Non-lethal deterrents are being used in maritime security to assault the senses with light and sound, providing an escalating threat response.

By Jon Rosamond

The Laser Weapon System was successfully trialled aboard the USS *Ponce* during a deployment to the Persian Gulf in late 2014. (Photo: USN)

SOUND AND FURY

While laser weapons designed to inflict permanent blindness are outlawed under a 1995 UN protocol, laser dazzlers are permitted because their operational rationale is visual disruption – brief flashes of intense light to warn the unwitting intruder that they are approaching a protected maritime space, or longer exposures to disorientate or temporarily blind the more determined aggressor.

High-end directed energy weapons – such as the 30kW Laser Weapon System deployed from 2014 aboard the USS *Ponce* and the 100-150kW demonstrator being developed by Northrop Grumman for USN service in the 2020s – are intended primarily to destroy swarming boats and unmanned aircraft, but they also promise an unprecedented ability to respond in a graduated manner to a variety of threats. Such a response could start with a visual warning and escalate to reversible jamming of sensors, to inflicting limited material damage and – if the threat persists – to causing disabling damage.

Handheld help

More appropriate for the maritime and port security sector however are the significantly smaller devices, often handheld, that use diode-pumped solid-state lasers to emit beams of green light. These are the preferred choice for security tasks because the human eye is four times more sensitive to green light than red in daytime and about 360 times more sensitive at night.

One of the most successful companies in this field is US-based BE Meyers, whose promotional literature for its Glare LA-9/P

and Glare Recoil laser dazzlers puts a special emphasis on measures designed to prevent accidental eye injury. The LA-9/P is the larger of the two devices and features a 250mW (maximum output) green laser for hailing and warning at distances of up to 4km at night and 1.5km in daylight. More debilitating 'offensive glaring' – intended to stop a determined aggressor – is achievable out to 500m.

If a bystander is within the nominal ocular hazard distance (NOHD), BE Meyers' trademarked 'Eye Safe' rangefinder technology immediately shuts off the laser. As soon as the individual has moved out of the NOHD, the laser output instantly resumes. The LA-9/P is powered by one CR123 and four AA batteries and is available with an optional rifle stock. Customisation options include variable output intensity, beam divergence, wavelength, external power and control interface.

Designed for attachment to an assault rifle or machine gun, the smaller Glare Recoil – which was selected last year by the USMC for its Ocular Interrupter programme – is said to be particularly suited for identifying, challenging and deterring in counter-piracy situations. The Recoil incorporates the manufacturer's patented 'SmartRange' system, which integrates a laser rangefinder (LRF), near-field detector (NFD) and accelerometer/gyroscope to prevent unwitting bystanders being subjected to unsafe levels of irradiance.

The LRF beam envelopes the green beam and pulses at 100 times per second, swiftly reducing the dazzler power when it senses an individual or object getting too close. Algorithms in the LRF take account of rain, snow, spray and dust 'to create a more accurate, resilient and adaptive understanding of the environment', according to BE Meyers.

The NFD detects any obstruction to the LRF receiving lens and shuts down the green beam automatically. The three-axis gyroscope senses movement of the device and reduces power until a steady aim is achieved. This prevents hazardous irradiance in situations where the device is moving faster than the LRF can detect objects and lose power output, the company said. The Recoil's 250mW dazzler has a maximum effective range of 900m and the angle of divergence can be varied from 0.23 to 4°. Power is provided by three CR123 lithium batteries.

A laser dazzler is deployed by the security team on board the Military Sealift Command combat support ship USNS *Ranier* during a simulated attack in July 2016. (Photo: USN)

Alfalight (owned since July 2016 by UK photonics specialist Gooch & Housego) offers two weapon-mounted Non-Lethal Ocular Disruptor (NLOD) devices, both using a 330mW green laser, for maritime security tasks. NLOD-1 and NLOD-2 are intended to visually suppress targets at ranges from 700m down to 20m (the minimum eye-safe distance) but will also send verbal messages or warnings out to 2km. Both devices have three operating modes: continuous beam, slow pulse (2Hz) and fast pulse.

With an optical beam diameter of 4mm at exit, divergence of 0.5° and a fast pulse of 6Hz, the NLOD-1 is sealed in an aluminium housing that can be immersed in water to a depth of 3m. The device measures 16cm in length, weighs 385g (including a rail mount and three CR123A batteries) and will operate at full power in temperatures from 45°C down to -20°C.

The smaller (9.5cm/200g) NLOD-2 has a beam diameter of 0.6mm, divergence of 0.46° and an accelerated fast pulse of 8Hz. Using two CR123A batteries, it can be immersed in 2m of water and will operate in temperatures up to 50°C. A holographic day sight is optional.

