

# **3<sup>D</sup> VISUALISATION AND MONITORING OF MARINE POLLUTANT AGGREGATIONS IN WEB-BASED GIS**

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*The paper presents the visualisation and monitoring of marine pollutant aggregations as the sample application of the real-time, remotely accessible marine GIS. The system is dedicated for instantaneous integration, processing and visualisation of marine data acquired by direct sampling, satellite remote sensing and underwater acoustic systems. The developed Web-based GIS is capable of producing 2<sup>D</sup> maps with overlaid various types of data, as well as generating the composed, time-varying 3<sup>D</sup> scenes presenting different elements of marine environment. As the sample application of the system, the visualisation of the 3<sup>D</sup> modelling of an oil spill drift and spreading within the southern Baltic area is presented. The data were obtained from the composed 3<sup>D</sup> modelling system CAROCS. The developed GIS, due to its remote accessibility and the on-line data processing, may be applied as a useful tool for maritime domain awareness and emergency management supporting, with respect to hazard of a different kind: pollution, ecological catastrophes, natural disasters. The system utilises the SQL spatial database for data storage and the Scalable Vector Graphics (SVG) and Virtual Reality Modelling Language (VRML) standards for remote presentation of geographical objects, and requires only the WWW browser with SVG and VRML viewer on the client side.*

## **INTRODUCTION**

Sea and seashore areas throughout the world are exposed to hazards of different kinds, e.g. terrorism, pollution, ecological catastrophes, or natural disasters. The problem of pollution detection and appropriate response strategies is one of the most important in this context, due to the marine ecosystems' continuous absorption of many pollutants of various origins, i.e. industrial waste discharges, ships catastrophes, and different kind, such as oil, heavy metals or chemicals. Many of those agents are characterised by great toxicity and cause devastation of the natural environment. What is more, the acquisition, processing, integrating and visualisation of various kinds of data describing many other components of marine

environment, and especially the remote, convenient accessibility to both the data and their processing results, constitutes the important problem in the context of numerous applications connected with aquatic ecosystems management.

The acoustic methods, being a well recognised tool for monitoring marine living resources and seafloor, are also suitable for pollution aggregations monitoring [1]. They seem to be promising, usually as a preliminary and complementary tool to application of other survey techniques. They are non-invasive, faster and less expensive than direct sampling, and when compared with optical techniques, they are capable of penetrating the lower depths more easily.

On the other hand, the huge development in the information technology during the last decades has provided the tools for much faster and more efficient access to survey data, allowing their remote, near real-time management, processing and visualisation [1]. For instance, nowadays it is quite easy to create the Web-based GIS-like application, equipped with the comfortable user interface, for nearly real time retrieving, appropriate processing, integration and visualisation of various kinds of marine data. However, several problems are to be solved usually to provide the appropriate and efficient functionality of the system, including:

- the proper choice of the database platform and the design of the database structures,
- the choice of the data formats for long distance (usually Internet) transfers and for optimisation of the data processing procedures, to allow for efficient transmission of all information needed by user,
- the development of the relevant data and layers management system on the server side, allowing the integration of many data types from distributed sources.

This paper presents the concept and the pre-prototype application of the newly developed nearly real-time, remotely accessible GIS for monitoring and mapping of water pollution and other components of marine environment. As the sample application of the system, the visualisation of the 3<sup>D</sup> modelling of an oil spill drift and spreading within the southern Baltic area is presented.

## 1. SYSTEM ARCHITECTURE AND FUNCTIONALITY

The developed marine GIS allows for the integration the different kinds of distributed data from various types of sensors and sources, along with the presentation of the data from the investigated marine region in two forms:

- 1) time-varying, multi layer 2<sup>D</sup> maps,
- 2) 3<sup>D</sup> animated perspective views.

For the user, the system provides functionalities which include several features typical for GIS systems, such as:

- map view management basic tools like scrolling, zooming panning etc.,
- organisation of map components as a set of thematic layers, like coastline, depth lines, pollution aggregations,
- easy map object information retrieval,
- customisation of the view and map appearance.

Two basic types of the data layers are processed by the system, viz.:

- static layers, which contain the information not expected to change during the single session of the system use, e.g. coastline, bathymetry etc.,
- dynamic layers, containing the time varying data which should be transferred continually to support the near real-time updating of the user's map contents, e.g. the

pollution aggregations.

In the latter case, two modes of visualisation are provided:

- 1) on-line visualisation and mapping,
- 2) playback of historical data.

The system is fully accessible via the Internet, maintaining its whole functionality for the authorised user. Any computer workstation equipped only with the WWW browser and SVG and VRML viewer is able to work as the system's client.

The general, simplified diagram of the distributed architecture of the system is shown in Fig. 1. The detailed architecture of the main server of marine GIS data, as well as the relations between the system components are shown in a block diagram in Fig. 2.

