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Risk Factors Detection for Strategic Importance Objectives in Littoral Areas

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Abstract. With the invention and development of underwater explosive devices the need to neutralize them has also appeared, both for enemy and for own devices once conflicts are finished. The fight against active underwater explosive devices is a very complicated action that requires a very careful approach.Also, in the current context, strategic importance objectives located in the littoral areas can also become targets for divers or fast boats (suicidal actions).The system for detection, localization, tracking and identification of risk factors for strategic importance objectives in littoral areas has as one of its components an AUV and a hydro-acoustic sub-system for determining the 'fingerprints' of potential targets.The overall system will provide support for main missions such as underwater environment surveillance (detection, monitoring) in harbor areas and around other coast objectives, ship anchorage areas, mandatory pass points and also provide warnings about the presence of underwater and surface dangers in the interest areas.

1. Introduction

Risk factors, for the purposes of this paper, consist in those internal, or external elements, situations or conditions that may, by their nature, affect the security of the country, resulting in adverse effects or attainment of our fundamental interests.

In recent years, a new category of risks - the non-classical asymmetric ones - which can consist of armed and non-armed actions, has been manifested in the last years, aiming to affect the national security by causing direct or indirect consequences on the economic and social life of the country. Among the risks of this type can be listed:

- transnational and international political terrorism, including its biological and informational forms;
- actions that can address the safety of domestic and international transport systems;
- individual or collective actions of unlawful access of information systems.

Among the above, international terrorism manifests itself in an unprecedented acute form, with multiple effects on state security and international stability in general.

Ports are generally vulnerable to terrorist attacks due to their size, general water and land accessibility, heavy traffic of materials and people, positioning in densely populated areas, etc. As ports have a high density of transport routes (roads, railways and waterways), they are much more open to terrorist attacks than other areas. The concentration of passengers, goods, property and business in the harbor areas are as many potential targets.

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Vessels and drilling platforms are a symbol. Above the company, the state itself is targeted by a terrorist attack. The crews, the passengers or the ship's destination are also irrelevant. A marine drilling and extraction platform is one of the most appealing targets and can be attacked by terrorists in three environments (water, air or underwater) and its damage / destruction is strongly mediated due to the economic impact and environmentally friendly.

In recent years, due to technical progress, accumulated experience, and the internationalization of the terrorist phenomenon, attacks on naval targets have become more frequent and well organized, ranging from attacking civilian ships with no defense capabilities to attacking large-scale combat ships. The experience of asymmetric actions such as those in the Gulf (1991, 2003), Yugoslavia (1999), Afghanistan (2002) demonstrated the vulnerability to cyber attacks or the possibilities of countering simple means on sophisticated means and research - Capable of operating virtually all electromagnetic spectrum.

On November 3, 2003, the Romanian Parliament adopted a law approving Government Emergency Ordinance no. 80/2003 for the acceptance by Romania of the amendments to the annex to the International Convention for the Safety of Life at Sea, 1974, and the International Code for the Security of Ships and Port Facility (ISPS Code) adopted at the International Maritime Organization Conference in London, Between 9 and 13 December 2002. There is no express provision under the ISPS Code on the protection of port facilities and ships in ports against terrorist or diversionary attacks launched from underwater [1].

2. Potential scenarios of terrorist actions against strategic coastal objectives

Table 1 presents a number of representative features that could be used to draw up scenarios of possible attacks [2].

Table 1. Characteristics of some possible terrorist attack scenarios.

Elements	Examples	
Authors	• Transnational Terrorist Groups • Islamic non-affiliated • Foreign nationalists	• Disgruntled employees • Others
Objectives	• Mass victims • Destruction of port, ship, drilling and extraction platform, etc.	• Undermining economic activities • Destruction of the environment
Locations	• ports • Stationary or deployment areas • Mandatory crossing points	• Roads and passes • Natural Reserves or Tourist Areas
Targets	• Military or commercial ships • Oil platforms • Ferries / cruise ships	• Port areas • Waterways
Tactics	• Explosible in suicide ships • Crash / hitting ships • Missiles launched from ships • Marine mines and / or improvised explosive devices	• Diversion divers • Underwater vehicles • remote / autonomous • Intentional sinking of merchant ships

Based on the information presented in table 1, it is possible to create numerous unique scenarios of attack, logic and operational veracity, based on different combinations of authors, objectives, locations, targets and tactics. In this way, plausible scenarios will be created and can not be avoided with limited anti-terrorist resources.

