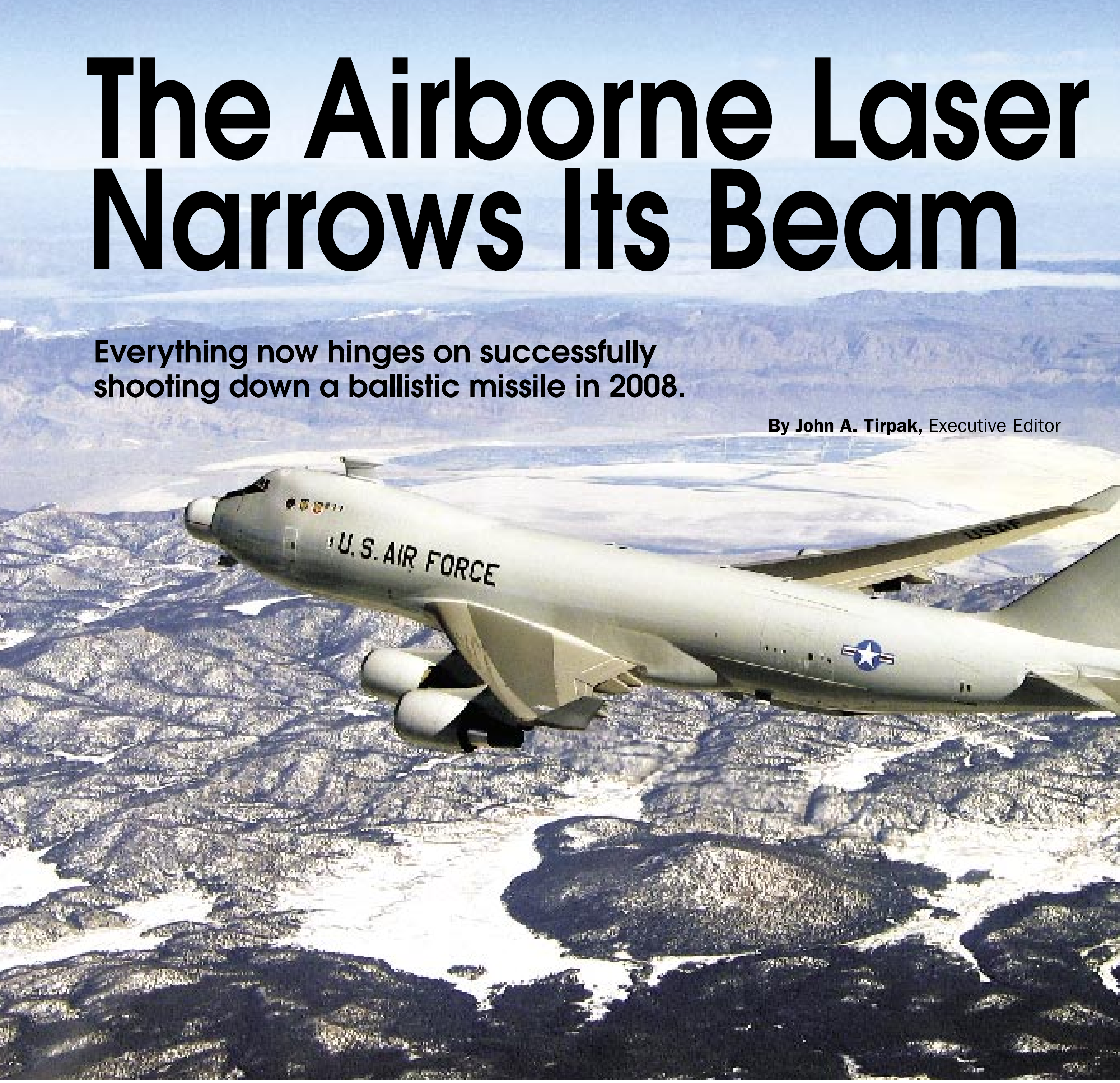
The Airborne Laser Narrows Its Beam

Everything now hinges on successfully shooting down a ballistic missile in 2008.

