AIRBORNE LASER (ABL)

Air Force ACAT ID Program

Total Number of Systems:	7 aircraft	
Total Program Cost (TY$):	$6335M	
Average Unit Cost (TY$):	$528M	
Full-rate production:	FY06	

Prime Contractor
Boeing

SYSTEM DESCRIPTION & CONTRIBUTION TO JOINT VISION 2010

The Airborne Laser (ABL) is intended to shoot down enemy theater ballistic missiles (TBMs) during their powered boost phase of flight. It is during this phase that TBM boosters are most vulnerable to laser radiation. The ABL engagement concept calls for the laser to focus on a distant missile's booster skin, rupturing it or damaging it sufficiently to cause the missile to lose thrust or cause a loss of flight control and fall short of its intended target. The aircraft will be a modified Boeing 747-400F (freighter), carrying a megawatt-class Chemical Oxygen Iodine Laser operating in the near infrared (1.315 microns). In addition to the laser, ABL will carry a beam and fire control system and a battle management, command, control, communications, computers, and intelligence (BM/C^4I) system. The beam control system will use adaptive optics to characterize and compensate for the degrading effects of atmospheric turbulence on the laser beam's propagation. The most notable feature of the aircraft will be the turret ball on its nose, which contains the laser's primary pointing mirror.

ABL will be rapidly deployable and add a boost-phase layer to the Theater Missile Defense's (TMD) Family of Systems. It will be positioned behind the forward line of friendly troops and moved closer towards enemy airspace as local air superiority is attained. The Air Force is proposing a seven-aircraft fleet, and envisions that five aircraft would deploy to support two 24-hour combat air patrols in a theater.

Theater missile defense is a central aspect of ***Joint Vision 2010***. ABL will utilize ***technological innovation*** to achieve ***precision engagement***. Operationally, it will provide ***full-dimensional protection*** of U.S. and friendly forces, cities, ports, airfields, and other infrastructure in the theater.

BACKGROUND INFORMATION

The technologies supporting ABL have evolved from more than 25 years of DoD and Air Force Research Laboratory (at Kirtland AFB, NM) work in the areas of laser power generation, pointing and tracking, and adaptive optics. In the early 1980s, the laboratory operated the Airborne Laser Laboratory, which successfully shot down five AIM-9 air-to-air missiles and a BQM-34 simulated cruise missile. In addition, the Strategic Defense Initiative Organization (now the Ballistic Missile Defense Organization) funded a number of efforts relating to adaptive optics and beam control. These technology investments established the technical feasibility of the airborne laser concept. In FY94, the Air Force launched a formal program that awarded two separate concept design contracts to competing teams. The program passed Milestone I and entered the Program Definition and Risk Reduction (PDRR) phase in November 1996. The Air Force selected a single team from the two competing concept teams by awarding the contract to the team of Boeing (prime), TRW (laser), and Lockheed Martin (beam control).

ABL successfully passed the first Authority to Proceed (ATP-1) decision in June 1998. This decision allowed the Air Force to commit to the purchase of a commercial 747-400, which is the airborne platform for the PDRR system. The ATP-1 decision was based on: (1) demonstration of a lightweight laser module; (2) demonstration of active tracking; (3) characterization of atmospheric turbulence; and (4) demonstration of compensation and fine tracking.

The ABL's budget for FY99 was reduced by $25 million, forcing a major restructure of the program. Planning for the restructured program was completed in March 1999, and resulted in a PDRR that was stretched by a year, with most major program dates (ATP-2, MS II, MS III) correspondingly delayed by a year. However, other than being delayed one year, EMD was unchanged. Within PDRR, some of the integration plans were changed and the funding for some test activities (e.g., atmospheric turbulence and lethality) was increased. More detailed PDRR test planning is currently underway in support of the PDRR Critical Design Review scheduled for April 2000.

An ATP-2 review is scheduled for late FY02. Current ATP-2 criteria include: (1) demonstrating performance of the integrated PDRR beam control system at low power; (2) laser scaling and multi-module operation of the PDRR laser modules; and (3) an integrated surveillance system performance. This review will authorize the long-lead purchase of the EMD aircraft. The PDRR-designed ABL will attain about half of the laser power planned for the operational system and should demonstrate the capability of the on-board BM/C^{4}I and beam control/fire control sub-systems. The PDRR ABL will undergo extensive testing to validate projected performance, and culminate with a series of lethal intercept demonstrations against boosting TBM-representative missiles beginning in late FY03. Milestone II for the ABL program is scheduled for FY04. After the EMD ABL is delivered, it will be used for both DT&E and IOT&E in FY05 and FY06. Milestone III is scheduled for 2QFY06.

