Hydrodron — New Step for Professional Hydrography for Restricted Waters

Conference Paper · June 2018

DOI: 10.1109/BGC-Geomatics.2018.00049

3 authors:

Andrzej Stateczny
Gdansk University of Technology
99 PUBLICATIONS **1,211** CITATIONS
SEE PROFILE

Daria Gronska
Marine Technology Ltd.
4 PUBLICATIONS **78** CITATIONS
SEE PROFILE

Weronika Bogdanowicz
Gispro Ltd.
6 PUBLICATIONS **141** CITATIONS
SEE PROFILE

HydroDron – new step for professional hydrography for restricted waters

Andrzej Stateczny
Faculty of Civil and Environmental Engineering,
Gdańsk University of Technology,
80-233 Gdańsk, Poland
Gabriela Narutowicza 11/12
a.stateczny@pg.edu.pl

Daria Gronska
Marine Technology Ltd.
Klonowica 37/5
71-248 Szczecin, Poland
d.gronska@marinetechnology.pl

Weronika Motyl
Marine Technology Ltd.
Klonowica 37/5
71-248 Szczecin, Poland
w.motyl@marinetechnology.pl

***Abstract*—Hydrographic Surveys in restricted areas are becoming increasingly important. Not only in the importance of the role of seaports, where frequently the maximum ships sail but also in consideration of the increasing value of inland waterways on which usual hydrographic vessels have a limited access. Presumably in this case an employment of autonomous or remotely operated unmanned vehicles is the only reasonable solution. As restricted areas include, among others harbours, roadsteads, rivers or lakes.**

The HydroDron floating platform, due to its mobility and dimensions, can operate on the aforementioned areas. It enables work without the participation of the crew, due to the automation of measurements. This means that the platform can be controlled by an operator located on the shore station – remote control mode or in autonomous mode can realizing the planned trajectory. Therefore the platform is able to perform hydrographic survey missions in the field of bathymetric measurements, sonar measurements and others. The hydrograph's work seeks to minimize the devices in order to relieve the survey vehicle along with the reduction of survey costs. An important feature of HydroDron is its multi-variant, which allows the configuration of the survey system for the user's needs. On the HydroDron platform, to achieve the requirements of acquisition of bathymetric and sonar data, a combined solution has been selected that has the ability to write both types of data. Three selected systems fulfilling the given requirements were analyzed.

The first system is 3DSS-DX-450 from PingDSP. System uses state-of-the-art acoustic transducer technologies, SoftSonar™ electronics, which is the main technology in this system and other advanced signal processing techniques. This allows to obtain accurate bathymetric measurements. The 3DSS-DX-450 system technology is able to resolve many simultaneous acoustic arrivals. It separates the backscatter from the seabed, the surface of the sea and the water-column. In this way, very good 3D image and bathymetric coverage is obtained. [1]

The EdgeTech 6205 system allows to create three-dimensional sea-floor coverage in real time data acquisition. It provides improved, integrated bathymetry and dual frequency side scan sonar system. It uses EdgeTech's unique MPES (Multi Phase Echo Sounder) technology. System combines beamforming technology and phase discrimination to determine each reflection along the seabed. In combination with EdgeTech's Full Spectrum® technology, it eliminates noise interference in a shallow water environment, resulting in wider and cleaner swath. [2]

The third analyzed system is a professional underwater mapping system, ensuring the accuracy of the special class, Klein HydroChart 3500. This system records simultaneously two high-resolution sonar frequencies and high-quality bathymetric data.

Some of the analyzed bathymetric systems have an integrated motion sensor. However, this is not a satisfactory solution on an autonomous floating platform. Two integrated inertial systems have been compared. The SBG company offers Ekinox inertial system based on MEMS technology. The second company Applanix proposes a system based on Fiber Optic Gyro technology. Both technologies are used to obtain high-quality motion data. They provide information of the parameters of pitch, roll and heave of the survey vehicle.

All equipment which is part of the HydroDron platform is configured to minimize the human contribution while surveying on restricted waters.

Keywords—acoustic measurements, object detection, unmanned autonomous vehicles.

