Efficacy of Airborne Laser Weapons in Future Warfare

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Not so long ago, laser weapons were only an idea depicted in sci-fi movies. While it was exciting to see how high-powered lasers could be used as weapons against an enemy force, the actual use of such technology on the battlefield seemed to be a distant dream. However, technological development and research over the last four decades transformed this distant dream into reality when the US Air Force (USAF)'s "Airborne Laser (ABL)" program mounted a laser weapon system on its Boeing 747.

Background

The ABL initiative's origin can be found in the 90s given the convergence of crucial technological developments, operational necessity, and individuals who pushed the program forward. Weapons proliferation with stockpiles of all kinds of missiles had steadily grown in several developing states.[1] By1996, around 20 countries had joined the "ballistic missile club" with several more eager to join. Furthermore, the difficulties faced during *Operation Desert Storm* compelled the United States to focus on the development of weapon systems that could defend against theater missile attacks and this necessity highlighted the importance of the ABL program.[2] Moreover, during the Gulf War, the US forces failed against Iraqi ballistic missile attacks. The Iraqi military fired almost 100 modified Soviet Scud-B missiles at US forces based in Saudi Arabia but the "Patriot Advance Capability-2 (PAC-2)" was unable to detect and destroy the Scuds. The Patriot missile system could detect and target only 40% of the Scuds, and out of those detected, the kill ratio was 1 in 6. In fact, several experts even questioned this success and the efficacy of Patriots against the Iraqi missile system.

Considering the threat, officials at the Theater Missile Defense section at the Department of Defense (DoD) and the Strategic Defense Initiative Organization (SDIO) concluded that the threat could not be countered by one system single-handedly. Instead, a "balance of

[1] L. Ross, C., 2011. Origins of the Airborne Laser. *Air Power History*, 58(1).
[2] Ibid.

integrated attack operations, comprehensive active defense against missiles in flight, extensive passive measures, and a robust C^3I and surveillance capability" was needed. Within this conception, ABL fits in the "boost-phase intercept" tier. Basically, ABL is a laser system deployed on an airborne platform consisting of four distinct laser systems and an "adaptive optics system."[3] The ABL-equipped aircraft orbits at approximately 40,000 feet. Whenever an enemy missile launch is detected, the ABL's Active Ranger System detects it and transmits the data about launch.[4] The Track Illuminator Laser (TILL) detects the missile and tracks its trajectory. Meanwhile, the ABL's Beacon Illuminator Laser (BILL) calculates the atmospheric variables between the aircraft and the incoming missile. After these calculations, the Chemical Oxygen Iodine Laser (COIL) is fired by the ABL using the Adaptive Optics System to balance the atmospheric turbulence and, COIL heats the boosting missile until her systems are incapacitated. ABL can be effective from long distances due to its delivery of the laser at the speed of light, allowing the ABL to stay within friendly air space and engage targets hundreds of kilometers away. This technology combination made the ABL formidable for theater ballistic missile defense; and seen as an "innovative laser missile defense program."

Current Developments

Lockheed Martin (LM)—an American aerospace, arms and advanced technologies company—has committed to equipping an aircraft with a "defensive laser weapon" in the next 5 years.[5] Its "Tactical Airborne Laser Weapon System" would aid in shooting down incoming missiles, for example, "surface-to-air missiles or air-to-air missiles."[6]

Lockheed Martin is also actively working on podded laser technology and enhancing production capacity. According to Mark Stephen, head of LM Missiles and Fire Control's

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[3] Stupl, J. and Neuneck, G., 2010. *Assessment of Long Range Laser Weapon Engagements: The Case of the Airborne Laser*. [online] Taylor & Francis Online. Available at: <https://www.tandfonline.com/doi/abs/10.1080/08929880903422034>.

[4] Ibid.

[5] Reim, Garrett. "Lockheed Martin Aims to put Laser Weapon on Aircraft in Five Years." Flightglobal.Com, 2020. https://www.flightglobal.com/fixed-wing/lockheed-martin-aims-to-put-laser-weapon-on-aircraft-in-five-years/140204.article

[6] Ibid.

Strategic Technology Development Efforts, “We’re making capital investments to be ready to manufacture key high-energy laser components at full-production rates and low cost. We’re investing over $20 million in our Orlando-based optical component center to expand the manufacturing footprint by 40%,” In fact, Lockheed Martin intends “to use this space to establish low-risk production processes that enable for us to build critical laser weapon optical components, some of which have never seen a production line at the rates our customers need.”

Furthermore, Lockheed Martin is also developing a high-power fiber laser for the “Self-protect High Energy Laser Demonstrator (SHiELD)” program of the USAF Research Laboratory. It initially envisioned mounting a miniature laser on a fighter jet by 2021, but due to technical problems, it has been delayed until 2023.[7]

Nevertheless, Lockheed Martin remains optimistic about laser technology. In Mark Stephen’s view, the company “would look at transitioning the capabilities from SHiELD into a laser pod with improved [size, weight, and power consumption] based on the investments that we’re making.” The airborne laser system is going to be based on the company’s experience of assisting the US Navy to develop “High Energy Laser” with “Integrated Optical-dazzler and Surveillance” effort and US Army’s “Indirect Fire Protection Capability-High Energy Laser.” Both these surface-to-air lasers have the capability to disable UAVs or loitering munitions. The Sniper pod, according to Stephen’s “has lasers inside of it that have to be maintained onto a target during high-speed maneuvers in flight.” He further adds, “So, the

[7] Keller, John. "Tactical Airborne Laser Weapons: Where Are We Now, And How Far Do We Have To Go To Get There?" *Military Aerospace*, 2017. https://www.militaryaerospace.com/power/article/16726321/tactical-airborne-laser-weapons-where-are-we-now-and-how-far-do-we-have-to-go-to-get-there.

technology and the algorithms we've developed over the last 40 years on those types of electro-optical systems with laser designators in them are directly applicable from a pointing and jitter control standpoint."

