

Frontiers

Full tilt

Tiltrotor Osprey has become versatile workhorse for U.S. Marines





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PHOTO: ASSOCIATED PRESS



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PHOTO: SHUTTERSTOCK



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PHOTO: BOEING ARCHIVES

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Over the past decade, the V-22 Osprey, the do-everything, tiltrotor aircraft made by Bell Helicopter and Boeing, has firmly established itself with the U.S. Marine Corps. Its growing list of capabilities include handling troop and cargo transport, as well as military and civilian rescue and evacuation. Today, it has worldwide presence, including having served in Iraq and Afghanistan. For the Marines, the Osprey has become their go-to aircraft. “It does whatever the Marine Corps wants it to do,” said one crew chief at Marine Corps Air Station New River, North Carolina, where *Frontiers* recently visited.

26 The art of flight

To help commemorate the company’s first 100 years in business, three Boeing engineers volunteered for an unusual assignment: Come up with compelling paper airplane designs that are fun to assemble and fly and that promote problem-based learning for kids. The airplanes also can be used as poster art.

30 Expansion and opportunity

As defined by Boeing International, Southeast Asia includes 10 nations—and Boeing has customers in eight, with its regional business centered in small but economically important Singapore. This month’s Singapore Air Show, the largest air show in Asia, is an opportunity for Boeing to showcase its commercial and defense products and capabilities.

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Boeing and its heritage companies have provided presidential air transport since Franklin Roosevelt was in office. The U.S. Air Force has announced the 747-8 soon will take over this prestigious role.

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Cover: At sunrise, MV-22 Ospreys await another day of training exercises at Marine Corps Air Station New River in North Carolina. BOB FERGUSON | BOEING

Photo: Lance Cpl. Hannah Melconian, a VMM-266 crew chief, supplies aircraft and systems expertise to Osprey pilots during flight. BOB FERGUSON | BOEING

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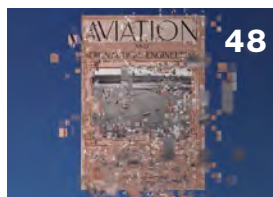
Part of a campaign featuring the CH-47 Chinook, the world standard in heavy-lift rotorcraft, this ad is running in domestic and global trade publications.



Part of the “A Better Way to Fly” campaign, this 787 Dreamliner ad is from a series showcasing the many ways Boeing airplanes and services enable opportunity and success for customers. The ads are running in trade publications and online.



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

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Mission-ready

Boeing employees to lead ‘a company like no other’ into its second century

As we approach our centennial this July, I’m reminded frequently that we have a company and history like no other, a company whose products and services positively impact hundreds of millions of people around the world each and every day.

Over the past century, generations of talented Boeing employees helped build the world’s largest aerospace company—and shaped the course of human history along the way. During that time, human beings went from walking on Earth to walking on the moon. They went from riding horses to flying jet airplanes and

spaceships. With each decade, aviation technology crossed another frontier, and with each crossing, the world changed.

Even after nearly 100 years in aerospace, it’s important we not lose sight of—or take for granted—the unique role our company plays in global advancement. Together, our mission is to connect, protect, explore and inspire. The work we do matters—to commercial airplane passengers, men and women in uniform, astronauts pushing the boundaries of space, and future generations of innovators, explorers and dreamers. Above all else, it

demands the utmost integrity and excellence in how we do it.

After a decade of restoration and renewal, Boeing is stronger, healthier and more competitive than ever. Our momentum continued in 2015, a year marked by many proud moments and continued strong performance by our global team.

But no matter how well we’re doing or how far we’ve come, our future in this more-for-less world is not guaranteed. Market realities are getting tougher, and traditional aerospace and emerging competitors want in on our business. And when it comes to talent, influence and



Dennis Muilenburg
President and CEO, Boeing

PHOTO: BOB FERGUSON | BOEING

capital, we compete with the world's best global companies; as good as we are, we're not yet world-class in all that we do.

As we look to 2016 and beyond, I believe the potential for incredible discovery and amazing achievement is as great for us as it was for Bill Boeing and the other aerospace pioneers. I also believe that the goals and standards we set for ourselves should be equally as bold, visionary and inspiring as those set by our leaders a century ago.

Our objective is to be the aerospace industry leader and what I call an "enduring global industrial champion." This means delivering superior customer value, leading with innovation and a fully engaged team, driving productivity improvements to win in the market and fuel our investments, operating with global scale and depth, and generating consistent top-quartile shareholder returns.

These are lofty, attainable goals. So how will we get there?

Earlier this year, we rolled out a two-part strategy to Boeing leaders that calls for an extension of what we're already doing well (build "strength on strength") and challenges all of us to aspire even higher ("sharpen and accelerate" our pace of progress).

The first part of the strategy—strength on strength—requires that we deliver on existing business and functional plans and customer commitments, and improve them where needed by leveraging our leadership foundation; reinforcing the fundamentals of functional excellence, disciplined execution and world-class innovation; and

doubling down on our open and inclusive "One Boeing" culture.

It also means continued focus on our strategic imperatives of delivering Commercial Airplanes growth and business continuity

on a significantly larger scale; speeding Defense, Space & Security repositioning and extending existing platforms; expanding our international advantage; leveraging and growing services; driving innovation through focused enterprise research and development; aggressively managing financial strength; and empowering and deploying a new generation of leaders.

The second part—sharpen and accelerate—demands that we stretch ourselves to grow faster, exceed our long-range business plans, and deliver world-class performance by sharpening our strategies to win and accelerating our pace of progress in three key areas: Best Team & Talent, Innovation & Growth and Performance & Productivity.

In each area, we have foundations to build on such as our leadership investments, backlog and product and services portfolio, and corporate initiatives, as well as elements where we must still achieve step-change improvement, including design and manufacturing; growth in our services business and internationally; safety, quality and productivity; and enterprise systems.

When we execute this second-century strategy as I know we can, we will position ourselves for continued market leadership; sustained top- and bottom-line growth; global differentiation;

"As good as we are, we're not yet world-class in all that we do."

and innovation, development and manufacturing excellence—all made possible by the best team and talent across industry. Together, we will achieve our mission.

