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Airborne Laser (ABL): Issues for Congress

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Prepared for Members and Committees of Congress

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Summary

The United States has pursued a variety of ballistic missile defense concepts and programs over the past fifty years. Since the 1970s, some attention has focused on directed energy weapons, such as high-powered lasers for missile defense. Today, the Airborne Laser (ABL) program is the furthest advanced of these directed energy weapons in relative terms and remains the subject of some technical and program debate.

The Department of Defense (DOD) has remained a strong advocate for the ABL and its predecessor programs. The Defense Department and most missile defense advocates argue that the ABL, which is designed to shoot down attacking ballistic missiles within the first few minutes of their launch, is a necessary component of any broader U.S. ballistic missile defense system. Until recently, Congress has largely supported the Administration's ABL program.

Funding for the ABL began in FY1994, but the technologies supporting the ABL effort has evolved over 25 years of research and development concerning laser power concepts, pointing and tracking, and adaptive optics. Delayed now for many years, the ABL program plans to conduct a lethality test now scheduled for August 2009. Assuming a successful test, the Defense Department has said that this test platform could then be made available on an emergency basis for a future crisis. To date, about $4.3 billion has been spent on the ABL program, including $632 million for FY2007. For FY2008, the Administration requested $548.8 billion, which was cut substantially in the House and Senate defense authorization bills. Total ABL program costs are not available because the system architecture has not been defined.

Program skeptics continue to raise several issues. Their questions include the maturity of the technologies in use in the ABL program and whether current technical and integration challenges can be surmounted. If the ABL is proven successful, there have been questions about the number of platforms the United States should acquire. Seven aircraft have been mentioned previously, and apparently this number remains the program's objective, but is this number appropriate? What stresses might continued ABL program slippage or delays place on the supporting industrial base? How does the ABL compare to alternative concepts? To what degree should the United States invest in alternative missile defense technologies in the event that the ABL program may not prove successful?

This report examines the ABL program and budget status. It also examines some of the issues raised above. This report does not provide a detailed technical assessment of the ABL program (see CRS Report RL30185, *The Airborne Laser Anti-Missile Program*, by Michael E. Davey and Frederick Martin.). This report is updated periodically as necessary.

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Introduction

The United States has sought to develop and deploy ballistic missile defenses for more than 50 years. Since President Reagan's Strategic Defense Initiative (SDI) in FY1985, Congress has provided about $110 billion for ballistic missile defense programs and studies. National missile defense (NMD) has proven to be challenging and deployment of an effective NMD system remains uncertain. Until recent years, NMD was a divisive political and national security issue. Debate has focused on the nature and immediacy of foreign missile threats to the United States and its interests, the pace and adequacy of technological development, the foreign affairs and budgetary costs of pursuing missile defenses, and implications for deterrence and global stability.

In the mid-1980s and into the early 1990s, Congress reacted to these concerns and questions by reducing requested missile defense budgets and providing legislative language to guide the development of missile defense programs and policy.

During this time, many in Congress appeared more concerned than the Defense Department and the military about near-term threats to forward-deployed U.S. military forces posed by shorter range ballistic missiles. Congress demonstrated those concerns by supporting the development and deployment of theater missile defenses (TMD),[1] oftentimes over the objections of the Defense Department. Since the end of the 1991 Persian Gulf War, and especially over the past several years, Congress generally has supported larger missile defense budgets. For FY2007, Congress appropriated $9.3 billion for missile defense programs, making it the largest Defense Department acquisition program.

[1] Theater missile defenses are anti-missile systems designed to destroy or deflect an attacking short-range ballistic missile from reaching its intended target. Those early TMD programs strongly supported by Congress in the mid-late 1980s included the Israeli Arrow program and the Patriot ATM (anti-tactical missile) system used in the Persian Gulf war.

The primary technological concept for missile defense since the early 1980s[2] has been 'hit-to-kill' interceptor missiles.[3] The utility of hit-to-kill as a ballistic missile defense (BMD) concept over the past 25 years remains mixed.[4] Alternatives to the hit-to-kill concept have also been pursued. One is the development of laser technology and the platforms on which lasers might be based. For most missile defense advocates the Airborne Laser (ABL) program represents the most promising near-term effort. Although the Air Force contends that the ABL is mature technology, some observers have questioned whether this technical assessment is accurate, pointing out that the various ABL components have yet to be fully integrated and tested. Considerable debate also continues over whether the ABL will be capable of dealing with likely future ballistic missile threats.[5]

The effort that led to the ABL dates to the early 1970s when the Air Force began development of an Airborne Laser Laboratory (ALL) — a modified KC-135A aircraft — to demonstrate that a high-powered laser mounted on an aircraft platform could destroy an attacking missile. After 10 years of research, development, and field testing (culminating in 1983) the ALL program announced that lasers had managed to "destroy or defeat" five Sidewinder air-to-air missiles and a simulated cruise missile[6] at short range. The ALL aircraft was retired in 1984 because its research purpose was considered no longer necessary.