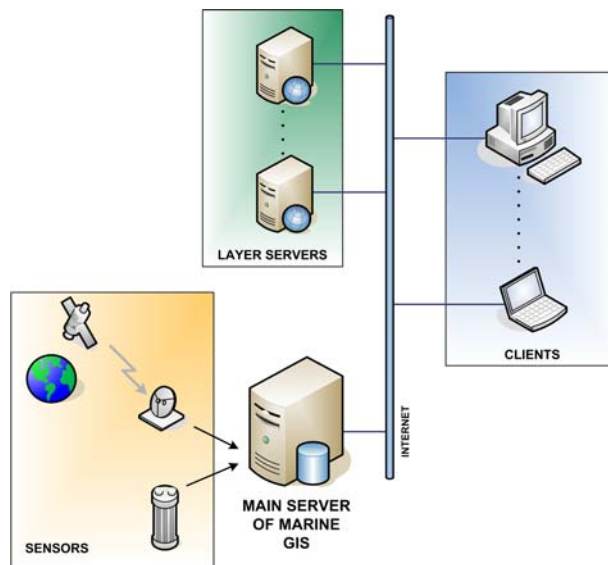


Fig.1 Distributed architecture of the system

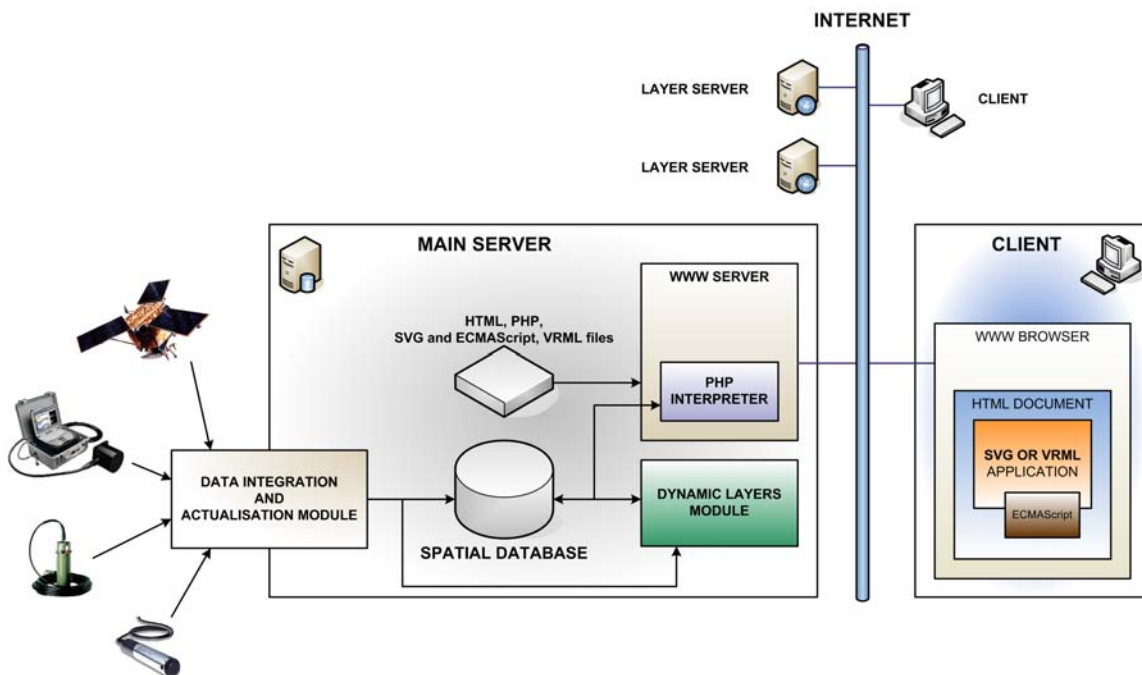


Fig.2 Detailed architecture of the main server of marine GIS data

The data showing the localisation and behaviour of the sea pollution aggregations, as well as the other marine environment components, are acquired by sensors of various kinds, including the acoustic ones. The Data Integration & Update Module is responsible for an appropriate processing and integration of the data from all the sensors, and for instantaneous updating the SQL Spatial Database, which stores both the static and dynamic layers. The application of the standardised, widely used format for the spatial data storage also enables their easy transferring to other systems. The layers data, along with the WWW pages which host the system, are sent to a client by the WWW Server. The spatial data, both from static and dynamic layers, are sent to a client in a standardised form also, namely, as the Scalable Vector Graphics (SVG) interactive document in 2<sup>D</sup> case, which is the dynamically created by the system server-side engine written in PHP language. Using the technology described in [2], the SVG document contains the graphical objects for presentation of the vector and raster data as well as the interactive elements, like buttons with assigned ECMA Script code implementing the basic GIS functionality directly on the client side. The scripts embedded in the SVG document are also responsible for the instantaneous updating of the dynamic data layers.