Just eight months into my role as CEO, I continue to be humbled and energized by the opportunity to lead this great company and this exceptional team. We have a big year ahead of us in 2016 and a bold, challenging and inspiring vision for our future. We are stewards of Boeing's incredible legacy, and I can think of no better team to entrust with this great responsibility in our second century. ●

Another star in the sky

Employees ready the vertical stabilizer for Norwegian Air's first 787-9, which bears an image of Swedish actress Greta Garbo, in the Everett, Wash., factory before attaching it to the aircraft's fuselage. All of the airplanes in Norwegian's fleet have different "tail fin heroes." The Norway-based airline operates 787-8s, and its first 787-9 will be delivered this month. PHOTO: ATLE STRAUME | NORWEGIAN AIR



“A new plane is like a comet sighting—it’s very rare and very exciting.”

—Keith Leverkus, program chief for the 737 MAX, as the program prepared for the airplane’s first flight. Reuters, Dec. 8

“It’s like a top-fuel dragster.”

—Barrie Grubbs, a Boeing field service representative assigned to Marine Corps Air Station New River in North Carolina. He was describing the MV-22 tiltrotor Osprey, operated by Marines at the base, as it transitions in flight from helicopter to airplane mode. See story, Page 12.

“My license plate is AWE4787—or ‘AWE 4 787.’ I thought that was very cool. I have a picture of it on my cellphone.”

—Sterling Jex Jr., who twice worked for Boeing, once at the Renton, Wash., site and later at Everett. Read his story and those of others on Boeing’s centennial story sharing website at boeing.com/our-stories.

eta Garbo
Swedish Actress





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CORPS


A photograph of two Marine Captains in full combat gear, including helmets and tactical vests, standing on an airfield. They are engaged in a conversation. The background shows the tail section of a large aircraft, likely a V-22 Osprey. The word 'CORPS' is overlaid in large, semi-transparent letters at the top of the image.

Photo: Marine Capt. Jonathan Chrisant, left, and Capt. Eric DeBerry say they were drawn to the V-22 Osprey because of its cutting-edge ability to fly as both a helicopter and an airplane.

SUPPORT

Bell Boeing Osprey is go-to transport for U.S. Marines

BY DAN RALEY | PHOTOS BY BOB FERGUSON

At Marine Corps Air Station New River in North Carolina, MV-22 Ospreys sit silently in the morning darkness, lined up in precise military order, sharing a rare moment. Only at rest do they mirror each other's actions.

As an orange and yellow sunrise gradually lights up the sky, the tiltrotor aircraft become visible with their massive nacelles locked in an assortment of positions—from vertical to horizontal, some with blades folded. Ospreys soon lift off the ground using different methods, from straight-up hovering ascents to rolling runway takeoffs, with blades and nacelles set accordingly. Three of the aircraft come face to face at an airfield intersection and, one by one, climb into the sky at various angles.

Part airplane and part helicopter, this unusual-looking flying machine has become so adept at changing

identities midflight that there is an endless request for its services, according to Lt. Col. Kirk Nelson, VMM-266 Fighting Griffins commander at New River.

“It’s done everything,” Nelson said. “The Osprey has proved that it’s up to the mission requirements. It’s battle-tested. People see the benefits. They want it. It’s in high demand.”

Over the past decade, the Marines’ oblong, shale-colored aircraft has established itself by expeditionary assault from land or sea, recovery of aircraft and personnel, air evacuation, aerial refueling, and rapid insertion and extraction. For the Marines, the Osprey has more than replaced the 1960s-vintage Boeing CH-46 Sea Knight helicopter, also known as the Phrog.

The Osprey was borne from a military need to fly farther and faster while getting in and out of conflict zones, a requirement escalated by the 1980 Iran hostage crisis, Marine personnel say. Bell and Boeing engineers ultimately came up with a transitional aircraft that could take off and land like a conventional helicopter yet cruise as fast as a turboprop airplane.

“It’s a pretty smart bird,” said Lance Cpl. Hannah Melconian, a VMM-266 crew chief. “You have so many uses for it; it’s whatever the Marine Corps wants it to do. I like the ability to go somewhere, do it quickly and do it effectively.”

To become fully deployable, the Osprey had to pass muster time and time again, demonstrating great resilience in the face of a rigorous development process that lasted more than two decades. In the end, the aircraft withstood changing technology, changing world affairs, accidents, modifications and delays.

Named after a bird of prey that tolerates a wide variety of habitats and can take flight vertically, the Osprey can fly at speeds over 270 knots (310 mph, or 490 kilometers per hour)—or twice the speed of a conventional helicopter. It can reach altitudes up to 24,000 feet (7,320 meters), which requires those on board to use

supplemental oxygen. Unlike other rotorcraft, it can fly over the top of inclement weather at a high altitude.

The Osprey’s advanced technology includes a digital cockpit, mission management system, advanced communications and an overall greater situational awareness for pilots and crew.

“When I was going through flight school, it was kind of new,” said Capt. Jacob Dyer, a VMM-365 pilot. “There weren’t a lot of people who knew a lot about it. We thought it looked kind of cool. It was a new adventure.”

The Osprey operates like this: It has large, pod-like nacelles at the end of its short wings that contain engines that turn black three-bladed rotors, each of which are 20 feet (6 meters) long and 2 to 4 feet (0.6 to 1.2 meters) wide from one end to the other. The nacelles can transition from vertical to horizontal, changing its flight capability from that of a helicopter, with rotor blades overhead, to flight similar to a prop-powered airplane. Marine pilots estimate they fly 90 percent of the time in airplane mode.

The in-flight transition from helicopter to airplane and back creates a physical sensation that

CRUISING SPEED

Approximately 270 knots | 310 mph,
or 490 kilometers per hour

CEILING

24,000 feet | 7,320 meters

MAXIMUM VERTICAL TAKEOFF WEIGHT

52,600 pounds | 23,980 kilograms

MAXIMUM ROLLING TAKEOFF WEIGHT

60,500 pounds | 27,440 kilograms

BUILDER

Bell Boeing



Photo: A fleet member for two years, Lance Cpl. Hannah Melconian performs ground maintenance checks on a V-22 Osprey, which goes through extensive inspections before and after each flight.



Photo: V-22 Ospreys await their next mission at Marine Corps Air Station New River near Jacksonville, N.C.



