ABL Laser Weapon

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Abstract

The focus of this paper is to overview the technologies that are a part of the Airborne Laser (ABL) project. The Airborne Laser project is designed to build a plane that is capable of shooting down intermediate range ballistic missiles. As these types of missiles are a great threat to our armed forces in war, the need for a better defense is eminent. The ABL system is capable of shooting down ballistic missiles while hundreds of miles from the missile launch sites, autonomously. All of the technology is carried inside and mounted to a highly modified Boeing 747-400 freighter. In this paper, more emphasis is put on the optical system and lasers onboard the ABL.

There have been many attempts at integrating lasers into military applications ever since lasers became known as a physical threat. Thus far, no laser has ever been successfully used in war for purposes of destruction or other harm. If the ABL system meets the rest of it’s milestones it will be the first deployable laser weapon known to man. This comes at a time when it is needed most. Ballistic missiles are now one of the biggest threats to American and allied armed forces. The shorter range ballistic missiles are especially hard to destroy as they are only aloft for a very short amount of time. Previous methods and attempts at destroying them often end with minimal results and limited success. However, a laser travels at the speed of light and therefore would be the fastest known method to destroying missiles once they are launched.

This is an interesting topic not only for the great technology behind it, but also for its intrigue as a science-fiction type scenario. To be able to shoot a missile out of the sky with a laser is the type of things you read in a fiction, now it can be a reality. There is also a lot of interesting physics and engineering behind something of this magnitude. Personally, the laser application is of great interest, including the ranging laser and high-energy laser involved with the ABL system.

The drawing shown in figure 1 is a rendition of the steps to successfully shooting down a typical ballistic missile with the ABL system. It is important to understand what this process is, so a brief description follows. The goal of the ABL is to attack a missile in its boost phase, which is seconds after it has been launched, and while it is still producing a plume behind it from the boost process. To detect this, the ABL has 6 infrared sensors positioned on the outside of the plane at different locations. These can sense the plume from the missile either autonomously or with the help of launch-detecting satellites. The range for these sensors is on the order of several hundred kilometers.
Once the missile has been detected the ranging laser, a CO2 laser, swings around and locks on to the missile. It then reports the distance and stays locked on to the missile. The next step is for the track illuminator laser to be aimed at the missile and it determines a location on the actual missile which will be attacked. This laser is fired through the nose turret on the plane and through all the optics inside that can also adjust for aircraft vibration. Along with this, the beacon illuminator laser is directed along the same path as the track illuminator laser to the missile. The beacon illuminator laser however is expanded as it goes through a 1.5 meter telescope inside the optics of the system. This laser serves the purpose of characterizing the missile’s dimensions through the beam-control adaptive optics.

Now that the missile has been completely diagnosed and is locked on, the high-energy laser (figure 2) is fired at it to destroy it. The laser is fired through the nose turret immediately following the beacon illuminator laser. It is focused from 1.5 meters in diameter to a small spot size on the missile’s exterior. Typically aimed at the missile’s oxidizer or fuel tank, the laser will cause the missile to explode in mid air. This only takes 2-3 seconds.
of focusing the high-energy laser on the missile before it is destroyed. Then the ABL is ready for another missile. The whole process is done extremely quickly as these short and intermediate range missiles are not in the air for very long at all.

The high-energy laser is a Chemical Oxygen-Iodine laser (COIL) operating on a megawatt scale of power. The wavelength of the laser light is at 1.315 µm, this is found to be in the near infrared range, just on the edge of not being visible. To pump the laser there are six van-size modules at the back of the airplane. These modules combine hydrogen peroxide with chlorine gas to produce an excited form of oxygen known as singlet delta oxygen (SDO). Then iodine granules are cooked in ovens onboard the plane to form iodine gas. The laser is then pumped with the mixture of SDO and iodine gas which causes it to lase. The photo in figure 3 shows the laser pumping device after some revisions.

The high-energy laser was built by Northrop Grumman Space Technologies (formerly TRW) and is housed in the rear section of the plane. The laser beam then passes through special pipes towards the front of the airplane. Along this path it travels through a Station 1000 bulkhead/airlock (figure 4, Boeing) which separates the laser compartment from the rest of the plane. This bulkhead serves as a constant remote environment monitor and acts to pressurize both sides of the cabin.

After passing through the bulkhead the laser goes through Lockheed Martin’s Beam Control/Fire Control system, mounted on a vibration isolated optical bench. This is the intricate setup of all of the optics involved with the laser; it also ties into the computer system onboard the plane. The purpose of the system is to maintain that the laser is accurately aligned and pointed at the target regardless of the target location and other atmospheric conditions. Along with these the segment provides several other functions for the weapon system:

1. Acquisition, Tracking, and Pointing (ATP) of a target
2. Fire Control engagement sequencing, aim point-and-kill determination
3. High-energy laser (HEL) beam wavefront control and atmospheric compensation
4. Jitter control, alignment/beam-walk control, and beam containment for HEL and illuminator lasers
5. Calibration and Diagnostics to provide autonomous real-time operations, and post-mission analysis.

There are three assemblies to the Beam Control/Fire Control system. Working backward from the front of the plane first is the turret assembly (figure 5). Not only is it used to fire the illuminating and high-energy laser beams, it also can be used as a target acquisition system. As such it contains a 1.5 meter rotating telescope utilizing passive flow control to
minimize aero-optical distortion. This telescope helps to pinpoint the missiles.

The Beam Transfer performs all the sensing of target information and ambient environment, and the subsequent control applied to the laser beams. This is done through the use of Common Path Common Mode (CPCM) architecture for wavefront and fine tracking sensing and control along with a beam path conditioning system and automatic calibration alignment. The two illuminator laser beams are used to gain certain information from the missile and the atmospheric conditions surrounding it. This data is then used to control a set of deformable mirrors for wavefront compensation and a set of fast-steering mirrors for beam stabilization. These corrections are also applied to the COIL high-energy laser beam to make sure that it falls right on target.

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Finally the Fire Control assembly is used as the brains behind all the physical changes to the laser beams. It consists of distributed, parallel, and multi-processor architecture for signal processing and control along with other important features. These three systems make up the control architecture for the laser beam modification and firing mechanisms. The extent of the information is limited due to this still being a classified military project.

**Conclusion:**

Before starting this project I had no previous knowledge of any high-energy laser technology being used. Upon seeing the article in the magazine, I was immediately intrigued by it. As a result of this project I have learned a lot about how much it takes to integrate many technologies into a final project. I have also realized the vast importance and effectiveness in solving problems that optics systems can provide. This is especially true for laser systems where optics is essential to a laser’s functionality. This field would be one that I would consider going into as it grasps my attention constantly.
Works Cited:


Electronic:


Image Appendix
*Images are typically of high resolution and can be expanded to view at greater detail.

Turret window being etched very precisely

Front view of the turret installed on the Boeing 747

Mirrors being etched for use in the beam control system