BOEING

Frontiers

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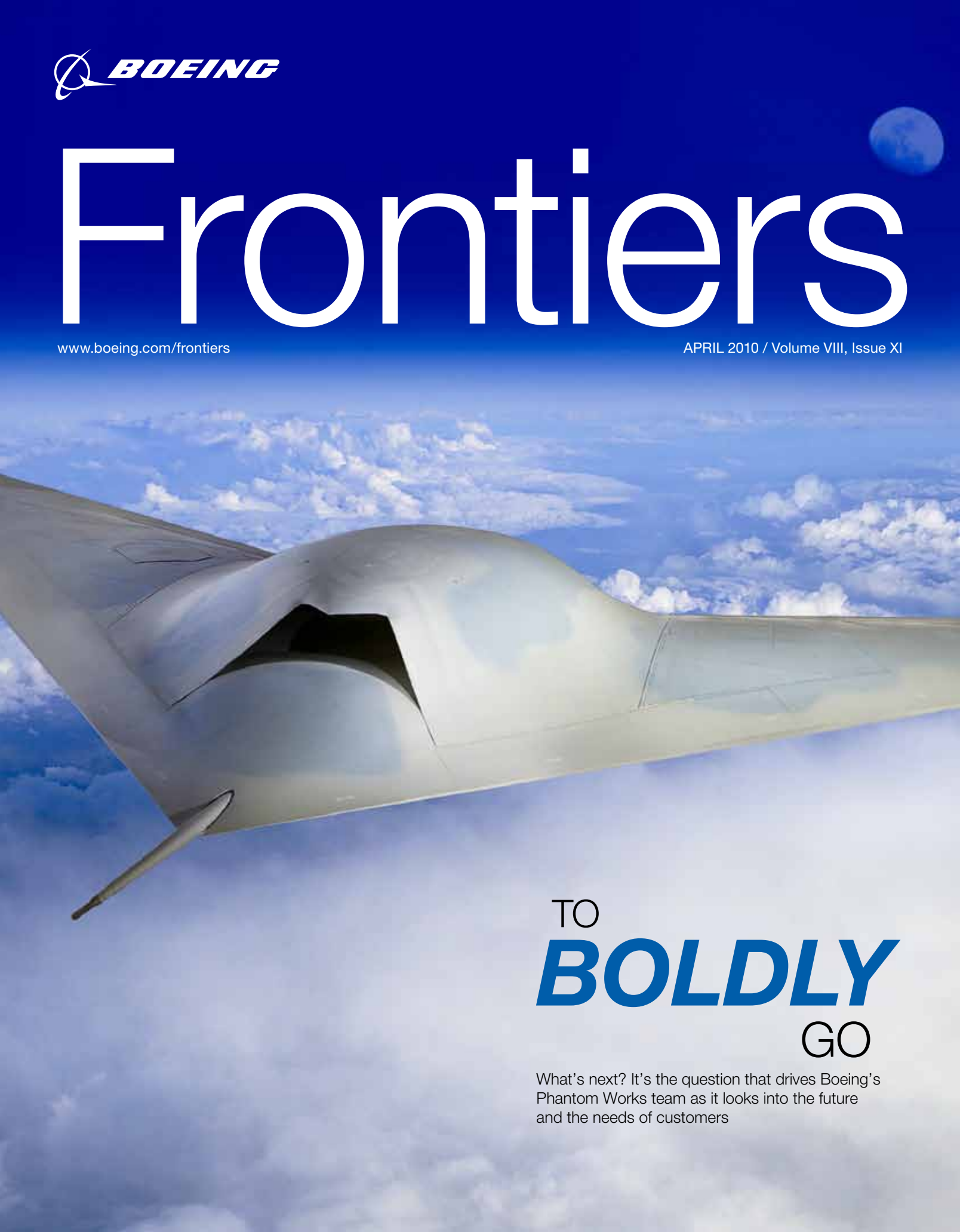
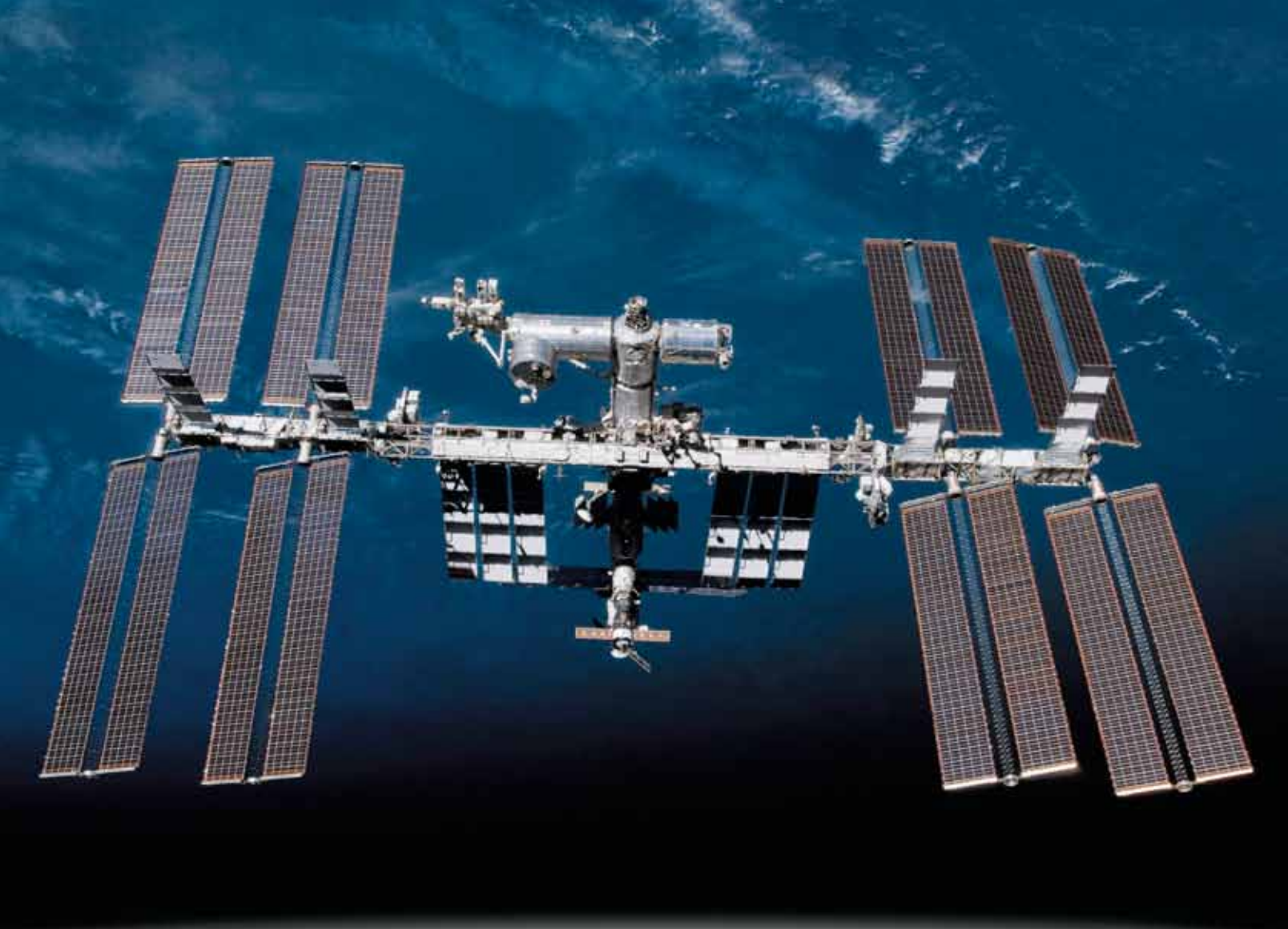


TO BOLDLY GO

What's next? It's the question that drives Boeing's Phantom Works team as it looks into the future and the needs of customers



THE COLLIER TROPHY IS NOW ON STATION.

It's our privilege to salute NASA and the entire International Space Station Team on being named the recipients of the National Aeronautic Association's 2009 Collier Trophy, the aerospace industry's highest honor. One of NASA's most ambitious programs, the Space Station continues to set new benchmarks for research and science that benefit the entire world. As the Station's prime contractor, Boeing is proud to join in celebrating this great honor for NASA.

BOEING

On the Cover

12 All about the future

Boeing's Phantom Works organization, part of Defense, Space & Security, has a small number of employees but has scores of projects in various stages of development, from toaster-size nanosatellites to the 410-foot-long (137-meter-long) SkyHook, a neutrally buoyant aircraft. The goal is to meet the evolving needs of customers while turning these good ideas and advanced concepts and technologies into superior products and services that are profitable for Boeing.

COVER IMAGE: THE PHANTOM RAY IS AN UNMANNED VEHICLE UNDER DEVELOPMENT BY PHANTOM WORKS THAT BUILDS ON BOEING'S SUCCESS WITH THE X-45A AND X-45B UNMANNED COMBAT VEHICLES. JOHN RANKIN/BOEING

GRAPHIC: THE FAST ACCESS SPACECRAFT TESTBED IS A PHANTOM WORKS–LED PROJECT FOR THE U.S. DEFENSE ADVANCED RESEARCH PROJECTS AGENCY TO DEVELOP AN ULTRA-LIGHTWEIGHT SYSTEM THAT CAN GENERATE UP TO 175 KILOWATTS OF POWER FOR SPACECRAFT—MORE THAN IS AVAILABLE FOR THE INTERNATIONAL SPACE STATION. BOEING

Ad watch

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

Inside cover:

This Boeing Defense, Space & Security ad was developed to celebrate the National Aeronautic Association's selection of the International Space Station team for the 2009 Collier Trophy, the aerospace industry's highest honor. The ad will appear in key market newspapers, including the *Washington Post*, and in select space and congressional trade publications.

Page 51:

The "One partnership. Endless possibilities" advertising campaign illustrates Boeing's commitment to success through its partnership with India, a relationship that has existed for more than 60 years. This ad depicts the traditional Indian activity of kite flying, where one team member assists the other, symbolizing Boeing's support of aerospace talent development programs in India. The ad is running in publications such as *Hindustan Times* and *Times of India.*

Back cover:

Global corporate citizenship refers to the work Boeing does—both as a company and through its employees—to improve the world. This ad illustrates Boeing's commitment to promoting the well-being of communities worldwide.

Frontiers

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36 The power of one

April is volunteering awareness month, and for many Boeing employees, volunteering is a powerful way they can help make a difference in their communities. Meet some of these volunteers and view an Earth Day photo essay showing how employees help protect the environment throughout the year.

PHOTO: BOB FERGUSON/BOEING

33 Technology chasers

From directed-energy weapons to lighter and far more efficient batteries, numerous advances are being made by Boeing teams in the Platform Systems and Subsystems technology domain. It's the largest of eight technology domains established by Boeing to help ensure new technologies are ready when they are needed—and provide the company a competitive advantage.

PHOTO: MARIAN LOCKHART/BOEING

INSIDE

Making the difference

Boeing employees can be counted on in the army of community volunteers

Anne Roosevelt
Vice president, Boeing Global Corporate Citizenship

Think of all of the positive acts that take place in communities across the globe every day. Then imagine what the world would be like without people willing to lend a hand to someone in need or offer new ideas for addressing the societal problems that face us all. Volunteers are these people.

Look around and you'll see countless examples of individuals who selflessly give their time and skills to make the world a better place. Volunteers are the ones who set the bar of life a bit higher for the rest of us. They are the ones who, by their actions, challenge us to be better people—people who truly care about the "other guy" and the future we're building for our children.

Each day, at every location, Boeing employees step up and make a difference as volunteers. (See related stories beginning on Page 36.) By doing so, they send a message to their communities that the people who work at Boeing are serious about being part of a company that is a good corporate citizen.

Part of our responsibility as good citizens involves taking care of the places we work—our factories and our offices—as well as the places we live. Participating in activities on Earth Day—observed April 22—has the power to catalyze millions of people who make personal commitments to creating sustainable communities.

Earth Day is a good time to applaud all of the employees who share their time, talents and resources to help build a better world, whether it is through supporting environmental initiatives in their communities or serving in other ways.

It is impossible to highlight all that employee volunteers do for our communities, but some that stand out include:

- Helping clean up the Duwamish River in Washington state and the spoil islands off the coast of Florida
- Helping preserve wetlands in Japan
- Protecting endangered plant species near Moscow
- Replanting trees devastated by wildfires in California and Australia
- Repairing and improving homes for the elderly and disabled in St. Louis
- Spearheading a project in Seattle to recycle used Boeing safety goggles while giving employment to military veterans

Employees have accomplished all this and more through partnerships with community-based nonprofit organizations including Boeing's Employees Community Fund. (See related story on Page 9.)

Volunteering also gives us the experience that develops and demonstrates our skills. We learn new things about ourselves and others when we volunteer—which expands our perspective and adds to the diversity of thought we can bring to the workplace. And we build new relationships that can expand our horizons.

Our volunteering—no matter what form it takes—helps the company establish partnerships with trusted community organizations, where we can increase our impact by joining with other corporate and community volunteers. Ultimately, the people you help now are people who could come back stronger to help others—and their communities—grow and thrive.

For all of those reasons, getting out and active in our communities as a volunteer is a win-win result for each of us—and for the company. This year we should challenge ourselves to find the time to help, whether it is in recognition of Earth Day, or just the recognition that community service helps all of us.

