POLSKIE TOWARZYSTWO INFORMACJI PRZESTRZENNEJ
ROCZNIKI GEOMATYKI 2019 ❍ TOM XVII ❍ ZESZYT 1(84): 59–71

River information services in terms of spatial data infrastructure

System usług informacji rzecznej RIS w aspekcie infrastruktury informacji przestrzennej

Witold Kazimierski, Marta Onichowska

Maritime University of Szczecin, Faculty of Navigation, Institute of Geoinformatics
Szczecin, Poland

Keywords: information services, geographic information systems, information exchange, data storage systems, information management, INSPIRE
Słowa kluczowe: usługi informacyjne, systemy informacji geograficznej, wymiana informacji, systemy przechowywania danych, zarządzanie informacjami, INSPIRE

Introduction

Implementation of the INSPIRE Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007, establishing an infrastructure for spatial information in Europe to support Community environmental protection or activities (Directive 2007/2/EC) has an impact on the environment, its modelling and on providing access to spatial information for the society. The idea of spatial information infrastructure is to combine spatial data from different sources across the Community in a consistent way and share them between several users and applications. The data to be shared covers most of the environmental data including also data about inland rivers vital for inland transportation.

Development of advanced information and communication technologies has an influence on the development of the inland waterway sector. Modern technologies allow creating many new services towards harmonized river information services on inland waterways (RIS). RIS services are related with planning, monitoring and traffic management of inland waterway transport, they provide accurate data to the waterway users to improve safety of navigation and environmental protection (Directive 2005/44/EC). The idea of implementation and the concept of River Information Services in Europe is given in general in Directive 2005/44/EC of the European Parliament and of the Council of 7 September 2005, on harmonized river information services (RIS) on inland waterways in the Community.

In this paper the authors present the concept of using the spatial data infrastructure in the river information services (RIS) area. The research problem is to answer the question whether the SDI concept can successfully support implementation of RIS in Europe and, on the other hand, if RIS data and services can be used as an element or supplementation of SDI in several topics. In order to answer these questions both the data and services have to be analyzed and compared; the proposition of their integration has been proposed. General analysis has been supplemented with the case study based on Polish solutions. As a result, the proposed concept of integration and data exchange will be discussed. Thus, theoretical framework for future implementation works is presented in the next sections.

In section "River information services" the basics of RIS are presented supplemented by special focus on data processing in RIS given in section "Data processing in RIS". Section "Spatial data infrastructure" provides description of SDI together with INSPIRE vision and services concept. In section "RIS and SDI common issues" comparative analysis is presented, which led to the concepts of integration discussed in sections "Concept of using SDI in RIS" and "Concept of using RIS in SDI".

River information services

River information services were established to improve safety of navigation on inland waterways. RIS integrate various services and systems provided by national authorities in one common concept (by common services standards). Moreover, RIS supports planning and managing inland traffic and transport through different countries. Skippers crossing the borders could expect the same technologies used to provide fairway and traffic information development of river information services makes inland navigation more safe, easy, efficient and environmental friendly (Directive 2005/44/EC). RIS is standardized by EU Regulations, like COMMISSION REGULATION (EC) No 414/2007.

RIS services

The RIS common architecture is needed to ensure optimal functioning and interoperability of services. River information services were divided into traffic-related and transport-related. Traffic-related services are Fairway Information Service (FIS), Traffic Information (TI), Traffic Management (TM), Calamity Abatement (CA). Transport-related services are Voyage Planning, cargo and fleet management, port and terminal management, statistics, and waterway charges.

All of these services are supported by RIS technologies to provide all necessary information for efficient and safe navigation.

RIS key technologies

RIS key technologies, based on specifications, standards and formalized reference data, can be divided into (CCNR, 2011):

- electronic chart display and information system for inland navigation (Inland ECDIS),
- electronic ship reporting (ERI),
- Inland AIS,
- Notices to Skippers (NtS).