Marine pilots and crew members liken to momentarily riding on a roller coaster or being in a wind tunnel. Barrie Grubbs, one of 35 Boeing field service representatives assigned to the Marine station at New River, compares the moment to sitting in a race car.

“It’s like a top-fuel dragster,” Grubbs said. “You slide backward when they punch it”—that is, go from helicopter to airplane mode—“and you lean forward when you come back out of the power, like when they pop the chute on the racetrack.”

A button the size of a large coin, called a thumbwheel, is located on each pilot’s thrust control lever in the cockpit. It is responsible for putting the Osprey transformation in motion. Rolling the thumbwheel backward lifts up the nacelles into helicopter mode; moving it forward rotates the nacelles forward and down into airplane mode. It takes 12 seconds to go from one position to the other.

“It’s just like learning to drive a stick and getting comfortable with it,” Dyer said, referring to an automobile’s manual transmission. “But if you injure your left thumb, you can’t fly this aircraft.”

New River is located on the North Carolina coast not far from Kitty Hawk—home of the world’s first powered-airplane flight—and directly across an inlet from Marine Corps Base Camp Lejeune. Visitors are greeted by a sign at the front entrance that proclaims, “Pardon Our Noise: It’s the Sound of Freedom.” The air station is considered the military helicopter and tiltrotor hub for the Eastern Seaboard, the Marines say.

Seven squadrons of Ospreys, or 80 aircraft overall, are stationed at New River, which they share with AH-1 Cobra and CH-53E Super Stallion helicopters, each type in operation since the Vietnam War. The different rotorcraft are deployed together on a small amphibious ship. Typical assignments are to a Marine Expeditionary Unit, or a Special Marine Air-Ground Task Force. Among



Photos: (Below) Pfc. Edly Delisaint wears a protective helmet and safety goggles when performing maintenance duties on the MV-22 Osprey at Marine Corps Air Station New River. (Right) Puddles reflect V-22 Ospreys awaiting flight.



those in this group, the versatile Osprey is the aircraft of choice, according to the Marines who fly and maintain it.

“You can work on a Model T or a Ferrari,” said Sgt. Daniel Wosek, a VMM-365 mechanic. “I prefer to go fast.”

The Osprey has conducted earthquake relief efforts in Nepal, typhoon relief efforts in the Philippines and Hurricane Sandy relief efforts along the eastern coastline of the United States. A U.S. Air Force CV-22 took significant enemy fire during a South Sudan evacuation, but refueled

and remained airborne until it could get its wounded to safety. The Osprey has rescued a downed Air Force pilot in a hostile part of Libya. With its speed and range the V-22 also is used in casualty evacuation or medical transport to get patients rapidly to medical treatment, in one case transporting a Marine with a ruptured appendix.

The aircraft is built jointly by Bell and Boeing. At the Boeing site in Ridley Township, Pa., employees design, engineer and manufacture

the fuselage, avionics, electrical wiring and hydraulic tubing; in Amarillo, Texas, Bell employees add the wings, empennage and rotors. At the Boeing site, a V-22 Readiness Operations Center tracks all Osprey flights worldwide and provides “big data” analytics to customers that helps streamline maintenance and identify potential parts or systems failures.

The Marines and Air Force Special Operations Command collectively operate 300 of 442 Ospreys that have been ordered, while the U.S. Navy

plans to buy 44 aircraft for its sea-based logistics and carrier on-board delivery operations. In July, Japan became Boeing's first international customer for the V-22, requesting the first five of 17 aircraft ordered, while other countries contemplate similar acquisitions.

The Osprey has become the most in-demand military asset, according to Kristin Robertson, Boeing vice president and Tiltrotor Programs and Bell Boeing program director.

"Other militaries around the world are watching what the U.S. is doing," Robertson said. "We can go where others can't. It's really changing

the way wars will be fought."

Rotor nacelles are usually set at 85 degrees from horizontal for takeoff, and 60 degrees to carry speed on the runway for a rolling takeoff, especially when responding to an emergency. At rest, with the nacelles full vertical, the blade tips hang 4 feet (1.2 meters) lower than the fuselage; the engines won't turn over until the nacelles are at 45 degrees or greater.

The Osprey seats 24, but typically travels with 18 people on board. Unlike many aircraft, the pilot occupies the right seat in the cockpit, with a co-pilot to his left, and a crew chief

stationed behind them, with yet another crew chief monitoring the back. Marines parachute off the open ramp at 4,500 feet (1,370 meters) or higher using a static line or freefall. For airdrops or ground unloading, cargo easily slides out the rear. Extra fuel tanks can be installed in the back of the aircraft as well.

The Osprey has refueling capability with an extendable probe that protrudes from the nose of the aircraft, enabling it to connect to a C-130 tanker. As it keeps evolving, the V-22 soon will have an added capability—it will be able to refuel jet fighters and helicopters in the air





Photo: The V-22 Osprey seats up to 24 troops and can carry equipment that won't fit in many military helicopters.



to extend their range and flying time.

“We can be a giver now,” Robertson said.

While the aircraft’s chief responsibility is troop and cargo transport, the Osprey can carry an M240 machine gun or a 50-cal. machine gun on the back ramp or a modified GAU 17 mini-gun in the belly.

Ospreys operate in such harsh environments, which include flying low through desert dust storms, that ground support and maintenance teams conduct rigorous inspections

leading up to and following each flight.

“This is a quality aircraft,” said Cpl. Colton Slaybaugh, a VMM-365 mechanic. “It has a lot of (or redundant) systems that back it up. If one goes out, it has two more to back it up. With other aircraft, when one goes down, you can’t fly.”

After returning from an overseas mission, the Ospreys are taken apart and given a complete overhaul. New River hangars were remodeled or upgraded for the aircraft, and available Ospreys are sometimes traded among

squadrons, with logos sandblasted off the tails and new ones attached, to fulfill immediate deployment needs.

Ground crews must be as resilient as the aircraft they service. There is much to learn.

“Coming into it, the V-22 was pretty complicated and it felt overwhelming, but with the training they gave me I feel confident to work on it,” said Cpl. Quinten Rigney, a VMM-365 avionics technician. “It was exciting to see it fly away after what I did.”