Volunteering, too, deepens our sense of pride in the company. How many of you have come home from participating in a community service activity that helps the environment, or a walk for charity and just felt good—tired, maybe—but good? And when you went into work the next day you still carried the energy of that event inside. Besides feeling good, you made decisions that had real impact. That's the Boeing spirit. ■

PHOTO: BOB FERGUSON/BOEING

Snapshot

CROWD PLEASER
One of two Boeing C-17 Globemaster III airlifters with the Qatar Emiri Air Force performs a flyby last month before several thousand spectators during an "Air Force Day" celebration in Doha, Qatar. Boeing delivered Qatar's first C-17 last August and the second in September. Qatar is the first Middle East nation to order the C-17 and has an option to purchase two more. A total of 214 C-17s are in service worldwide, and 19 of the airlifters are operated by international customers. One of Qatar's C-17s was recently used, along with many others, to transport aid to Haiti and to Chile after devastating earthquakes in those countries. FELIX SANCHEZ/BOEING

Quotables

"We're second place in a duopoly; that means you're in last place. And I don't want to be in last place. I want to be in first place."

– Jim Albaugh, president and chief executive officer of Boeing Commercial Airplanes on March 9, telling industry analysts he wants to re-establish Boeing's jet delivery leadership position.

"We now have proof that there's substantial interest out there. … With careful marketing and a little bit of time, the international market for the C-17 could double or triple."

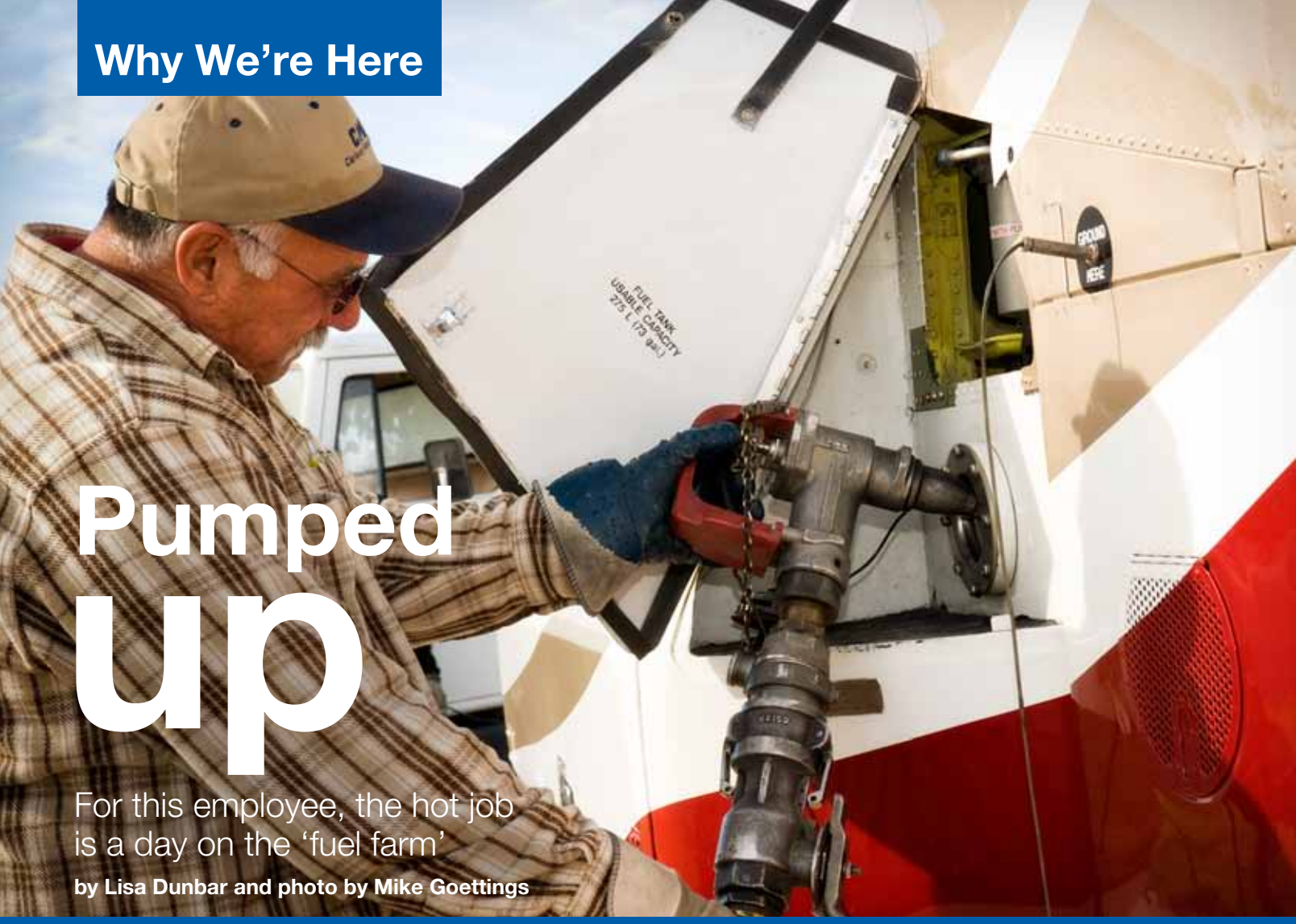
– Loren Thompson, a defense policy analyst with the Lexington Institute, on how India's interest in the C-17 showed there was a significant international market for the aircraft, as reported in the *Los Angeles Times* on March 1. India has requested to purchase 10 C-17s.

IAM PROMOTIONS

No promotions listed for periods ending Feb. 26 and March 5,12 and 19.

ETHICS QUESTIONS?

You can reach the Office of Ethics & Business Conduct at 1-888-970-7171; Fax: 1-888-970-5330; Web site: http://ethics.whq.boeing.com



Pumped up

For this employee, the hot job is a day on the 'fuel farm'

by Lisa Dunbar and photo by Mike Goettings

There's more to fueling Apache helicopters than meets the eye. In this *Frontiers* series that profiles employees talking about their jobs and the way their work fits into Boeing's overall goals, Robert Perez, an Apache fuel operations technician at the Boeing site in Mesa, Ariz., explains why keeping pilots safe is front and center.

The temperature has climbed to a scorching 110 degrees Fahrenheit (40 degrees Celsius) as I drive along the hot asphalt to rows of parked Apache helicopters on the flight line. The aircraft control tower has just radioed me that an Apache on pad A-3 needs fuel. So I drive a fuel truck to the pad, meet the aircraft's crew chief and begin pumping fresh fuel—up to 380 gallons (1,438 liters) if the tank is empty—into the aircraft.

I know how important it is to pilots and others involved in Apache flight tests that the aircraft fuel is clean and safe. The fuel for these aircraft isn't quite the same as the gasoline we put in our cars and trucks. If I get a bad tank of fuel in my vehicle, it may stall and all I have to do is pull over to the side of the road. But pilots can't pull over in the air, so it's critical that the aircraft fuel is clean.

I keep a 3,000-gallon (11,360-liter) truck and two 1,200-gallon (4,540-liter) trucks ready for fueling at all times. On a busy day, I can pump around 2,400 gallons (9,085 liters) of gas into a dozen aircraft. I see to it that 8,000 gallons (30,280 liters) of fuel are delivered to the Mesa site about every two weeks. I follow a rigorous daily routine of testing pumps, cables and fire equipment. I also test the bulk tanks for leaks. I sample the fuel for water, debris and contamination and then send it to an on-site lab to make sure it's OK.

This is a great job because I do something different every day. And despite the heat, I love being outside rather than sitting behind a desk. The best part of my job is knowing that what I do—though it's on the ground and behind the scenes—makes a difference. Every time they take off, these pilots are counting on me and others on the ground. It's a responsibility I don't take lightly. At the end of each day, I can go home knowing I've done everything in my power to keep Boeing's Mesa "fuel farm" a top-notch operation. ■

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PHOTO: Robert Perez fuels a chase helicopter that is used for Apache flight testing in Mesa, Ariz.

Supporting Haiti relief

When a massive earthquake rocked Haiti earlier this year, Boeing C-17s delivered six search-and-rescue teams trained by the National Disaster Search Dog Foundation to search for survivors. The organization is one of many funded in part by donations from Boeing employees.

The Bell Boeing MV-22 Osprey also was used in Haiti. The versatility of the tilt-rotor aircraft allowed it to ferry supplies from off shore despite damaged runways and other infrastructure. The Ospreys were deployed with the 24th Marine Expeditionary Unit.

Between Jan. 14 and Feb. 9, C-17s from the U.S. Air Force Air Mobility Command flew 1,110 sorties to Haiti, delivering 9,370 tons (8,500 metric tons) of emergency cargo and more than 12,000 passengers—including the canine teams from the Los Angeles County Fire Department and California Task Force 2.

Contributions from the Employees Community Fund of Boeing California have provided more than $22,000 in grants to the foundation, which trains abandoned or abused dogs for search-and-rescue missions. In addition, Boeing employees across the globe donated $1.2 million to the American Red Cross for Haiti. The company also contributed $1 million, targeting most of its grant to nongovernmental agencies that will help Haiti rebuild its education, health care and transportation infrastructure.

Each year, Boeing's Employees Community Fund helps more than 4,000 nonprofit groups—with donations going to aid disaster relief, fight hunger and homelessness, prepare children to succeed in school, sustain arts and cultural activities, and protect the environment. Last year, employee donations to the Employees Community Fund and gift-matching funds topped $39 million—driving Boeing's overall 2009 giving to nearly $143 million.

May marks Employees Community Fund Awareness Month. Employees with access to Boeing TotalAccess can contribute through "My Community Giving" at any time.

PHOTO: Search-and-rescue members from the Los Angeles County Fire Department and California Task Force 2 are shown aboard a U.S. Air Force Boeing C-17 bound for Haiti earlier this year. LOS ANGELES COUNTY FIRE DEPARTMENT

Out of this World Wide Web

Boeing engineers help astronauts surf the Web from space

"*Hello Twitterverse! We r now LIVE tweeting from the International Space Station -- the 1st live tweet from Space! :) More soon, send your ?s*"

Courtesy of Boeing, NASA astronaut T.J. Creamer became the first person to send an unassisted "tweet" from space earlier this year when he updated his Twitter account using a special software upgrade to the International Space Station. Astronauts now have the ability to personally access the Internet, much in the same way they would from home, via the "ultimate wireless connection" known as the Crew Support LAN, or local area network.

Boeing's responsibilities included onboard LAN configuration updates and security requirements.

"The crew is up there 24/7 for months at a time and they do get time off, but before this capability was added, they did not get to do things like surf the Web, buy stuff on eBay or order gifts for special events back home without having a third-party get involved," said Brian Oakley, leader of the Crew Support LAN project for Boeing. "So this is a great new feature for the crew and I'm glad we were able to be a part of the team that made it all possible."

– Adam Morgan

PHOTO: Japanese astronaut Soichi Noguchi uses a computer in the Harmony node of the International Space Station. Like fellow astronaut T.J. Creamer, Noguchi has been posting images to his Twitter account (http://twitter.com/Astro_Soichi). NASA

Riveting attire

'Flying Fortress Fashions' worn by women who built B-17s were both functional and popular

by Mike Lombardi

PHOTO: Mary Lucig examines stock from shop bins. The curved edge of her apron was not only a design element inspired by the shape of an airplane wing; it also helped prevent the apron from being caught in machinery. The chevron on the sleeve indicates a year's service at Boeing. BOEING ARCHIVES

This year marks the 75th anniversary of one of the most important airplanes in Boeing history—the B-17 Flying Fortress. The success of the Flying Fortress, and those who flew it in combat, made the airplane the symbol of American air power and made Boeing one of the most respected brands in the world.

But the story of the B-17 also includes the workers on the homefront who built more than 12,000 of the four-engine bombers for the war effort. One of the most famous icons of the war was "Rosie the Riveter," a name proudly adopted by the millions of women who took up jobs at shipyards, armament factories and aircraft companies to help build the "arsenal of democracy."

Women welcomed the chance to prove they could perform manufacturing jobs and the chance to contribute to the war effort, but there was some unease about leaving behind more traditional roles to enter the work force.

To ease the transition and make the workplace more inclusive, Boeing organized ride sharing and busing. The company assisted working moms in locating day care and provided work shifts that would allow mothers to be at home during the day. An extensive recreation program was put into place that helped all employees cope with the stress of work and war.

To design suitable and appealing work clothes for women factory and office workers, Boeing teamed with one of the country's leading custom fashion designers at the time, Muriel King, who returned to her hometown of Seattle to design a line of attire called "Flying Fortress Fashions."

> *"I found these marvelous women resolute in their determination to do the job faster and better in every way than it has ever been done before."*
>
> *– Muriel King, fashion designer*

King was known for her work in New York and in Hollywood, where she designed the personal wardrobe for movie actress Katharine Hepburn and also created costumes for movie stars Rita Hayworth, Margaret Sullavan and Ginger Rogers.

Even though King worked with Hollywood stars, when she was asked in 1943 who were the most interesting women of the day, King stated: "Unquestionably the women building our planes … I found these marvelous women resolute in their determination to do the job faster and better in every way than it has ever been done before."

Before starting her designs, King studied the work done at Boeing and consulted with female employees as well as safety officials (a number of accidents had been traced to apparel). Other concerns that needed to be addressed included functionality, durability and appeal. King said the task challenged her creative ability.

But King delivered a line of coordinated fashions that included coveralls, slacks, blouses, aprons and turbans for the factory and a "Flying Fortress" suit of interchangeable slacks, skirt, jacket and blouse for the office. All were made of "Fortress" rayon fabric and cotton twills. The designs featured curved edges both for safety and to replicate the form of an airplane wing. The color selected was a gray-blue—Boeing women preferred blue and Muriel's studies found that gray-blue hid dust and stains better than any other shade of blue.

A further enhancement to the Flying Fortress Fashions were emblems, intentionally similar to those worn on military uniforms. These included a Boeing insignia for the sleeve as well as four different insignia worn on the collar that represented the major divisions of the company.