In order to be able to define operational features of a system of protection against such attackers, in addition to good ktsowledge of environmental conditions (propagation, position of natural obstacles, fund profile, statistical properties of clutter, etc.) Also considering those characteristics of the threat related to the movement and its "fingerprint" from the perspective of the sensor used in the detection and identification process [3]. Table 2 presents such data from the perspective of hydroacoustic detection (active or passive).

Table 2. Characteristics of targets from detection perspective using active sonar systems [1].

Attacker/weapon	Speed [kts]	Action depth [m]	Target strength [dB rel. 1 μPa/1 m]	Generated noise level
Diver	0,5 - 1	1 - 20	-25	Low
Torpedo	10 - 50	> 20	-20	High
Fast ship	5 - 40	0,1 – 0,5	?	High, but strongly oscillating
Mine	-	5 - 10	-15	-
AUV / ROV	2 - 5	5 – maximum zone depth	-20	Low
Mini submarine	2 - 5	5 - 30	-10	Low
Unforeseen attackers (e.g. dolphins)	1 - 35	1 - 50	-15 to -30	Medium - High

We note that potential aggressors with high availability have evolving and specific characteristics from the point of view of sonar detection dispersed in a relatively wide range of values so that the process of establishing some technical and operational requirements becomes extreme difficult. Consider, for example, the case of divers:

- Equipment can be purchased relatively easily;
- The production of explosive charges or their acquisition on obscure channels should not be considered a difficulty;
- May be launched by pleasure boats, beaches nearby, objective vessels, commercial vessels, etc.;
- The specific characteristics vary significantly depending on the sonar system (working frequency, modulation type, etc.), the breathing circuit used (closed or open) and so on;
- Evolves in an environment whose features make detection difficult: noise due to extremely high traffic, shallow waters, high masking possibilities, etc.

At 1 kts (≈ 0.5 m / s), the diver travels a distance of 500 m in about 17 minutes. These 500 m are declarative detection distances for active sonar systems for discovering divers, ensuring a detection probability of more than 90%. If we take into account the time needed to detect, identify and classify the target, establish the trajectory, assess its degree of danger, and so on, it can be noticed that the time required for the intervention of the counter-action team remains for about 8-10 minutes, which will involve the use of ultra-fast means of travel, localization and "instantaneous" neutralization of the aggressor. This can be aggravated by the fact that the target strength for an open-circuit diver can reach -27 dB (at 100 kHz), the air bubbles trailing in a ship's path mask the target for a significant time, and the presence of various objects in the surveillance area, in addition to allowing divers to hide, significantly impedes the operator's activity [4].

From the analysis of the terrorist actions that targeted merchant ships and port facilities to the present, the following were noted:

- Attacks with the use of small and fast ships loaded with explosives are the easiest to organize and fulfill. Such an attack on a ship, harbor facilities or drilling platforms involves first of all an attempt to approach the target with one or more craft until the arsenic reaction to neutralize the threat is late.

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- Any organization, however poor or poorly funded, may engage in "amateur divers", but this is not the only risk. Strong organizations can afford to train professional teams of underwater terrorists. Diving can be equipped with me or improvised explosive devices that they can place on the ship's body, on various submersible elements of marine platforms or port infrastructure.

On the basis of the conclusions presented, we consider that the detection of threats to the strategic objectives at the seaside should focus, but not be limited to, the two types of targets. In this vision, the following research directions have been identified:

- The use of physical barriers to delay the aggressor;
- The use of passive detection methods and non-acoustic sensors, as well as the development of robust data fusion algorithms to increase the probability of detection and simultaneously decrease the probability of false alarms;
- Conducting in-depth research and creating specific footprint databases in order to increase detection and target classification capabilities simultaneously with the decrease of the interval between the first alarms alignment and the moment of aggression identification / classification.