Although the ALL test targets were not ballistic missiles, the Air Force and the Defense Department became increasingly interested in the possibility of using high-powered lasers aboard aircraft to destroy enemy ballistic missiles during their boost phase.[7] Through the 1980s and mid-1990s, further research on various ground laser

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[2] Prior to the early 1980s, the United States had pursued missile defense concepts that largely employed nuclear-tipped missile interceptors, because a high degree of accuracy was not required. Some conventional explosive warheads were used to develop the Patriot PAC-2 system used in the 1991 Persian Gulf War. Advanced and exotic concepts, such as various lasers, are now being considered.

[3] A kinetic kill interceptor would seek to destroy its intended target through a direct collision at relatively high speeds. The force of the impact would then destroy the attacking missile or warhead, render it inoperable, or divert it from its intended target. With such an approach, however, a near-miss has the same practical affect as a large distance miss — the target is not destroyed.

[4] See CRS Report RL33240, *Kinetic Energy Kill for Ballistic Missile Defense: A Status Overview*, by Steven A. Hildreth.

[5] There is considerable on-going technical debate outside of government regarding ballistic missile countermeasures, and the design or procedural measures by which an adversary might seek to defeat or mitigate missile defenses. See especially the report by the American Physical Society, *Report of the American Physical Society Study Group on Boost-Phase Intercept Systems for National Missile Defense: Scientific and Technical Issues*, July 2003.

[6] See CRS Report RL30185, *The Airborne Laser Anti-Missile Program*, by Michael E. Davey and Frederick Martin.

[7] The Defense Department defines the boost-phase as that portion of the flight of a ballistic missile or space vehicle during which the booster and sustainer engines operate. This can last up to several minutes. During this time, a ballistic missile is relatively large and (continued...)

concepts and designs and tracking and beam compensation tests convinced Pentagon officials to proceed with the conditional development of the ABL in June 1998 (although low-level funding for the program began as early as FY1994). Currently, the ABL program is the primary focus of the Missile Defense Agency's (MDA) Boost Defense program.[8] The ABL's lethality test demonstration, which is designed to test the various subsystems and target and destroy a ballistic missile, has been delayed many times. According to the Missile Defense Agency, that lethality test, which was initially scheduled for late FY2003, is now planned for August 2009.

Congress has provided strong funding support ballistic missile defenses in the face of growing concerns about the proliferation of missiles around the world. Of all the current efforts, most missile defense advocates believe the ABL shows the best near-term promise for destroying enemy ballistic missiles during their boost-phase. While the missile is still in the earth's atmosphere, the airborne laser would seek to rupture or damage the target's booster skin to cause the missile to lose thrust or flight control and fall short of the intended target before decoys, warheads, or submunitions are deployed. The expectation is that this would occur near or even over the enemy's own territory. Second, although the United States has primarily pursued kinetic energy kill mechanisms for missile defense some 25 years, many defense analysts believe that if the United States chooses to pursue increasingly effective missile defenses for the longer term future, then alternative concepts such as high-powered lasers may be the answer.

This report tracks the current program and budget status of the Airborne Laser program. In addition, this report examines several related issues that have been of interest to Congress. It will be updated occasionally as necessary. This report does not provide a technical overview or detailed assessment of the ABL or Air-Based Boost Program.[9]

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[7] (...continued)
vulnerable — its rocket engine plume makes the ballistic missile highly visible, the missile is under tremendous pressures, and it is slower relative to later portions of the flight trajectory.

[8] Because the ABL's predecessor — the ALL — came under the Air Force's Space and Missile Systems Center (SMC), the ABL at first also came under the responsibility of the SMC. After a prototype model was completed, ABL personnel management functions were transferred to the Air Force's Aeronautical Systems Center (ASC) in 2001 (both SMC and ASC are under the Air Force's Materiel Command, based at Wright-Patterson AFB, Ohio). Also in 1991, ABL funding and program management was transferred to BMDO (the Ballistic Missile Defense Organization, which was MDA's precursor organization). ASC is responsible for ABL's personnel and MDA is responsible for program execution or carrying out the program.

[9] A useful technical review of the ABL program at that time is CRS Report RL30185, *The Airborne Laser Anti-Missile Program*, by Michael E. Davey and Frederick Martin.

System Overview

It is envisioned that the ABL would use a high-power chemical laser mounted in the aft section of a modified Boeing 747 aircraft[10] to destroy or disable all classes of ballistic missiles during the initial portion or first several minutes of their flight trajectory (from shortly after launch and before they leave the earth's atmosphere). Analysts indicate that during this period (up to several minutes) the missile is at its most vulnerable stage — it is slower relative to the rest of its flight, it is easier to track because the missile is burning its fuel and thus has a very strong thermal signature, and it is a much larger target because any warhead has not yet separated from the missile itself. Analysts also point out the advantages of destroying the missile before any warhead, decoys, or submunitions are deployed, and potentially over the enemy's own territory.