I. INTRODUCTION

In recent years, the importance of unmanned surface vehicles has significantly increased. Many of them have been developed for military and environmental purposes [3]. There are many autonomous vessels in the world. Due to the autonomy of available vehicles, they can be divided into fully autonomous, semi-autonomous and remotely controlled vehicles [4]. Autonomous vehicles implement the previously designed trajectory. They have appropriate software for planning the measurement mission by the operator. Remotely controlled allows the operator to fully control the maneuvering of the platform. Among them, single-hull platforms and catamarans can be distinguished. ASVs are produced both as small vessels and as larger vessels with almost seagoing range. Typically, in order to ensure safe navigation, they are equipped with a multi-beam echosounder. An important element of hydrography is to ensure the safety of navigation in restricted areas. Hydrographic measurements not only become more and more important in view of the growing role of seaports, but also in the greater importance of inland land routes. The use of autonomous measuring vehicles in restricted areas is often an only reasonable solution, due to their small size and maneuverability. In addition, the use of larger crews may be impossible or unprofitable. During hydrographic measurements, the aim is to minimize the number of devices on the floating platform in order to relieve the survey vessel. It is also related to the reduction of operation costs.

II. HYDRODRON CONCEPT

The subject of the research was the development of an autonomous / remote controlled multi-purpose water platform for the implementation of hydrographic survey missions in areas of ports, embankments, anchorages, bays and lakes, rivers and other compressed areas. The platform can perform measuring missions in the field of bathymetric, sonar and other measurements in the autonomous mode, performing the planned trajectory and in the remote control mode, especially in a difficult navigational situation.

The HydroDron platform is an unmanned catamaran with electric drive. The use of double-hull platforms will ensure sufficient stability, while two independent engines, adequate manoeuvrability. The unit will be operated at sea level up to 2 degrees on the Douglas scale and wind force up to 3 degrees on the Beaufort scale.

In addition, the platform is adapted to the entrance of an operator to the board. For this purpose, a special composite platform was built. It is demountable. A person on the vessel can control the unit using the diagnostic dashboard. The navigational sensors are mounted on an automatically folding mast - frame and installation of interchangeable measuring sensors on an automatically folding holder mounted in the middle between the hulls.

Foldable mast and sensor holder will ensure safe transport of the platform and its safe access to the measuring region. The navigational equipment installed permanently on the unit, which has been analyzed, can include a satellite compass, a motion sensor (MRU) to control the tilts of the unit and a course correction integrated with the ASV autopilot and navigation software.

This ensures a precise position during the manual or automated manoeuvres of the platform. The HydroDron is also equipped with a sensor system to monitor the situation on and around the platform to assess the navigational situation around the vehicle. The innovative survey vessel will achieve high efficiency and lower costs compared to existing methods on the hydrographic market.

III. BATHYMETRIC AND SONAR SYSTEM

One of the main tasks of the autonomous/remote controlled multitask platform is the implementation of survey missions in the field of bathymetric, sonar and other measurements in the autonomous mode realizing the planned trajectory and in the remote control mode, especially in a difficult navigational situation. An extremely important feature of HydroDron is the ability to carry out many variants of installing measuring equipment on the platform. The aim is to minimize the equipment available on the platform. Therefore, in order to meet the requirements of bathymetric and sonar data acquisition, it was decided to choose a combined solution with the ability to register both types of data. Three interferometric systems were selected for analysis in accordance with the adopted assumptions: 3DSS-DX-450, EdgeTech 6205 and Klein HydroChart 3500.

A. 3DSS-DX-450

A compact sonar 3DSS-DX-450 provided by Ping DSP company is one of the systems combining the acquisition of bathymetry and sonar data.

The small device is suitable for mounting on autonomous floating vehicles. It can be used on the HydroDron platform, due to the fact that it is adapted for hydrographic surveys of shallow waters.

3DSS-DX utilizes the latest technologies acoustic transducers, electronics SoftSonar™ and advanced signal processing techniques to get perfect bathymetry and side scan 3D images. This patented technology is able to perform many simultaneous acoustic journeys, separating backscatter from the seabed and sea-surface. This means that it is able to detect targets in the water column. The result is a 3D image with side scanning covering the entire water column and perfect bathymetry. The device simultaneously performs 3D side-scan, 2D side scan and bathymetry as shown in Fig 1.

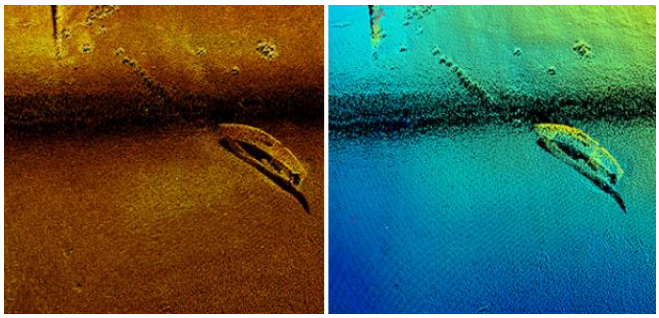

Figure 1. 3D image (on left) and bathymetric data (on right) acquired with 3DSS-DX-450 [1]

Ping DSP provides dedicated software for displaying 3D point cloud in real time and software for capturing targets on the sonar image. It also supports third-party software such as Hypack, which is available on the HydroDron platform.

