintings, and 950 archival storage boxes. His favorite items are heritage company founder James S. McDonnell's personal briefcases. They contain items such as McDonnell's books and slide rules.

"We collect, preserve and make available for business use information, data and artifacts that belong to Boeing, and some are very expensive by way of monetary value and heritage," said Brownlee, an eight-year Boeing historian. "You need to be the guardian of that."

The St. Louis archive also supports the nearby James S. McDonnell Prologue Room, an air and space exhibit in the Boeing Defense, Space & Security building that consists of artifacts, models, paintings and dioramas. Brownlee manages the Prologue Room.

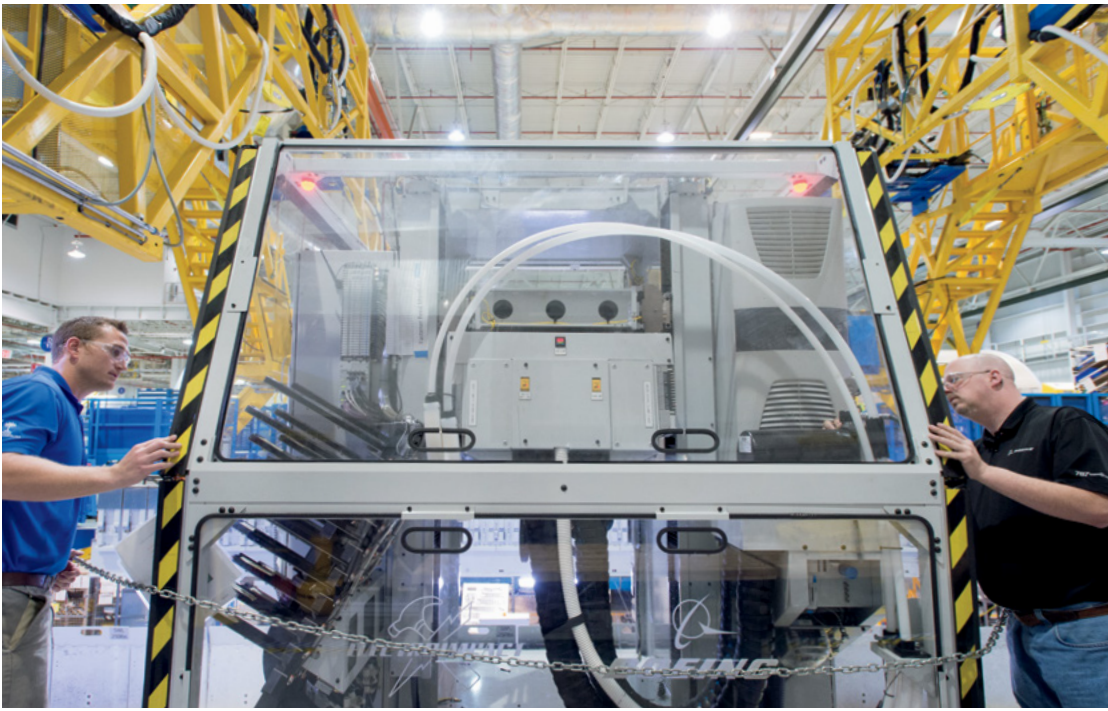
While the companywide archives exist to guide Boeing into the future, they come with another responsibility. According to Lombardi, they need to be protective of the past, too. They need to do more than store the invaluable artifacts and photos belonging to the company. They need to show who was responsible for previous innovation and discovery—and how they did it, he said, adding that former employees have requested this.

"I know a lot of people who are gone now, who looked me in the eye and said, 'Make sure that they remember who we were and what we did,'" Lombardi said. "And I take that personally." ■

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Photos: (Left, from top) In St. Louis, Henry Brownlee supervises the Boeing Archives and James S. McDonnell Prologue Room; historical dioramas depict significant events, such as the continuous improvement of the F-4 Phantom II. (Right) Boeing has a huge collection of aircraft models, including countless planes that were considered but never produced.





Scrappy success

Creative ideas and teamwork help Boeing improve environmental performance

BY PATRICK SUMMERS

Anne Stilts looked with satisfaction at a small mountain of foam scraps piled on a loading dock at Boeing's factory in Renton, Wash., one of the company's busiest production facilities.

The pile came from leftover padding from thousands of packages that bring parts to the nearby 737 assembly lines.

