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Dream material

787 pioneers advanced composites—and ways to recycle them

BOEING

"The real challenge is to make our aircraft more recyclable—we need everyone who has anything to do with the aircraft to begin to think in a more sustainable way."

Jeanne Yu
Boeing Director of
Environmental Performance

DESIGN FOR THE ENVIRONMENT

Stories of
innovation
at Boeing

www.boeing.com/stories

18 Living in a materials world

After a decade of research, Boeing and the aerospace industry are on the threshold of large-scale composite recycling. It's a significant transformation that benefits the environment, consumers and manufacturers. It also means the 787 Dreamliner, the advanced passenger jetliner that makes extensive use of strong and lightweight composite materials, will be more recyclable than a metal airplane when it reaches the end of its useful life.

COVER IMAGE: PAUL CAMPBELL, BACKGROUND, AND CHAN TEP INSPECT A 787 COMPOSITE STRUCTURE MANUFACTURED AT BOEING'S FREDERICKSON PLANT SOUTH OF SEATTLE. BOB FERGUSON/BOEING

PHOTO: BETTY RAUTIO, FOREGROUND, AND RON SODEN CONDUCT THE COMPLEX BAGGING PROCESS OF COMPOSITE SKIN MATERIAL BEFORE LOADING IT INTO AN AUTOCLAVE AT THE FREDERICKSON PLANT. BOB FERGUSON/BOEING

Ad watch

The stories behind the ads in this issue of *Frontiers.*

Inside cover:

"Design for the Environment" is one in a series of innovation stories told by Boeing employees such as Jeanne Yu. Learn more at www.boeing.com/stories.

Page 6:

This *Flight International* ad features the winners of the Boeing-sponsored Engineering Student of the Year Award. Part of the Flightglobal Achievement Awards, it recognizes outstanding students working on aeronautical or space technology and was presented at last month's Farnborough International Airshow in the United Kingdom.

Back cover:

This ad shows a 777-300 Extended Range jetliner flying over Cape Town, South Africa. With its long range, high efficiency and best-in-class cargo capacity, the 777 helps connect Africa to the world. The ad will run in trade and business magazines throughout Africa.

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Difference makers

Nearly 3,000 Boeing employees around the world, along with friends and family members, pitched in to help their communities last month during Boeing's annual Global Day of Service. At events in more than a dozen countries, these volunteers showed Boeing employees are dedicated to making the planet a better place to live.

PHOTO: ASSOCIATED PRESS

Early bird

It typically takes three to five years to build and test a satellite. By streamlining processes and standardizing designs, employees with Space & Intelligence Systems in El Segundo, Calif., have turned that standard on its head, delivering a new medium-power satellite to the customer in record time—just 29 months.

PHOTO: DANA REIMER/BOEING

Technology's bread and butter

Whether it's a safer and more efficient way to test fuel tanks or a device that helps mechanics drill straight and true each time, the replication of good ideas, new technology and innovations across the company's programs and worldwide facilities, led by employees of Boeing Research & Technology, bolsters safety, productivity—and competitiveness.

PHOTO: MATTHEW THOMPSON/BOEING

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The Airborne Laser Test Bed, a modified 747-400 carrying a huge chemical laser designed to shoot down ballistic missiles, has been retired. But the groundbreaking research the program conducted in directed energy weapons—and the talented employees who performed it—are adding value throughout Boeing. PHOTO: KURTISS HUMPHREY/BOEING

32 Flying through change

Boeing's rotorcraft facilities near Philadelphia are being transformed as part of a massive construction project that is renovating factory and office space even as Chinook helicopter production rates have increased. The renovation has created an improved working environment for employees and is being accomplished on time and on budget. PHOTO: FRED TROILO/BOEING

INSIDE

07 Leadership Message

Boeing's people are the key to its future and it's vital that the talent pipeline continue to flow, says Mike Delaney, vice president of Engineering, Boeing Commercial Airplanes. The company has great opportunities ahead, he says, but it's also going to lose thousands of years of experience as older employees retire. Initiatives are under way to make sure a new generation of employees is ready to lead the way.

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Congratulations

Engineering Student of the Year 2012 Graduate Level

Jianying Tracy Ji
Washington State University (WSU)

Jianying Tracy Ji, PhD candidate at Washington State University (WSU), has been selected as the 2012 Boeing Engineering Student of the Year at the graduate level. She is recognized for her work in the area of advanced rechargeable lithium battery materials.
Jianying made significant achievements in creating a new and novel electrolyte with ultraflexibility and high conductivity based on a natural plant protein.

Engineering Student of the Year 2012 Undergraduate Level

Yayu Monica Hew
University of Texas at Arlington

Yayu Monica Hew has been selected as the recipient of this year's award. Yayu is a junior at the University of Texas at Arlington and is majoring in both Aerospace Engineering and Physics.
As an undergraduate research assistant, she developed, built and tested an ultra-low power wireless strain gage system for use in remote monitoring of structural integrity.

Flightglobal Achievement Awards 2012

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What makes Boeing great

People are Boeing's future and it's critical to keep the talent pipeline flowing

"Our people are our future. It is time to challenge them and allow them to grow into the leaders of tomorrow."

– Mike Delaney
Vice president of Engineering, Boeing Commercial Airplanes

PHOTO: ED TURNER/BOEING

The future is bright for Boeing. We have great products, great customers and huge market opportunities. Our people create those products, serve those customers and enable us to capture and sustain major portions of our markets. In other words, our people make this company and its products great.

When talking with employees around the company, I am often asked what I foresee as potentially limiting Boeing's ability to prosper. That answer also has to do with people … and whether Boeing can continue in the future to develop, build and support the innovative products that safely serve millions every day, protect freedom, and drive commerce and economies around the world.

We need to ensure we have the talent to compete in the future.

Ironically, Boeing will soon find itself in a period of almost unparalleled opportunity for its employees, coupled with an equal amount of risk. Let me explain.

We have a large population of employees nearing the end of their careers, with decades of know-how, and a smaller but expanding population with just one to five years of experience. Between is a deep valley; knowledge and experience are not equally distributed across the workforce. This is important, as the leaders of tomorrow—those who will drive development of the next great products—typically emerge from the population between early-career employees and the more experienced. But that population is small.

For example, 22 percent of the Commercial Airplanes engineering workforce is eligible to retire. In five years, another 25 percent will become retirement eligible. While we don't expect everyone to leave the company at the same time, once we hit this five-year window we could lose 1,000 to 1,500 of our most experienced people in engineering every year. That's 25,000 to 37,500 collective years of experience leaving annually.

Unless we retain people or find ways to pass along what they know, we will lose that knowledge forever. The demographics are comparable across many parts of the company and across the aerospace industry in general.

Commercial Airplanes is working on a variety of talent-management initiatives as part of our corporate Engineering Excellence effort—our strategy for achieving technical excellence while delivering business results. Efforts include developing the pipeline of future technical employees by supporting Science, Technology, Engineering and Math—STEM programs—in school districts where Boeing has large populations of employees.

We also are tapping surplus engineering talent from Boeing defense programs affected by shrinking defense budgets, and recruiting the best, brightest, most capable people from engineering schools across the United States and internationally. Once they join us, key initiatives such as the Ed Wells Partnership—administered jointly by Boeing and the Society of Professional Engineering Employees in Aerospace—help develop these employees' skills and careers.

Other efforts involve a number of methods to transfer knowledge from our experienced employees to early-career employees including training, mentoring, knowledge capture and leveraging the learning of our subject-matter experts and Technical Fellows. Even the way we identify candidates for manager and executive leadership positions likely will change. Given the demographics I described, we need to promote people into management and executive roles earlier in their careers than ever before. This will present great opportunity for many.

Boeing has a proud, long, pioneering history in aerospace. Our colleagues before us bequeathed us the responsibility to carry on the tradition of building industry-leading products—products that change the world. It is our turn to do the same.

Our people are our future. It is time to challenge them and allow them to grow into the leaders of tomorrow. ■

Snapshot

UNITED WE STAND: An estimated 1,000 employees from Boeing's Renton and Fabrication facilities in Washington state commemorate the more than 10,000 orders Boeing has received for all models of the 737 jetliner since the program began in 1967. Last month's purchase by United Airlines of 50 Next-Generation 737s and 100 of the 737 MAX now in development pushed Boeing past the milestone. The 737 is the only commercial jetliner to receive 10,000 or more orders. PHOTO: MARIAN LOCKHART/BOEING

Quotables

"We negotiated what we believe to be the best airplane with the best engine at the best price."

– *Jeff Smisek, United Airlines' president and chief executive, telling reporters why the airline ordered 100 Boeing 737 MAX airplanes instead of the competing plane from Airbus. United also ordered 50 Next-Generation 737-900ERs (Extended Range).* Chicago Sun-Times, *July 12.*

"The language we're hearing from several of the customers is that they're ready, and they're vying to be ... the first."

– *U.S. Marine Col. Greg Masiello, who runs the V-22 Osprey program, explaining the strong interest of international customers in the Bell-Boeing V-22 tilt-rotor aircraft to reporters at the Farnborough International Airshow in the United Kingdom. Reuters, July 10.*

Bright lights, big safety

Boeing scientist has a laser-like focus on workplace safety

By Terri Christofferson

Denny Rossbach is a chief scientist for Boeing Test & Evaluation in Albuquerque, N.M., and an expert on laser technology. In this *Frontiers* series that profiles employees talking about their jobs, Rossbach explains why he's also developed a passion for workplace safety. PHOTO: BOB FERGUSON/BOEING

Lasers can do wondrous things, and Boeing uses them for applications such as helping align 777 fuselage sections during final assembly and in precision-guided and directed energy weapons. But since they can produce tremendous energy, I know that this is not a place to take shortcuts in workplace safety.