TEST & EVALUATION ACTIVITY

The current ABL TEMP was approved in April 1996 in support of the November 1996 Milestone I decision. The System Program Office is working on an updated TEMP to reflect progress made in the program since Milestone I, and to reflect changes made in this year's restructure. TEMP development, which began in 2QFY99 after the restructure changes were accomplished, includes the detailed planning of PDRR ground and flight testing. Atmospheric data were collected in Korea and Southwest Asia over four seasons using balloons and aerothermal probes in FY98. In FY99, these data were reduced and analyzed to gain a better understanding of the operational turbulence levels ABL might encounter. Initial results of the data analysis show turbulence somewhat greater than predicted. Although these results tend to support the Air Force's estimate of ABL's performance, the margin between the designed and required performance may prove to be significantly less.

As part of the restructured program, plans have been made to collect additional atmospheric data with a stellar scintillometer; a more sophisticated measuring system. The stellar scintillometer will provide more direct measurements of atmospheric turbulence than can be provided with balloons and airborne aerothermal probes. Measurements with the stellar scintillometer occurred in 3QFY99 in the continental U.S., and seasonal measurements are scheduled in both Southwest and Northeast Asia in FY00.

In FY96, tracking and compensation demonstrations in support of ATP-1 were conducted at White Sands Missile Range and at MIT Lincoln Laboratory's Firepond facility. The restructured program added an additional series of tracking and compensation tests at White Sands' North Oscura Peak. The ranges at North Oscura Peak will be longer (~50 km) than in the previous tests (~5 km), and the path-integrated turbulence levels should be more representative of ABL engagements. Dynamic cooperative tests were completed in 3QFY99, and dynamic, non-cooperative tests are scheduled for 2QFY00.

As laser development continues, testing is also being performed to measure power and beam quality. In 3QFY99, the third phase of flight-weight laser module development and testing was completed. Several other development and test phases are planned during PDRR, leading up to the mature PDRR and EMD laser designs.

Another area of ongoing test activity pertains to lethality mechanisms. Several experiments have been conducted by the Air Force Research Laboratory to measure fundamental thermodynamic and optical properties of relevant materials, including some countermeasure candidates. These measurements include high temperature properties and the response of their materials. To gain a better understanding of the internal operating condition of an in-flight missile, critical components and sub-systems have been investigated under simulated flight and/or propulsive conditions.

PDRR testing will consist of a series of ground and flight tests that incrementally demonstrate capability, leading up to several end-to-end demonstrations of the full PDRR system engaging boosting TBM-representative missiles beginning in September 2003. The PDRR test program is closely tied to the integration schedule of the PDRR system, with ground and flight test activities scheduled after each stage of segment integration. The major segments of the PDRR system will be integrated in three major steps:

- Integration of the BM/C^{4}I on the aircraft.
- Integration of the beam control and fire control segment with the BM/C^{4}I and aircraft segments.
- Integration of the high-energy Chemical Oxygen Iodine Laser with other segments on the aircraft.

TEST & EVALUATION ASSESSMENT

DOT&E has several concerns regarding ABL's potential effectiveness. The effects of atmospheric turbulence and countermeasures may decrease the laser's lethal engagement range and force the ABL platform to move closer to enemy anti-air defenses. In addition, the interoperability aspects of ABL testing, including cross-cueing and damage assessment of successful intercepts and support of other TMD systems, need to be fully explored through simulation and demonstration. These and other issues will continue to be tracked by DOT&E. DOT&E has noted specific technical challenges faced by ABL, including the:

- Development of an autonomous surveillance system onboard the ABL that provides timely, accurate missile targeting information required to meet stressing ABL engagement timelines.
- Contractor's ability to build Chemical Oxygen Iodine Laser flight modules that provide adequate power for the operational system and are sufficiently low weight to fit within the current aircraft platform capabilities.
- Development and demonstration of a laser beam compensation and tracking system that meets stringent pointing and tracking requirements for engaging ballistic missiles.
- Demonstration of a fully capable BM/C^{4}I system in the PDRR system that interacts in real-time with other TMD systems for cross-cueing and fire control.
- Ability of the contractor to successfully integrate all of the above systems into the finite weight and volume limitations of the 747-400 aircraft.
- ABL's ability to meet the reliability and maintainability requirements without excessive contractor support.
- Limitations and vulnerabilities of the planned ABL lethality mechanisms against all threat missiles, and the potential effects and responses to predicted enemy countermeasures.