"It's visual confirmation that we're doing something good," Stilts, an environmental scientist with Boeing Environment, Health & Safety, said of the new recycling project. "Because

of the sheer scale of work at Boeing, even a simple idea like recycling foam can have a huge outcome."

The pile of foam exemplifies the creative ideas that are improving the environmental performance of Boeing operations, thanks to close collaboration among teams of employees throughout the company, said Beth Gilbertson, energy and resource conservation representative from the Site Services team of the Shared Services Group.

"I hear a lot of ideas from Renton employees on ways we can reduce our energy and water use and solid waste," Gilbertson said. "I'll go over ideas with Anne and we work together to move projects forward and get things done."

Site Services maintains buildings

and infrastructure and provides services, such as energy and water use management, that enable environmental stewardship throughout the company's operations. Environment, Health & Safety, a part of Boeing's 18,000-person Engineering, Operations & Technology team, supports conservation and waste reduction programs and provides resources that encourage employees to get involved in workplace environmental projects.

The groups, and others, together drive company progress in meeting environmental targets of zero growth between 2012 and 2017 in annual greenhouse gas emissions, water intake, hazardous waste generation and solid waste sent to landfills—all while



airplane production continues to grow.

The foam recycling is part of the waste reduction and conservation plan at the Materials Marketplace, the Renton site's new central receiving station for parts and material bound for the 737 factory managed by the Commercial Airplanes' Materials Management Group.

Designing a system that would efficiently collect a huge volume of discarded foam required creativity and cooperation, said Kelly Richard, 737 Materials Management coordinator.

"We brought our groups together and shared ideas on designing carts to collect the foam and selecting a local recycler to process the material," Richard said.

The discarded foam is now collected in pushcarts—designed by 737 Lean+ professional Jon Kramp—lined with large reused plastic bags. The foam-filled bags can be removed easily and staged on the Marketplace loading dock for pickup by the recycling company, Richard said.

Between February and July this year,

the Marketplace recycled 2,404 cubic yards (1,839 cubic meters) of foam, enough material to fill more than 10 737 jetliners and provide critical help in meeting the environmental targets.

"If all of us didn't work together and collaborate so well, this project couldn't have happened," Gilbertson said.

Working together also helped Boeing's North Charleston, S.C., site reduce waste on the 787 Dreamliner assembly line. The automated drills that help assemble the aircraft's midbody sections use a steady flow of coolant fluid to keep tools at a temperature for proper functioning. The midbody team noticed the coolant was getting contaminated with fine dust from the carbon-fiber material used on the 787. The contaminated fluid was clogging coolant lines and required frequent replacing.

"The coolant was lasting several days instead of several months. We were picking up 10 drums of used coolant for disposal each week," said Michael Ward, operations specialist with Environment, Health & Safety.

"Now, we've reduced that to one."

Ward and Site Services machine maintenance technicians Michael Smith and Wayne Pierson brought the problem to a midbody employee team that focuses on improving work processes. The team helped design a filtration system that removes most of the carbon-fiber particles from the coolant, so it can be reused.

"Coolant used to be our largest liquid waste contributor; now it's our smallest," Ward said.

Added Smith: "It's a solution that can grow and expand along with our airplane production. It's all possible because people from different areas worked hand in hand." ■

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Photos: (Left) Michael Ward, left, and Michael Smith inspect an automated drilling tool at Boeing South Carolina. ALAN MARTS | BOEING (Above) Beth Gilbertson, left, and Anne Stilts sort through foam pieces bound for recycling at the Renton, Wash., site. JIM ANDERSON | BOEING

ON THE MOVE



Poland is a nation of change and innovation, and Boeing seeks to grow its long-standing presence there

BY ERIC FETTERS-WALP

Poland has an expanding economy, a highly educated population and a growing manufacturing base, all located in the heart of Europe.

Since communism ended in Poland a quarter-century ago, the nation's economic output has more than tripled, and the country has become a prominent member of the European Union.

Stan Prusinski, Business Development director for Boeing Defense, Space & Security in Central and Eastern Europe, visited Poland several times before it underwent revolutionary changes in 1989. It is an entirely different place now, he said. "The Poles have crammed 50 years of economic development and political

democracy into the past 25 years," said Prusinski, the son of Polish immigrants to the U.S. "Poland has perhaps changed more than any other country in the region."

