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Spatial Data Infrastructure in Poland – lessons learnt from so far achievements

Elzbieta Bielecka[1], Dariusz Dukaczewski[2]*, Ewa Janczar[3]

[1]Military University of Technology
Faculty of Civil Engineering and Geodesy
2 gen. W. Urbanowicza St. 00-908 Warsaw 46, Poland
e-mail: elzbieta.bielecka@wat.edu.pl, ORCID: http://orcid.org/0000-0003-3255-1264

[2]Institute of Geodesy and Cartography
27 Jacka Kaczmarskiego St. 02-679 Warsaw, Poland
e-mail: dariusz.dukaczewski@igik.edu.pl, ORCID: https://orcid.org/0000-0002-9885-2257

[3]Marshal Office of the Mazowieckie Voivodship in Warsaw
26 Jagiellonska St., 03-719 Warszawa, Poland
e-mail: ejanczar@wp.pl

*Corresponding author: Dariusz Dukaczewski

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Abstract: Polish spatial data infrastructure dates back 2010, the year when the Spatial Information Infrastructure Act transposing INSPIRE Directive entered into force. The present study provides valuable insight into the current status of Polish spatial data infrastructure (PSDI) as well as lessons learnt from so far efforts in implementing the principles and provisions of the INSPIRE Directive. Particular respect is given to policy, interoperability of data as well as cooperation between actors involved in PSDI establishment and maintenance. Data managed by the Surveyor General (SG), perceived as a backbone of a spatial data infrastructure, are of special importance. Finally, some conclusions and recommendations for further developments are given to foster SDI implementation in Poland. Results of the analysis clearly show that Polish spatial data infrastructure is in line with INSPIRE, and in a half of way being fully operational.

Keywords: Polish SDI, interoperability, harmonisation, organisation and cooperation, INSPIRE

1. Introduction

Dynamic development of spatial data infrastructures at continental, national and local levels is the response to permanently growing demand for geospatial data. The idea of spatial data infrastructure (SDI) dates back to the end of 80. of 20 century. It was firstly

introduced by John McLaughlin in the paper 'Towards a national spatial data infrastructure' at the 1991 Canadian Conference on GIS and then developed by the United States National Research Council's Mapping Science Committee in the report on 'Toward a coordinated spatial data infrastructure for the nation' (Masser, 2009 p. 219). SDI is perceived as a relevant sets of policies and institutional agreements, standards, technology, as well as human resources essential to facilitate the discovery and use of geospatial information by users, and for purposes other than those it was created for (Bernard et al., 2005). It provides a foundation for geospatial data discovery, evaluation, and applications for users and data providers within all levels of administration, commercial and non-profit sectors, researchers, and all citizens (Nebert, 2001, p. 3). Due to its character, especially number of actors involves in SDI creation, new and innovative information technologies, substantial costs and big amount of data, SDI is usually government-related.

The European spatial data infrastructure was set up in May 2007, when the Directive 2007/2/EC of the European Parliament and of the Council establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) entered into force. INSPIRE first and foremost benefits politicians and public authorities at the European, national and local levels, but also improves on-line access to public spatial information for citizens. It aims at delivering readily accessible, harmonised and high quality spatial information for Community policies (e.g. environmental, agriculture, transport) and for the general public to access spatial information (Directive 2007/2/EC). The main assumption of the Directive is building SDI in Europe as the patchwork of national spatial data infrastructures that are established and operated by the Member States (Annoni and Smits, 2003). This vision of the European spatial information infrastructure underlines the need for standardization and compliance with common implementing rules. The Directive imposes on the Member States first of all to establish a coordination structure as well as adopt and implement legal measures to remove formal impediments to spatial data sharing (Graglia and Campagna, 2009). Moreover, in the initial stage countries are required to identify spatial data sets pertinent to 34 INSPIRE themes and document them in such a way that they can be accessed on the Internet together with metadata. Next, data should be harmonised in common data models and online services for spatial data discovery, visualization and download established. It is expected by the European Commission that till 2020 INSPIRE be fully operated.