All of the RIS key technologies are linked by reference data such as the RIS Index and hull data (Figure).

Inland ECDIS is a navigation information system displaying electronic inland navigation charts, vessels' positions and additional navigation-related information. Inland AIS is an automatic identification system for exchanging static and dynamic vessel data and voyage related data between vessels and vessel – shore (both equipped with AIS transponders) via VHF. Electronic ship reporting facilitates data exchange between partners in inland shipping process and in intermodal transport process via Internet. Notices to skippers are standardized information provided by inland authorities to RIS users and contains fairway and traffic related information, weather information, water level information and ice information, transmitted by e-mail and SMS subscription, web application and as information displayed in Inland ECDIS.

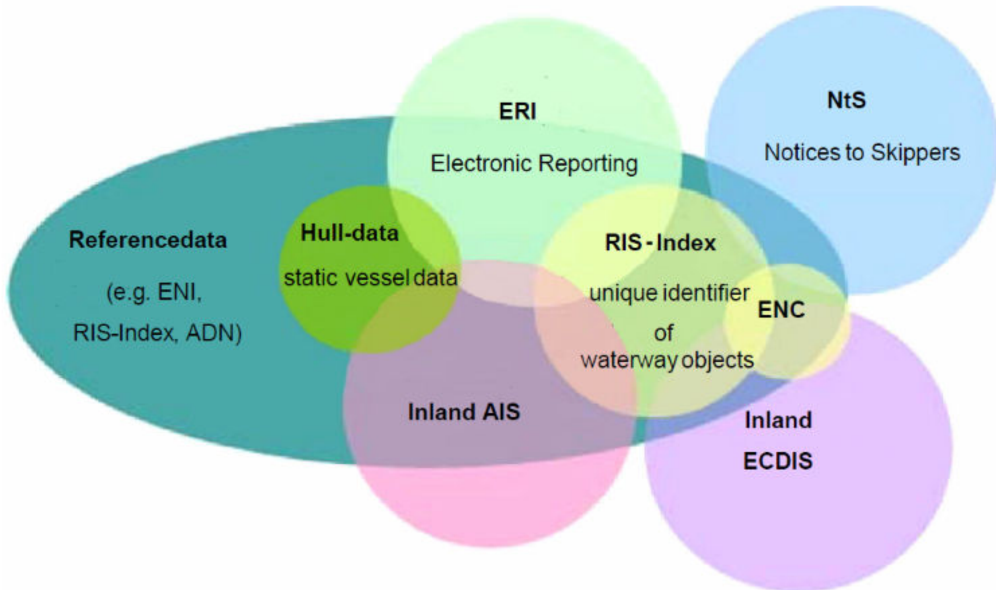

Figure. RIS key technologies and reference data (CCNR, 2011)

Data processing in RIS

River information services collect, process, transmit and manage data from many different sources. Data are transmitted continuously from devices (hydro-meteorological stations, water gauges, cameras, the AIS system, radars) installed in the RIS area and from national authorities. Additionally, some static data for IENC are also collected by surveyors (Łubczonek, 2016). All data are processed and transmitted to inland waterway users.

Inland ENC

The development of Inland Electronic Navigational Charts by Inland ENC Harmonization Group was started in 2003. All data used in Inland ENCs production are standardized. Inland ECDIS Standard specified frameworks of Inland ENCs production where Product specification (IEHG, 2015), Codes for Producers and Waterways and IENC Presentation Library were given. Moreover, specification for bathymetric Inland ENC is also included. Each electronic navigational chart is a database with standardized content, structure and format used in inland electronic chart display and information systems ECDIS. Inland ENC contains all necessary data to safe navigation such as, for example, a bank of waterways, shoreline construction, any facility that is considered a hazard to navigation, boundaries of the navigation channel, isolated dangers, official Aids-to-Navigation (e.g. buoys, beacons, lights, notice marks), waterway axis with kilometres/hectometres, etc. (IEHG, 2015)

Dynamic data

Data used in vessel tracking and tracing are mainly connected with traffic. The RIS centre gathers AIS data, radar data and records of VHF communication if available. Data from cameras are also stored. Cameras observe the inland traffic for 24 hours per day. All data are kept in databases for a certain time and are available in case of accidents and for analysis or statistics.