With 44 years' experience in the design, development, integration and test of electro-optical and high-power laser systems, I've taken it upon myself to do what I can to help create a safer workplace.

Early in my career, I saw a co-worker get badly hurt by a laser. I had to physically push him out of the beam to stop the burn. That incident really hit home for me and made me realize that workplace safety is something we shouldn't take for granted.

That interest in safety has inspired me to earn laser safety certification and led to membership on a cross-industry committee that oversees laser safety standards. I've helped create a comprehensive safety process and culture at my work site, where we use potentially lethal high-energy laser systems every day.

I've also sought out training and seminars that enabled me to create a custom electrical safety class, tailored specifically for our site's needs. The course, modified and certified by Boeing's Hazardous Energy Process Management team with Environment, Health and Safety, was approved for companywide use. I'm happy to see that my work is helping strengthen workplace safety training at other Boeing sites.

Everyone is trying to be more productive. But sometimes it seems that people are trying to do what they think will be faster, when they should focus on doing things safely yet efficiently.

There are always opportunities to work more safely—we just need to identify them and find solutions. I feel fortunate to work in an environment where those actions are recognized and encouraged. And it's gratifying to know that my contributions help people across Boeing work safely—so they can be productive both at work and at home. ■

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Higher learning

Skylab expanded our knowledge about Earth—and how we could live and work in space

By Henry T. Brownlee Jr.

Compared with the massive and spacious International Space Station that circles Earth today, America's first space laboratory, Skylab, was a little like roughing it in a tent on a camping trip.

But Skylab, which was launched into orbit nearly four decades ago, was a leap forward in spaciousness and amenities compared with previous spacecraft, and it demonstrated that people could live and work in the harsh environment of space.

"Skylab … has taught us that man is worth far more than his weight in machinery and computers in overcoming unforeseen difficulties in space," said Sanford "Sandy" N. McDonnell, former president and chief executive of McDonnell Douglas Corp., which built Skylab. "This should put an end to the debate about man's ability to perform useful work in space."

The Skylab mission, however, almost ended before it began. During launch by a Saturn V rocket from Cape Kennedy on May 14, 1973, a meteoroid shield protecting Skylab tore off, ripping away one of the spacecraft's two solar panels that were to provide electrical power.

The loss of the meteoroid shield caused the temperatures in Skylab to rise to 126 degrees Fahrenheit (52 degrees Celsius), making it uninhabitable. Engineers at NASA and McDonnell Douglas, along with other industry experts, worked for 10 days to devise a plan to train astronauts how to repair the damaged station.

An Apollo spacecraft carrying astronauts Charles Conrad Jr., Paul Weitz and Joseph Kerwin was launched and rendezvoused with Skylab on May 25. They successfully made repairs, freeing the remaining but jammed solar panel and placing a protective heat shield that dropped the inside temperature to 75 degrees Fahrenheit (24 degrees Celsius).

By June 4 the orbiting workshop was fully operational.

Skylab's mission was not just to determine whether humans could live and work in space for long periods of time. It was designed as a laboratory to gather information about Earth's resources and the environment and to use its solar telescope to better understand the sun and how it affects Earth.

The largest section of Skylab was a converted third stage of the mighty Saturn V rocket developed to send U.S. astronauts

beyond Earth's orbit on their way to the moon. McDonnell Douglas in Huntington Beach, Calif., built the third stage of the Saturn V for the Apollo lunar program and would modify it into the Saturn Orbital Workshop, the living and working quarters of Skylab.

A separate Airlock Module for Skylab was built by McDonnell Douglas in St. Louis.

In all, three three-man crews of U.S. astronauts, including those on the repair mission, occupied the workshop for a total of 171 days, 13 hours. Skylab's 10,000 cubic feet (280 cubic meters) of living and working area was the site of nearly 300 scientific, technical and life science experiments, according to NASA.

The final Skylab crew left the workshop on Feb. 8, 1974, after completing its 84-day mission. Among its duties was observing the comet Kohoutek.

Early on, there were discussions about possibly refurbishing Skylab and boosting it into a higher orbit using a space shuttle. But when the shuttle program was delayed, Skylab's fate was sealed. Uninhabited, it re-entered Earth's atmosphere in July 1979 and burned up, scattering debris over the Indian Ocean and sparsely inhabited Western Australia.

LeLand F. Belew, Skylab program manager at the NASA Marshall Space Flight Center in Huntsville, Ala., perhaps best summed up Skylab's accomplishments at the time, when he said: "The wealth of information obtained during man's longest journey into space has provided the answers to many questions, as well as revealing new questions and knowledge about the sun, the Earth, space and man himself. An adventure of today, Skylab was also an investment in tomorrow. Its results are a legacy for all … forever." ■

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PHOTOS: (Left) After Skylab was damaged during launch, astronauts freed its remaining stuck solar panel and placed a protective sun shield on the lab, shown here. **(Insets, from left)** The Skylab 4 crew demonstrates weightlessness; the Skylab 2 crew trains before its flight. NASA

One day, a world of difference

Thousands of Boeing employees volunteer for Global Day of Service

By Peter Pedraza









Sending a powerful message about the importance of community service, thousands of Boeing employees volunteered in nearly 100 events in 13 countries across the globe during Boeing's third-annual Global Day of Service last month.

From mentoring children in Beijing and cleaning beaches in California to assembling food packages in Israel and building oyster reefs in Charleston, S.C., nearly 3,000 employee volunteers and their families and friends helped in their communities.

The annual event serves as a focal point for the many volunteer activities that Boeing employees engage in year-round.

"For nearly 100 years, corporate citizenship has been an important part of Boeing's culture," said Lianne Stein, vice president for Boeing Global Corporate Citizenship. "We continue to contribute time, money and resources to strengthen communities around the world and we are proud that Boeing employees give their talents to help others." ■

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PHOTOS: (Clockwise from top left) Boeing South Carolina employees restore oyster habitat. JOSHUA DRAKE Boeing India and Aviall employees host an interactive learning event in New Delhi. ASSOCIATED PRESS Illinois Institute of Technology's Boeing Scholars learn how to prepare resumes and cover letters. BRANDON LUONG/BOEING Employees host technology-centric education for the St. Louis Youth and Family Center. PETER GEORGE/BOEING Tel Aviv employees assemble food packages for the needy. ASSOCIATED PRESS Boeing Defence Australia employees plant a "Paradise Garden" at MacDonald Nursing Home. BOEING Employees clean up Navy Beach in Seal Beach, Calif. BRITTANY KUHN/BOEING Boeing China supported Beijing Special Olympics students. LIU ZHIJIAN **(Center)** Boeing employees repair the Imagine Children's Museum in Everett, Wash. PAUL GORDON/BOEING **(Opposite page)** Boeing South Carolina's Anthony Soto. JOSHUA DRAKE

"We continue to contribute time, money and resources to strengthen communities around the world and we are proud that Boeing employees give their talents to help others."

– Lianne Stein, vice president for Boeing Global Corporate Citizenship

Early delivery

Boeing team completes new 702MP medium-power satellites in record time

By Diana Eastman

From celery to cellphones, the time it takes to get a product to market is critical for sellers and buyers.

In the satellite business, the pressure is magnified. The worldwide demand for services—such as mobile communication, Earth observation and space surveillance—increases daily. But it takes years to manufacture a complex spacecraft that can provide the needed capability for a life span of almost two decades.

Typically a new satellite gets built and tested in three to five years. But Boeing Space & Intelligence Systems employees in El Segundo, Calif., are turning that standard on its head.

They completed the company's first 702MP (medium-power) satellite in just 29 months, one month ahead of the aggressive schedule set with its customer Intelsat, a Luxembourg-based provider of global mobile communications. The spacecraft, designated Intelsat 22, or IS-22, was launched in March and is now on orbit and providing video, network and voice service to customers.

With the second 702MP on deck for an August launch, the Space & Intelligence Systems team has continued to keep an eye on cycle time. It will deliver that payload ahead of schedule as well. The third satellite also is on track for early delivery.

"When we finished IS-22 and I heard we did it in 29 months, I was pretty amazed," said Patrick Cooke, a structural analyst engineer with the space systems team. "We've never done a first build that fast. It's a credit to the hard work of a lot of people."

The 702MP design was introduced to the market in 2009 in *Frontiers* magazine, and Intelsat became the first customer. The spacecraft is engineered to hold both a primary and secondary payload. A secondary, or "hosted," payload enables a commercial satellite provider to offer business, government and military customers a faster, more economical way to get into space than buying a dedicated satellite.

The introduction of a medium-power variation of Boeing's successful 702HP (high-power) spacecraft is part of an aggressive strategy by Space & Intelligence Systems to re-establish its business in the burgeoning commercial satellite market.

"We are known for our technical excellence and breadth of experience, but staying competitive means we also must offer affordable, flexible and creative solutions. We see the 702MP and hosted payloads as game-changers," said Jim Simpson, vice president of Business Development for the Space & Intelligence Systems division.