By John A. Tirpak, Executive Editor



The Airborne Laser, formerly a full-up weapon development project, was recently reduced to a basic technology demonstration effort. Some thought the demotion was a prelude to harsher action and that the Pentagon soon would kill off the program altogether.

It hasn't turned out that way. In fact, the program, though long delayed, is far from dead. Its managers still aim to deliver a critical fighting capability to the nation.

The effort has been narrowed considerably, though. The ABL project is today focused on a single goal: demonstrating that the system can shoot down a ballistic missile in its boost phase. Nearly all planning and engineering aimed at future operational versions of the system has been put on hold, pending the success of a real-world test set for late 2008.

If the shootdown is successful—and it will be just one element of a whole "campaign" of tests and demonstrations aimed at proving the ABL's viability—then the Pentagon could well launch a development program to field a more definitive system within the decade.

The downgrading of the ABL occurred in February. However, said Air Force Col. John A. Daniels, the ABL program director, the 2008 shootdown has been the focus for some time.

The program falls under the supervision of the Missile Defense Agency. Its leaders reasoned that, if the program could not demonstrate basic success,

Boeing photo

There won't be a second Airborne Laser to join this unique aircraft until 2015 at the earliest, but the program continues.

then "it didn't make a lot of sense to talk about the second airplane and then subsequent production airplanes," Daniels said.

Cost and Complexity

The ABL program, explained Daniels, is extraordinarily complex, and the Defense Department and MDA leadership "did not want us to get sidetracked and begin spending some dollars toward the second airplane and beyond." He added, "They wanted us to keep our eye on the ball."

Money certainly played a role in the downscoping of the program, Daniels acknowledged, but he believes the approach taken is "prudent," in that success will lead, "eventually," to actual production aircraft.

The ABL program was originally budgeted for $1.1 billion in 1996, but the most recent cap on the program, set this spring, is $3.6 billion.

The first ABL—a 747 stuffed with pipes, pumps, motors, chemicals, computers, and state-of-the-art optics—is now being modified in preparation for nearly two years' worth of tests that will build up to the late-2008 shot. The Pentagon has not decided the type of missile to be engaged, but it will be representative of the types of theater ballistic missiles deployed by some of America's unpredictable adversaries.

Daniels said the Pentagon's program objective memorandum—the out-years spending plan—contains money to start trade studies for a second ABL beginning in Fiscal 2009.

"It's there," he said, but under the rescoped program, neither he nor his industry or government team is "distracted" by production planning. Daniels said he and the team are not "spending much time or effort on that because we have our heads down and we're trying to get this lethal demonstration executed."

Boeing is the prime contractor and integrator and provides the battle management system. Northrop Grumman provides the main laser system, and Lockheed Martin is the supplier for the beam and fire-control systems.

The ABL program got under way in 1996, when the Air Force, under Chief of Staff Gen. Ronald R. Fogleman, offered the concept as a way of obtaining a rapidly deployable system to defend US troops and allies against theater ballistic missiles, which proved vexing in the 1991 Gulf War. Iraqi Scud-type TBMs slipped past Army Patriot air defense systems and wreaked havoc in rear areas of Saudi Arabia, killing scores of troops. Saddam Hussein also fired Scuds into Israel, in a vain attempt to broaden the war. Israel, though it took casualties, didn't take the bait, and the tactic failed. However, the problem of TBMs remained as one of the great unresolved military challenges of that conflict.

The Air Force envisioned a fleet of seven ABLs, which it saw as the minimum needed to maintain one "orbit"—a 24/7 capability—in a given regional hot spot.

Heart of the Matter

The heart of the ABL is an enormous chemical oxygen-iodine laser, or COIL, contained in the body of the aircraft. It requires thousands of gallons of chemical fuel that must be mixed and pumped at high speed to produce the intense light needed for destructive effect. These megawatts of energy, focused through a ball turret in the nose, would be aimed at a boosting missile more than a hundred kilometers away. The laser makes use of adaptive optics that compensate for atmospheric distortion, thus keeping the beam tightly focused.