Based on the data collected, the so called traffic images are generated in the RIS Centre containing traffic information. Tactical traffic information is information affecting the vessel master's or VTS operator's immediate decisions made in relation to navigation in real navigational traffic and concerning local traffic. Strategic traffic information (STI) signifies information affecting medium- and long-term decisions made by RIS users.

Two main services using traffic data in RIS are tracking and tracing. Vessel tracking means the function of maintaining status information of the vessel, such as the current position and characteristics, and — if needed — combined with information on cargo and consignments. Vessel tracing means the retrieving of information concerning the whereabouts of the vessel and — if needed — information on cargo, consignments and equipment (Directive 2005/44/EC).

Environmental data

The entire RIS area is covered by hydro-meteorological sensors to provide information about weather conditions and water levels. Water gauges measure current water levels and – if installed on bridges – it is possible to calculate clearance to the nearest part of construction (Stateczny, 2016a). All data are transmitted continuously to the RIS centre, where they are stored and sent to skippers. The water level parameter is very important to plan voyage and the quantity of cargo. This data can be processed and used to analyze the area conditions. Meteorological data provide continuous information about the air temperature, wind directions and speed, pressure, humidity and intensity of precipitation (Stateczny, 2017). All data from devices are transmitted to the RIS centre, then collected and published to RIS users by the dedicated web application in the form of Notices to Skippers. The most important weather condition are speed and direction of speed because it influences the vessel maneuverability in a limited area. All of hydro-meteorological data are stored for about few years in RIS databases (Stateczny, 2016b).

Spatial data infrastructure

INSPIRE SDI concept

The INSPIRE Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007, establishing an infrastructure for spatial information in Europe entered into force on 15 May 2007. The Directive shows the idea of common use and share of the environmental spatial information by European public sector organizations. Data specified in the Directive are divided into spatial data themes. Data should be described by metadata with geographic reference and available by web services like geoportal. On the national level each country has to elaborate its own frameworks of data spatial infrastructure (Zwirowicz-Rutkowska, 2017; Zwirowicz-Rutkowska et al., 2016).

SDI Services

The network services created according to the INSPIRE Directive have to allow: discovering, viewing, downloading and transforming of geographical information. The web services should deliver data via the Internet and allow data processing like data transformations. An Open Geospatial Consortium OGC and the International Organization for Standardization ISO defined the technical standards, such as formats for spatial data transmission and communication protocols between data servers. There are a few OGC standards used in SDI (Steiniger, Hunter, 2012):

- OGC data delivery standards such as: WMS-Web Mapping Service, WFS-Web Feature Service and the transactional equivalent WFS-T, and the Web Coverage Service WCS,
- OGC data format standards such as: SFS- Simple Feature Standard, GML- Geography Markup Language, KML-Keyhole Markup Language,
- OGC data search standards such as: CSW Catalogue Service and Gazetteer Service WFS-G,
- Also OGC standards: WPS- Web Processing Service, CTS- Coordinate Transformation Service, WTS- Web Terrain Service, SLD- Styled Layer Descriptor, SE- Symbology Encoding and WMC- Web Map Context.

ISO standards define schemas for describing spatial data and services. Data providers, service providers, Internet, GIS server services and users are the shareholders of the spatial data infrastructure (Kazimierski, 2017).