In order to drive the high-energy laser, capacitors or batteries would be charged using the parent aircraft's jet turbine. Till date, Lockheed Martin has declined to reveal the system's technical parameters, including firing rate of the laser and its range etc. It is worth mentioning that such dynamics would be contingent upon the objective that USAF desires to defend.

Likewise, China is striving to equip its fighter jets with airborne laser pods.[8] The *South China Morning Post* reported that "the official weapons and equipment procurement website of People's Liberation Army (PLA) has invited defense contractors to provide information about airborne laser attack pod."[9] The pod, depending on its power level, could be used against an incoming missile threat or against an adversary's aircraft and other ground or sea-based targets. According to Wei Hu Tang, a military affairs analyst, China has already developed a 100-kilowatt airborne laser weapon.[10] The airborne pods would be mounted on "Shenyang J-15 Flying Shark" carrier-based fighter, "J-20 Mighty Dragon", and support aircraft such as the "Xi'an Y-20".[11] The employment of these laser pods would be determined by the amount of power available, with lower level lasers being used to shoot down, disable air-to-air missiles (AAMs), or blind enemy pilots, and higher power weapons being used to damage or destroy aircraft or larger ballistic missiles.

On the other hand, Russia is developing an airborne laser weapon system to counter space-based missile defence sensors. The program initially started during Soviet era and the laser-mounted Ilyushin IL-76MD-90E transport plane had its test flight in August

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[8] Mizokami, K., 2020. *China's Airborne Laser Weapon Would Change Dog fighting Forever*. [online] Popular Mechanics. Available at: <https://www.popularmechanics.com/military/aviation/a30502725/china-airborne-laser/>.

[9] Ibid.

[10] Szondy, David. "Laser Weapons: Is this the Dawn of the Death Ray?" *Newatlas*, 2018. https://newatlas.com/laser-weapons-future-warfare/52801/.

[11] Stupl, J. and Neuneck, G., 2010. *Assessment of Long Range Laser Weapon Engagements: The Case of the Airborne Laser*. [online] Taylor & Francis Online. Available at: <https://www.tandfonline.com/doi/abs/10.1080/08929880903422034>.

1981.[12] However, the program collapsed following the dismemberment of Soviet Union. The project was revived in 2009, but again discontinued in 2011 due to lack of funding. Recently, it was restarted because of the increasing risk from space-based threats.

Efficacy of Airborne Laser Weapon Systems

Directed Energy (DE) and ABL weapons are a more effective solution to addressing tech-driven threats with a superior performance than offered by traditional missiles. The speed of the laser beam offers real-time data transmission when the target is spotted, and provides extremely focused energy by converting laser into thermal energy inflicting material damage to the target systems. Lockheed Martin's Senior Fellow, Laser and Sensor Systems, Dr. Rob Afzal observed that, "They're designed to be precise, to yield minimal collateral damage and, in essence, offer an endless magazine."[13] He further added, "As long as you have power, you can shoot—that's a critical capability when you have to take on a large number of low-cost distributed threats such as a swarm of drones, each carrying a small explosive."[14]

Analysis

From a military standpoint, there are numerous advantages of using laser DEW. Some of the potential advantages include:

- Laser beams can travel at the speed of light. This greatly streamlines targeting, since there is no need to calculate the trajectories of projectiles. Additionally, the laser beam can travel in a straight line for virtually hundreds of miles. On the flip side, it could complicate maneuvers for an evasive target.

[12] Eshel, T., 2016. *Russia Plans to Deploy Anti-Satellite Airborne Laser Weapons*. [online] Defense Update. Available at: <https://defense-update.com/20160926_a60.html> [Accessed 13 May 2021].
[13] Lockheed Martin. 2021. *How Laser Weapons are changing the Defense Equation*. [online] Available at: <https://www.lockheedmartin.com/en-us/news/features/2019-features/how-laser-weapons-are-changing-the-defense-equation.html> [Accessed 15 May 2021].
[14] Ibid.

- Laser weapon systems are highly accurate. In comparison to a missile that would follow an arched path, the laser travels in a straight line and engages the target with accuracy and precision.
- The effects of a laser on a set target can be adjusted if one with variable output power is used. However, a precondition for that is that resulting laser intensity on target and damage mechanism needs to be well understood.
- Laser weapons are also highly controllable. They can be adjusted to cause only the desired damage. Additionally, the laser beam can even distinguish between different materials so that only the target is engaged and collateral damage is minimized.
- Advent of fiber technology has made the size of laser weapons significantly smaller than traditional weapons. This means that they can be mounted on aircrafts and warships.

Conclusion

Airborne lasers are still in their nascent stage of development and are a long way from becoming a standard battlefield weapon. Nevertheless, efforts are underway by major powers of the world to develop and advance this technology. While it is unlikely that airborne lasers weapons would replace traditional weapons, they would provide offensive and defensive capabilities that may render various military technologies obsolete or fundamentally change how they would be employed.

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