Poland as the European Union country creates the national spatial data infrastructure according to the rules established by the INSPIRE Directive and agreed common implementing rules for the key components of infrastructure, i.e. metadata, interoperability of spatial data sets and services, network services, data and service sharing and monitoring and reporting. However, it is worth mentioning that the general concept of building a spatial data infrastructure in Poland was already developed at the end of the 1990s (Bielecka, 2003). The present study provides valuable insight into the current status of Polish spatial data infrastructure (PSDI) as well as lessons learnt from so far efforts in implementing the principles and provisions of the INSPIRE Directive. Particular respect is given to policy, interoperability of data as well as cooperation between

actors involved in PSDI establishment and maintenance. Data managed by the Surveyor General (SG), perceived as backbone of a spatial data infrastructure, are of special importance. The original contributions of the paper go beyond the in depth description of the Polish spatial data infrastructure and are as follows: the analysis of national spatial data regulations conformity with the INSPIRE data specifications; the investigation of the subsequent steps of data interoperability, and, finally, some key findings concerning PSDI implementation. The remainder of the article is structures as follows: section 2 describes methods and materials used, sections 3 – the main findings, that is, the current status of PSDI and lessons learnt, section 4 presents the discussion with the PSDI findings in the broader context, and the final conclusions – in section 5.

2. Methods and data

The applied research methodology is both descriptive and analytical. The descriptive approach lays down in determination, identification and description the conditions of the Polish spatial data infrastructure development and bases on documents study and the questionnaires survey. The scope of this research includes: legal, organizational, technical aspects as well as data and their users. The legal issue covers mainly the compliance with EU Regulations. The organizational aspect shows the model of PSDI organisation, cooperation practices and culture, while the technical analysis relays mainly on data harmonisation and standards. Spatial data analysis was performed only in relation to data managed by the Surveyor General.

Legal acts, research papers, technical guidelines and specifications that define the countrywide scene of spatial data infrastructure were thoroughly studied. They constitute a source of fundamental importance because they give an outline of tasks, needs, expectations of different bodies involved in PSDI development. The most valuable documents are ‘Strategy for data harmonization in Poland’ (GUGiK, 2012), ‘Programme for the construction of Infrastructure for Spatial Information’ (Rada IIP, 2016) as well as INSPIRE national reports and sets of monitoring indicators (from 2009 till 2016) (MR, 2017). Furthermore, the questionnaire survey conducted in May 2017 covered 21 geodetic and cartographic regional ans local authorities, allowed to better define those user groups which are the most active in spatial data using as well as the spatial data sets that are most often downloaded. The survey group was selected due to the fact that the majority of spatial data is collected and managed by the geodetic and cartographic administration bodies. Respondents were asked to answer three questions: (1) the total number of spatial data sets made available in 2014, 2015, 2016 and 2017 years; (2) who requested these data; and (3) which spatial data sets are most often made available? The question 2 and 3 were closed question with a multiple choice of user group (question 1) and spatial data sets (question 2).

The research, an example of the exploratory case study, aims at summarizing current achievements in the establishing of PSDI, as well as the indication of such approaches, in the form of lessons learnt, that may be useful for others, not necessarily European coun-

tries that adhere to the building of NSDI. In particular, it aims to answer the following questions:

(1) What are the lessons learnt from so far efforts and achievements in SDI implementation in Poland? Which findings have the broader character than local?
(2) Who is the main user of spatial data managed by geodetic and cartographic service (authorities) and what data are the most downloadable?
(3) What are the challenges facing the implementation of Polish spatial data infrastructure? Are they comparable with other countries building NSDI?

Finally, the authors note some strengths and weakness of PSDI that are summerised in the key findings section.

3. Review of the status of Polish spatial data infrastructure

3.1. Vision, mission, strategic goals and legal framework

Polish spatial information infrastructure extends far beyond spatial data and services and bases on the principles and implementing rules established by the INSPIRE Directive and the national legislation. Its vision is in line with the INSPIRE Directive and aspires to make harmonised, accurate, timely, and high quality spatial data readily available to support economic growth, sustainable development and social progress. The mission of PSDI intends to establish framework of the policy, standards, organisation, applications, spatial data and services that allow to (GUGiK, 2012):

– create the conditions for effective and efficient use of spatial information in the society in line with the INSPIRE Directive.
– Support e-government by delivering interoperable data and services in one infrastructure, and in one access point – geoportal.gov.pl.
– Promote the acquisition, dissemination and use of geospatial data in the public administration, business, academia and all citizens.
– Improve the quality of spatial data maintained by the public sector by delivering sets of standards, common rules, and recommendations.

