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USE OF ACOUSTIC WARNING DEVICES TO COMBAT MARITIME PIRACY

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Abstract. The use of acoustic systems to combat piracy can be an important branch of the ship's security yet fully underdeveloped in true capacity. Although after the incident when the USS Cole destroyer was involved, resulting in shipwreck and the death of sailors, early research and innovation procedures were launched on early warning on small vessels and craft that hide their true identity. Their real intent is not established at the most opportune times for their classification as possible risk factors or foe. The Long Range Acoustic Hailing Device (LRAD) is a breakthrough in delivering highly intelligent communications and concentrated acoustic output warning tones. Usage distances up to 2.5 nautical miles offer a net benefit in the fight against piracy, and not only. LRAD also provides a high level of protection against threats in various fields, being increasingly used by the military navy of various states, the Coast Guard, public order, port and port facilities or permanent ship bases, in more than 70 countries worldwide. Thus, the use of LRAD on board commercial vessels has begun with small steps, although the prospect of global implementation can only depend on the lack of information and knowledge of the possibilities and benefits of these systems. Multiple seafarers reports of the results of the use of the Long Range Acoustic Hailing Device in the fight against piracy are the basis for its adoption as a first step in eradicating maritime piracy.

1. Overview

These acoustic devices (Figure 1) are capable of emitting very intelligible sound at a very high volume. The distance to which the sound may be effective varies depending on several factors, including the sound level, the direction and frequency of the acoustic source, the sensitivity and directionality of the receiver, and the transmission channel environment. The noise level decreases or diminishes with the distance.



Figure 1.- LRAD system (user panel)

(Source: <https://crab.wordpress.com/2007/12/10/a-short-history-of-audio-weapons/>)

Consequently, as a general rule, higher source levels have a larger range.

Sound devices can be of two shapes, as follows:

1. Directional Models: These LRADs are characterized by their ability to create long distance voice, directional, and warning tones. Their direction is usually 5° to 60° conical radius at a 2 kHz tone.
2. Omni-directional models: These acoustic devices are capable of creating 360° voice communications and warning tones. These devices are capable of being heard at a distance of 2.5 miles from the emitter's antenna.

Following the terrorist attack in October 2000 on the USS Cole (DDG-67), which resulted in the death of several sailors and the ship's serious damage, LRAD Corporation created the market for acoustic calling devices (AHD) and long-range acoustic systems (Figure 2).



Figure 2 - LRAD system installed on board a military ship

(Source: <https://newatlas.com/lrad-long-range-acoustic-device/11433/>)

By delivering highly intelligent communications and concentrated soundtrack warning tones, LRAD resolves uncertain situations by clearly determining the intention of non-responsive ships, saving both vessel crews and shipped goods by preventing incidents.

LRAD also provides a high level of protection against threats in various fields, being increasingly used by the military marinas of the various states, the Coast Guard, port and port facilities or permanent naval bases.

2. Fields of use

Adaptation to new threats imposed by terrorist groups or carrying out piracy or illicit activities has also put the authorities in a position to look for new ways of combating or preventing (Figure 3).



Figure 3- LRAD system - areas of use
(Source: <http://www.vimadglobal.es/en/lrad-300x/>)

Thus, LRAD systems are used in over 70 countries around the world in various areas such as Coast Guard, Public Order (Figure 4), ports and port facilities, checkpoints, maritime transport, mass notification, early warning systems, critical infrastructure protection, military applications and the protection and control of wildlife.

