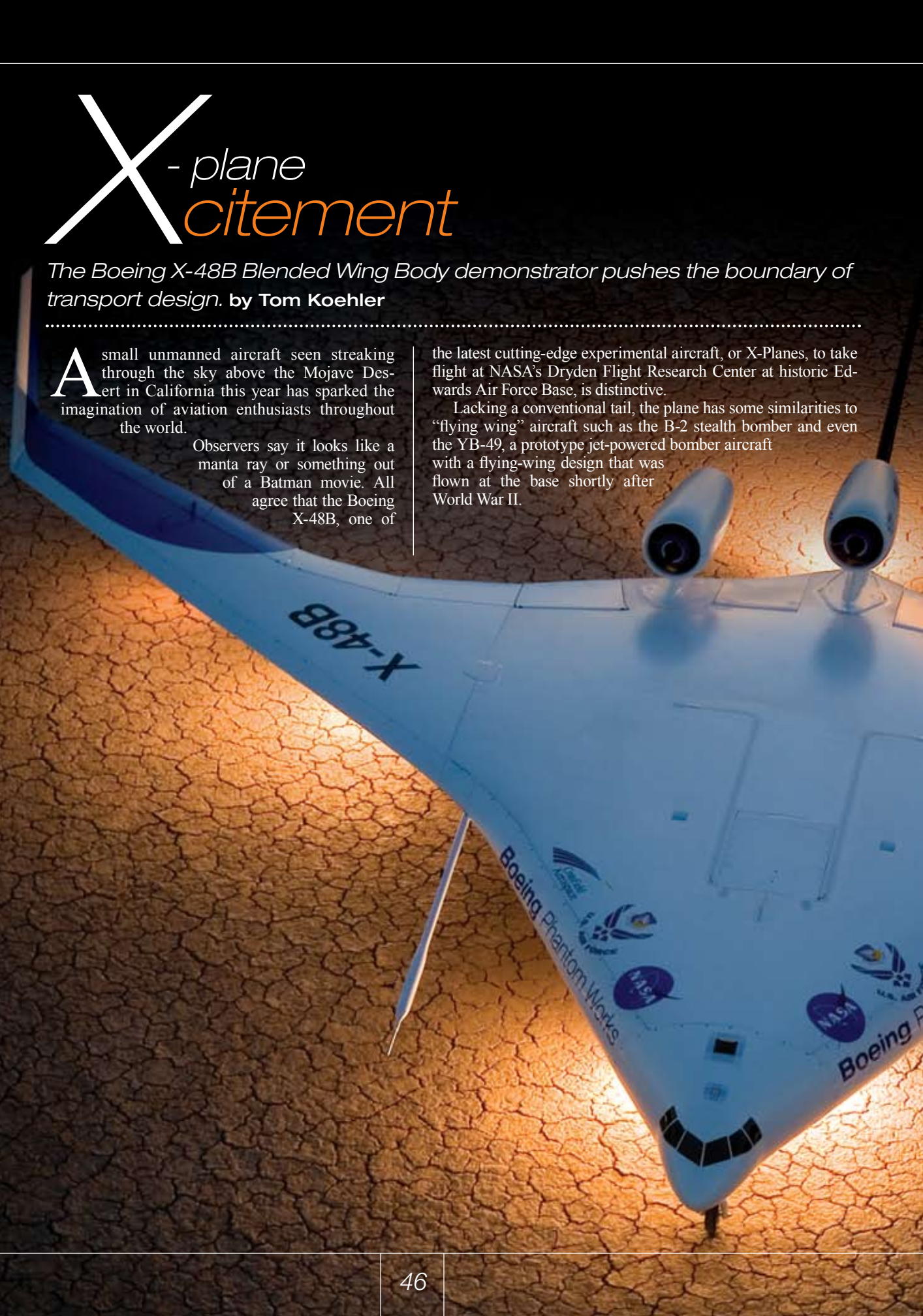
X-plane citement

The Boeing X-48B Blended Wing Body demonstrator pushes the boundary of transport design. **by Tom Koehler**

A small unmanned aircraft seen streaking through the sky above the Mojave Desert in California this year has sparked the imagination of aviation enthusiasts throughout the world.