SDI Data

According to the INSPIRE Directive all data used in SDI concept refer to the environment and are classified in themes. The first group contains, among others, coordinate reference systems, geographical grid systems, geographical names, as well as hydrography with hydrographic elements, such as marine areas, river basins and sub-basins. The second part includes elevation data including bathymetry, land cover, geology and orthoimageries. The last group of themes are soils, land use, atmospheric conditions, meteorological geographical features, oceanographic geographical features, buildings. Meteorological geographical features in the SDI concept contain weather conditions such as temperature, precipitation, wind speed and direction. Each theme has its own guidelines and recommendations specifying the data content and structure, reference systems, data quality, metadata, data capture and portrayal. The Hydrography section includes (EC, 2017):

- waterbodies (rivers, streams, lakes, watercourses, reservoirs),
- land water boundaries (coastlines, shorelines),
- catchments,
- hydrographic networks,
- hydro Point of Interest (rapids, falls, cascade),
- man-made objects (bridge, dam, weir, lock),
- wetlands,
- shores.

In the section of Meteorology Geographical Feature the following parameters are presented (Directive 2007/2/EC):

- wind speed and direction,
- temperature,
- relative humidity,
- evaporation amount,
- precipitation amount.

RIS and SDI common issues

The main goal of this paper was to perform the analysis of RIS and SDI integration possibilities. It was noticed that these two systems for processing and providing spatial data are working in parallel and thus they are supplementing but may also in some cases duplicate each other. Data processed and stored by River Information Services could be used in the SDI concept. Collected data are of the high quality, checked and measured by surveyors. Some RIS data are fitted in INSPIRE Directive themes; this concerns, for example hydrography, meteorological conditions or bathymetry with contour lines.

Comparison of INSPIRE HYDRO and RIS Data

Hydrography data provided by INSPIRE viewing services as layers are also used by River Information Services in Inland ENCs production, which are used as the database for other RIS services as vessel tracking and tracing and notices to skippers. Data used in RIS are much more detailed and directed towards safety of inland navigation. Inland ENC layers are collected with the high quality and accuracy higher than data used by INSPIRE services. Detailed comparison of the layers relating to hydrography is presented Table 1. It can be noticed that, in general, some of INSPIRE layers are not present in RIS Data, however it has to be kept in mind, that the IENC model is created for other purposes and in many cases these data are more accurate. As such they should rather be compared to more precise models like base maps presented in (Kędzierski et al., 2016). Thus, it can be said that the INSPIRE hydrography data set is much more generalized than relating RIS data. On the other hand, RIS data are more specialized and dedicated to final users, while the INSPIRE data set is more complex.

Table 1. Data in SDI and RIS services

INSPIRE Hydrography Data	RIS Data (mainly Inland ENC)
Watercourse, Standing Water	River, canal, lake
Land Water Boundary	Shoreline
Drainage Basin, River Basin	–
Hydro Node, Watercourse Link	–
Rapids, Falls	–
Crossing, Dam or Weir, Embankment, Sluice, Lock, Ford, Shoreline Construction	Bridges, dams or weirs, locks, shoreline contraction (groin, training wall), Cable ferry, Free Moving Ferry
Wetland	Land region (swamp)
Shore	Land area

Bathymetry is another set of data, crucial for navigation. Thematically data used in the RIS bathymetric layer production are similar to the SDI Elevation theme – bathymetry (EC, 2013); comparison is presented in Table 2. However, the main differences again concern the accuracy and specificity of data. Bathymetric data collected and processed in RIS are gathered by surveyors with echosounders, according to the IHO (International Hydrographic Organization) requirements and they are sometimes supported advanced technical solution of bottom modelling (Włodarczyk-Sielicka et al., 2016; Wawrzyniak et al., 2017). Depth information in inland navigation is very important to plan the voyage. Moreover, wild rivers are often changing their riverbeds by moving the ground. Thus, measurements are very detailed, precise and performed with the high vertical and horizontal accuracy. Taking all this into account it can be assumed that all presented data from RIS could be used in the INPIRE SDI concept if enhancing of the data quality is required.

