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Application of Global Navigation Satellite System and Hydroacoustic Techniques to Safety of Inland Water Navigation

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Abstract

The paper presents description of application of integrated, Global Navigation Satellite System (GNSS) and hydroacoustic technologies, for elaboration of actual bathymetric chart and creation of an Inland Interactive Underwater Objects Base (IIUOD). In the paper the description of some integrated bathymetric experiments conducted on Great Mazurian Lakes is presented. A small area of Lake Sniardwy, the largest lake in Poland, has been measured using modern technology with precise satellite positioning and hydrographic techniques. The idea and first results of the implemented base is analyzed and described. The database (IIUOD) is created for visualization of dangerous underwater objects and finally for safety of inland water navigation.

Keywords: GNSS, Hydrography, Interactive Inland Underwater Objects Database (IIUOD), Inland Navigation

1. Introduction

1.1. Safety on inland water reservoirs

Marine navigation is the process of planning and controlling the safe movement of boat from one place to another [1]. The inland waterways navigation especially includes piloting in be done without actual bathymetric charts, digital bottom visualization and information about under water obstacles. The inland water reservoirs in Poland consist of lakes, rivers and channels.

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In most cases there are shallow estuaries – usually lakes. The maximum depth – 106.5 m (2010) can be found in Lake Hancza in the north– east Poland but many lakes have an average depth of 5-20 m. In north – east part of Poland there is situated Warmia and Mazury. This marvellous region is frequently called the Land of a Thousand Lakes. It is the center of recreation for tourists from all over Poland and from abroad. There is an amazing opportunity for sailors and fishermen. In the summer time there is almost 10,000 sailing boats on the Great Mazurian Lakes in Poland, carrying 50,000 tourists every day. Unfortunately many of the mentioned reservoirs have dangerous for sailors shallow regions with stones and reefs. The dangerous places make the inland waterways very difficult to navigate.

1.2. Inland water bathymetric charts

Almost all of polish lakes and rivers do not have up-to-date digital charts. The most part of them has been measured almost 50 years ago. Existing analogue maps do not present the real and accurate bottom surface. Therefore it is very important to explore their bottom shape to ensure the general safety by creating digital, bathymetric charts and digital bottom visualizations, marking the inland waterways and dangerous shallow stone reefs especially on inland waterways of Great Mazurian Lakes [6].

1.3. Inland Interactive Underwater Objects Base

In the United States the basic information about wrecks and obstructions in the coastal waters is included in Automated Wreck and Obstruction Information System (AWOIS) implemented in 1981 by the National Ocean Service (NOS). This system contains information on over 10,000 submerged wrecks and obstructions. The AWOIS was implemented to assist the Office of Coast Survey in planning hydrographic survey and to help in safety navigation for marine archaeologists and historians, fishermen, divers, salvage operators, and others in the marine community [4]. The polish inland sailing safety can be partly ensured by elaborating new up-to-date bathymetric charts and marking the shallow areas by cardinal boys in IALA system. Moreover, there is a need to creation the Interactive Inland Underwater Objects Base (IIUOD). The main idea of preparation such a base is to get more detailed bathymetric raw data of selected shallow parts of the Great Mazurian Lakes. The aim can be achieved by collecting information of underwater objects, especially reefs, big stones, wrecks with the use of the side scan sonar, direct under water research by divers using the DGPS receiver (underwater GIS) and camera. The collected information should be professionally elaborated in order to create Digital Terrain Model presentations and to prepare three dimensional visualizations. The concept of creating the interactive www base site expects users to add their own reliable raw data to enrich the main base of information.

This paper describes the basic segments of proposed IIUOD and shows first results of experiments conducted for creation the interactive hydrographic base.

2. Integrated GNSS and Hydroacoustic Technologies

The most of experiments were carried out on the biggest lake in Poland – Lake Sniardwy with the use of Integrated Bathymetric System developed by the author in order to examine under water environment [5]. The technology of bathymetry surveying used to examine under water environment is based on RTK/DGPS technology, single beam echosounders (SBES), side scan sonar (SSS) and direct under water research. It makes possible navigation of the small hydrographic boat along the pre-defined profiles, examination of bottom shape, computation of water volume, elaboration of bathymetric charts and monitoring of dangerous shallow places. The developed Integrated Bathymetric System basically consists of:

– The Global Navigation Satellite System,
– The bottom detection system,
– The special hydrographic (QINSy), GNSS and CAD software.

