THE SYSTEM FOR MONITORING OF UNDERWATER POTENTIALLY DANGEROUS OBJECTS AND INTEGRATED INFORMATION CONTROL SYSTEM WITH USING OF AUTONOMOUS DEVICES

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Abstract

The present project suggests the system of on-line monitoring of underwater potentially dangerous objects. The system provides on-line notification in case if radioactivity and toxicity at the objects being under control of autonomous vehicles exceed safe for environment levels.

The system consists of the set of specially developed autonomous devices which monitor the level of radioactivity and toxicity of underwater potentially dangerous objects. The devices are being deployed on the bottom for the period up to 1 year. The underwater devices are equipped with specially developed spectrometric sensors for radioactivity control and potentiometric ion-selective sensors for chemical control of underwater environment for the depth up to 300m.

In case when the level of radioactivity or toxicity exceeds safe for environment levels the autonomous control devices come up to the surface and transmit the data about the level of radioactivity or composition and levels of toxic substance concentration through the satellite communication system.

The integrated information system for control of the condition of underwater dangerous objects provides registration of such objects at the territory of Russian Federation and receiving of satellite signals from recovered underwater autonomous equipment. The data from the autonomous devices is being processed and analyzed and the results are being transmitted to the corresponding bodies of the Ministry of Emergency of Russia.

The system of monitoring and information control system are being developed for using in the main aquatories of Russian Federation – Black and Baltic Sea, Barents Sea, a number of areas at the Far East.

Introduction

One of the most significant problems of environmental safety of Russian Federation is a problem of long-term monitoring of underwater potentially dangerous objects (UPDO) containing radioactive, chemical toxic components and explosives.

Russian company Seatechrim Ltd. conjointly with a number of companies and Scientific Institutes have been designing and manufacturing components and subsystems for monitoring of such objects for the last three years. The project allows to provide data on pollution rate for the Monitoring Center located in the Ministry of Emergency of Russian Federation.

The integrated information system controlling the condition of underwater potentially dangerous objects being under development includes but is not limited to the monitoring of the following objects:

- the sources of radiation pollution;
- the sources of chemical pollution including submerged chemical weapon;
- objects with explosives;
- other potentially dangerous objects (pipelines, oil wells, sunken vessels, etc.).

The sources of potential pollution have different origin (Vialyshev A.I. *et al*, 2006).

The allies in WW II (USSR, USA and Great Britain) made a decision to liquidate captured chemical weapon and poisons by submerging on great depths in Atlantic ocean after the Second World War has finished. However many vessels were towed and submerged in Skagerrak and Kattegat connecting Baltic and North seas on depth from 200 to 680m. The total amount of submerged vessels according to different sources varies from 42 to 60.

Shells, bombs and containers with poison substance were submerged loose 70 miles to the south-west from Liepaya (5000t) and in the area of Bornholm Island (30000t) at the depth of 100-105m. The thickness of their jackets varies from 2 to 6, rarely to 10-12mm. The average corrosion rate of steal constructions in Baltic sea comes to 0,1-0,15 mm per year depending on the environment and rate of electrochemical corrosion. Furthermore, the possibility of mass (so-called "volley") emission of poison substance exists in the areas of tight burial of chemical weapon. Corroded jackets of underlying ammunition can be damaged by upper layers and the poison substance can come out to the environment.

The process of depressurization of the containers with poison substance lying loose on the bottom can be extended for tens and hundreds years. The jacket fouled with sea shells can't be destroyed in a moment, the process of poison leakage takes time and sea water can hydrolyze much of it.

Negligibly small amount of poison substance got into a human organism through food chain has not only strong toxic but also mutagenic action.

Chemical mutagens cause changes in body and gametal cells of a human as well as radiation does. Moreover, stable compounds of poison substances and their toxic by-products got into human organism cause more dangerous consequences than radiation exposure.

The main conclusion of both Russian and foreign specialists comes to the following:

1) Ammunition and containers with poison substance submerged loose don't pose much hazard provided that safety requirements are followed (that is dangerous areas should be closed for fishing, shotfiring etc.)