The ‘Strategy for data harmonisation in Poland’ assumes that Poland will be not only information but also knowledge-based society efficiently using geospatial information. So the overall goal of PSDI is streamlining, improvement and promoting delivery and use of geospatial information, which is essential for sustainable development of Poland and its regions. The ‘Programme for the construction of Infrastructure for Spatial Information’, updated every three years gives the milestones of PSDI development in the timeframe adjusted to the INSPIRE road map (Rada IIP, 2016). The foundation and primary legal act for establishment SDI in Poland is the Spatial Information Infrastructure Act of the 4th of March 2010 (SII Act, 2010), which is transposition of the 2007/2/EC INSPIRE Directive into the Polish Law. The Act makes noticeable reference to the INSPIRE goals when it defines the overall rules for creation spatial information infrastructure and introduces legal mechanisms for achieving interoperability of spatial data, metadata, and network services. It establishes organizational structure, rules and

responsibilities for administration authorities as well as mechanism for cooperation and coordination of SDI implementation and monitoring. The SII Act admits creation of regional, local and thematic infrastructures on the condition of ensuring that they are inter-operational and in compliance with the national regulations. Moreover, the SII Act introduces same substantial changes in the Law of Geodesy and Cartography and considerable influences the spatial data sets maintained and managed by the Surveyor General. Several ministry regulations entered into force in 2011–2013, establishing among others data models for reference data (e.g. cadastral, topographic, geographic names, administration units, addresses, and geodetic control networks), national reference system, and standards for data acquisition, storage and delivery.

Due to the fact that implementation of PSDI is a complex process, spatial information issues are regulated in many legal acts and enactments. The Act on Access to Public Information creates general rules of access to information held by public bodies (or on behalf) and to use of these data in activities strictly connected with their statutory tasks. Restrictions to use data and information connected with personal data contain the Personal Data Act, fully compliant with Directive 2002/58 on privacy and electronic communications. Whereas, general policy of access to and reuse of public data, especially data exchange standards and protocols compliant with ISO and OGC (like: xml, GML, http) are introduced in the Act on the Computerization of Activities of Entities Performing Public Tasks. Policy of data sharing varies due to users groups and data themes. Environmental data are generally free available for all users, while data maintained by the Surveyor General (e.g. cadastral, topographic, ortoimages, NMT) are licensed and paid. Users have claimed that data ownership and licensing rules are a huge barrier of geoinformation sector development. Recently, Poland has put a big effort into streamlining access to spatial data, in particular, those managed by the Surveyor General (Country Fiche Poland, 2016; Surma, 2016). Since 2014, spatial data from geodetic and cartographic resources are free available for education and research. In 2017 the Ministry of Digital Affairs announced increase access to open and free data. Protection of intellectual rights including data sets and data bases is addressed in the Law on Copyright and Neighbouring Rights. Though, the issue of spatial data sets is insufficiently regulated yet. A licensing framework is addressed only to geodetic and cartographic data and has a form of standard agreement (Dukaczewski, 2015).

Lesson learnt

Generally, legislation is needed for implementing any SDI at the national level in a realistic timeframe. Legal acts should be preceded by sound investigation of users' needs, existing and forthcoming standards, best practice, cost-benefits analysis and alternative solutions. Users often claims that data sharing and licensing policy limit the reuse of spatial data. Streamlining the legislative process constitutes a big challenge in the effective implementation of SDI within a changing political scene and rapid geoinformation technology development. Strategy documents revision is necessary, based on a shared vision and values of all administration involved in spatial data.

3.2. Organizational structure

Formal organizational structure of SDI in Poland is regulated by national law, namely the SII Act. Huge diversity of spatial data providers, data sets and rules for data acquisition and delivery is a major problem of achieving interoperability, hence the SII Act introduced a hierarchical, three-level organization structure (Figure 1). Coordination at the national level is fell to the Ministry of Digital Affairs, who is responsible for all activities associated with the establishing and operating of the spatial data infrastructure in Poland and cooperates with the European Commission. The Spatial Information Infrastructure Council is a consultative and advisory body for the minister, it acts as an expert on joint implementation and use of spatial information. The second level – thematic – of PSDI coordination comprises of the twelve leading authorities, responsible for implementing the particular spatial data themes. The leading authority is the central government administrative body responsible for development of infrastructure elements for the themes assigned to it. The SII Act designates six ministers and six presidents/chiefs of central administrative bodies (Figure 2) as leading authorities. The main tasks assigned to them are coordination, cooperation, planning and assistance in achieving interoperability at the theme level.