2.1. GNSS equipment

The Differential GPS positioning system uses two GPS receivers. The first of them, placed at a known mark is a stationary receiver called base or master reference station. There can be used the permanent reference station (ASG-EUPOS) or a local station set up only for the dedicated project. The base station receiver determines the errors of measurement data between fixed and observed station position (corrections). The DGPS corrections in RTCM format can be sent via radiomodem or GPRS (General packet radio service) to the rover GPS receiver in unknown location and can be applied to measurement data. The results of experiments and analysis of accuracy of boat positioning during bathymetric survey show that the comparison of the phase OTF mode horizontal position with coordinates obtained in real time code Differential GPS presents differences from -0.95 m to 1.05 m for latitude dB and longitude dL [7]. According to IHO Standards for Hydrographic Surveys, where the horizontal accuracy for Special Order reservoirs is 2 m, achieved accuracy is sufficient for majority of bathymetry surveying [3].

2.2. Hydrographic system

The hydrographic SBES equipment includes two single beam digital hydrographic echo sounders: Simrad EA 501P and Reson Navisound 515. Additionally YSI 600R sonde for water quality sampling is used. The EA 501P system basically consists of transducer, transceiver and personal computer. The DGPS receiver can be connected to the Laptop serial port (NMEA-GLL format), and position data can be provisionally combined with the measured echo data. The EA 501P Simrad general specification is as follows: the transceiver 200 kHz frequency, max. freshwater detection depth – 600 m, accuracy about 0.25% of measured range, calculation interval for 0 to 10 per second. Dual channel Navisound 515 uses two frequencies transducer (38 and 200 kHz). The YSI 600R provides water quality sampling for both surface water and groundwater. This sonde measures temperature, conductivity, dissolved oxygen, and potential of hydrogen (pH). The speed of sound in water is estimated by a simple empirical formula [2].

The hydrographic system consists also of an Imagenex SportScan dual channel (2×330 kHz) side scan sonar. The high resolution digital SSS is operated directly from PC computer. The towfish operates from a standard 12 Volt DC power supply or boat's battery, and the RS-232 connector plugs directly from the Kevlar towfish cable into the back of a PC computer or laptop. The SportScan software can read GPS raw data into the PC computer, display it on the screen, and use the speed over ground to adjust the aspect ratio of the sonar image. Objects can have their height and length determined with the click on the sonogram. All data can also be stored on hard disk for later display and analysis. The side scan sonar has maximum operated depth of 30 m and it is used for underwater objects such as big stones and wreck localization. The bathymetric system combined with side scan sonar gives a great chance to study the underwater environment, and especially to monitor underwater objects and dangerous stones.

The special GPS and CAD software of the system allows the measurement profiles to be designed, enables navigation along the profiles, recording and combining the positioning/bathymetric data, and finally creating bathymetric maps. For elaboration of raw-data the originally developed software Echo Converter is used.

The Integrated Bathymetric System is mounted on board of small, but safe and easy to operate motorboat called "ORBITA". It is perfectly suited for raw-data collection during inland water measurements.

Preliminary found under water objects during hydroacoustic measurements can be directly investigated using innovate technique called underwater GIS. Having approximate wreck coordinates the diver can navigate to the object with the use of GIS – GPS receiver (Thales Mobile Mapper). The GPS unit is placed in special waterproof housing. The satellite signals are delivered via GPS floating antenna connected to the receiver with the 20 meters long strong cable. This simple system allows the operator utilize the GPS receiver up to 20 meters of depth.

3. Experimental Procedures

3.1. Preparations for experiment

Some of Great Mazurian Lakes has its waterways marked by floating signs and dangerous places by Cardinal Buoys in IALA (International Association of

Lighthouse Authorities) system. Unfortunately the biggest reservoir – Lake Sniardwy has not yet such a system. That is why the small fragment of this lake was chosen to be examined in order to create IIUOD (Fig. 1). The project on the Lake Sniardwy consists of the following stages:

- DGPS/GPRS permanent and spare local reference stations configuration,
- Designing of measurement profiles,
- SBES hydrographic system calibration, bathymetric survey,
- SSS localization of underwater objects, underwater GIS – direct investigation,
- Elaboration of measurement raw-data, creation of bathymetric digital chart,
- Creation of Interactive Inland Underwater Objects Database.