This high-energy laser will rupture the skin of a missile, causing its pressurized fuel to explode. The missile would then fall back on the nation that launched it, along with whatever warhead it might be carrying. This last point also could make the ABL a powerful weapon of deterrence.

Carried onboard as well are other lasers that target the missile, track it, and assess the air turbulence between the nose turret and the target. This in turn feeds the onboard computers, which adjust the beam to compensate for the turbulence, to keep it as coherent as possible.

In its early vision, funded by the Air Force out of its own budget, the ABL was expected to yield an initial operational system in 2006.

However, the program has been beset by chronic delays. Target shootdown dates slipped several times, and the new 2008 goal is more than six years past the originally planned lethal test in 2002.

Asked why the program has slipped so much, Greg Hyslop, Boeing's ABL program director and vice president, said the magnitude of the task wasn't fully understood at the beginning.

"I think people underestimated the technical challenge of this program," Hyslop said, "and what it would take to put a megawatt-class laser on an airborne platform ... with the pointing and jitter levels that we're trying to achieve. That is a very difficult technical problem and an integration problem."

Unique among defense projects, the ABL requires the disciplines of aeronautical, mechanical, electrical, computer, propulsion, chemical, and optical engineering, to name just a few.

Boeing photo

Big Crow, seen here, is a KC-135 that will simulate ballistic missile targets for the ABL. The aircraft employs intense heat lamps to mimic the hot plume of a missile in boost phase. Onboard sensors and telemetry help correct the ABL's aim.

"My sales pitch for engineers is ... whatever your background, I can find a job for you at ABL," Hyslop observed.

It quickly became unwieldy to juggle the often-incompatible demands of the two main thrusts of the program: the optics and the chemical laser. It was necessary to start flight testing the battle management system and laser optics, but the labyrinthine plumbing and laser modules needed extensive time on the ground to be sorted out.

The solution was to buy an old Air India 747 carcass and use it to fit-test the laser inside. That carcass, poking its nose through a hangar at Edwards AFB, Calif., is called the System Integration Lab, or SIL. Work could proceed on getting the laser to properly fit and work in the SIL while the battle management and optical system could be developed on the actual flying prototype.

Sub in a Bomber

"It's a lot of mission equipment," Hyslop said of the ABL's guts. The chemical laser, targeting and illuminating lasers, battle management system, and the large ball-turret optical system together weigh "over 200,000 pounds," he noted.

"The dry weight of a B-2 bomber is around 100,000 pounds, so [it's like] we're building two B-2 bombers inside this fuselage," Hyslop said, adding that "it's pretty densely packed" and seems more like a submarine inside than an aircraft.

He added that the weight of the ABL has remained "stable" for two years.

"I think everybody has a good handle on all the plumbing requirements. Now, it's just making sure we can interface plumbing with aircraft structure, and we do all that in the right way."

Although modern computer design tools can help engineers fit plumbing and wiring into an aircraft and check for conflicts before any metal is installed, such tools were not used early on, Hyslop said.

"Not as much went into the preliminary design phase as it should have. Since then, for the installation, we've done a lot more of that."

The ABL's program milestones are described as "knowledge points," because their successful attainment inform the pace at which the program can go forward.

There were two knowledge points achieved in 2005, Daniels said.

"The first one was that we had to fly the airplane with the optical system and the battle management system on board and demonstrate that it was airworthy, that we could point the turret where we needed to turn it in flight," and begin to collect data on jitter of the aircraft, Daniels said. The test showed the mirrors and optics were all correctly aligned and that the software is operating properly. All this was accomplished in July of 2005.

The second goal of the year was to get the high-energy laser fully installed in the surrogate airframe and run it; this was accomplished in December of 2005, about 10 weeks later than planned. The laser was fired about 70 times, getting up to one shot with a duration of 10 seconds.