To help with recruitment and to promote the new Boeing uniforms, Seattle department stores carried the Fortress Fashions line and set up window displays.

Purchasing the Fortress Fashions was voluntary. They became so popular an article in *Life Magazine* stated that they were being purchased as fast as the manufacturer could produce them, and that they had become popular at other aircraft plants on the West Coast, including Douglas and Lockheed. ■

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PHOTOS: (Top) One of Boeing's Rosie the Riveters wears a Flying Fortress uniform while working on the interior of a B-17 fuselage. **(Bottom)** Rosie the Riveters (from left) Violet Matson, Elaine Tosch, Katherine Cushing, Violet Walinder, Elsie Clark and Vivian Speer show off the Flying Fortress Fashions on the wing of a B-17. Muriel King, right, teamed with Boeing to design the attire. **BOEING ARCHIVES**

Flying machines of the **future**

Boeing's Phantom Works looks into the future to come up with some 'pretty cool stuff'

by Marc Sklar

GRAPHICS: (Above) The Phantom Ray unmanned flying test bed, shown in an artist's concept, is 36 feet (11 meters) long with a wingspan of 50 feet (15 meters). It is scheduled for systems, ground and flight tests this year. MICK MONAHAN/BOEING

(Right) Phantom Works and SkyHook International are developing this neutrally buoyant hybrid aircraft for heavy-lift operations into remote areas. It will be capable of lifting up to 40 tons (36 metric tons). JOE NAUJOKAS/BOEING

As a massive hybrid neutrally buoyant aircraft delivers oversized pipeline equipment north of the Arctic Circle, a homeowner uses the Internet to check the cheapest time to run a load of laundry.

At 65,000 feet (19,800 meters) over a battlefield, a liquid-hydrogen-powered aircraft keeps tabs on troop movements and helps control unmanned attack aircraft flying from carriers 500 miles (800 kilometers) offshore.

Officials in a major city monitor massive security operations for a global sports event, while hundreds of miles above, nanosatellites—each the size of a toaster oven—collect data on crop conditions, flood threats, the health of the planet and more.

The stuff of science fiction? No. Just a glimpse at some of the capabilities and applications of projects in various stages of development by employees of Phantom Works, the division of Boeing Defense, Space & Security charged with advanced development. With a team of only about 2,000 employees, Phantom Works has numerous programs and initiatives going at any one time in fields as varied as aviation, space, energy management, and military and intelligence operations.

"What we do is look into the future and work with our customers to determine where capability gaps may exist," said Darryl Davis, Phantom Works president. "That can mean anything from advanced aircraft to spacecraft to network systems to energy management to hovercraft to

hybrid airships to unmanned vehicles to security systems, as well as all the components that go into those. It's pretty cool stuff!"

Stuff with intriguing names such as Phantom Ray, Phantom Eye, SkyHook and WaveRider.

"It's really cool to work in an environment where leadership provides whatever is needed to nurture creativity," said Krishna Badrinath, a manager with Advanced Modeling & Simulation. "We get to work on projects that leverage smart ideas and best-in-class technologies. Ultimately, that helps Boeing be far more competitive."

Ann Meyer is also a manager with Advanced Modeling & Simulation. Last summer, her 16-member team executed 16 modeling and simulation demonstrations for multiple BDS businesses in only four hours. "We were told that the success of the event was influential toward enhancing Boeing's work with the customers," Meyer said. "I'm thrilled that our small team can significantly impact things like sales or Boeing's presence around the world."

Phantom Works and BDS focus resources on what's known as rapid prototyping. This is the process of rapidly and affordably developing a model, vehicle or system. Phantom Works typically focuses on "technology demonstrators" to prove a new technology or set of technologies. These usually are built using minimal tooling.

One result of this prototyping effort is Phantom Ray, announced in early 2009. Phantom Ray builds on Boeing's successes with the X-45A and X-45B Unmanned Combat Air Systems, and the development work done on the X-45C. In 2010, Phantom Ray will undergo ground and systems tests, leading to first flight later in the year. Flying and testing Phantom Ray will demonstrate Boeing's commitment to be a leader in the unmanned aircraft business.

Another Boeing-funded prototype is the Phantom Eye High Altitude Long Endurance (HALE) unmanned aircraft program. Tests of a liquid-hydrogen-powered propulsion system are under way while the prototype aircraft is being built. The HALE prototype would be able to remain on station for more than four days at an altitude of about 65,000 feet (19,800 meters). It would

"We get to work on projects that leverage smart ideas and best-in-class technologies."

– Krishna Badrinath, a manager with Advanced Modeling & Simulation

PHOTO: FRED TROILO/BOEING

"I'm thrilled that our small team can significantly impact things like sales or Boeing's presence around the world."

– Ann Meyer, a manager with Advanced Modeling & Simulation

PHOTO: MICHAEL GAIL/BOEING

GRAPHIC: The Phantom Eye High Altitude Long Endurance prototype is being built to stay aloft for up to 10 days and carry up to 2,000 pounds (910 kilograms) of payload. Potential applications for the liquid-hydrogen-powered aircraft include battlefield and border observation, port security and telecommunications.

MICK MONAHAN/BOEING

carry out intelligence, surveillance and reconnaissance missions. A full-production aircraft would likely be able to stay on station for up to 10 days.

While Phantom Eye would be stationed over one area for long periods of time, the X-51A WaveRider will streak across the sky at more than a mile per second (1.6 kilometers per second). A program of the Air Force Research Laboratory and Defense Advanced Research Projects Agency, WaveRider is a scramjet demonstration aircraft for hypersonic flight testing.

"The X-51A will set the foundation for several hypersonic applications including access to space, reconnaissance, strike, global reach and commercial transportation," said Joseph Vogel, Boeing X-51 program manager. "This is a true flying vehicle, not just the engine demonstrator the program was initially established to be. It has all the systems of an aircraft."

Four flight tests are scheduled this year. The demonstrator will launch over the Point Mugu Pacific Test Range in California from a U.S. Air Force Boeing B-52H carrier aircraft. After release, an onboard booster will accelerate the X-51A to about Mach 4.5 (or 4.5 times the speed of sound) before its air-breathing engine takes over and hurls WaveRider to speeds in excess of Mach 6.

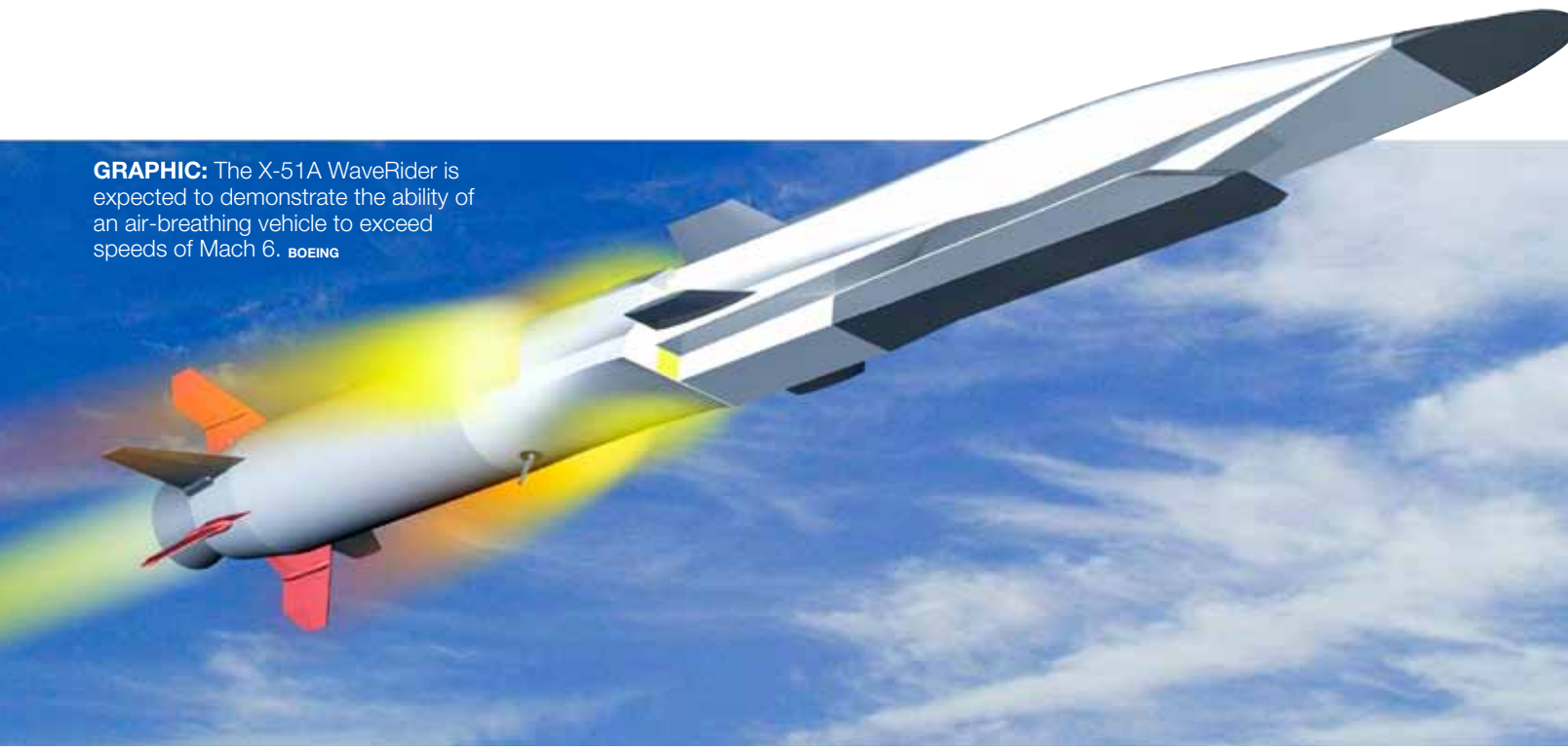
In December, the WaveRider took to the skies in a "captive carry" test under the wing of a B-52H. "That test was the culmination of many months of hard work by the X-51A team to verify that hardware, electrical and software integration was complete," said Vogel. "It was a key step on the way to our upcoming flights."

On the other end of the speed range is the SkyHook Heavy Lift Vehicle. (See story on Page 22 of the August 2009 issue of *Frontiers*.) Currently being designed by Boeing for its Canadian partner SkyHook International, the neutrally buoyant vehicle will measure 410 feet (137 meters) long, 205 feet (62 meters) wide and 141 feet (43 meters) high. SkyHook combines a helium-filled envelope that carries the weight of the vehicle itself with four helicopter rotors that generate the power to lift payloads of up to 40 tons (36 metric tons). Ducted propellers are used for maneuvering and can propel the aircraft horizontally, at maximum payload, up to 200 nautical

"I'm confident our work will result in a deployed system that will be a huge benefit to the warfighters."

– Phil Stranahan, integrated software product team lead with Advanced Network & Space Systems

PHOTO: MICHAEL GAIL/BOEING



GRAPHIC: The X-51A WaveRider is expected to demonstrate the ability of an air-breathing vehicle to exceed speeds of Mach 6. BOEING

miles (230 miles, or 370 kilometers) without refueling. The SkyHook can be used for hauling heavy equipment to remote sites for uses such as power-line installation, or for extractive industries, such as mines, when roads do not exist.

At much higher altitudes, a Phantom Works–led team is successfully demonstrating an enhancement to the Global Positioning System that helps warfighters obtain vital positioning information even when enemies are jamming the signals. The High Integrity GPS program will make access to the positioning information more reliable.

"What's unique about the program is that the requirements for the system are developed as the technology matures; so we've had to build software that can incorporate changes along the way," said Phil Stranahan, who leads an integrated software product team with Advanced Network & Space Systems. "It's very challenging, but I'm confident our work will result in a deployed system that will be a huge benefit to the warfighters."

In mid-2009, the U.S. Defense Advanced Research Projects Agency awarded a Phantom Works–led industry team a $15.5 million contract for phase 2 of the Fast Access Spacecraft Testbed. The program is an effort to develop a new ultra-lightweight High Power Generation System that can generate up to 175 kilowatts of power for spacecraft. That's more power than is currently available to the International Space Station.

Boeing also continues research in nanosatellites and picosatellites. These tiny spacecraft (nanosatellites are spacecraft weighing less than 22 pounds, or 10 kilograms; picosatellites weigh less than about 3 pounds, or 1 kilogram) are demonstrating both what small satellites and smaller components can do to boost the capability of larger satellites. Boeing's CubeSat TestBed 1 nanosatellite has completed more than 10,000 Earth orbits and successfully demonstrated numerous advanced technologies.

Also on the drawing board are ideas for advanced fighter aircraft for the U.S. Navy, known as F/A-XX, and a next-generation U.S. Air Force bomber.

Wendy Teare, an operations analyst with Advanced Boeing Military Aircraft, is conducting virtual experiments with Navy

engineers and operators in the Virtual Warfare Center. "Through these events, our customer has become a seamless member of our team and, accordingly, has helped us anticipate what the Navy needs in the future in terms of fighter aircraft," she said.

Phantom Works also is focused on moving into adjacent markets to support BDS growth plans. Leveraging networking and systems-of-systems expertise, BDS started its Energy Solutions group last year. The organization has already won, along with energy industry partners, U.S. Energy Department grants to work on Smart Grid technology. Smart Grid covers all aspects of the electrical grid, from production and transmission to consumption and efficiency as well as security. It includes new technology and networking of information to allow everyone from power companies to customers to make smarter decisions on use and generation of energy.