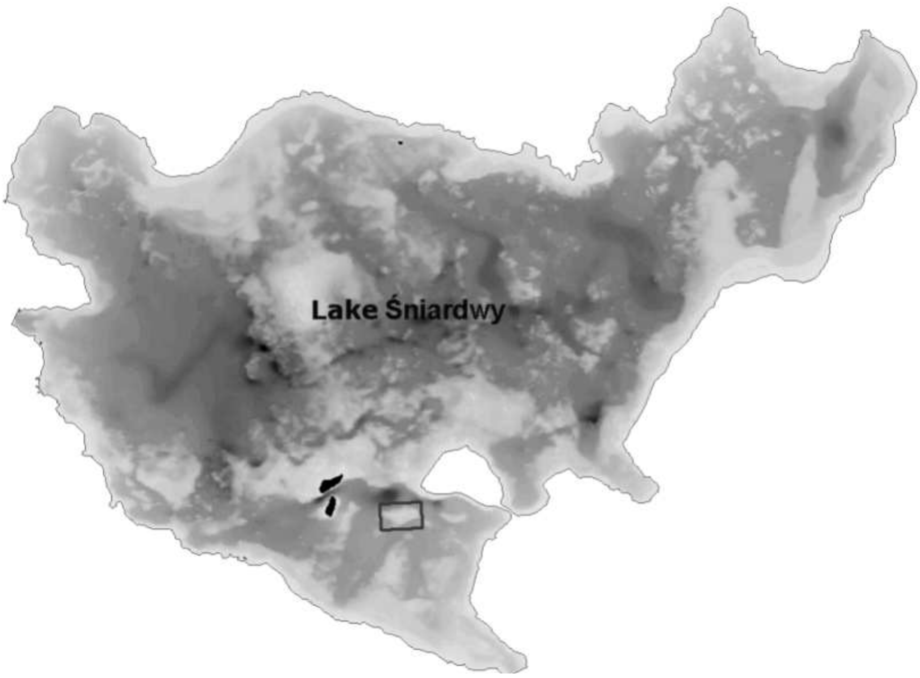

Fig. 1. Lake Sniardwy – test area location

The permanent DGPS/RTK/GPRS reference station is situated about 30 km from test area in Gizycko, a tourist town located in the very heart of Great Mazurian Lakes. Differential GPS satellite measurements were based on the GPRS (General packet radio service) data teletransmission system. The level of GSM coverage and GPRS service quality in the specific region of operation (on the lakes) are fully sufficient for the purpose of the bathymetric surveys. The DGPS corrections are sent to the rover GNSS receiver every 1 second. In the surroundings of the project area the backup local reference station was activated also (Ashtech Z-Surveyor GPS receiver). Thales Mobile Mapper GPS receiver was also configured to receive

EGNOS corrections. The measurement profiles were designed on digital shore map of the lake parallely, every 5 meters one after another.

Before hydrographic sounding the single beam echo sounder was calibrated. The YSI 600R sonde was used to determine temperature and conductivity of the water column from bottom to the surface. The speed of sound in water was estimated by YSI 2SS software using Clay and Medwin formula [2]. The mean value of sound speed was determined to be 1480 m/s. Simrad EA 501P was also controlled by conducting bar-check calibration. An average speed of sound was entered directly into the echo sounder before data acquisition. Accurate sensor offsets was measured between the echo sounder transducer and the reference water level and then applied within the acquisition system. The GPS antenna was mounted vertically over the echo sounder transducer, which was placed in the hull of hydrographic boat. Therefore no horizontal offsets need to be applied.

3.2. Bathymetric survey

After the data acquisition system had been properly configured and all of the necessary calibrations had been completed, on-line data acquisition could begin. Bathymetric survey at the chosen fragment of the Lake Sniardwy was divided into two stages. Hydrographic work has been conducted with the measurement profiles designed every 50 meters and 5 meters one after another. In the first part of the experiment based on 50 m profiles 1,936 raw sounding data were collected. The mean depth is 4.34 m, minimum depth is 0.57 m and maximum 12.65 m. In the second part of the experiment based on 5 m profiles 27,826 raw data were recorded.

The mean depth is 4.90 m, minimum is 0.40 m and maximum 12.60 m. During the experiments, on board of the motor boat two GPS receivers were installed: Thales Mobile Mapper in EGNOS mode and Ashtech Z-Xtreme working in DGPS/GPRS mode. The DGPS unit was receiving real time corrections from base reference station via GPRS Cellbox modem. At the same time the receiver was sending out differentially corrected boat position to the software ESRI ArcView 8.3, for navigating along the pre-defined profiles using Laptop monitor, in NMEA-GGA message format and to the EA 501P Simrad echo sounder in NMEA-GLL format. In the navigation software the position of the boat was displayed against the background of the digital shore map on board screen. This allows the navigation along pre-defined measurement profiles. Combined position and depth data were saved on the Laptop hard disk, which was controller of the hydrographic system also.

The mean local water surface was taken as the reference water surface during the project. The kinematic post-processed OTF precise technique was used to control the hydrographic survey and adequate ellipsoidal height/water-level relationships have been developed. The reference water surface was reduced to the vertical datum in Poland based on Kronstadt '86.

3.3. Localization of underwater objects

The measurements on the fragment of Lake Sniardwy included localization of underwater stones and reefs and other objects also. Firstly a hand held receiver with ability to achieve EGNOS or DGPS/GPRS corrections was used to collect over preliminary coordinates of stones and dangerous underwater objects in shallow test area. Then the single beam echo sounder and the Imagenex SportScan side scan sonar were used for bottom and underwater object detection. During measurements many dangerous stones were localized and marked.

