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MANAGEMENT OF THE PROJECTS OF HUMANITARIAN DEMINING OF UKRAINE'S WATER AREAS: THE PROBLEMS OF FORMING ORGANIZATIONAL STRUCTURES

УПРАВЛІННЯ ПРОЕКТАМИ ГУМАНІТАРНОГО РАЗМІНІРОВАНИЯ АКВАТОРИЙ УКРАЇНИ: ЗАДАЧИ ФОРМИРОВАНИЯ ОРГАНІЗАЦІОННИХ СТРУКТУР

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Abstract. The current state of project management for humanitarian demining of the water areas of Ukraine has been analyzed. Genesis of the theory of management of such projects is formulated; they constitute a part of the projects on diving, biotechnical, robotic and combined demining. The publication suggests a generalized structure of the studies on elaboration of the theory of management of the projects on humanitarian demining of water areas considering formation of organizational structures for the project management with the use of unmanned (remotely operated) technologies. The study indicates that improving the quality and productivity of humanitarian demining in water areas with unmanned technologies is possible and quite feasible. The organizational structures based on biotechnical systems and marine robotics are developed.

Keywords: project management; humanitarian demining; organizational structure; marine robotic vehicle.

Анотація. Виконано аналіз сучасного стану управління проектами гуманітарного розмінування акваторій України. Сформульовано генезис теорії управління такими проектами у складі проектів водолазного, біотехнічного, робототехнічного та комбінованого розмінування. Запропоновано узагальнену структуру досліджень з удосконалення теорії управління проектами гуманітарного розмінування акваторій у напрямку формування організаційних структур управління такими проектами за безлюдними технологіями. Показано можливість і доцільність підвищення якості й продуктивності операцій з гуманітарного розмінування акваторій за безлюдними технологіями. Розроблено організаційні структури на основі біотехнічних систем і засобів морської робототехніки.

Ключові слова: управління проектом; гуманітарне розмінування; організаційна структура; засіб морської робототехніки.

Аннотация. Выполнен анализ современного состояния управления проектами гуманитарного разминирования акваторий Украины. Сформулирован генезис теории управления такими проектами в составе проектов водолазного, биотехнического, робототехнического и комбинированного разминирования. Предложена обобщенная структура исследований по совершенствованию теории управления проектами гуманитарного разминирования акваторий в направлении формирования организационных структур управления такими проектами по безлюдным технологиям. Показана возможность и целесообразность повышения качества и производительности операций гуманитарного разминирования акваторий за безлюдными технологиями. Разработаны организационные структуры на основе биотехнических систем и средств морской робототехники.

Ключевые слова: управление проектом; гуманитарное разминирование; организационная структура; средство морской робототехники.

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Problem statement. Mine action has been practised worldwide as a humanitarian and pragmatic phase of demining since the end of the World War II. In accordance with the current definition provided by the United Nations in the International Mine Action Standards (IMAS), mine action is the activities which aim to reduce the social, economic and environmental impact of mines and explosive remnants of war including unexploded sub-munitions [1].

As a key component of mine action, humanitarian demining covers a range of services aimed at eliminating the dangers and risks associated with mines, ammunition and other explosive objects [2]. This includes carrying out technical inspections (assessment missions), drawing up maps, clearing particular areas, marking, and submitting documentation on the areas cleared from explosive objects to local government authorities.

Since Ukraine was in the thick of events during the World War I and World War II, the problem of demining stays relevant for its territory and population during peacetime as well. Ukrainian mine clearance services are removing explosive objects on a daily basis, while random discoveries result in casualties.

The issue of humanitarian demining within water bodies constitutes a problem that needs to be treated separately.

Underwater potentially hazardous objects (UPHOs) are the explosive objects and remnants of war. They pose a danger to the marine environment and a threat to the life and health both of holidaymakers and people living in a coastal area. They also complicate the social and economic development of the coastal areas of Ukraine,

in particular, those involved in water transport and tourism business.

Appropriate units of the State Emergency Service of Ukraine (SESU) annually detect and dispose of more than 3000 explosive remnants of war in the water areas of the Black and Azov Seas and other water bodies of Ukraine.

A substantial percentage of the emergencies registered in the water bodies of the Mykolaiv region are associated with its geography, namely, a long stretch of the Black Sea coast (127 km), a large number of water bodies (845), rivers, and a large number of enterprises engaged in sea navigation.

