2019-12

Counter Directed Energy Warfare (CDEW)

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Monterey, California: Naval Postgraduate School

NPS NRP Executive Summary
Evaluating the Effectiveness of Counter Directed Energy Weapon (CDEW) Technologies and Strategies
Report Date: 10/14/19 Project Number (IREF ID): NPS-19-N003-A
Naval Postgraduate School

NAVAL RESEARCH PROGRAM
NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

EVALUATING THE EFFECTIVENESS OF COUNTER DIRECTED ENERGY WEAPON (CDEW) TECHNOLOGIES AND STRATEGIES

Period of Performance: 10/15/18 – 10/14/19

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Prepared for:
Topic Sponsor Lead Organization: ASN(RDA) - Research, Development, and Acquisition
Topic Sponsor Organization: Office of Naval Research (ONR)
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EXECUTIVE SUMMARY

Project Summary

Directed-energy weapons (DEWs) will proliferate and become a threat exploited by adversaries due to high potential mission success and low cost per engagement compared to traditional weapons. DEWs are systems that use electromagnetic energy to damage a target, resulting in disruption or neutralization of the target. DEW technologies include high-energy laser (HEL) and high-power microwave (HPM)/high-power radio frequency (HPRF) weapons. Counter DEW (CDEW) methods and capabilities will be required to defend against these novel threats. This research project studied the potential DEW threat environment, identifying potential naval asset vulnerabilities and CDEW methods and strategies. The study produced high-level concepts and has laid the foundation for future studies and planned research efforts.

Keywords: *directed-energy weapon, DEW, counter directed-energy weapon, CDEW, high-energy laser, HEL, high-power microwave, HPM, high-power radio frequency, HPRF, combat identification, CID*

Background

Recent DEW developments by China and Russia are prompting the study of strategies and capabilities for countering these potential threats. Reports from as recently as May 2018 cite that China has been developing laser weapons "ranging from low-powered tactical beam emitters to a high-energy strategic weapons system (Zhen 2018a)." China's laser systems include: (1) ground or vehicle-based systems with 10kW of power that can destroy small fixed-wing aircraft, helicopters, and drones at low altitudes and short ranges (2km); (2) a larger 30-100kW vehicle-based system with a larger range (4km); (3) a vehicle-based electro-optical system to support early warning, missile guidance, and lethal capabilities; and (4) individual low-power laser guns that can dazzle or blind an enemy from a short range. It was also reported in May 2018 that two U.S. pilots were injured by military-grade lasers shone into their eyes from China's naval base in Djibouti (Zhen 2018b).

In March 2018, a leading Russian defense official confirmed that laser weapons alluded to by President Vladimir Putin are in service and capable of disarming targets with rapid precision (O'Connor 2018). Less is openly known about Russian DEW capabilities. However, it is reported that Russia is working on aircraft-mounted lasers as part of an "anti-satellite complex (Killalea, 2018)," and a ground vehicle-based high-energy laser (mounted on "massive low-bed wheeled trailers") possibly for anti-missile defense.

The potential consequences of adversarial DEW capabilities are numerous. They could affect military communications through anti-satellite and anti-electronic capabilities. They could affect situational awareness by blinding or dazzling our sensors and through the anti-satellite and anti-electronic capabilities. They could also attack drones, small aircraft, helicopters, and small boats. These capabilities could be harmful to the Navy's ability to operate in maritime and littoral regions. It could also affect naval logistics and support platforms.

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Various technologies and strategies have recently been considered for countering DEWs. Technological approaches include target hardening such as reflective coatings and the use of materials with improved thermal properties and exotic metamaterials that can potentially bend electromagnetic waves around a target (Hewitt 2017). Strategic approaches include evasive maneuvers, deployment of decoys or obscurants, and swarm attacks.

Findings and Conclusions

Through a process of data gathering, concept development, and analysis, this project conducted a high-level study of the naval tactical CDEW domain. The purpose of the study was to better understand the future directed energy (DE) threat environment, potential effects on naval assets, and to develop conceptual CDEW solutions. The results of this study provide a knowledge foundation for the Office of Naval Research and the naval DE community.

Two capstone projects by Naval Postgraduate School (NPS) master's students in systems engineering are underway to support this research project. The first student team is studying the potential effects of a future DE threat environment on naval unmanned aerial vehicles (UAVs) (Ansley, et al 2019, 2020). This group started its project during the summer 2019 quarter and will finish in March 2020. They are studying UAV vulnerabilities in an adversarial DE environment. They are developing and evaluating concepts for CDEW strategies and methods that can defend naval tactical UAVs against DEW threats. A second student team has begun performing a similar study for manned naval aircraft (Murray, et al, 2020). This team will graduate in September 2020.

This study began the process of understanding the possible future DE threat environment. This task was organized into four categories: possible adversarial DE threats, threat characteristics, naval tactical assets at risk, and naval tactical mission affected. This research is still underway with a white paper report (Johnson 2020), and a related presentation (Johnson 2019) that will be made at the Directed Energy Professional Society Symposium in November 2019.

This project included a high-level study of DE threat identification, or DE combat identification (CID). A need was identified for tactical warfighters to be made aware of DE threats in the operational environment. Three types of DE CID were identified and studied. The first is preventative DE CID in which intelligence, surveillance, and reconnaissance means would find possible adversarial DE weapons before they are used. The second is a real-time detection ability that can identify that there are active DE weapons being used in an operational environment. The third would be a battle damage assessment capability that would identify that a naval asset had been lased after the fact—perhaps being the target of a laser soft-kill or hard-kill. A DE CID capability could include the ability to determine attribution—identifying the specific adversary responsible for a DE attack. The capability could also include identifying threat classification to determine the type of DE weapon and characteristics such as power level.

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One purpose of this project was to study CDEW methods and strategies that can be used to defend naval tactical assets against potential adversarial DE threats. A literature review and discussion with subject matter experts identified methods involving protective coatings and materials, the use of the atmospheric and environmental effects to obscure and protect assets, the use of decoys and countermeasures, and a concept for implementing swarms of UAVs for safety in numbers. Research in this area is ongoing with the student capstone projects.

This study identified an additional outcome that could support the NPS DE modeling and simulation (M&S) project that has recently been initiated. The M&S project is modeling a variety of naval tactical operational scenarios involving HELs. This CDEW project produced adversarial DE threat scenarios that can be used to analyze the DE environment as well as support DE wargaming in the M&S system. The M&S project could include models of adversarial DE threats, models of the effects of these threats on naval assets, and models of CDEW strategies and methods. The M&S could model both soft-kills and hard-kills as well as anti-satellite, anti-UAV, anti-aircraft, and anti-ship DE weapons.

Recommendations for Further Research

This study lays the foundation for further research in the following areas: DE threat characterization, DE threat identification, development of CDEW methods and strategies, and CDEW modeling and simulation.

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Acronyms

Directed Energy	DE
Directed-Energy Weapon	DEW
Combat identification	CID
Counter Directed-Energy Weapon	CDEW
High-Energy Laser	HEL
High-Power Microwave	HPM
High-Power Radio Frequency	HPRF
Modeling and Simulation	M&S
Naval Postgraduate School	NPS
Unmanned Aerial Vehicles	UAV