Marc Allen, president of Boeing International, said Poland often has acted as a "first mover." The nation was among the first former Warsaw Pact nations to dramatically transform economically in the early 1990s. The country's 86-year-old flag carrier, LOT Polish Airlines, was the first airline in Central Europe to operate the 767, and the first in all of Europe to take delivery of the 787 Dreamliner. Poland's armed forces are the first in Europe to acquire the ScanEagle unmanned aircraft system, made



by Boeing subsidiary Insitu.

“It’s always one of the first when it comes to innovation,” Allen said of Poland. “It’s a place that a number of companies see as an attractive manufacturing location due to its good industrial base and skilled workforce. It’s great to see the country’s market develop.”

Boeing’s presence in Poland includes hundreds of employees. More than 300 alone work in the Gdansk offices of Jeppesen, a Boeing Commercial Aviation Services subsidiary. That location focuses on providing aviation navigation data and tools, software development, and research and has seen dynamic growth, said Rafal Stepnowski, managing director at the site.

“For the past couple of years, we have been the fastest-growing unit in CAS’ Digital Aviation organization,” he explained. “The passion and qualifications of people here and the pride of being part of the Boeing family make us the destination of choice when it comes to data and software work for the organization.”

In addition to flying six 787-8 jetliners, with two more Dreamliners on order, LOT’s fleet includes three 737s. The national flag carrier has announced plans to nearly double its fleet over the next five years and increase its service to Europe, North America and Asia significantly starting in 2016. Enter Air, which has become Poland’s largest holiday tour and

charter airline during the past five years, operates an all-Boeing fleet that includes 17 737-400 and 737-800 airplanes. In June, the airline announced an order for two Next-Generation 737-800s and two 737 MAX 8 airplanes.

“The 737 has been the cornerstone of our dynamic growth, and the addition of the 737 MAX to our fleet represents an exciting new chapter in Enter Air’s successful history,” said Grzegorz Polaniecki, CEO of the airline. “With this latest acquisition, we will be able

Photo: The Old Town district of Warsaw, the historic center of Poland’s capital city, dates to the 13th century and is a UNESCO Heritage Site. SHUTTERSTOCK

to boost our expansion across the European holiday market.”

Additionally, Travel Service Polska, a smaller charter airline, operates two Next-Generation 737-800s.

Poland’s strategic location in Central Europe, next to the Baltic Sea and between Germany and the Eastern European nations, made it an attractive target for invading military forces in the past. With that in mind, and shifting geopolitical powers in the region, the nation is undertaking a multibillion-dollar modernization plan for its armed forces, Prusinski said.

“Boeing long ago expanded to Poland with our commercial products; now we seek to further assist Poland with the cutting-edge defense products that equip the U.S. armed forces,” he said. “We can offer a number of technologies that can directly affect this modernization.”

Poland is already an active part of efforts to improve Central and Eastern Europe’s security assets. The nation was a key contributor and active participant in the region’s Strategic Airlift Capability consortium in obtaining C-17 Globemaster III aircraft. It is also a member of the NATO Airborne Early Warning and Control Force, which operates E-3 Airborne Warning and Control System (AWACS) aircraft across Europe. In response to Poland’s modernization program, Boeing officials say the company is ready to support with products and capabilities that meet the country’s national security needs, such as the AH-64E Apache, the P-8A Poseidon and the Maritime Surveillance Aircraft.

Boeing seeks to build on its existing presence in Poland in other ways, beginning with its supplier relationships. The company and UTC Aerospace Systems recently announced an extended manufacturing contract to produce more parts in Poland for the Next-Generation 737, 737 MAX and 787. That includes increasing the number of 737 landing gear components made by UTC at plants in Rzeszow and Krosno. When combined with new manufacturing at other UTC sites in Poland, including the production of 787 auxiliary power units, the value of the work in support of Boeing airplane

POLAND AT A GLANCE

Official name	Republic of Poland / Rzeczpospolita Polska
Capital city	Warsaw
Area	120,700 square miles (312,600 square kilometers)
Population	38.3 million (estimated in 2014)
Gross domestic product	\$941 billion (estimated in 2014)

SOURCE: U.S. GOVERNMENT

programs is expected to exceed \$1 billion over the next 15 years.