"I come to work each day knowing I am part of something big and new," said Ken Stoltman, with Energy Solutions. "Being in business development, I get to be one of the first to interface with companies who want to work with us in the rapidly growing energy market. I love watching their faces light up when I tell them of our energy competencies, such as being the record holder for the world's most efficient solar cell, or that we've been creating energy solutions for 35 years. I get to tell them about an unmanned aerial vehicle that can monitor thousands of miles of transmission lines, or a communications system that integrates a utility's massive logistics command and control network."

What's next? That is the question that drives the Phantom Works team. "We constantly invest in people, technology, processes and ideas," said Dave Whelan, vice president, strategic innovation for Phantom Works, and BDS chief scientist. "We see innovation as a core competency of Boeing, and especially Phantom Works, that spans our business planning horizons from today's products to tomorrow's advanced systems and on to the technology enablers for our 'systems after next.'" ■

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“I come to work each day knowing I am part of something big and new.”

– Ken Stoltman, with Energy Solutions, which was formed last year as part of Boeing Defense, Space & Security

PHOTO: RICHARD RAU/BOEING

“Our customer has become a seamless member of our team.”

– Wendy Teare, an operations analyst with Advanced Boeing Military Aircraft

PHOTO: RICHARD RAU/BOEING

From ideas to ***profits***

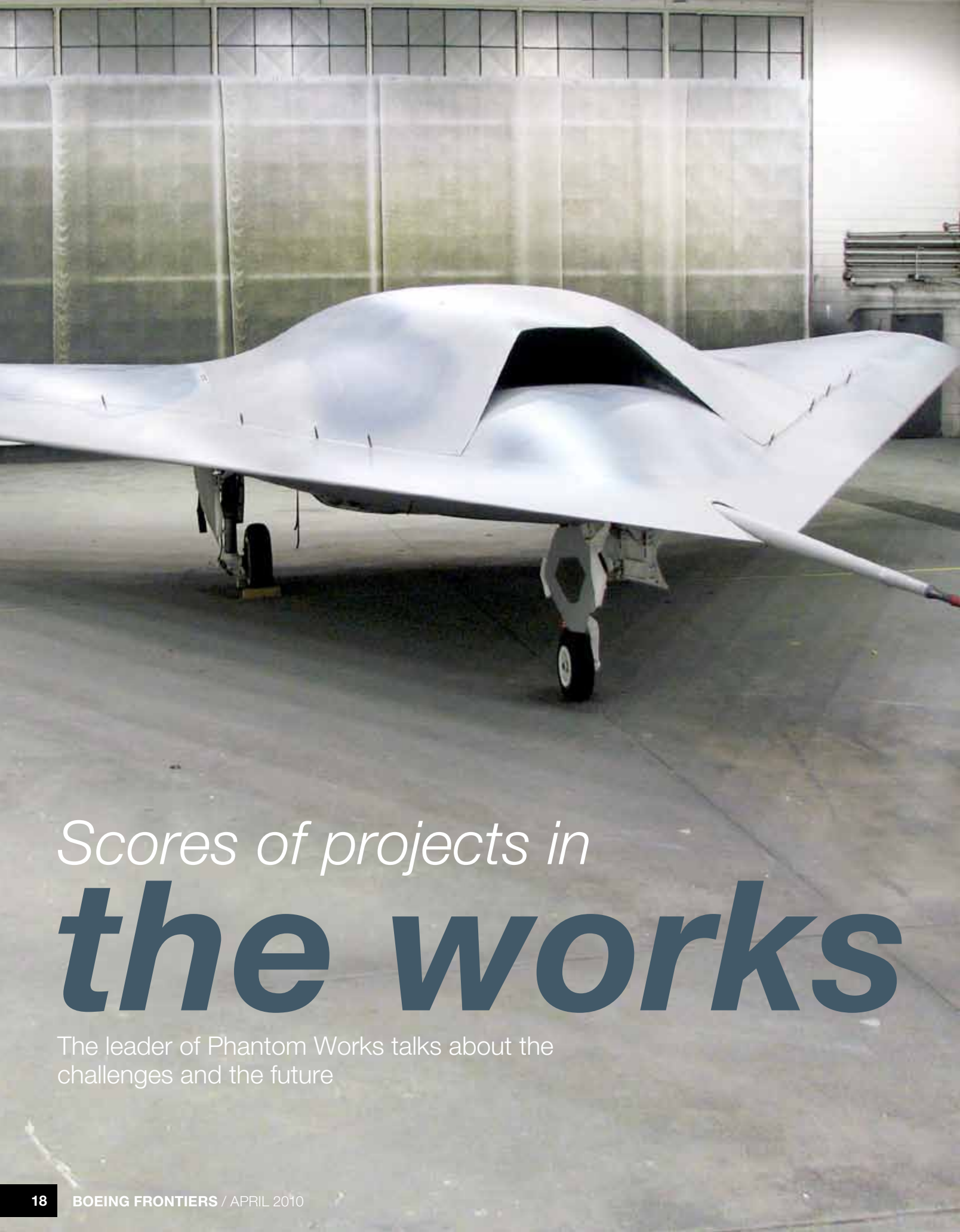
While maintaining a strong customer focus, the end goal for Phantom Works is to turn its development programs, prototypes and concepts into profitable programs for Boeing Defense, Space & Security business units.

“Our goal is to invest in research and development projects in market growth areas that will allow us to bring great products to customers quickly,” said Daryl Pelc, Phantom Works vice president, Engineering and Technology. Projects that have made the transition to the business units include:

- The A160T Hummingbird unmanned rotorcraft—an endurance record holder, it has demonstrated cargo hauling for the U.S. Marine Corps
- Ship-to-Shore connector—a proposed replacement for the U.S. Navy’s Landing Craft Air Cushion, a hovercraft used for transporting forces and equipment for coastal landings
- ScanEagle UAS—a small tactical unmanned aircraft system now providing U.S. and allied military forces with high-quality imagery for intelligence, surveillance and reconnaissance

– Marc Sklar

GRAPHIC: Phantom Works is providing technology assessments to help the U.S. Navy analyze its options for a future manned or unmanned aircraft known as F/A-XX. CHUCK SCHROEDER/BOEING



Scores of projects in the works

The leader of Phantom Works talks about the challenges and the future

"The type of projects we get to work on ... keeps the innovation juices flowing."

– Darryl Davis, president of Phantom Works

PHOTO: BOB FERGUSON/BOEING

As president of Boeing's Phantom Works, Darryl Davis is at the center of an organization that by definition takes risks. He's responsible for developing advanced concepts and technologies and executing new programs before they reach the System Design and Development phase. *Frontiers* recently spoke with Davis about the challenges of being on the "front end" of the business.

Where does your interest in flight originate?

I come from a small town in Indiana. On Sunday afternoons, my dad would pack us up in the station wagon and we would go out to this little county airport, and we'd sit there and watch these little airplanes buzz around the airport. Because of my dad's fascination with aviation, I naturally took an interest and read anything I could get my hands on about airplanes. Next thing you know, I was in college studying to be an aeronautical engineer. Did I know then exactly what I wanted to do? No, I just knew I was extremely interested in things that flew and simply followed that passion. I can tell you I did the right thing because this is a lot of fun.

What is Phantom Works?

Fundamentally, we're all about the future. What we do is look at all the things Boeing Defense, Space & Security is doing and determine where we can open new markets for Boeing. We interface with the three other BDS businesses (Boeing Military Aircraft, Global Services & Support, and Network & Space Systems) to help them develop advanced concepts and technologies that address potential markets and meet the evolving needs of customers. Our job is to take the risks and deliver the future for BDS.

What are some of the challenges?

The big challenge is deciding what to work on first. To do that, we have to anticipate where significant revenue streams are going to be in the future and align our capabilities accordingly. There has to be alignment between our internal investment and where we think customers will focus their resources. In a perfect world we'd do everything at once, but of course we can't because we're limited in people, dollars and facilities. So, the challenge is to pursue projects that will have the highest payoff.

Of course, defense spending cutbacks are also a challenge, but we're focused on quickly bringing programs online that can offset portfolios that may change in the next five to 10 years due to changes in defense spending priorities.

What can we anticipate from Phantom Works in 2010?

We're continuing our move toward rapid prototyping—showing customers we can field programs without a major design and development effort. Phantom Ray, an unmanned flying test bed to develop advanced air system technologies, is scheduled to make its first flight in late 2010. Tests of the High Altitude Long Endurance aircraft are under way. The unmanned aircraft would carry out intelligence, surveillance and reconnaissance missions. Flight tests for the X-51A are scheduled for the first part of this year. Flying at speeds in excess of Mach 6, the vehicle will set the foundation for several hypersonic applications.

Those are just the big milestones for 2010. But there are numerous Phantom Works programs at various stages of development.

What is Phantom Works' competitive advantage?

It's got to be our people! We don't have large manufacturing facilities, but we do have a small team of employees who do amazing things. They're not only bright and creative; they're flexible. You have to be since projects can be dropped very quickly, or new opportunities can pop up just as quickly. Also, our programs ultimately transition from development to one of the three BDS business units, so our people have to be pliable enough to come into this environment, work a program, then take that program and what they've learned to the businesses.

What do you like best about your job?

We are on the front end of the business, and that is fun! We get to experiment, prototype and flight-test. Successfully transitioning a program to one of the business units is what it's all about. But, no sooner do we do that, we're on to the next project. The type of projects we get to work on and the tempo of the work keeps the innovation juices flowing. It's a great challenge. ■

PHOTO: The Phantom Ray unmanned flying test bed is being built by Phantom Works to develop advanced air system technologies. First flight is planned for late 2010. BOEING

Crew frontiers

NASA's new focus on commercial spaceflight provides opportunities for Boeing's highly skilled work force

by Ed Memi

Much as Boeing helped launch commercial aviation decades ago, it is now moving toward development of a space transportation system that will use commercial services to ferry astronauts to and from low Earth orbit.

NASA recently awarded $18 million to Boeing to design a commercial crew capsule. In addition to Boeing, NASA selected four other companies for the Commercial Crew Development contest. The space agency later will follow with a more comprehensive competition, but the timing remains undefined.

"NASA will accelerate and enhance its support for the commercial spaceflight industry to make travel to low Earth orbit and beyond more accessible and more affordable," NASA Administrator Charles Bolden said, in announcing the five companies awarded contracts.

Don McCorvey, space shuttle flight controls subsystem manager and Commercial Crew Vehicle avionics lead, is heading Boeing's effort to design most of the avionics for the new spacecraft. "Building a commercial vehicle like this really hasn't been done before," he said. "It's a great opportunity to design a brand-new vehicle—a lower-cost vehicle that doesn't sacrifice safety—that can be sold to NASA and other customers."

Keith Reiley, Commercial Crew Development program manager for Boeing, said the company is in a strong position to compete for a follow-on contract. The 2011 NASA budget includes about $6 billion for commercial crew programs over the next five years and follows a decision by the Obama administration to cancel the Constellation program to return to the moon and instead rely on commercial operators to fly astronauts to the International Space Station. The United States now intends to support the station through at least 2020.

As envisioned, the Boeing-designed system will fit on various rockets, including the Delta IV, Atlas V and Falcon 9. The system will likely be larger than the Apollo-era space capsule and able to transport as many as seven astronauts.

NASA's announcement comes at a key time for Boeing Space Exploration. With the Space Shuttle program ending later this year, the company is looking for opportunities to leverage its 50 years of experience designing and developing spacecraft and launch vehicles. The Commercial Crew Development program offers the highly skilled Space Exploration work force a new path.

Under its agreement with NASA,

"It's a great opportunity to design a brand-new vehicle—a lower-cost vehicle that doesn't sacrifice safety—that can be sold to NASA and other customers."

– Don McCovey, Boeing's space shuttle flight controls subsystem manager and Commercial Crew Vehicle avionics lead

Boeing will research and further develop system concepts and key technologies for a capsule-based crew transport system. The company also will define its vision for the overall system and perform demonstration testing of life support, avionics and landing systems, and critical subsystems. Boeing is teaming with Las Vegas–based Bigelow Aerospace to define its concept.

"Boeing has been in this game for a long time," said Brewster Shaw, vice president and general manager for Boeing Space Exploration. "And we intend to be in this game for a long time into the future." ■

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GRAPHIC: Boeing's Commercial Crew Development capsule is shown docking at the International Space Station in this artist's concept. JOHN RANKIN/BOEING

‘Little Bird’ grows up

Boeing’s new AH-6i helicopter comes from a good pedigree

by Marc Sklar

The prototype came from the genius of the Hughes Tool Co. Aircraft Division, predecessor to today’s Boeing Rotorcraft Systems operation in Mesa, Ariz.; the catalyst was a 1958 U.S. Army plan to improve light observation, manned surveillance and tactical transport for the future. The result was the OH-6A Cayuse, named for the Native American tribe.

Five decades later, its modernized, advanced descendant, the AH-6i, is being marketed by Boeing to international customers.

In what could be the archetype for rapid and Lean development, the AH-6i made its first flight last September. “In less than seven months we went from designing to flying this aircraft,” said Lauralie Campbell, AH-6i program manager. “This aircraft has taken as much as possible from the AH-64D Apache Block III technology, which helps with cost and taps into the demonstrated success of Apache.”

A new, integrated “glass cockpit” has much of the look, feel and functionality of the advanced Apache cockpit, Campbell noted. In addition to the new cockpit, the AH-6i includes a modified nose, to provide additional space for avionics, and the highest payload for any aircraft in its class.

“I’ve been with flight test for 30 years,” said Keith Sucher, Experimental Flight Test crew chief for the AH-6. “I’ve always had a love for this family of helicopters, and the AH-6i is the culmination of all we’ve done over the years. It’s always been a great aircraft—simple, reliable and easy to maintain.”