2) Ammunition in the bilges of submerged vessels pose much more threat. All the bombs and shells are in similar conditions, the corrosion rate is almost the same. It means that thinning of their jackets to some breaking point can lead to immediate destruction of the ammunition under the action of the upper shells as it was mentioned above.
The other potential source of pollution requiring control and monitoring is submerged radioactive waste.

13 areas in the North region of USSR (Abrossimov Bay, Stepovoy Bay, Tsivolka Bay, Sedoy Bay etc.) and 10 areas in Far-East region (including Japan sea, east shore of Kamchatka) were chosen for submergence of radioactive waste.

Submergence of containers with radioactive waste is not always followed by leakage of radioactive nuclides. Only the damage of the container jacket (3-5mm thickness steal) and damage of the inner volume filling of the container (concrete, asphalt or furfural) can cause the leakage (Vialyshev A.I. and Lissovskiy I.V., 2006).

Methods

Till recently the monitoring of UPDO was based on occasional sea expeditions. The research vessel with special measuring equipment could come close to the supposed place of UPDO location and carry out necessary measurements. One of the advantages of such monitoring method is the possibility to achieve high accuracy measurements of any required parameters because such method allows to use any types of deployed underwater measuring equipment.

However, disadvantages of this approach are obvious. First of all, the cost of carrying out of sea works is extremely high if it is necessary to make measurements in a large number of places where UPDO are located. It is caused by high cost of the survey vessels and underwater operations itself.

Such approach is selective and doesn't allow to carry out long-term monitoring.

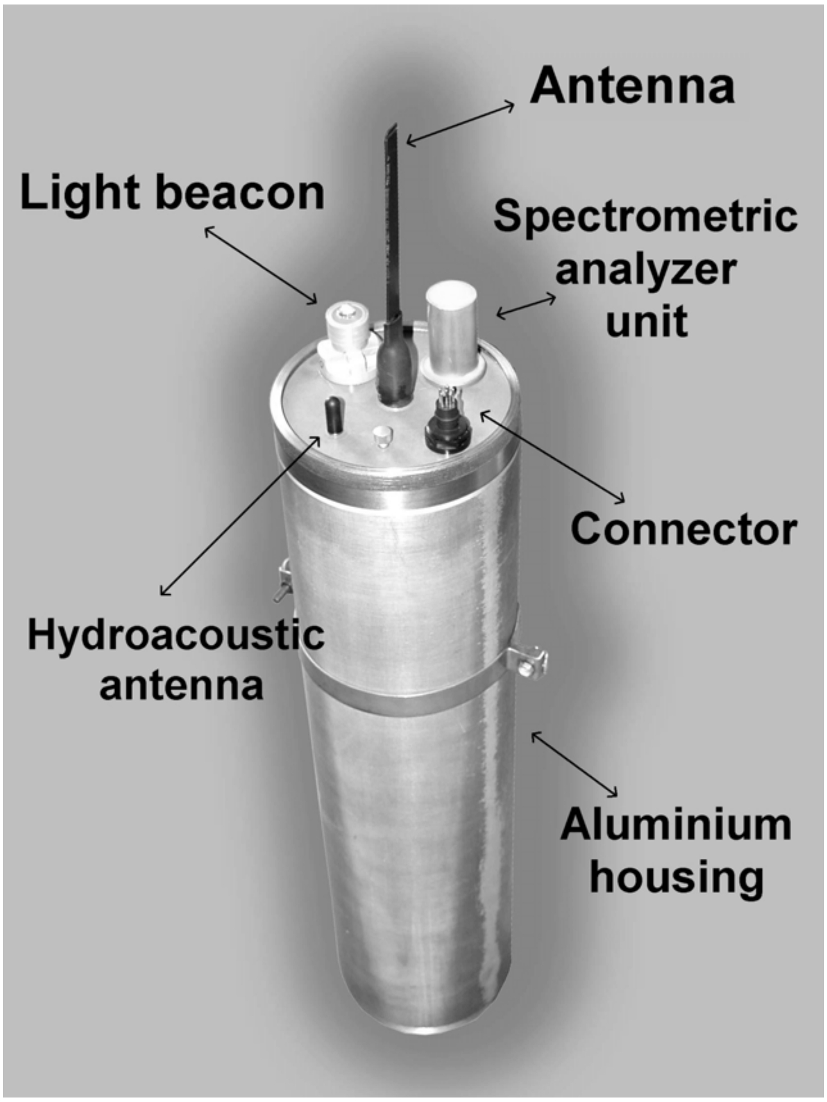
The monitoring of UPDO with using of vessels is impossible because of the large amount of UPDO and variety of their types. Therefore the development of some types of autonomous monitoring devices is necessary.