In general, the $25 million FY99 congressional cut slipped most ABL milestones by approximately one year. Risk reduction activities were added to PDRR, but current ABL acquisition strategy remains essentially unchanged; PDRR simply takes place over a longer period of time. The risk reduction efforts added by the Air Force after ATP-1 will serve to demonstrate key ABL operational capabilities through ground testing at the component level as soon as possible.

The top-level ABL operational issue is whether it can meet its Probability of Kill and weapon range requirements in operationally representative scenarios using laser dwell times that support multiple, near simultaneous launches and conserve laser fuels. An important point related to this issue is that the ABL Operational Requirements Document does not currently require ABL to have the capability to handle multiple, near simultaneous theater ballistic missile launches, although the ABL Technical Requirements Document does. This requirement will need to be addressed at future program milestones, and an update to the Operational Requirements Document is expected.

Since the ABL is a radically new weapon system, it is a high-risk development program. There is a significant amount of test activity planned for PDRR. These tests will address the fundamental ABL issues of atmospheric turbulence and compensation, lethality, laser development, and performance. As the system is developed and integrated, tests will demonstrate, in a logical progression, increased capability. In light of these challenges, DOT&E has several concerns regarding the adequacy of the test program planned for ABL. A primary concern is that the EMD phase is very short (24 months); six months have been planned for IOT&E during EMD. Unless tremendous maturity can be demonstrated during PDRR, this compressed schedule adds unnecessary risk to the EMD phase. The ABL schedule is driven by a high risk, success oriented, development program that underestimates the amount of testing required to verify integration and operation of sub-systems (laser generation, target detection, beam control, and BM/C^{4}I) onto the aircraft, as well as the operational utility of the aircraft. Although EMD is still several years away, more definitive test planning for developmental and operational testing must begin now. DOT&E will closely monitor these test activities to ensure that, where possible, risk is reduced. In accordance with DOT&E concerns, we would highlight the following areas:

- Although the PDRR contains a reasonable amount of testing, the pace of test activity is very ambitious and success-oriented. For example, the program plans on conducting 79 engagements during PDRR, but there will only be approximately 14 flight-test months available. Of these 79 engagements, 36 will involve the Chemical Oxygen Iodine Laser weapon, with only ten months available between final integration in May 2003 and the Milestone II scheduled for March 2004.

- The EMD schedule is not considered executable as planned. Detailed EMD test planning has not begun, but only two years have been allocated for the entire EMD phase. Fabrication, assembly, and integration of the EMD system will take place during this two-year period, leaving the remaining time to conduct DT&E and OT&E before Milestone III. The short EMD schedule was originally justified on the basis that the PDRR and EMD systems would be very similar, but due to cost and performance trades, the two system designs are diverging.

- The ABL STAR lists approximately 30 missiles that the ABL must effectively negate. These missiles include a diverse range of operating characteristics, including liquid and solid-fueled, single and multi-stage, and metal and composite-body missiles. End-to-end testing may be limited to only one or two of these missile types. Developing surrogates for all threats in the STAR is a costly and unlikely option. Thus, data will have to come from other sources, including laboratory and sub-scale ground testing and modeling and simulation. Many lethality test activities are planned, but a comprehensive lethality plan should be developed to ensure that test activities support the data requirements in the overall test plan.

Operational suitability is an important focus on the ABL because it implements many state-of-the-art technologies. Indeed, many of the ABL technologies, such as high-energy gas lasers and optics, have been traditionally employed in laboratory environments and not on operational, flying military systems. This includes toxic chemicals and attendant safety procedures. The test teams in both PDRR and EMD must ensure attention to operational suitability. The EMD phase must contain enough testing to ensure that suitability can be adequately evaluated.

DOT&E is working with the ABL program office to ensure that critical data concerning ABL's projected performance are available at planned program decision points. DOT&E will continually assess and analyze the technical challenges to ABL to ensure, as possible, that developmental risk is minimized. ABL technical challenges include:

- Effects of atmospheric and airframe generated boundary layer turbulence and the ability of adaptive optics to counteract these effects in a real-time, closed-loop manner against a non-cooperative target.
- Integration of highly sensitive optical instruments into a dynamically vibrating air platform.
- Software development, integration, and testing of the critical ABL BM/C^4I system.
- Validation of ABL's potential to achieve expected kill mechanisms against the full spectrum of threats, launch scenarios, countermeasures, and missile dynamics.