It is easy to forget that the Osprey,



Photo: An Osprey transitions from helicopter to airplane mode by simultaneously changing the position of nacelles located at the end of each wing from vertical to horizontal. A pilot changes the nacelle setting using a coin-sized button, called a thumbwheel, located on each pilot's thrust control lever in the cockpit.

even with nearly a decade of service, is still viewed as a relatively new aircraft by Marine pilots and mechanics at New River. It continues to delight, especially when tested in an unfamiliar environment, according to Marines there.

Melconian, VMM-266 crew chief, witnessed the Osprey's agility firsthand as it darted across a mountainous European landscape on a training run. She had a breathtaking view.

"We flew low-altitude tactics in high mountains," she said. "We do it all the time here, but in flat terrain. There, we

flew down crevices of mountains, over valleys, over peaks. That's when I truly saw what the Osprey could do. I was amazed at what our plane could do."

Negotiating jagged mountain ranges is one thing. Traversing the Atlantic Ocean in a rotorcraft is quite another. Perhaps a half-dozen times, Ospreys have completed transoceanic flights between the European mainland and New River—no easy feat.

In late July, four Ospreys, escorted by a pair of C-130 aircraft for refueling, left the European coast and made

several overnight stops before reaching North Carolina. The crossing took three days. Had the Ospreys returned home by ship, it would have required 11 days of travel.

"The crew took it as a sense of accomplishment—we did it," said Capt. Eric DeBerry, a VMM-266 pilot. "It hadn't been done that many times. It was a source of pride for us. It makes you feel that you're proof of concept." ●

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Photo: MV-22 Ospreys at sunrise on the flight line at U.S. Marine Corps Air Station New River in North Carolina. To download a poster of this image, visit boeing.com/frontiers/downloads.
BOB FERGUSON | BOEING





Photo: From left, Boeing Commercial Airplanes engineers Mahesh Chengalva, Elizabeth Benson and Alexandra Sonnabend launch paper airplanes they designed for the Boeing Flypaper project. ASSOCIATED PRESS



Know when to fold 'em

Boeing engineers design paper airplanes for centennial project

BY DAN RALEY

A living room was the factory floor. Sheets of paper made it an active assembly line. Clever folds produced an airplane ready for rollout. A test flight merely required the flick of a wrist.

All that's left for the Boeing Flypaper project—the quest to come up with a compelling paper airplane design that doubles as poster art—is the ongoing delivery.

To help commemorate the company's 100 years of airplane-making, Boeing asked engineers Elizabeth Benson, Mahesh Chengalva and Alexandra Sonnabend to create something aerodynamically progressive out of paper, combining their professional expertise with childhood memories. The engineers said they used a certain level of sophistication, yet had some fun.

"I liked the idea," Sonnabend said. "I grew up on the playground

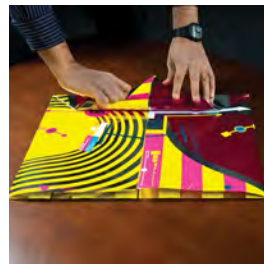
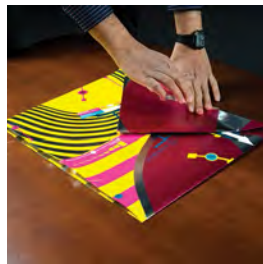
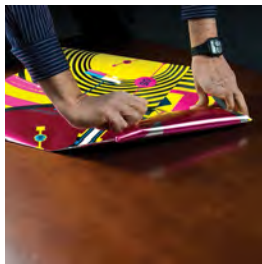
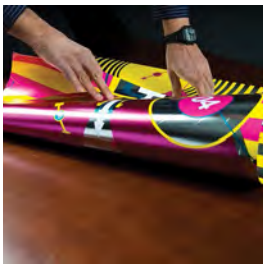
with friends, with stacks of paper airplanes, climbing up trees and throwing them."

A team of graphic artists gave the finished airplane designs the full treatment, adding bright colors and rigid patterns. If left unfolded, they become posters. Either way, the dual-purpose Flypaper is now available for purchase in the Boeing Store as a centennial keepsake, while being widely distributed from grade schools to engineering schools for career-minded inspiration.

The intent of Flypaper is to motivate the next generation to design and build actual airplanes, according to David Jenks, senior manager, Corporate Identity, Global Brand Management & Advertising.

"This is the perfect intersection between science and art," Jenks said. "It is something fun to which just about anyone can relate

Photo: Elizabeth Benson, a structural analyst for the 777X folding wingtip, said the ability to troubleshoot and make change is important whether building a commercial jet or a paper airplane. ASSOCIATED PRESS



and understand. It can also inspire them to think more seriously about a future career in science and technology.”

The opportunity to combine science with art led Boeing to Benson, Chengalva and Sonnabend, who submitted designs for the Flypaper project, which was created by the FCB advertising agency. Thirty engineers originally were approached. Final designs received a numbered folding system for easy use.

Chengalva, a Boeing structural methods lead engineer in Everett, Wash., folded paper airplanes as early as age 3 or 4 in India. He owns eight model airplanes, including a large 777X that he built with his kids. He organizes weekend hobby outings for groups of Boeing employees and their family members. He’s a true aviation enthusiast who took his Flypaper airplane assignment to heart. Chengalva said he went for a long structural design, similar to a real commercial airplane, to make it strong. He kept the center of gravity low for stability. He made sure to have plenty of wing area for lift.

“It might look simple, but there is a lot of engineering in this,” said Chengalva, holding up an orange, black and green paper airplane. “It flies like a real airplane. It’s the same air that a 747 encounters. It’s a creature of the air.”

Sonnabend spent much of her childhood traveling from her native New York state to Germany to visit family members. The long transoceanic flights, she said, inspired her to join the aerospace industry.

“I wanted to work in a concentrated field where I could influence inter-

national travel and help connect the world,” Sonnabend said.

She currently is acquiring hours to obtain her private pilot’s license, getting close to her first solo flight. Flypaper was just another way to further celebrate her love of aviation, she said.

Sonnabend felt a little challenged at first in settling on a paper airplane design. The mechanical engineer works in Renton, Wash., on 737 landing gear and hydraulics—airplane parts that aren’t necessarily transferrable to a paper airframe.

She went with something adventuresome for her paper airplane submission, which features canards, or small forewings, favored by some jet fighters and used on Boeing’s Sonic Cruiser, which was never built.