The 702MP is not a completely new design—it's an evolutionary model that draws heavily from the flight-proven 702HP, which reduces the risk for customers. The satellite's modular design enables it to be scaled to different communication needs.

The division has kept the 702MP affordable in part by emphasizing standardization in design, electronics, supplier agreements and production. Streamlining efforts in the satellite factory also has reduced costs and increased throughput.

"Our employees understand the marketplace and our need for speed," Simpson said. "Their success in building a new, high-quality satellite in record time is a big deal and has led to a very satisfied customer." ■

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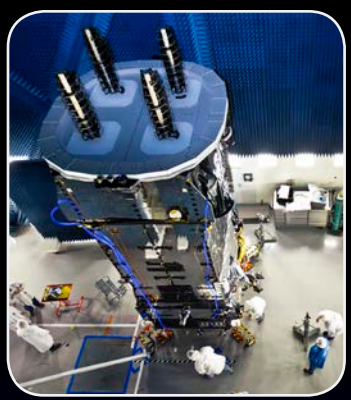
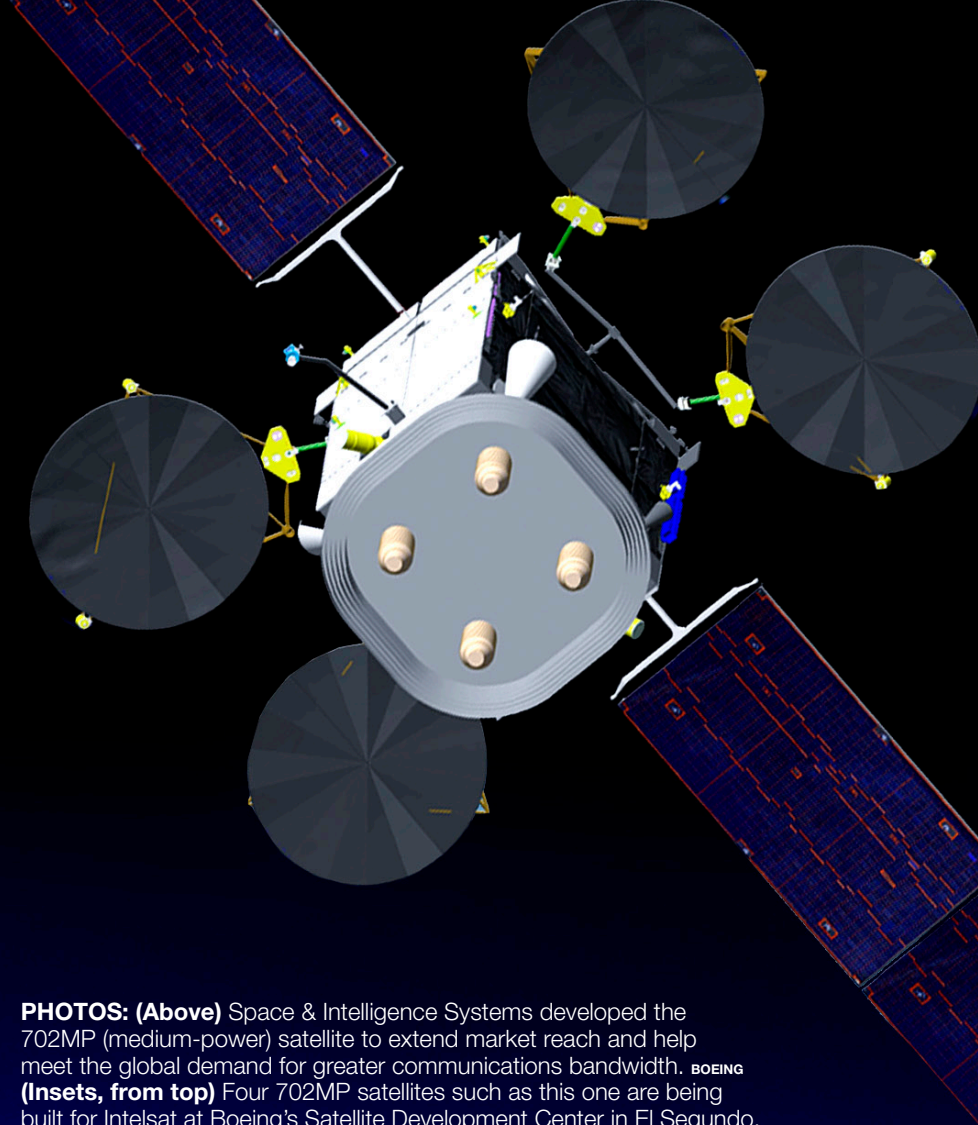
"We've never done a first build that fast. It's a credit to the hard work of a lot of people."

– Patrick Cooke, structural analyst engineer





PHOTOS: (Above) Space & Intelligence Systems developed the 702MP (medium-power) satellite to extend market reach and help meet the global demand for greater communications bandwidth. BOEING **(Insets, from top)** Four 702MP satellites such as this one are being built for Intelsat at Boeing's Satellite Development Center in El Segundo, Calif. CRAIG COOK/BOEING Structural analyst engineer Patrick Cooke inspects the center tube of a 702MP payload module during static testing, the first of a series of tests to ensure the satellite can withstand the rigors of launch and space. GLADYS WICKERING/BOEING

‘Safety in action’

The 777 program has sharply reduced workplace injuries with a focus on safety

By Patrick Summers and photos by Gail Hanusa

Safety coordinator Craig Morgan knows firsthand how a workplace injury can change a person’s life. And he’s committed to helping his co-workers avoid a similar challenge.

Morgan was a mechanic installing 747 cargo doors at the Everett, Wash., factory in 2002. One day, while using his feet to help guide the rolling tool that carried the doors, Morgan’s left foot slipped and twisted on a tool edge, tearing tendons and ligaments attached to his left ankle.

“You know how everybody says they want you to go home the way you came in? That day I didn’t, and it has affected me ever since,” he said.

Morgan has endured five surgeries in the past 10 years, and while able to work, he can no longer take part in several of his former favorite pastimes, including competitive softball and jogging.

He has, however, brought his personal experience, perspective and passion for safety to his current job as full-time safety coordinator in the 777 jetliner program at the Everett factory. Safety coordinators have played an important role—along with a robust safety plan, new workplace safety tools and activities and engaged leadership—in helping the 777 program reduce the number of lost work-time injuries by 42 percent in 2011.

“As the airplane program with the largest number of employees at the Everett site, the 777 had a lot of room for improvement,” said Rick Monger, program safety manager. “We still have a lot of work to do and a long journey ahead of us to reach the target of zero workplace injuries.”

Safety leaders aim to continue reducing workplace injuries this year by building on the foundation put in place with the 2011 safety plan. The strategy they designed features both new and established solutions and activities, including:

- New employees must complete a seven-week physical conditioning class delivered by Shared Services Group Health Services before they start work on the factory floor.
- Athletic trainers and physical therapists

PHOTOS: (Opposite page, clockwise from left) Safety coordinator Craig Morgan replaces a panel covering a gap on the floor; team safety leaders perform regular workplace inspections; Trang Le performs daily factory-floor warm-up exercises at the start of a shift; Brandon Benfit joins in. **(This page, clockwise from left)** Electrician Terence Page wins prizes in a weekly "Treasure Chest" drawing that recognizes safe behavior, while Morgan looks on; Larry Seng, left, leads daily warm-up exercises; team safety leaders Robert Delvechio, left, and Ben Cool lead regular safety inspections; team safety leader Rob Huss, left, and Morgan replace protective temporary flooring.

provide stretches or deep-tissue massage to help prevent strains or sore muscles from becoming more serious injuries.

- Safety coordinators and managers investigate every injury or near miss, with the goal of being notified within 30 minutes of an incident.
- Managers walk the factory floor to help ensure compliance with safety requirements.

The 777 safety plan is supported by a network of nearly 140 employees throughout the program who address local safety concerns and work with the coordinators to focus the company's resources on issues that need attention.

"Our attitude is 'safety in action'—if you see something that needs attention, don't let it go; fix it before somebody gets hurt. Be proactive," said 777 safety coordinator Chris Malouff.

After showing substantial improvement in 2011, the monthly-average rate of decline in 777 workplace injuries leveled off this year and began to move in the wrong direction, prompting a sharp focus on compliance with safety requirements and personal accountability.

"The core of a safety culture is a continuous-improvement mindset—the desire to always be better than the day before," said Jason Clark, 777 manufacturing director. "The areas where we have the strongest safety culture are where we also have the best demonstration of 'servant-leaders'—managers who enable employees to be active in the improvement process."

Clark said he has about 175 employee involvement teams active in all areas of operations, including safety.

"A strong culture also means caring enough to stop and tell a co-worker if they aren't wearing safety glasses and having the person say 'thank you' because they are truly grateful for the reminder," Clark added.

For Morgan, the visibility of the coordinators helping people on the factory floor may be the most important component of a credible safety culture.

"I used to walk out on the floor and not get much of a response," he said. "Now I'll have four or five people come up to me and ask for help fixing something. They trust it's going to get done."