The ABL program will integrate a weapons-class chemical laser aboard a modified Boeing 747-400 series freighter aircraft (747-400F). The chemical laser has been assembled in the System Integration Laboratory (SIL), a 747-200 fuselage, and tested. The Air Force acquired the 747-400F in January 2000 directly from the Boeing Commercial Aircraft assembly line and flew it to Wichita, Kansas, where Boeing workers made extensive modifications to the aircraft. Among other things, they grafted huge sheets of titanium to the plane's underbelly for protection against the heat of the laser exhaust system, and added a 12,000-pound bulbous turret on the plane's front to house the 1.5 meter telescope through which the laser beams would be fired. This plane made its maiden flight in July 2002; it logged 13 more flights in 2002 before relocating to Edwards Air Force Base in California.

Since 2002, the focus of the ABL program has been on system integration, an effort that is considered challenging. Officials have reported completing ground integration and testing of the Beam Control Fire Control (BCFC) segment and most of that segment's integration into the ABL aircraft. Additionally, six laser modules in the SIL have been integrated and tested. Further integration and testing of the BCFC, laser modules in the SIL, and communications links took place in 2005. However, the primary goal to have achieved a lethality test by 2005 was not met. That test has now been moved further to August 2009. Program officials said the delay was due largely to program restructuring and budget changes. Others suggested that technical and integration problems continue to prove more challenging than anticipated.

In 2006, Boeing announced successful surrogate low-power laser testing from the ABL aircraft. In October 2006, Boeing rolled out the ABL aircraft in Wichita, Kansas, announcing successful completion of major system integration milestones in preparation for some flight testing that will lead to the lethality test in August 2009.

As of January 2007, ABL had completed over 50 flight tests. In March 2007, the ABL successfully completed the first in a series of in-flight tracking laser firings at

[10] The laser beam exits the aircraft through a bulbous turret on the front of the aircraft, but the COIL (Chemical Oxygen Iodine laser) is located in the aft section of the aircraft.

an airborne target. Officials argue this is an important step toward demonstrating the aircraft's ability to engage an airborne target.

Major ABL subsystems include the lethal laser, a tracking system, and an adaptive optics system. The kill mechanism or lethal laser system (as distinct from the other on-board acquisition and tracking lasers) is known as COIL (Chemical Oxygen Iodine Laser). COIL generates its energy through an onboard chemical reaction of oxygen and iodine molecules. Because this laser energy propagates in the infrared spectrum, its wavelength travels relatively easily through the atmosphere. The acquisition, tracking, and pointing system (also composed of lasers) helps the laser focus on the target with sufficient energy to destroy the missile. As the laser travels to its target, it encounters atmospheric effects that distort the beam and cause it to lose its focus. The adaptive optics system compensates for this distortion so that the lethal laser can hit and destroy its target with a focused energy beam.

The current ABL program began in November 1996 when the Air Force awarded a $1.1 billion PDRR contract (Program Definition Risk Reduction phase) to several aerospace companies. The contractor team consists of Boeing, Lockheed Martin, and Northrop Grumman (formerly TRW). Boeing Integrated Defense Systems (Seattle, WA) has overall responsibility for program management and systems integration, development of the ABL battle management system, modification of the 747 aircraft, and the design and development of ground-support subsystems. Lockheed Martin Space Systems (Sunnyvale, CA) is responsible for the design, development, and production of ABL target acquisition, and beam control and fire control systems. Northrop Grumman Space Technology (Redondo Beach, CA) is responsible for the design, development, and production of the ABL high-energy laser. A number of subcontractors are also involved.

It is envisioned that a fleet of some number of ABL aircraft would be positioned safely in theater then flown closer to enemy airspace as local air superiority is attained. Although the Defense Department once indicated that a fleet of five aircraft might support two 24-hour combat air patrols in a theater for some unspecified period of time in a crisis, there has been no public discussion in recent years as to how many aircraft might eventually be procured or deployed as part of a future BMD system. It is likely, however, that current plans are to acquire seven production aircraft.

Program Status

The current ABL development and acquisition strategy is described in terms of several 'blocks' or two-year periods of research, development, testing and evaluation activities. The program goals for ABL Block 2006 (2006-2007) are to continue integration and ground and flight test activities for the first ABL aircraft or weapon system test bed. Program officials further plan to improve domestic production capabilities for advanced optics and sensors for high-energy lasers. The program expects to study and establish baseline capabilities for a more advanced second ABL weapon system after a successful lethal demonstration.

