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# Unmanned Aerial Platform Using for Monitoring of Oil Pollution of Sea Aquatorium

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**Abstract**

The objective is to carry analysis of oil spill monitoring using Unmanned Aerial Platform (UAP). Authors are using analysis of functional requirements for UAP. Recommendations for implementations of UAP with two types of aerial carriers with oil pollution measuring cell and sampling device are proposed in paper. The challenges of oil pollution detecting and monitoring were defined and possible solutions described. Sampling device with oil pollution measuring cell and sampling deice were developed for minimizing time of monitoring programme and online transmitting to ground control centre with presentation on electronic chart had proposed.
**KEY WORDS:** *Oil spill, oil spill monitoring, Unmanned Aerial Platform*

## 1. Introduction

Oil pollution of sea aquatorium is very serious problem due to increasing of activities connected to oil production, transportation and increasing intensity of shipping. Only 26 percent's of oil are directly discharged into the sea. The remaining oil, of the total pollution quantity is discharged from dry cargo vessels (bilge waters, residues of fuels and oils that are accidentally or intentionally discharges into the sea), from natural sources, but most of all oil production enterprises, in particular from companies located on the coast or on the rivers flowing into the sea. The oil pollution monitoring of large marine areas with objective to detect oil pollution of today being carried out using various technical equipment - satellites, seagoing ships and various aircraft. At present, the use of a remote piloted aircraft (RPA), which provide more detailed information for monitoring aquatorium tasks is intensively developed. GPS-guided remote piloted aircrafts (RPAs) have the capacity to obtain very high spatial resolution (<10 cm) imagery of specific landscape features with revisit times determined by the operator as opposed to fixed satellite revisit times [2]. For effective solution of this problem with many factors should be created automated unmanned aerial platform, which will provide online detecting, monitoring dynamic of oil slick and sampling.

## 2. Functional Requirements for Unmanned Aerial Platform.

The main objective is developing a highly effective system-complex platform for monitoring of oil pollution of sea aquatorium. This approach will provide protection against intentional or accidental oil pollution.

The basic criteria of the requirement to increase the possibility of identifying possible pollution of the water surface with oil pollution is the methodology with using aerial platform equipped with a complex device with several types of sensors and a special device for sampling from the surface of the water.

As a result of the analysis of the identified oil pollution data, the main Unmanned Aerial Platform (UAP) tasks are oil pollution detection, monitoring of dynamyc of oil spill, obtained data transmition and processing. The monitoring of oil pollution includes surveilance of the main parameters of the marine environment and the preparation reports about changes in time.

The UAP concept has to be developed for data collection about water quality, detecting of oil pollution control and liquidation of oil spills. For development of efective loew cost monitoring, it is necessary to establish a special system based on using UAP for monitoring, detecting of oil spills and estimation of sea aquatorium status taking into account ship traffic and technological process in terminals for transportation of oil in ports.

The UAP for oil pollution monitoring program should include the following tasks:

- the possibility of a 24-hour operation of sensors, moreover, the image characteristics must not depend on the time of day;
- possibility of detection regardless of weather conditions;
- performing a determination of the type of polluting product;
- ensuring the monitoring of the distribution dynamics of oil spill;
- sampling with the help with using a specially designed RPA;
- monitoring of large areas of the marine region where illegal pollution is present;
- quantitative estimation of oil pollution according to the parameters obtained with the help of RPA sensors;
- discovering and collecting evidence of oil pollution from ships;
- transmitting of operational information to the responsible services in the event of an oil pollution accident;

- regular sampling of background pollution of oil products.

The large number of sources of pollution and refuse of the polluters to provide information creates certain difficulties, for determination volume of oil spills and taking operational measures to eliminate it. The distribution of pollution levels and nature of statistical data is also increasing due to uncertainties in the events of oil spills and illegal discharges.

Due to the UAP for surveillance mission of oil pollution of sea aquatorium must cover coastal areas and districts that are far from the coast, as well as inland waters and ports. Taking into account the monitoring of the marine waters using the platform, which includes RPA, specifics, needs for continuous information and dynamically changing movements of ships, the area of aquatorium should be divided into areas with short and long range Fig. 1. The radius of short range areas is 50-80 kilometres, the radius of the long range areas is 150-200 kilometres.

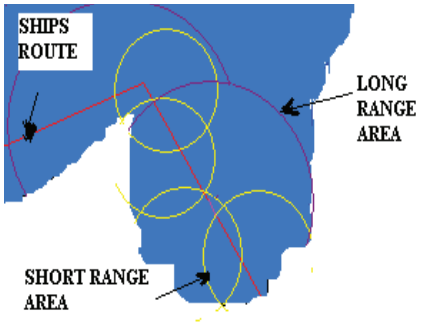


Fig. 1 The short and long monitoring areas

The dividing of the controlled area into monitoring zones should be done taking into account the RPAs types, which is parts of the UAP, and their technical characteristics.