Table 2. Data in SDI and RIS services

INSPIRE Elevation Data (bathymetry)	RIS Data (mainly Inland ENC)
Break Line	–
Contour Line	Depth Contour
Isolated Area	Caution area, Obstruction
Spot Elevation	Soundings
Void Area	–
Elevation Grid Coverage	This data are used in chart production process (in bathymetric layer preparation) but not available for user
Elevation TIN	This layer could be prepared in chart production process from bathymetric data

Comparison of data models in SDI and RIS

In Poland, during implementation of INSPIRE Directive on the national level, the Geoportal service was created. Authors of the national SDI concept had difficult task to build one common spatial data infrastructure and to implement data from national authorities, stored in different databases (Bac-Bronowicz et al., 2015). Geoportal uses thematic data bases with data from national authorities, one of which is Topographic Objects Data Base (BDOT). This seems to be the most representative, publically available, database for comparison with RIS.

BDOT10k is a topographic database containing information about objects locations according to the national rules. Data sets are available in gml, file database and shapefile formats. The BDOT10k basic resource is a collection of objects classified on three levels of details and covering 286 kinds of objects grouped in 57 classes and 9 categories – water network, communication network, utilities network, land cover, buildings, structures and equipment, land use complexes, protected areas, territorial division units, other objects (Regulation, 2011).

Inland ENC's in Poland are implemented according to European standards and were created for approximately 100 km of waterways in Lower Oder region (Łubczonek, 2015). ENC's contains data from land surveys and national authorities. The IENC standard introduces Encoding Guide describing recommended objects, attributes and attribute values. Encoding Guide has 19 thematic groups which are divided into 42 thematic layers (e.g. meta

Table 3. Comparison of selected layers in BDOT10K and Inland ENCS Standard

	Topographic Objects Data Base (BDOT10k)	Inland ENC
Scale	1: 10 000	1: 2 000
Object class	Waterway network (SW): – river and stream (OT_SWRS) – canal (OT_SWKN) – drainage ditch (OT_SWRM)	Natural Features: Hydrology (HYDRO): – Canal (non-navigable (CANALS) – Rivers (non navigable) (RIVERS) – Named Water Area (SEAARE) – Dredging Lake (DEPARE) – Lake (LAKARE)
Attributes	River and stream (OT_SWRS): – periodicity, – type: river (Rz), stream, brook or stream (St), river, stream, brook or stream (RS), – location: on the surface (0), under surface (1) – width, – course: main flow (Cgl), lateral arm (Rbc), – operational status: navigable (Z), not navigable (NZ), – idMPHP (map identifier for the hydrographic division of Poland), – watercourse (relation to list of names of watercourses).	Dredging lake (DEPARE): – Depth range value1 (DRVAL1) – Depth range value2 (DRVAL 2 – quality of sounding (QUASOU) – Source date (SORDAT) – Source indicator (SORIND)
Data accuracy	1,5 m- 5 m	2 m
Presentation	Line, area	Area

features, hydrology, topography, vegetation, settlements, buildings, political boundaries) and then into object classes.

Comparison of selected layers in BDOT and ENC standard, presented in Table 3, confirms earlier observations, but in the more detailed approach. The data model of ENC is designed for 5 – times bigger scale and as such it has to be more detailed, while the BDOT model is more generalized. However, the accuracy of data is similar in both cases. Theoretically it equals to a few meters. The practical research however, presented for example in (Zaniewicz et al., 2014), shows that the geometrical accuracy is different and that dedicated methods for geometrical integration should be implemented.

Each of these services – Inland ENC and BDOT – has its own organized data structure with different requirements of accuracy, presentation and attributes. These rules allow to standardize services and are the guidelines for information providers, trying to unify the data exchange between databases on the national or even the international levels.