Xtreme Alternative Defense Systems is marketing its Threat Assessment Laser Illuminator Rifle 3 (TR3) laser dazzler for counter-piracy and other maritime applications. The TR3's green laser has a power output of 2.5-3W and should deter the crew of a boat approaching from over 1km away in daylight and 3km at night, well beyond the range of conventional firearms.

More dogged aggressors will be disorientated and suffer temporary visual impairment from a laser spot measuring 65cm in diameter at a range of 1,000m. Weighing 3.8kg, the TR3 is powered by a rechargeable lithium battery. A single charge is enough for 2,000 or more 'shots' in over an hour of constant use. Accessories include a video camera sight with tracking auto-focus and 200x zoom, key punch-code access pad, collapsible rifle stock and bipod mount.

Noise pollution

Acoustic hailing devices (AHDs) produce focused, highly directional sound waves capable of delivering voice messages or warning tones over distances of several kilometres, enabling a port security officer or vessel watch team to determine the intent of an approaching craft and issue authoritative instructions at standoff distances.

Known colloquially as 'sound cannon' or 'sonic weapons', they can generate sound pressure levels (SPLs) that are capable of damaging the human inner ear if deployed against targets at close quarters. The largest AHDs could potentially induce sufficient discomfort to repel a boat crew that has entered a restricted maritime space.

Like most providers of such systems, however, LRAD Corp states categorically that its market-leading Long Range Acoustic Device (LRAD) – which projects sound waves in a 15-30° beam – is not a weapon but a 'highly intelligible, long-range communication system and a safer alternative to kinetic force'. ▶

BE Meyers' Glare LA-9/P green laser can deliver warnings out to 4km at night and 1.5km in daylight. (Photo: USN)

In 2009, the logistics ship USNS *Lewis & Clark* deployed an LRAD while evading attack by pirates, broadcasting verbal warnings to two approaching skiffs at a range in excess of 1.8km, and in 2011 the Republic of Korea Navy used a similar device while freeing the crew of the hijacked chemical tanker MV *Samho Jewelry*.

On 1 February this year, LRAD Corp said it had secured export orders worth over $1 million, including acoustic devices for law enforcement, defence and public safety applications in China and LRAD 1000Xi systems for a maritime application in Japan.

Announcing a previous 1000Xi sale to an unnamed coast guard agency in Southeast Asia in 2016, the company said that its 'attention-commanding warning tones and voice broadcasts determine the intent of boats not responding to radio calls, establish large standoff zones around coast guard vessels and provide enhanced communication during coastal defence operations. LRAD systems ensure commands and instructions in any language are clearly delivered, heard and understood over wind, engine and background noise.'

Capable of delivering such instructions out to 3km in 'ideal conditions', or a more realistic 1,250m against 88dB of background noise, the 1000Xi features a carbon-fibre emitter head, an MP3 control module for playing recorded messages, a microphone for live broadcasts and a remote operation capability. Technical specifications include a maximum continuous SPL of 153dB (at 1m), sound projection in a +/-15° beam at 1kHz and typical power consumption of 720W for warning tones or 190W for voice messages. Weighing 39.4kg and with overall dimensions of 91x102x33cm, the device can operate in temperatures from 60°C down to -33°C.

In January, LRAD Corp announced that it was expanding its XL product line, which employs patent-pending driver technology to generate higher audio outputs from smaller and lighter hardware. Designed for shipboard and shoreside installation, the new 1950XL system is said to deliver 'highly intelligible' spoken messages out to 5km and empowers hails, warnings and voice communications beyond normal standoff distances.

The compact 450XL device – which is intended for use on board smaller naval, coast guard, police or port security craft – has the audio output 'of a unit almost twice its size and weight', according to the company, and can reach out to 1,700m.

Aboard and ashore

Also designed for small vessels is the similarly sized 300X-RE system, which has a maximum output of 150dB and can deliver intelligible speech to 1,000m in ideal conditions, reducing to 350m in a more typical operating environment with 88dB of background noise. Weighing 11.3kg and with a front face measuring 63x36cm, the 300X-RE has a remote MP3 control module with 2GB of storage memory. Typical power consumption is 50W for voice messages and 150W for warning tones. The 500X-RE has a maximum range of 2km and is the USN's AHD of choice for small vessels, according to the manufacturer.

LRAD's RX systems are protecting naval bases and commercial ports in Bahrain, Jordan, Qatar and the US. With frontal dimensions of 142x164cm and weighing 154kg, the 1000RX is one of the company's larger models and its acoustic output of 159dB will carry messages out to 3km under ideal conditions or 1,250m against background noise.

Suitable for deployment aboard ships as well as ashore, the 500RX has twin emitter panels mounted on a pan and tilt drive and controlled remotely across an IP network, allowing the operator to remain in a safe location some distance from the device. A maximum SPL of 154dB gives a range of 2km/650m.