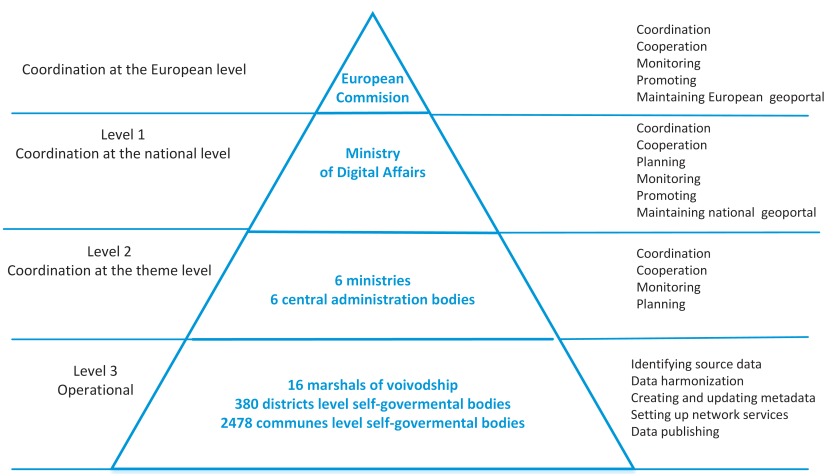

Fig. 1. Organizational structure of PSDI

The Surveyor General bears the most obligations, being responsible for the 15 themes, belonging to all Annexes of INSPIRE. Another important player in the SDI scene is the Ministry of Environment, the active leader of the data themes related to the environment. The Ministry together with the central agencies supervised (Water National Authority, Nature Conservator, Inspectorate of Environmental Protection, National Geology Institute) are responsible of 13 themes (marked in green in Figure 2).

The third level – operational – constitute local administration bodies that operate the data sets, corresponding to at least one of the themes listed in the SII Act Annexes I–III.

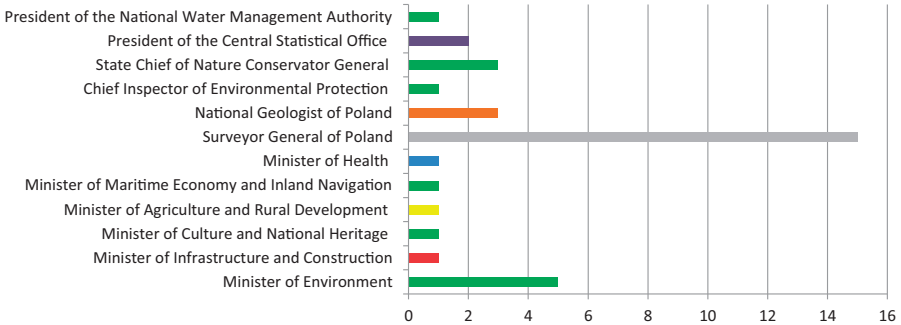

Fig. 2. Leading authorities in Polish SDI and number of INSPIRE themes assigned to them. In green – themes supported environmental policy

They are responsible for data harmonisation and publication in pertinent spatial data services. To minimise implementation costs they could create and maintain infrastructure elements, such as geoportals, metadata repository and spatial data services, together with other PSDI stakeholders. The cooperation between stakeholders' involved in establishing and maintaining SDI in Poland concerns financial, legislative, methodological, and technical issues, e.g.: common applying form founding projects, elaborating work flow of data interoperability; promoting efficient use of spatial information in decision making; common acquisition of technical resources necessary to perform data harmonisation and establishment of spatial data services. Very important role in the cooperation and coordination of PSDI has fallen to the Surveyor General and its office – the Head Office of Geodesy and Cartography, the national mapping agency. Until the January 2017 the SG was a coordinated body at the national level. Now, his role in emerging the spatial data infrastructure is still significant. The SG is responsible for the data that have the reference character, like: cadaster, topography, geographical names, administration units, ortoimagery, and elevation. It also manages the central access point to spatial data and services – geoportal.gov.pl.