3. Detection of risk factors against strategic objectives at the seaside

The passive detection of small and fast craft or self-directed divers may be based on the identification of their "fingerprints" in the marine noise recordings, and this identification of "fingerprints" is limited to finding hidden periodicity in a generally uncorrelated noise. Periodicity is provided by the propeller, propeller, engine, or respiratory cycle shaft in the case of the diver.

It has been mentioned in many specialized papers [5], [6], [7] that this periodicity of the acoustic fingerprint of the ship or diver can be observed in the hydrophone signal spectrogram and that the analysis of the cycle frequency in the output signal of the hydrophone allows detection of the ship or diver and estimation of its respiration rate.

As shown in [8] a method of processing signals with very good results for the detection and estimation of the rotation frequency of the propeller and the rate of respiration is the method using the DEMON algorithm (Detection of Modulation On Noise) and for a hydro-acoustic system The use of a DEMON algorithm according to the scheme illustrated in the following figure is proposed for the determination of the potential target fingerprints (HDAPT).

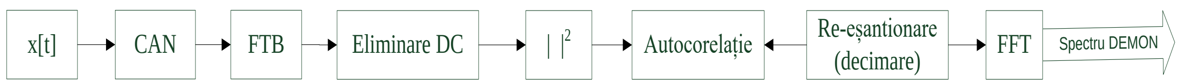

Figure 1. Block diagram - DEMON HDAPT [8].

For the implementation of the HDAPT algorithm and the display of results in clear, intelligible formats for the operator, two software applications specific to the detection of ships and self-directed divers have been developed. The signal source, representing the noise of the moving ship or the breath of the diver, can be in analogue format (connection to the audio inputs of the computing system) or in digital format (ASCII, * .wav, * .mp3 etc.).

In case of vessel detection, the DEMON diagram is displayed in the main menu (figure 2). The operator can identify on the DEMON diagram whether in the ambient noise picking from the hydrophone there are signals with specific characteristics of the noise produced by the propeller propeller. Based on the data obtained by applying the HDAPT algorithm, the application calculates and displays the ship's specific characteristics and displacement characteristics: the rotational speed of the portable spindle (rot / min) and the number of propeller blades.

Using a variety of ship noise records, it was found that, in general, under normal weather and normal traffic conditions, it is necessary to apply a medium band pass filter, resulting in higher output

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(Figure 2, right). In situations where the natural noise level is significant, the results obtained are superior if a low frequency range is used for the band pass filter (figure 2, left).

In addition to the results of the HDAPT algorithm, the signals acquired after filtering JF (left) and MF (right) are also displayed on the screen.