Otherwise, Sonnabend said she concentrated on center of gravity, wanting it established as far forward in her paper airplane as she could make it. A broad wing surface also was important to her, ensuring a smooth flight.

“Nobody inherently enjoys turbulence to start,” she said. “To mitigate that turbulent airflow is very important.”

Benson was 5 or 6 when a babysitter taught her how to fold paper airplanes and together they tossed them into a sunken living room in Portland, Ore. It was a fun-filled moment that instantly had her mulling a career in aerospace, she explained.

“It got me thinking analytically,” she said. “I developed an enjoyment of airplanes.”

Benson, who is a structural analyst engineer for the 777X folding wingtip in Everett, tracked down that same babysitter for consultation when

she took on the Flypaper project.

Borrowing from her Boeing expertise, Benson made sure her paper airplanes had folding wingtips, too.

Two things were important to her in crafting the paper airplanes: The center of gravity had to be just right, to ensure airworthiness, and the bigger the wings, the better the glide. Otherwise, she fell back on the problem-solving principles that guide her in her job, she said.

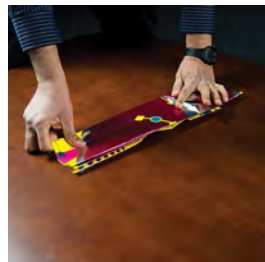
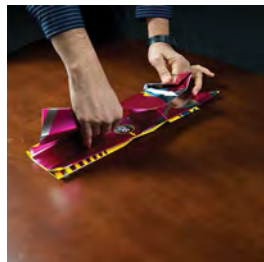
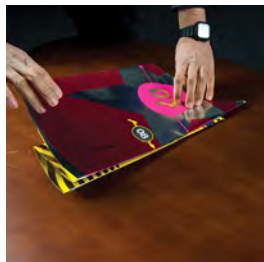
“This is where the engineering comes in,” Benson said. “It’s ‘OK, this doesn’t work; try this.’ The ability to troubleshoot is important. We build something, but the ability to make change is so important.

“Here it was, ‘How do you balance the weight on the paper or how can you fold that?’”

The three engineers recently met in Everett for the first time, comparing and simultaneously tossing their paper airplanes. A Boeing lobby was their runway, a circular couch their flight deck. Imagination was the flight plan. **100**

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The great

Southeast Asia represents a growing market for Boeing

BY ERIC FETTERS-WALP

Southeast Asia contains more than 600 million people, several of the world's largest cities and thousands of islands, making air travel ideal for connecting the region's countries with one another and the rest of the globe.

It's a region that attracts visitors from all over the world, a place with long, rich histories and diverse people and cultures.

"What I know about the region and really cherish about it is there is no homogeneous nature to the countries here—they're all different in history, culture, food and people," said Skip Boyce, president of Boeing Southeast Asia and a former U.S. ambassador who has spent more than 20 years in the region.

Located adjacent to China and India, two of the biggest developing economies on Earth, many of Southeast Asia's nations also have a growing middle class that can more easily afford to travel by airplane. Which is why Boeing's list of potential customers in the region is growing, said Dinesh Keskar, senior vice president of sales for Asia Pacific and India, Boeing Commercial Airplanes.

"Since 2009, capacity in the region has risen 80 percent, and passenger traffic has risen even more—so we predict the region will need almost 4,000 new aircraft over the next 20 years," said Keskar, who is based in Singapore. "Low-cost carriers are booming, and the region has lots

of aerospace suppliers, as well as a growing presence of Boeing services."

Southeast Asia, as defined by Boeing International, includes Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Vietnam. Boeing has customers in nearly all of those nations, with its regional business centered in the small but economically important city-state of Singapore. That nation's air show, billed as Asia's largest, takes place in February, and Singapore itself is home to a number of expanding Boeing facilities.

"Southeast Asia is one of our core growth regions. It's been a longtime customer on both the commercial and defense sides, and we see good economic growth ahead," said Marc Allen, president of Boeing International. "We already have a meaningful business presence and opportunities across the region, especially in services."

Boeing and SIA Engineering Company recently formed Boeing Asia Pacific Aviation Services, a joint venture to provide engineering, repair and maintenance services for Boeing airplanes. Plans call for that business to eventually employ more than 200 people. Additionally, Boeing subsidiaries Aviall and Jeppesen have recently expanded their regional headquarters in the nation.

"In an increasingly competitive market, our customers in this region are more open to adopting new

Southeast



Photo: A view of Singapore's Downtown Core, with the 28-foot-tall (8.6-meter) Merlion statue in the foreground. The statue represents Singapore's roots as a fishing village and its original name, which meant "lion city."
SHUTTERSTOCK



technologies that will bring greater operational efficiencies and cost savings to their business,” said Gardiner Porter, managing director for Jeppesen’s Asia-Pacific region. He said Jeppesen, which recently expanded in Singapore, plans to continue growing its regional presence by focusing on software development, crew management systems and customer support.

The Boeing Flight Services Singapore campus supports training on Next-Generation 737s, 777s and 787 Dreamliner training suites. As Boeing’s largest training campus outside the U.S., it fills a critical need for pilots and technicians in the region. Boeing also has field service technical support teams in seven of the region’s countries.

On the defense side, Singapore flies the Boeing CH-47 Chinook, the AH-64D Apache Longbow and F-15SG multi-role fighters and the ScanEagle unmanned aircraft system. Indonesia also has eight Apaches on order, and its government took delivery in 2014 of the country’s first-ever presidential plane, a

Boeing Business Jet 2, or BBJ 2.

In Malaysia, Boeing is upgrading avionics and weapons systems on the Royal Malaysian Air Force’s Hornets, and Insitu’s ScanEagle is used to support Malaysian military forces. Malaysia also has a long-running campaign to replace its jet fighters.

