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IMPACTS OF INTEGRATED MONITORING SYSTEM UPON CONTROL AT SEA

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Abstract: *This paper treats problems concerning different aspects of control at sea. Normally, it includes control and safety of various activities at sea and environmental protection. Trends in management process show that it is necessary to divide maritime areas into zones with precise spatial dimensions and activities to be organized in particular groups – navigation, offshore activities, marine agriculture, tourism, etc. Contemporary researches in maritime safety point out that the control of sea is available by means of integrated maritime surveillance systems. The impact of coastal state`s authorities needs of reliable surveillance system which helps in real time situational awareness. Moreover, coordination between governmental institutions, non-governmental organization and multinational cooperation and mutual understanding between neighboring countries is another milestone. Integrated maritime surveillance is sub-system of maritime control system that figure out its essential characteristics.*
Key words: *control at sea, maritime safety and security, risk management, safety of navigation.*

Nowadays, the control at sea includes control and safety of a wide spectrum of activities at sea and environmental protection. Trends in management process show that it is necessary to divide maritime areas into zones with precise spatial dimensions and activities to be organized in particular groups – navigation, offshore activities, marine agriculture, tourism, etc. Contemporary research in maritime safety has lead to the idea that the control of sea is available by means of integrated maritime surveillance systems. The impact of coastal state`s authorities needs a reliable surveillance system which helps in real time situational awareness. Moreover, coordination between governmental institutions, non-governmental organization, regional cooperation and mutual understanding between neighboring countries is another cornerstone. Integrated maritime surveillance is a sub-system of a maritime control system that figure out its essential characteristics.

Modern challenges to maritime safety to a very large extent affect the marine aspects of both the national and the union policy of the state. This contributes to the fact that since joining the EU in 2007, Bulgaria has become an external maritime border of the European community. The fact that out of the six littoral states of the Black Sea, which is one of the most isolated in the world ocean, only two countries are member of EU, is an additional challenge in the implementation of the maritime policy of the state [4]. Furthermore, in terms of global security policy and the key position of the Black Sea, in recent years it established itself as a region of great importance to the interests of EU and NATO.

Maritime sovereignty of the country is a priority and a special feature of the system of government with a high degree of integration of all institutions involved in defending the country's interests in the national maritime areas. It is therefore necessary to establish and pursue a national policy ensuring maritime sovereignty, which regulates the commitment of all institutions that provide monitoring, control and protection of the external sea border.

Essence of integrated maritime surveillance

As a Member State of the European Union, the Republic of Bulgaria has adopted an Integrated Maritime Policy for the European Union. It presents recommendations on the need for greater coordination on maritime surveillance through deeper cooperation within and between competent authorities for protection of maritime areas of the Member States and other relevant agencies. The improvement and optimization of maritime surveillance activities and interaction at European level are important to meet the challenges and threats related to safety of navigation, marine pollution, law enforcement and overall protectivity in maritime areas.

Integrated maritime surveillance aims to provide authorities with an interest or work in this area with a means of exchanging information and data. The exchange of data will make surveillance cheaper and more effective.

In 2009, a EU Communication[1] – „Towards the integration of maritime surveillance: A common information sharing environment for the EU maritime domain", set out four guiding principles for the development of a common environment for sharing information:

- An approach interlinking all user communities.

[1] COM(2009)538 final.

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Exchange of information should allow all stakeholders more efficient use of maritime surveillance information. Based on a „need to know", the system must enable both the civilian and paramilitary structures for exchange of information on national, regional or international level.

➢ Building a technical framework for interoperability and future integration

The establishment of the system for maritime monitoring and surveillance must be designed so that the interaction take place on different information layers in order to obtain the most complete picture of the situation in maritime areas. The system must allow different levels of decentralization, depending on system users.

➢ Information exchange between civilian and military authorities.

The connectivity between the systems for monitoring civilian and military organizations will help to ensure two-way information exchange and allow avoiding duplication of systems, which requires common standards and procedures for access to the use of the information.

➢ Specific legal provisions to materialise this Common Information Sharing Environment.

Legislative basis related to the use of the system must ensure compliance with the confidentiality of the data, protection rights of intellectual property and personal data protection in accordance with national and international law.

Activities in maritime areas that require integrated monitoring system

➢ Control of shipping.