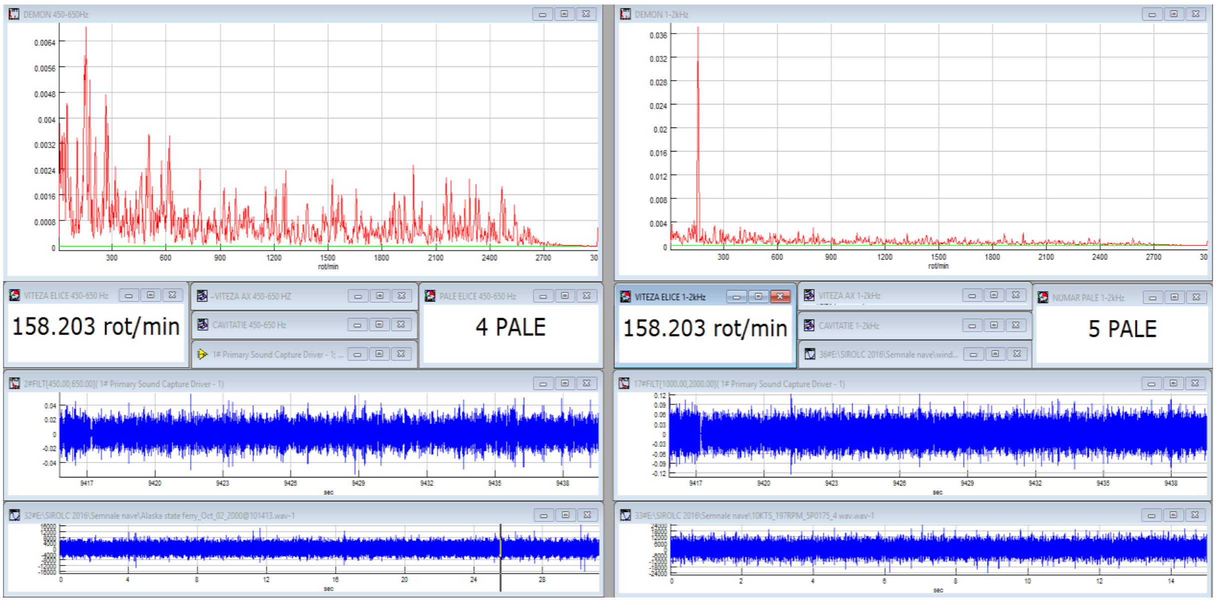

Figure 2. Graphical operator interface for detection of Alaska State Ferry.

For the detection of a diver in the algorithm, parts of the hydrophone signal are processed, representing about 4 to 5 relatively stable breathing periods. Considering the limits for a normal respiration between 10 and 30 breaths per minute (0.15 ... 0.5 Hz) [9], it results that a rhythm of 10 breaths per minute, it takes about 30 seconds, while when the diver is moving fast (with over 30 breaths per minute) the interval required for detection would be reduced to one-third. On the other hand, the higher the number of periods of breathing, the more the algorithm applied is less sensitive to relative rhythm variations and ambient noise. For these reasons, a diver detection software application was designed and developed that simultaneously processes 10, 20 and 30 second intervals from the hydrophone signal.

Figure 3 shows the graphical interface of the operator, observing the results of the hydrophone noise processing on three horizontal sections (bottom-up - for 10, 20 and 30 s intervals):

- The DEMON diagram;
- Spectrogram;
- The calculated breathing rate value;
- The oscillogram of the acquired noise.

On the right of each section is a circular instrument, which automatically signals (the needle in the red area) the diver's detection. If the ambient noise is due to natural phenomena (wind, rain, etc.), even if the noise level covers the noise produced by the breath of the diver, the application calculates correctly all the parameters because there are no impulsive noise characteristics.

In observation by the operator, the main indication of the presence of a diver near the hydrophone is the presence on the spectrogram of the vertical bands specific to the acoustic energy emitted by the diver's diving apparatus during inhalation of the air [9].