For international customers, the AH-6i offers a proven platform with the latest technology and the capability to carry out light attack and reconnaissance missions. The weapons suite includes Hellfire missiles, all varieties of 2.75-inch (70-millimeter) rockets (including laser-guided rockets), 7.62mm mini-guns, the GAU-19 .50 caliber Gatling gun and the FN/Herstal HPM400LC .50 caliber gun pod.

Weapons can be mixed and matched across four weapons stations and are automatically configured, with status displayed to the pilot. The electro-optic and infrared sight and targeting system provides pilots with day TV, low-light TV, infrared camera, laser range finder, laser pointer and laser designator capability—all tied into the advanced cockpit.

"In my entire career I've never seen an avionics suite and integrated cockpit come together so quickly," said Al Winn, Boeing vice president of Apache Programs. "It's a testament to the AH-6i and Apache teams. This proves the open-systems architecture of the Apache Block III is a success."

Boeing now is developing a version of AH-6 to fly in the thinner air at high, hot altitudes such as in Afghanistan, with the speed to keep up with the Apache and Sikorsky UH-60 Black Hawk helicopters as well as perform reconnaissance missions.

After 50 years, the "Little Bird" that started as the OH-6 has grown into a modern raptor with a promising future. ■

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AH-6i

key capabilities:

- Flexible mission configuration
- Combat-proven design
- Integrated and qualified weapons system
- Low maintenance costs
- High reliability
- Transportable by military C-130 transport
- Lightweight multiple weapons mount

PHOTOS (Left): The AH-6i light attack and reconnaissance helicopter for international customers is the latest derivative of the OH-6A Cayuse, which has a heritage of successful military service including models in use with U.S. Special Operations forces. MIKE GOETTINGS/BOEING

(Right): A Hughes OH-6A Cayuse hovers above a full-scale mock-up of its commercial sibling, the 500, in 1965. BOEING ARCHIVES

Learning the ropes

For U.S. Marines, the V-22 has become an everyday workhorse

by Jeff Barnett and photos by Bob Ferguson

Most people aren't prone to dangling from a rope below a moving aircraft 100 or more feet (30 meters) above the ground. But for U.S. Marines, this can be as routine as tying their boots.

Boeing photographers recently observed Marines Corps training at North Carolina's Camp Lejeune as Bell Boeing MV-22 tilt-rotor aircraft hovered, landed and lifted off again and again. The exercises included fast-roping, or sliding down ropes slung out the back of a hovering aircraft, as well as rapid offloading and special operations insertion and extraction.

The U.S. Marines are the chief operators of the MV-22 Osprey and are integrating its capabilities into routine training and development. The Marines rely on the Osprey to perform the critical missions of moving troops and material from amphibious shipping inland, or supporting troops on the ground from austere land bases. The Osprey's unique ability to hover and land like a helicopter or fly fast like a fixed-wing aircraft makes it well suited for these roles.

The Marines are tasked with skill sets such as amphibious operations and air assault, said Lt. Col. Michael C. Starling, the operations officer for the Special Operations Training Group. "The MV-22 is making a huge impact on the way we train. It's helping our Marines learn how to operate around helicopters and other aircraft and develop the skills we rely on to complete our mission, skills such as insertion and extraction techniques, fast-roping, and more."

"I think the public's perception is that the MV-22 is still experimental," said Master Sgt. Mark Bradley. "To us, it's an everyday workhorse." Twenty minutes after making that comment, Bradley was swinging from an Osprey 100 feet up! ■

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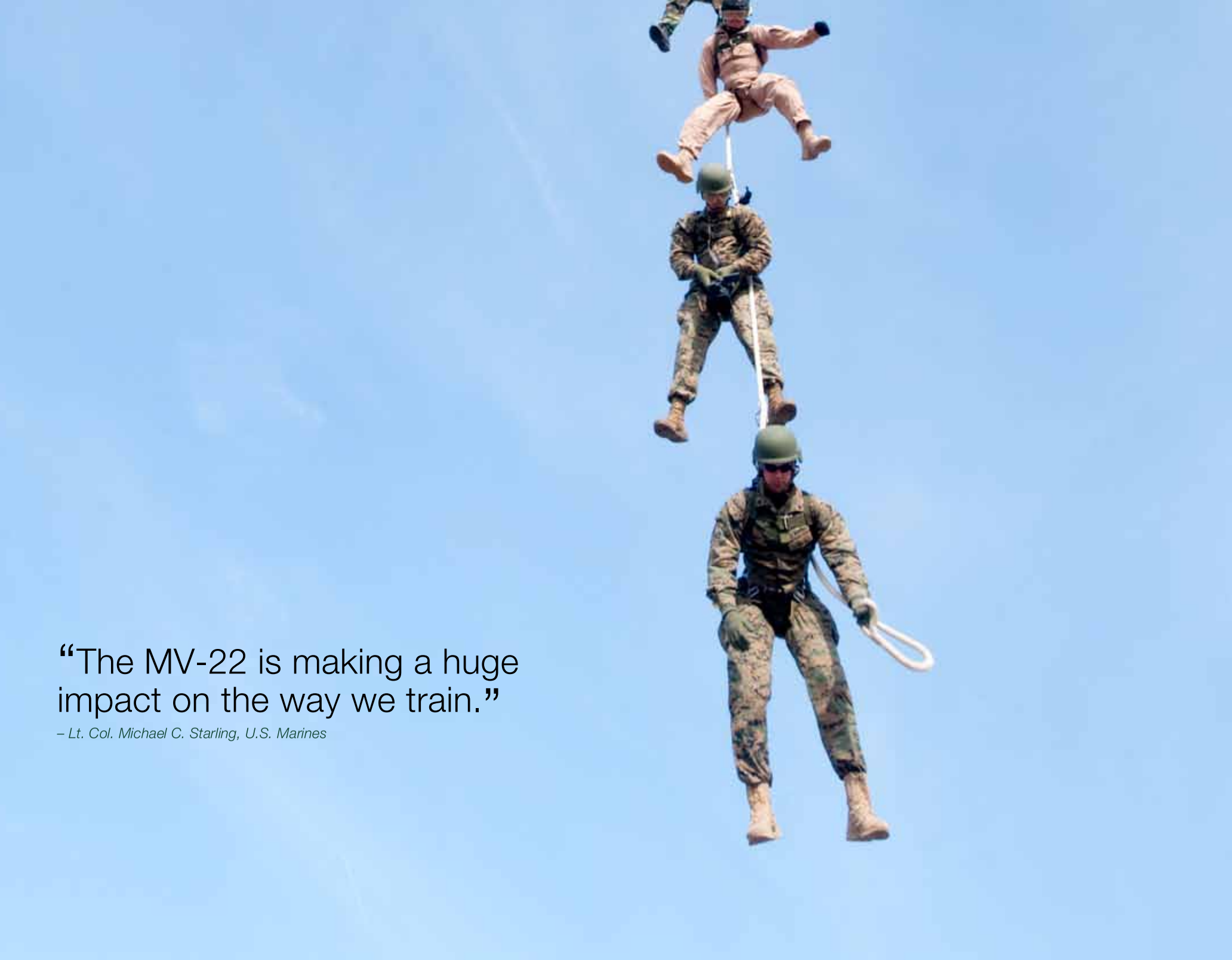


“The MV-22 is making a huge impact on the way we train.”

– Lt. Col. Michael C. Starling, U.S. Marines

Fine line

Boeing's 777 has always been an efficient airplane. Now its assembly line is operating more efficiently, too.

by Eric Fetters-Walp and photos by Bob Ferguson

For more than a decade, the 777 had been produced in "slant line" formation at the final assembly line in Everett, Wash., with airplanes parked wing to wing in stationary positions, the once-traditional manufacturing method for all Boeing models.

It worked well enough. But the successful 737 moving assembly line in Renton, Wash., showed there were production gains that could be realized using a moving line of jets parked nose to tail.

"It wasn't broken," said Kim Pastega, Commercial Airplanes director of 777 manufacturing, of the old way the line had operated, "but it really is about growth and productivity. We believe we have a competitive advantage the way we build airplanes here today."

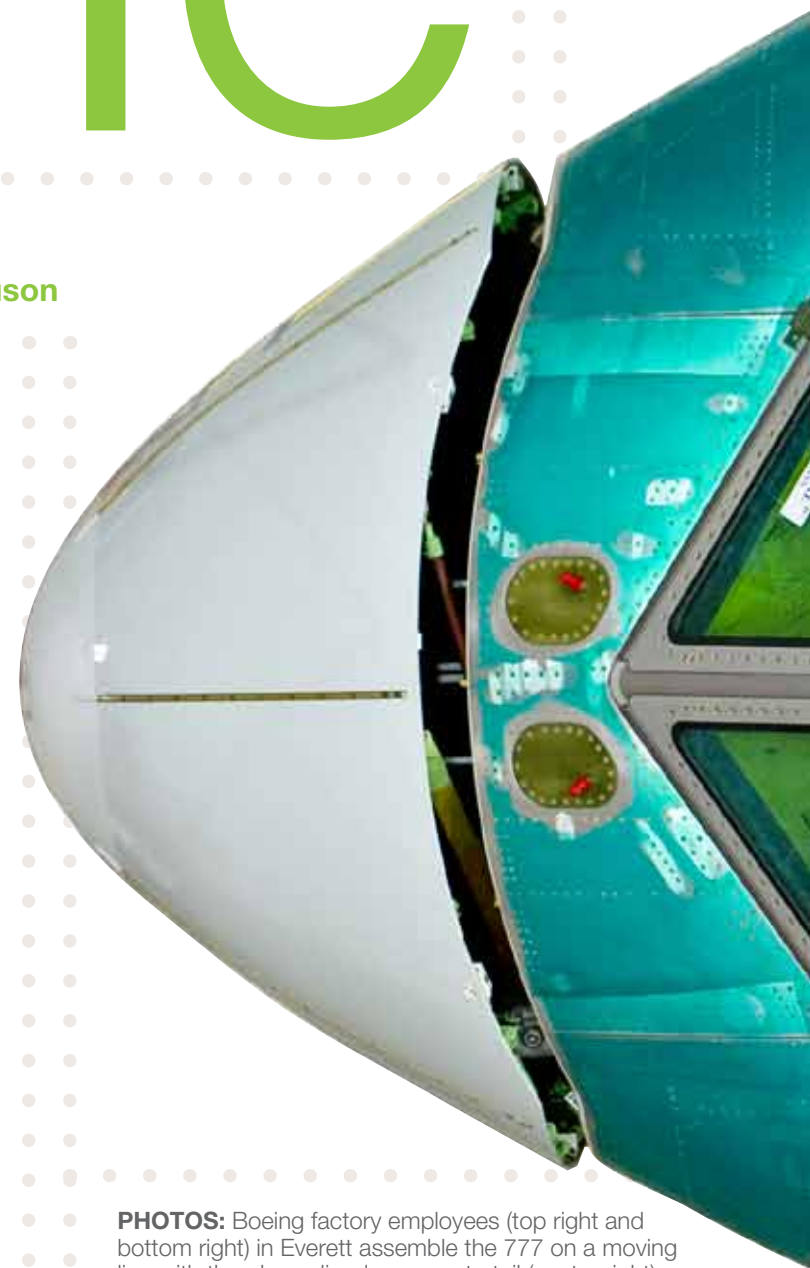
The transition has been a lengthy one. Boeing first started portions of the 777 moving line in 2006, after several years of planning. But progress toward making the entire final assembly line ready to move was interrupted by the introduction of the 777 Freighter in 2008.

During planning and preparation, 777 managers looked at lessons learned on the 737 program, which launched its moving line in 2002. "That really gave us a great foundation to learn from," said Larry Loftis, 777 vice president and general manager, who also was a director for the 737 line when it was transformed.

Since the 777 program's moving line officially started up on Jan. 12, it has moved an average of 1.6 to 1.8 inches (4.1 to 4.6 centimeters) per minute. That has reduced the 777 final assembly process—the time it takes between the arrival of initial fuselage sections into systems installation to the day the completed jetliner rolls out the factory doors—from 26 days to 17 days, Loftis said.

The moving assembly line idea has been replicated worldwide in large manufacturing processes since Henry Ford introduced it to the automotive world a century ago. Boeing became the first commercial airframe manufacturer to use the concept in building jetliners, starting with its 717 production line in Long Beach, Calif., in 2000. Boeing found the moving line helped to reduce assembly time and also cut costs by incorporating Lean+ principles into production processes.

Boeing's moving lines are different from many moving production lines in the size and complexity of the product being



PHOTOS: Boeing factory employees (top right and bottom right) in Everett assemble the 777 on a moving line with the planes lined up nose to tail (center right) rather than in the traditional slant positions. The moving line, which officially started up in early January, has dramatically reduced the time it takes to assemble a 777—from 26 days to about 17 days.

"What makes the 777 line unique was taking a baseline plan and adopting it on a scale and magnitude that's never been done before."

– Kim Pastega, Commercial Airplanes director of 777 manufacturing

assembled. The 777 line is believed to be the most extensive moving production line used to build a commercial airplane. A new, empty 777 weighs 366,940 pounds (166,441 kilograms) and includes about 3 million parts.

"What makes the 777 line unique was taking a baseline plan and adopting it on a scale and magnitude that's never been done before," Pastega said. "It absolutely needs every single person engaged to help with the implementation."

Before planning for the line's startup could begin, 777 employees spent significant time looking at how parts flowed to airplanes under construction and how the former production system worked, Loftis said. With that done, switching to a moving line required coordinating not only the assembly and tooling crews but also everyone else from suppliers to the employees who maintain the tugs that move the airplanes along the line, said Gary McCulley, director of 777 Final Assembly.