Morgan said earning that trust is important. "I see a lot of people come through here. I just want everyone to go home safe." ■

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Material advantage

Recycling composites offers many benefits for Boeing, the environment—and the 787

By Robin McBride

PHOTOS: (Clockwise from top left) Excess composite material left over from the barrel-winding process at Boeing South Carolina is collected and recycled. The site produces the 787 Dreamliner 47 and 48 sections. ALAN MARTS/BOEING Small pieces of composite material from a shredded 787 test wing are gathered for recycling. BILL CARBERRY/BOEING Pete George uses a kayak paddle made from reclaimed carbon fiber; composite manufacturing employees Chan Tep, left, and Paul Campbell prepare to perform a quality check on a 787 structure at the Frederickson, Wash., plant. BOB FERGUSON/BOEING A completed 787 Dreamliner. ED TURNER/BOEING

Pete George never expected his work with advanced composites for the 787 Dreamliner program to benefit his weekend kayaking getaways. But it has.

"Our paddles have a bit of the Dreamliner in them," said George, an Associate Technical Fellow with Next-Generation Composites, Boeing Research & Technology. "They are lighter and more efficient, just like the 787."

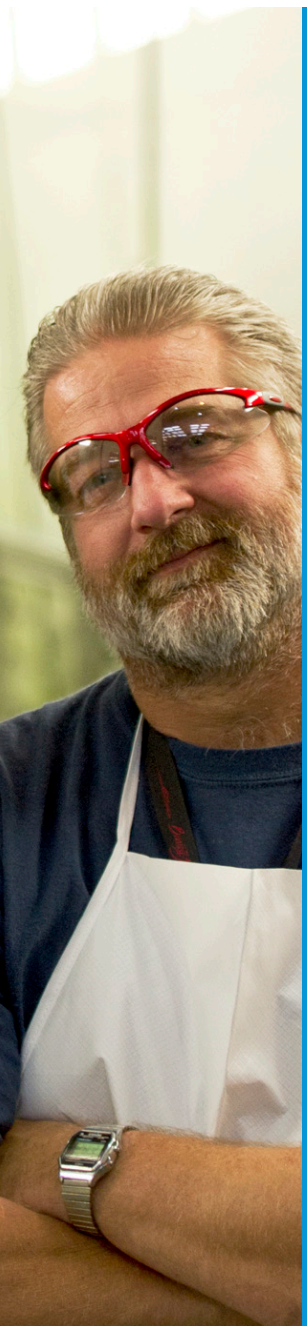
Produced by a company in Washington state, the kayak paddles used by George are the first commercial products to employ carbon fiber reclaimed from production of the 787.

"These paddles are a great first step in Dreamliner composites recycling," said Bill Carberry, project manager and strategy leader for Sustainable Materials, Airplane Environmental Performance and Boeing Commercial Airplanes Product Development. "It's a fun and fitting way for this beneficial reuse to emerge."

Boeing and the industry today stand at the threshold of large-scale global composites recycling, a transformation that will benefit manufacturers, consumers and the environment. Getting to this point required a decade of concerted effort across the enterprise as Boeing experts explored the issues then identified and fostered technologies for composites recycling. Boeing also created beneficial global alliances.

"We are confident all this collaboration will pay off," Carberry said. "We now know that when a composite airplane like the 787 reaches the end of its useful life, it will actually be more recyclable than a metal airplane because we can reclaim a higher percentage of high-value material from it."

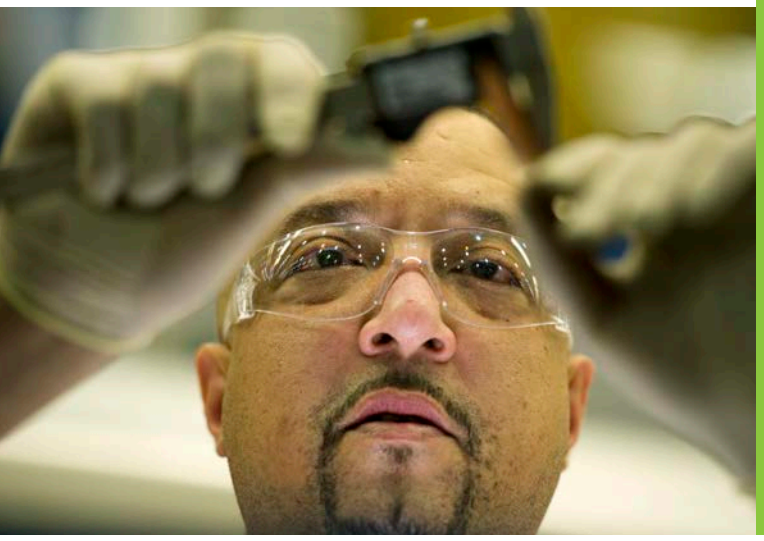
Carbon-fiber composite materials were essentially unrecyclable in 2002 when Boeing experts first began to study the issue. The 787 program was then two years away from launch, and it would be many decades



When a composite airplane ...

"like the 787 reaches the end of its useful life, it will actually be more recyclable than a metal airplane."

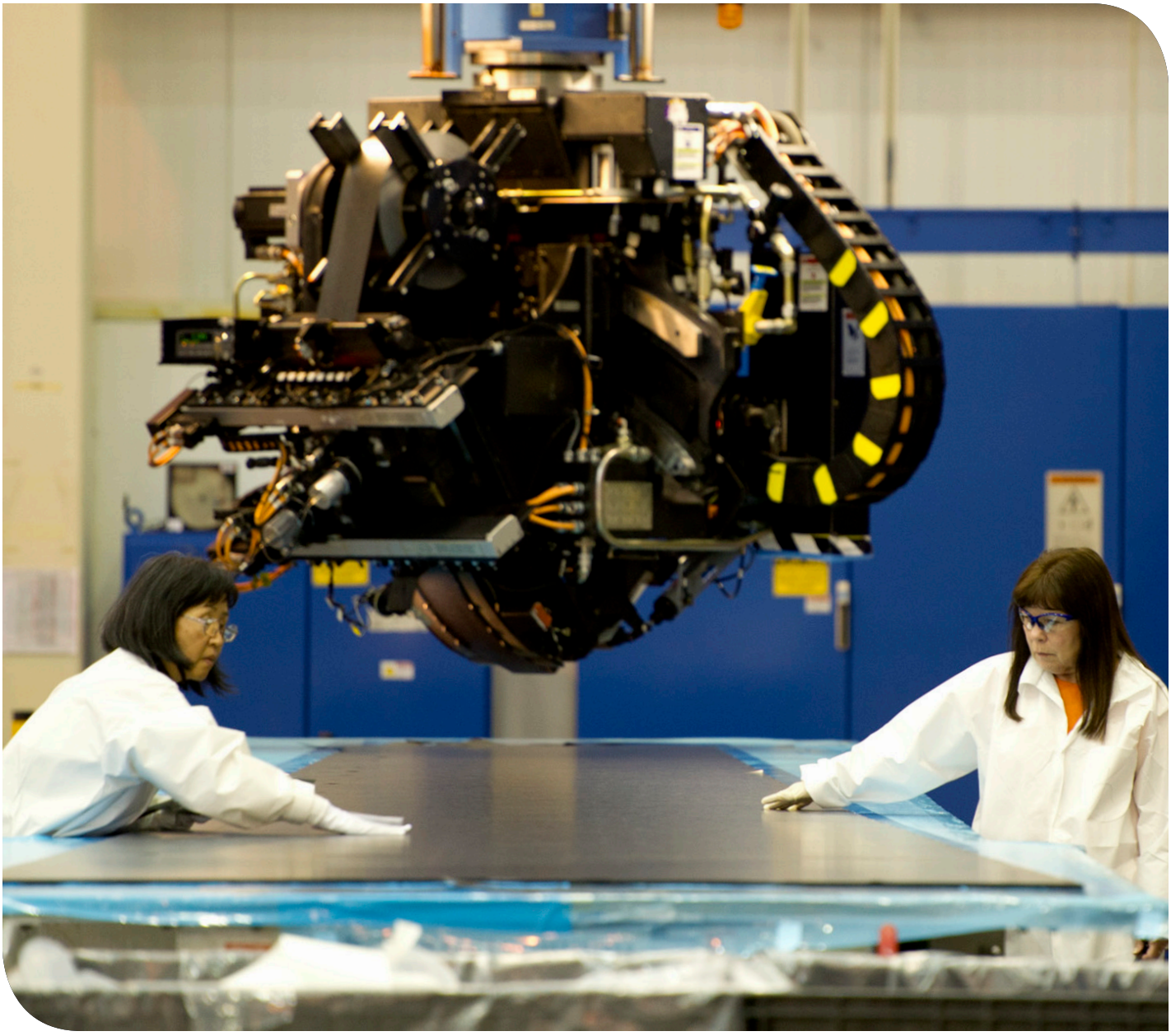
– Bill Carberry, project manager and strategy leader for Sustainable Materials, Airplane Environmental Performance and Boeing Commercial Airplanes Product Development



Making ...

the 787 recyclable benefits Boeing by reducing the plane's environmental manufacturing footprint, and because manufacturing scrap can be turned into new airplane components.

PHOTOS: (Clockwise from top left) Mechanics Zaak Walton, Jim Bush and Kipp Walter assemble a 787 vertical fin; laminating machine operator Sun Vedder, left, and Quality Assurance inspector Kandi Rowland inspect workmanship; mechanic Adrienne Ferguson works on 787 tip assembly; mechanic Corey Haywood checks a part in the assembly process. BOB FERGUSON/BOEING



before the first Dreamliners were retired from service. Nevertheless, Boeing's design focus from the start spanned the entire product life cycle of the Dreamliner, including what happens to the airplane when it's time to be scrapped at the end of its service life.