Comparison of SDI and RIS Services

Data used in the INSPIRE SDI concept are provided in the form of web services by geoservers. Users can view and download data by geoportal in one place using the Internet. All INSPIRE data are oriented to the natural environment (Zwirowicz-Rutkowska et al., 2016). Data used in RIS are important from safety of inland navigation point of view and are usually collected, stored and processed by public authorities. River information services are provided to users in standardized form in the entire European Community. Data are shared by dedicated applications and most of them are available via the Internet. Meteorological data, notices to skippers, electronic ship reporting and some vessel traffic data and tracing services are provided by web applications. Inland ENCs are produced to dedicated devices and software Inland ECDIS is not available for free like other services. Inland ECDIS could gather all data provided from vessels and from RIS to limited number of devices, this is important for safety of navigation. Moreover, public authorities could provide more services than standardized ones, such as geoportal with Inland ENCs, mobile applications.

The main difference in providing data between SDI and RIS is that SDI data are gathered in one geoportal service and available via the Internet, while RIS data are provided to users by few ways and are not available in one web service. RIS is mainly focused on the safety of navigation by providing all necessary information to make quick and safe navigation decisions which influence the environmental protection.

It can be noticed that RIS services are dedicated solutions standardized by separate bodies, which do not refer to commonly used OGC standards for web services. In this situation INSPIRE data are easily available (at least for viewing) to RIS users, while RIS data requires dedicated software and thus they are not easily available for a wide society.

In the Polish SDI concept the following services are used (Dygaszewicz, 2006):

- Catalogue Service for a Web – used for search and discover service – metadata could be published, searched and connected with other services from other countries,
- Web Map Service – for viewing service – use for data in raster format and based on data collected in databases,
- Web Feature Service – for downloading service – data could be download in XML format and other vector format.

All data in the SDI concept are gathered and available in the central catalogue service, where they are distributed to users and the services are implemented in the Polish Geoportal (Gaździcki et al., 2004).

RIS services use the client-server solution to provide information oriented to safety of navigation – warnings, notices, weather conditions, water levels, electronic navigational charts. All RIS data are collected in local servers and distributed to users via web applications as complete service like Notices to skippers (distributed in code or XML format), Electronic Ship Reporting, VTT. RIS data could be displayed, searched or downloaded by inland waterway users in the client-server technology. Two main kinds of services are push and pull services in which the data are available to users on request or constantly. In general, the web services technology based on XML messages is implemented, however these are dedicated services and they do not follow OGC standards, as in case of Geoportal.

Concept of using SDI in RIS

Some of data and services provided by INSPIRE could be used in RIS as a data base for other services. Geoportal is a good way to share data with users. Hydrography, bathymetric and meteorological data could supplement RIS sensors and services. If the geoportal form is used to provide data in RIS, we could gather data in one place. The RIS geoportal could use Inland ENCs as a data base, and meteorological stations and water gauges to provide dynamic information about weather conditions and water levels, notices to skippers information related with Inland ENC objects, camera views as observations of traffic in most limited parts of waterway (locks, ports, berths) and Inland AIS data – for positions of vessels, including their speeds and courses. Inland ENC layers are given in a code way and they may be viewed, but not downloaded. All data in RIS are checked by inland authorities. However, it has to be noticed that, in general, the RIS data quality should be higher as they are dedicated for navigation purposes. Thus, the main input of SDI to RIS concept should be services standardization and not the data themselves. OGC standards used in INSPIRE could be easily used for RIS push services; owever pull services should rely on the RIS standards. We can easily imagine, for example, providing of IENC by RIS Centre for download with the RIS standards and for viewing with the WMS standards, as it is in SDI concept.

Concept of using RIS in SDI

Data collected by River Information Services could and should supplement data in the INSPIRE SDI concept. According to presented tables some RIS data could be used as INSPIRE layers. Data prepared by RIS are much more detailed and accurate what could be used by other authorities for the needs of environmental analysis.

This can be done in two ways. Firstly, RIS Centres may provide the data to the national SDI provider for integration in SDI services. Secondly, RIS Centres can establish SDI services with their own data, like WMS. They would be, the so called branch SDI services and can be easily integrated in all SDI services chain with the interoperability ensured.