The implementation of UAP for monitoring of pollution of sea aquatorium will increase reliability, safety and to eliminate the human error factor.

An unmanned aerial carrier with a multifunctional payload will solve the problems of water pollution with oil products and monitoring of contamination. The UAP with an algorithm that includes automatic take of, landing and the flight optimization algorithm for objects, which are divided into groups, depending on the type will allow the display of information on the state of water pollution and the real-time and sampling from the water surface [6]. The main criteria for reliable operation of UAP, taking into account the wide range of monitoring is flight speed and operational range of the RPAs.

For oil pollution monitoring performance, the RPA speed must be in the range from 0 km / h to 180 km / h. According to the analysis of HELCOM statistical data, the largest amount of accidents and unauthorized oil spill occur near the coast. The UAP should be developed on base of fixed wing RPAs and multirotor RPAs. For improvement of effectiveness of remote sensing should be used complex approach which individual RPA monitoring in defined areas and multi agent monitoring. The multi agent monitoring is perspective solution for large areas of sea aquatorium because provide communications between agents. This is very important because distances between RPAs and ground control centre are large. These agents often reside within an agent framework, where they may operate independently on open environments [7]. The implementation of fixed wing RPAs and multirotor RPAs provide opportunity maximally used of strong features of each type. RPAs as part of UAP can use for take off other mobile units such as ships. In addition, the use of opportunities for RPA to take off from ships increases their operational mobility [4]. The UAP should provide tracking of all flight parameters, automatic control system of alarms and transmission of messages for all changes in flight parameters (altitude, flight direction, speed). Careful design of the aircraft trajectory (waypoints, strips, speed, attitude, etc.) and a flexible real-time mission management capacity (sensor configuration, flying directions, etc.) are instrumental in achieving productive and safe acquisition missions [3].

### 3. Using of UAP for Oil Pollution and Spill Monitoring

Implementation of two types of aerial carriers with unique capabilities and characteristics to monitor water quality and oil pollution will allow simultaneous monitoring of areas with large areas and the taking of samples of water oil pollution in defined areas. For development UAP for marine monitoring missions must take into account, in particular, the following principles: reliability, compliance with maritime observation requirements, simplicity of management and, finally, price [1]. Small RPAs potentially offer a low-cost alternative to conventional remote sensing platforms, and research to date shows promise [5].

First type aerial carrier for monitoring: an airplane type RPA with a multifunctional payload system focused on the maximum range of observations, analysis and transmission of data in all circumstances and in all situations. A payload system that delivers maximum accurate information about water quality, allows you to simultaneously use a VNIR camera, a thermal camera, and a hyperspectral or multispectral camera [4]. The carrier is designed for long-term flying to provide extensive monitoring area coverage, the system provides for unique flight safety systems on the

ground and the surface of the water with passive and active protection in case of an emergency. The second type of carrier is a multi-rotor platform with a vertical take off and landing capability and a long hovering in fixed position in the air. This type of platform allows you to replace time-consuming and inefficient monitoring of pollution using mobile stations and ships. The special algorithm allows the use of a platform for monitoring oil and bacterial contamination, as well as sampling from the surface of the water, using a special container that allows determining the thickness of the oil film. The platform is intended for monitoring and taking water samples for the purpose of pollution detection.

A payload system for maximally accurate information on water quality allows simultaneous use of a VNIR camera, a thermal camera, and a hyperspectral or multispectral camera [4].

In the management complex realized intelligent automatic monitoring control system that was able to receive data in real time and to decide what type of platform is necessary for the specific monitoring and providing taking in the daily mode and in an emergency situation on the surface of aquatorium area for solving tasks. The management system will perform take on, route formation, flight on a specified route, monitoring, take-off and landing in automatic mode [4]. The control system will allow fully automatic control, will react immediately to changes in the monitoring situation, allowing the transition to the priority mode to operator's management.

The management system will have digital communication channels with all security services on the site of the reservoir to provide online services with operational services.

## 4. Development of UAP and Devices for Monitoring

Eliminating of deficiencies and compliance with the contemporary requirements for oil pollution monitoring system is possible with development of UAP with devices for detecting, measuring and sampling from surface of water. This solution is complex and allows surveilance and detection of contamination with a view to confirming the results. The use of RPA with fixed wing during monitoring as unit of UAP allows for the visual identification of contaminated areas using payload sensors. For effective monitoring of large areas of sea aquatorium UAP should be equipped with device with oil content measuring sell. The implementation of measuring sell in special device will provide evidence of oil pollution and online transmitting information for multi agents of UAP. In this case second type of aerial carrier will be sent to position where detected oil contamination. This solution allow maximally efficiently using endurance of multi rotor RPA in hovering position regarding requirements of monitoring program. The obtained data, for example, the spots of pollution, must be compared with the parameters of the assessment of water pollution of sea aquatorium. This requires taking a sample from the surface of the water to check the accuracy of the visual observation and measuring cell signal results. Using UAP complexes that include RPA provide possibility practically constantly track the situation on the area.