The Main Department (MD) of the SESU annually takes practical measures to clear the Black Sea of UPHOs in the areas of the Kinburn Spit, the Berezan Island, the Ochakov Port, the region's estuaries, etc. in the order of rapid response. The largest clusters of UPHOs located in the Mykolaiv region include flooded barges with ammunition detected in the coastal strip of the Yagorlytsky Bay and the mine-laying ship “Kolkhoznik” near the Kinburn Spit. During their humanitarian demining, the pyrotechnic unit has detected 7640 explosive items, including 18 aviation bombs, 49 mortar mines and 1128 shells of various calibers, all destroyed according to the established procedure.

Only over 2016–2017, the total of 37500 m² of the Black Sea water area have been surveyed and 1160 explosive remnants of war have been detected and disposed of, including 562 shells and 4 aviation bombs.

The Black Sea in the Mykolaiv region is a resort area where underwater tourism has been rapidly developing

in the recent years. Taking into account the current threat posed to sea navigation by the possibility of an unsanctioned explosion and detonation of UPHOs, the SESU MD takes appropriate measures to prevent emergencies and casualties and ensure the population's safety. Humanitarian demining of the Black Sea is annually considered at the meetings of the Regional Commission on technogenic and ecological safety and emergencies at the Mykolaiv State Region Administration. These issues are also included to the National Target Program On Protection of Population and Territories against Emergencies [3, 4].

The water areas of the Mykolaiv region which are subject to inspection and clearance of UPHOs make up more than 100 hectares. Such amount of underwater works should be carried out with the use of advanced project management methods, with the principal scientific objectives yet to be accomplished being the development of effective organizational structures, appropriate technical and staffing support of humanitarian demining projects. A promising direction is the introduction of unmanned (remotely operated) technologies based on application of biotechnical systems and involvement of marine robotics in almost all major stages of humanitarian demining, from search and inspection to neutralization of UPHOs. This will reduce the risks to the lives and health of the participants of such works and improve the quality and efficiency of humanitarian demining of water areas.

Latest research and publications analysis. The issue of demining of land and water areas is sufficiently covered in publications [5, 6]. Practical guidelines for the effective use of demining facilities are given in normative documents and catalogs [7, 8]. The problems of theory and practice of using underwater robots in marine anti-mine missions (combat demining) are most thoroughly described in monographs [9, 10]. The Ukrainian experience of using underwater robotics in the tasks of water area clearing from UPHOs (humanitarian demining) is rendered in detail in papers [11–13].

These and other publications cover certain issues of the facilities and technology for the UPHO search and humanitarian demining of land and water areas. However, the matter of comprehensive definition of the scientific problem of project management with regard to creation and application of advanced, in particular, robotic underwater technologies in the practical activities of the specialized units of the SESU has not been considered in the scientific publications so far.

THE ARTICLE AIM is to analyze the current status of the project management of humanitarian demining of water areas in Ukraine and determine the organizational structures for the project management of humanitarian demining based on unmanned technologies as a task of national importance.

Basic material. Destruction of the hulls of sunken warships and vessels with ammunition, as well as containers with chemical warfare agents flooded in the ter-

ritorial waters of Ukraine during the World War II, poses an ever-increasing threat in the Black and Azov Seas [14]. It requires the development of appropriate organizational and technical measures for water area clearing from UPHOs [15].

Let me consider this problem in more detail as a task of project management.

Currently, there is a number of effective organizational and managerial documents in Ukraine that collectively regulate humanitarian demining. They constitute the terminological and informative basis for mine action [16, 17], discussing clearance of land areas and disposal of anti-personnel mines in the first place [18].

Standard [1] appears to be the most comprehensive document on the project management of humanitarian demining, rendering its major processes — planning, preparation, mine clearing, quality management, etc.

The management of humanitarian demining of water areas as a project activity is described in standard [20]. It deals with the methods of technical and non-technical inspection of UPHOs, including the use of underwater robotic equipment — towed, remotely controlled (via a tether) and autonomous underwater vehicles. However, the standard does not cover the creation of organizational structures for underwater humanitarian demining and does not fully disclose the current capabilities of remotely operated technologies for the UPHO search and neutralization.