For Boeing’s commercial airplane business, Southeast Asia is host to many notable customers, from Philippine Airlines, Asia’s first and longest-running airline, to Singapore Airlines to Vietnam Airlines to Garuda Indonesia to Malaysia Airlines Berhad to Thai Airways International. And the region’s commercial aviation growth has continued, led in recent years by newer low-cost carriers, Keskar said. Those include Scoot, Singapore Airlines’ low-cost, long-haul subsidiary, which is an all-787 airline, and Thailand’s Nok Air, which flies a dozen leased Next-Generation 737s and has ordered eight more, as well as seven 737 MAX 8s. Indonesia’s low-cost Lion Air, that nation’s largest domestic airline, placed one of the largest commercial airplane orders in Boeing history in





Photos: (Top) Indonesia's Lion Air is one of the region's growing low-cost carriers. **JIM ANDERSON | BOEING**
 (Left) Boeing supports Giving it Back to Kids, a nonprofit based in Danang, Vietnam, that provides children living in poverty with access to education, medical care and dental treatments. **TIM REINHART | BOEING**

Flying with Boeing

Boeing commercial airline customers in Southeast Asia include:

Brunei

Royal Brunei Airlines

- Operates 787 Dreamliners
- Previously ordered 737s, 757s and 767s

Indonesia

Garuda Indonesia

- Operates 737s, 777s and 747s
- Orders include 50 737 MAX 8s

Lion Air

- Operates 737s and 747s. The airline also owns Malindo Air, Batik Air and Thai Lion Air; all operate Next-Generation 737s
- Orders include more than 200 737 MAXs

Sriwijaya Air

- Operates an all-Boeing fleet of 737s
- Took delivery of its first all-new airplanes in 2015

Malaysia

Malaysia Airlines Berhad

- Operates 737s and 777s
- Has ordered more than 150 Boeing aircraft throughout the airline's history

Myanmar

Myanmar National Airlines

- Operates Next-Generation 737-800s
- Took the nation's first newly delivered airplanes in 2015

Philippines

Philippine Airlines

- Operates 777-300ERs (Extended Range)
- Asia's first and longest-operating airline

Singapore

Singapore Airlines

- Operates 777s. The airline group also owns Scoot, an all-787 low-cost, long-haul airline; SilkAir, which is moving to an all-Boeing fleet, with 54 orders for 737s; and Singapore Airlines Cargo, which operates 747-400 Freighters
- Has orders for 787-10 Dreamliners

BOC Aviation

- A leasing company based in Singapore
- Has orders for more than 100 737s, including 50 MAX 8s

Thailand

Thai Airways International

- Operates 787-8s, 787-9s, 777s, 747-400s and 737s
- Partially owns Nok Air, which flies 20 Next-Generation 737s and has ordered five more 737s, as well as eight 737 MAX 8s

Vietnam

Vietnam Airlines

- Operates 777s and 787s
- Took delivery of its first 787-9 in 2015

VietJet Air

- Has announced intent to collaborate with Boeing on fleet expansion
- Became the first Vietnamese private airline to enter the international market in 2013



2012. That included orders for up to 230 737s, including 201 MAXs, and purchase rights for another 150.

“If you look in the region, you can see the seeds of Boeing’s future, with the 737 MAX, the 787 and the 777X all on order in that part of the world,” Keskar said. He added that the recent delivery of Myanmar National Airlines’ first leased Next-Generation 737-800 is a sign that economic growth is spreading to the region’s emerging countries as well.

It may take from five to 10 years, he said, but Myanmar could be an important market for Boeing. “Similarly, Cambodia and Laos will grow very fast, and in Vietnam, we’ve only scratched the surface,” Keskar said.

In addition to its customer base and expanding presence across Southeast Asia, Boeing has an extensive chain of suppliers across the region, especially for commercial airplane components.

In Malaysia, for example, 14 suppliers support all of Boeing’s commercial models, including Aerospace Composites Malaysia, or ACM, a

joint venture owned by Boeing and Hexcel that expanded by 40 percent in 2013 to increase production.

In the Philippines, a cluster of five suppliers also produces parts used on every Boeing commercial airplane model. That includes B/E Aerospace’s facility there, which makes the lavatory system for every 737.

Boeing also has assisted efforts to establish an aerospace industrial base in Vietnam, where Mitsubishi Heavy Industries, or MHI, operates a subsidiary factory that has delivered more than 1,000 shipsets of 737 wing flaps and has expanded to assemble 777 and 777X main entry doors. Nikkiso Japan also makes 777 main entry “blocker” doors, as well as 737 and 787 parts, near Hanoi.

Despite the region’s economic growth, not all of its residents are thriving, Boyce said, noting there still are areas of poverty in many Southeast Asian nations. Boeing, through its Global Corporate Citizenship programs, supports efforts that tackle that issue, including a job-training project in rural Bali that teaches residents how to

grow, harvest and market coffee beans. The company also supports an extensive project to help human trafficking victims successfully re-emerge into society, providing everything from emotional counseling to job placement. Other corporate citizenship efforts focus on protecting the region’s threatened wildlife, assisting homeless children and orphans, and improving access to education for children with disabilities.

“The diversity of what we do,” said Boyce, “is really fantastic.” ●

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Photos: (Far left) Pilots train at Boeing's Flight Services campus in Changi, Singapore. It is the company's largest pilot training center outside the United States. BOB FERGUSON | BOEING
(Below) Four F-15SGs en route to Mountain Home Air Force Base, in Idaho. KEVIN FLYNN | BOEING





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Photo: Scoot's first 787, *Dream Start*, arrives at the airline's home base in Singapore in early 2015. STEVE KOPECKI | BOEING

Dream start

World's first all-787 airline is 'Scoot'ing along

BY JOANNA PICKUP

Ten new Boeing airplanes, new routes and expanded on-board offerings have made this a busy year for Scoot, the Singapore-based low-cost, long-haul carrier.

The Singapore Airlines subsidiary took delivery of its first 787 Dreamliner, aptly named *Dream Start*, in early 2015 and has grown its fleet to 10 787s, a combination of both 787-8s and 787-9s. One of Scoot's 787-9s will be on static display on opening day of this month's Singapore Airshow, the largest aerospace and defense event in the dynamic Asia market.

Since it began operations in 2012, Scoot has flown more than 6 million passengers. It serves 18 destinations across eight countries, including Tokyo; Bangkok; Taipei and Guangzhou, China; and Melbourne, Australia. With 10 more 787s on order, Scoot plans to continue to open new markets and routes, beginning with Jeddah, Saudi Arabia, and India this year.

Campbell Wilson, Scoot's chief executive officer, said 2015 was an important year for the airline.