"At Boeing, we 'Design for Environment' because it's good for the earth and good for business," said Jeanne Yu, director of Environmental Performance for Boeing Commercial Airplanes. "One aspect of our environmental commitment is that we're always looking to see how we can make tomorrow's airplanes even more recyclable than today's."

A recyclable Dreamliner benefits airlines because it is worth more both during its service life and when its useful days come to an end and it is scrapped. Making the 787 recyclable also benefits Boeing by reducing the plane's environmental manufacturing footprint, and because manufacturing scrap can be turned into new airplane components or sold to provide additional revenue.

"We're deeply involved in composite recycling because it benefits us and our customers," Carberry explained. "As this emerging market sector grows, our strategy has been to align our suppliers and ourselves with top-quality airplane recyclers worldwide."

Early on, Carberry and his team surveyed aircraft recycling companies around the world and sought out alliances with the best of them. Out of this activity grew the Aircraft Fleet Recycling Association, founded in 2005. This nongovernmental organization supports the responsible recycling of all aircraft, whether metal or composite. A valuable global forum, it promotes industry best practices, regulatory compliance and environmental sustainability in aircraft disassembly and the salvaging or recycling of parts and materials.

Known informally as AFRA, this association has grown steadily. Today it has more than 60 members in 16 nations around the world. In addition to defining recycler accreditation standards, the association has published, with Boeing assistance, the industry's first-ever guidance for end-of-life scrapping and recycling of composite aircraft such as the 787.

Starting nearly a decade ago, Boeing also evaluated composite

recycling technologies. Most were in their infancy when the 787 program began.

“We assessed emerging composite recycling startups around the world and developed relationships with the finest of these,” George said.

In 2007, Boeing teamed with the University of Nottingham in the United Kingdom because of promising composite recycling research under way there. Stephen Pickering and his University of Nottingham team were working on a novel way to restore some of the strength sacrificed when cured composites are cut up for recycling, severing their long carbon threads.

With Boeing financial assistance and expertise, Pickering and his team successfully developed a process that removes these “chopped fibers” from their encasing epoxy and then realigns them to create a stronger recycled material.

“The research we’ve completed is challenging, satisfying and important to the world,” Pickering said. “We look forward to scaling these solutions up to commercial volumes.”

Cured composites recycled in this manner will find a variety of sporting, automotive and aerospace applications, though not in primary structures such as aircraft fuselages. With global demand for high-grade composites burgeoning, the patented University of Nottingham–Boeing process promises to increase prices that recycled composites will command in the marketplace, ensuring the emergence of a vibrant composites recycling industry without government support.

Boeing experts also gained valuable hands-on experience by scrapping a pre-production 787 fuselage test section in 2009.

“We learned quite a lot about how to take a 787 apart and how not to take one apart,” Carberry noted with a smile.

Building on this foundation, Boeing Fabrication recently implemented pilot composite-recycling programs at two Puget Sound sites, Frederickson and Advanced Developmental Composites, as well as at Boeing South Carolina. Frederickson manufactures the 787 composite tail fin, as well as other 787 parts. Boeing South Carolina assembles 787s.

At all three sites, workers routinely collect composite manufacturing scrap, both uncured and cured. Uncured composite is a resin-impregnated, pliable carbon-fiber fabric or tape. A cured composite has already been hardened into its final shape by being baked in an auto-

95%

Recycling composite scrap material requires 95 percent less energy than would be needed to produce virgin material.

PHOTOS: (Clockwise from left) Tim Anderson, far left, and Marci Coen, background, use an instrument to check for leaks in the bagging material before a part is cured in an autoclave, while Tim Wright checks the pleats in the material; composite fabricators conduct a final check on a completed 787 vertical fin before shipping; mechanic Vadym Vasylyshyn on the 787 vertical fin assembly line; laminating machine operator Sheila Lampkin bags a part for the autoclave. BOB FERGUSON/BOEING

clave. Boeing recycling efforts address both types. Cured composites are a bit harder to recycle, but there will be greater need for cured material as market demand grows for recycled fiber, according to Carberry.

A cultural change is under way at the Boeing sites, too. Workers are embracing the collection and segregation of scrap for recycling. Some of the recovered material is used for research, but the majority is sent to Materials Innovation Technology, a pioneering composites recycler at Lake City, S.C., some 90 miles (145 kilometers) from Boeing South Carolina. Boeing hopes to eventually entice a similar facility to serve the Puget Sound region, avoiding the need for transcontinental rail shipping.

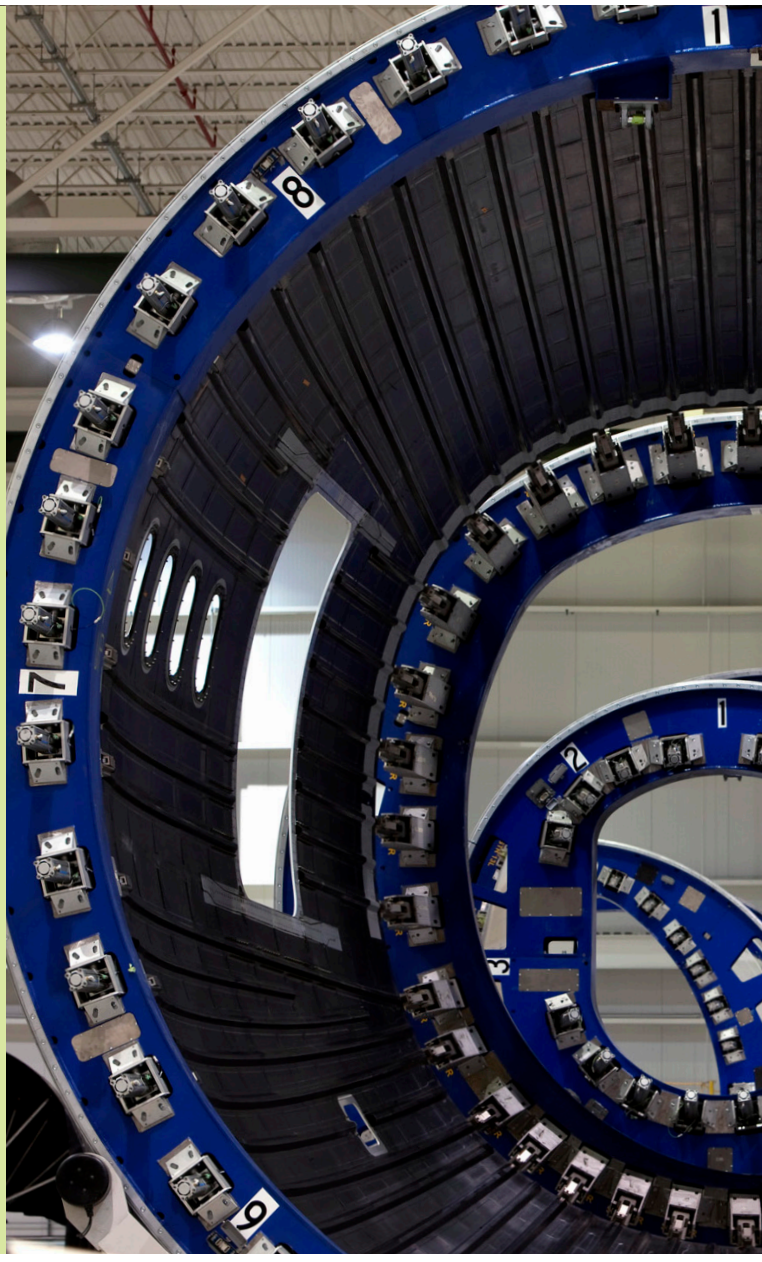
"Recycling composites offers countless benefits," said Odette Schindler, an environmental engineer with Environment, Health and Safety at Boeing Fabrication's Frederickson site.

One of those benefits is helping Boeing meet what's known as ISO 14001 requirements to continually decrease a site's environmental impact. Frederickson is one of many Boeing sites certified to ISO 14001, a comprehensive body of environmental management standards promulgated by the International

Most exciting ...

"and rewarding are the environmentally responsible material forms we're creating."

– Pete George, Associate Technical Fellow with Next-Generation Composites, Boeing Research & Technology



PHOTOS: (Clockwise from far left) Boeing manufacturing sites collect excess carbon fiber material for recycling. ALAN MARTS/BOEING Boeing South Carolina produces one-piece 787 composite fuselage barrels, known as the aft fuselage sections 47 and 48. ED TURNER/BOEING Richard Moore loads a composite skin panel onto an abrasive water jet trimming machine; mechanic Fred Staples measures fastener height on a 787 vertical fin; Composite Manufacturing Center employees prepare to load a completed 787 vertical fin onto a trailer for shipping. BOB FERGUSON/BOEING

Organization for Standardization.

Recycling is a key element of the comprehensive Boeing Environmental Strategy, which also addresses energy use, greenhouse gases, hazardous waste and water usage.

At Boeing South Carolina, for example, composite recycling is one reason the site achieved the zero-waste-to-landfill designation in March 2011.