Lessons learnt

However, organization structure of PSDI is hierarchical it works like matrix-managed. This is because the leading authorities implement SDI components independently (within their respective competences and only for selected data themes) and are not subordinate to the coordinator. Hence, multilateral agreements and consents rather than dependencies decide on appropriate development of PSDI. Undoubtedly, the road-map should be based on sound scientific and business practice. Poland have adapted INSPIRE road map and its straightforward goals. As a consequence the Surveyor General developed a 'Programmes for building spatial data infrastructure' in Poland for every leading body. This plan refers to all commitments made by INSPIRE and is not adjusted to the financial and technical capabilities of the government in Poland. The review of so far efforts (COM, 2016; Surma, 2016) undoubtedly states that successful implementation of SDI relay mostly on a leader knowledgeability and respectability. The Surveyor Gen-

eral and the President of SDI Council meet these requirement. They clearly articulate opportunities and threats that Polish SDI is facing. Notwithstanding their indisputable position, because of political changes, the coordination authority and the President of the Council have been changed in April 2017. One of the primary challenges for administration involved in SDI building is constant base funding. This is clearly visible in every Poland stay of play report (MR, 2017) and coordinated efforts made by different administration bodies undoubtedly contribute to greater efficiency in obtaining funds for the implementing SDI in Poland (Country Fiche Poland, 2016).

3.3. Data interoperability

INSPIRE covers data that correspond to the 34 themes listed in the three Annexes to the Directive. In Poland 11 out of 13 themes specified in Annexes I–II (without hydrography and geology) are maintained by the Surveyor General. Data sets referring to Annex III themes are maintained by many public bodies, and they are significantly fragmented and much diversified in terms of: coordinate reference systems, encodings, quality, thematic scope, attributes thematic classification, rules of portrayal. Some data sets have no documentation on data structure and content, so re-engineering investments were necessary to recover databases structure (GUGiK, 2012; Janczar, 2018). Therefore, achieving interoperability of data that belong to Annex III is extremely difficult. In contrary, data maintained by the Surveyor General and stored in the National Geodetic and Cartographic Resources (NGCRs), were harmonised recently. This harmonisation aimed at adjustment the geodetic and cartographic public resources to the INSPIRE implementing rules and finally achieve interoperability of data and services. The INSPIRE Directive defines interoperability as 'the possibility for spatial data sets to be combined, and for services to interact, without repetitive manual intervention, in such a way that the result is coherent and the added value of the data sets and services is enhanced'. This definition is also adopted in Poland, in the SII Act. INSPIRE assumes two ways of achieving interoperability: on-the-fly and off-line. On-the-fly approach relays on data transformation from the source model(s) to the target (INSPIRE) data model using transformation services. Off-line approach bases first of all on adaptation of the source data content and structure to the INSPIRE data model. Such adaptation requires often substantial changes in source data. Achieving interoperability of data is done during harmonisation defined as an adjustment of heterogeneous and inconsistent data into one cohesive data set capable to deliver consistent and unambiguous information products, in a way that is of no concern to the end-user.

Data harmonisation is the most difficult phase of INSPIRE and Polish SDI as well (COM, 2016). It comprises many different aspects, so there are many ways and approaches to deal with data heterogeneity (Rajabifard, 2010). In Poland off-line data transformation has been chosen. Large dispersion of source data, differences in data models, data quality, coordinate reference systems, as well as necessity of involvement of highly qualified experts were behind such a decision. Besides, off-line approach was suggested by the 'Strategy for data harmonisation in Poland'. The harmonisation started from data

source identification (step 1), and in depth studies of data content and structure (see Figure 3). This analysis came to the conclusion that spatial data stored in the NGCRs need substantial improvement. Hence, a set of Ministerial Regulations covered: coordinate reference system, metadata, identifiers management, positional accuracy, conceptual data models, harmonised vocabularies and data encoding entered into force in 2011–2014. The provisions of these Regulations are in line with ISO 19100 series standards and the INSPIRE methodology of designing and documenting spatial data models. The comparative analysis of the scope of the INSPIRE data themes specification and the Polish Ministerial Regulation (Table 1) shows that, data quality is still the issue insufficiently covered by Polish legislation, which constitutes a big challenge in future PSDI development. Although, some mandatory quality requirements are described in pertinent Regulation, there is a luck of comprehensive approach to data quality evaluation, control