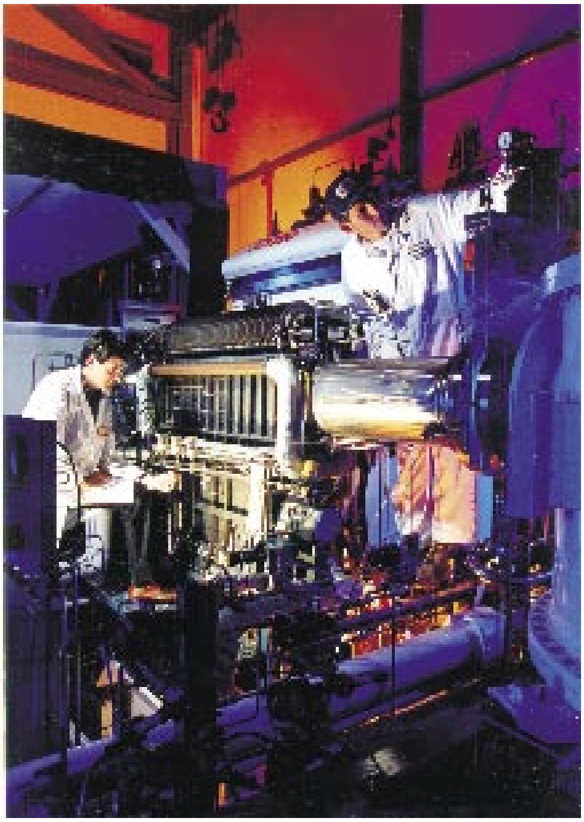
"We got good power, and, most importantly, we got good reliability out of that laser," Daniels said. "We were able to operate it several times in quick succession."

The dwell time needed for the laser to rupture a missile skin is classified,

AP photo by Ruhollah Vahdati

Iran tested its long-range Shahab-3 in November exercises (shown here). Tehran launched more than a dozen ballistic missiles in a single day.

Boeing photo



Technicians check out one of the ABL's six laser modules. Workers recently disassembled and refurbished the entire chemical oxygen-iodine laser system in preparation for the crucial tests.

but Daniels said it was less than 10 seconds.

So far, 2006 has been "by far the most technically challenging" year of the program, Daniels said, because the goal this year is "putting it all together."

The first goal is to have the flying prototype fully modified to accept the high-energy laser. This requires strengthening decks, building tie-downs and organizing the extensive plumbing, installing the illuminating and tracking lasers, and making sure "it all works," Daniels said. This work, "a very technically challenging knowledge point due to hardware and software integration," was to be done in late August, but Daniels said it would be finished in late September. The modifications were being done at Boeing's Wichita, Kan., facilities.

The year's second big goal, which Daniels hoped in August to have accomplished by the end of December, is to fly the all-up system—with a surrogate, lower-power battle laser—and actually test its lasers on a simulated target.

Big Crow

The first target is a KC-135 called "Big Crow," which has a ballistic missile painted on its side. High-intensity heat lamps have been installed at the tail of the "rocket," which offer a thermal and infrared signature that mimics the plume of a boosting missile. The kilowatt-class Beacon Illuminator Laser (BILL) and Tracking Illuminator Laser (TILL) will be tested in these flights, which will also be done near Wichita. The Big Crow also has its own lasers, which can provide instant feedback on how well the ABL's systems are reading the atmospheric distortion and maintaining beam control.

Lastly this year, the high-energy laser was to be dismantled, checked, and refurbished.

"That's not a small task," Daniels said. Each of the six laser modules in the system "is about the size of a Chevy Suburban sport-utility vehicle sitting on its end," not to mention the "thousands of parts" in the plumbing system. In August, Northrop Grumman reported that the teardown was going well and that the COIL parts were showing little wear and tear.

Hyslop said there were "few surprises" upon inspection of the COIL parts and that the system was in good shape, considering that it has had chemicals running through it for several years.