B. EdgeTech 6205

EdgeTech 6205 is a device that uses Multi Phase Echo Sounder (MPES) technique to collect bathymetric data in high quality. An example of the projection is shown in Fig. 2. In addition, it is possible to receive images with double frequency in ranges that are much longer than in traditional systems [5].

EdgeTech also has Full Spectrum® technology, which makes it possible to go beyond the specifications of IHO S-44, NOAA and USACE relating both to detection of objects and uncertainty of bathymetric data. It is possible to obtain a wider and cleaner coverage, as well as to eliminate acoustic disturbances and multipurpose effects, through the use of both technologies. The system is also compatible with the Hysweep Survey software, whose interface allows the acquisition of interferometric data in real time.

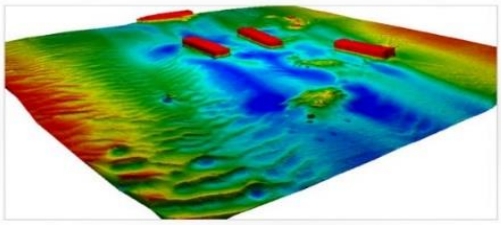

Figure 2. Bathymetric data acquired using Edgetech 6205 [6]

The 6250 is equipped with software containing EdgeTech Discover Bathymetric Acquisition and Sonar Control 6205, which is based on Windows. Thanks to this compatibility, the number of devices on the vessel vehicle platform is significantly reduced, and an additional advantage is the occurrence of Hypack on HydroDron. It is possible to register two-frequency sonar and bathymetry simultaneously, and the available system configurations are: 550/1600 kHz (Dual Frequency Side Scan with 550 kHz bathymetry data), 230/550 kHz, (Dual Frequency Side Scan with 550 kHz bathymetry data), 230/550 kHz (Dual Frequency Side Scan with 230 kHz bathymetry data). The indisputable advantages of this system are coverage sectors up to 200° and equiangular or equidistant distribution of points [6]. Fig. 3 shows the sonar image that was acquired by using Edgetech 6205.

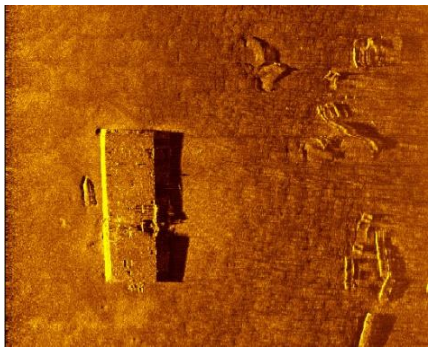

Figure 3. Sonar image acquired with Edgetech 6205 [6]

C. Klein HydroChart 3500

The Klein HydroChart 3500 system is one of the interferometric systems that combines the acquisition of bathymetric and sonar data. This was mentioned in publications [7,8].

Klein HydroChart 3500 is a professional bathymetric system for survey shallow waters. It ensures the accuracy of the Special Order IHO SP-44. The system simultaneously records two high-resolution sonar frequencies and high-quality bathymetric data [7].

The Klein HydroChart 3500 is delivered fully assembled with motion detectors (pitch, roll, heave, heading) and sound, mounted within the Sonar Head Unit (SHU) coupled with a water column reverberation resistant altimeter [9].

The HydroChart 3500 interferometric sonar is able to provide up to 12x vertical coverage without a gap in the nadir of bathymetric data, based on a signal to noise ratio over 8 dB. In combination with approved navigation vessels, the HydroChart 3500 offers bathymetric measurement tools and charting applications from 1.5 to 50 m deep [7].

The Fig. 4 shows the side scan displayed in Triton Perspective software which is dedicated to the system.

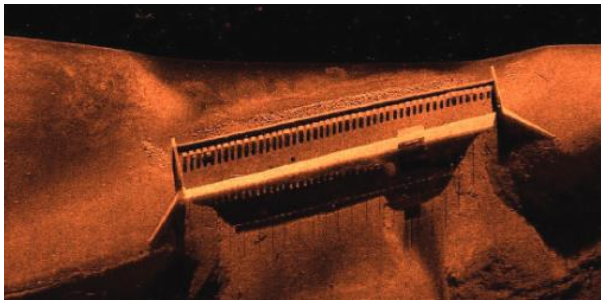

Figure 4. Side Scan displayed in Triton Perspective software [9]

The output data is compatible with most programs, including Hypack software available on HydroDron. The use of data in the Hypack software is shown in Fig. 5.