3.4. Underwater GIS

Finally the direct underwater investigation was done (Underwater GIS). The coordinates of preliminary found objects were directly put into the Thales Mobile Mapper GPS receiver. It allowed the diver to navigate to the object in order to confirm localization and prepare photo and video documentation. This simple system gave the operator possibility to dive with the GPS receiver up to 20 meters of depth. Must be reminded that the GPS receiver was placed in waterproof housing and connected to the floating GPS antenna. During underwater GIS experiments the diver can see his trajectory on the screen and the GPS autonomous positions can be stored in the unit (Fig. 2). The positions can be also differentially corrected in post-processing mode.

Fig. 2. Underwater GIS

3.5. Raw Data Elaboration

After field data acquisition was complete, the data elaboration started. The special software Echo Converter and Echo View have been originally developed. These programs can import echograms from Simrad binary format and export as *.txt file. Bad depth and coordinates data can be shown, filtered and stored. Surveyor can take a careful check of the records to ensure that the digital data accurately depicts the true bottom. During depth editing, the digital depth record should be compared to the analog echo sounder trace. This software is open and can be enriched of new options for adjusting and smoothing of survey data.

The Echo Converter includes algorithm, originally developed by the author, for the time correlation of GPS horizontal position and depth data. During hydrographic measurements the combined position and depth data are being saved on the Laptop's hard disk. Both data sets a short latency. Latency is the time difference between the recorded time positioning data and the recorded time of depth detection. The latency typically depends on the depth detection frequency and boat speed. While surveying at slow speed, depth detection frequency is high, and this shift will be small. At higher speed the displacement increases, proportionally to the speed. The results of the experiment show that the differences of depths range from -0.12 m to 0.13 m, with the maximum depth of 18.58 m [8].

Elaboration of the digital bottom model was carried out with the spatial interpolation method named kriging (Fig. 3). Kriging is a geostatistical estimation procedure of the value of the parameter in random location of the interpolation area. This method is based on the assumption that interpolated parameter is treated as regionalized variable. The spatial dependence of points is expressed throughout the semivariogram.

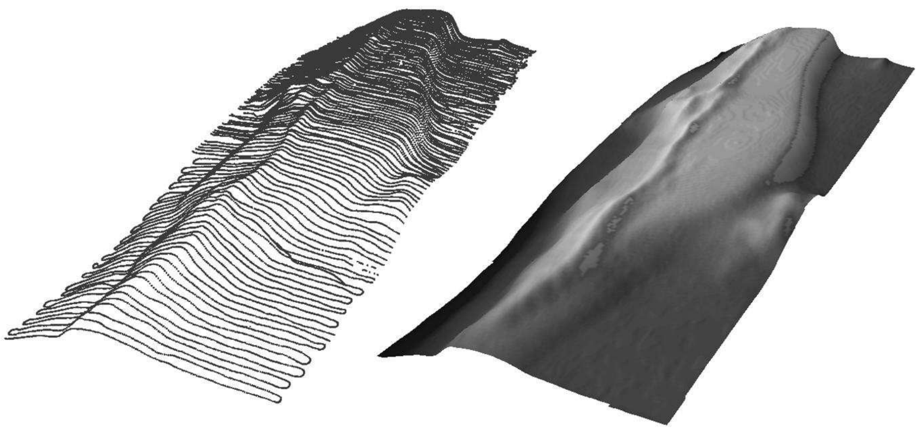

Fig. 3. Digital bottom model

Regular grid was interpreted using GIS software, which provides an ideal environment for datum conversion, geo-referencing, profile extraction, interpretation and visualization. Digital Bottom Model was generated with the use of ESRI ArcGIS Software and ArcGIS 3D Analyst extension. The regular grid resultant in interpolation process was used to construct Digital Bottom Model. After raw hydrographic data elaboration and Digital Bottom Model creation the bathymetric chart of part of lake Sniardwy was prepared (Fig.4).

