Application of GIS and Web Technologies for Danube Waterway Data Management in Croatia

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Abstract

The paper gives a general description of the Danube waterway data management in Croatia. For this purpose, we initiated the development of a specialized geographic information system (GIS), the so called River IS, which provides efficient waterway related data management for the Croatian part of the Danube River. In addition, Croatian activities in the Pan-European Programme Consortium Operational Management Platform River Information Services (COMPRIS) and INTERREG project Data Warehouse for the Danube Waterway (D4D) are described. Greatest emphasis is placed on our research how to solve the major problems identified by “GIS Forum Danube” expert groups. We present our solutions to two important D4D project objectives. The first project objective concerns preparation of national GIS data of the participating countries in the world geodetic WGS84 coordinates as well as checking the transnational compatibility of GIS data. The second important project objective concerns development of a commonly agreed catalogue of object types and their attributes necessary to describe waterway related data. For example, the conversion of the Croatian national geographic data into Inland ECDIS digital navigation maps is described.

1. General information about River Information Services

The “GIS Forum Danube” was founded in 1997 as a trilateral working group by the waterway directorates from Germany, Austria and Slovakia. Since 1999 the Group has been accepted by the Danube Commission as a Working Group (Danube Commission 2005). Hungary joined in 2000, Croatia in 2002 and finally Romania and the Ukraine in 2003, while Serbia & Montenegro approached the initiative in 2004. The “GIS Forum Danube” aims at more intensive exchange of geographic data and closer cooperation in terms of the waterway management along the Danube River. In 1998, the European Union initiated the development of the concept of River Information Services (RIS) that describes all kind of information services for inland navigation. RIS constitutes a concept of harmonized information services to support traffic and transport management in inland navigation, including interfaces to other transport modes. A suitable framework for the international exchange of RIS related information has to be established (European Commission 2005). For that purpose, the use of Information and Communication Technology (ICT) has become crucial. ICT is an important instrument to enable efficient waterway management.

European Union research support can be found in each phase of RIS progress. Several research and development projects focused on RIS initiatives have worked continually on the technological developments, system integrations, standardization, international cooperation and networking (European Commission 2005). For example, the pan-European programme Consortium Operational Management Platform River Information Services (COMPRIS) is a FP5 Programme which started in 2002. COMPRIS deals with the pan-European standardization and piloting of RIS, which is a prerequisite for full installation of RIS.
on all navigable waterways. Project results include standards for RIS technologies such as Notices to Skippers, Inland Automatic identification System (AIS), Inland Electronic Chart Display and Information System (Inland ECDIS), Electronic Ship Reporting (in cooperation with the Electronic Reporting International, ERI working group), etc. Another example is the INTERREG project Data Warehouse for the Danube Waterway (D4D), which set the first milestone in the exchange of waterway related data between the competent authorities. D4D project can be considered as the first step in fulfilling the requirements of the European ministers of transport (Conference in Rotterdam, 2001) who have defined as their main goal the implementation of RIS on the main European waterways by the end of 2005 (via donau 2002).

2. Danube waterway data management in Croatia

Since 2000 we have been conducting our research activities for the purposes of the special joint project between the Rudjer Boskovic Institute and the Croatian Ministry of the Sea, Tourism, Transport and Development (MSTTD). The aim of the project is to develop a specialized geographic information system (GIS) for surveillance of the Croatian segment of the Danube and Drava Rivers (i.e., River IS). Since 2003 this work has continued as part of the CROatian River Information Services (CRORIS) project (CMMATC/via donau 2003). The aim of this project is to involve Croatia in the RIS system development. CRORIS will be developing independently but with expert and institutional cooperation with COMPRIS.

Later on, the Inland Navigation Development Centre (CRUP) was formed with main aim to render project management services in the development and modernization of inland navigation by utilizing the latest technical achievements. Signing the Contract between CRUP and MSTTD in May 2004, Croatia officially started with the development and implementation of RIS (CRUP 2005). CRUP became coordinator of this important and complex project, and we participate in CRORIS as its partner. We also actively participate in the work of expert groups for similar activities within the D4D project.