The changed security environment in the oceans and new insight into the risks to shipping caused the first version of a document to come up in 2014 titled: Naval Cooperation and Guidance for Shipping (NCAGS) – Guide to owners, operators, masters and officers[2]. It is aimed at establishing and developing cooperation between the shipping industry and the Navy. This increases the security of the maritime transport system by: providing military assistance, guidance and leadership of NATO to increase the safety of commercial shipping and support in the conduct of military operations in the protection of shipping in peacetime, in crises and conflicts.

The implementation of NCAGS is possible only if there are agreements on:

- establishment of joint regional structures on the problems of maritime safety and security;
- mutual exchange of information related to security between the institutions of the neighboring countries, etc.

In view of the increasing maritime risks and limited operational and financial resources of stakeholder institutions have, optimizing the exchange of information can be more efficient and cost effective as a solution. The ambition of the structures that are related to the operational surveillance activities is to have timely access to the best possible information that is relevant for their activity, and can rely on smooth exchange of information between their systems, focal points and means for maritime patrol and surveillance.

Active counteraction to the new security threats in the maritime areas, the need for effective protection of marine environment and to ensure safety of navigation require sustained efforts by the Navy, national institutions and international organizations. On this basis, it is appropriate the emerging tasks in control of maritime areas and protection of shipping to be solved in the form of system operations, which may cover the following aspects:

- maintenance of a favorable operational regime;
- protection and support of shipping;
- preserving the marine environment;
- protection of sea resources;
- security of the maritime oil and gas extraction facilities.

➢ Search and rescue (SAR).

SAR at sea is associated with locating scene of the accident in the maritime space and conducting search and rescue operations coordinated by the Rescue Coordination Center.

The establishment of an independent structural unit to perform assigned the Maritime Administration Executive Agency functions in rescue activities in maritime areas correspond with the undertaken obligations of the Republic of Bulgaria arising from: UN Convention on the Law of the Sea (UNCLOS), the International Convention on Search and Rescue at Sea (1979) and the International Convention for the Safety of Life at Sea (SOLAS-74).

SAR operations in maritime areas are conducted with the aim of tracing, assistance and/or rescue distress or damaged ships or aircraft, fell overboard or missing people, which is determined by the intensive exploitation of the sea and its resources as well as airspace above it.

The experience of conducted SAR operations shows that the reaction time of a signal distress is a critical factor on which depends the survival of the people. The duration of such operations is small, such as the remoteness from the shoreline increases the response time and reduces the opportunities for participation of forces and technical equipment. The establishment of

[2] ATP-02.1. Edition A Version 1.

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systems for surveillance and control in maritime areas of the Republic of Bulgaria should be reduced to conducting operations to the most favorable situation – „action call". [1]

While conducting the SAR operation at sea space, there participate various institutions with specific duties and responsibilities. Each of these institutions has its own capabilities to participate with personnel and equipment. It is essential in which part of the Bulgarian SAR area of responsibility is the disaster happened and what his character. With moving away from the coast line, the capacity of individual structures to carry out SAR operations decreases. The problem is that it is necessary to distribute capabilities in maritime areas, depending on the declared capacity of the organizations to participate in SAR operations in national maritime areas. The development of the relevant SAR capabilities requires the subsidy, construction and maintenance of technical equipment for SAR. This problem still requires further study and it leads to the creation of conditions for continuous inter-institutional / departmental rivalry for funds.

- Border security.

Following the accession of the Republic of Bulgaria to the EU in 2007, border security is part of the general concept of global security in the region and Europe, and is a long-term strategic goal of the Republic of Bulgaria, which is the external border of the Union. As such, the Republic of Bulgaria must ensure a single standard of control and security in accordance with EU requirements for successfully combating the illegal trafficking of people, arms and drugs and prevent terrorist acts at sea.

The right of citizens to free movement across the EU is one of the „fundamental freedoms" provided further in the Treaty establishing the European Economic Community from 1957, but that does not automatically lead to the removal of border controls at the borders of the Member States. Abolition of border controls at the borders between countries is foreseen by the Schengen Agreement. At present the Republic of Bulgaria is not yet part of the Schengen area, since it failed to fulfill the procedures to fully implement the agreement. Management of external borders, in accordance with Art. 5 and 6 of the Convention implementing the Schengen Agreement, a set of actions of the relevant competent state bodies aimed at checking and border surveillance. For this reason, the EU aims to establish common standards for the control of external borders and the gradual introduction of an integrated management system for those borders.