The transition also required that line employees learn a new system, Loftis said. The new system requires flexibility. "Change is always hard. The system is designed to highlight any problems, so you have to fix them rather than just live with them. The process forces you to look at all waste and get rid of it," he said.

Recurring problems that crop up in the assembly process gain faster attention now, said Steve Hall, Production manager for 777 Final Assembly. That's because when encountering a serious problem, an employee can halt the moving line.

"It's real visible if you're not moving," Hall said. "There's a sense of urgency when there's a problem."

So far, Hall said, a "handful" of major issues have been identified during transition to the moving line. Those are being addressed as phase 2 of the moving line is implemented, he said. The goal is to be at phase 3—full implementation of the moving line—by the end of summer.

That should be possible, Loftis said, given the enthusiasm Boeing workers have shown since the moving line started in January. The 777 assembly teams—many of which have adopted nicknames—track their performance on the line, a process aided by new large display screens hanging in the Everett factory.

"We've had some great successes with our employees helping us implement this," Loftis said.

Pastega agreed, saying early doubts about the change largely have subsided. "I think our team really understands this is all about the value and competitiveness of the 777."

Hall has worked on the program since 1994, before the 777's first flight. From his office area overlooking the 777 line, he said he's happy the new assembly strategy for the long-successful airplane program is in motion. "It's gratifying to see the effort and the collaboration that's gone into that," Hall said.

"It takes a whole family to make that airplane go down the line." ■

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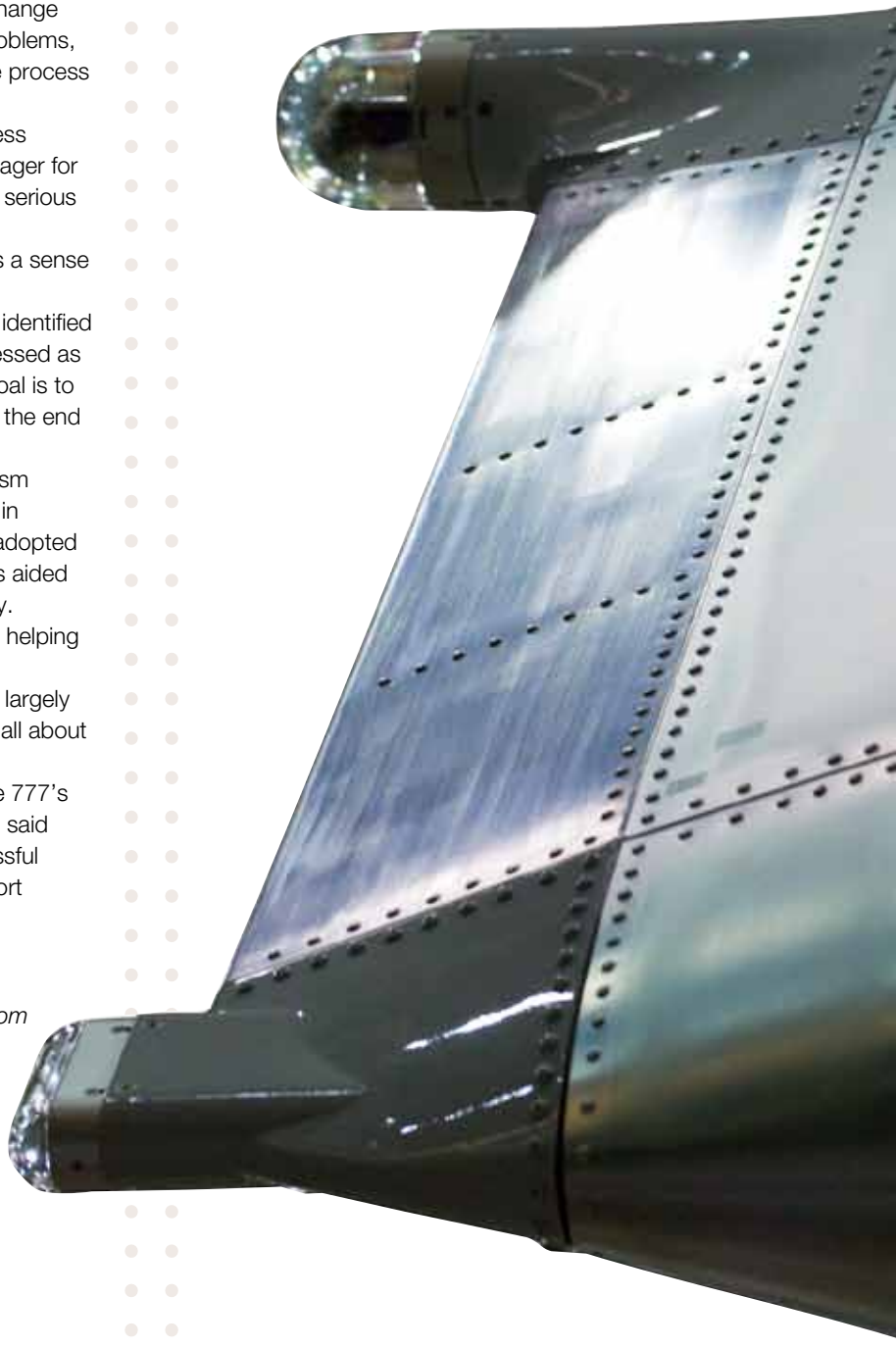
4 of a different kind

All models of the 777 are assembled on the moving line, underscoring the stability of the new production system. Indeed, just recently, all four models—a 777 Freighter, 777-200ER (Extended Range), 777-200LR (Long Range) and a 777-300ER—were being assembled simultaneously.

The four variants have successfully moved down the line twice now without major hiccups in production, said Matt West, 777 Business Operations manager. "There



are significant configuration differences between these models, including fuselage structure, wing and systems ... These eight airplanes went through the factory build process flawlessly."

As of mid-March, customers had ordered 1,117 Boeing 777s, of which 845 had been delivered. The 777 entered passenger service in 1995.

– Eric Fetters-Walp

PHOTOS: The tailcone of the 777 fuselage is shown in the background. One of the moving line's most crucial points is Final Body Join, where the forward and aft fuselage sections are put together with the wing/body assembly (below left). The 777 moving line can be stopped at any time by one of the employees if there is a serious problem. A large display screen in the 777 bay (bottom right) helps employees track their performance and the progress of planes in final assembly.

The system is designed to highlight any problems, so you have to fix them rather than just live with them. The process forces you to look at all waste and get rid of it.

– Larry Loftis, 777 vice president and general manager

Air of success

As Rwanda sets path toward economic resurgence, its national airline has big plans, too—with Boeing jets

by Eric Fetters-Walp

Like its home country, RwandAir is on the move.

With two Next-Generation 737-800 airplanes on order, RwandAir is one of Boeing's newest customer airlines. The new jets are scheduled for delivery in 2011, and in the interim, the airline is adding used 737s to its fleet. It's a substantial step for RwandAir, which was launched less than eight years ago as the national airline of Rwanda and previously had leased a fleet of regional airplanes.

"Today, RwandAir owns and operates two of its regional jets and looks to add to this structure with Next-Generation 737s for its future," said Rob Faye, Boeing Commercial Airplanes Sales director for Rwanda.

RwandAir's rise mirrors recent economic progress in the nation of 9.7 million, fostered by Rwandan President Paul Kagame's government. Kagame has emphasized the importance of attracting more foreign investment and expertise. "Rwanda has made huge strides economically and stands out as a model for others," Johnnie Carson, U.S. assistant secretary of state for African affairs, said recently. Carson pointed out that the World Bank recently named Rwanda as the top business reformer in the world. It was the first time a sub-Saharan nation in Africa had earned that title.

"The philosophy behind Rwanda's economic growth includes bringing in industry experts from around the world to assist in developing business and to mentor Rwanda's future leaders," Faye said. "RwandAir is a great example of this philosophy at work." Tony Blair, the former British prime minister, is among those advising the nation's government, and RwandAir's management includes several former managers and pilots from major U.S. carriers.

As President Kagame looks to RwandAir to help spur economic growth, the airline is expanding its flight schedule to make use of its airplane acquisitions. It operates direct flights from the Rwandan capital, Kigali, to neighboring nations, as well as to South Africa, a popular connecting point for flights to and from countries around the world.

"RwandAir is focused on its future," Faye said. "The right people, the right equipment, the right operational processes and the right attitude are the foundations for success, and RwandAir is focused on expanding its business connections with important regional hubs such as Johannesburg, Dubai, Lagos and Cairo."

Through partner airlines, RwandAir also offers connecting flights to Europe, the Middle East and China. Eventually, the airline wants to offer its own daily flights to and from Europe. Boeing's 737-800s will help expand the airline's range to include potential direct flights to and from cities in North Africa and the Middle East. ■

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> "The right people, the right equipment, the right operational processes and the right attitude are the foundations for success."
>
> *– Rob Faye, Boeing Commercial Airplanes Sales director for Rwanda*

GRAPHIC: RwandAir, one of Boeing's newest customer airlines, has ordered two Next-Generation 737-800 airplanes, like the one shown in this artist's concept, for delivery in 2011. ED TURNER/BOEING

From beams to batteries

Strategic advancements in systems and subsystems are strengthening Boeing's products—and competitive position

by Bill Seil

The human body is made up of many systems—respiratory, circulatory, digestive, nervous—that keep us alive, engaged and productive.

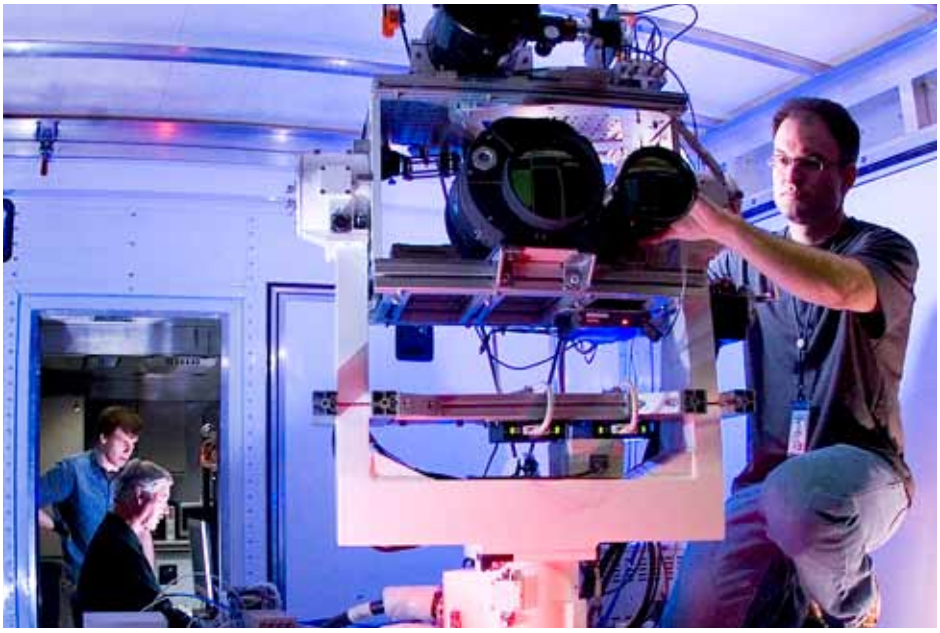
Similarly, Boeing products are filled with complex networks of systems and subsystems that allow them to carry out their various missions—from maintaining a safe cabin environment in jetliners to guiding satellite orbits.

Boeing devotes considerable resources to developing systems that make use of the best and latest technology. The goal is to minimize a product's size, weight and power consumption to improve performance and speed, and reduce cost. Systems and subsystems research and development leads to enhanced capabilities in Boeing products, and that drives the company's competitive advantage.

The Platform Systems and Subsystems technology domain is one of eight areas in Boeing's Enterprise Technology Strategy, established in 2007, which gives Boeing a coordinated "One Company" approach to technology development. It is the largest of the domains, responsible for about one-fourth of the company's advanced research and development investments.

Investment in each domain is based on business units' plans for current and next-generation products to ensure that technologies are ready when needed. It's one way Boeing research teams are helping support the goal of being the world's best and best-integrated aerospace-based company.

"In the first year, much of our effort was devoted to organizing the domains and aligning investments with technology areas that were of greatest value to the enterprise," said Doug Swanson, the domain's leader. "Today, we've become an effective group of teams that is developing new technologies and sharing information on technologies that already exist within the company."

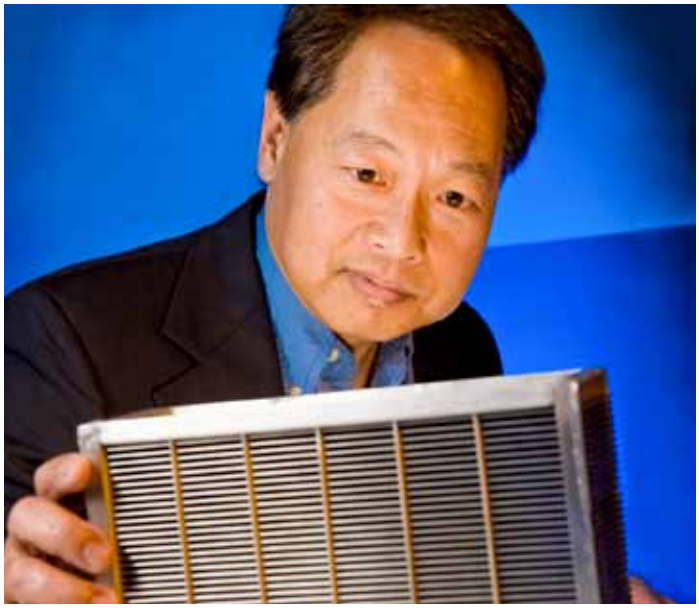


Systems and subsystems teams are working in sophisticated areas such as directed-energy weapons, electronic systems, and sensors and sensor exploitation. Researchers are finding new ways to optimize the effectiveness of energy systems to reduce costs, improve fuel efficiency and enhance product performance. Advancements are being made in onboard systems integration, which will make the next generation of Boeing products more effective. In addition, new tools and process are being developed that will improve the way complex systems are designed.

