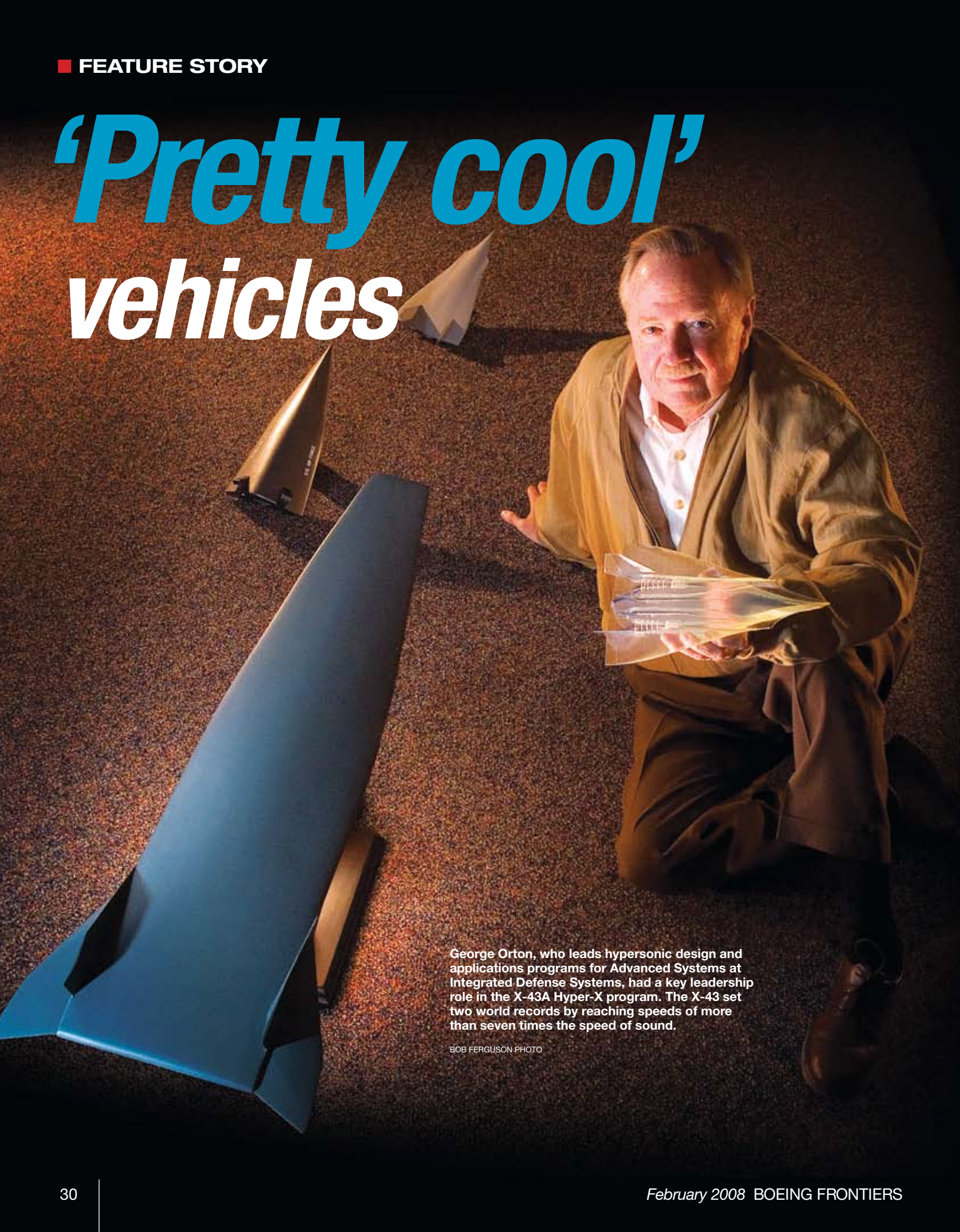
‘Pretty cool’ vehicles



George Orton, who leads hypersonic design and applications programs for Advanced Systems at Integrated Defense Systems, had a key leadership role in the X-43A Hyper-X program. The X-43 set two world records by reaching speeds of more than seven times the speed of sound.

BOB FERGUSON PHOTO

Despite questions over funding and uses, Boeing's work in hypersonics continues

By Daryl Stephenson

Hypersonic flight is fast flight—at least five times the speed of sound and beyond, or Mach 5+. Vehicles that operate in space—the Space Shuttle, launch rockets and boosters—do this routinely. Their power is derived from traditional rocket engines, which burn lots of fuel and liquid oxygen, then flame out when the propellants are exhausted.

For nearly 50 years, engineers have imagined that airplanes, space planes and missiles, powered by airbreathing scramjet engines, could fly at hypersonic speeds, too. These hypersonic vehicles would operate primarily in near space—the upper atmosphere at altitudes of up to 150,000 feet (about 45,500 meters). The vehicles would be economical, because the scramjet engines would have few moving parts and would use less fuel than rocket engines.