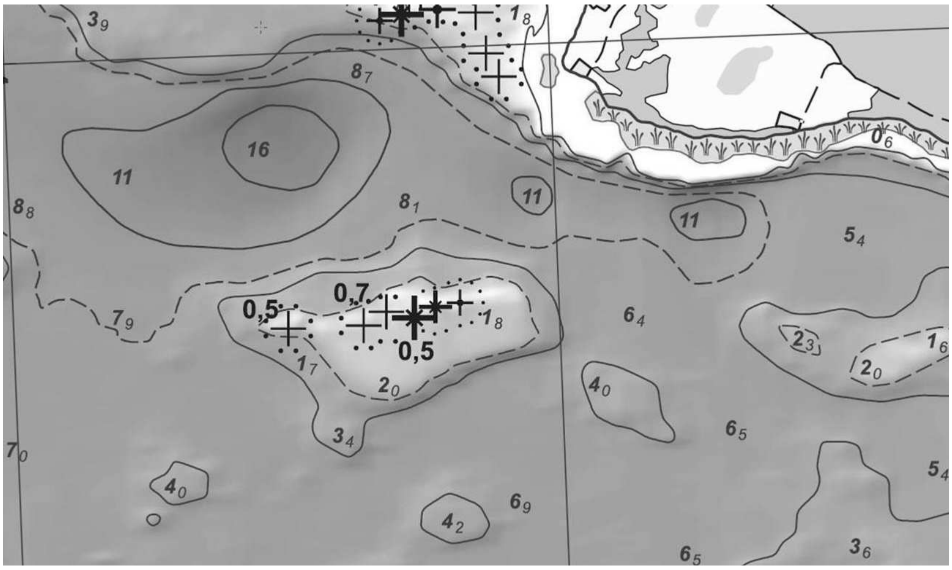

Fig. 4. Bathymetric chart

3.6. Determination of coordinates and parameters of underwater obstacles

Use of echograms from bathymetric survey for reading the coordinates of underwater obstacles within the test area and determining their basic attributes (size, height above the bottom, distance from water surface) was the next step of the work. Bathymetric data was filtered using the Echo Converter application to eliminate the erroneous raw data.

Printed echograms and digital data were analyzed for the purpose of locating underwater obstacles. Interpretation of the obstacle in the form of stones on the echogram is not difficult.

Analysis of echogram printout and comparison with the digital image of depths in Echo Converter software allowed development of numerous attributes describing the stones (Fig. 5). The position from GPS measurement was recorded every second while the echo sounder determined the depth with the interval of 0.3 second and as a consequence not all the points possessed the coordinates. On the other hand, all the depths had the time of measurement. To determine their positions linear interpolation of the coordinates was performed using the coordinates of the neighboring data.

Coordinates of data points obtained from interpolation and the depths allowed identification of numerous attributes that could be used for describing an obstacle – stone: latitude and longitude of the stone end and beginning, depth of stone base and top. Such data allowed computing four additional attributes: stone height (as the difference between the base depth and top depth), latitude and longitude of the center of the stone, width of the stone (horizontal length along the survey profile).

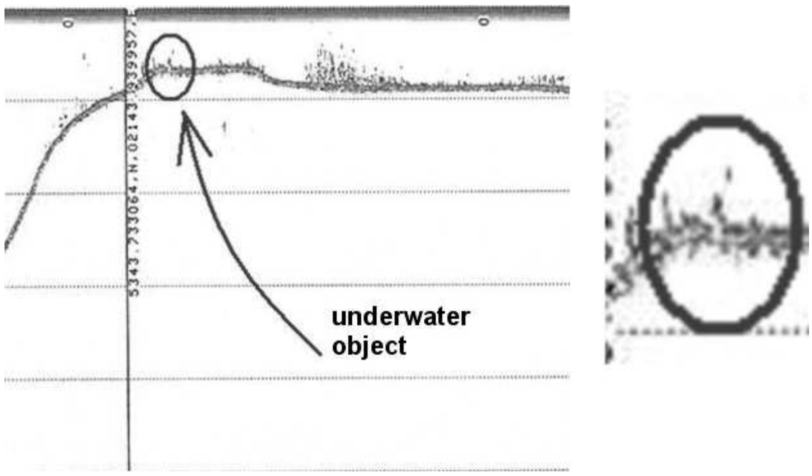

Fig. 5. Fragment of echogram of Lake Sniardwy test area

The above data concerning the located stones was collected in the form of the MySQL attributes database.

Using the earlier described digital terrain model of the surveyed bottom fragment, the 3D visualization of stones located was developed (Fig. 6). With data concerning the stones obtained directly from the survey: coordinates, top and base depth, stone height and its horizontal width available the underwater stones were represented in the form of bars. The bar thickness corresponds to the spread of the stone while its height represents the difference between the base depth and the stone top depth. The height, for the purpose of obtaining better legibility, was rescaled (the height of the bar corresponds to the triple height of the stone).

4. Development of the Concept for the Interactive Inland Underwater Objects Database

Modern data gathering technology using the GNSS, direct hydroacoustic sounding (SBES, SSS) and direct underwater inventory taking employed during implementation of the project allows collecting precise, reliable spatial data in a fast and effective way. As a result of the field measurements completed, a large set of source data was obtained for processing of which modern computation software available in the market as well as own applications dedicated to performance of certain tasks related to data processing were used. Preparation of data sets forming the starting material for development of an interactive geo-database allowing fast spatial iden-