Observers say it looks like a manta ray or something out of a Batman movie. All agree that the Boeing X-48B, one of the latest cutting-edge experimental aircraft, or X-Planes, to take flight at NASA's Dryden Flight Research Center at historic Edwards Air Force Base, is distinctive.

Lacking a conventional tail, the plane has some similarities to "flying wing" aircraft such as the B-2 stealth bomber and even the YB-49, a prototype jet-powered bomber aircraft with a flying-wing design that was flown at the base shortly after World War II.



Several notable aerospace achievements have taken place at the site including Chuck Yeager's famous flight breaking the sound barrier in the X-1, test flights of the X-15 rocket research airplane at altitudes of up to 50 miles and the first landings of the Space Shuttle. Today, much of the buzz centers on what Boeing and NASA researchers affectionately refer to as "Skyray 48."

Blended wing body concept

A team of 20 Phantom Works engineers and technicians, working closely with NASA and in cooperation with the U.S. Air Force Research Laboratory, is using the X-48B as a research platform to explore and validate the structural, aerodynamic and operational advantages of a concept called the "blended wing body," or BWB. With a 21-foot wingspan, the 500-pound remotely piloted plane is an 8.5 percent scale model of a heavy-lift, subsonic airplane with a 240-foot wingspan that possibly could be developed in the next 15 to 20 years for military applications.

"While Boeing constantly explores and applies innovative technologies to enhance its current and next-generation products, the X-48B is a good example of how we also look much farther into the future at revolutionary concepts that promise even greater breakthroughs in flight," says Bob Krieger, who recently announced his retirement as Boeing chief technology officer and president of Phantom Works at the end of 2007.

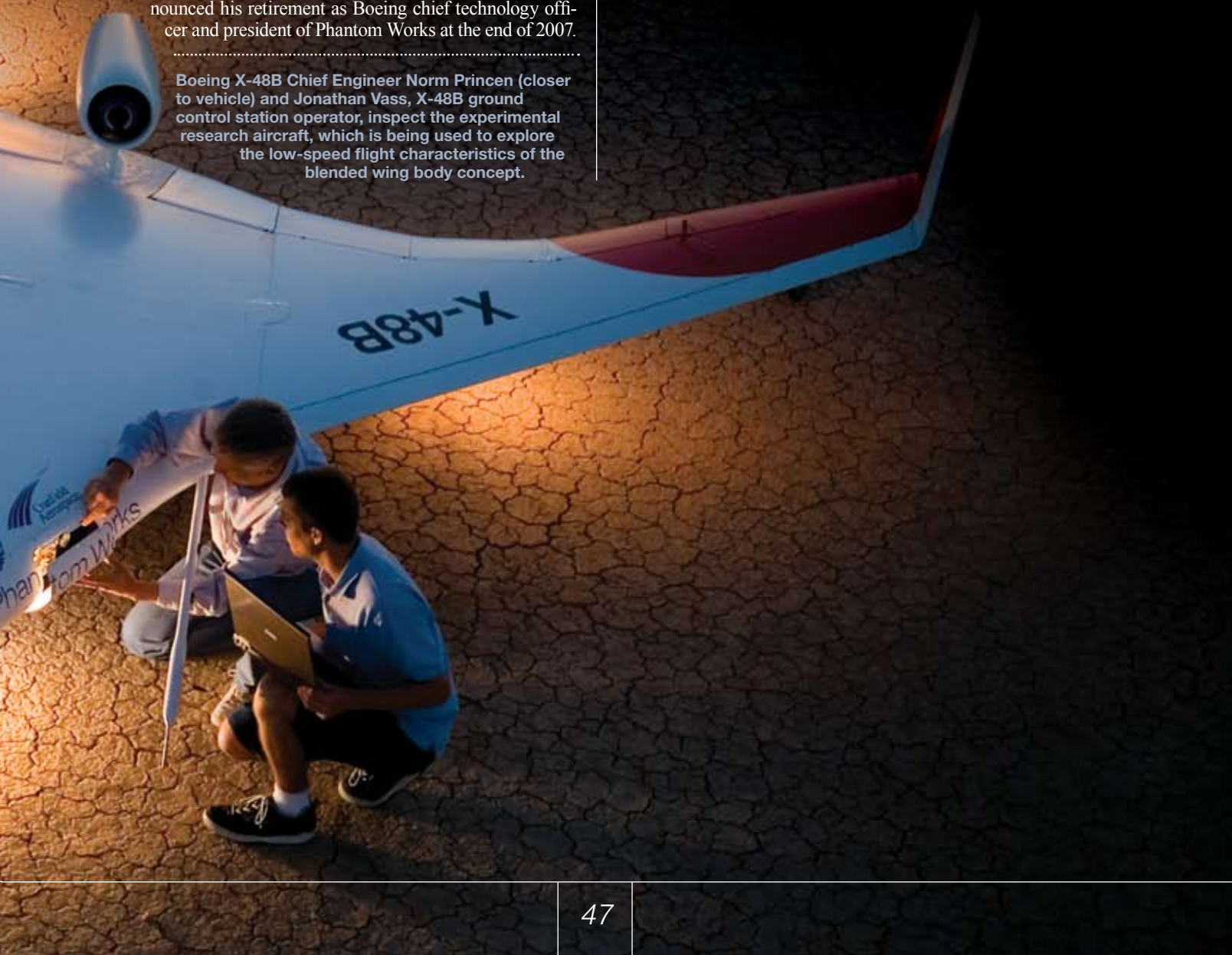
The Boeing advanced R&D team believes the BWB concept will offer the potential someday of much more fuel-efficient and quieter airplanes.

