Eye in the sky

An unmanned Boeing aircraft called Phantom Eye is designed to stay aloft for up to four days—keeping an eye out for what's below

by Chris Haddox

Persistence, persistence, persistence. That's the answer that Phantom Works President Darryl Davis gives when asked why Boeing is building Phantom Eye.

A hydrogen-powered, High Altitude Long Endurance, or HALE, demonstrator, Phantom Eye is being designed and built at Boeing facilities in St. Louis and Seattle as well as Irvine and Huntington Beach in California. Its mission is to stay aloft for up to four days at altitudes as high as 65,000 feet (20,000 meters) while keeping a persistent eye on what's below for intelligence, surveillance and reconnaissance (ISR) missions.

"There is a great demand for persistence and at the same time have enough payload capability for specific missions," Davis said. "Several teams in the Pentagon and in the intelligence community are very interested in what we're doing here."

What Phantom Works is doing isn't new to Boeing, but the way it's doing it is. Boeing has taken an unmanned aircraft to 65,000 feet before. In 1988, the Condor reached 67,028 feet (20,430 meters) and stayed at that altitude for two and a half days, a record. The big difference between Condor and Phantom Eye is the propulsion system. Condor used two 175-horsepower liquid-cooled, fuel-injected, 6-cylinder piston gas engines. Phantom Eye will use two Ford 150-horsepower 2.3-liter (140-cubic-inch) 4-cylinder engines, fueled by hydrogen. And Phantom Eye is much lighter. Takeoff weight is about 9,800 pounds (4,450 kilograms), about half that of Condor.

No one knows those engines better than Bill Bigbee-Hansen. He's an Associate Technical Fellow with Boeing Research & Technology in Seattle. Bigbee-Hansen was part of Condor's propulsion team and now leads Phantom Eye's propulsion team. Lessons learned from Condor are definitely being applied to Phantom Eye, he said. "Early decisions were made to reduce downstream costs and testing," he said. "Experience gained on Condor was leveraged as much as

PHOTO ILLUSTRATION: The Phantom Eye demonstrator is scheduled to make its first flight in early 2011. It will fly at altitudes up to 65,000 feet (19,800 meters) for up to four days.

BRANDON LUONG/BOEING; PHANTOM EYE GRAPHIC: MICK MONAHAN/BOEING; SKY PHOTO: SHUTTERSTOCK.COM

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– Bill Bigbee-Hansen, Associate Technical Fellow, Boeing Research & Technology

possible on Phantom Eye.”

Phantom Eye is a large aircraft with a 150-foot (45-meter) wingspan.

“At 65,000 feet a mechanic won’t be able to come to the rescue, so first-time quality has to be built into everything we do,” Bigbee-Hansen said. “We’re building a plane to fly maintenance-free for 100 hours, so every connection, every sensor and every seal needs to work and hold.”

While the propulsion system is key to Phantom Eye’s success, the airframe is deceptively simple. Several composite materials technologies for the prototype are being used, allowing for low-cost manufacturing without compromising performance.

“We have tested the engine in an altitude chamber at 65,000 feet for a total of more than 600 hours. Now we need to bring the engine and airframe together,” Davis said.

That job belongs to Teri Finchamp. As Phantom Works’ production operations manager, she’s responsible for the manufacturing and integration of Phantom Eye and Phantom Ray, Boeing’s fighter-sized unmanned aircraft set to make its first flight in late 2010.

“It’s going great. We’re right where we need to be on both programs,” she said.

First flight is scheduled for 2011.