Composite recycling also allows significant reduction in the cost and environmental impact of aircraft production. And there are other advantages. Boeing engineers are pursuing "closed-loop reuse," a concept that will see lightweight composite scrap material go back into new 787 Dreamliners.

"We generate scrap when we cut out the 787's windows and doors," said Tony Soto, the Environment, Health and Safety senior manager at Boeing South Carolina. "The company's vision is to have this unavoidable scrap recycled and then put it back into our products in nonstructural applications."

In a closed-loop system, what would normally be discarded as waste or scrap is reused. This saves money and energy and is better for the environment. Recycling the composite scrap material requires 95 percent less energy than would be needed to produce virgin material, according to Carberry.

On the commercial front, recycled composites might become aircraft lighting fixtures, mounting brackets or passenger cabin sidewalls and ceilings. The Interiors Responsibility Center at Everett, Wash., which manufactures passenger cabin fixtures and components for Boeing jetliners, is evaluating a newly developed recycled material, created from uncured 787 composite scrap, that has a superb finish.

"As a chemical engineer, what's most exciting and rewarding for me are the environmentally responsible material forms we're creating," said George, the Associate Technical Fellow. "It's not often you get to bring something entirely new into regular use."

Small wonder, then, that George sees so much more than mere paddles as he propels his kayak through the scenic waters of the Northwest. ■

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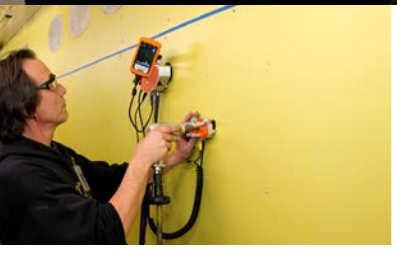
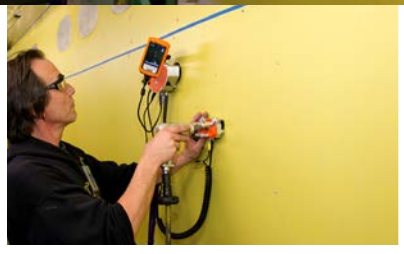
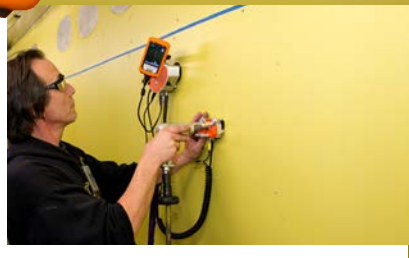
Replicating success

Innovative minds at Boeing Research & Technology are replicating technology across the company

By Nathan A. Hulings







Marty Inman, a 767 mechanic with Commercial Airplanes, recalled the days of wearing protective suits and respirators while running tests of the airplane's wing fuel tanks. The gear was necessary because the tests involved hazardous ammonia gas and spraying indicator paint.

Today, his team can do the same work wearing jeans and T-shirts, thanks to a new testing process that uses helium.

"Using helium has improved the safety and testing process significantly," said Inman, a lead mechanic with the 767 wing test team in Everett, Wash.

The helium leak test method, where workers pump a combination of helium and oxygen into fuel tanks and then use wand-like tools to detect leaks, was first used by the 777 line in 2001. But it has since been replicated on every airplane built in Everett, making the site ammonia-free for the first time since the 1970s.

It's an example of how Boeing Research & Technology, part of Engineering, Operations & Technology, is always finding ways to replicate across the company the technology that is developed to improve Boeing products or services.

Whether it's a safer, more efficient way to test fuel tanks or a device that helps mechanics drill straight and true each time, technologies that are beneficial to the initial customer often gain more life through replication at other Boeing facilities around the world.

"Replications are the bread and butter of technology development," said Amir Anissipour, a program integration manager with Boeing Research & Technology who helps connect successful technologies with programs.

"There's no need to reinvent the wheel when innovative and flexible options exist."

As the company's advanced, central research and development organization, Boeing Research & Technology is strategically situated within the company to facilitate the dissemination of ideas across Boeing. The organization supports not only Boeing's Commercial Airplanes and Defense, Space & Security business units but also the U.S. Defense Department, Homeland Security, NASA and the Federal Aviation Administration. All are trying to find better, faster and more affordable ways to design, develop,

produce, deliver, operate and maintain current and future products, systems and services.

When it comes to innovation that benefits customers and the Boeing enterprise, replication is just as important, if not more important, as invention, noted Matt Ganz, Boeing Research & Technology vice president and general manager.

"Boeing has an advantage over other aerospace companies—it's the power of 'One Boeing,' " Ganz said. "When we combine the talents of our business units with the technical and functional leadership provided by EO&T, we are able to solve our customers' toughest technical challenges. Once we do that, we want to replicate the solution as much as possible. Given the size, scope and diversity of our operations, it's hard to imagine why we can't replicate great ideas two, three or even more times in different places throughout the enterprise."

Consider the widespread success story from the use of a new drilling device known as the Halosensor.

Like his other teammates, Dino Go, an engineer with Boeing Research & Technology, keeps an eye out for discoveries that can help multiple Boeing programs. Go knew he had a game changer when he began working with the drilling device several years ago after seeing it demonstrated at a trade show in Seattle.

Equipped with a computer processor, the Halosensor works by latching to the outside of a wing while a magnet is placed on the blind side to create a magnetic field. A screen showing a cross-hair turns green once the pilot hole is found, providing an accurate location for final drilling.

The device's accuracy—down to the tens of thousandths of an inch—has drastically reduced errors on the Everett and Renton, Wash., assembly lines. Before the Halosensor, workers used a manual tool that was not as accurate, requiring timely and expensive rework that added weight to the wing and required additional stress analysis and FAA oversight.

"We knew this device had the potential to solve a lot of production issues," Go said.

The device's original success on the 747 line caught the attention of others, and soon the use of Halosensors was replicated on the 737, 767 and 777 lines. ■

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PHOTOS: (Left) Mechanic Curtis Glaze operates the Halosensor on the 767 wing to locate blind pilot holes for more accurate drilling. Since being introduced several years ago, the Halosensor has been replicated on the 737, 747, 767 and 777 lines. TIM STAKE/BOEING

PHOTOS: (Above) Marty Inman, a 767 mechanic, uses a wand-like tool to perform a helium leak test on a 767 wing fuel tank in Everett, Wash. **(Below, clockwise from left)** Mechanic Chung Nguyen performs a helium leak test on the lower 767 wing fuel tank at the factory in Everett, Wash.; Inman; Nguyen. MATTHEW THOMPSON/BOEING Glaze operates the Halosensor. TIM STAKE/BOEING

"Replications

are the bread and butter of technology development."

– Amir Anissipour, program integration manager, Boeing Research & Technology

Ahead of its time

Lessons learned from Airborne Laser program will help shape future of directed energy technology

By Eric Fetters-Walp

When a distinctly bulbous-nosed 747 landed on a cloudy day in the Arizona desert earlier this year, it closed out a two-decades-long experiment that pushed forward the possibilities of laser defense.

The Airborne Laser Test Bed, a modified 747-400 carrying a large chemical laser, may now sit in storage. But the program left a legacy of not only technology that's being used in Boeing's continuing directed energy programs but also a group of talented engineers adding value to a variety of programs across the company.

"There is a realization, even if you weren't an Airborne Laser fan, that there was technology and lessons learned we should hold onto for the future," said Mike Rinn, vice president of Directed Energy Systems and the Airborne Laser's program manager for several years.

Many of the Boeing employees who developed the Airborne Laser, along with colleagues from Lockheed Martin and Northrop Grumman, say the program was unlike anything else on which they've worked.

"It was exciting. There were lots of struggles, technically and programmatically, but it was a great challenge and a very rewarding time," said Richard Flanders, former program manager for the Airborne Laser Test Bed. "It stretched people, and I think they really enjoyed that."

The idea of an aircraft-mounted laser did not start with the Airborne Laser program in the 1990s. From the mid-1970s through 1984, the U.S. Air Force modified a Boeing KC-135 to test a small gas-dynamic laser in its Airborne Laser Lab program. Before it was retired, the laser lab destroyed five AIM-9 Sidewinder air-to-air missiles and a Navy BQM-34A target drone in tests.

While the first proposals for the Airborne Laser Test Bed program were prepared in the early 1990s, it gained official footing in 1996 when the Air Force awarded a development contract to the Boeing-led team. Boeing was tasked with providing the aircraft, battle management systems, overall systems integration and testing. Northrop Grumman provided the megawatt-class chemical oxygen iodine laser, or COIL, and associated targeting lasers. Lockheed Martin developed the beam and fire control systems.

Once the Airborne Laser Test Bed

“We accomplished things that had never been done and that experts said couldn’t be done.”

– Robert Vets, who served in a variety of engineering and team lead roles on the Airborne Laser program, now with the Boeing Commercial Airplanes Innovation Center

PHOTOS: (Left) The Airborne Laser Test Bed, a modified 747-400, flies over Edwards AFB, Calif. U.S. AIR FORCE **(Inset)** The beam from the laser was directed through this optic in the aircraft’s nose. KURTISS HUMPHREY/BOEING

was assembled and tested, the COIL was the highest-energy laser ever fired from an aircraft and the most powerful mobile laser device in the world.

The program, which averaged 500–600 employees and peaked at about 1,200 people, was never large, but it was the highest-profile program in Boeing’s laser weapons portfolio for a long time, said Dale Parkes, who was lead engineer for the Airborne Laser’s fire control system.