In addition, for 3<sup>D</sup> visualisation purpose, the Virtual Reality Modelling Language (VRML) is utilised. If the client requires the use of 3<sup>D</sup> mode of the marine data presentation, the VRML window is created and the VRML code is also dynamically generated and sent by the system server-side engine. It facilitates the construction of perspective views of the scene and its several 3<sup>D</sup> components, e.g. the bodies of underwater pollutants' aggregations.

Besides using its own database, the system is also able to receive the data layers from the other, remote and distributed databases and systems, and then to send them to a user in a form fully integrated with other layers. The open architecture of the system software allows for easy extension of its functionality to a new data layer type supporting. It requires only the definition of the source of new data as well as the procedure for new data format reading and displaying on the map.

## 2. THE SAMPLE APPLICATION

The sample application of the presented Web-based GIS is shown below. This is the visualisation of an oil spill drift and spreading within the southern Baltic area. The presented data were obtained using the composed 3<sup>D</sup> modelling system CAROCS [3] for prediction of an oil spill behaviour, including several processes like:

- advection of an oil spill due to current and wind fields,
- wave mass transport,
- horizontal and vertical diffusion of oil particles,
- evaporation and decomposition of the particular kind of oil.

The system used the results of the hydrodynamic model HIROMB for the Baltic Sea [4] as well as the wave model WAM4 [4] as its input data. The models' spatial resolution was 3 NM and data temporal resolution 1 hour. The simulation concerned real oil spill, observed during the Polish aerial surveillance in June 2003 [4], most probably from the ship Fu Shan Hai, sunken after collision on 31<sup>st</sup> May 2003 near the Bornholm Island. The oil leaked from the shipwreck to the water column near the seafloor. The situation from the first surveillance was used to prepare the input to the system.

The sample screenshot in Fig. 3 presents the 2<sup>D</sup> visualisation of modelling results of the oil spill drift and spreading for one given point in time. Additionally, the depth of an oil particle is symbolised by its colour on the map. As a background, the coastline of the Southern Baltic Sea, the isobaths and some other details from a nautical map are also visible.



The background data, including the Baltic Sea bathymetry grid, have been accommodated using the "Baltic GIS Portal" site [5] resources.

The sample snapshot of the 3<sup>D</sup> animated view presenting the modelled position and shape of the oil spill, on the background of the bathymetry relief, is shown in Fig. 4. Fig. 5 presents the time sequence of the system predictions, visualised in 3<sup>D</sup> – for 90, 150 and 200 hours from the initial stage of the scenario.

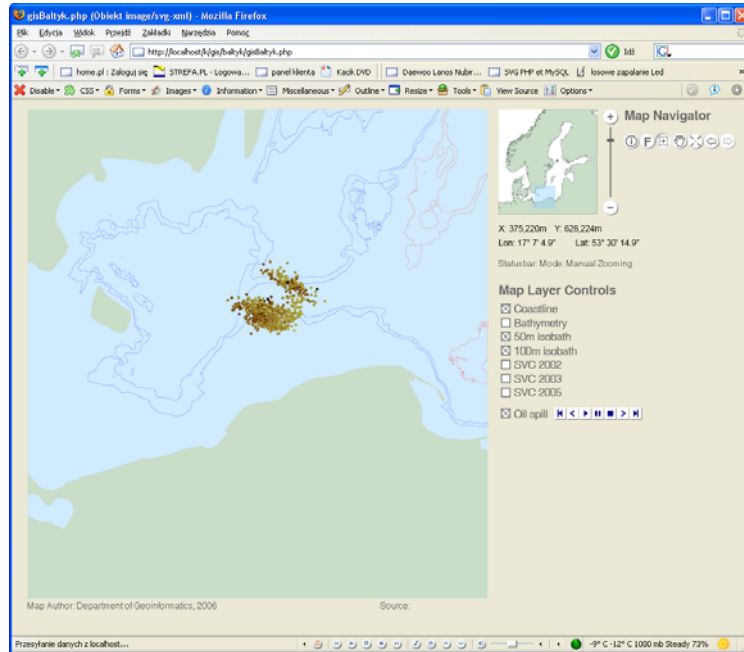


Fig.3 Sample 2<sup>D</sup> map view, presenting the actual position and shape of an oil spill, calculated by the CAROCS model using the set of physical, hydrological and meteorological inputs