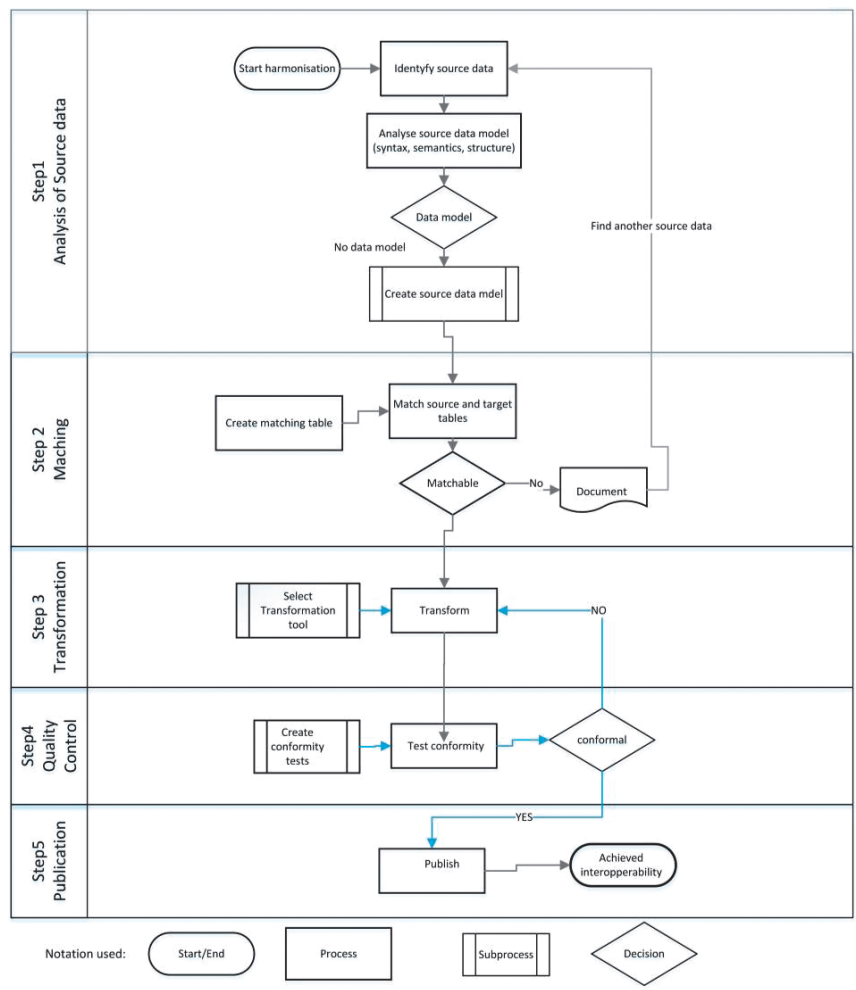

Fig. 3. Spatial data harmonisation work flow

and improvement. Abstract test suits are undoubtedly essential to allow data produces preparing high quality data.

Table 1. Compliance of Polish Ministerial Regulation with INSPIRE data themes specification

Scope of INSPIRE data themes specification	Polish Regulations	Comments
Applications schema	+[1]	UML according to ISO 19103
Identifier management	+	Follow the general INSPIRE rules
Feature catalogue	+	In line with ISO19110
Coordinate reference system	+	2-dimensional Coordinate Reference Systems, in line INSPIRE[2]
Temporal reference system	+	In line with INSPIRE
Data quality	+/−	Only positional accuracy and consistency
Metadata	+	In line with INSPIRE and ISO15115, ISO19119, ISO19139
Delivery	+	Adapted to national standards
Encodings	+	XML-based encoding
Data capture	+/−	Not compliant
Portrayal	+	Adapted to national standards
Abstract test suite	−	No abstract test suites
Use cases	−	No use cases
Code list values	+	Included in application schemata and Feature catalogues

[1] + – the issue is included in Polish Regulations, − – not included, +/− – partially included
[2] – the geodetic reference system and projection systems are standardized, documented and interconvertible

The second step of data harmonisation is schema matching and schema mapping. The most difficult is semantic matching, as any description of real object is 'always an abstraction, always partial, and always just one of many views (Portele, 2017). If matching is successful the transformation rules have to be defined, and matching executed (step 3). If not – additional data sources are necessary. Transformed data should be carefully examined against INSPIRE rules (step 4). Conformity is indispensable to guarantee quality for the load process. The process ends with publishing spatial data in network services (step 5).

Poland steady increase its effort in achieving interoperability. This is particularly well visible in numbers of documented and set on line spatial datasets (Figure 4). The higher progress has been made in 2015, when 15,430 land use spatial data comprising land use were identified. These are local data sets and in near future should be integrated as a national one.