"We were challenged by NASA early in the 1990s to see if we could find a better configuration for a subsonic transport than the conventional tube-and-wing," says Bob Liebeck, a Boeing Senior Technical Fellow and Phantom Works' BWB research program manager. "Our team came up with this BWB concept, and our studies early on showed the potential for a remarkable reduction in fuel use of about 20 to 30 percent compared with a conventional transport on the same mission.

"Initially, the potential for reduced fuel use was attractive enough in itself. But we subsequently learned that because the engines in the design mount high on the back of the aircraft, the BWB also offers the potential for a 50-decibel reduction in cumulative noise around airports during takeoff and landing," Liebeck says.

Unlike the traditional airplane design in which a tube-like fuselage is fitted with wings, the BWB merges the fuselage with the wing. The result is a cross between a conventional aircraft and a flying wing such as the B-2.

continued on page 48



Boeing X-48B Chief Engineer Norm Princen (closer to vehicle) and Jonathan Vass, X-48B ground control station operator, inspect the experimental research aircraft, which is being used to explore the low-speed flight characteristics of the blended wing body concept.

Members of the Boeing X-48B research team include (kneeling, from left) Terry Von Klein, flight controls lead; Norm Princen, X-48B chief engineer; Norm Howell, project pilot; Tom Gurbach, director of Integrated Defense Systems Advanced Global Mobility Systems; and (standing, from left) Dave Hyde, simulation lead; Mike Kisska, project manager; Bob Liebeck, BWB program manager; Derrell Brown, BWB chief engineer; and Bill Vargo, BWB business operations.

Skyray 48's
successful first flight

Calm excitement filled the ground control station. Engineers peered intently at their computer screens as the pilot, sitting next to them, flexed his fingers over the controls. Outside, the ground crew tending the aircraft put away their equipment and stepped away from the aircraft. Preparations for the first flight of the unmanned X-48B blended wing body research aircraft were complete.

Years of research, design, construction, and wind-tunnel and ground tests coalesced into this one moment.