An analysis of the current state of humanitarian demining in Ukraine indicates that the genesis (emergence and development) of the theory of project management of humanitarian demining of water areas is currently represented by four types of projects:

- diving demining;
- water area clearing with the use of biotechnical systems;
- demining with the use of underwater robotic vehicles;
- combined water area clearing, which engages application of the three methods mentioned above.

These types of humanitarian demining projects have been developing consecutively, from diving to biotechnical and robotic ones, and are currently quite popular. However, the theoretical issues of management of such projects have not been fully elaborated. For instance, formation of the organizational structures intended for managing these projects has not been studied to the required extent, and so are the special features of management of such projects, in particular, the risks associated with their implementation.

Thus, let me propose a generalized framework for the studies aimed at elaborating the theory of project management of humanitarian demining of water areas. It is presented in Fig. 1.

Let me give a brief description of the project management features under consideration.

Obviously, project management of manual demining is a traditional activity of the SESU managers. It requires organization of specialized demining diver units

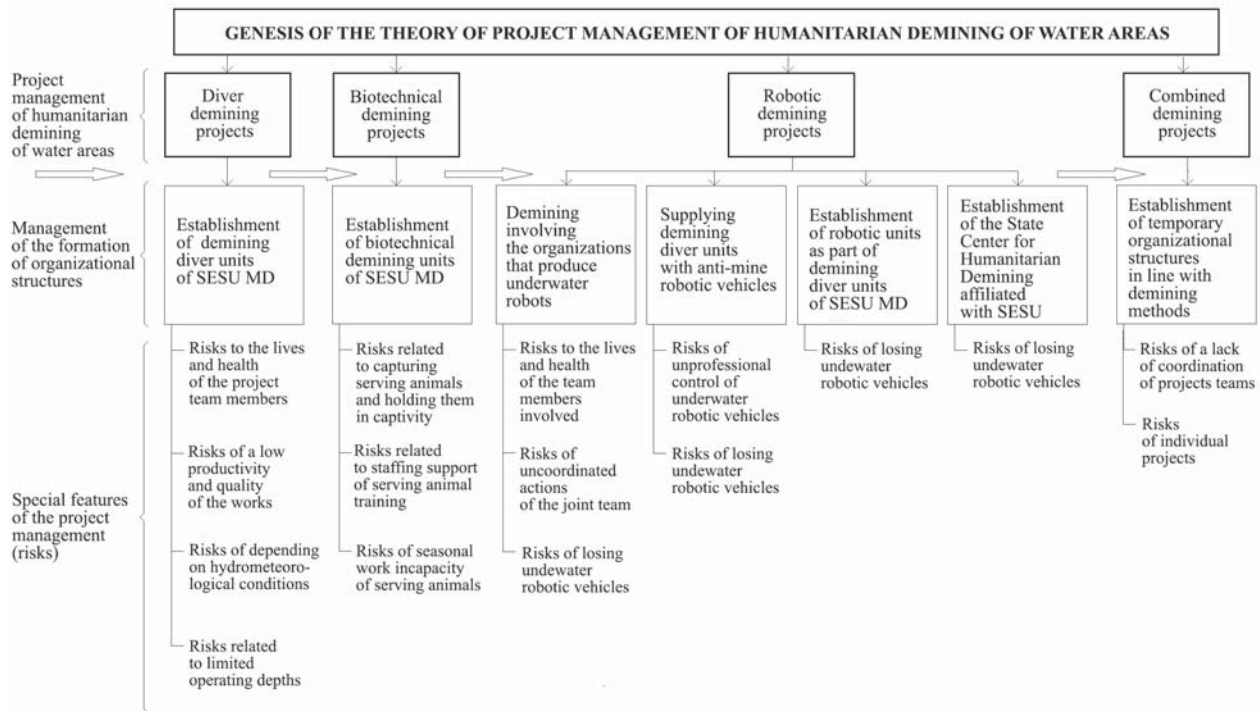


Fig. 1. General framework of the main tasks of project management of humanitarian demining of water areas in Ukraine

within the SESU MD as the main performers of water area clearing [21].

Within the water area clearing project, the Special-Purpose Rescue Unit was established as part of the SESU MD in the Mykolaiv region in 1999. Then in 2005, a pyrotechnic group was incorporated to this unit and started performing the respective works. In 2009, the Rescue Diving and Underwater Demining Group was established as a result of expansion of humanitarian demining tasks. Its main tasks were determined by a number of legislative acts [3, 4]. The group is organized according to the functional principle; each management body specializes in a particular function at all levels of management (Fig. 2).