According to Commission Staff Working Document (COM, 2016) in 2016 Poland was one of the five countries that identified and reported more than 90% of datasets (the remaining ones are: Germany, France, Italy and UK). Moreover, all identified spatial data sets are documented and published in discovery and view services. It is considered by EU Commission as a high level of maturity. The number of download services also

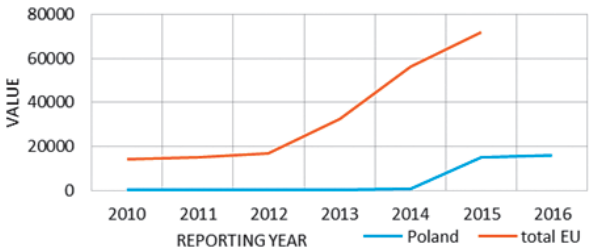

Fig. 4. Documented spatial datasets 2010–2016 (based on the monitoring indicators (MR, 2017))

increases, at the beginning of 2016 a nearly 450 spatial datasets were available in the services.

Standarisation plays particularly important role and differs considerably among leading bodies being responsible for the national source geospatial resources. Standards for application schema elaboration, concept semantics description, data coding, spatial reference system and others are implemented in spatial data maintained by the Surveyor General and the Chief National Geologist. Standards are also used in statistical and environmental data, they are in line with pertinent European regulations for statistics or environment protection and monitoring. Regrettably in spatial planning, covered the INSPIRE data theme "land use", standards are not applied, despite national regulation exists. The so far efforts to standardise this domain failure due to many reasons, including unawareness of the role of standards in data collection and delivery (Jaroszewicz and Piotrowska, 2016).

Highly qualified and very well educated experts in geoinformatics (geomatics), rather than trained technical informatics or surveyors, guarantee effective PSDI implementation. Their commitment to successful development of infrastructure is exceedingly desirable. Since the first decade of 21 century a few universities in Poland graduates in geoinformation (Werner el al., 2915, Mościcka and Zwirowicz-Rutkowska, 2016), which undoubtedly diminish the problem of well-educated staff.

Lessons learnt

Complexity of data interoperability is tremendous. This is stressed not only by Poland but also by many EU countries (Surma 2006; COM, 2016). Much thought should be given to elaborating and adopting standards, employment highly qualified expert and delivery software and applications for data storing, management and publication. Necessity of adaptation to constantly evolving IT technology is and always will be a big challenge. Interoperability with INSPIRE guarantee the application of common standards and implementing rules. Regulations, guidelines, and technical specifications, usually based on international ISO 19100 (Geographic Information) standards ensure the conceptual and formal consistency of harmonised data sets. The focus on collaboration to develop and improve national standards in accordance with international standards should be of highest attention of all administration bodies. Technical interoperability is of utmost

importance, otherwise it is almost impossible to interconnect many systems that were developed by different organisation for different purpose. However, technical interoperability allows only data exchange. Information exchange requires harmonisation of existing data, where the key issue are agreed concept definitions, application schema, and coordinate reference system. The data maintained by the Surveyor General have been already harmonised, which resulted in increased data usage by scientific community, public administration and commercial sector (Janczar, 2018). Providing data of appropriate quality is another challenge of PSDI. In general pertinent regulations concerning data quality exist (Bielecka, 2015), but the quality control is ineffective, mainly due to its non-automatic character. Hence, it is necessary to elaborate quality strategy dealing with quality problems at every step of data delivery, processing and publication.

3.4. Spatial data sets and data users

The geodetic and cartographic authorities provide access to eleven spatial databases, eight of them are mentioned in Table 2 (column Source data). The remaining are: fundamental and detailed geodetic network points, register of infrastructure utilities, and register of value and prices of real estate. The geodetic and cartographic data are of utmost importance for many user groups, especially: public administration, land surveyors, commercial sector, universities, research institutes, schools, non-governmental organization.