For complying with the constructed EU rules in managing the external borders it is necessary to implemented a wide range of measures that can be divided into five categories as follows:

- I-st category of measures - a major pillar in the management of external borders is the Schengen Borders Code, which sets the rules for crossing the external border crossing points and the conditions for the temporary reintroduction of internal border controls [8];

- II-nd category of measures - not all Member States have external borders to control and not all are equally affected by border traffic flows. For this reason the EU has funds[3] in order to compensate part of the costs of the parties to the external borders;

- III-rd category of measures - refers to the establishment of centralized databases (Schengen Information System, Visa Information System and Eurodac [4]) for the purpose of migration and border management;

- IV-th category of measures - there is a set of measure designed to prevent and sanctioning of unauthorized entry, transit and residence

- V-th category of measures - directed to be operational cooperation in border management. The creation of the European Agency for Border and Coast Guard (Frontex) will contribute to more effective management of migration, improving the EU internal security and protect the principle of free movement of persons [9].

When developing a draft of the Strategy for Integrated Border Management of the Republic of Bulgaria (2014 - 2017), based on the European concept of integrated border management, taken into consideration are changes in the geopolitical situation, trends in illegal migration and cross-border crime, common commercial Community policy, the EU common policy for governance of the Schengen area and the strategic guidelines for further development in the fields of freedom, security and justice.

During the period 2009 - 2013 a tendency to reduce passenger flow of EU citizens and increase passenger flow of nationals of third countries passed through border checkpoints of the Republic of Bulgaria [Fig. 1].

Despite reducing the passing persons across our borders, the collection and exchange of information enabling risk analysis and assessment of the necessary administrative capacity and technical equipment aimed at improving border security and countering threats to security and

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[3] For the period 2014-2020, this mechanism for sharing the financial burden acts as a fund of Homeland Security: Borders and visas.

[4] Regulation (EU) No 603/2013.

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public order. A major element for improving security is the establishment of modern system of border security on the principle of integrated border control.

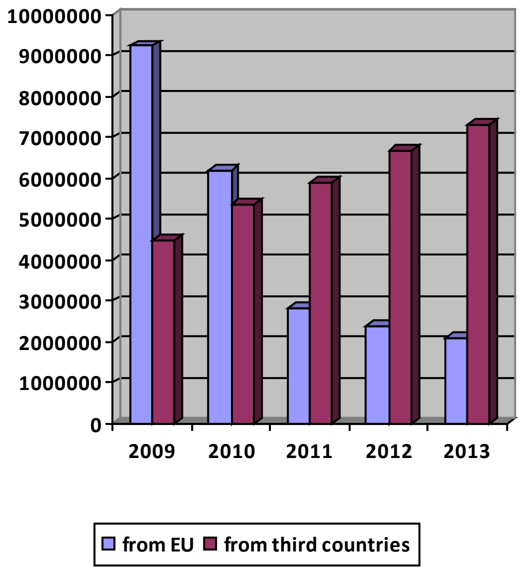

Fig. 1 Sitizens passed through Bulgarian borders

The integrated border control implements the functions of all institutions in the field of border controls for interaction at national and international level to effectively counter terrorism, cross-border crime and illegal migration in all its formswhile respecting the right to free movement.

- Environmental protection in the maritime areas.

Due to reduction of easily accessible resources for extracting on land, last year, except transport operations at sea, there was a redirection of economic interests to the untapped opportunities offered by the water-covered parts of the Earth. Interests related to development activities in maritime areas as globally and at national level shift to exploration and exploitation of natural resources in the seas and oceans.

The efforts of all stakeholders in the field of maritime activity (International Maritime Organization, state administrations, representatives of maritime business, etc.) are aimed at the implementation of adequate measures to control and reduce the risk of pollution from ships. Provisions introduced by the Convention MARPOL 73/78, together with other normative acts related to security and maritime safety, such as the introduction of traffic separation schemes and the establishment of international training standards for seafarers, helping to reduce „accidental" pollution by oil products.

Despite all international regulations, one of the most serious and extensive contamination of marine areas in the world is related to incidents at sea as a result of oil tanker crashes[5] followed by the spill of cargo or accidents[6] on oil rigs.

The most serious case of pollution in the Black Sea relates to the storm near the Kerch Strait on 11 November 2007. As a result of a force majeure (wind speed reached 32 m/sec and the state of the sea was very rough to high), combined with poor technical condition of the vessels and lack of proper organization of ship traffic, five ships sank and other 8 vessels were grounded in the Strait in the Azov and Black Sea. Following those incidents, apart from human victims (20 people were declared missing), more than 2000 metric tons of heavy fuel oil and 7000 metric tons of sulphur fell into the sea, which created a real threat for an environmental disaster. Despite the actions and measures taken, experts are adamant that the recovery of the ecosystem in the region will take 10-15 years. [209]

Due to the great isolation of the marine environment in the Black Sea pollution due the activity, can lead to a real danger of an ecological catastrophe in maritime areas, which may have adverse impact a lasting effect on the entire region.