“At one point at the Albuquerque, N.M., site, almost everybody had worked on this program. It became an area for career development in addition to the intellectual property and technology,” said Parkes, now technical lead engineer for Modeling and Simulation in Boeing’s Directed Energy Systems organization.

Robert Vets, who served in a variety of systems engineering and team lead roles on the Airborne Laser program between 1997 and this year, said the difficulty of the program’s goal made it attractive.

“The Airborne Laser is an important type of program because we accomplished things that had never been done and that experts said couldn’t be done,” said Vets, now a project engineer for Boeing Commercial Airplanes’ Innovation Center. “It’s important for Boeing to have programs that do the impossible and push the frontiers of technology.”

He and other alums remember well the evening of Feb. 11, 2010, the program’s shining moment. The Airborne Laser Test Bed aircraft took off from Edwards Air Force Base that day and headed for the Western Sea Range off the coast of Southern California. At 8:44 p.m. Pacific time, a short-range ballistic missile was launched from a mobile launch platform on the ocean.

With a mix of Airborne Laser employees, military officials and others watching from a control room at Naval Base Ventura County Point Mugu in California, the Airborne Laser aircraft’s sensors detected the boosting missile and tracked it with a low-energy laser. The aircraft then fired a second low-energy laser to measure and compensate for atmospheric disturbance. Finally, the Airborne Laser Test Bed fired the high-energy COIL, which heated the boosting ballistic missile to critical structural failure.

“Seeing that missile get destroyed, it was remarkable,” Flanders said. “Given

all the publicity around the program, I'm not sure everyone understood what was accomplished, what was demonstrated."

Added Parkes: "The 'wow' factor of shooting down a ballistic missile with light was just amazing."

The entire engagement occurred within two minutes of the target missile's launch. But they were eventful minutes, marking the first time a laser weapon had engaged and destroyed an in-flight ballistic missile and the first time any system had accomplished it in the missile's boost phase of flight. It followed the Airborne Laser's successful intercept and destruction of a research rocket launched from the ground on Feb. 3, 2010.

Technical challenges prevented a repeat of the successful shootdown in attempts over the following year. In fall 2009, the Pentagon shifted the Airborne Laser from a potential weapons system program to a research and development program and then canceled it in 2011.

Despite the challenges, the U.S. Missile Defense Agency awarded its Technology Pioneer Award in 2009 to three Boeing Airborne Laser Test Bed engineers and three of their teammates for advancing key program technologies. And in 2010, the Air Force Association honored the program with the Theodore Von Karman Award, the association's highest honor in science and engineering.

"The uniqueness of putting a powerful laser on an airplane and then firing it, accurately, while accounting for atmospheric distortion … it will be many years until those accomplishments are repeated," said Greg Hyslop, vice president and general manager of Strategic Missile and Defense Systems. "Those things are no-kidding rocket science."

The Airborne Laser Test Bed's complex technology, including its adaptive optics—which corrected for atmospheric distortion in targeting the laser on missile and systems for controlling high-energy lasers, now is being used in other Directed Energy Systems programs, other Defense Department programs and even in astronomy. For example, Rinn said, the High Energy Laser Mobile Demonstrator (HEL MD) program for the U.S. Army wouldn't exist without the Airborne Laser program's developments, noting that program's manager and some of its employees came from the Airborne Laser team.

Former Airborne Laser employees also are helping to develop the Mk 38 Tactical Laser System as well as other Directed Energy Systems weapons. Others who worked on the Airborne Laser now are applying their experience to engineering and testing for Commercial Airplanes.

"Very few actually retired," said Flanders, now a scheduler for 787 Test & Validation. "We placed somewhere around 95 percent of the engineering staff that was on that program."

While the Airborne Laser Test Bed aircraft now sits in the Air Force's "Boneyard" in Arizona, many who worked on the program say the groundbreaking research and feats accomplished were ahead of their time.

"We're already looking at next-generation airborne lasers," Rinn said. "It's taking the pathfinding work that the Airborne Laser did and carrying it forward." ■

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The High Energy Laser Mobile Demonstrator (HEL MD) program for the U.S. Army wouldn't exist without the Airborne Laser program's developments.

– Mike Rinn, vice president of Directed Energy Systems

PHOTOS: (Right) The retired Airborne Laser Test Bed is now parked in the "Boneyard" at Davis-Monthan AFB, Ariz. KURTISS HUMPHREY/BOEING **(Inset)** The High Energy Laser Mobile Demonstrator is being developed for the U.S. Army by Boeing Directed Energy Systems using knowledge gained on the Airborne Laser Test Bed. BOEING

Advancing technology at the speed of light

1996 – U.S. Air Force awards contract to Boeing-led team to develop the Airborne Laser.

2001 – The Air Force acquires a Boeing 747-400 Freighter, retired by Air India, and the aircraft's wingless fuselage was used to test the system's components in the System Integration Laboratory at the Edwards Air Force Base Birk Flight Test Center in California. The chemical oxygen iodine laser (COIL) in the lab was fired successfully more than 50 times.

2002 – After completing major modifications to a new 747-400F, known as YAL-1, the aircraft makes its first flight from Boeing Wichita on July 18.

2004 – "First light" of the chemical oxygen iodine laser is achieved in ground testing, along with the first flight of the Airborne Laser aircraft fitted with the battle management and beam/fire control systems.

2005 – While aircraft flight tests continue, the team fires the Airborne Laser's high-energy laser at lethal power and duration in ground tests.

2006 – The team completes modifications YAL-1 to accept the COIL's modules and integrate the system's two solid-state illuminator lasers into the beam/fire control system on board the aircraft.

2007 – During active flight tests, the Airborne Laser Test Bed homes in on, tracks and then fires a low-power test laser at a target board attached to an Air Force test aircraft.

2008 – The Airborne Laser team completes installation of the high-energy COIL in the aircraft and begins firing the laser in ground testing.

2009 – The Airborne Laser begins flight tests in April with the entire weapon system integrated aboard the aircraft. In August, the high-energy laser fires for the first time in flight.

2010 – After tracking and engaging a target rocket during January and destroying a ground-launch research rocket in early February, the Airborne Laser successfully destroys a boosting ballistic missile off the coast of California on Feb. 10. Less than an hour later, the system engages a second solid fuel short-range missile to meet all test criteria.

2012 – The Airborne Laser Test Bed aircraft is flown on Feb. 14 from Edwards Air Force Base to Davis-Monthan Air Force Base in Arizona, where it is in storage with the 309th Aerospace Maintenance and Regeneration Group.

Makeover model

Renovation of Boeing's rotorcraft site near Philadelphia is accomplished without disrupting vital production

By Debby Arkell and photos by Fred Troilo

Anyone who has ever tackled a home-renovation project knows how tricky upgrading an older home can be. One change often leads to others, and sticking to a budget and schedule can be challenging.

Imagine renovating an 83-year-old rotorcraft factory, upgrading 400,000 square feet (37,000 square meters) of manufacturing space and aging infrastructure, all while workers are building high-technology helicopters at ever increasing rates.

Such is the task of Project Implementation teams at Boeing's factory in Ridley Township, a Philadelphia suburb, where CH-47 Chinook military helicopters are built. Fuselage assemblies for the V-22 Osprey tilt-rotor aircraft also are produced at the site, but in a different building.

Project Implementation, a service group within Shared Services Group's (SSG) Site Services, is responsible for the major construction. In June 2009, Project Implementation teams in Philadelphia began this massive project. That work continues—within budget and on schedule.

"This is by far the biggest Boeing investment made at Philadelphia," said Boeing's Chris Calhoun, project manager. "It's one thing to build new to support a

PHOTOS: (Clockwise from above left) Upgrades completed at Boeing's rotorcraft plant near Philadelphia have turned an 83-year-old building into a state-of-the-art manufacturing facility; reintroduction of windows at the Chinook factory lets in lots of natural light and allows employees to see test flights of the helicopters they build; more than 1,100 construction workers have been involved in the renovation effort; the project has required careful choreography so construction crews do not interfere with fast-paced helicopter production.

"We're optimizing this work environment to bring the best for the employee, customer and Boeing."

— Leanne Caret, vice president and H-47 Program manager

site like we did in South Carolina. To fully overhaul existing, aging buildings is quite another." At Boeing South Carolina, a new final assembly factory was built for production of 787 Dreamliners.

The multimillion-dollar renovation to the Ridley Park site, which has involved more than 1,100 construction workers, is occurring in phases. Phase one addressed infrastructure needs associated with increased Chinook production rates, which will have doubled by the time the entire project wraps up in 2015.

Flight ramp improvements and office and factory modernization are complete, creating a much improved working environment for employees. (See the July 2011 issue of *Frontiers*.) Massive windows replaced solid steel walls, providing terrific views and bringing natural light into the work area; installation of a central utility plant now provides much-needed air conditioning.

Indeed, many of the site's buildings were originally constructed in the 1920s for steel manufacturing. The buildings had no lights at the time; the work area used natural lighting, streaming through glass walls and an atrium, two design features the renovation re-emphasized.

"It's bright, clean and new," said engineer Kevin Morais, H-47 Manufacturing lead and a 20-year rotorcraft employee. "There's more room for the support functions to colocate, and everyone I need to help support the production line is now an arm's length away. It's great seeing the faces of folks coming through on tours. They can't believe it's the same place."