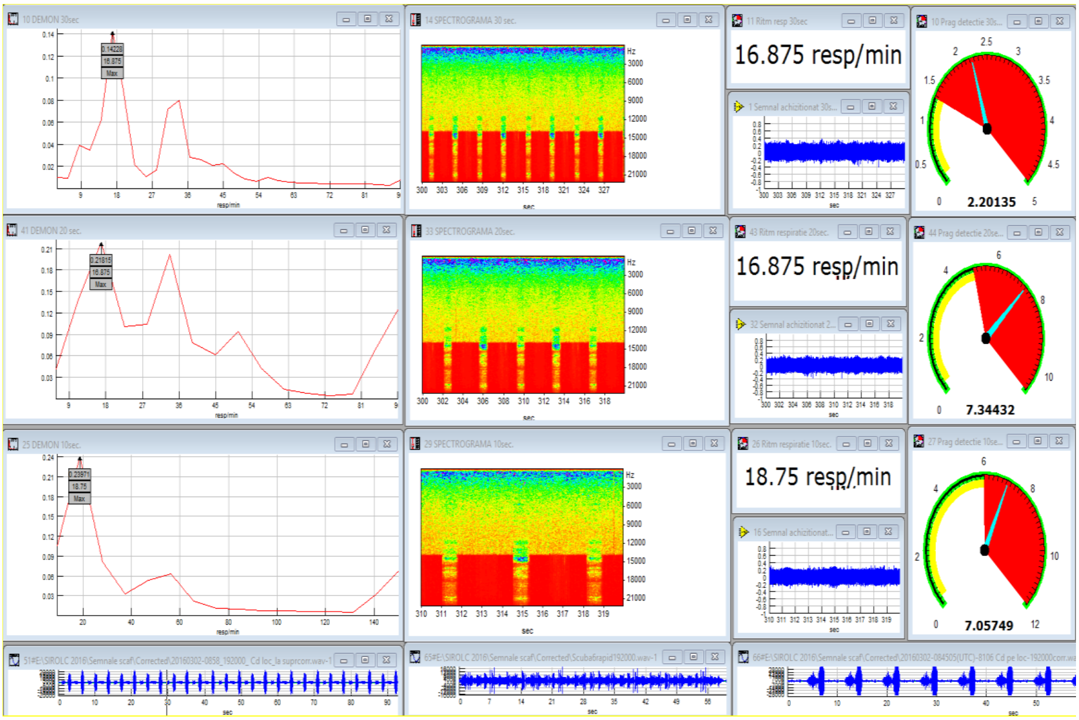

Figure 3. Operator Graphic Interface for Divers Detection (strong wind conditions).

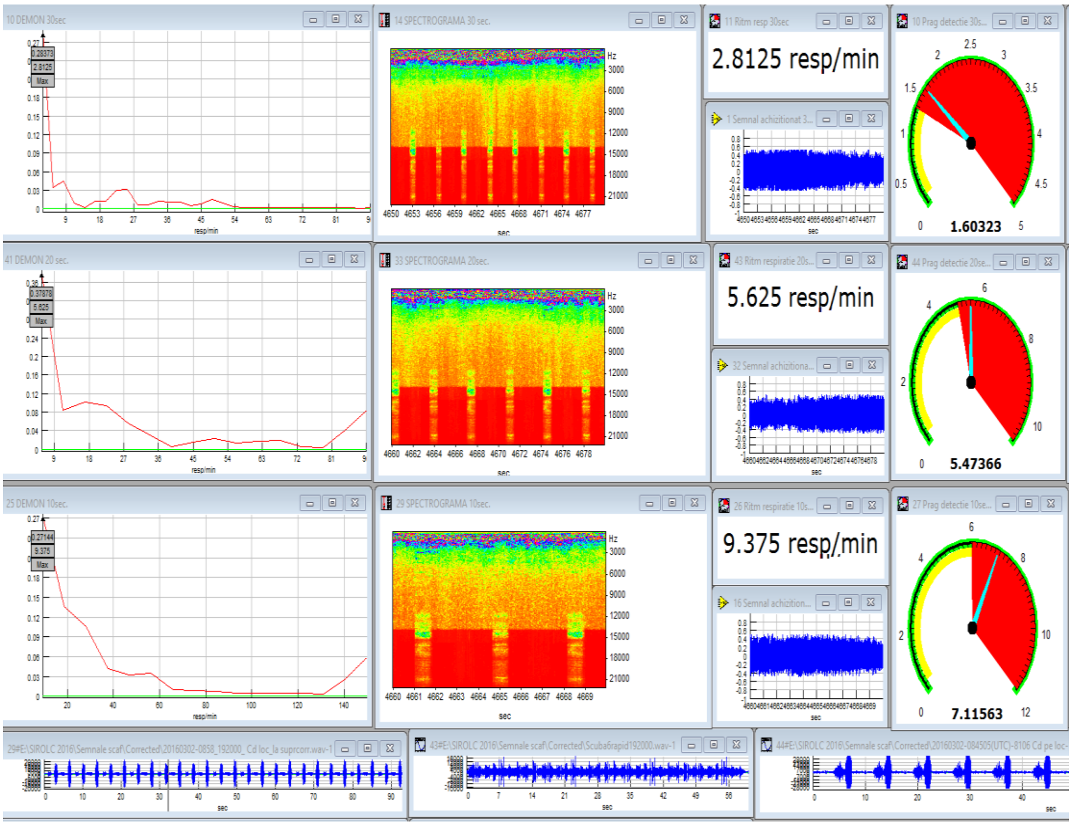

Figure 4. Detection of divers in strong wind conditions and simultaneous evolution of a helicopter and a ski-jet in the area.