To solve problems related to environmental protection in maritime areas, in 2008 the European Union adopted Marine Strategy Framework Directive [7] (MSFD), whose main objective is to maintain or achieve a healthy marine environment by 2020. For reaching this goal, it is necessary that Member States to develop national maritime strategy, including a set of measures to achieve or maintain DSMOS.

The year 2016 saw the development and adoption of the Marine Strategy of the Republic of Bulgaria for environmental protection in the Black Sea. Assessment of the state of the marine environment, in line with the MSFD, the national

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[5] In 1967 the tanker „Torrey Canyon" sank and spilled 119000 metric tons of crude oil off the coast of Britain. In another case in 1978 the tanker „Amoco Cadiz" crashed and 223000 metric tons of oil were spilled off the coast of France, etc.

[6] On 20.04.2010, the combustion of hydrocarbons caused an explosion on the oil platform Deepwater Horizon. The subsequent secondary explosion caused a huge fire that could not be controlled due to failure to close the well. On 22.04.2010 the oil platform sank in the Gulf of Mexico. In the investigation of the incident 11 crew members were declared missing and considered dead, but of the rescued 115 people, 16 were injured. The resulting oil spill is the largest recorded in US history. [10]

[7] Directive 2008/56/EC.

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strategy is carried out on the basis of eleven qualitative descriptors. To reduce the pressure on the marine environment, maritime strategy of Bulgaria recorded the program of measures [8] (duration 2016 – 2021), which ensure the achievement and maintenance of a healthy marine environment as required by MSFD.

Besides the positive aspects of the implementation of the MSFD, in achieving regional cooperation, Bulgarian representatives in the Black Sea commission have difficulties in the use of the Convention for the protection of the Black Sea against pollution. Of the six parties to the Convention, only Bulgaria and Romania are EU members. The other countries have different priorities in their policies towards safety and security in the Black Sea, but also in terms of cooperation with the EU. Direct questioning by the direct application of EU legislation causes more of negative reaction than willingness to cooperate.

Logical base for comparison of hypotheses and revealing of security risks

The processes of detection, identification and classification of safety and security risks and threats needs the reliable continuous monitoring of wide areas. Normally, a detection and identification criterion of a potential threat is the presence of suspicious physical objects situated or moving in the vicinity of a given point or area of interest, their mutual disposition and physical dimensions. For instance, tracking the movement of objects through the AIS and VTMIS allows identification and further classification of unauthorized entry into security areas of a hostile object or potential source of threat [2]. The magnitude and direction of the vector of movement are crucial for a successful classification stage. Fast incoming craft, large tonnage vessels sailing near or toward a given point of interest should be considered as a source of threat. Further, another criterion for detection, identification and classification is the behavior of the crew - for example a tendency to cooperate by following instructions issued by radio exchange with the control authorities, to share information, etc. It is necessary to seek compatibility between the declared intentions and actual behavior of the target. It is possible for a particular realization of threat to be represented as the latest in a series of related accidents.

The verification of the tenability of the established hypothesis for the emergence and viability of a particular scenario for the realization of a threat can be achieved using *Pearson's chi-squared estimation*, taking into account all the necessary assumptions. First, there is a list of n observations of variable value **X** and data excerpt of population is taken:

$$x_1, x_2, x_3 \ldots\ldots x_n \qquad (1)$$

After the arrangement of numerical indicators of the sample in ascending order we obtain the variation series:

$$x^{(1)}, x^{(2)}, x^{(3)}, \ldots\ldots x^{(n)} \qquad (2)$$

The following inequalities are in force for that series:

$$x^{(1)} \leq x^{(2)} \leq x^{(3)} \leq \ldots\ldots \leq x^{(n)} \qquad (3)$$

Let us call X an indicator of realization of a specific threat for maritime safety. Hence, X should be **a** continuous random variable and is usable during the process of analysis of gathered information and assessment of threat. The statistical information is available in interval table of frequencies of occurrence of any specific threat. The assessment of the parameters of distribution and assumption about the type of distribution of this random variable X is followed by non-parametric main hypothesis H_o. The hypothesis H_o is based on the assumption that X possess a distribution function $F_0(x)$ and has got a density of distribution $f_0(x)$. After that, the next step is to set up working hypothesis H_1, according to which random variable X has an distribution function $F_1(x) \neq F_0(x)$ and its density distribution is $f_1(x) \neq f_0(x)$. Further, the steps are as follows:

- Determine estimates of unknown parameters of the alleged law of distribution $F_0(x)$ that represent realization of the threat.
- Determine theoretical probabilities:

$$p_k = P(X \in I_k); \text{ when } k = 1; 2; \ldots\ldots; m. \qquad (4)$$

- Determine the observed value of *Pearson's chi-squared criterion:*

$$\chi_0^2 = \sum_{k=1}^{m} \frac{(n_k - np_k)^2}{np_k} \qquad (5)$$

The hypothesis is set up when it is true that the value of $\frac{n_k - np_k}{np_k}$ takes values in the range $N(0,1)$ when k is positive integer $k = 1; 2; \ldots\ldots m$.

Actually, the evaluation criterion is the sign of inequality, i.e. the hypothesis H_o is considered to be confirmed with a level of confidence $p = 1 - \alpha$, when the following condition is met:

$$\chi_0^2 < \chi_{1-\alpha}^2(f) \qquad (6)$$

[8] In applications III.2 and III.3 of the strategy are listed 52 existing measures and 23 new measures (national and cross-border) in the implementation of which will achieve a healthy marine environment.

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Where:

f = m−r−1 is a level of freedom concerning distribution of χ_0^2.

m - the final number of frequencies in the composite interval table;

r - the number of parameters of the theoretical distribution which is determined using a sample of series;

α - significance level, usually a priori calculated tabular value.

The hypothesis H_o is rejected if the inequality is:

$$\chi_0^2 \geq \chi_{1-\alpha}^2(f) \qquad (7)$$

Another aspect is the association of a scenario of realization with the available information gathered during surveillance. It is utilized by modeling the spatial trajectory of motion of any given physical object. It is important for all points of interest and security zones to be displayed in advance. In order to simplify the modeling, it is possible to identify the movement of the tracked object with a trajectory of a possible destructive process.

In general, the trajectory of the destructive process is a curved line. The line consists of set of points having domain of definition ***M***, which represents the path of the moving point. Coordinates of its changing position are known functions of time varying parameter ***t***. If the domain of definition ***M*** is described using Cartesian coordinates ***(x, y, z)*** *and* $f_1(t)$, $f_2(t)$, $f_3(t)$ are functions of the known parameter ***t*** having values in finite domain ***D***, it follows that the spatial line ***(c)*** resembling the trajectory of threat could be defined by following parametric equations:

$$(c): \quad \begin{aligned} x &= f_1(t) \\ y &= f_2(t) \\ z &= f_3(t) \end{aligned} \qquad t \in D \qquad (8)$$

The time parameter ***t*** obtains values in the common domain ***D*** and it is limited in interval from t_0 to t_r representing the time interval from the very first moment when potential source of threat "pops out" at the sensor until the realization or elimination of that potential source of threat.

That type of representation of the trajectory is applicable when it is necessary to describe the movement in air and underwater environment, i.e. when the path of the moving point is placed in a three-dimensional space.

The physical context of Cartesian coordinates is as follows: ***x*** - geographical latitude (according to the applicable system WGS-84 or UTM); ***y*** - geographical longitude (WGS-84 or UTM); ***z*** - height above the sea level or depth.

The model is more or less simpler while the trajectory resembles motion of surface target. In that aspect, all points belong to the plane determined by sea surface. We have ***z = 0***. The result, after substitution in the system of parametric equations (8), is a line determined in Cartesian coordinates ***(x, y)***. The line (f), when described parametrically having argument ***t ∊ D,*** is:

$$(f): \quad \begin{aligned} x &= f_1(t) \\ y &= f_2(t) \end{aligned} \qquad t \in D \qquad (9)$$

Where: ***x*** - *geographical latitude (according to WGS-84 or UTM);* ***y*** - *geographical longitude (according to WGS-84 or UTM).*

The detection reliability of the existence of a threat is linked with the ability to record any change during monitoring of environment. The probability of detection of a threat depends on the sensitivity of sensors, adequate use of indicators, applied procedures, qualification and training of personnel [3].

The probability of preventing the realization of a threat increases with increasing the rate of obtaining an indication of possible changes in the condition of the environment. It is obvious that a very important aspect of realization of the threat should be prevented by early warning and use of integrated C4ISTAR systems. The final goal is the early detection of signs of emergence of the threat and detection characteristics of the threat.