The theory was validated in 2004, when the NASA-Boeing X-43A Hyper X vehicle, powered by a scramjet engine, set two world speed records for air-breathing vehicles with flights at Mach 6.83 and Mach 9.68. Boeing was a major contributor to the X-43A program, as it has been for virtually every other hypersonics technology and systems development program since the X-30 National Aerospace Plane that lasted from 1986 to 1995.

"If you take the hypersonic problem and pick it apart into its constituent pieces, we still don't know the basic fundamentals of hypersonic flight—flow, fluid mechanics, etc."

—Kevin Bowcutt, Boeing's chief scientist for hypersonics

Although the X-43 program was closed in 2006—and although observers say the development of hypersonics technology currently stands at a crossroads amid uncertainty over funding and potential applications—Boeing's involvement in hypersonics has continued.

Two efforts are based on missile research and development programs in the Advanced Systems organization of Integrated Defense Systems. One is the X-51 WaveRider Scramjet Engine Demonstrator for the U.S. Air Force. The intent of this aircraft: to demonstrate a hypersonics propulsion system in flight that could be applied to space access, reconnaissance-strike and global reach. The other program is the Hypersonic Flight or HyFly missile demonstrator for the Defense Advanced Research Projects Agency and the Office of Naval Research (ONR), which is maturing a dual combustion ramjet (DCR) strike missile concept.

Recently added to the Boeing hypersonics portfolio is a collaborative venture with Australia called HIFiRE—or Hypersonic International Flight Research Experimentation. Boeing Phantom Works and IDS Advanced Systems are jointly funding the company's involvement in HIFiRE. In this effort, Boeing is working with Australia's Defence Science Technology Organization and the University of Queensland on critical flight tests and is contributing to the design of a free-flying, WaveRider-type hypersonic vehicle.

Plans for the HIFiRE program call for 10 total flight tests over five years in Australia. The first flight test is planned to take place this spring.

"Most work to date on hypersonic vehicle designs has been focused on two-dimensional scramjet engine concepts, whereas the HIFiRE flight tests planned by Boeing and its Australian partners will focus on advanced three-dimensional scramjet concepts and other performance-enhancing technologies," said Kevin Bowcutt, Phantom Works Senior Technical Fellow and Boeing's chief scientist for hypersonics. He's also the company's technical lead on HIFiRE.

"The whole focus of HIFiRE is to do fundamental hypersonic physics flight experiments—hypersonic aerodynamics, hypersonic propulsion, hypersonic heating and materials," Bowcutt said. "If you take the hypersonic problem and pick it apart into its constituent pieces, we still don't know the basic fundamentals of hypersonic flight—flow, fluid mechanics, etc."

Indeed, Bowcutt has been trying to understand the fundamentals of hypersonic flight since 1984, when he wrote a doctoral thesis on optimum aerodynamic shapes as part of a fellowship in hypersonics at the University of Maryland.

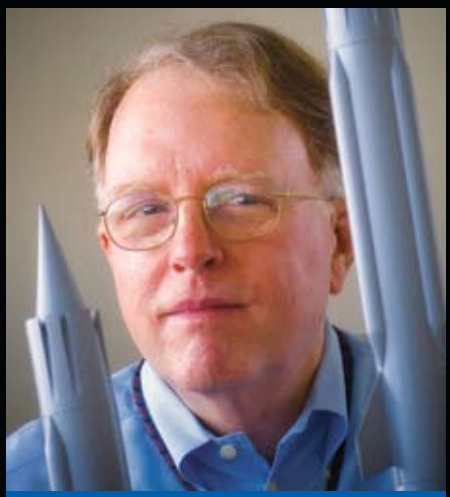
Bowcutt said he believes the development of hypersonics technology has progressed to the point "that we're getting close to where we could actually implement this technology into an operational system. After the X-51 and the HyFly programs have successful flight tests, we'll have a very strong basis for developing a hypersonic missile. That's kind of a natural first step—some kind of hypersonic cruise missile that will go 500 to 600 nautical miles in about 10 minutes."

How soon development of a hypersonic missile will take place "will depend largely on the rate of spending applied to fundamental research, technology maturation and flight system demonstration," Bowcutt said. "It could happen within 10 years with sufficient funding. On the other hand, it could take 15 or 20 years if funding is steady but smaller, as in the current situation."

HYFLY IN FLIGHT

John Fox, IDS Advanced Systems Program Manager for HyFly, agrees that the best chance of any near-term application of hypersonics technology would be a missile program.

DARPA and the ONR are conducting HyFly strictly as a research and development program, Fox said. "There's no commitment by the military services to use this technology in a real missile-development



BOB FERGUSON PHOTO

John Fox, program manager for the hypersonic HyFly missile, said the most likely application of hypersonics would be on a missile program.

program. That's what we'd like to do—win a next-generation cruise missile program for Boeing, which we think could well be a high-speed missile," he said.

Fox said the team's biggest challenges were to get the DCR engine operating properly using a conventional missile hydrocarbon fuel and developing a material system for the engine that will withstand very high temperatures. Engine supplier Aerojet has developed a new ceramic matrix composite material for the engine, which DARPA considers breakthrough technology, he said.