"To take one of those apart, refurbish it, put it back together, and then have it pass its acceptance test, that was a major accomplishment on the program," he asserted.

Early in 2007, the ABL goes back to Edwards, where the refurbished COIL will be installed.

"By the end of 2007, we hope to have a full-up ABL weapon system that's ready to start ground and flight testing early in 2008," Daniels reported. He emphasized that the philosophy of the program will continue to be "crawl, walk, run."

In the lead-up to the lethal shootdown demonstration, the ABL will target the Big Crow and some other surrogate missiles, some of them instrumented to provide feedback on laser performance. The program may also try its sensors on an F-16 climbing in afterburner, which resembles a ballistic missile, Daniels said.

Finally, in late 2008, an all-up demonstration will be run to show that the ABL can acquire, track, target, and destroy a boosting missile at a range that is classified, but "militarily useful," Daniels said.

And Next? ...

What happens then? The program will not come to an abrupt halt, nor will it go immediately into a weapon development phase, Daniels reported.

Following the shootdown test, if it is successful, the ABL will be tried out in a variety of conditions and scenarios, possibly against more challenging targets. The data acquired from these tests will be used to better shape the eventual weapon program and help refine the design of follow-on ABL aircraft.

"We know this first airplane is a true prototype," Daniels said, "and there's going to be significant changes between the first airplane and the second airplane that's funded by the Missile Defense Agency."

Lt. Gen. Henry A. Obering III, head of the MDA, told *Air Force* Magazine in an e-mail message that the whole ABL program doesn't hinge on a single shot and isn't the only game in town.

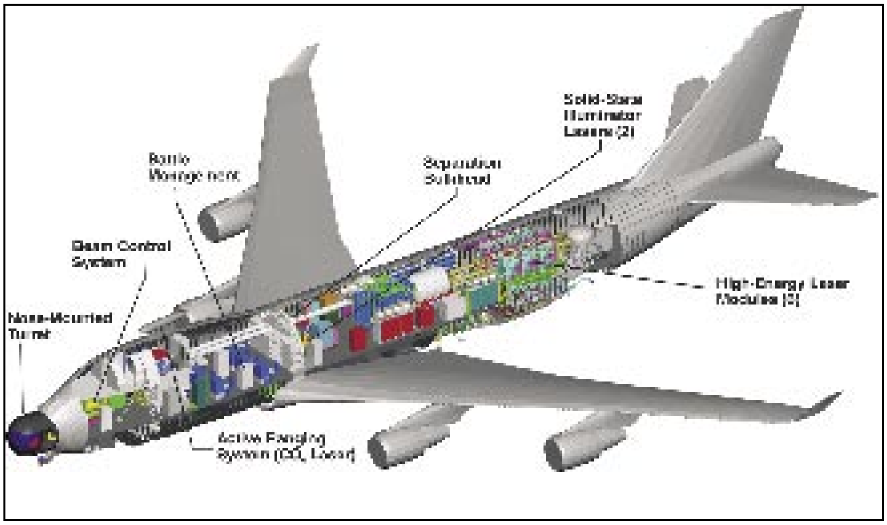
"We have adopted a test build-up approach that will give us good confidence as we conduct the lethal engagement," Obering said.

"Remember, this is not just a single point for the program; this is more of a campaign, since the program will continue to conduct flight tests against all classes of boosting missiles."

As a backup—or competitor—to ABL, the MDA has launched the Kinetic Energy Interceptor program, which seeks to develop a rocket that could shoot down a boosting ballistic missile.

"It has always been our view," Obering said, "that the flexible and high-perfor-

Boeing illustration



The labyrinthine interior of the ABL is described as more akin to a submarine than an aircraft. Even if live shootdown tests are successful, it remains to be seen whether the ABL can be made to operate in a militarily useful, repeatable, and reliable way.

mance KEI booster could also be used as part of an affordable, competitive next generation upgrade for our midcourse or terminal interceptors."