The accumulation of information of the environment enlarges the database. It is possible to detect an incipient threat after conducting a comparative analysis of the existing database to another while refreshing the picture of the situation. Safety and security in the dynamic maritime environment require intensive search of approach to creating an adaptive spatial and temporal organization of control at sea. The formation of the conditions to counter a threat requires creating a spatial organization of monitoring and developing minimal requirements for control at sea. The development of an integrated monitoring system responds to these requirements. The structure of the system and links between elements should be optimized by means of a model of information field.

The principle of increasing the density of the information field is realized through the deployment sensors with sensitivity required to register changes in the environment that serve indicators of the existence of a threat to the stage of evolutionary development of the threat. The aim is to create a field with a gradient of increasing intensity, directed to the specific object or area of interest. The analysis of the experience of some

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leading coastal states reveals some modern trends, visible in regional scope. These systems have significant potential for further implementation to enhance security and ensure the protection of littoral and offshore objects. Integrated monitoring systems support the management of security all over the world. Nevertheless, there are three main ways for development:

- Technical aspect - includes implementation of new technologies, constant modernization of used platforms, technical appliances and devices, etc.
- Improving procedures - includes troubleshooting, certification and verification of existing plans, development of adequate new procedures, conducting wide spectrum stress-tests, identifying and recording of learned lessons, analysis of incidents worldwide, etc.
- Education and training of personnel - includes developing education programs, specialized courses, simulations, conducting live exercises, etc.

Subsystems of integrated monitoring system are monitoring of underwater environment, monitoring of sea surface and monitoring of air targets.

Usually, the elements of the subsystem of technical appliances for **monitoring of underwater environment** are:

- Mobile and fixed sonar and underwater systems, such as low-frequency active sonar.
- Mobile and fixed sonar for passive surveillance.
- Long-range hydro acoustic systems performing observation of the underwater environment.

Information is transferred via landlines and mobile underwater sensors supplying information via a secure network to a center for displaying underwater environment, including satellite based communications. It consists of variety of hydro acoustic systems, and when conditions allow in the region, magnetometers are usable [5]. This allows significantly expanding the spectrum of abilities to control the underwater environment. According to the mobility, active sonar are fixed and mobile; according to the structure of the sensor and how to obtain the image are hull mounted sonar, variable depth sonar (VDS), towed sonar, self propelled variable depth sonar (SPVDS), side scan sonar, etc.

Passive acoustic systems are highly effective to detect wide spectrum both surface and underwater targets due to its concealment and enormous detection distances. Moreover, mobile underwater remote operating vehicle (ROV) can carry hydro acoustic system, magnetometer or optical device. ROVs are applicable when the risk is significant but it is crucial to detect and to classify the threat as early as possible.

Underwater surveillance, according to the tasks, type of used technical equipment and position is divided into two groups:

- realized by surface units by means of active sonar and magnetometers, positioned so as to provide overlapping information fields of sensors.
- realized by passive hydro-acoustic sensors and various units engaged in systematic activities in search of underwater targets.

Monitoring of the sea surface is classified as follows:

- Achieved by means of both visual and technical methods. Different types of radars, including automated radar plotting systems (ARPA) and optoelectronic devices that cover the blind zone of the system. A main requirement to the integrated systems is to provide recognition in the visible and infrared optical ranges including high-sensitivity television camera operating at low and very low light levels (LLTV), highly sensitive optoelectronic systems in the near infrared and thermal sensors operating in the Long Wavelength Infrared spectrum (LWIR) and the Medium Wavelength Infrared (MWIR) spectrum. Thermal cameras ensure 24/7 all weather surveillance of littoral or offshore environment [5].
- Achieved by means of unmanned flying remote operating apparatus or different type of drones and satellite monitoring. Use aero-space techniques for monitoring increases reliability and allows early warning. Drones pose ability to monitor wide areas around designated platform, having flexible requirements for logistic support. It is used to control of navigation, maritime critical infrastructure, sea lanes or particular areas, for instance search and rescue (SAR) areas, offshore developing areas (ODA), etc. The use of drones is based on principles of economy, efficiency, flexibility and integrity. Integrated use of system of drones is potential essential element of integrated monitoring system and, undoubtedly, has positive effects upon control at sea up to 20 hours at distance up to 2000 km per flight. Radars are effective early warning devices, having the opportunity to discover middle-sized surface targets of the distance of 20-25 nautical miles.