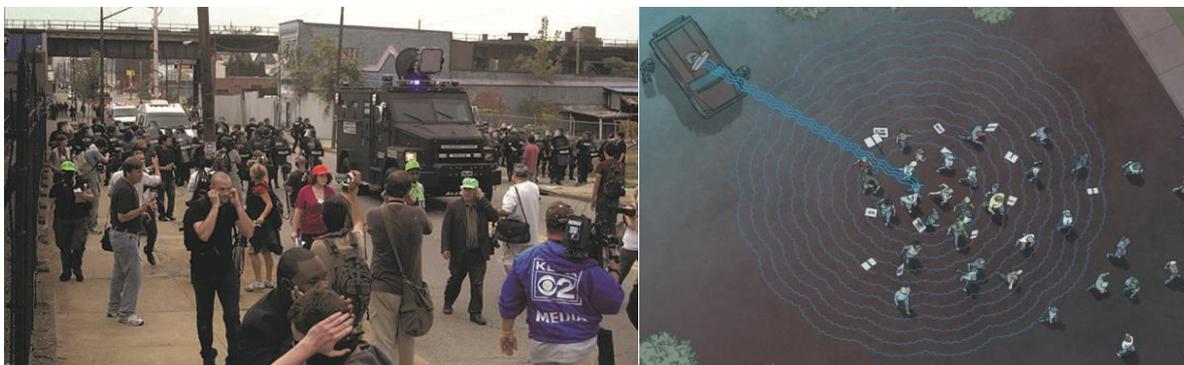


Figure 4 - Using the LRAD system for crowd control
(Source: <http://images.huffingtonpost.com/2016-08-22-1471885539-1383661-lrad1.jpg>)

2.1. *Military Navy*

Most Naval Forces around the world began to adopt LRAD as part of the defense component (Figure 5) and as a means of identifying potential intruders or threats. The escalation of force requires information and time, and in order for the correct differentiation of the intentions of a target to be made as easy as possible, early warning and observation messages tend to make the difference between intruders, terrorist threats, fishing vessels or commercial ships.



Figure 5- LRAD installed aboard a carrier
(Source: <https://crdprotection.com/lrad-1950xl/>)

Acoustically-performing features allow LRADs to be used to enforce sea bans.

For example, the US Army uses LRAD-RX systems for perimeter security and the provision of safety zones around certain naval bases.

2.2. *Coast Guard*

Coast Guard missions to combat territorial trips and threats to the country's security have led to the observation of LRAD capabilities that transmit voice and warning tones to Coast Guard staff to determine the intention of ships not responding to radio calls and to apply regulations in the maritime and coastal areas.

During interceptions of suspicious craft, LRAD systems ensure that both Coast Guard's commands and instructions are clearly heard and understood to overcome the barrier produced by engine, wind, or background noise.

2.3. *Ports and port facilities*

Ports such as Corpus Christi, Texas, Ras Laffan, Qatar and Aqaba or Jordan have purchased and installed advanced security systems that include LRAD-RX to broadcast multilingual messages and warnings for incoming ships that do not respond to radio calls, avoid unpleasant situations that tend to affect port security (Figure 6).



Figure 6- LRAD used to protect port facilities
(Source: <http://www.marsecreview.com/tag/lrad/>)

LRAD-RX systems provide maritime facilities with improved perimeter protection, more efficient for staff and goods.

2.4. Public order

Public Institutions with public order maintenance missions use the LRAD system for the transmission of messages and acoustic signals aimed at the control and security of certain areas. Thus, due to the increasing development of the production technology of these systems, the integration and mobility methods have grown and can be placed as favorably for use in large or small spaces, requiring automotive or helicopter platforms (Figure 7) or just by one person (Figure 8).



Figure 7- LRAD installed on a car / helicopter platform
(Source: <http://newscorpse.blogspot.ro/2009/10/sonic-warfare-us-police-admit-they.html>,
https://www.lradx.com/lrad_products/lrad-500x-mmt/)



Figure 8 - LRAD transported by one person

(Source: <http://filmingcops.com/wp-content/uploads/2017/06/lrad.jpg>)

2.5 Commercial ships

The increasing need for LRAD to be used on board commercial vessels stems from reports from crews of vessels that have already mounted such a device, whose importance increases as its use provides additional protection to the ship, especially in areas where the likelihood of piracy actions to occur.

A number of reports can confirm that it was necessary to use a LRAD, that it was successfully used and of course it will be used whenever the situation so requires, as can be seen in some examples briefly detailed in the (Figure 9).

a. M/V C Handy

On February 28, 2012, the captain of Taiwan C Handy confirmed that a LRAD system was used during a pirated battle, allowing C Handy to navigate safely through Somali waters.

b. M/V Green Ridge

It was a group of five small speedboats, disguised as fishermen, two of whom headed for the ship. The captain was called to LRAD. Once the craft has reached a mile away, LRAD has been started. Speed boats have reached up to 250 meters from the ship before returning. The system was used at full capacity.





Figure 9- LRAD installed on board merchant ships

(Source: <http://www.murrayontravel.com/2008/11/cruise-ship-security---lrad-sound-cannons.html>)

3. Features and measurements

Acoustic sound devices differ from conventional speaker systems in three key ways. These include volume, clarity and directionality. Different AHD manufacturers use different methods to measure their products, but each has a common standard (Figure 10).