In March 2007 Boeing announced that it had successfully fired the ABL's tracking laser in-flight at an airborne target for the first time. A company representative stated that "The Airborne Laser team has successfully transitioned to the next major test phase, completing the first in a series of in-flight laser firings at an airborne target."[11]

The goals for ABL Block 2008 (2008-2009) are for further ground and flight testing of the first ABL weapon system and studies defining the second ABL weapon system. Additionally, integration of the ABL into the wider ballistic missile defense system is expected and the initiation of ground support activities for the ABL. The lethality test of the ABL is anticipated during this period. In Block 2010, programs officials plan to evaluate a broader spectrum of ballistic missile threats as part of the overall ballistic missile defense system in place at that time. During this period, the primary focus will be on the second ABL aircraft. More specifically, this includes completion of design activities and initial fabrication of weapon components.

The total ABL program cost cannot be given or estimated because of the acquisition strategy adopted by MDA for missile defense. Nor has the final system architecture been identified, meaning that the total number of ABL aircraft to be procured has not been determined. Prior to adopting this new evolutionary acquisition or "spiral development" strategy,[12] however, there were a couple points of reference as to what the Pentagon envisioned. In its FY1997 Annual Report to Congress, DOD's Office of Test and Evaluation envisioned seven ABL aircraft for a total program cost of $6.12 billion (then year dollars). The objective to acquire seven production aircraft likely remains. The most recent cost estimate, from the Clinton Administration, was $10.7 billion (life-cycle costs) for the same number of aircraft. No other system cost data are available. In March 2007, MDA Director Lt. Gen. Trey Obering testified that it is too early to tell how much the ABL will cost to operate because program managers do not know what technical achievements will be made in the coming years.[13]

Until recently, Congress has largely supported the ABL program by appropriating the Defense Department's requests, which have totaled about $4.3 billion. See table below, which shows the President's Budget (PB) request and the amount Congress appropriated. For FY2007, the Bush Administration requested about $632 million for the ABL program, which Congress approved. For FY2008, the Bush Administration requested $548.8 billion for the ABL program. In the House version of the defense authorization bill (H.R. 1585) the request was decreased to $298 billion. The Senate decreased the ABL request by $200 million in its version of the defense authorization bill (S. 1547).

[11] "Boeing-led Airborne Laser Team Fires Tracking Laser at Airborne Target." *News Release.* March 16, 2007.

[12] See CRS Report RS21195, *Evolutionary Acquisition and Spiral Development in DOD Programs: Policy Issues for Congress*, by Gary Pagliano and Ronald O'Rourke.

[13] Marcus Weisgerber. "Obering: Too Early to Tell How Much ABL Will Cost to Operate." *Inside the Air Force*. March 23, 2007.

ABL Budget Request & Appropriations
($ million)

Fiscal Year	1994	1995	1996	1997	1998	1999	2000
PB	1.90	20.00	19.95	56.83	157.14	292.22	308.63
App.	1.90	20.00	19.95	54.28	157.14	276.22	308.63
Fiscal Year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
PB	148.64	410.0	597.97	610.04	474.3	483.9	631.6
App.	233.64	483.5	597.97	610.04	474.3	454.7	631.6

Issues for Congress

Several factors combine to affect the near future of the ABL program. First, the ABL continues to face technical challenges. Second, in January 2002, the MDA dropped the traditional requirements-setting process in favor of a "capabilities-based" approach, intended to more quickly field a system capable of responding to some, if not all of the current ballistic missile threat. Third, on June 13, 2002, the United States withdrew from the Anti Ballistic Missile (ABM) Treaty, thus removing numerous barriers to potential anti-missile platforms. Fourth, the MDA is exploring alternatives to the ABL for the Boost Phase Intercept (BPI) mission. Finally, recent changes in funding profiles for both the ABL and for the MDA's new kinetic kill vehicle reinforce the uncertainty related to the ABL program. Specific issues that may confront Congress include the severity and implications of the ABL programmatic and technological challenges, how the ABL might be employed if and when it is fielded, the potential for industrial base problems, the scheduled lethality test, and consideration of boost-phase alternatives to the ABL.

Technology and Program Challenges

As a new type of weapon system, the ABL has faced technological challenges throughout its history.[14] The GAO has pointed out the challenges of developing and fielding a new type of weapon system, when it noted that "only one of the ABL's five critical subsystems, the aircraft itself, represents mature technology."[15] In October 1997 the GAO issued a report (GAO/NSIAD-98-37) highlighting the program's technical challenges and calling them "significant." In 2001, DOD's Director of

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[14] For a more comprehensive assessment of the ABL's technical challenges see CRS Report RL30185, *The Airborne Laser Anti-Missile Program*, by Michael E. Davey and Frederick Martin.

[15] General Accounting Office, *Defense Acquisitions: Assessments of Major Weapon Programs*, GAO-03-476, May 2003, p. 18.