2.1 CRORIS project

The CRORIS project will develop knowledge of how to integrate RIS into relevant commercial and administrative procedures in Croatia, as well as implement a test section along the Croatian stretch of the Danube of 140 km (CRUP 2005). Due to its integration in relevant pan-European research and development activities, the RIS concept will be standardized and harmonized at the European level. The main beneficiaries of the project will include the customs, ship-owners, shipmasters, harbormasters, and others directly or indirectly involved in transportation of goods and passengers on Croatian waterways.

The CRORIS project will have two main phases (CRUP 2005). The first phase concerns research and development and comprises all activities that are necessary to prepare harmonized full installation and operation of RIS in Croatia. This phase also ensures cooperation and close alignment of RIS development activities with Croatia’s neighboring countries. The second phase focuses on full installation of RIS on the Croatian part of the Danube and Drava Rivers. The main goal is to develop and implement information services for all relevant actors at the governmental level (Ministry of Internal Affairs, port authorities, etc.) and at a commercial level (port, ship operators, shippers, etc.).

2.2 Main functionalities of the River Information System (River IS)

We initiated the development of the River IS as a specialized geographic information system that provides various data about the Croatian part of the Danube River, data about the surrounding objects, values of parameters measured at measurement stations, dynamic data about the river profiles and water levels as well as other data relevant to river navigation surveillance. The most important requirements concern provision
of automatic data access and processing, as well as their temporal and spatial presentations. Based on the performed WEB-GIS-DBMS integration, it is possible to analyze all the necessary types of information, so that presentations such as maps, statistical reports, time series diagrams and others could be obtained in due time (Bec/Pecar-Ilic/Ruzic 2003, Pecar-Ilic/Ruzic 2004). Some examples of the web application for temporal and spatial presentation of waterway data are shown in Figure 1.

Fig. 1: Examples of the web application for temporal and spatial presentation of the Danube waterway related information in Croatia

The XML-based approach using modern object technologies has been chosen for the development of Web applications (Pecar-Ilic/Ruzic 2004). The Autodesk MapGuide™ was used as Internet GIS. It consists of the following modules: MapGuide™ Server (which enables dynamic access to digital maps as well as to ODBC data sources through the Internet and Intranet), MapGuide™ Author (for creation of digital maps), and MapGuide™ Viewer (for the presentation of maps). Spatial and attribute data were managed by Oracle® ORDBMS. Microsoft family products such as Active Server Pages (ASP), ASP.NET, ActiveX Data Objects (ADO) and ADO.NET were also applied. Additionally, for efficient application development, supporting eXtensible Markup Language (XML) technologies such as eXtensible Stylesheet Language Transformation (XSLT), XPath and Scalable Vector Graphic (SVG) were applied. Web application enables the following functionalities (Bec/Pecar-Ilic/Ruzic 2003, Pecar-Ilic/Ruzic 2004):
1. Automatic generation of a digital river navigation map and the corresponding report based on specified user input;
2. Reporting upon selected objects from the digital map (river navigation marks, water level data, etc.);
3. Automatic generation of reports with average water level values in the form of a tables and a SVG time series diagrams;
4. Automatic display of water level data on digital maps (momentary water levels as well as water levels for a given date and time).

3. Data warehouse for the Danube waterway - D4D project

D4D is an Interreg III B project within the scope of the “GIS Forum Danube”. For its purpose the “GIS Forum Danube” has defined several working packages (WPs) or expert groups. These working packages concern the data warehouse (WP1), software tools (WP2), geo-related basic data (WP3), models (WP4), infrastructures (WP5), and RIS standards (WP6). Croatia is active in all expert groups and we are personally actively involved in WP1-WP4.