Figure 10- LRAD 1000RX and LRAD 950RXL

(Source: <https://crdprotection.com/lrad-1000rx/> și <https://crdprotection.com/lrad-950rxl/>)

3.1. Volume

Since the sound is attenuated at a set rate, extremely high outputs are required to cover the necessary distances. Acoustic warning devices have an output power of 135 decibels (dB) or greater. The

acoustic level of the source is usually expressed in acoustic pressure or SPL. SPL is a logarithmic measure of the sound pressure of a sound relative to a reference value. It is measured in decibels (dB) above a standard reference level. For reference, at a distance of one meter, a normal spoken voice is about 50 dB, and a 30-meter motor is 150 dB (Figure 11).

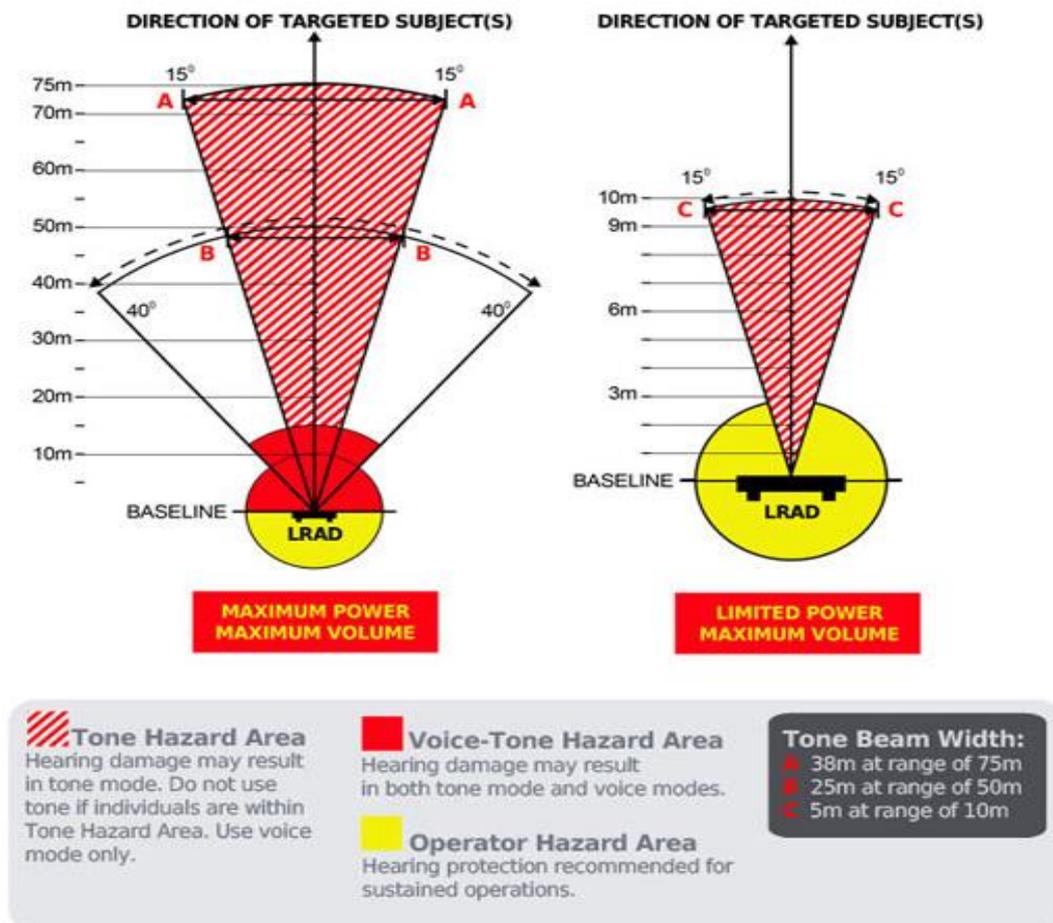


Figure 11- Volume and dangerous areas
(Source: <http://www.adxs.co.za/information/faq-2/>)

3.2. Clarity

An important weakness of common speaker systems is their clarity. Their cones create sound that is distorted, resulting in the effect known as "Charlie Brown," where the message is camouflaged and misunderstood. The sound emitted by the acoustic sound devices is intelligible at a great distance. Clarity is difficult to measure because it is a subjective reference. However, different scales have been created to compare the devices. A common measure is the speech transmission index. The levels of this index range from 0 to 1.0, with 1.0 being the perfect clarity.