Operational Test and Evaluation called the ABL a "high technical risk" program and outlined a number of technical challenges to be overcome.[16]

There is some consensus on the ABL's current technical challenges. In congressional testimony, the GAO pointed out that the ABL program office agreed with its assessment of the technological maturity and technical challenges in most instances, only disagreeing about the adaptive optics' maturity and challenges.[17] However, consensus appears to break down when evaluating how these challenges might affect budget and schedule. The GAO asserts that "problems with maturing technology have consistently been a source of cost and schedule growth throughout the life of the program."[18] But the ABL program's new requirements setting process, and its focus on developing a less sophisticated system based on currently available technology, may result in less risk of cost and schedule growth in the future.[19] The Missile Defense Agency asserts that program adjustments made in February 2004 have put the program on budget and schedule. GAO subsequently found that changes in the ABL program would result in a knowledge-based approach that was likely to result in a more cost-effective program.[20]

Two technical issues have long challenged the ABL program: beam control and adaptive optics and system integration.[21] The essentials of these two challenges have not changed that much in recent years.

The ABL system's weight has been another concern. The ABL was designed to carry 14 laser modules that were planned to weigh a total of 175,000 lbs. The six laser modules produced thus far already exceed this weight budget by at least 5,000 lbs.[22]

ABL proponents admit that the laser modules are currently heavier than anticipated. Nonetheless, they argue that they are within the requirement for the whole weapon system to fit within the 747's maximum takeoff weight — 800,000

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[16] Laura Colarusso. "DOT&E Says ABL Faces Major Challenges: Lethality Test Postponed," *Inside the Air Force,* March 1, 2002.

[17] Testimony of Robert E. Levin, in U.S. Congress, House Committee on Government Reform, Subcommittee on National Security, Veterans' Affairs and International Relations, GAO-02-949T, July 16, 2002.

[18] GAO-03-476, p. 18.

[19] Robert E. Levin, op. cit., and GAO-03-476, p. 18.

[20] GAO-04-643R, p. 6.

[21] See CRS Report RL30185, *The Airborne Laser Anti-Missile Program,* by by Michael E. Davey and Frederick Martin., for an in-depth treatment of the adaptive optics and systems integration challenges up to February 2000. In May 2004, the GAO released a report (GAO-04-643R) which found that the ABL still suffered from beam control "jitter." Industry representatives say that they have a plan in place to resolve this problem.

[22] Gopal Ratman and Gail Kaufman, "Pentagon Works to Solve ABL's Weight Gain," *Defense News,* March 3, 2003, p. 6. Some press accounts assert that the 6 laser modules are 25,000 lbs over the weight budget. Marc Selinger. "Airborne Laser on Track Despite Weight Gain, Official Says," *Aerospace Daily,* March 7, 2003.

lbs. with the six laser modules on the aircraft.[23] ABL critics remain skeptical that with fewer modules the same level of lethality can be achieved, thus raising questions as to whether the ABL will be required to fly closer toward its targets in hostile air space and whether weight trade-offs will result in reduced fuel capacity and increased need for aerial refueling to perform its mission. Recent military operations in Afghanistan and Iraq suggest that DOD's aerial refueling fleet is already overburdened.

Concept of Operations (CONOPS)

Another group of ABL questions that may confront Congress pertains to the aircraft's concept of operations, or CONOPs. As the program nears procurement and potential fielding, questions remain about the number of aircraft to be procured, where the aircraft might be deployed, and how they would be used.

A number of questions are likely to be asked regarding this size of the ABL inventory. The ABL will be a highly visible asset. It is very large, and will be escorted by fighter aircraft. Its high altitude will also help to distinguish it from other wide-body aircraft. Long in-theater on-station time for the ABL is premised on forward basing. These forward bases would likely not have chemical replenishment capabilities, which would necessitate return flights to the United States if the laser is used. It appears plausible that an enemy could wait until an orbiting ABL is being refueled, or is absent before initiating a missile attack. Thus, a force of seven aircraft might only be expected to provide 24-hour theater ballistic missile (TBM) BPI coverage of one theater. DOD's decision in the Spring of 2006 to postpone the purchase of five ABL aircraft brings the issue of exactly what a small number of ABL aircraft — in this case two — could achieve operationally.

Past doctrine and current real-world events suggest that U.S. interests could be threatened simultaneously in more than one theater and by more than one country with TBMs. Would seven aircraft be sufficient to adequately address potential threats? To address growing deployment requirements and to improve personnel retention, the Air Force has organized itself into 10 Air Expeditionary Forces (AEFs) that rotate on predictable schedules. How would a force of seven ABLs support the 10 AEFs? The Air Force, and other Services, frequently complain about the onerous and disproportionate O&S (Operations and Support) costs of "high demand, low density" (HD/LD) assets such as JSTARS and U2s. Would procurement of only seven aircraft create another HD/LD problem for the Air Force? On the other hand, buying more aircraft would require more people to fly and maintain them.