One of the main D4D project objective is to network national GISs and ensure an efficient data exchange between responsible authorities and skippers (GIS Forum Danube 2004). For that purpose, all waterway related data would be stored in a distributed database (data warehouse) and made available to the participating countries. This common database will serve as a basis for a number of additional applications. In the first phase, conversion of the geographic data into electronic navigation charts (ENC) is planned according to the European Inland Electronic Chart Display and Information System (Inland ECDIS) Standard. The Inland ECDIS standard has been passed by the Central Commission for Navigation on the Rhine (CCNR) and is recommended by the Danube Commission and the European Commission for Economy of the United Nations (UN/ECE). All these Commissions recommend the Inland ECDIS standard to be used for exchanging inland navigation relevant data at international level. Charts according to this standard have already been produced before the start of COMPRIS and D4D projects for the Rhine River and the upper part of the Danube.

The next phases of the D4D project will involve further applications relating to calamity abatement, ecology, tourism, etc. (GIS Forum Danube 2004). A good example are the activities of the European Environment Agency (EEA) concerning distribution of scientific and application-oriented environmental information and implementation of the Web-technologies for the Environmental Information and Observation Network (EIONET) (Pillmann 2002). Such experience could be of great interest for the establishment of inland waterborne transport management as well as communication.

4. Results of our activities in the D4D expert groups

The first important D4D project objective is that the data within the databases should be created in the World Geodetic System 84 (WGS84) coordinates (Hintenaus 2004). However, national GIS data of the participating countries are originally prepared in their respective national coordinates. An important precondition for the data exchange is checking the transnational compatibility of GIS data.

The second important D4D project objective is the development of a common data model to implement the corresponding data warehouse (Hintenaus 2004). National lists of objects and their attributes have been collected and compared within the activities of “GIS Forum Danube”. Based on the reduced set of data, a commonly agreed catalogue of object types and their attributes has been prepared. Common data sets will be used to automatically produce electronic navigation charts (ENC) according to the Inland
ECDIS format. National GIS data will have to be converted into the D4D database using national converters.

4.1 Development of the Inland ECDIS digital navigation map

To satisfy the first D4D project objective, accurate transformation of the Croatian national HDKS2001 data into the ETRS89 system (compatible with WGS84) was necessary. The digital navigation map for the Croatian segment of the Danube River was created from the Danube Commission printed maps, which were digitized and geo-referenced using the Croatian national geodetic system. During the production of the Croatian electronic navigation map (ENC), we discovered that the AutoCAD Map software used for the map production did not transform accurately Croatian national GIS data into WGS84 coordinates. To this purpose, we developed a correction procedure that can resolve the problem with errors below the centimeter range (Ruzic/Pecar-Ilic/Eres 2004). Accuracy of the procedure was tested by several approaches. Firstly, we tested our procedure with available GPS control points, as well as with WGS84 compatible Hungarian data at the state border between Croatia and Hungary. Secondly, the produced Croatian ENC was also compared with a recent satellite picture (produced by LANDSAT 7) of the Danube River at the Croatian-Hungarian state border (see Figure 2).

Fig. 2: Comparison of ENC with the satellite picture of the Croatian segment of the Danube River

Good agreement was obtained in both tests. Afterwards, we successfully converted the digital navigation map for the Croatian segment of the Danube River into the corresponding Inland ECDIS format (see Figure 3). For example, this Inland ECDIS map comprises the left and right banks of the Danube River, the middle of the waterway with depth and water velocities, river navigation signs and marks, bridges, etc.
Croatian Inland ECDIS map for Danube River can be downloaded for free (CRUP 2005). Inland ECDIS Viewers are available from several companies but we use that from Seven Cs AG & Co. KG.