Measuring 91x104cm, weighing 80kg and with a peak power consumption of 1,000W, the 500RX also has an integrated video camera and optional Maxabeam searchlight to illuminate targets out to 3.5km. Able to withstand wind speeds of 90kt, the system can be integrated with radar to provide automated intruder alerts and responses.

The similarly sized and configured 950RXL – unveiled by LRAD Corp in November 2016 – produces a maximum SPL of 156dB and an acoustic range of 3km/1,250m. It is the commercial version of a remotely operated system provided to the USN.

'Military organisations around the world are filling the critical gap between initial engagement and escalation of force with LRAD's unparalleled long-range communication and scalable non-lethal, non-kinetic deterrent tones', the company said. 'LRAD systems are in use in more than 70 countries around the world and are the only AHDs that meet all US military requirements.' The company also suggests that its AHDs can be carried by USVs to provide an ▶

'autonomous, remote first-response capability for port, harbour and ship security'.

Ultra Electronics said that most of its HyperSpike AHDs – which comprise arrays of wideband transducers with a patented waveguide, eliminating interference by producing an acoustic beam that is in phase – are suitable for maritime law enforcement applications.

The smallest ruggedised HyperSpike device is the handheld HS-10-R (also known as the HS-Micro II), which weighs less than 7kg and has a peak SPL of 144dB, a useable communication range of 750m-plus and eight hours of battery life. Frequency coverage is 400Hz to 7kHz, the beam width is +/-15° (ie a 30° cone) and the device has a Speech Transmission Index (STI) rating – a widely accepted measure of voice intelligibility – of 0.85 (ratings from 0.75 to 1 are judged 'excellent'). The HS-10-R can be operated remotely via a wired smartphone app and can cope with temperatures from 60°C to -20°C.

Intended for mounting on board small craft, the HS-14 has a cylindrical emitter head weighing 16.8kg with dimensions of 37x42cm. It has a maximum output of 151dB, range of 1.5km, frequencies from 300Hz to 8kHz, a narrow acoustic beam of +/-12°, STI of 0.81, internal 16GB file player, thermal management system and peak power consumption of 750W.

Weighing almost 41kg, the larger HS-18 model has a maximum SPL of 156dB, range of 2km, frequencies from 245Hz to 10kHz, a very narrow acoustic beam of +/-5° and an STI of 0.96. Optional devices such as a video camera, searchlight or laser dazzler can be accommodated within the Opti-Port equipment bay, a 146mm diameter space in the centre of the acoustic wave, intended to minimise the calibration and maintenance time for any device fitted.

Both the HS-14 and HS-18 are offered in remote guise with an optional pan and tilt mount from Moog, allowing a number of units to be programmed for distant operation within a single network. Intended for larger ships, the HS-40 is claimed to be the world's first 160dB+ directed voice projection system and the 'loudest AHD in production', according to Ultra Electronics. Maximum output is 163dB and the usable range exceeds 3km. Most notably, it can produce a warning tone of 135dB at a range of 100m. The HS-40 emitter head is 997mm in diameter, 343mm deep and weighs 86.2kg. The frequency range is 225Hz to 12kHz and the STI is 0.91.

LRAD Corp insists that its acoustic hailing devices – such as the 500X shown here – are not weapons but 'highly intelligible, long-range communication systems and a safer alternative to kinetic force'. (Photo: USN)

Clear speech

While LRAD and Ultra Electronics use conical speakers, HPV Technologies has developed a family of Long Throw – Planar Magnetic Speaker (LT-PMS) hailing and warning systems, utilising its Magnetic Audio Device (MAD) planar transducer. The flat panel MAD-1 has a light diaphragm and a frequency response from 180Hz to 18kHz, producing 'exceptional clarity' and levels of sound distortion that are 'virtually undetectable', even at maximum volume, according to the manufacturer.

Seven LT-PMS models are available, from the handheld 1HH with a single transducer to a mighty 96-driver array weighing 603kg. The larger models are particularly suited to longer-range maritime duties. As additional drivers are combined into a single system, not only does the volume increase but the acoustic beam dispersion tapers into a smaller area. 'With a tighter pattern and more power, the speaker can throw sound farther while remaining articulate and clear,' HPV Technologies states. 'The acoustical results become progressively more powerful as listening distances get extended to beyond a mile.'

Furthermore, said HPV, the output volume from planar drivers attenuates at a much lower rate, typically 1.5dB for each doubling of distance, compared with 3-6dB for conventional speakers. The company claims that spoken messages delivered by LT-PMS speakers 'can be heard at distances which cannot be matched by any other product or transducer technology'.

Thus the 5.5kg battery-powered LT-PMS-1HH has a useful range of 200m and dispersion angles of 30° horizontal and 20° vertical, while the LT-PMS-24, which integrates 24 transducers in a unit weighing 122.5kg, can reach out to 1,200m with dispersion angles of 5x5°. The largest model offered, the 2.3x2.4m LT-PMS-96 array, has just 2° of dispersion and a range of 1,600m.