It is currently unclear what impact the ABL might have on the Air Force's already strained aerial refueling fleet. While based at some yet-to-be determined U.S. base, ABLs will likely deploy to forward operating locations such as Guam, Diego Garcia, RAF Fairford England, and Elmendorf AFB Alaska during crises. Although these bases are likely closer to tomorrow's hot spots than the continental United States, they are still hours of flying time away from the Persian Gulf, the Korean

[23] ABL officials argue that given system integration lab ground results in 2005, the ABL is expected to provide an operational viable capability with six laser modules.

Peninsula, and Central Asia. ABLs will require refueling to get to the crisis theater, refueling to maintain combat air patrols in-theater, and refueling to return to base. What effect will the ABL's current weight gain have on its fuel load? Might increased payload mean less fuel and therefore an even greater aerial refueling requirement?

Some observers have questioned how the ABL would be employed to counter intercontinental ballistic missiles (ICBMs). The consensus is that Russia and China currently field ICBMs that could plausibly threaten the United States; there is no such consensus on the future ability of North Korea or other so-called "rogue states" to field such missiles. (Some believe that such capabilities will emerge in the distant future, if ever. Others see the proliferation of such missiles as inevitable, and that it could occur sooner rather than later.) Current estimates suggest that the ABL's 400 km range (about 250 miles) is too short to stand outside Russian or Chinese airspace and still engage those countries' ICBMs in boost phase. Would the ABL fly into these countries' airspace during crisis to address potential ICBM launches in boost phase? Or would the ABL's laser need to be more powerful? Or will some alternative be deployed to supplement or replace the ABL for these scenarios?

Another set of questions pertains to using the ABL in or near commercial airspace. How will the aircraft be operated, and what rules will be established to eliminate or reduce the potential of accidently hitting a commercial aircraft? The ABL should fly above the altitude of most commercial aircraft, which should help mitigate this potential problem. However, the ABL's laser is designed to shoot over long distances, and the target ABL is attempting to engage may be within the same altitude as most commercial aircraft.

It appears that ABL CONOPS questions are also affected by MDA's decision to abandon the traditional requirements process. MDA has adopted a "flexible" requirements process that is driven as much by technological maturity as it is by operator needs. Thus, it is difficult to assess how the ABL might be employed because it is not currently clear what the ABL's capabilities will be, once fielded.

Industrial Base Issues

A final set of issues revolves around the ABL industrial base. Missile defense officials have cautioned that the ABL is pursuing very specialized technologies that are not routinely pursued in civilian or even defense industries. Turbulence in ABL funding or schedule, they maintain, jeopardizes the ABL industrial base because these specialized vendors will seek other business if ABL business appears threatened. The industrial base supporting advanced optical components of the ABL is most frequently cited as "fragile."[24] The criticality of these vendors to the health and progress of the ABL program has not been clearly established. DOD may, or may not, for example, find expertise in the optical telecommunications industry that would be applicable to ABL needs. Once the health of the ABL-specific contractor

[24] See, for example, Testimony of LtGen. Ronald Kadish, Director, Missile Defense Agency. Hearing Before the House Armed Services Committee, Military Procurement Subcommittee. June 27, 2002.

and subcontractor base has been established Congress may be asked to help preserve some of the "critical path technologies" that enable the ABL. If this take place, a key calculation to make may be the break point at which keeping a number of specialized companies in business outweighs the potential value of fielding the ABL.

It is also argued that cancelling the ABL could harm the laser industry *writ large*, rather than just those sub-industries associated with the ABL. This is because, ABL supporters assert, the ABL program is far and away the largest of its kind, and a "pathfinder" for other laser programs. Cancelling the ABL could slow down the entire U.S. laser development industry, they say. Others may disagree with this argument and argue that ABL survival or cancellation should be based on its own merits. The dearth of laser programs outside of the ABL, they could argue, indicates that the ABL's cancellation would have little affect on other programs, because there aren't many to affect.

Lethality Test and Contingency Capability Issues

The lethality test now scheduled for August 2009 (some six years later than original plans) is seen as a critical next step in the ABL program's development. The objectives of this test include:

- to demonstrate an actual shoot-down of a missile over the Pacific Ocean, possibly a Scud missile;
- to test the IRST (the Infrared Search & Track System), to see if the ABL can find, hold and track the intended target; and
- to demonstrate that the adaptive optics systems is able to compensate for atmospheric distortion.

The lethality test is considered important for a number of reasons, many of which have to do with the long advocated potential for this ABL test aircraft to provide a limited capability for emergency or contingency missions immediately after the lethality test. First, the test will demonstrate whether or how well the various ABL subsystems and component parts are working together. The fact that this test has been delayed several times and for several years now, suggests to some that continued systems integration problems are forcing this delay. Depending on the test results, additional system integration tests may be required. If significant technical problems arise or additional technical challenges are identified, the availability of this ABL platform for near-term emergency missions would likely be questioned.