Nowadays, trends point out that it is appropriate to integrate radar sensors and electronic-optical devices into systems in order to assess the situation. Further, the system is able to perform automatic calculations and issue automatic warnings about dangerous movements and the revealed source of threat.

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The monitoring of airspace it is carried out by means of shore and platform based air surveillance radars together with fighter aircraft and satellite surveillance. The organization of monitoring is specific and depends on choice of elements and connections between elements. An important factor in control of airspace is the so called radar coverage. Because of the large size of the covered areas long range radars are used that have the capability to detect air targets up to 200 nautical miles. Also, a traffic control radar data is used because it provides recognized picture compilation of the traffic and because it covers the "blind zones" of the long range radar. The real-time mapping of flights is based on the air traffic control system. Undoubtedly, air control system and air surveillance radars should be connected with an integrated monitoring system [5].

The process of formation of recognized picture is achieved by means of detection a deviation of the environmental parameters of a predetermined equilibrium or "normal" state of environment, corresponding to the formation of a favorable security environment in maritime areas. The specifics of the environment at sea requires monitoring of a priory predetermined finite number of indicators for following reasons - distance from shore, technical reliability of the sensors and information system for operation in harsh marine environments, structural features of the sensors and power requirements, and last but not least connectivity and organization of data transfer.

Other obstructions arise from the intersection of interdepartmental interests and involvement of various institutions in monitoring of wide spectrum indicators of the environment. The real-time condition of the environment it is revealed by predetermined monitoring of selected finite number of indicators. The level of reliability is set in advance depending on the risk of realization of a given destructive process. Therefore, a possible solution is to create an integrated system for monitoring maritime areas.

The monitoring and further disclosure of indications is related to data that meet the characteristics of the model, which confirms or rejects the hypothesis of the existence of the destructive process.

For example, there are basic requirements associated to needed filters and displays of information concerning cognition process and perception of personnel. Incoming amount of information reduces the uncertainty in the assessment of environment conditions and presence of sources of threat and establish criteria for the "normal" condition via selection of indicators in aspects quality and quantity. The management of the information flow in the data layer enables the enhancement of management of processes related to security, safety and ecology. Important stages during design of integrated monitoring system are:

- Design of architecture framework and requirements.
- Selection of sensors according to requirements and designed structure.
- Positioning of sensor for measuring designated parameters. The location is defined by geographical coordinates and altitude to a particular geodetic point attached to the geoid with specified predetermined accuracy.
- Values measured, standardized to the requirements of processing information system. Mandatory standards allow achieving operability of the integrated information system and thus facilitate receiving data with a preset accuracy.

Data from the sensors should be grouped, presented to users as a function with discrete or continuous values projected on the information layer of the system. Refresh of the system is performed in accordance with specified minimum requirements for the discretion of the monitoring indicators of the environment. Reliable information is obtained by processing of satellite images, images from the air monitoring sensors of surface surveillance radars together with data from autonomous underwater and surface stations. Systems for monitoring of coastal zone designed by means of geographical information system complement the capabilities of systems for satellite monitoring.

The probability of early detection increases when the information from the sensors is continuously compared with the available database. The probability of early detection decreases because of hampering factors such as intensive ship traffic, interference due to strong waves, rain, fog, etc. In fact, these factors lead to decreasing of capabilities of the system for processing collected data. Hence, it hampers the timely detection of dangerous surface targets, underwater or flying objects. The knowledge of the physical and geographical features of the area, characteristics of maritime traffic favorably affect the monitoring of the environment.

On the other hand, sensors should be concentrated precisely in differentiated special protective zones - around offshore power generation equipment, oil pipelines, traffic separation scheme and in marine areas with a concentration of ship traffic. The integrated monitoring system needs a sufficient flow of information - electromagnetic, chemical, physical and biological indicators on the state of the environment. The information fields thus

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established are characterized by spatial boundaries, gradient, density and balanced specific configuration of used indicators. They should be managed in order to provide all necessary outcome characteristics of intended information field.

Vessel Traffic Monitoring and Information Systems (VTMIS) is an integrated tool to fulfill the requirements for safety at sea, protection of human life, and protection of the environment. Potentially, it is an important element of integrated monitoring system serving as a tool of control at sea.