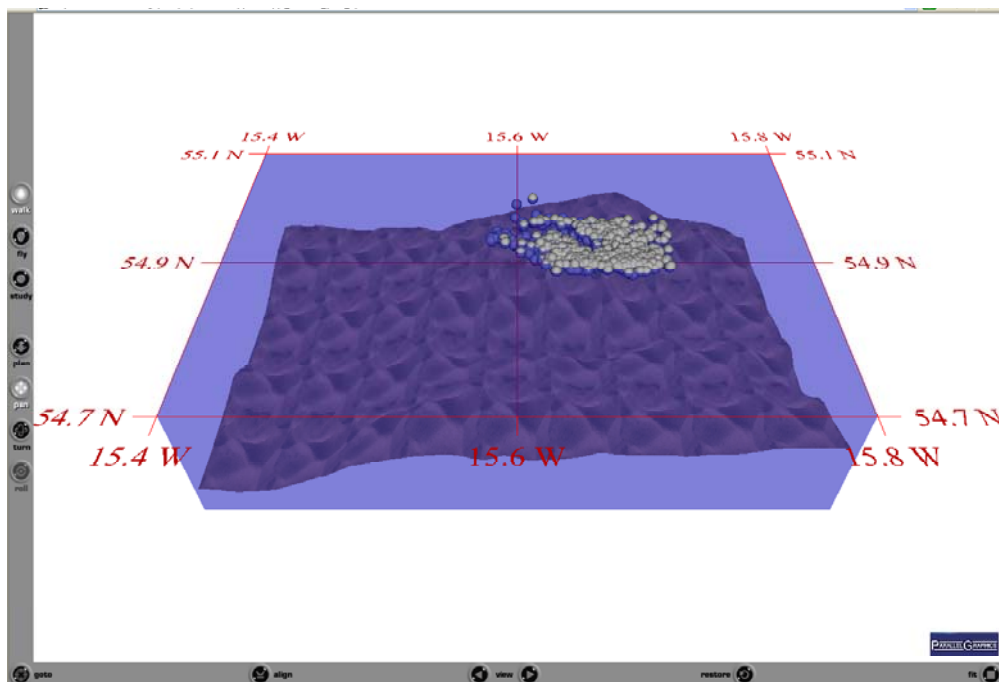


Fig.4 Sample snapshot of the 3<sup>D</sup> animated view presenting the modelled position and shape of the oil spill

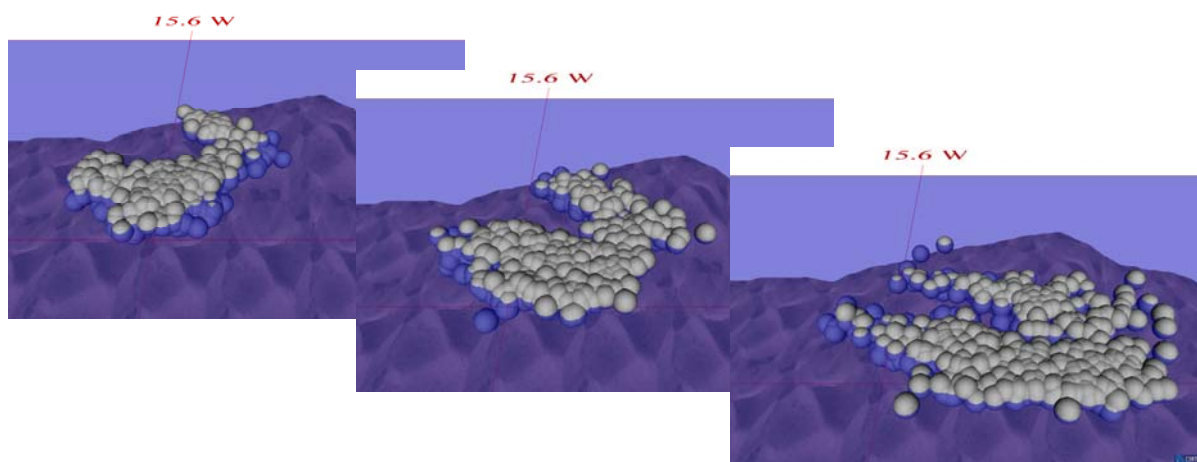


Fig.5 3<sup>D</sup> presentation of the time sequence of the predicted oil spill migration – for 90<sup>th</sup>, 150<sup>th</sup> and 200<sup>th</sup> hour from the initial stage of the scenario

### 3. CONCLUSIONS

The concept and sample application of the real-time, remotely accessible marine GIS were presented. In the system, the investigation results for several components and parameters of marine environment may be easily integrated together, and visualised and mapped in the similar way as in the presented example of oil spills. The presentation and analysis of various kind of data makes the system the useful tool in investigation of the structure and properties of marine ecosystem. The instantaneous, nearly real time mode of data receiving, disseminating and visualising, makes the system also useful in emergency managing in a case of ecological catastrophe for instance, or with respect to other hazards. The more advanced GIS tools, like geoprocessing or spatial analysis procedures, are under development and will be integrated with the system in its next versions.

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