Radios crackled. "Tower, Skyray 48 in position, lake bed runway 23. Request clearance for takeoff …"

"Skyray 48 roger. Main base winds 220 at 6. Report airborne, lakebed 23 …"

"Wilco."

"Five, four, three, two, one, brakes …"

Quickly, the manta ray-shaped aircraft rolled down the dry lake bed runway. It trailed a plume of dust as it picked up speed, its three small jet engines whining. With an excitement that comes only from an aircraft's first flight, everyone watched as the triangular red, white and

continued from page 47

The blending of the wing into a wide, flat, tailless fuselage helps to get additional lift with less drag than an airplane with a circular fuselage generates.

Fay Collier, head of the Subsonic Fixed Wing Project with NASA's Fundamental Aeronautics Program, confirms that NASA has been interested in the BWB concept for some time. "The design offers a number of potential benefits – increased volume for carrying capacity, efficient aerodynamics for reduced fuel burn and, possibly, significant reductions in noise due to propulsion integration options," Collier says.

Flight-control research

Aviation pioneer Jack Northrop began experimenting with flying wings as long ago as the 1920s, and the U.S. military showed strong interest in the concept toward the end of and just after World War II. Several experimental prototypes were built. However, because the design lacks a tail for stability, it was prone to control problems. Flying it was a difficult challenge for even the most experienced pilot.

A YB-49 flying-wing prototype crashed at what was then called Muroc Air Force Base in 1948, killing the crew, including U.S. Air Force test pilot Glen Edwards. A year later, the high-desert base by the side of a large dry lake was renamed after Edwards.

What's different today, according to the Boeing and NASA research team, is technology. Advanced flight-control computing systems including high-bandwidth control actuators can aid the pilot in managing the many required control surfaces on the trailing edge of the wing that are needed to compensate for the missing conventional tail rudder. The X-48B has 20 control surfaces on the trailing edge, including ailerons and elevons, as well as rudders on the winglets. The outer pair of control surfaces open like clam shells to act as speed brakes.

Over the past 10 years, Boeing and NASA have compiled a great deal of aerodynamic information on the BWB design from computer modeling simulations, as well as from wind-tunnel testing. This data has been used to develop sophisticated flight-control software. A major goal of the X-48B flight research program has been to test and validate the data and the flight-control system, and gather more-detailed information, especially on the stability characteristics of the BWB design during takeoff, landing and other low-speed flight.

Bob Liebeck, Boeing BWB program manager: "The BWB concept offers potential for more fuel-efficient and quieter airplanes."

"We want to fully understand the aerodynamics of the BWB design, all the way up to and beyond stall, so that we can learn how to fly a BWB as safely as any other large transport aircraft with a conventional tail," says Boeing X-48B Chief Engineer Norm Princen.

Built in accordance with Boeing requirements by Cranfield Aerospace, Ltd., in the United Kingdom, the X-48B has been intricately constructed with advanced composite materials to ensure that it has the proportionate mass distribution of a full-sized airplane. Engineers describe this as "dynamic scaling" – and it is an important requirement for obtaining realistic flight-test data.

Cranfield Aerospace also built the ground-control station in which Boeing experimental test pilot Norm Howell, who usually flies C-17s, uses conventional aircraft controls and instrumentation while looking at a monitor fed by a forward-looking camera on the aircraft.

blue X-48B leapt into the air. "Skyray 48's airborne," Boeing pilot Norm Howell called, matter-of-factly.

And with that, at 8:42 a.m. on July 20, 2007, a significant milestone in the history of blended wing body research was passed at NASA's Dryden Flight Research Center at Edwards Air Force Base, Calif. Against the backdrop of a pristine blue sky, the X-48B climbed to an altitude of 7,500 feet, circled back and landed 31 minutes later.

Afterward, several members of the Boeing team reflected on the accomplishment.

Bob Liebeck, Phantom Works BWB research program manager, who began developing the BWB concept in 1990, was near the takeoff location for the first flight.