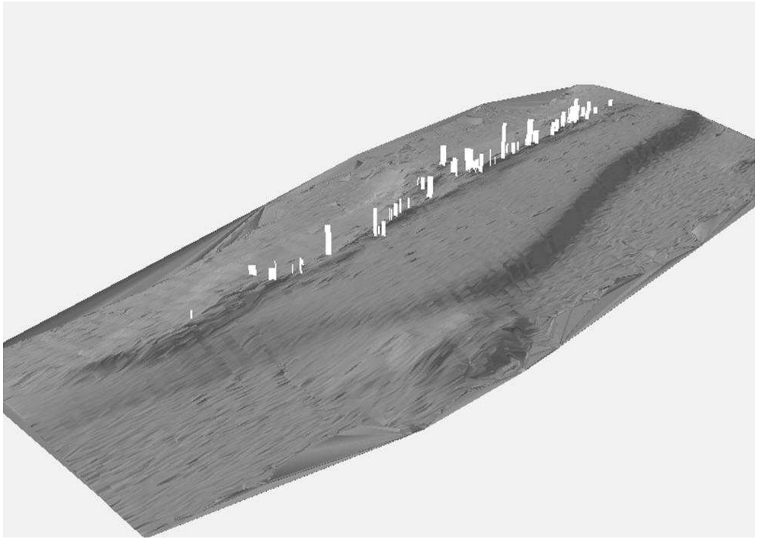

Fig. 6. Stones presented in the digital bottom model

tification of dangerous places within a given water reservoir was the final effect of data processing. Development and commissioning for use of the Interactive Inland Underwater Objects Database IIUOD) involved the necessity of solving numerous important problems, starting with defining the functional scope, determining the scope of necessary data and ending with the components of technical design of the system. Satisfying the requirements securing suitability of the solutions for a possibly wide group of users required selecting such a system architecture that would be suitable for the majority of them and that would additionally be suitable for conducting necessary updates, adding new data and expanding the potential of the system itself without disrupting the integrity of it. Designing a solution satisfying the above assumptions securing fast and easy access to the information on underwater obstacles in inland waters required an appropriate technology of access to the geo-spatial data. As a result of conducted tests it was decided to design the IIUOD in the form of a system of spatial data distribution via the Internet (Fig.7) [9].

Providing the user with the appropriate interface allowing comfortable and efficient work was one of the basic criteria in designing the universal solution for spatial data distribution on the net. The scope of skills in computer systems operation required from the IIUOD user should be limited to the minimum and be limited to the use of standard tools available in the Internet viewer (e.g. Microsoft Explorer, Mozilla Firefox, Opera, Safari, etc.). Additionally, system architecture used in designing the IIUOD should still assure the possibility of direct use of the data in the existing Spatial Information Systems (SIP), Topographic Database (TBD) and other professional spatial data collection systems. The GIS software currently

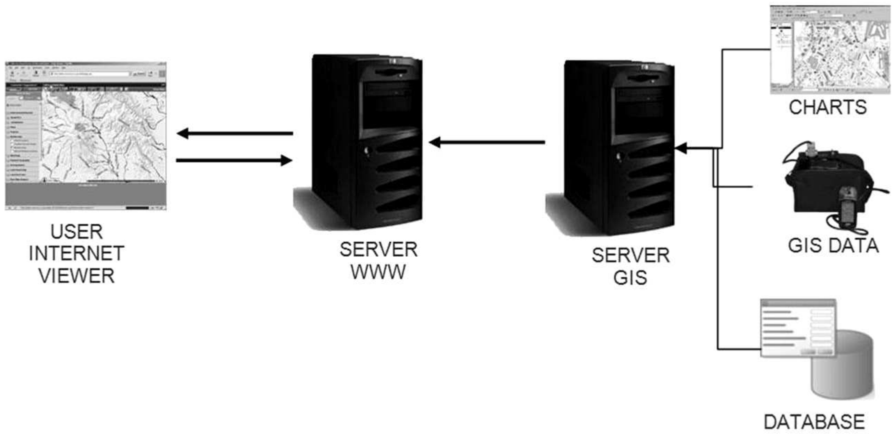

Fig. 7. Operational principles of a simple system for data distribution via the Internet

available in the market allows work using the data made available, among others, on WMS (Web Map Servers). This possibility allows direct combination of locally stored data with the remotely accessible data, which offers the possibility of direct use of the data from the IIUOD server in those systems. According to the above assumptions, Internet subject site assuring free access to the IIUOD was prepared. It allows, among others, free use of the available information on potential risks present in the indicated area (visualization of underwater obstacles) and information on the position of cardinal signs (dangerous places). Additionally, for the selected test area the current depth charts, spatial models and precise geographic coordinates of dangerous spots as well as sample sonograms, animations and photographs from direct underwater inventory taking were made available.

4.1. Spatial data distribution system structure

Rapid development of information and telecommunication technologies increased the possibilities of information and services distribution directly to the users significantly. During the recent years the number of Internet users with wideband access to the network assuring high-speed data transmission increases continually. This results in the development of the areas that require transmission of high volume data sets, including, among others, cartography and GIS systems.