Fig. 3: Croatian Inland ECDIS map for the Danube River segment near the mouth of the Drava River

4.2 Development of the Object Catalogue

The second important D4D project objective is the development of a common data model of the Danube waterway to implement the corresponding data warehouse (Hintenaus 2004). National lists of objects and their attributes have been collected from all participating countries and compared within the activities of “GIS Forum Danube”. For that purpose, we proposed a redefinition of similar attributes in order to reduce their number to minimum and enable more efficient data processing. The Croatian Catalogue of Object types and their corresponding Attributes was prepared as an illustration of these proposals (Ruzic/Pecar-Ilic 2004). Finally, based on the reduced set of data, the commonly agreed catalogue of object types and their attributes was prepared and implemented as a MS Access database and the corresponding application. In this way, the D4D object catalogue defines the format of all data that may be exchanged between partner countries within the D4D project and the “GIS Forum Danube”. The object catalogue is organized in nine object groups, which completely describe the waterway related data (Schedlbauer 2004). These object groups are Reference point, Kilometre marking, Topography, River bottom, Navigation, Constructions, Traffic routes, Hydrography as well as Borders and regions. Each object group includes one or more objects and each object has one or more corresponding attributes.

At present D4D object catalogue is available only in English, German and Slovak languages. Each participating country will be able to translate the whole D4D object catalogue into their national language (Schedlbauer 2004). For example, Figure 4 presents the functionality of the MS Access application, which enables the description of a waterway object in English as well as in Croatian. The most important parts of this application are the language dialog box, main dialog box, object group names, object names and attribute names. In the next D4D project phase, common data sets will be used to automatically produce
ENC according to the Inland ECDIS Standard. Additionally, national GIS data will have to be converted into the D4D database using national converters (Hintenaus 2004).

Fig. 4: Description of Waterway axis object and its attributes both in English and Croatian enabled by the D4D Object Catalogue application in MS Access

5. Conclusions

According to the demands of the European Ministers of Transport, River Information Services (RIS) pursuant to European recommendations shall be installed along main waterways by the end of 2005. This declaration was recently supported also by the new European Commission RIS Directive. The “GIS Forum Danube” is regarded as the perfect platform for managing projects such as COMPRIS and D4D. Croatia actively participates in activities of the “GIS Forum Danube”, a member of which became in 2002, as well as in expert groups of these two projects. To involve Croatia in the RIS system development, the CROatian River Information Services (CRORIS) project has been started with expert and institutional cooperation with COMPRIS.

Since 2000 we have been conducting our research activities for the purpose of the Croatian national joint project that will improve waterway related data management in Croatia. For that purpose, a specialized geographic information system for surveillance of the Croatian segment of the Danube River (i.e., River IS) has started to develop and in 2003 became a part of the CRORIS project. Based on the performed WEB-GIS-DBMS integration, it is possible to analyze all the necessary types of information, so that presentations such as maps, reports, time series diagrams and others could be obtained in due time. In addition, employing the eXtensible Markup Language (XML) as the format of exchanged data as well as some of the supporting XML technologies (such as XSL, SVG, etc.) in developed applications could help establish the standard for exchanging data between CRORIS, its partners, and the regulatory bodies.
Our solutions to the two main objectives of the D4D project are also presented. According to first project objective, we developed a correction procedure for transformation of national GIS data into WGS84 coordinates. Accuracy of the procedure was tested by several approaches and good agreement was obtained in all cases. For example, the procedure was tested with WGS84 compatible Hungarian data at the Croatian-Hungarian state border. The produced Croatian electronic navigation chart (ENC) was also compared with a recent satellite picture (produced by LANDSAT 7) of the region. Afterwards, Croatian ENC of the Danube River was successfully converted into the corresponding Inland ECDIS map, which can be downloaded for free from the relevant Web site. The second D4D project objective concerns development of the commonly agreed D4D object catalogue for the Danube waterway data management. For that purpose, we proposed a redefinition of similar attributes in order to reduce their number to a minimum and enable more efficient data processing. The Croatian Catalogue of Object types and their corresponding Attributes has been prepared as an illustration of these proposals.

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