"It was a dream year for us because of our new 787s," he said. "And we are very proud to be the world's first all-787 airline."

Wilson said the "superior" operating economics of the 787 have allowed the airline to open new routes. "The Dreamliner's innovative features," he added, "have allowed Scoot to redefine and elevate the low-cost carrier experience for our guests, at value fares."

Passengers on board Scoot's 787s can experience the carrier's well-known "Scootitude"—its fun personality—and new on-board amenities such as ScootTV, Wi-Fi Internet connectivity, in-seat power and new seats.

"Demand for the kind of services and low-cost fares Scoot provides will continue to grow in the rapidly expanding aviation market in Southeast Asia," said

Dinesh Keskar, senior vice president of sales for Asia Pacific and India, Boeing Commercial Airplanes.

Southeast Asia is one of world's fastest-growing commercial airplane markets, according to the *Current Market Outlook*. Over the next 20 years, Boeing forecasts Southeast Asia will need 3,750 new airplanes valued at \$550 billion. Air travel in that region is also expected to grow 6.5 percent per year.

"Scoot is well-positioned to capture the growth of this market with its unique business model, distinct personality and fleet of all 787s," Keskar said. ●

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For more about Southeast Asia and the growing commercial jetliner market in that part of the world, see story, Page 30.

Photo: A Boeing-built 747, used as *Air Force One*, flies over Mount Rushmore in South Dakota. BOEING



Hail to the chief!

Carrying the U.S. president, Boeing airplanes have a rich legacy as *Air Force One*

BY MICHAEL LOMBARDI

The cable to Boeing CEO William Allen came from the chief pilot for President Dwight D. Eisenhower.

“The President is enjoying his 707 tour of Europe,” it read. “My heartiest congratulations on a wonderful airplane.”

That 1959 message from U.S. Air Force Col. William Draper was the icing on the cake for Allen and The Boeing Company, coming during a very successful first year of service for the company’s new 707, which also had been chosen for the prestigious role of serving the U.S. president.

Officially, airplanes selected for presidential service carry the call sign SAM, for Special Air Mission. But in 1953, during Eisenhower’s presidency, another call sign became famous as a result of a near collision over New York City. The president’s airplane and an Eastern Airlines flight were both flying under the same flight number, 8610. After that near disaster, any time the president was aboard an Air Force airplane it would fly with the call sign Air Force One.

Today, Boeing’s 747, in the regal presidential livery of blue and gold, is a very visible and proud symbol of the United States and continues the tradition of Boeing jets serving in the prestigious role of *Air Force One*.

That tradition will continue. In January 2015, the Air Force announced that the latest version of Boeing’s venerable jumbo jet, the 747-8 Intercontinental, eventually will replace the current presidential fleet.

Boeing and Douglas airplanes have a long association with America’s presidents. Franklin Roosevelt was the first president to fly while in office. In 1943, he flew aboard a Boeing 314 Clipper to the Casablanca conference and during the flight he celebrated

his 61st birthday in style—in the 314’s spacious dining area. Roosevelt was also the first to have a dedicated presidential airplane, a Douglas C-54 that was nicknamed *Sacred Cow*.

President Harry Truman used a Douglas VC-118 (DC-6) called *Independence*, after his hometown in Missouri.

Eisenhower brought the presidential fleet into the jet age with the Boeing 707-120.

In 1961, the first jet built for the purpose of carrying the president was ordered from Boeing. Based on the intercontinental 707-320B, the aircraft was designated VC-137C, given the serial number 62-6000 and call sign SAM 26000. Famed designer Ray Loewy designed the livery and interior, with contributions from President Kennedy and first lady Jacqueline. The Caslon font used for the legend “United States of America” was chosen by Kennedy for its similarity to the heading of the Declaration of Independence.

SAM 26000 carried President Kennedy to Berlin in June 1963, during the Cold War days with the Soviet Union, where he made a famous speech best remembered for his words, “Ich bin ein Berliner!” Tragically, that same year the plane returned the body of Kennedy to Washington, D.C., after he was assassinated in Dallas. SAM 26000 also took President Richard Nixon on his groundbreaking visit to the People’s Republic of China in February 1972. Today, the plane is preserved at the National Museum of the United States Air Force.

Ten years after 26000 was delivered, a second VC-137C was ordered. That airplane rolled out of the Renton, Wash., plant on July 10, 1972. It received the tail number 27000

and call sign SAM 27000.

SAM 27000’s first flight as *Air Force One* occurred on Feb. 9, 1973, when President Nixon traveled from Andrews Air Force Base in Maryland to San Clemente, Calif. The plane went on to serve Presidents Gerald Ford and Jimmy Carter, but it was President Ronald Reagan who used it the most.

It carried Reagan to Berlin in 1987, where, in a historic speech near the Brandenburg Gate, he urged Soviet leader Mikhail Gorbachev to “tear down” the Berlin Wall that separated East and West Germany.

Today, SAM 27000 is preserved at the Reagan Library’s Museum of Presidential Transportation in Simi Valley, Calif.

In 1990, Boeing delivered two VC-25As (747-200B), to take over duties as *Air Force One*. Once again, the design was influenced by a first lady, this time Nancy Reagan, who chose American Southwest motifs and colors for the interior.

SAM 28000 first flew as *Air Force One* on Sept. 6, 1990, when it transported President George Bush to Kansas, then Florida and back to Washington, D.C. A second VC-25A, tail number 29000, had the honor of carrying three presidents—Bill Clinton, Jimmy Carter and Bush—to Israel for the funeral of Prime Minister Yitzhak Rabin.

Both 747s later performed another service—flying the remains of Reagan and Ford to Washington, D.C., for their state funerals. ●

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To view a photo essay of Boeing’s 50-plus years of presidential service throughout the jet age, click here.

Winds of change

One of Boeing's first women test pilots had a diverse career that included sales and time on the factory floor

BY DAN RALEY

As Boeing approaches the start of its second century in July 2016, *Frontiers* visits with some of the men and women who have helped make Boeing a global leader in aerospace.

Marlene Nelson's passion is flying gliders. She soars through the sky and goes wherever the wind takes her.

Nelson treated her Boeing career in the same fashion. For 34 years, she never knew exactly where she was going to land, but she always welcomed the journey.