In addition, Wytwórnia Zespołów Kooperacyjnych, which previously supplied more than 3,000 doors for the 757, now manufactures leading-edge Krueger flaps for the 777 and 747-8. Boeing has been sourcing airplane components and assemblies in Poland for more than 20 years, with annual expenditures expected to reach nearly \$75 million in 2015, according to Boeing. It also is working with Polish Armaments Group on agreements that will increase its ability to support and modify the advanced defense systems Boeing offers to the Polish government.

Boeing Research & Technology–Europe also is collaborating with the Polish government, LOT and academic institutions on air traffic management research to make commercial aviation in Poland more efficient. Boeing additionally has partnerships with Warsaw University of Technology’s Department of Materials Science and Engineering to research and develop environmentally progressive composite

Photo: Two AH-64 Apache aircraft perform a flyover during the Armed Forces Day parade in Poland. U.S. EMBASSY WARSAW







materials and the Military University of Technology in Warsaw, which is working in the area of cyber-research.

At the same time, Boeing Global Corporate Citizenship supports a range of community organizations and events across Poland, particularly educational programs that emphasize science and engineering including Łódź Children's University, a learning program for children ages 7 to 12. The Feminoteka Foundation, with Boeing support, runs the "Girls Aim High" program, which is designed to encourage young women to choose careers stereotypically considered for men only and help them develop leadership skills.

Additionally, Boeing has sent Polish teachers to Space Camp in Huntsville, Ala., has participated in the Polish-American Internship Initiative since 2014 and supports educational projects at the Museum for the History of Polish Jews in Warsaw. Boeing, too, is a supporter of Poland Business Week, a six-day business education program in which high school students experience a simulated work environment and develop business management skills.

Both Allen and Prusinski noted that Poland has a rich history in aviation, highlighted by Frank Piasecki, the son of a Polish immigrant who was a pioneer in developing the helicopter. His first company merged with Boeing in 1960 and went on to develop the Chinook helicopter line.

Prusinski said Poland continues to encourage such ingenuity and entrepreneurship.

"I look at over 1,000 years of Polish history and I see a great people who have great aspirations for their nation and for future generations," Prusinski said. "In the long run, the discipline, creativity, skills and high education level of the Polish people are characteristics that I believe Boeing must harness for our mutual benefit." ■

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Photo: LOT Polish Airlines, the national flag carrier, ordered its first Boeing jetliners in 1988 and was the first airline in Europe to take delivery of the 787. SHUTTERSTOCK

Miles ahead






The final C-17 has left the factory, but its remarkable story is still being written

BY JAMES WALLACE AND TIFFANY PITTS
PHOTOS BY PAUL PINNER

It certainly has lived up to the name—Globemaster.

Regardless of the mission, the massive, four-engine C-17 Globemaster III has been an airlift workhorse around the world, in wartime and in peace, for more

Photo: The last C-17 built in Long Beach, Calif., leaves the factory.



than 20 years. It has carried soldiers, tanks, equipment and supplies into war, and wounded warfighters out for lifesaving medical care at hospitals far away. When natural disasters hit, the C-17 is often one of the first aircraft on the scene with help—and hope.

The first one rolled out of the McDonnell Douglas plant in Long Beach, Calif., in December 1990. With employees on hand to see it off, the last C-17, ship No. 279, left the factory for the paint shop on Aug. 7. It may have marked the end of the C-17 assembly line, but hardly the end for what is one of the world's most versatile airlifters.

Among the Boeing employees who turned out to see No. 279 leave the factory were Cary Lacayo and Daniel Anderson, who was there at the beginning, too, for that first rollout.

Anderson has managed the C-17 engine shop and several other build and test packages in final assembly since 1992.

He was one of the “move managers” for ship 279.

“Moving the last production ship out of final assembly was a surreal experience, as I had been on the move team for ship 1, which was T-1, a flying test aircraft,” he said.

The U.S. Air Force took delivery of its first C-17 in 1993, and eventually 222 more. The C-17 is expected to continue to be the mainstay airlifter for the Air Force

Photo: Cary Lacayo, an aircraft hydraulic mechanic and C-17 final assembly team lead, connects the aircraft tow bar to move the aircraft to the paint shop.



for decades to come. Other customers include Australia, Canada, India, Kuwait, Qatar, the United Arab Emirates, the United Kingdom and the Strategic Airlift Capability, a consortium of 12 nations, of which 10 are members of NATO.