“The wait can be difficult,” said Phantom Eye program manager Drew Mallow. “Just imagine being able to provide global reach for an ISR mission that’s measured by days instead of hours, all from one aircraft. Now that’s persistence.” ■

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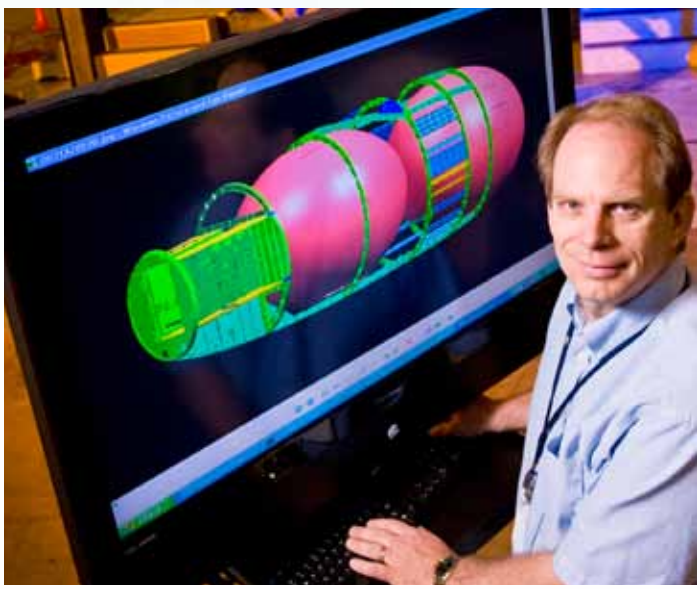
PHOTOS: (Above) Liquid nitrogen is used to verify the integrity of welds in Phantom Eye’s liquid-hydrogen tanks when rapidly chilled to cryogenic temperatures. BALL AEROSPACE

(Right) Bill Norby, Hydrogen Systems Integrated Product Team manager for Phantom Eye, works with a computer model showing the liquid-hydrogen tanks in Phantom Eye’s fuselage. RON BOOKOUT/BOEING

(Far right) The Phantom Eye High Altitude Long Endurance aircraft shares many similarities with Boeing’s Condor (shown here), which reached altitudes of more than 67,000 feet (20,400 meters) in the late 1980s. Phantom Eye is scheduled to make its first flight in early 2011. BOEING ARCHIVES

It's not rocket science—or is it?



Bill Norby has a difficult time talking to his friends and neighbors about his work on Boeing's Phantom Eye demonstrator. Not because it's classified, but because it's complicated.

"I get a lot of blank looks," said Norby, manager of the Hydrogen Systems Integrated Product Team.

He tries to keep it simple:

"*We store hydrogen as a liquid but the engine burns it as a gas. To do so, the hydrogen has to be boiled off and we raise the temperature of the gas by taking it through a heat exchanger and then feed it into the engine at near room temperature. What makes it simple is that we don't require a compressor or a fuel pump. We use the tanks, a set of cryogenic valves, a couple of heat exchangers, and relief valves. Future systems may be more complicated, but this one is pretty simple and well-suited for an aircraft flying at 65,000 feet for four days ...*"

But what's simple to Norby sounds like rocket science to others. In a way, it is. The design features elements used in rockets and space launch vehicles; Phantom Eye is Boeing's first fixed-wing vehicle to use a liquid-hydrogen fuel system.

"It's a different kind of beast, to be sure," Norby said. "We like to say it's 'Condor on hydrogen.'"

Condor is the High Altitude Long Endurance, or HALE, aircraft Boeing flew in the late 1980s. It reached altitudes of 67,000 feet (20,400 meters), but its engines burned hydrocarbon-based fuel, not hydrogen. Phantom Eye's design is similar to Condor's except for the girth of the fuselage, which is needed to house two 8-foot- (2.4-meter-) diameter hydrogen tanks.

"Most aircraft carry fuel in the wings; not Phantom Eye," Norby explained. "All the hydrogen is stored in the tanks and that benefits the rest of the plane. By taking the weight out of the wings, it simplified the wing design and created more payload room."

Work on the hydrogen fuel system began in 2004, and Norby said recent testing on the tanks has gone well. They should be delivered to St. Louis and installed in the fuselage this summer, bringing Phantom Eye one step closer to first flight in 2011.

– Chris Haddox