He said that both projects are "on track," and the KEI will make the first flight of a high-acceleration booster in 2008, the same year ABL will make its first shootdown demonstration.

"We are preserving decision flexibility with respect to our boost phase programs until we understand what engagement capabilities they can offer," Obering asserted.

In March, Obering told reporters at an MDA conference that it remains to be seen if the ABL could be made into a reliable weapon system. Even if the system is successful in getting airborne and shooting down a missile, it could prove too finicky to be a practical weapon system.

If "every time we come back and land, we have to recalibrate ... and refine that laser," the system may be unworkable, he said.

"If it becomes labor intensive like that, it could not very well be made affordable or operational in that regard. ... Even though you may meet your technical goal, you want to make sure that you met supportability and operability goals as well."

Reason for Optimism

Still, many are upbeat. In April, Obering told the Senate Armed Services Committee strategic forces panel that, even though there are "many technical challenges with the Airborne Laser," the run of successes since 2004 "gives me reason to be optimistic that we can produce an effective directed energy capability. An operational Airborne Laser could provide a valuable boost-phase defense capability against missiles of all ranges."

There won't be time or money to take half-measures with the next ABL, Daniels said. Because the systems are so expensive, "we can't afford to have a second airplane that's a prototype. [It] has to be a real bridge to production; it's got to be very much like a production aircraft."

The emphasis in designing the second airplane will be on improving its functionality—to "fix the things that haven't worked as well as we would have liked on the first airplane"—and making it more reliable and maintainable, more like a weapon system, he said.

A lot of attention will be paid to reducing life cycle costs and making the airplane easier to produce.

"If we spend some money up front before we lock in the design of the second airplane, we have the opportunity to not only reduce the production cost significantly, but ... reduce the O&S [operation and support] cost, which as you know will eat your lunch on an airplane that's hard to maintain." Emphasis will be put on reducing parts count and making the aircraft lighter.

"It has to be a stable ... simpler design," Daniels asserted.

Finally, "Tail 2" may need an increase in performance, either from the laser or the algorithms that tweak its beam. Daniels said that the lag between the shootdown demonstration and the launch of the weapon program may allow some "technology insertion" that could improve performance or simplify the design. He said that the Air Force Research Lab is working on improvements to the COIL, the basic design of which is largely unchanged since the late 1970s.

He said, "We're also doing a lot of exciting work with solid-state illuminators" that could improve the BILL and the TILL. However, even advanced solid-state lasers—powered by electricity—will not be able to match the power of a COIL for the foreseeable future, "so I think the chemical laser is going to be with us for a while." Optics and refined processing algorithms could also produce greater power without changing the COIL design, Daniels said. (See "Toward a New Laser Era," June, p. 72.)

While all this is being done, the first ABL will continue to be flight tested, and the lessons learned will be applied directly to the design effort. Also, the Air Force, which would fund and operate the ABLs after they are developed, will be working on their concept of employment. The current concept of operations for the ABL, which would serve with Air Combat Command, was written in 2001 and signed by ACC's then-commander, Gen. John P. Jumper.

The "down payment" on the second airplane—funding for long-lead production parts—is not now scheduled until Fiscal 2011. Modifications to an airframe probably wouldn't start until 2013, "so, realistically, ... we wouldn't be back in the air with a second airplane, doing testing with the weapon system, before the 2015-2016 timeframe," Daniels forecast.

Does that mean the US will be without a boost phase intercept system until 2015? Daniels doesn't think so. The experimental version of the E-8 Joint STARS was deployed, midtest, to combat in the 1991 Gulf War, nearly a decade before achieving true "operational" status. Daniels believes the first ABL will be similarly useful should a national crisis arise requiring such a capability, even if it is limited and not a full-up weapon system.

"If we are successful in our lethal demonstration and some nation around the globe flexes its muscles and tensions rise," Daniels observed, "even if our reliability is not that good, I suspect the stakes are so high" that the first ABL "absolutely" will be sent into battle. ■