Implementation of integrated maritime surveillance

Maritime surveillance is a factor in ensuring security and safety for the activities carried out at sea. For surveillance and control of maritime spaces in Bulgaria, three systems are built, each of them providing a different institution depending on its specific activity:

- Coastal radar control system of navigation and security of the maritime boundary „Ekran“[9] - provides the Bulgarian Navy with a unified picture of maritime traffic entering or located in Bulgarian waters;
- Integrated system "Blue Border"[10] – provides Chief Directorate "Border Police" with the ability to monitor and control vessel traffic in the maritime space of the Republic of Bulgaria and guarding of maritime boundary;
- "Vessel Traffic Management Information System (VTMIS) - Phase 3" is fully operational from 2015 – with implementation of the third phase of the project all information and communication subsystems are integrated into a common national maritime information system which expands coverage and functionality of the system [7]. Realization of the project meets the requirements of EU directives – 2002/59/EU[11] and 2010/65/EU[12].

As a result of the implementation of the third phase of the project all communication and information subsystems are integrated into a common national maritime information system, have expanded the scope and functionality, taking into account the latest requirements of international and European documents and technological developments in the field.

At present, national authorities and responsible EU bodies for different aspects of surveillance – e.g. border control, safety and security, fisheries control, customs, environment or defense, collect data separately from each other and often do not exchange them. For this reason, the European Commission and EU Member States and EEA (The European Economic Area) countries jointly develop common information sharing environment (CISE). The purpose of this general environment is to integrate existing systems and monitoring networks and give all concerned authorities access to the information they need in carrying out their tasks in the maritime space.

On a national level, this is achieved by interagency agreements between the Ministry of Defense and Ministry of Transport, Information Technology and Communications, like the Navy are given the opportunity to use the work places om VTMIS. The lack of organizational structural element that integrates information from three systems and then distributes it in features to users, which would provide enough reaction time can be regarded as an essential gap in inter-institutional relations.

Main functions of the integrated surveillance system:

- increases efficiency by locating illegal immigration and all kinds of smuggling;
- increases the level of security for vessels in the coastal zone and provides immunity against piracy and terrorism;
- provides the responsible institutions in carrying out operations of search and rescue at sea;
- control the fishing activities and care for the protection of marine resources;
- it provides the necessary information concerning monitoring and tracking of suspected vessels sailing in maritime spaces, in accordance

[9] The project „Ekran“ has been started since 2011. It consists of an operational center for maritime sovereignty, regional control centers of shipping, coastal radar stations for surveillance and integrated digital communications and information system, using the latest fifth-generation information system „Lockheed Martin“ for monitoring and managing vessel traffic. The system is able to collect data from 2,000 sensors in Bulgarian territorial waters, giving the Navy the opportunity to see the Bulgarian coast.

[10] The "Blue Border" has been established since 2011.It was built with funds from the "Schengen" Instrument and allows control of surface conditions in real time.

[11] Establishing a Community vessel traffic monitoring and information system.

[12] Reporting formalities for ships arriving in and/or departing from ports of the Member States.

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with commitments between the border and coast guards of the Black Sea countries.

To realize the integrated maritime surveillance in the Republic of Bulgaria on 18 January 2017 the first meeting on the project Integrated Bulgarian Maritime Surveillance (InBulMarS) [13] was conducted.

Beneficiaries in this project are: Executive Agency Maritime Administration, Chief Directorate Border Police, National Customs Agency, Bulgarian Navy, Bulgarian Ports Infrastructure Company and National Agency for fisheries and aquaculture.

The main objective of the project InBulMarS is to make a preliminary study for determination of the needs and requirements for improving the cross-sectoral information exchange in the field of maritime surveillance.

The specific project objectives are to:

- identify needs in operational centres and in surveillance assets for further cross-sectoral information exchange at national level;
- define new information services, based on the CISE Data and Service model, which would be set up and provided to other sectors at national level and possibly exchanged with other Member States;
- identify requirements and obstacles of CISE integration and to facilitate the integration of data available in different ICT systems in a single user interface [6].

In summary, it should be said that it is vital for control at sea to keep good coordination between governmental institutions and non-governmental organizations on a regional level. Integrated maritime surveillance is a crucial sub-system of maritime control system and it contains essential systems characteristics. Nowadays, there are many examples of realized integrated maritime surveillance systems both as national and regional projects in Black Sea area. These projects expand different aspects of control at sea such as control navigation, offshore activities, marine agriculture, tourism, and safety of various activities at sea, and last but not least, environmental protection. The main objectives of most contemporary projects are focused on a preliminary study for the determination of the needs, procedures and requirements for improving the cross-sectoral information exchange and implementation of modern high-technologies in the field of maritime surveillance.

[13] The project has a deadline for implementation from 01.01.2017 until 31.12.2018. The total project budget is € 238820 of which EU contribution - € 191056.

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