"It's been a nice ride," said Lacayo, an aircraft hydraulic mechanic and C-17 final assembly team lead. He was the move captain for the rollout of ship 279.

A favorite memory, he said, is surfing off Huntington Beach and seeing one of the C-17s fly overhead, knowing he had worked on the aircraft earlier that day.

Asked to sum up his emotions as he watched 279 leave the factory, Lacayo had a one-word answer: "Satisfied." ■

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For more about the C-17, see the February 2015 and March 2015 issues of *Frontiers*.

Photo: The move crew walks the "Last One" down the move path.







Where Eagles dare

Nelda Lee never thought of herself as a trailblazer—just someone who did her job as well as she could

BY DAN RALEY

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

On a misty day in St. Louis on April 29, 1980, an F-15 Eagle took off with Nelda Lee on board.

Women had ridden in the jet fighter before, but only as passengers. None had done what Lee, a flight-test engineer for Boeing heritage company McDonnell Douglas, was about to accomplish.

Traveling with pilot Gary Jennings on a circuitous route through southern Missouri for maneuvers and into Illinois and back, Lee, a licensed private pilot, became the first female to take the stick and, with Jennings supervising, log flight time on the F-15.

“The engine was more powerful than anything I’ve ever flown,” said Lee, who retired from Boeing in 2014. “You have to engage yourself with the airplane. You have to think ahead. If you think, Turn left, it turns left. It’s sensitive. You just become part of it—it was awesome.”

As Boeing prepares to celebrate its centennial, Lee is among the many men and women who have made milestone contributions to the company. In her case, the Alabama native has been an aviation trendsetter on multiple levels.

She was the only woman in her aerospace classes at Auburn University. She was among the first women design engineers for McDonnell Douglas. She was its first woman flight-test engineer. And, of course, she had her moment in that F-15.

Lee has left a deep imprint on those who have followed her into the

F-15 and EA-18 assembly and delivery center in St. Louis, influencing different generations of women who now work on the military jets.

“She was truly a groundbreaker for us in test flight,” said Joan Desmond, a flight-test engineer and Boeing employee for 29 years. “The impression she left on us was that there was always a way to get it done.”

Lexi Smith graduated from Georgia Tech University last December before joining Boeing as a flight-test engineer. It didn’t take her long to learn about Lee and her company legacy.

“It’s very inspiring to see her and

how everyone looks up to her,” Smith said. “It makes me want to try harder and earn that respect. I owe a great deal to women like her, who came in first. That took a lot of courage.”

For Lee, it was more about curiosity than boldness that guided her career. She grew up on a 317-acre (130-hectare) farm. Her father was a mechanical engineer who always repaired everything himself. She developed that same sort of creativity and intuitiveness.

Without ever stepping onto an airplane, Lee decided she would pursue the aviation world in college

Photos: (Left) Nelda Lee, with an Advanced F-15, not only helped build and test earlier versions of this jet fighter—she got to fly one. BOB FERGUSON | BOEING (Below) Lee learned how to fly while attending Auburn University. COURTESY OF NELDA LEE



because it intrigued her. She read books on flying. She learned how to fly a Cessna 150 while at Auburn as part of a class.

One month after graduation, McDonnell Douglas put her to work designing the DC-10 wing. Eventually, she transferred departments and became the original woman flight-test engineer for the F-15.

"I thought about space, but I fell in love with that airplane," Lee said.

In her new role, she coordinated testing for the F-15, which involved talking to pilots, other engineers and customers. She wrote test plans and made sure each jet matched order specifications.

Lee continued to fly privately, joining in cross-country competitions that involved women. She also was the 247th woman in the world to earn a Federal Aviation Administration rating to operate helicopters, something she did temporarily as a hobby. She has 3,000 flight-hours.

Her hands-on F-15 excursion happened by circumstance. In the early days of the program, employees had

the opportunity to sign up in the radio room to fly in the back seat, but they needed to wait and see if their name would be called. Mark Bass, a fellow flight-test engineer who would later become vice president for the F-15 program, was selected but couldn't be located at the time. Lee took his place. It was the ultimate reward. She was well-acquainted with the F-15.

"I locked in with the airplane," she said. "I knew something about it. I wasn't going into it blind."