The management of such projects should provide for a mandatory risk management associated with:

- risks to the life and health of the project team members, primarily demining divers who inspect and neutralize UPHOs;

- a low productivity of underwater demining because a lot of time is spent on preparation to diving and the divers move slowly under water;

- a substantial dependence of diving technologies on the hydrometeorological conditions in the water area, since sea disturbance, seasonal currents, ice, water and air temperature all limit the diving session;

- the possibility of non-fulfillment of underwater works at the depth beyond the diver's reach.

Management of the projects on water area demining with the help of biotechnical systems engages marine serving animals (MSA) like cetaceans or pinnipeds [22, 23]. These systems have been widely used by the USSR, the United States and other coastal states against naval mines and saboteurs, as well as with the purpose of World Ocean research.

Fig. 3 shows the basic divisional form of the organizational structure of the Unit of Marine Serving Animals of the SESU MD. The divisional form is chosen due to the unique complexity of the marine technical and biotechnological technologies implemented by this unit.

The unit includes the following major departments.

The Department of MSA Capture must operate under licensed quotas. It has the service ship 1 with the appropriate equipment and a team of experts on board to capture marine animals. It should be noted that the process of capture is accompanied by high risks of possible injuries and death of the animals. Thus, the activities of the department are extremely complex as for the technologies of search for the animals in the open sea, their safe capture and transportation. Being subordinated to the head of the unit, the head of the department develops plans for the MSA capture, organizes training and coordinates work of the department's groups at sea.

The Department of Holding MSA in Captivity should accommodate animal enclosures and custom-built indoor swimming pools with seawater. It comprises expert groups specializing in marine animal care, feeding and treatment. Following the recommendations of the head of the unit, the head of the department plans the daily activities on MSA care through managing the expert groups ashore.

The Department of MSA Training consists of highly skilled animal handlers provided with special equipment, enclosures, and water areas allocated to perform effective MSA training. Directed by the head of the unit, the head of the department devises working plans of the group leaders regarding the development of brand new methods of MSA training for humanitarian demining of the water areas and/or application of the recommended

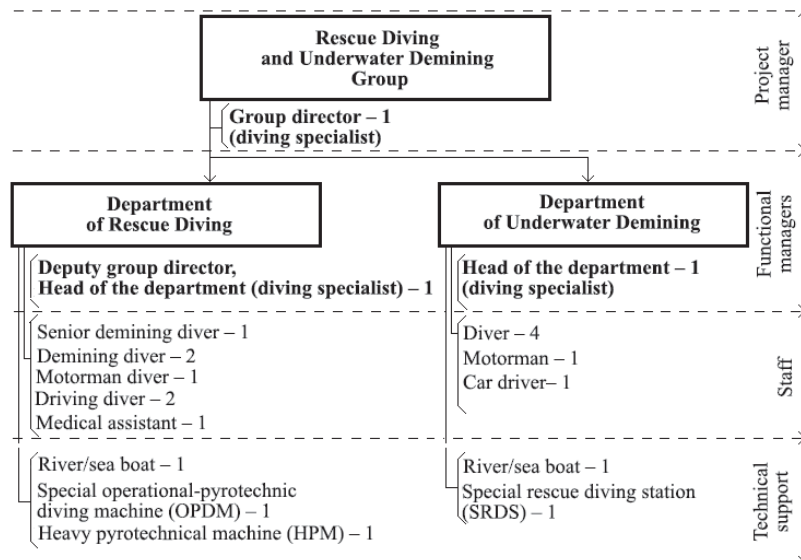


Fig. 2. Organizational structure of the functional type for the Rescue Diving and Underwater Demining Group of the Engineering and Transport Division of the Special-Purpose Rescue Unit of the SESU MD in the Mykolaiv region