Development of information technology and popularization of the Internet caused that the majority of currently used applications operate using the client-server technology. Depending on the server implementation mode, division of tasks and number of computers performing individual tasks we can identify an appropriate number of layers within a given architecture. In that case we talk about n-layered architecture. Thanks to implementation of the multilayered architecture individual tasks can be scattered within the global network reliving the application from spatial limitations.

There are many solutions allowing design of spatial information systems design in the network including commercial systems such as: ESRI ArcIMS, Geomedia Web Server, Map Guide, MapInfo MapExtreme and Oracle Application Server with MapViewer, as well as Open Source type software, e.g. UMN MapServer made available on the GPL license available in the market. In the software of that type technologies and solutions developed by their producers, frequently covered by patent rights and incompatible are used.

That is why maintaining mutual compatibility, that is the possibility of using the data created using the system for work in a different system, was an important element in the design of the spatial data distribution system. To achieve that the solution chosen had to be compatible with generally applied standards and specifications. The current standards and specifications that should be satisfied by GIS systems are defined by the organization called the OGC (Open Geospatial Consortium) established in 1994.

According to the OGC standards and specifications of the WMS (Web Map Server), defining the interface of spatial data server based on HTTP protocol, the system was designed on the bases of open source type tools including UMN MapServer, MySQL, PHP and Apache software. That system design assures full compatibility with the standards, compliance with system design assumptions and low cost of making the data available, ease of operation and separation of system functions into independent modules (facilitating system modernization significantly).

4.2. Design of the application based on the UMN MapServer software

Choice of the appropriate software for the application server of the IIUOD depended on satisfying numerous requirements. The system selected should satisfy several basic conditions, including, among others:

- assure user access to the map and data via the Internet,
- minimize hardware requirements on the side of the user by processing the data on the server side (client application presents the processing results only),
- possess the possibility of using both vector format (ESRI ShapeFile) and raster format (JPG,TIFF/GeoTIFF, PNG, GRID) data in any representation system,
- assure simultaneous access of numerous users,
- allow compatibility with popular database management systems including, e.g. MySQL, PostgreSQL, Oracle, etc.,
- limit the purchase costs of licenses and computer hardware necessary for its operation,
- be compatible with other software for distribution of spatial data.

As a result of conducted analyses UMN MapServer software was selected as satisfying the project requirements. Building an application using the UMN MapServer software as the server requires application of several basic components including the: Map File, Geographic data, MapServer CGI, HTTP server, Template file, Start page, HTML page.

Source mapping data, processes bathymetric data (SBES, SSS), vector and raster depth charts, data from the direct underwater inventory taking and other materials developed as a result of the bathymetric and land survey described in previous points were used for starting up the Interactive Inland Underwater Objects Database for safety inland navigation. Those include both vector format data in the form of ESRI Shapefile files, raster bases in the GeoTIFF format, spatial models and data drawn from the prepared underwater obstacles database in the MySQL format. All the layers were transformed to the uniform system of coordinates – WGS84.

The vector layers contain information on the coastline of selected lakes, depth contour lines, detailed location of cardinal signs and buoys. The raster bases are the selected fragments of topographic maps and the orthophotomap developed on the basis of aerial photographs as well as reservoir bottom elevation models.

4.3. Start-up of the UMN MapServer application

For the purpose of the research project the Internet server situated at the premises of the Chair of Satellite Geodesy and Navigation (University of Warmia and Mazury in Olsztyn) with the fast Internet link made available by the University was established. MS4W applications package was used for installation and operation of the UMN MapServer on the MS Windows platform. That package contains all the components necessary for appropriate operation of MapServer facilitating fast establishment of a stabile and reliable platform for making maps available on the Intranet/Internet networks by the user. An important characteristic of the package is its current update to the latest version of the program components including the latest versions of the Apache server, PHP script language and UMN MapServer.

In answer to the demands formulated by the client, the IIUOD server makes spatial data available in the form of graphic image (raster map in JPG format, in the defined system of coordinates with the size defined). The user obtains the possibility of interfering with the looks of the map by selecting the subject layers, zooming, moving, searching for data and by using other operations on the map.

In the started system based on the UMN MapServer, individual functions of applications are performed by 2 separate modules that can operate independent of one another, which are: Maps server module and user interface module based on the Internet WWW site.

The server module is responsible for storage of source data and for making it available to the user interface server. The operational principle is based on transmitting the appropriately formatted request from the user interface containing the detailed information on the map scale, map area selected and layers to the maps server and on those bases the resulting map is generated by the server. The configuration data necessary for performance of the task such as the location of source data, parameters of presentation of individual layers, looks of the legend and map scale is stored in the Map File type file.

Processing of client requests is done by one of the MapServer modules – PHP Mapscript. In case of each request sent by the user interface, on the basis of the Map File file, a MapObj class object is generated and next, using the methods of that class the resulting area of the map is set, individual layers are switched on or off and other types of changes in the looks of the resulting map are made depending on the content of the client request.