In order to implement the operational monitoring and prevention program of the existing problems, a method and device for controlling oil pollution of marine waters and internal waters was developed in the research process. The method and the device include the taking samples of water from the surface of the water, preparation for transportation, possible determination of oil pollution by the measuring device, data transmission over the data transmission channel, display of the contaminated area on the electronic map, and delivery of the sample to the specified location using a fixed wing RPA.

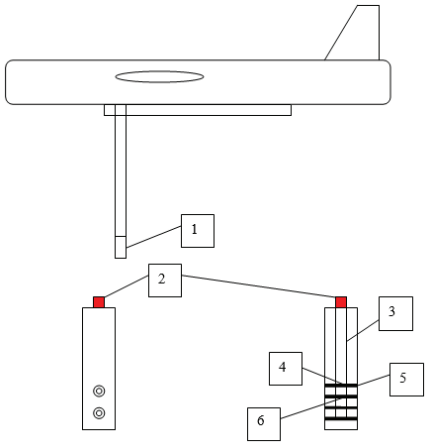


Fig. 2 RPA equipped with a special sampling device with measuring sell

The total payload of a RPA depends on the power it can provide. Consequently, the possibilities for taking oil pollution are limited. Taking into account the requirements for the flight radius, the RPA with fixed wings solves the problem of remote sensing for areas with long distance from coast.

The device schematically displayed on Fig. 2 contains a fixed wing RPA equipped with a special sampling device that is to be executed in the form of a metal holder. A sampling device installed in the RPA hull and a sampler 1 mounted on the holder.

Innovative solutions were used in the development of the sampling device. In order to ensure precision and possible immediate detection of oil pollution, a device with a sensor for detecting pollution in its body was developed. In order to provide high-quality information on the state of water, it is envisaged to take samples on a variety of levels. The construction of the sampling device includes a cylindrical sampler with solenoid valve with spring 2 connected to the rod 3 with sleeve with pistons 5 of sampler's chamber. In the cylindrical body of sampler, holes was made for receiving water during taking sample. Inside the upper section in the sampler's in the upper piston photoelectric cell 4 was mounted and in the lower piston lighting led 6. This solution provides for the possibility after sampling make water control over the presence of petroleum products and contamination. A photoelectric cell consisting of a photocell and a diode in case of presence of petroleum products (optical changes are recorded) send signals to the RPA Electronic Control Module (ECM) and further through using communication system to control centre. The method is implemented as follows. RPA is sent to a oil spill area with known GPS coordinates. After the RPA arriving to the assigned area, the ECM gives the command to open the sutters of compartment of sampling device.

After opening of shutters ECM gives command to rotate the sampler holder in an upright position. PRA is lowering at a height where the probe device touches the surface of the water. When the probe device touches the surface of the water, the ECM gives the solenoid valve a command to open the distributor of the sampling device. The water inlets in the housing of the sampling device. The ECM gives to the solenoid valve a command to close the sampling device. The distributor pistons will make after sampling sealing of sample in sampler. ECM allows the mechanism to rotate the probe holder horizontally. After turning the probe holder back, ECM gives a command to close the shutters of the sampling device compartment. Collection of samples and transportation process is done in automatic mode. The photoelectric cell consisting of a photocell and a diode in the presence of oil products (optical changes are recorded) sends a signal to the RPA ECM and then transmitted through communication system to control centre; simultaneously, the coordinates of the verification point are also transmitted. The information on pollution received is displayed in the electronic cartographic system. In the process of research, a fixed-wing RPA has been developed for the purpose of taking of sample, oil pollution detection, online transmission of information and transport of specimens. Unlike other devices, RPA is equipped with a sampling device that is installed in the RPA hull section with the help of a holder is raised to the working position. In order to ensure the legal requirements for the sampling procedure, a container with a cylindrical sampling device, consisting of 2 sections with openings and a distributor with a plunger inside, a solenoid valve, which opens the distributor of the sampling device and, after the assembling of the container, is carried out the container sealing. Measuring cell in a container in case of oil pollution detection, sends a signal to the ECM and transmits information about pollution with a presentation on the electronic cartographic system. This technical device ensures long-distance oil pollution monitoring.

## 5. Conclusions

This paper is aimed to analyse possibilities of implementation of UAP for solving existing problem of detecting and monitoring of oil spills. Functional requirements for UAP using for oil pollution monitoring program were overviewed. Recommendations for implementations of UAP with two types of aerial carriers with oil pollution measuring cell and sampling device were offered. Using UAP based on two types of aerial carriers fixed wing and multirotor improve efficiency of performing of designed tasks. Using UAP with aerial carriers equipped with oil pollution measuring cell and sampling device provides on line transmitting of result to ground control station with presentation of results on electronic chart. The automated control system will provide on base of online information effective use of each type of aerial carrier and eliminate deficiencies of existing remote sensing methods.

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