As with small craft detection software, for testing and training, the operator can select and observe the results for overhead diver noise and other noises (eg from a helicopter, ski-jet, etc.) pre-recorded.As can be seen in Figure 4, due to the high level and the impulsive character (but with less repetition) of helicopter and ski-jet noise, the DEMON diagram moves to the left, the calculated periods are lower, and the final result is significantly affected (the noise produced by the diver is the same as in Figure 3).

4. Conclusions

There are no safety and security solutions that guarantee 100% protection of strategic objectives in seaside areas, but a set of measures can be implemented to help mitigate risks. In this respect, the detection of risk factors is an imperative requirement, and the detection of threats such as fast surface craft and autonomous divers are a first step.The HDAPT signal processing algorithm (DEMON) has produced good results for detecting the threats mentioned under normal operating conditions, and results are similar to those obtained by applying algorithms of the same type presented in the literature.When used with other sources of information (AUVs, surface sensors - radar, AIS etc.) of hydroacoustic threat detection systems incorporating the applications described in the paper and some information fusion solutions, the level of Protection of strategic objectives in coastal areas will increase significantly.In the future, it is intended to test the software applications developed using a wide range of noise recordings (for boats, ships and divers) performed under different hydro-meteorological conditions and presence of disturbing factors (naval, air traffic, etc.).

References

[1] Hanganu M and Slămnoiu G 2010 *Platformele de foraj marin româneşti şi securitatea acestora* (Bucureşti: Editura U.N.Ap. „Carol I”) 37, 50-51, 124-129, 170-177

[2] Parfomak P W and Frittelli J 2007 *Maritime Security: Potential Terrorist Attacks and Protection Priorities*: Congressinal Research Service The Library of Congress) 7

[3] Kessel R T 2007 Protection in ports: countering underwater intruders *Undersea Defence Technology Europe* (Naples, IT: UDT Europe) 4

[4] Sharma N S, Yakubovskiy A M and Zimmerman M J 2013 SCUBA Diver Detection and Classification in Active and Passive Sonars - a Unified Approach *2013 IEEE International Conference on Technologies for Homeland Security (HST)* 193-194

[5] Donskoy D M, Sedunov N A, Sedunov A N and Tsionskiy M A 2008, Variability of SCUBA diver's acoustic emission *Proc. SPIE 6945*, Optics and Photonics in Global Homeland Security IV 694515 doi: 10.1117/12.783500

[6] Labat V and Dare D 2014, Analyse de signaux acoustiques marins: identification de frequences caracteristiques via la methode DEMON, *Congres Francais d’Acoustique (12; 2014; Poitiers)* Poitiers France 345-350 HAL Id: hal-01087837

[7] Chung K W, Sutin A, Sedunov A and Bruno M 2011, DEMON Acoustic Ship Signature Measurements in an Urban Harbor, *Advances in Acoustics and Vibration* vol. 2011 Article ID 952798, doi:10.1155/2011/952798

[8] Slămnoiu G, Radu O, Roşca V, Pascu C, Damian R, Surdu G, Curcă E and Rădulescu A 2016 *IOP Conf. Ser.: Mater. Sci. and Eng.* **145** 082013

[9] Donskoy D M, Sedunov N A, Sedunov A N and Tsionskiy M A 2008, Variability of SCUBA diver's acoustic emission, *Proc. SPIE 6945,694515 Optics and Photonics in Global Homeland Security IV* 1-11

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