The technology domain architecture has been effective in getting business units to collaborate on technologies that have multiple applications across various platforms. For example, the team determined that a lightweight heat exchanger used in Boeing Defense, Space & Security Systems' internally funded High Altitude Long Endurance prototype aircraft could be used in the 787 Dreamliner, resulting in a significant weight savings.

Platform systems and subsystems is

PHOTO: Rafe Guidice, senior engineer, prepares for a test at Boeing Directed Energy System's facility in Albuquerque, N.M. BOB FERGUSON/BOEING



an area where diverse components are combined to perform a specific function. Each of these components could be owned by Boeing, a supplier or even a competitor. Consequently, the domain has followed BDS' lead in making selective use of vertical integration to ensure access to needed components.

In general, Boeing acts as a systems integrator, overseeing the work and products from a group of partners and suppliers. But in vertical integration, the company is directly involved in the technologies from top to bottom—not only the systems and subsystems but also the components and even the devices within the components.

Vertical integration guides the company to develop advanced technologies that make Boeing products more competitive, said Don Cowher, director of BDS Electrical Engineering. One example of work at the device level is research in new materials that allow electronic subsystems to run at higher frequencies and higher temperatures, which could lead to better, more economical and faster devices.

When vertical integration is not appropriate, subsystems to support system requirements are adapted from existing products or specially developed by suppliers. Boeing routinely works with suppliers and others within the aerospace industry to anticipate future system technologies and ensure their availability.

"Good collaborative relationships with suppliers also are important to acquiring the right systems for Boeing products," said Jerry Holmes, who leads Platform Systems and Subsystems technology activity for Commercial Airplanes.

One area of interest to Commercial Airplanes is "backplane technology," which could replace wiring junction boxes with smaller, lighter devices. The substitution would enable easier, faster assembly and significantly reduce the system's weight. The team is also supporting the development of lightweight, low-pressure ducting that replaces glass fiber with lightweight foam core material.

The domain addresses not only technologies that meet near-term systems needs but also breakthroughs for the next generation of Boeing products. That requires keeping pace with rapidly changing technologies and evolving business priorities driven by the competitive marketplace.

"We have outstanding teams of talented people who follow new developments and are able to anticipate change," said Joe Grasso, a manager in the Electronics, Communications & Sensing Technology organization of Boeing Research & Technology and a member of the Platform Systems and Subsystems domain steering team. "They adapt and shift direction to address new priorities. Often they see opportunities and help to drive change."

One trend is toward more highly integrated and efficient systems and subsystems, Grasso said. There is a demand for systems to have more functionality while, at the same time, being lighter, smaller and less power-hungry, he said.

In addition, there's been research on batteries. They're an essential part of most Boeing products, yet there had been little coordination between business units on how batteries are acquired or designed for special needs, said Ron Morinishi, a Platform Systems and Subsystems manager and domain steering team member.

"While lithium-ion batteries are now being integrated into our current platforms, there are more advanced batteries in development that will be lighter and orders of magnitude more efficient," Morinishi said. "We need to work at the enterprise level to move toward these new technologies and adapt them to our future programs."

With research happening in so many areas, it's little wonder that the people overseeing this domain speak enthusiastically about its activities.

"This is the kind of thing I've always found fascinating," said Ken Hays, the Senior Technical Fellow on the Platform Systems and Subsystems domain leadership team. "You look at the details of technology and work them up through the organization and into products. Those products are then sold to customers who put them to work. It's a very complex process that can be quite challenging. But it's also very rewarding." ■

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This article is part of a continuing series that looks at the Enterprise Technology Strategy and its eight technology domains. Here are the previous stories in the series.

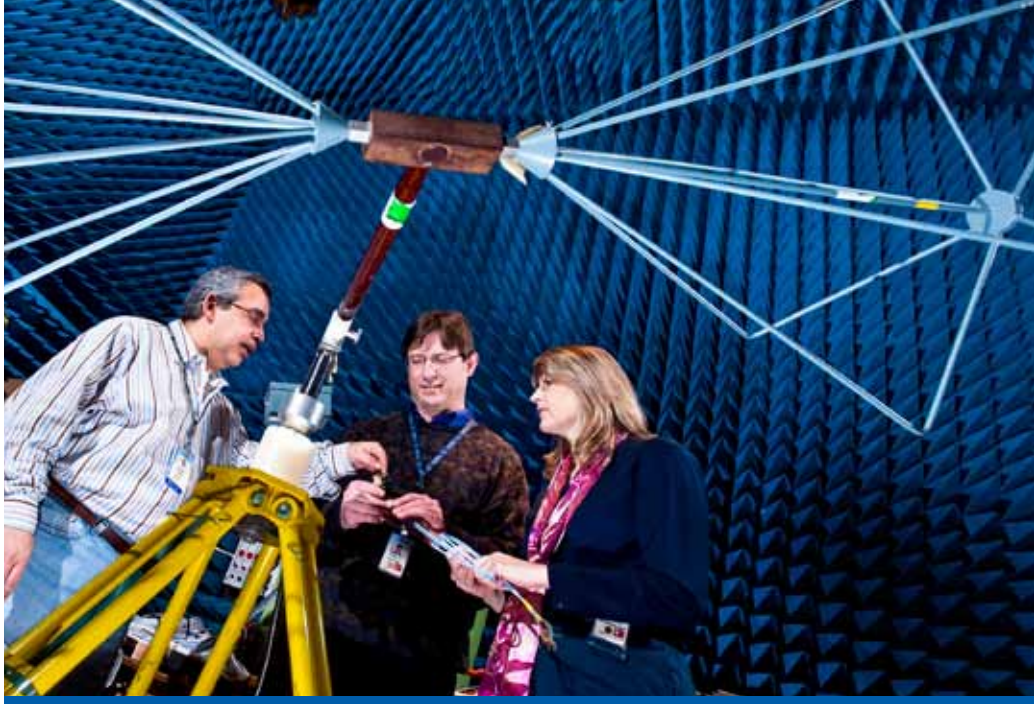
Introduction to the ETS and the domains: May 2008, Page 41

Support & Services domain: October 2008, Page 33

Systems Engineering & Analysis domain: November 2008, Page 38

Platform Performance domain: August 2009, Page 38

Structures domain: December 2009–January 2010, Page 38



PHOTOS: (Far left) Platform Systems and Subsystems leader Doug Swanson (right) and Senior Technical Fellow Kamiar Karimi monitor a Variable Frequency Start Generator at the Boeing Test & Evaluation Aircraft Energy Management Lab in Seattle. MARIAN LOCKHART/BOEING

(Left) Ron Morinishi, a manager in Boeing Research & Technology's Platform Systems and Subsystems Technology organization, examines a new lightweight heat exchanger for Boeing defense and commercial products. RON BOOKOUT/BOEING

Charge it!

Expertise in electromagnetic effects is driving process and product improvements companywide

The Electromagnetic Effects Technology group of Boeing Research & Technology is truly a team "charged" with a critical task.

Diane Heidlebaugh, senior manager of the team, whose work supports the Platform Systems and Subsystems domain, said her group's efforts relate to most of the company's eight technology domains, since structures, systems and platforms must all be protected from electromagnetic threats such as lightning, static charges, broadcast signals and electromagnetic weapons. There also are issues of electromagnetic compatibility, where nearby systems must be designed so they don't interfere with one another.

"Electromagnetic effects have a huge hidden cost on programs across the enterprise," Heidlebaugh said. "People don't realize the scope of their cost because they are so widely distributed among various parts of the platform."

Her team is developing a suite of analysis tools that can determine how systems and structures will react to electromagnetic fields before they are built. Over time, these tools will reduce the need for time-consuming tests on prototype equipment.

In 2009, the Electromagnetic Effects Technology group won a Boeing Technical Replications Award, which recognizes the application of technical ideas to new areas or programs that drive product and process improvements. The team was honored for its development of a lightweight aluminum foil wire mesh that is placed over carbon and glass-fiber surfaces and dissipates energy from lightning strikes before it can damage the structure below.

– Bill Seil

PHOTO: The Electromagnetic Effects Technology team is developing a suite of computer-based analysis tools that can predict the effects of electromagnetic fields on products and systems still in the design stage. From left are Omar Zubi, lead engineer for electromagnetic effects labs; Frank Lenning, a Technical Fellow with this team; and Diane Heidlebaugh, the team's senior manager. MARIAN LOCKHART/BOEING

Volunteer power

Boeing employees drive positive change locally and globally every day

by Tim Houston

From cleaning up protected habitats in Japan to mentoring inner-city youth in Houston to leading cancer fundraisers in Washington state, Boeing employees are stepping up to help their communities.

There are as many approaches to volunteering as there are volunteers. And many employees use the work they do for Boeing as a springboard for how they contribute as a volunteer.

Charles Stewart, an engineer in the Boeing Defense, Space & Security Guidance, Navigation and Control organization, sees his volunteer work with the Boeing Black Employees Association as a way to raise awareness among disadvantaged kids of the things engineers work on every day.

"I grew up in a lower-income area, so I know what it's like to have to struggle to rise above your surroundings," Stewart said. "Many kids in these situations lack the vision to see the opportunities. … It's very rewarding to see the light go on in their eyes when you get them enthused about engineering."

Nigel Lo, a 24-year Boeing veteran, pursued an interest on his own time and integrated aspects of it into his career at Boeing—in his case, by creating and leading the 6-Step Group Mentoring Program. The program gives employees an opportunity to engage in a mentoring relationship and learn fundamental career skills. As a volunteer with a passion for mentoring, Lo has helped more than 1,300 employees develop their professional skills.

"Career growth is a continuous journey, and employees need to constantly learn and improve themselves to keep their career up to date," said Lo, a manager in BDS Program Management Training & Development. "Each of us can make a difference by reaching out to other employees and engaging them in some way."

For John Drollinger, a configuration management specialist with Commercial Airplanes, the organizational expertise he has gleaned at Boeing is helping him manage 62 fundraisers for cancer research as the chair of the American Cancer Society's Western Washington Regional Relay for Life Council.

"I lost my father to cancer when I was 16, so I do what I can to ensure that no other 16-year-old will have to go through what I did," Drollinger explained. "Knowing

Earth Day 2010:
Forty years of 'thinking globally'

April 22 is Earth Day 2010, and this year marks the 40th anniversary of the worldwide event held to inspire awareness of and appreciation for our planet's environment. Over the past four decades, Earth Day has served as a call to "think globally and act locally" to preserve the planet's finite natural resources.

Last year, thousands of Boeing employees at more than 50 locations participated in Earth Day events at work sites and in their communities, and more sites are expected to participate this year. Whether recycling, reducing energy consumption, promoting continuous improvement or helping preserve natural assets in the community, Earth Day actions support Boeing's strategic business objectives in many ways.

"Earth Day is a great opportunity to drive change and make a difference locally—both on and off site," said Mary Armstrong, Boeing vice president of Environment, Health and Safety. "Of course, Earth Day is just one day of the year. To fully achieve Boeing's environmental objectives, we need to focus on improving our environmental performance every day."

– Tim Houston

To learn more about Earth Day events and other environmental activities at Boeing, including ways to get involved in these efforts, visit Boeing's Earth Day Web site at ***http://environment.web.boeing.com*** *on the Boeing intranet. Visit the Global Corporate Citizenship Employee Involvement page at* ***http://community.web.boeing.com/employee_involvement*** *to learn about community service activities happening at local sites.*

that I'm helping someone else fight this disease gives me energy. And, I've been able to bring the knowledge I've gained volunteering for the Relay Council back to my job at Boeing."

Noriko Oyama volunteered with a Boeing team to clean up part of Japan's Nagoya harbor, near Boeing's facility there, as a way to show support for the community. A Boeing information technology analyst based in Tokyo, Oyama and her son joined other volunteers, their families and a group of children from the area to remove trash from the Fujimae Tidal Flat—Japan's biggest stopover for migratory birds. Boeing's Global Corporate Citizenship supports environmental initiatives such as this cleanup project through investments of volunteering, grants and other resources.

"Volunteering gives me a chance to interact with people in the community and give back a bit, and helps motivate me in my daily work," Oyama said. "After seeing all the garbage we collected, [my son] wished we could have spent more time cleaning the beach."

To support all that employee volunteers do, Boeing is launching an Employee Volunteer Program.

"We are taking a 'One Boeing' approach to volunteering to build on the amazing work our employees already do," said Patrice Mingo, director of Strategic Programs for Boeing Global Corporate Citizenship.

Boeing employees will also be participating in Earth Day this month.

"Through volunteering, employees drive positive change in our communities worldwide and open themselves to new opportunities to develop their professional skills and demonstrate their leadership capabilities," Mingo added. "Many employees see their efforts as a natural extension of their careers and a way to make their jobs more personally engaging and rewarding." ■

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PHOTOS: (Left and inset) Volunteer Charles Stewart (left in inset), an engineer with Boeing Defense, Space & Security, helps disadvantaged youth get excited about engineering and science. BOB FERGUSON/BOEING

(Above) Nigel Lo (left), a manager with BDS Program Management Training & Development, helps Boeing employees engage in mentoring relationships and learn fundamental career skills. MARIAN LOCKHART/BOEING

Every day
is Earth Day

Boeing employees work throughout the year to protect the environment—developing innovative solutions, conserving energy and resources, recycling, reducing waste, and leading environmental projects in their communities. This photo essay reflects some of their efforts.