Construction teams now are replacing the site's ancient boilers and reconfiguring manufacturing-support areas into office and training space as well as a new cafeteria. Latter stages of the project will include further mechanical and electrical infrastructure improvements and conversion of the old boiler house into a firehouse.

The sitewide overhaul and consolidation includes Boeing's first Leadership in Energy and Environmental Design (LEED) factory renovation, meeting criteria enacted by the U.S. Green Building Council, and supports Boeing's initiative to be a leader in energy-efficient design.

Leanne Caret, vice president and H-47 Program manager, said the investment in upgrading to a world-class facility was necessary to achieve productivity targets needed to meet current customer commitments. It also will help Boeing win new business.

"These renovations are a reflection of Boeing's commitment to our customers, our employees and the Philadelphia region," Caret said. "The way the improvements are being executed demonstrates our partnership with SSG and across the enterprise, and we couldn't be more proud of how we're optimizing this work environment to bring the best for the employee, customer and Boeing."

The biggest challenge since the massive project began more than two years ago has been managing the project's phases to avoid disrupting Chinook production. Not only has production increased during the ongoing renovation, but the construction work has been accomplished with no lost time due to accidents.

"They laid out a good plan before starting each phase," Morais said. "Disruption has been minimal, and it's been a pretty smooth ride considering all the work that's been going on."

Tim Lunger, a manager with Defense, Space & Security who serves as the project's factory representative, has worked closely with Site Services and construction and planning teams. He said the renovation required careful choreography between construction and production work.

The success of undertaking such a massive project and not interrupting vital production, he added, mirrors the groundbreaking "Move to the Lake" initiative in Renton, Wash., where Boeing builds 737 jetliners. Boeing consolidated operations there nearly 10 years ago. Engineering and administrative offices now are close to the factory floor, improving operations and efficiency.

"Like Renton, we're connecting office space and the products we produce," Lunger said. "This investment speaks to how important our work is to Boeing, to our customers and to the soldiers we support." ■

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"Our goal is to operate our factories and offices with the highest standards of efficiency while making the right decisions for the environment."

– Rich Noviello, SSG Site Services Operations director

PHOTOS: (Clockwise from top) The chemical processing facility expansion at Portland, Ore., added drought-tolerant plantings and "bio-swales," or landscape features that filter pollutants in water runoff, enhancing stormwater control. SKYSHOTS AERIAL PHOTOGRAPHY Site Services managers Chris Van Gels (from left), Bryan Kury and Pam Tanner discuss plans for further energy reduction in the 270 building in St. Louis, which recently received an ENERGY STAR from the U.S. Environmental Protection Agency. PETER GEORGE/BOEING The Boeing rotorcraft manufacturing facility in Philadelphia is pursuing both a Leadership in Energy and Environmental Design, or LEED, rating and an ENERGY STAR as a result of a major renovation project. FRED TROILO/BOEING An energy-efficient lighting system contributed toward a LEED registration for the Boeing Tianjin factory in China. BOEING An artist's concept of the Everett, Wash., Delivery Center. BOEING As part of the efforts to improve energy performance, Mike Kunce, left, and Tom Harmon of Site Services check operating conditions at the main office building at the St. Louis site. PETER GEORGE/BOEING

Building performance

Efficient facility operations support business goals and meet environmental challenges

By Kathy Spicer

Change is in the air at Boeing buildings around the world.

Advancing the environmental performance of the company's buildings and facilities may not be the most visible initiative at an aerospace company known for its innovation and technology. But with more than 85 million square feet (7.9 million square meters) of factory, office and laboratory space to manage, operate and maintain, the challenge to be cost-efficient while moving toward more sustainable business practices is a growing priority.

"Taking specific measures to conserve and increase energy efficiency," said Keith Warner, program manager for the companywide Conservation Initiative, "has a direct impact on cost-savings for our business partners while at the same time improving the air quality for local communities. Improvements such as these benefit all stakeholders, including our customers and suppliers."

The Utilities and Conservation team for Shared Services has been working to apply a common set of environmental building standards to Boeing facilities. Most notably, Boeing has adopted the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) rating system as a design standard for increasing the sustainability of new construction or major renovations. Additionally, Boeing has achieved the U.S. Environmental Protection Agency's ENERGY STAR label for 10 buildings for outstanding building energy efficiency, and it has been an ENERGY STAR Partner of the Year for the past two years.

The benefit of these programs, Warner explained, is the framework they provide for Boeing to operate its facilities with less waste, increased recycling and reuse of materials, improved energy and water efficiency, and reduced pollution. Upgrading and improving mechanical systems—such as air-handling, lighting and water tower operations—are critical in maintaining these savings.

Most recently, Boeing received an ENERGY STAR for the central Boeing Defense Systems building in St. Louis and LEED certifications for Boeing's Space & Intelligence Systems headquarters building in El Segundo, Calif., and the chemical processing facility expansion in Portland, Ore. The company is also pursuing a LEED Silver rating for its joint venture composite manufacturing facility in Tianjin, China.

And there are plans to meet environmental standards for the company's new Boeing Long Bridge construction in Arlington, Va.; the renovated Chinook factory near Philadelphia; and the new delivery center for twin-aisle commercial jets in Everett, Wash.

"Our goal is to operate our factories and offices with the highest standards of efficiency while making the right decisions for the environment," said Rich Noviello, SSG Site Services Operations director, who is leading the effort to collaborate with manufacturing and process leaders to promote energy efficiency and conservation.

"It's a big challenge," he said, "but with a building portfolio the size of Boeing's, every inch of savings can make a difference." ■

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Upward mobility

As it adds 737s, Oman Air is poised for greater success *By Saffana Michael*

With a growing fleet of Boeing jets, Oman Air is focused on expansion—vertically.

Perhaps that's only fitting for an airline based in Muscat, nestled against the Hajar Mountains that dominate the landscape of this country on the southeast coast of the Arabian Peninsula.

Vertical expansion—adding flight frequency, not more routes—continues to be key to growth for Wayne Pearce, the man who took the reins of Oman's national airline as chief executive earlier this year.

"We want to further enhance the operations of our current fleet by adding more flying hours to each aircraft," said Pearce, who expressed satisfaction with the operating economics of the airline's 737-800s. Oman Air operates—through lease and direct purchase—a fleet of 13 737-800s and two 737-700s and has six more 737-800s on order.

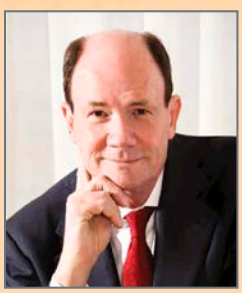
The 737 is able to operate effectively in very hot climates, Pearce said, adding that the Boeing jet has "proved itself with its dispatch reliability, ease of maintenance and safety record."

Keen to play an active role in promoting tourism in Oman, a country known for its stunning natural landscapes, architecture and history, the airline also plans to gradually expand its regional and international destination network, especially after it takes delivery of its six 787s that were ordered at the Dubai Airshow in 2011.

"The operating economics of the 787 and enhanced passenger experience will not only allow us to continue pursuing our vertical growth strategy," Pearce said, "but will also enable our plans to expand our network, while increasing business and leisure traffic into Oman."

The airline operates a fleet of 26 airplanes and flies to 41 destinations worldwide. It has won both praise as a Four Star airline (named by SKYTRAX) and the title of "World's Best Business Class Airline Seat" for two consecutive years (2011 and 2012 World Airline Awards).

Perhaps few Omanis are bigger fans of Boeing airplanes—especially the Next-Generation 737s—than Adil Al Sheibani,



"The 737 is able to operate effectively in very hot climates."

– Wayne Pearce, Oman Air CEO

PHOTO: OMAN AIR

senior manager of Development Engineering for the airline. He joined Oman Air in 1994 as an apprentice and has completed a course in Renton, Wash., where the 737 is assembled, for his B1 aircraft maintenance license.

"This airplane has the minimum [entry-into-service] issues," Al Sheibani said of the 737. "I just want to thank the people up at Renton for assembling such a great airplane."

Al Sheibani is part of the airline's campaign to encourage more Omanis to join the aviation sector. Pearce noted that 57 percent of the airline's pilots are Omanis, and many more will soon start working for the airline.

"We want to be prepared when we get our new 737s and 787s," Pearce said.

For Al Sheibani, it's a matter of national pride.

"Even today," he said, "one of the most gratifying moments is to see our airplanes take to the skies and know that our engineering crew have ensured the safety and comfort of our passengers, which is of paramount importance to us." ■

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PHOTO: An Oman Air 737 lands at Oman International Airport. With a current fleet of 15 737s, the airline has six more 737-800s on order. OMAN AIR

In Focus

BANK SHOT

A Boeing F/A-18 Super Hornet performs a steep banking maneuver during a flight demonstration at last month's Farnborough International Airshow in the United Kingdom. The special effect is caused by water vapor that condenses around the aircraft during high-speed maneuvering in certain atmospheric conditions, such as when the air is humid, and the low pressure of airflow around the jet. Other Boeing aircraft making demonstration flights or on static display at the Farnborough show included the Bell-Boeing V-22 Osprey, F-15E Eagle, C-17 Globemaster III, AH-64D Apache, and the 737-900 and new 787 Dreamliner jetliners. PHOTO: GETTY IMAGES

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