"As the engines were started, I briefly reflected on how special this experience was – to stand on Muroc Dry Lake with all its aviation history, and watch an airplane I helped to create make its first flight," Liebeck says. "And the takeoff was more moving than I imagined – the thing flies! We had done it."

In his 46 years at Boeing, Liebeck, a Senior Technical Fellow and a recipient of many aerospace awards, has served as program manager on several advanced-concept airplane programs, some of which culminated in successful flight vehicles. But, he says, the feeling at the time of X-48B's first flight was "irreplaceable."

Howell, a Boeing C-17 test pilot who has flown F-4Gs in Iraq, says the airplane handled as predicted by flight simulations. "I am very pleased with how the vehicle is handling," he says. "It does handle like a conventional large transport airplane, such as a C-17. My hat is off to the engineering team."

"First flight is a monumental achievement for any program, manned or unmanned," says Boeing X-48B Project Manager Mike Kisska. "I thought about how this program is staffed with an exceptional group of professionals and how privileged I've been to work with each of them. All that work, all those late nights, all the things that make coming to work difficult at times and challenging – it all pays off in that one moment when you see air underneath the wheels of that aircraft."

For Boeing X-48B Chief Engineer Norm Princen, the real impact of first flight did not sink in until several days later. "That's when I realized what we had really accomplished," he says. "I was on cloud nine for the entire week. We still have a lot of work to do to prove that the blended wing body concept is as safe and reliable as current transport aircraft. But this was a huge step towards that goal."

Three model gas-turbine engines, each with 50 pounds of thrust, power the flight test vehicle, which was designed to fly at altitudes up to 10,000 feet and speeds up to 120 knots. A second vehicle, which was used during wind-tunnel testing in 2006 at the Old Dominion University NASA Langley Full-Scale Tunnel in Virginia, is available as a backup.

In addition to hosting the X-48B flight-test research activities, NASA Dryden is providing engineering and technical support – expertise garnered from years of operating cutting-edge air vehicles, including many X-Planes. NASA also provides critical telemetry and command-and-control communications during flights, as well as T-34 chase aircraft support.

Norm Howell, X-48B project pilot: "My hat is off to the engineering team."

Six flight tests were conducted during July and August. As many as 25 more flights are planned this year and early next year to gather additional data in the low-speed flight regimes. Later, the X-48B may be used to test the BWB's low-noise characteristics and possibly its handling characteristics at much higher speeds.

Potential BWB applications

"We believe the BWB concept does hold tremendous promise for the future of military aviation as a multipurpose military platform in 15 to 20 years," says Darryl Davis, president of Integrated Defense Systems Advanced Systems.

"It has the potential to do many jobs for the Air Force including aerial refueling and the transporting of cargo, as well as serving as a regional or strategic bomber, or a persistent intelligence, surveillance and reconnaissance platform," Davis says. "By using a common platform for these missions, the Air Force could reduce its logistics footprint and associated costs. And the BWB's aerodynamic efficiencies would reduce fuel consumption, operating costs and dependency on foreign energy sources."

Tasked with transitioning new programs into the IDS business areas, IDS Advanced Systems is closely monitoring Phantom Works' BWB research, Davis says. As the research progresses, IDS will work with potential military customers to move the BWB concept forward.

Boeing Commercial Airplanes product development engineers also have looked at the BWB concept as one of many proposed unconventional configurations for future commercial airplanes. Although these engineers are monitoring the progress of Phantom Works' BWB research and are keeping their minds open to new technology and market developments, they do not envision commercial BWB applications for at least 20 years.

Next steps

Boeing and NASA researchers have been pleased with the results of the X-48B flight testing. They say that the flight data closely correlates with data previously gathered during wind-tunnel testing. But they view current testing as just the beginning of what they hope will be a larger effort someday to build a full-sized, manned BWB vehicle.

"We would like to see a manned aircraft eventually come out of this program, and we want to make sure that it is safe for flight," says Mike Kisska, Boeing X-48B project manager. ■