"My colleagues never fail to impress me with their generous spirit and the ingenuity they use to promote positive change in the community."

– Adam B. Schulman, Business Management, Human Resources and Administration

PHOTOS: As a member of Salt Lake City's Green Team, Ryan McNatt, a chemical management specialist, assists employees on the shop floor with recycling knowledge and methods. **BOB FERGUSON/BOEING**

Insets: (Left) Recycling cardboard in Huntsville, Ala., are (from left) Danny Bradford, Greg Lanier, Christina Reich and Jeb Bartram. In 2009, site employees recycled about 6.8 tons (6.2 metric tons) of cardboard. **ERIC SHINDELBOWER/BOEING**

(Right) Among the Boeing employees who recently joined forces with TreePeople to plant 75 native oaks in Chatsworth Park, a wilderness area in Los Angeles, are (from left) Kamara Sams of Environment, Health and Safety Communications; Nan Bouchard, vice president, Defense, Space & Security Program Management; and Jean Chamberlain, vice president and general manager, U.S. Air Force Tanker Program. **VANESSA PEREDA/BOEING**

"We've found people have great ideas about how to reduce the environmental impact of their work. We give these people a voice."

– Molly McLaughlin Schapker and Erin Haworth, 777 production support engineers and 777 Green Team co-leads

PHOTOS: Timothy Kemp, a senior aircraft painter in Boeing's Mesa, Ariz., site, applies chrome-free primer to auxiliary power-unit covers. MIKE GOETTINGS/BOEING

Insets: (Top) Ron Cole, a fabrication associate in Salt Lake City, holds aluminum chips produced by a mill—and "pucks" of compressed chips after they've been processed by a machine that compresses them for recycling. BOB FERGUSON/BOEING

(Bottom) Cathi Parker (left) and Betty Jahner are participating in a six-month pilot initiated by the Tukwila Go Green team. The pilot is proving the benefits of recycling protective garments, like the ones Parker and Jahner are wearing, made of Dupont Tyvek. Lab coats, coveralls, pants and sleeve covers made of this material, which is 100 percent polyethylene, are not biodegradable. Getting these garments out of the waste stream is part of running a healthy business and watching the bottom line. JIM ANDERSON/BOEING

"Employees want to know how they can get involved to help save energy. People are changing their energy-consumption habits at work and at home."

– Alan Griffin, energy conservation engineer at the Boeing site in Huntsville, Ala.

PHOTOS: In Houston, Facilities teammates William Cazzell (left) and Rick Rivas Jr. examine the chilled water piping system leading to Houston's new innovative magnetic bearing chiller. The chiller has many features that have helped cut energy consumption. **BOB FERGUSON/BOEING**

Insets: (Top) Construction administrator John Widtfeldt verifies settings on the master lighting control panel for the 18-26 building in Kent, Wash. The facility was recognized for its environmentally responsible building design in 2009. **ALAN MARTS/BOEING**

(Bottom) Houston-based Site Services teammates Javier Ortega and Wanda Jones discuss building operations and maintenance requirements relating to Houston's Bay Area Boulevard facility, which was recognized for its environmentally responsible building design in 2009. **BOB FERGUSON/BOEING**

Money matters

Changes to Boeing savings plans help you better build your financial future

by Jill Gulbrandsen and Carrie Howard

It's always a good time to think about your retirement savings. After all, the choices you make every day to secure your financial well-being add up, over time.

To make it easier for employees to reach their retirement savings goals, Boeing made important changes to the Boeing savings plans effective April 5, 2010. These changes include the addition of new advisor services, a new investment fund lineup and new automatic rebalancing options.

PERSONALIZED, OBJECTIVE ADVICE

Eligible nonunion current and former employees in the Voluntary Investment Plan (VIP) and the Financial Security Plan (FSP) have access to new resources that provide personalized financial planning through the ING Advisor Service, powered by Financial Engines®. Starting April 5, you can access the Personal Online Advisor through Boeing Savings Plans Online or speak with an ING Investment Advisor Representative through the Boeing Savings Service Center via Boeing TotalAccess. Or, for a monthly fee, you can have a professional manage your account by enrolling in the Professional Account Manager program. The company is discussing union-represented employees' participation in the ING Advisor Service with their unions.

NEW INVESTMENT FUND LINEUP

New investment fund choices are available for your savings plan to provide a wider range of options to meet your personal goals and risk tolerance. You can select one or more Lifecycle Funds based on your planned retirement date or create your own diversified investment mix by choosing among individual funds.

AUTOMATIC REBALANCING

Once you've determined the investment mix that will help you meet your savings goals, you can choose to have your account automatically rebalanced monthly or quarterly to stay in line with your original investment elections and risk tolerance.

INVEST IN YOURSELF

A newsletter mailed to your home in March provides details about these important changes. You can also attend a live webcast (scheduled between April 5 and May 3) to learn more about the changes and ask questions. The newsletter and webcast schedule are available through Boeing TotalAccess. ■

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"Life after retirement is in my hands. I'm making sure my retirement years are financially secure by taking advantage of the retirement planning resources Boeing offers."

– Bridgette Iden, executive office administrator, Satellite Development Center, El Segundo

PHOTO: DANA REIMER/BOEING

New fund lineup

Lifecycle Funds

- Lifecycle Retirement Fund
- Lifecycle 2020 Fund
- Lifecycle 2030 Fund
- Lifecycle 2040 Fund
- Lifecycle 2050 Fund

Index Funds

- Bond Market Index Fund
- Balanced Index Fund
- S&P 500 Index Fund
- International Index Fund
- Russell 2000 Index Fund

Actively Managed Funds

- VIP Stable Value Fund
- FSP Stable Value Fund
- Short-Term Investment Fund (DC RIP Salaried and Hourly only)
- Global Bond Fund (new)
- Diversified Real Asset Fund (new)
- U.S. Large Companies Fund
- Global Equity Fund (new)
- International Companies Fund
- U.S. Small/Mid Companies Fund
- Science and Technology Fund

The Boeing Company Stock

- Boeing Stock Fund (VIP only)

Financial planning *checklist*

Boeing provides many tools and resources to help employees reach their long-term financial goals. To make full use of the resources, refer to this checklist throughout the year:

- **Determine how much income you will need in retirement.** Eligible nonunion current and former employees in the Voluntary Investment Plan (VIP) and Financial Security Plan (FSP) can use the Personal Online Advisor on Boeing Savings Plans Online or call the Boeing Savings Service Center to speak to an ING Investment Advisor Representative through Boeing TotalAccess. With your password in hand, call 866-473-2016 and say "Savings."

- **Enroll in (or increase your contribution to) your Boeing savings plan.** As an employee, if you are not already participating in the Boeing savings plan or you need to increase your contribution rate, log on to Boeing Savings Plans Online through Boeing TotalAccess or call the Boeing Savings Service Center through TotalAccess at 866-473-2016.

- **Consider using the ING Advisor Service to create an investment strategy.** For current and nonunion employees in the VIP and FSP, the ING Advisor Service can help in creating a balanced portfolio that fits individual risk tolerance and financial goals.

- **Manage your Boeing savings plan investments.** Explore the new automatic rebalancing feature available through Boeing Savings Plans Online and, if you are eligible, consider using the ING Advisor Service for expert guidance.

- **Review your Pay & Benefits Profile.** Available to most active employees on the Boeing payroll, the personalized Pay & Benefits Profile is accessible online year-round via "My Pay & Incentives" on Boeing TotalAccess.

- **Watch for ING's midyear Personal Evaluation statement.** Later this summer, eligible nonunion employees in the VIP and FSP will receive an evaluation of their Boeing savings plans account. It provides a view of what your investments might offer in the future and recommendations for achieving your goals.

- **Attend a financial planning seminar.** Two seminars—Plan Well (for those further from retirement) and Retire Well (for those close to retirement)—are available live or on demand from the Boeing Education Network.

- **Increase your financial intelligence.** My Learning Center, provided by ING and available in the Resource Center on Boeing Savings Plans Online, offers articles as well as video and audio clips on investing, retirement planning, tax strategies, budgeting and estate planning, among other topics.

- **Take care of your health.** Taking care of yourself now can help you enjoy retirement later. Eat right, exercise regularly and get routine checkups and health assessments to catch health issues early, before they become bigger, more expensive problems.

– Jill Gulbrandsen and Carrie Howard

Boeing Company – **BA**

NYSE: Industrials/Aerospace & Defense

As of 3/19/10

$70.72

Stock snapshot

52-week range:	
52-week high	**$73.30**
52-week low	**$32.54**

International competitors

EADS* – **EAD.PA**

As of 3/19/10	**14.87**
52-week range:	
52-week high	**14.83**
52-week low	**8.12**

**Prices in euros*

U.S. stock indexes

S&P 500

As of 3/19/10	**1,159.90**
52-week range:	
52-week high	**1,169.84**
52-week low	**766.20**

S&P 500 Aerospace and Defense Index

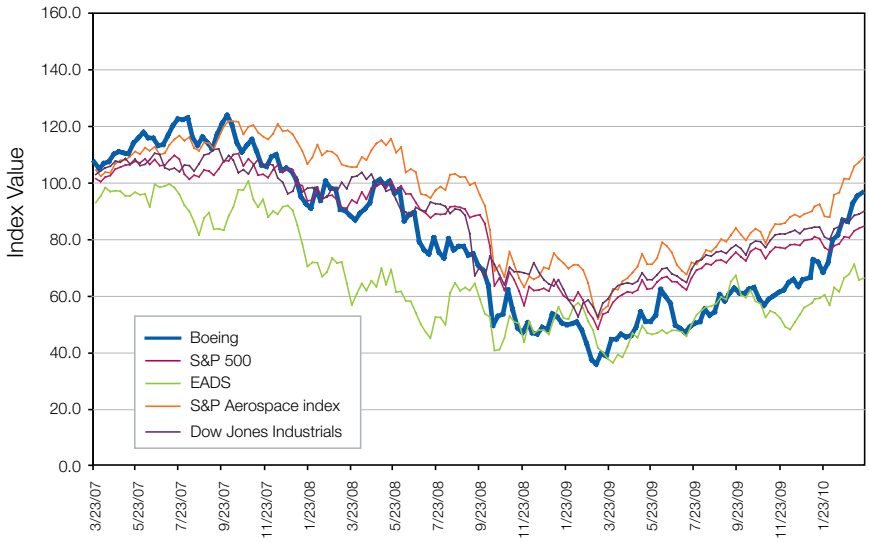
As of 3/19/10	**375.86**
52-week range:	
52-week high	**375.86**
52-week low	**226.75**

Dow Jones Industrials

As of 3/19/10	**10,741.98**
52-week range:	
52-week high	**10,869.50**
52-week low	**7215.77**

Stock price chart

The chart below shows the stock price of Boeing compared with other aerospace companies, the S&P 500 index, the S&P 500 Aerospace and Defense Index, and the Dow Jones Industrials. Prices/values are plotted as an index number. The base date for these prices/values is March 23, 2007, which generates three years of data. The prices/values on that date equal 100. In other words, an index of 120 represents a 20 percent improvement over the price/value on the base date. Each data point represents the end of a trading week.



Boeing stock, ShareValue Trust performance

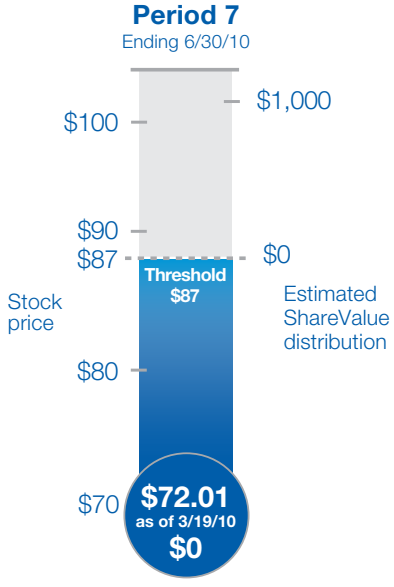
ShareValue Trust, or SVT, is an incentive plan that allows eligible participants to share in the success of their efforts to improve productivity and grow the business.

The program—which runs for 14 years and ends in 2010—features seven overlapping investment periods. The program is currently in Period 7.

This graph shows an estimate of what a "full 4-year participation" ShareValue Trust distribution (pretax) would be for Period 7 if the end-of-period average share prices were the same as the recent price shown.

The share price shown is the average of the day's high and low New York Stock Exchange prices. Updates to participant/employment data will be made periodically.

For more information on the ShareValue Trust, visit www.boeing.com/share.



FLYING DREAM

Since the 787 made its first flight on Dec. 15, three more Dreamliners have taken to the skies as part of a 787 flight-test program that will eventually involve six planes. In this image, the first 787 (ZA001) is shown flying above the clouds during one of its flight tests. The first four 787s are powered by Rolls-Royce Trent 1000 engines. The final two test planes will have General Electric engines.

"Our confidence in the reliability of this airplane grows day by day," said Scott Fancher, vice president and general manager of the 787 program. PHOTO: LEO DEJILLAS/BOEING


ONE PARTNERSHIP.
ENDLESS POSSIBILITIES.
India is a country rich in talent. And Boeing's commitment as a partner promises to explore this potential. By joining forces with institutions to create and enhance existing aerospace programs through scholarships and hands-on experience. And scaling newer heights with design competitions and interactive forums. Partnering to nurture a vast undiscovered resource pool, the possibilities of what it will achieve are, indeed, endless.
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THERE IS HOPE IN EVERY HAND.
Sometimes the greatest strength can come from the gentlest touch.
There's a power in the simple act of reaching out to help someone in need.
Boeing proudly supports all who give hope to those who need it most.
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