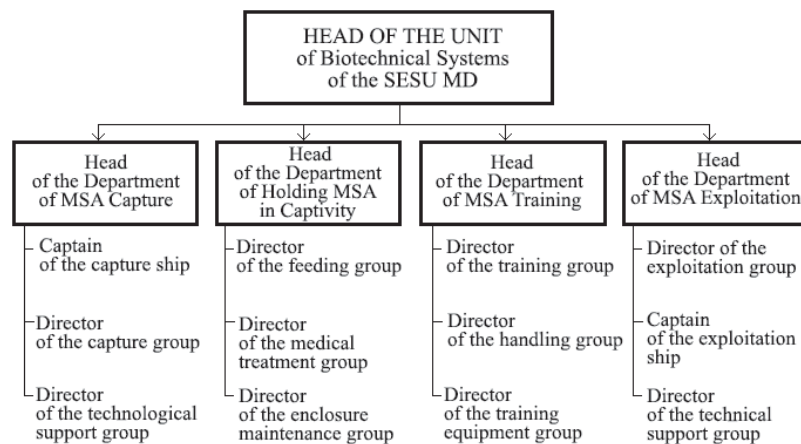


Fig. 3. Basic organizational structure of the divisional type for the Unit of Marine Serving Animals of the SESU MD

ones. The head of the department also organizes the work of the animal handler group 1 and the enclosure maintenance groups.

The Department of MSA Exploitation should include the animal handler group 2 provided with the service ship 2 to deliver MSAs to a designated sea work area. The ship must be fitted with special equipment to keep MSAs onboard for a long time while transporting them to the work area, releasing them into water to perform clearance activities, and taking them onboard again upon the work completion. The head of the department is basically an executive manager who plans and organizes the work of the leaders of the department's groups in line with the main purpose of the unit — UPHO detection and disposal.

Let me point out that the projects of humanitarian demining that involve MSAs have the drawbacks associated with the following risks:

the risks related to capturing marine animals and holding them in captivity, which require deployment of specialized organizational structures with enclosures for

living and training of the animals, as well as specialized floating facilities for their transportation and exploitation in a specified water area;

the risks related to organizing and training a high-skilled animal handler team for the training and exploitation of marine animals;

the risks of seasonal incapacity of MSAs for demining missions, since all the species of marine animals have certain biological peculiarities and limitations that affect the possibility of their year-round exploitation.

It is worth noting that the projects on creation and implementation of biotechnical systems in Ukraine had been only developed in the Research Center of the Armed Forces of Ukraine “State Oceanarium” (Sevastopol) until 2014 and are currently discontinued due to objective reasons.

However, if proper maritime units are established within a state institution, such projects will become a promising trend of the development of humanitarian demining of water areas.

At present, the most attractive direction for the development of the projects of humanitarian demining of water areas is the use of marine robotic vehicles (MRV): towed, remotely operated and autonomous underwater vehicles (TUV, ROV and AUV, respectively), unmanned surface vessels (USV), and unmanned aerial vehicles (UAV) [24]. This is evidenced by both national and worldwide experiences in the organization of such projects [25].

Since 2010, the specialists and equipment (underwater robotic vehicles) provided by the Admiral Makarov National University of Shipbuilding have been engaged in the survey of sea and river water areas. This enabled realizing robotic demining projects, which is a brand new type of the projects on humanitarian demining of water areas in the national practice. The survey suggested detecting the ships with ammunition flooded during the World War II, determining their exact coordinates and approximate amount of ammunition, establishing if there are any UPHOs on the sea bottom soil near the sunken objects, and planning the required operations.

Publication [26] considers the scientific foundations of management of the joint projects of humanitarian demining of water areas performed by the SESU units and organizations developing marine robotic vehicles.

Provision of the Rescue Diving and Underwater Demining Group (Fig. 2) with robotic vehicles will substantially increase the functionality of the group in particular and the Rescue Unit in general, offering the following opportunities:

- highly effective search for UPHOs and their inspection via unmanned technologies;
- high-quality video documentation of the UPHOs and cleared water areas supplied with geodetic data;
- objective instrumental measurement of the UPHO characteristics;
- real-time data supply for preparation of the UPHO disposal;
- fast underwater transportation of the instruments and stock to the area of underwater diving works;

– support and documentation of the diving works with the effect of presence of the operation’s executive when implementing robotic technologies; a prompt response to the current situation under water.

Fig. 4 demonstrates the effective organizational structure of the divisional type for the Rescue Diving and Underwater Demining Group provided with marine robotic vehicles. They are operated by the staff assembled through combining job positions (highlighted in italics).