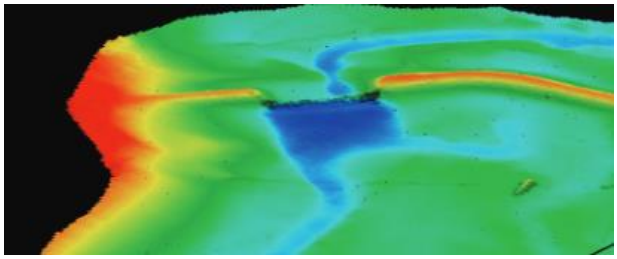

Figure 5. Bathymetry displayed in Hypack MBMAX 64 [9]

The Klein HydroChart 3500 system, thanks to the combination of the sonar and echosounder, reduces the number of devices placed on the vehicle and can be used on the HydroDron.

IV. INERTIAL NAVIGATION SYSTEM

The operator must know the exact position and orientation of the platform to ensure the safety of navigation on restricted waters. Using the GNSS (Global Navigation Satellite System) means unobstructed line of sight to several GNSS satellites. The INS (Inertial Navigation System) system complements the GNSS system, which provides complete navigation information [10].

Some of the bathymetric systems described have an integrated motion sensor, however, this is not a sufficient solution when working with the intention of mounting on the ASV platform. Poor quality of information provided on the parameters of longitudinal and lateral movements and vertical displacements forced the equipping of the platform with an INS inertial system.

SBG Systems and Applanix offer integrated inertial systems, consisting of two GNSS antennas and an IMU (Inertial Measurement System) motion sensor. Both sensors are included in high accuracy inertial systems.

Both devices present two technologies used to acquire data on platform traffic. The device proposed by Applanix company uses Fiber Optic Gyro technology, while SBG Systems uses MEMS technology.

D. SBG System

The SBG Ekinox 2-D system was selected for the analysis. The Ekinox series is a product range of high-resolution inertial systems. Thanks to the selection of high quality MEMS sensors, advanced calibration procedure and design algorithms, the presented Ekinox 2 series achieves 0.02° attitude accuracy. MEMS technology opens many new possibilities in the world of hydrography [11]. Microelectromechanical MEMS systems known for their small size, energy efficiency, low price and robust performance fill the gap between the magnetic compass and FOG (Fiber Optic Gyroscopes) used in the Applanix system described in this paper. The biggest challenge was developing the accuracy of heading in the MEMS system [12].

Ekinox 2-D is an inertial navigation system with an integrated GNSS receiver with two antennas and motion sensors. The system combines the inertial measurement system of the Inertial Measurement Unit (IMU) and launches the Extended Kalman Filter (EKF) to fuse inertial data in real time with internal GNSS information [11].

The Ekinox 2-D system can be directly connected to sonar for hydrographic research and is ideal for applications in devices requiring an exact course, such as ROV and AUV, and supports data from DVL (Doppler Velocity Log) for further work [11]. Ekinox 2-D sensors are compatible with all hydrographic programs including Hypack software available on HydroDron.

E. Applanix

The POS MV WaveMaster is a complete inertial system that provides high-quality data on parameters such as location, course, altitude, position and speed of the marine vessel and on-board sensors. POS MV is used in a wide range of hydrographic works and activities [13].

The principle of operation is that the system provides an integrated solution for measuring vessels, with special distinction for places where the quality of the GPS signal is poor. Furthermore, this system provides accurate information on the vessel's position, taking into account the movements of vessel that was caused by poor weather conditions [14].

The system is characterized by roll and pitch efficiency up to 0.02°, optimal GNSS support independently of the conditions (provided by IN-Fusion 2.0) and data time given in microseconds [13].

Applanix POS MV WaveMaster uses the Fiber Optic Gyroscopes (FOG) system, which measures the rotation of the Earth to provide heading [11].

V. CONCLUSION

The paper presents the use of a modern HydroDron platform on restricted waters. HydroDron is an autonomous/remote controlled floating platform, one of the most important of which

is its multi-variant. This means that the user can customize the equipment on the platform according to his own requirements and survey characteristics. The work presents the possibilities of selecting such systems, which reduce the amount of equipment on the platform, thus relieving the vehicle and increasing its manoeuvrability.