Lee pulled on a pressurized flight suit and the ground crew guided her through evacuation procedures. The jet lifted off in a gradual climb rather than steep vertical ascent because of the rainy weather. It stayed under 18,000 feet (5,500 meters), because Lee wasn't qualified in a pressure chamber. It traveled at speeds between 400 and 450 mph (640 to 725 kilometers per hour), staying subsonic. She logged an hour and a half of flight time. She got to fly the jet, and more.

"We had a long approach that started in Illinois and Gary (the pilot)

said, 'Nelda, it's your airplane,'" Lee recalled. "As we got closer, I said, 'Gary, we're about ready to touch the ground.' He had to have his hand back on the stick by then, but I'd like to think my hand was on the stick, too."

Lee always has wondered if she should have pursued a career as a pilot, but she never regretted becoming an engineer. She took her job seriously. She was high-energy and a problem-solver. She worked until it was time to hand everything over to her younger peers.

As for turning into a pioneer, it was never something that she actively sought. It just happened. She was focused on the basics.

"I didn't think about blazing a trail or becoming one of a kind," Lee said. "I didn't come to work to do that; I came to work to work. I wanted to do my job well." **100**

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Photo: Nelda Lee was the first woman to serve as a flight-test engineer for the F-15 Eagle program. COURTESY OF NELDA LEE





Eastern charm for the long haul

A growing fleet of 777-300ERs helps China Eastern expand service—and profits—in the North American market

BY SUNNY XU

The skies above the Pacific grow busier all the time, as airlines on both sides of the ocean put more planes in the air—connecting more cities. And a growing number of those passengers are from China.

The rise of Chinese outbound travel, which exceeded 100 million passengers for the first time last year, is reshaping China Eastern Airlines. The Shanghai-based carrier operates six Boeing 777-300ER (Extended Range) airplanes, with 14 more scheduled to join its fleet in coming years.

“The 777-300ER fleet will be the driving force for our Pacific plan,” said Liu Shaoyong, chairman of China Eastern Airlines. “It’s aimed at increasing our market development in the China-U.S. sector, including raising awareness of our brand, and increasing our market share in the North American market.”

China Eastern is one of three major airlines in mainland China. With a fleet of nearly 500 long-haul and short-haul airplanes, it serves about 80 million

travelers annually and ranks among the world’s top five airlines by passenger volume.

The airline is also the largest 737 operator in China. In July it announced plans to add 50 Next-Generation 737-800s to be flown by China United Airlines, a wholly owned subsidiary of China Eastern.

“We are confident that these new 737s will play an important role in positioning the airline for long-term success in the competitive Chinese commercial aviation market,” said Ihsane Mounir, senior vice president of Commercial Airplanes Sales for Northeast Asia.

Liu said the airline’s goal is to provide customers with a world-class travel experience with Eastern charm. The 777-300ERs feature economy-class, business class with full-flat seating, and six private, first-class suites with 6-foot-7-inch-long (2-meter) beds. The Boeing Signature Interior sets the mood throughout, with LED lighting providing 23 potential colorschemes.

With delivery of the first of 20 777-300ERs last September, China Eastern also has launched its new livery, a simpler, more free-form version, with the letters C and E in the shape of a swallow.

Since November, China Eastern’s 777-300ERs have provided service from Shanghai to Los Angeles, followed early this year by New York and Toronto. It plans to further expand service to North America, Liu said.

Strong traffic, lower fuel prices and the lower operating cost of the 777-300ER have made the airline’s North American routes profitable so far this year, Liu said, explaining that the airline had planned to make North America a “core profit generator” in three years’ time, but reached profitability sooner than expected.

“We have been flying international long-haul for more than 20 years,” Liu said. “There have been profits reported in certain months by certain routes, but for the entire North America market to turn in profits, this is the first time.” ■

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Photo: A China Eastern 777-300ER (Extended Range) in flight. CHAD SLATTERY

MILESTONES

IN FOCUS

Double Eagle

Two U.S. Air Force F-15C Eagles from the 18th Wing at Kadena Air Base, in Japan, take off from Joint Base Elmendorf-Richardson near Anchorage, Alaska, while participating in Northern Edge, a joint training exercise held in June. Boeing builds the F-15 air superiority fighter in St. Louis.

PHOTO: ASSOCIATED PRESS







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