The 24, 54 and 96 driver models can be fitted with optional waveguides for increased SPL output and enhanced mid/low-frequency performance (increasing the useful range by about 100m), a laser pointer for precise aiming and a video camera. Remote operation via a third-party network control interface is also available. ▶

Diver disruption

Currently in service with the USCG is the Enhanced Underwater Loudhailer (eLOUD), developed by Applied Physical Sciences, whose website said the system will warn, deny access to, move and/or suppress divers at ranges out to 460m. eLOUD consists of a man-portable, battery-operated control unit and a lightweight three-speaker vertical line array, developed by Oceanears (Ocean Engineering Enterprises), that can be deployed from a vessel or quayside at depths to 21m.

A 400W power amplifier provides a frequency range of 300-5,000Hz and maximum SPLs of 190dB at 2,700Hz and 180dB at 500Hz (both at 1m range). The same transducer array is used in the Enforcer Underwater Communication and Diver Disruption System, designed and manufactured by UK-based Westminster International, although this company said it will deliver clear, powerful warning messages to 800m.

If the warnings are ignored, Enforcer will produce high-powered disruptive sound frequencies that are 'designed to have a maximum disorientation effect on the diver' and 'are likely [to] induce a sense of discomfort or panic, causing [them] to leave the area or surface for interception', according to Westminster. 'Should the diver remain in the water, the frequencies are likely to have a continued adverse effect which could cause sickness and confusion.'

A completely different route to underwater defence is being taken by Hydroacoustics Inc (HAI), whose products use low-frequency blasts of sound energy delivered by 'air guns' to force intruders to the surface. Sold to navies and coast guard agencies worldwide, the company's Diver Interdiction Systems are available as portable units deployed from patrol craft, ships or locations ashore, or as static networked assets with air guns anchored or attached to buoys or piers.

The portable system consists of: a control box; an energy pack containing two or three bottles of compressed air (at 4,500psi); an umbilical (high-pressure air hose, electrical cable and suspension rope); and the air gun itself. A stationary network will feature an array of guns served by a single controller.

The Glare Recoil was developed for the US Marine Corps Systems Command Ocular Interruption programme. (Photo: BE Meyers)

The acoustic blast is initiated by a trigger mechanism on the controller, with electrical power provided by batteries or by radio frequency remote firing. Guns are available in five sizes, with chamber volumes of 10, 20, 40, 60 and 100in^3; air bottle packs have total air capacities of 150, 290 and 570ft^3; and operating pressures range from 1,000psi to 2,500psi.

The number of shots available depends on the total air capacity, the system operating pressure and the size of the gun chamber, but estimates for typical configurations range from 36 shots (for a 40in^3 gun with 290ft^3 energy pack operating at 2,000psi) to 213 shots (for a 10in^3 gun with 150ft^3 of air operating at 1,000psi).

HAI states that these systems 'provide a scalable deterrence... by various means including the frequency with which the pulses are transmitted, the creation of tones superimposed on the broadband output, the use of increased air pressure and an increased number of guns that are simultaneously fired'.

Audiovisual response

The Distributed Sound and Light Array (DSLA) is under development by Pennsylvania State University's Institute for Non-Lethal Defense Technologies and sponsored by the Pentagon's Joint Non-Lethal Weapons Program (JNLWP). It integrates a Target High-Output Responder-16S phased acoustic projector with a green laser disrupter and four bright white xenon lights (two enhanced searchlights and two spotlights).

Acoustic energy is produced by 16 horn-loaded compression drivers rated at 200-300W and capable of generating SPLs of up to 150dB, according to one unconfirmed report.

Switchable from tight focus to very wide spread, the acoustic beam is steered electronically by an operator viewing the target through a camera located atop the array. The low-frequency sound can penetrate ship structures, even in the presence of loud background noise.

The laser has pulsating and continuous modes and while irradiance can be adjusted from 69 to 32,700μW/cm^2 at 200m, the same report notes, output is kept below 1,000μW/cm^2 (the American National Standards Institute threshold for eye-safe exposure to lasers) when aimed at people.

With the optical devices gaining the target's attention and the sound projector conveying specific instructions, the DSLA is 'especially well-suited for hailing and warning vehicle and vessel operators', the JNLWP stated. 'At night, the DSLA can severely degrade an individual's ability to perform threatening tasks.' The DSLA is undergoing human effects and operational effectiveness testing to ensure it can be safely deployed without causing permanent harm to individuals.

Amid continuing claims from critics who allege that non-lethal deterrents are inherently dangerous, and with manufacturers and operators remaining under the spotlight of public scrutiny, such trials will remain a crucial part of the development process for any innovative new device designed to bolster international maritime security. ■