As HydroDron is a mobile solution, its operating costs are much lower than that of a classic manned measuring vessel. Platform transport does not require advanced handling equipment because the unit is relatively light and compact. In addition, it can be launched from most types of quays, because due to the slight immersion can work at small depths. For safety reasons, HydroDron is not intended for operations on the open sea.

This is due to the fact that the equipment described in the paper enables simultaneous bathymetric and sonar data acquisition. In addition, they are designed for mounting on small unmanned measuring platforms such as HydroDron.

The selected measuring equipment does not restrict or exclude the use of other solutions, according to the requirements of the future user. The place to mount the measuring head has been adjusted so that it can also be used to install smaller measuring heads (single-beam echo sounders) or larger (multi-beam or interferometric echosounders). Other, peripheral measuring equipment: GNSS, INS, sensors, etc. are the basis for their use for integration with other depth sensors or bottom imaging sensors.

Acknowledgment

The results presented were financed from the European Regional Development Fund under the 2014-2020 Operational Programme Smart Growth. Project entitled „Developing of autonomous/remote operated surface platform dedicated hydrographic measurements on restricted reservoirs” *implemented as part of the National Centre for Research and Development competition: INNOSBZ.*

References

[1] Ping DSP, Pruducts Description. [Online]. Available: http://www.pingdsp.com/3DSS-DX-450.

[2] EdgeTech, EdgeTech Brochure. [Online]. Available: https://www.edgetech.com/wp-content/uploads/2015/10/6205-brochure-032316.pdf

[3] M. Caccia, M. Bibuli, R. Bono and G. Bruzzone, “Basic navigation, guidance and control of an Unmanned Surface Vehicle”, Auton Robot, August 2008, vol. 25, issue 4, pp. 349-365, DOI: 10.1007/s10514-008-9100-0.

[4] Tariov, S. Kruszko, “Bezzałogowe pojazdy podwodne – stan obecny, potencjał biznesowy, perspektywy rozwoju”, Elektronika : konstrukcje, technologie, zastosowania, 2011, vol. 52, pp. 148-156.

[5] L. A. P. de Souza, M. da Silva, T. Hiller, D. Wolfe and L. N Brison, “Reservoir monitoring using a multi-phase echo sounder: A case study”, Acoustics in Underwater Geosciences Symposium (RIO Acoustics), 2015 IEEE/OES, Rio de Janeiro, Brazil, 2015, DOI: 10.1109/RIOAcoustics.2015.7473602.

[6] EdgeTech 6205, Pruducts Description. [Online]. Available: https://www.edgetech.com/.

[7] Y. Ai, S. Armstrong and D. Fleury, “Evaluation of the Klein HydroChart 3500 interferometric bathymetry sonar for NOAA sea floor mapping”, OCEANS'15 MTS/IEEE Washington, Washington, DC, USA, 2015, DOI: 10.23919/OCEANS.2015.7401818.

[8] Y. Ai, S. Armstiong, T. Ward and D. Fleury, “Klein HydroChart 3500 Bathymetric Data Quality Control with CUBE Processing”, MTS/IEEE Oceans Conference, Monterey, CA, 2016.

[9] Klein HydroChart 3500, Pruducts Description [Online]. Available: http://www.kleinmarinesystems.com/PDF/datasheets/Klein_HC3500_rev1217.pdf.

[10] X. Meng, H. Wang and B. Liu, “A Robust Vehicle Localization Approach Based on GNSS/IMU/DMI/LiDAR Sensor Fusion for Autonomous Vehicles”, Sensors (Basel), September 2017, vol. 17, DOI: 10.3390/s17092140.

[11] SBG Systems, Pruducts Description [Online]. Available: https://www.sbg-systems.com/products/ekinox-d-dual-antenna-gps-inertial-system.

[12] A. Guinamard, “MEMS opens a world of new opportunities in Hydrography”, Feature Story, March 2013, vol. 19, issue 2, pp. 10-11.

[13] Applanix, Product Description [Online]. Available: https://www.applanix.com/.

[14] S. Rudkowski, K. Makurat, K. Wnuk, P. Ciesielski, L. Gajewski, K. Nowak, J. Edut, D. Cichowska, R. Wróblewski, K. Szefler and J. Koszałka, “Badania dna morskiegonaobszarzemorskiej farmy wiatrowej „Bałtyk Środkowy III””, Warsaw, February 2014.