This organizational structure offers the following major advantages:

- no risk to the lives of the group members during water area inspection and demining;
- possibility of performing the works at the depths beyond the diver’s reach;
- low dependence on hydroclimatic conditions of the work area;
- higher readiness of the group to work and high overall efficiency of maritime operations.

Its disadvantages include the need for a vast combination of the positions of the group members (that is, assigning additional duties to most of them) to operate the MRV, which hinders the full-scale, effective use of the modern MRVs. This is especially the case if the complex underwater technologies are implemented under severe hydrometeorological conditions, when high professional requirements are put forward to the MRV crews.

Besides, this organizational structure does not provide for a simultaneous use of all MRV types due to staffing limitations.

Yet, this drawback can be eliminated through establishing a specialized Department of Marine Robotic Vehicles with a highly skilled staff capable of performing a full range of robotized surface and underwater technical works, providing high productivity and quality. Such a subdivision of the Rescue Diving and Underwater Demining Group must be supplied with a complete set of equipment for the water area clearing from UPHOs.

Fig. 5 presents the improved organizational structure of the divisional type for the Rescue Diving and Under-

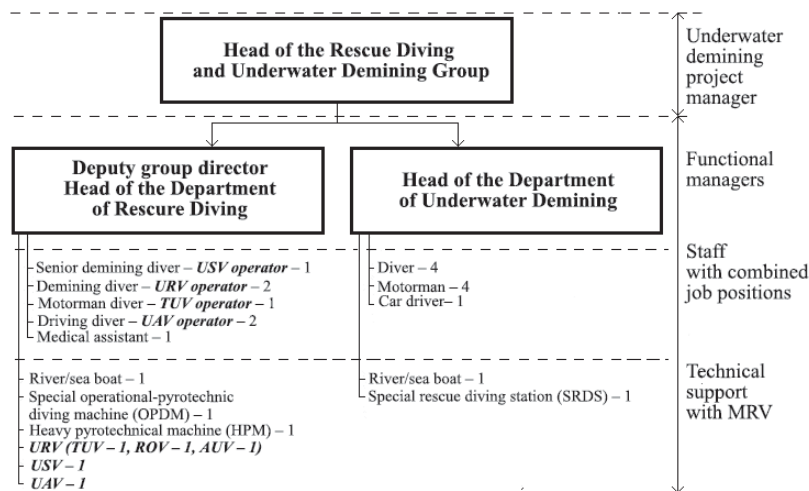


Fig. 4. Current organizational structure of the divisional type for the Rescue Diving and Underwater Demining Group of the SESU MD in the Mykolaiv region provided with marine robotic vehicles

water Demining Group which includes the Department of Marine Robotic Vehicles with the staff for their operation (highlighted in italics).

This organizational structure offers more opportunities than the previous version. The presence of the Department of Marine Robotic Vehicles allows performing the tasks of humanitarian demining of water areas to the full extent, which takes the implementation of these projects to a whole new level.

Moreover, as there is a complete team of MRV operators, the MRVs can be used either collectively (to perform a complex maritime operation when clearing a large water area) or separately (to perform several operations simultaneously).

The proposed organizational structure has the disadvantage of the high overhead costs required for continuous maintenance of numerous complex MRVs in the working condition within a single SESU MD group.

This drawback can be overcome by establishing a brand new unit of the SESU which would be engaged in the UPHO search and disposal (humanitarian demining of water areas) with an extensive use of advanced robotic technologies on the state scale. This approach substantially reduces the overhead costs of maintaining the MRVs and increases the effectiveness of their intended application, since it enables centralized management of the processes of formation, technical and staffing support, long-term and operational planning, and realization of such a unit. Within the SESU, the Center for Humanitarian Demining of Water Areas may well play the role of this unit as part of the Unified State System for the Prevention and Elimination of Emergencies. The main tasks and basic structure of the organizational and technical support of the Center are proposed in Fig. 6.