This problem can be solved through development and manufacturing of the autonomous devices for periodical measurements and spectrometric analysis of radiation background in the places where UPDO are located. Such devices would also control toxicity of sea water in the places of UPDO location and transmit the message in case of exceeding the determined level through a satellite communication system after recovery.

The operation principle of the system for radiation monitoring (SRM) is the following:

The SRM is being deployed on the bottom at the area where the UPDO is supposed to be located. The system includes radiation spectrometer, radio beacon, electronic microprocessor-based control system, electromechanical anchor release, ~~hydroacoustic antenna~~, power supply, flashing beacon (Picture 1) .

Picture 1. System for radiation monitoring (SRM)



The radiation rate is being measured with specified frequency according to a determined schedule. The SRM recovers from bottom to the surface and transmits encoded ~~radio~~ signal if the radiation rate exceeds a determined level set before deployment. The signal is being received by a satellite system and transmitted to the Center of radiation monitoring for recording and analyzing.

The system selectively measures gamma-rays in the specified energy bands. Since gamma-rays consist of gamma-ray quantum with one or several energies and form discrete spectrum the system can uniquely determine radioactive nuclide.

The spectrometric (radiation) analysis unit is based on the scintillation gamma-ray detector with CsJ(Tl) crystal $\varnothing 19\times 45$mm which is optically coupled with photodiode. The unit includes amplifier of the detector signals, multichannel analyzer of pulse amplitude and data storage and processing device.

The autonomous system for control of sea water toxicity uses ion selective electrodes. It is known that inorganic compounds are the products of poison substance hydrolyze. Hydrochloric acid is a product for yperit and phosgene, hydrofluoric acid is a product for sarin and soman, hydrocyanic acid is a product for tabun. Thus the methods based on the detection of secondary compounds of poison substances (hydrochloric acid and hydrofluoric acid) can be used for detection and control of leakage of poison substance into the sea water (Stepanets O.V. *et al*, 2001).

Therefore the increased concentration of the products of poison hydrolyze is one of the evidences that poison substance is present in sea water environment.

Ion selective electrodes of device deployed on the bottom allow to detect presence of the products of poison substance hydrolyze, then the monitoring device recovers to the surface and transmits encoded radio signal via satellite .

Such devices are the main part of the integrated information control system (IICS); they can be deployed for a period of 1 year to the bottom on the depth up to 600m.

The integrated information control system (IICS) of the condition of underwater potentially dangerous objects (UPDO) carries out a number of functions. (Picture 2.)

1. It receives the signals from recovered autonomous systems of control of UPDO condition; processes and analyzes the received data and informs the corresponding services of the results of data processing.
2. The system uses acquired and analyzed data for providing updated list of existing UPDO.
3. Forms the system of long-term monitoring of underwater potentially dangerous objects which provides immediate warning if the determined rate of radioactivity or toxicity of the objects is exceeded.

Results

The main differences between the integrated information control system (IICS) of the condition of underwater potentially dangerous objects (UPDO) and other environment monitoring systems are the following:

1. The IICS is being developed specially for monitoring of UPDO according to specific requirements.

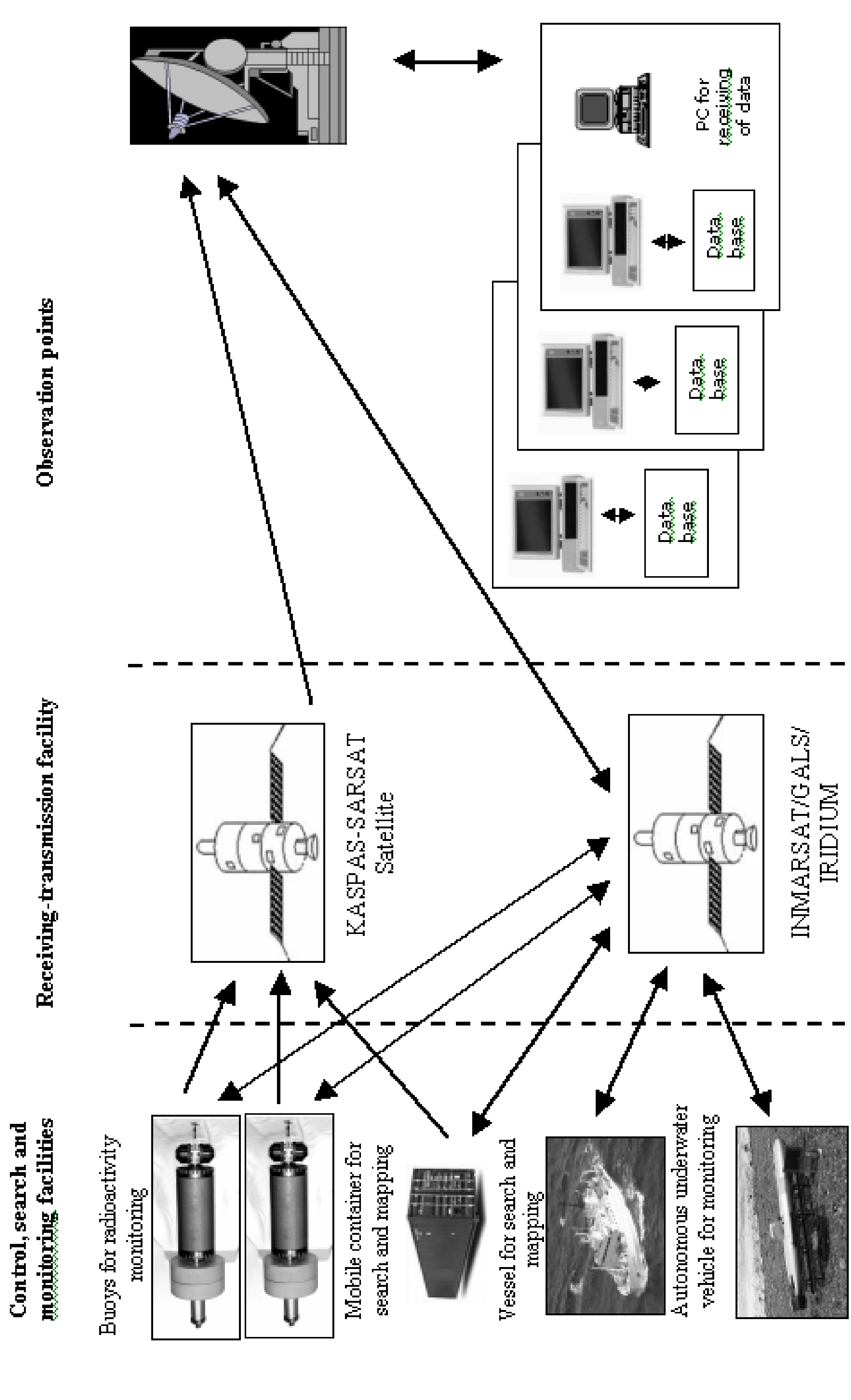
2. Reliability and quality of the measured underwater data related to observed objects are more important than speed of acquisition of information about the emergency with UPDO in the process of monitoring.

3. The IICS supposes deployment of monitoring devices in immediate proximity to UPDO which requires carrying out of some survey and mapping operation.

4. All the devices for monitoring, their design, manufacturing, and deployment are subject to the characteristics of the specific observed UPDO and its location.

Thus taking into consideration the specific character of the territory of Russian Federation, specificity of observed objects, variety of UPDO types we can conclude that the integrated information system controlling the condition of the underwater potentially dangerous objects suggested for development is of great importance for monitoring systems applied in Russian waters and doesn't have any analogues.

Picture 2. Scheme of information interchange



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