It can be noticed that theintegrated model of spatial data web-services can be thus adopted in other specialized solutions for navigation in inland waters (Zaniewicz et al., 2016; Kazimierski et al., 2017) or in maritime systems (Borkowski, 2017).

Summary

The paper presented deliberation on the use of the SDI concept in River Information Services. The description of both of them was provided, introducing their history, concept as well as data and services provided. Detailed comparison of data models in both systems was presented and the services were compared. The major difference is that SDI provides data according to OGC open standards with the services easily interpreted by Internet viewers, while in RIS a set of dedicated standards is used. This results in the necessity of having dedicated software for viewing the data is needed.

The concept of integration of both systems was discussed. It is proposed that the RIS Centre providing RIS data becomes a part of the SDI chain supplementing the system with new data and services and, at the same time, granting the access to various other SDI data. Thus the concepts and advantages of both systems can be integrated fulfilling the requirements of the widely understood users.

Acknowledgment. This research outcome has been achieved under the grant No 1/S/IG/16 financed from a subsidy of the Ministry of Science and Higher Education for statutory activities.

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Streszczenie

Usługi informacji rzecznej (RIS) są odpowiedzialne za zbieranie, przetwarzanie, przechowywanie i zarządzanie danymi z wielu różnych źródeł. Dane gromadzone są przez specjalistyczne urządzenia pomiarowe, pomiary terenowe oraz podmioty zewnętrzne. Wszystkie usługi mają na celu poprawę bezpieczeństwa żeglugi śródlądowej i skupiają się wokół danych hydrometeorologicznych oraz danych przestrzennych, niezbędnych do opracowywania elektronicznej mapy nawigacyjnej. Infrastruktura informacji przestrzennej SDI pozwala na gromadzenie i wykorzystywanie danych z różnych źródeł przez różne podmioty w celu uniknięcia redundancji w pozyskiwaniu danych. Obecnie obydwa systemy w Polsce funkcjonują jako niezależne. Przedstawiona w artykule koncepcja integracji danych systemu RIS oraz infrastruktury informacji przestrzennej SDI prezentuje możliwości wykorzystania danych gromadzonych przez oba systemy. Autorzy poddali analizie wdrożone usługi informacji rzecznej RIS na Dolnej Odrze oraz wdrożoną koncepcję SDI w Polsce. Ponadto przedstawili wspólne obszary gromadzonych i wykorzystywanych danych, określonych według tematów INSPIRE, jak:

ukształtowanie terenu (batymetria), warunki meteorologiczno-geograficzne oraz hydrografia. W artykule zaproponowano możliwości integracji danych, a także teoretyczne i metodologiczne ramy ich wymiany. W celu uniknięcia redundancji proponuje się obustronną wymianę danych pomiędzy systemami. Dodatkowo w celu określenia zasad integracji przeanalizowano modele danych, usługi oraz architekturę systemów SDI oraz RIS. Dane gromadzone w ramach usług informacji rzecznej RIS mogą stać się uzupełnieniem dla tematów zidentyfikowanych w ramach usług INSPIRE, zapewniając tym samym lepszy dostęp do danych innym podmiotom.

Abstract

River Information Services and INSPIRE Spatial Data Infrastructure are examples of two systems which are providing spatial data for public use. The first one is dedicated for stakeholders of inland shipping and waterways users, while the second one is commonly used by publicity for viewing spatial information. Thus, both systems provide spatial data, however, they are dedicated for different groups of users. The paper addressed the problem whether both systems could collaborate technologically. The scope of data processed in systems, as well as the set of offered services are described and compared. Finally, the concept of data integration and interoperability of services is presented.

Authors details / Dane autorów:

dr hab. inż. Witold Kazimierski, prof. AM
https://orcid.org/0000-0002-9637-0457
w.kazimierski@am.szczecin.pl

mgr inż. Marta Onichowska
m.onichowska@gmail.com

Received / Przesłano	28.09.2018
Accepted / Zaakceptowano	25.02.2019
Published / Opublikowano	30.03.2019