The main departments of the Center for Humanitarian Demining include:

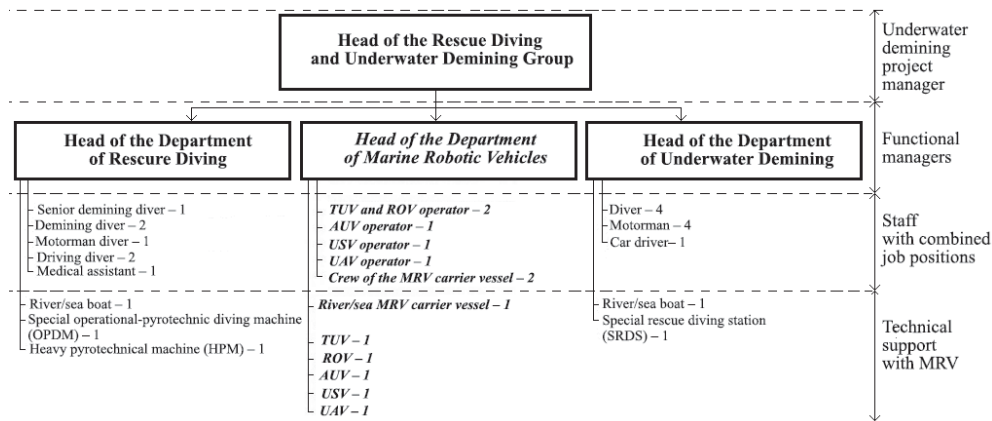


Fig. 5. Improved organizational structure of the Rescue Diving and Underwater Demining Group of the SESU MD in the Mykolaiv region complemented with the Department of Marine Robotic Vehicles

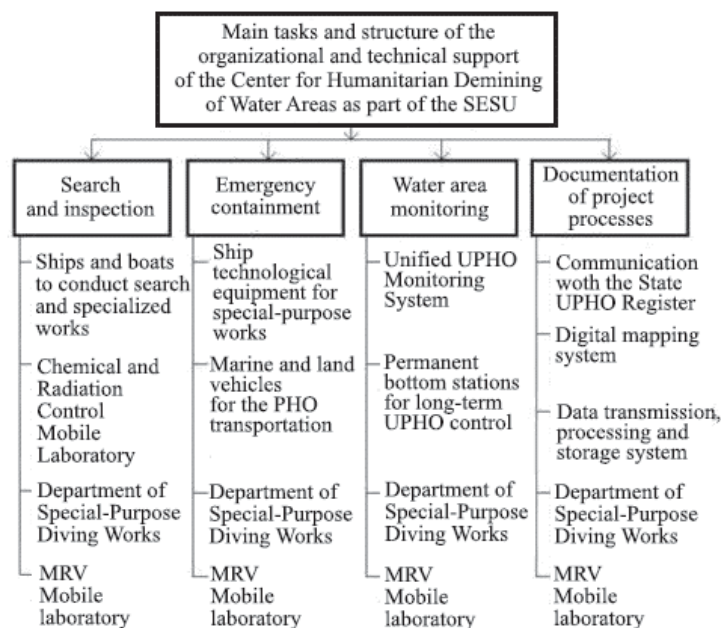


Fig. 6. Main tasks and structure of the organizational and technical support of the Center for Humanitarian Demining of Water Areas as part of the SESU

– the Department of Special-Purpose Diving Works (currently operating as part of the SESU) and the Department of Mobile Laboratories (MRV, Chemical and Radiation Control);

– the Department of Communications and Documentation dealing with the processes in the projects of humanitarian demining of water areas, which is intended for digital mapping (documentation of UPHOs supplied with geoinformation), fast transmission, processing and centralized storage of the data containing the project results; an essential function of this department is to provide information to the State UPHO Register.

Fig. 7 shows the basic organizational structure of the divisional type for the Center for Humanitarian Demining of Water Areas as part of the Unified State System for the Prevention and Elimination of Emergencies. As implied by this framework, project managers for demining operations in specific water areas are either activity-specific managers or specially appointed experts with an experience in marine works of such a level of complexity.

The organizational structure should operate in accordance with the following modes of the Unified State System for the Prevention and Elimination of Emergencies:

- regular mode;
- high alert mode;
- emergency mode.

Accordingly, it conducts the following operations during the implementation of special underwater works:

- in the regular mode: monitoring and control over the condition of the water area, situation in the UPHO and in the water area, planning and implementation of emergency prevention measures;
- in the high alert mode: intensified monitoring and control over the condition of the environment, situation in the UPHO and in the water area, prediction of possible emergencies and their magnitude, placement of appropri-

ate forces and means into the state of alert, deployment towards a threatened water area if necessary;

- in the emergency mode: organization of population protection, deployment of the response group towards the water area where the emergency occurred, determination of the scale of the emergency, organization of the response to the emergency, water area clearing from UPHOs, continuous monitoring of the environment in the emergency area and the situation in the UPHO.