Other major challenges were integration of this complex engine into the titanium airframe, and providing thermal protection of the avionics and other subsystems from the severe thermal environments, both internal and external to the vehicle. The HyFly guidance system is based on technology used on the Boeing Joint Direct Attack Munition.

The HyFly program has had three flight tests so far, all launched from an F-15E operated by a Boeing flight crew at the U.S. Navy's missile test range at Pt. Mugu, Calif. These included an unpowered separation test of a HyFly vehicle (without a DCR engine and booster); a test flight with a live rocket booster, which has the job of propelling the HyFly vehicle to a fast enough speed (about Mach 3.5) for the DCR engine to ignite and operate; and a flight test of the HyFly vehicle powered by the DCR engine. The final flight test, with a goal of achieving Mach 6 cruise, is scheduled for early 2008.

X-51 MAKES PROGRESS

Joseph Vogel, IDS Advanced Systems program manager for the X-51, has been involved with hypersonic vehicles his whole career, having worked on the Space Shuttle and International Space Station programs for Boeing after joining the company from NASA.

The X-51 program itself is making significant progress, Vogel said. It's been through a Critical Design Review, which validated the design, assembly, integration and flight-test plan for the Air Vehicle Demonstrator; and numerous successful firings of the demonstrator hydrocarbon-fueled scramjet engine built by Pratt & Whitney. The program is on track to start flight tests in August 2009.

"The integration of the whole system into this air vehicle, which has the potential to fly at speeds of Mach 6 and above, has been a challenge that our team has met successfully," Vogel said. "We've learned a lot about unpredicted vibration and acoustics, and it appears overall that we're turning the theoretical into reality. Looking at the data and seeing what we have, I don't think we have anything in front of us that we can't overcome."

A unique feature of the X-51 will be how long it will actually fly by itself, Vogel pointed out. "The duration of flight for the X-51A will be about 300 seconds," he said. "That's substantially longer than a lot of the other hypersonic vehicles that have been flying (such as the X-43A, which flew for 10 seconds). Basically, the X-51's a pretty cool vehicle."

'REALLY CAN BE DONE'

George Orton, who leads hypersonic design and applications programs for IDS Advanced Systems, said programs "like X-51 and HyFly can show that a very high-speed missile is practical. These are primarily propulsion technology programs, but they'll demonstrate that high-speed flight with a missile-like vehicle really can be done. That could provide a real shot in the arm for the Air Force and Navy in terms of future missile programs."

Like Bowcutt, Orton has worked on hypersonics programs since the National Aerospace Plane program and was directly involved in the X-43 program in a key leadership role. He also worked on the Gemini, Space Shuttle and International Space Station programs.

"Without question, the X-43A Hyper-X program was a great accomplishment," he said. "We set two world records with a combined NASA-ATK-Orbital Sciences-Boeing team. It was the first time that a scramjet was integrated onto an airframe. And it proved that the scramjet really can produce acceleration and could be a viable engine for the future. It was really a breakthrough."

The success of the X-43A generated excitement as well, Orton recalled. "When the Hyper-X flew, there were a tremendous number of hits on the NASA Web site. The only other recent experience like that was the Mars rovers. In spite of that, we have to wait and see and be a little patient about the development of this technology."

Kevin Bowcutt, Boeing's chief scientist for hypersonics, believes hypersonics technology has progressed to the point that it could be implemented into an operational system.

BOB FERGUSON PHOTO

"If [the Combined Cycle Demonstrator] were to get going, I think that could be a tremendous shot in the arm for future aircraft as well as for space access."

—George Orton, hypersonics leader, IDS Advanced Systems

There is a major challenge today for hypersonics in "establishing a need for high-speed flight," Orton said. "Without a compelling need—whether it's a reconnaissance/strike aircraft, a high-speed missile or space access—to do this research, it's very difficult to find funding for it. Does it provide an advantage in terms of cost and the way we do business over other assets that we have? Technically, we've proven that scramjets work. I think we can do the technical things—but we have to have a need and a focus."

Vogel said he sees the development of hypersonics technology "at a crossroads. I think the technology is at the point where it can be matured into something, whether it be a weapon system, a reconnaissance vehicle, or the next phase into access to space or low Earth orbit. But it's going to take a lot more time and investment (by government and industry) to get over the next hurdle, which is integration with other technologies."

DARPA and the U.S. Air Force are currently considering a program that could provide such a need and focus, Orton said. The program, called the Combined Cycle Demonstrator, would involve the design of a hypersonic aircraft that could take off from the ground, fly to a speed of Mach 7, then fly back to Earth and make a powered landing.

"If this program (the CCD) were to get going, I think that could be a tremendous shot in the arm for future aircraft as well as for space access," Orton said.

DARPA and the Air Force have not issued a go-ahead for such a program yet, Orton said. "But the technology work we're doing now with the Air Force, NASA and DARPA is laying the groundwork for a program like that," he said. ■

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