Nonlethal Small-Vessel Stopping With High-Power Microwave Technology

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **2012**	2. REPORT TYPE	3. DATES COVERED **00-00-2012 to 00-00-2012**
4. TITLE AND SUBTITLE **Nonlethal Small-Vessel Stopping with High-Power Microwave Technology**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center, Dahlgren Division,Corporate Communication, C6,6149 Welsh Road, Suite 239,Dahlgren,VA,22448-5130**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES **See also ADA556728.**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

The employment of small vessels to attack merchant ships and other seafaring units has emerged as a significant threat to international navigation and safe operations on the high seas. Along with swarm tactics, small vessels have been known to carry improvised explosive devices, help smuggle terrorists and weapons, and serve as attack platforms on the water for larger weapons. While kinetic solutions serve as the decisive option, alternative solutions that employ nonlethal means are being explored. A depiction of a swarm of small vessels ready to attack is shown in Figure 1.

The Naval Surface Warfare Center, Dahlgren Division's (NSWCDD's) Directed Energy Warfare Office (DEWO) is evaluating directed-energy (DE) concepts based on high-power microwave (HPM) technology for nonlethal vessel-stopping applications. Nonlethal weapons are defined by the Department of Defense (DoD) as weapons that are explicitly designed and primarily employed so as to incapacitate personnel or materiel while minimizing fatalities, permanent injury to personnel, and undesired damage to property and the environment.[1]

Several methodologies exist for using nonlethal means to stop small vessels. They include:

- Running-gear or prop entanglement systems
- Exhaust stack blockers
- A sea-anchor vessel-stopping system, which casts a net across the bow of a vessel to impart resistance
- Small-craft disablers, which insert a spear into the hull and deploy a fin that drags in the water, making steering impossible

Prop entanglement systems, exhaust stack blockers, and sea-anchor systems are useful and effective, but all are operationally difficult to deliver when deployment methods rely on positioning them in front of, or directly over, a vessel moving

Figure 1. Depiction of a Small-Vessel Swarm Ready to Attack

at high speeds. Small-craft disablers also are a formidable vessel-stopping solution and may be easier to deploy, but they cause permanent damage to the vessel in question.

Under the direction of the Joint Non-Lethal Weapons Directorate (JNLWD), the DEWO is in the initial stages of a multiyear effort to evaluate DE concepts for nonlethal vessel-stopping applications. It is currently focusing on HPM technology. This technology uses HPM sources to radiate radio frequency (RF) pulses downrange to interfere with motor-control electronics and significantly impede or stop small-vessel motors with minimal collateral damage. These RF pulses can be generated using different technologies ranging from wideband LC oscillators and microwave tubes (e.g., magnetrons, klystrons, and backward wave oscillators) to emerging solid-state technologies (e.g., nonlinear transmission line and photo-conductive switching). An outboard motor on a test stand is shown in Figure 2.

In comparison to kinetic weapons or other nonlethal systems, HPM avoids gross physical destruction to the vessel while, more importantly, providing zero-to-low risk of human injury. HPM accomplishes this at safe distances using speed of light delivery, therefore making evasion difficult, if not impossible, with the added benefit of scalable effects ranging from disruption to damage. Despite its numerous advantages, the use of HPM technology as a nonlethal weapon presents challenges as well, including a trade-off between system size and standoff range. This is particularly important when considering the use of HPM systems in different environments.

Upfront HPM source development costs represent one of the biggest challenges. However, long-term savings associated with HPM technology can offset this challenge. For example, prop entanglement systems might be deployed only once before they are rendered useless. HPM sources integrated onto a ship or other military vehicle can be employed in potentially thousands of missions, therefore resulting in a lower cost per single use, bringing overall associated costs of the system down significantly. Priorities for HPM nonlethal weapons include developing a system effective against different types of small vessels.

NSWCDD's Directed Energy Division began HPM susceptibility testing to determine the effectiveness of HPM weapons against relevant outboard engines. This involves testing small vessels in

Figure 2. Outboard Motor Test Stand

a variety of environments, including reverberation and anechoic chambers, and open-air testing. All help identify different, effective waveform parameters such as frequency, pulse width, rise time, and required power or energy on target. They further facilitate the identification of design specifications necessary for an eventual HPM source. This source, once developed, will then be integrated into one of several potential platforms. Candidate concepts of deployment include U.S. Coast Guard and naval vessels in addition to unmanned surface or aerial vessels. Another potential application might be to supplement existing Coast Guard or Navy platforms used for fast-boat interdiction with an HPM vessel-stopping capability. A small-vessel test using an HPM source is shown in Figure 3.

Developing solutions for the growing threat that small vessels pose to navigation and safe operations in the world's oceans is one of JNLWD's top priorities. Using nonlethal HPM weapons to stop vessels will provide the warfighter with a viable option for swarm threat and fast-boat interdiction. DEWO is working diligently to accelerate this technology and provide a DE alternative to kinetic weapons and fulfill this long overdue capability gap.

Reference

1. *Department of Defense Dictionary of Military and Associated Terms*, Joint Publication 1-02, 12 April 2001 (as amended through 19 August 2009).

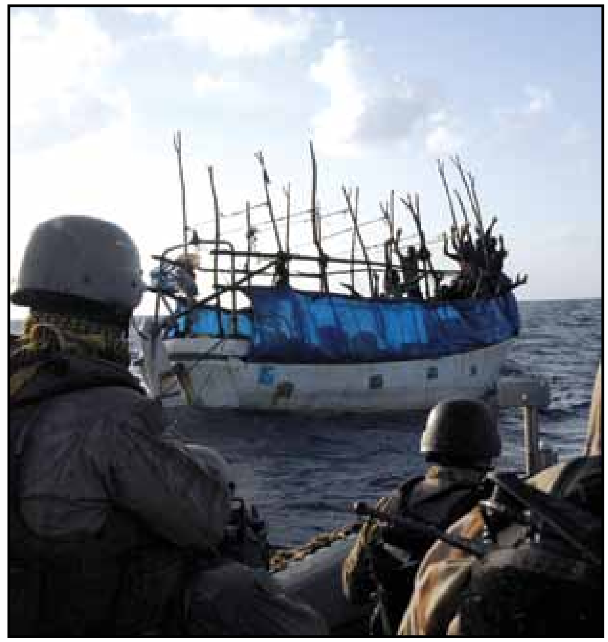

Figure 3. Small-Vessel Testing Using a High-Power Microwave Source