Second, depending on the nature and outcome of the lethality test itself, use of this ABL test aircraft may not be appropriate in an emergency or contingency mission. For instance, if the lethality test fails to hit or destroy a Scud or other ballistic missile, military planners may not want to rely on a test aircraft deployed during a crisis. Additionally, if the lethal test is not considered significant (for example, the test is conducted against a very short range missile at very close range), military planners similarly may not have confidence in actually using the ABL test platform during a crisis. Some in the ABL program have suggested that the platform could be made available only as a airborne sensor and for battle management purposes. Others have questioned whether meaningful testing protocols can be developed if the ABL system is not yet integrated.

A third question pertains to how effective and extensive this flight test will be. Prior to the most recent test program restructuring, some 35-50 other missions were planned to validate design and other changes; additional air refueling missions were also considered. During the flight tests, ABL test aircraft were to operate with a relative large contingent of personnel, including 2 aircrew and up to 16 others. Test missions were expected to last 4-8 hours.[25] A May 2004 GAO report (GAO-04-643R) notes that the lethality test contract has been restructured three times and that costs have tripled. Will MDA be able to execute a highly robust and investigative test considering these increased costs? Press accounts suggest that the latest lethality test contract contains flaws that may inhibit the test.[26]

Alternatives to the ABL

These programmatic and technological challenges lead to another family of questions regarding the ABL's current and potential standing in missile defense vis-a-vis other missions and platforms. Might other platforms offer promise in the theater Boost Phase Intercept mission area? A Kinetic Energy Interceptor (KEI), unmanned aerial vehicles (UAVs), and ship-based, or space-based interceptors are potential options.

ABL officials believe the program's technical challenges are being overcome.[27] MDA is simultaneously pursuing, however, a Kinetic Energy Interceptor (KEI) that has come to be viewed as a potential alternative. This program was established in 2003, and early statements by MDA focused on the interceptor's commonality rather than its possible use as an ABL alternative. For instance, former MDA Director Air Force Lt. Gen. Kadish told reporters that the agency finds kinetic interceptor attractive because "given that we no longer have the constraints of the [1972 Anti-ballistic Missile] treaty and the way the services have put together operational requirements documents . . . I think it is now possible to think and actively pursue commonality that makes sense and a common interceptor with a common type of kill vehicle."[28]

Changes to budget and schedule, however, have brought the ABL and KEI into much more obvious competition. MDA's FY2004 R&D request for KEI (then called common boost- and mid-course interceptor) represented a six-fold increase in funding for this technology and was perhaps the first sign that MDA had some doubts about ABL's ultimate feasibility.[29] Slippages to both programs' schedules have

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[25] Robert Wall, "Debugging ABL," *Aviation Week and Space Technology,* September 1, 2003, pp. 55-56.

[26] Amy Butler, "ABL Shooting for 2008 Demonstration," *Aviation Week and Space Technology,* May 2, 2005.

[27] Marc Selinger, "Airborne Laser on Track Despite Weight Gain, Official Says," *Aerospace Daily,* March 7, 2003.

[28] Thomas Duffy, "Boeing to get Follow On Work for Common Missile Interceptor," *Inside Missile Defense,* September 18, 2002.

[29] U.S. Congress, Senate Committee on Armed Services, *National Defense Authorization Act*
(continued...)

increased the apparent competition between ABL and KEI. MDA director Lt.Gen. Trey Obering has described these potential weapon systems as being in a "flyoff."[30] The FY2007 budget request for KEI was $386 million. Future budgets for KEI climb so about $852 million (FY2009) to $1.65 billion (FY2011).

At issue is whether the KEI represents a prudent hedge against potential slippages the ABL schedule, or a drain on funds and other resources that could be devoted to the ABL, or other MDA programs. This question was probed at length in a March 15, 2005 House Armed Services, Strategic Forces Subcommittee Hearing. Subcommittee members expressed concern about the appropriate balance between the two programs.[31] During this hearing, MDA Director Lt.Gen. Trey Obering explained the decision to cut $800 million from the KEI's FY2006 budget request: "...to meet our top-line budget reductions, I decided to accept more risk in this area and restructure the kinetic energy intercept effort..." In their report H.R. 1815 (109-89), House Authorizors expressed their concern about pursuing both programs (p.232). Authorizors required MDA (Sec. 231) to provide a comparison of the two programs, including capabilities and costs.

Other potential alternatives for the BPI mission might be explored. With their long endurance and increasing payloads, Unmanned Aerial Vehicles (UAVs) may one day offer alternatives to the ABL. UAVs have been studied as BPI platforms since the mid-1990s. At the time, a UAV-based Boost Phase Intercept approach was viewed as a back-up to ABL in case that program encountered difficulties. Congress provided $15 million in FY1996 for a joint U.S./Israeli advanced concept technology demonstration (ACTD) program to study the feasibility of using up to 20 UAVs with three to six lightweight missiles each to conduct BPI in an Iraq-like scenario.[32]

The Army Space and Strategic Defense Command estimated that the 20-UAV architecture could cost $1.5 billion over a 10-year life span, compared to a then-estimated $6 billion 10-year life cycle cost for the ABL and a $17 to $23 billion 10-year life cycle cost for a space-based laser.[33] In addition to potentially lower cost, possible UAV advantages include the ability to operate closer to TBM launch points than the ABL, and the ability to conduct the BPI mission without endangering the

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[29] (...continued)
for Fiscal Year 2004, report to accompany S. 1050, 108th Cong., S.Rept. 108-46, (Washington: GPO, 2003), p. 236. This program is proposed to develop an interceptor missile that can be either ground- or sea-based, for boost and mid-course phase intercept of ballistic missiles.