3.3. Concentration

AHDs are ultimately characterized by directionality. To ensure message transmission to the target, AHDs form the sound in an audio beam in the range of 30° -60°. This modeling is done by designing transducers as well as different reflex cones. Focusing on an AHD is usually measured at the tip of the tip. This is usually in the range of 1-2 kHz. Not all sound frequencies can be routed equally. Low bass

frequencies are hard to format. As such, their direction may be a radius of 40 degrees or more depending on the construction of the AHD (Figure 12).

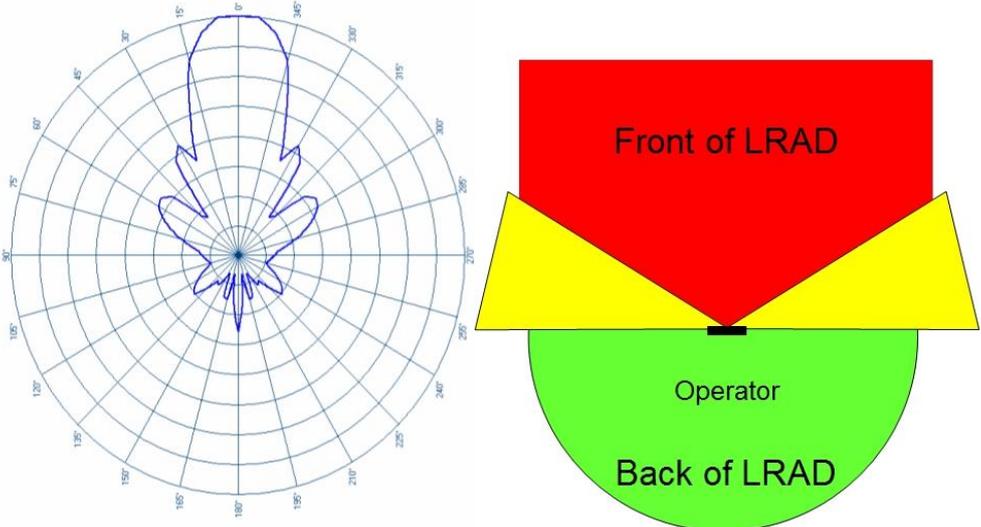


Figure 12 - The directionality feature (sound pressure levels)
 (Source: <https://hubpages.com/politics/forum/138920/whats-excessive-force-in-crowd-control->)

4. Non-lethal weapons

Sound devices have the potential to be used as non-lethal weapons. The human ear can typically support a sound pressure level of 120 dB before experiencing pain. AHDs are capable of an acoustic energy of 135 dB or more. Any sound pressure level above 90 dB requires hearing protection. With the increase in volume, there is a risk of hearing loss. The non-lethal effective range of an AHD depends on the total strength of the unit. Typically, this range is 50 meters or less (Figure 13).

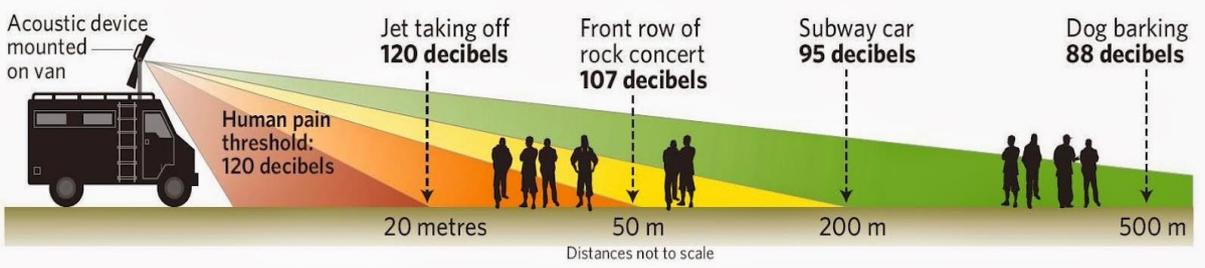


Figure 13 - Effects of the LRAD system on distance and power
 (Source: <https://hubpages.com/politics/forum/138920/whats-excessive-force-in-crowd-control>)

According to the manufacturer's specifications, systems weigh between 15 and 320 kilograms (6.8 to 145.1 kg) and can output sound at a range of 30 ° -60 ° to 2.5 kHz.