The South Dakota native, according to colleagues, put together a career as diverse as any in the company, one that moved in so many different directions—designing, building, selling, marketing, teaching, flying the finished product and improving the safety of Boeing airplanes.

Nelson was as comfortable working on the factory floor as she was sitting at the flight controls of a 737 or in a sales meeting opposite Fred Smith, FedEx founder, president and CEO.

"When I came to Boeing, I really wanted to get the big picture," said Nelson, the first woman mechanical engineering graduate from South Dakota School of the Mines and Technology. "There is so much value in really understanding how the rest of the company operates."

As Boeing prepares to celebrate its centennial, Nelson is among the many men and women who have made milestone contributions to the company. She is a pioneer employee many times over. She is included among the company's first female test pilots, salespeople, chief project engineers and factory managers.

It's a legacy that has left a sizable

impression on former colleagues such as Corky Townsend, director of Aviation Safety with Commercial Airplanes.

"She is the most unique person I've run into because she had so many jobs," Townsend said. "Some people have had a couple of them; no one has had so many."

Nelson received 10 employment offers following college graduation and she chose aviation and Boeing. A design engineer beginning in 1974, she helped create a bracket that held landing-gear hoses on the 747. She was involved in a trade study that considered the use of fly-by-wire spoilers for the 767.

She next spent a decade in flight training. She taught customer airline pilots the systems knowledge and procedures needed to fly Boeing jets and she wrote operation manuals. She also worked on a wind-shear initiative that made air travel safer through technology and procedures that alert pilots and help them avoid an extreme weather condition that can cause accidents.

In 1986, Nelson became one of Boeing's original women test pilots, logging 1,200 hours of 737 and 757 flight time over two years. It wasn't a random decision. She grew up around pilots—her father owned a Piper Cub airplane and her uncle was a crop-duster.

Nelson showed an interest in sales and was hired to help launch the 747-400 Freighter. She recalled returning home from one trip carrying a customer's certified check for \$1 million as part of a potential sale. She and her team made it a point to know the overnight shipping company strategists. They studied how that business was run. In the end, Nelson said, they helped foster a long-term

relationship with FedEx that remains solidly in place today.

"I don't think there was anything she didn't think she could do," Townsend said. "She didn't necessarily always have a desire to do something else. A lot of times she was asked to lead something new and bring something different to that role."

In the 1990s, after earning her sales credentials, Nelson was recruited to lead flight operations engineering and two years later was named director of marketing.

Nelson's services were in great demand around the company, according to Townsend. Nelson spent two years as 747 deputy chief project engineer at the Everett, Wash., factory before Ed Renouard, 747 and 767 program vice president and general manager, asked her to run the 747 assembly line. The work was extra challenging, Nelson said. Engineers moved into the factory for the first time. The production rate doubled.

At first, she admittedly felt out of her comfort zone. Three years later, Renouard asked her to become 747 chief project engineer, continuing the engineering migration to the factory. Nelson said she and the others met weekly to measure progress and to identify production obstacles.

"Out of all of my jobs, working in the factory, next to the production line, was the best," Nelson said. "The buck stops there. We had to figure it out together."

Nelson's final Boeing position was director of Aviation Safety. Her group conducted accident investigations and safety reviews of airline events to determine whether changes in airplane design or flight-crew procedures were necessary



Photos: (Left) Marlene Nelson was chief project engineer, factory manager, test pilot and director of safety, among many roles she held at Boeing. MARIAN LOCKHART | BOEING (Below) Nelson taught airline pilots the systems knowledge and procedures needed to fly Boeing jets. BOEING

to keep the fleet safe, she said.

Nelson retired in 2007 and spends much of her free time flying gliders. She recently traveled to New Zealand to experience the frequent lens-shaped, or lenticular, clouds there. She explained that she is drawn to the peacefulness and the quiet of soaring.

She's still moving from place to place, an approach that served her well while manning all of those different jobs at Boeing. She also created a lot of opportunities for others.

"If I could rewrite my career, it wouldn't be any different," Nelson said. "I like to think my time there changed Boeing a little, especially when I see more women in leadership roles now." **100**

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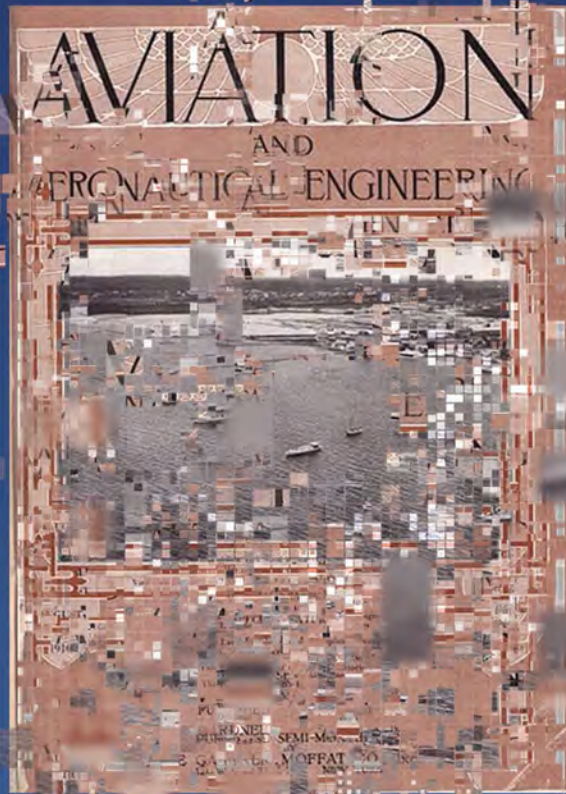
Field day

U.S. Air Force personnel with the 20th Special Operations Squadron and combat controllers with the 26th Special Tactics Squadron execute an aerial and ground demonstration for cadets at the U.S. Air Force Academy in Colorado Springs, Colo. The academy's distinctive cadet chapel served as a dramatic backdrop for the Veterans Day demonstration last year. Air Force Special Operations and the U.S. Marine Corps operate the Bell Boeing V-22 Osprey. For more about the tiltrotor Osprey, see story, Page 12. PHOTO: SENIOR AIRMAN SHELBY KAY-FANTOZZI | U.S. AIR FORCE





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