4.4. User Interface Module

The user interface was made on the basis of the WWW page. The pages are made available on the net using the WWW server – Apache available in the package. Thanks to this solution the application is independent of the operational system used by the user and the hardware configuration of the user's computer. The graphic interface was designed in a way offering the division of the screen into 3 independent sections. To the left the menu with selection of available map options is displayed, the central part is the working space containing the map generated by the server, to the right the tools that serve manipulation with the map area was positioned.

The user interface was based in the PHP script language functions by which the HTML code is generated in the WWW server and JavaScript allowing presentation of the page in the Internet viewer (Fig. 8). The design of the page uses the Cascade Style Sheets (CSS), which simplifies modification and possible later changes significantly. JavaScript language was used for performance of advanced operations in the template.

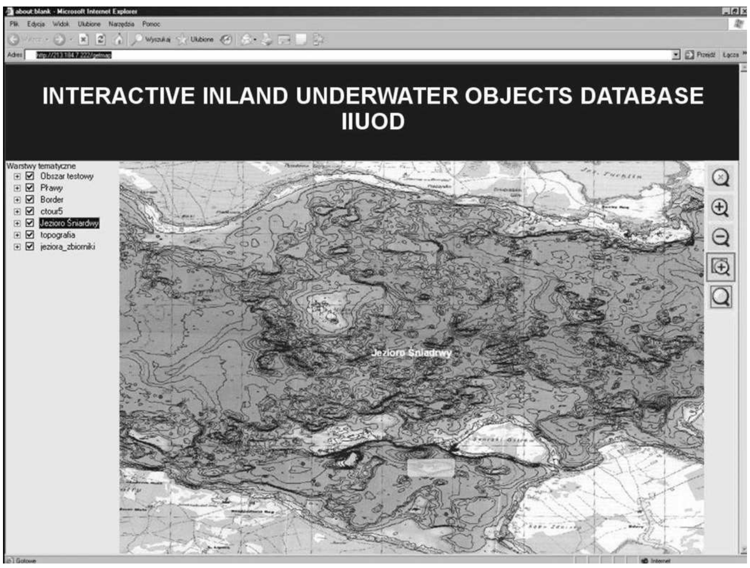

Fig. 8. Interactive Inland Underwater Objects Database server implementation

5. Conclusion

The paper presents the application of Global Satellite Navigation System (GNSS) and hydroacoustic techniques to develop the experimental Interactive Inland Underwater Objects Database (IIUOD) for safe inland water navigation.

Based on the existing materials and own experience and knowledge the pilot objects were defined and field studies using the Integrated Bathymetric System were planned. Specialist bathymetric unit was adjusted for performance of field survey. DGPS/RTK local reference station and transmission links radio modems and GSM/GPRS terminals were established. Numerous field experimental works were conducted, specialist equipment was designed and produced (underwater casing for the GPS receiver), several stages of hydroacoustic sounding were conducted and direct underwater inventory was taken. The integrated bathymetric measurements were carried out on the main test object of the project, a fragment of Lake Sniardwy with a large number of dangerous stones. The data from hydroacoustic sounding was processed, digital depth chart was produced and the Digital Model of the Bottom and 3D visualizations using the OpenGL library were prepared. Additionally, the design of the Internet website for the Interactive Inland Underwater Objects Database was developed and the test version of the Internet service was started up. Analysis of accuracy of the Digital Model of the Bottom generated on the basis of sounding with different level of detail in raw data collection was also conducted.

The technology developed for collection of underwater spatial geodata using the GPS technology (underwater GIS) deserves particular attention. Using the estimated coordinates of the objects read from sonograms and echograms it is possible to plan the route of underwater inventory taking and next implement it precisely navigating under the water using a GPS receiver. Direct underwater inventory was taken on the test objects. The conducted survey experiments confirm effectiveness of the technology in case of locating of underwater obstacles, wrecks, rocks and other objects. The technology can also be used for studying the presence of surface objects such as stone reefs, areas covered with vegetation, etc. under water.

Development of the first in Poland technology for creating the IIUOD based on the dynamic DGPS/EGNOS/GPRS measurements and direct hydroacoustic sounding is the final effect of the experimental project [9]. The project was implemented on the selected test water area – a fragment of Lake Sniardwy, and the prototype IIUOD database was established for scientific research purposes.

The IIUOD can be made available through the Internet services of tourist information centers. This would allow free access to reliable information on potential risks present within the area of the planned trip (visualization of underwater obstacles). The test IIUOD contains the current depth charts, plans of navigation routes, drawings with locations of cardinal signs (dangerous spots), spatial models and precise geographic coordinates of dangerous spots, sample sonograms, animations, photographs from the direct underwater inventory taking and other information supporting planning of the safe stay in the specific area of the Great Mazurian Lakes. Moreover the IIUOD – www base site expects users to add their own reliable information end raw data to enrich the main base of information.

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