5. Operating principle

The parameter "ka" represents the number of waves multiplied by the loudspeaker radius and is often used to characterize the directivity of the sound source. For this source, ka = 19 to 2.5 kHz, and according to the LRAD datasheet, the beam angle is approximately 30 °.

Spherical "point-source" spherical devices respect the known loss of 6 decibels (dB) in favor of doubling the distance from the source.

The large speakers have a near-field interference pattern that produces peaks of 6 dB or greater than the output pressure and nulls where the pressure is essentially zero. The higher the loudspeaker and the frequency increases, the greater the efficiency of the action area. The approximate field of this device is approximately 8 meters (26 ft).

These systems are also called "sound guns" or acoustic alarm devices and are capable of transmitting sound far beyond traditional speakers.

LRADs use a series of piezoelectric transducers to function. This means they take power and turn it into sound by changing shape very quickly.

The sound produced by LRAD is not only powerful, it is also extremely easy to target in a narrow beam. This makes it useful for countless applications where the sound can be used with precision (Figure 14).

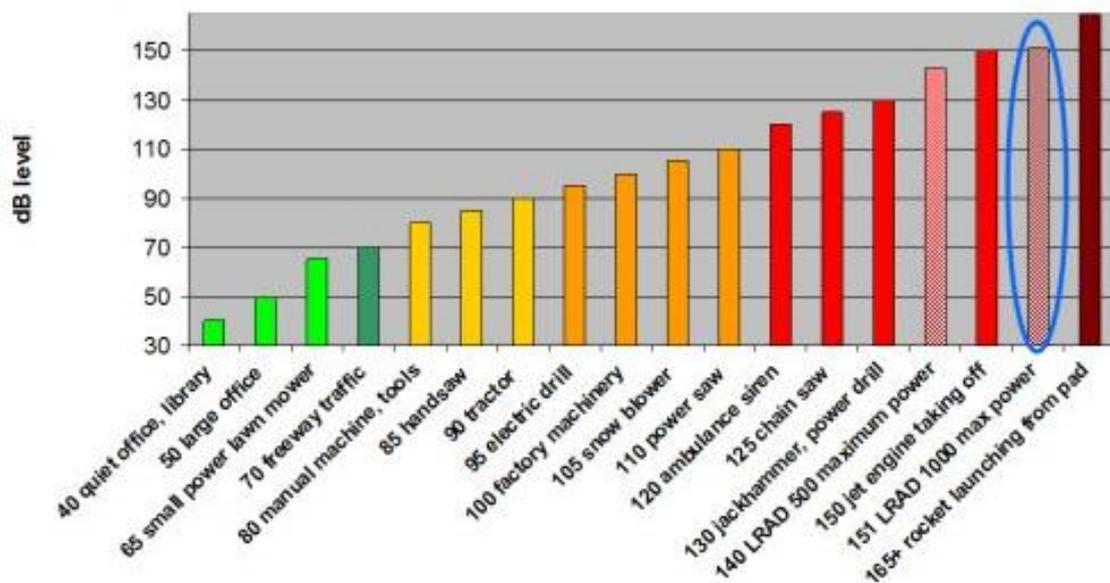


Figure 14 - The LRAD Company Diagram showing the position of the system's intensity on a sound scale (Red Sounds can cause hearing loss)

(Source: <https://hubpages.com/politics/forum/138920/whats-excessive-force-in-crowd-control->)

6. Conclusions

The implementation of the Long Range Acoustic Hailing Device (LRAD) began in 2002 and continues today in various fields of activity where the importance of this system is a step forward in the field of security and safety. Whether we are talking about the protection of targets, military or commercial ships, or simply about sending a message to a small group of fishing boats, the usefulness of this device increases with the emergence of more dangers.

In the current context in which response and response time to combat asymmetric threats such as terrorism, piracy or armed robbery is a decisive factor in the outcome of events so assigning an identity or early identification of intention can save lives and eliminate the risk of damage or total loss of the ship or cargo.

Prevention has come to be the first means of attacking and combating these risks. Through the above presentation of the many key elements in this field, it is attempted to encourage the use of this device, which combined with the system presented in the previous chapter could ultimately combat any attempt to produce acts of terrorism or other unlawful actions.

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