[30] Thomas Duffy, "Obering: 2008 'Flyoff' Between ABL, Kinetic Energy Interceptor," *Inside Missile Defense,* March 16, 2005.

[31] U.S. Congress, House Armed Services Committee, Strategic Forces Subcommittee, *Fiscal Year 2006 Budget Request for Missile Defense Programs*, hearing, (Washington: Federal News Service, Inc., 2005).

[32] "Congress Provides $15 Million in FY-96 for Joint U.S.-Israel BPI Program," *Inside Missile Defense,* December 20, 1995.

[33] Pamela Hess, "USAF Questions Army Plan to Use UAVs for Boost-Phase Intercept Mission," *Inside Missile Defense,* October 11, 1995.

lives of aircrews. Perceived UAV deficiencies include a lack of adequate payload carrying capability. Considering the rapid recent advances in UAVs and their operational success, however, some analysts believe it may be time to revisit the UAV-based approach and weigh its efficacy relative to the ABL program. In the mid 1990s, the Air Force also studied outfitting F-15s with special air-to-air missiles to destroy TBMs in boost phase. Some in Congress have expressed their preference for UAVs over manned aircraft in this role. In its report (S.Rept. 104-112/S. 1026), the Senate Armed Services Committee wrote that "to the extent that kinetic-energy BPI systems hold promise for TMD applications, the committee believes that reliance should be placed on unmanned aerial vehicles (UAVs)."

Some constraints on ship-based missile defenses have been eliminated by the Bush Administration's decision to withdraw from the 1972 ABM treaty. Ship-based systems are attractive to missile defense planners because ships often can be maneuvered close to hostile areas. A number of BPI experiments are planned for FY2004 combining modified Standard anti-aircraft missiles with the Kinetic Kill Vehicle (KKV).[34] In July 2004 the Congressional Budget Office published a report in which five BPI options were explored. Two of these five options were space-based. While space-based options had some advantages over terrestrial options, such as greater global coverage, they also were much more expensive; perhaps prohibitively.[35]

Although platforms other than the ABL might conduct TMD BPI, it is also possible that the ABL might be capable of performing additional or alternative missions. When in charge of the program, the Air Force studied alternative roles for the ABL including cruise missile defense, destroying or disabling enemy satellites, or intercepting high altitude surface-to-air missiles. In November 2002, the Air Force Scientific Advisory Board recommended that the Air Force also consider using the ABL to attack time critical targets on the ground. In May 2005, the Commander of the U.S. Strategic Command reportedly advocated that alternative uses for the ABL be studied.[36] Potential alternate missions that have been discussed in 2006 include shooting down manned aircraft, cruise missiles, air-to-air missiles, and surface-to-air missiles. In addition to destroying these alternate threats, the ABL, some argue, could also contribute to a variety of command and control missions, such as airborne command and control, combat identification (CID), electronic support measures, and bomb damage assessment.[37]

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[34] Thomas Fuddy, "Study to Define Candidates for Sea-Based Boost-Phase Interceptor," *Inside Missile Defense*, May 29, 2003.

[35] *Alternatives for Boost-Phase Missile Defense*, July 2004. Available at [http://www.cbo.gov].

[36] Marc Selinger, "DoD looking at more roles for Airborne Laser," *Aerospace Daily & Defense Report*, May 12, 2005.

[37] Ann Roosevelt. "ABL Considers Missions Beyond Missile Defense." *Defense Daily*. January 23, 2006. Ann Roosevelt. "ABL Considers Future Contributions Beyond Missile Defense, Officials Say," *Defense Daily*. January 31, 2006.

Today, the only alternative — albeit similar — role that MDA is considering for the ABL is BPI of intercontinental ballistic missiles (as opposed to theater-range ballistic missiles). MDA officials state that they need to concentrate on developing the ABL's technology to conduct its primary mission of theater ballistic missile defense before ancillary roles can be considered. Others may question whether abandoning the assessment of alternative uses for the ABL is prudent. Congress has appropriated about $4.3 billion for the ABL thus far. Some are likely to maintain that more should be done to investigate potential returns on this investment. The ABL is DOD's most mature high power chemical laser program. If MDA determines that UAVs or ship-based KKVs offer more potential in TMD BPI, studying alternative uses for the ABL might be a way to exploit the advances made by the program.