Therefore, the Center’s MRV Mobile Laboratory should be able to follow four main types of MRV application scenarios, namely, water area clearance from:

- a single UPHO;
- a group of UPHOs located on a single underwater facility, for example, on a sunken ship;
- UPHOs located in a considerable area of the bottom surface;
- UPHOs occurring over a considerable area of the bottom surface.

Management of the project on creation of the Center for Humanitarian Demining within the SESU goes beyond the scope of this publication and is the subject of a separate study. Let me only consider the main directions of project management aimed at establishment of the Center. Based on the system approach to process management, they are as follows:

development of the organizational structure of the Center, which should comprise appropriate units for the tasks indicated in Fig. 6;

material and technical support of the Center’s units, in particular, with the help of safe and highly effective robotic technologies of water area clearing;

formation of the necessary operational-tactical resources (in particular, appropriate MRVs) in the projects on water area clearing from explosive objects;

personnel support of the Center’s activities, in particular, training of the personnel capable of effective ap-

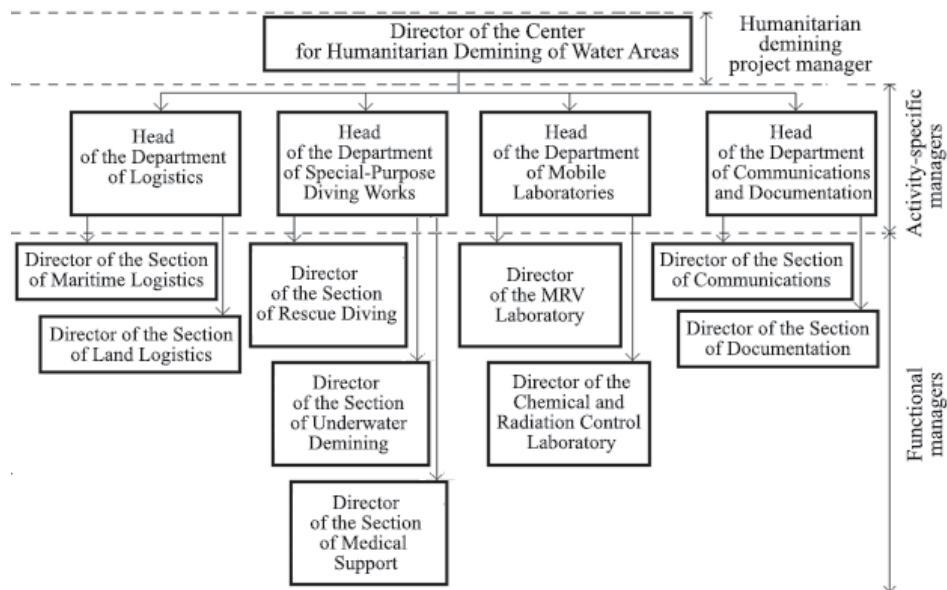


Fig. 7. Basic organizational structure of the divisional type for the Center for Humanitarian Demining of Water Areas

plication of the MRV according to its intended purpose.

It should be highlighted that these activities are also relevant for the organizational structures shown in Fig. 4 and 5.

CONCLUSIONS. 1. At present, humanitarian demining of the water areas of Ukraine is a relevant task of national importance, since sunken explosive objects pose a threat to people's life and health and make it impossible to use water areas in the public interest.

2. The analysis of the current state of the project management for humanitarian demining of the water areas in Ukraine has shown that the respective theoretical issues are at an initial stage of their development, while demining is carried out solely on the basis of conventional organizational structures that involve diving technologies.

3. The publication presents the genesis of the theory of the project management of humanitarian demining of

water areas, particularly, the development of organizational structures for such projects. It includes four types of projects: diving, biotechnical, robotic and combined demining. There have been proved the possibility and expediency of improving the quality and productivity of the operations on humanitarian demining of water areas with the help of marine robotic vehicles, particularly those manufactured in Ukraine.

4. There have been developed the organizational structures intended for project management of humanitarian demining of water areas based on the use of marine robotic vehicles, which are proposed for realization by the Main Department of the SESU and by the Center for Humanitarian Demining of Water Areas as part of the Unified State System of Prevention and Elimination of Emergencies in Ukraine.

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