Table 2. INSPIRE themes assigned to the SG, the source data sets and responsible administration body

INSPIRE data Theme	Source data	Administration Body
Coordinate reference systems	ASG-EUPOS	Surveyor General
Geographical grid systems	No data	Surveyor General
Addresses	Register of Cities, Streets, Addresses	Commune administration
Cadastral parcels	Cadastral data	District administration
Geographical names	Register of Geographical Names	Surveyor General
Administrative units	Register of Territorial Division Units	Surveyor General
Transport networks	Topographic Object Database	Surveyor General
Elevation	Digital Terrain Model	Surveyor General
Otoimagery	Ortophotomap (0.5 m pixel)	Surveyor General
Land cover	Topographic Object Database	Surveyor General
Buildings	Cadastral data; Topographic Object Database	Surveyor General, Districts
Soil	Soil-Agricultural Maps	District administration
Production and industrial facilities	Topographic Object Database	Surveyor General, Districts
Utility and governmental services	Topographic Object Database	Surveyor General, Districts

The survey shows that the total number of spatial data sets requests from NGCRs in 2014–2017 was nearly 440 thousands. Land surveyors (58.6% of total requests num-

ber), public administration (23.6%), commercial sector (23.1%) and academia community (13.3%) are these user groups that are highly involved in spatial data using, as is presented in Figure 5a. Since 2014 most of spatial data sets, stored in NGCRs, are already interoperable and widely available. It should be emphasized that the data are free of charge for research and education as well as for administration bodies of all levels. These had led to very high interest in the spatial data sets by scientific community and public bodies in 2014 and consequently less attentiveness in the following years (2015–2017).

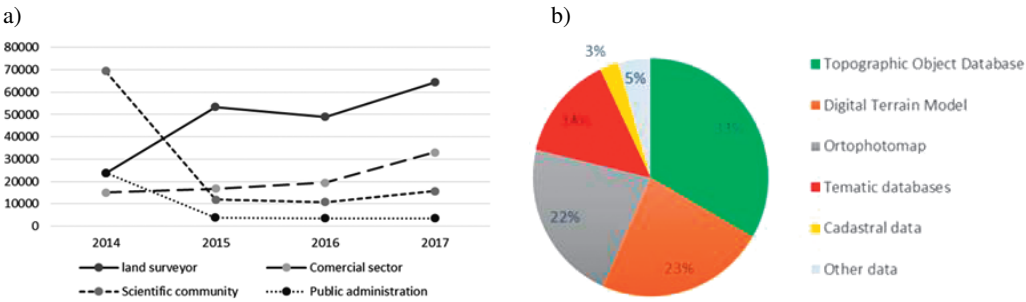

Fig. 5. a) Number of data requested from the NGCRs (based on the conducted survey); b) The exploitation of National Geodetic and Cartographic spatial dataset by governmental administration

The most frequently used spatial data set are cadastral and topographic data. Local administrations bodies generally use land information data, like cadaster and Register of Cities, Streets (Izdebski, 2017) while, governmental administration uses more diversified spatial data sources. One third consitute topographic data derived from Topographic Objects Database, a seamless, vector database with the level of detail corresponding to maps at a scale of 1:10,000. At the same time, this database is the source data for the five INSPIRE data themes of which one belongs to the Annex I (Transport networks), two – to Annex II (Land Cover, Buildings) and two – to Annex III (Production and industrial facilities, Utility and governmental services). Elevation data and ortoimageries are still important for governmental bodies (Arozarena et al., 2016; Klein and Müller, 2012). In Poland they constitute about 22–23% of all spatial data requested by public administration (see Figure 5b). Data listed in Figure 5b support decision-making by public administrations in spatial planning and land management (Dukaczewski, 2016; Janczar, 2018), forest administration, real estate management (Calka and Bielecka, 2016), logistics (Moscicka et al., 2016), cultural heritage protection (Moscicka, 2015).

4. Key findings and discussion

Some findings are of utmost importance not only in the development of SDI in Poland but also in other counties or organisations. They are: strategy and road-map, organisational model and culture, cooperation and partnerships, technical competency, standarisation, investments and funding, as well as workforce competence. Partnership with all admin-

istration bodies involved in spatial data is crucial and allows to share cost and access to data that would not be otherwise available. The organisational culture and leadership highly influence the way the strategic goals and milestones are achieved and undoubtedly influence the successful SDI implementation. Nevertheless, of the coordinating mechanism, clarity over who does what is necessary when many administrative bodies are involved. Spatial data infrastructure in Poland, but also in other countries, have to be developed with the future in mind. That is why investments in evolving geoinformation technology, skilled and knowledgeable experts as well as continuous founding are extremely important. The open access to spatial data is strongly expected by commercial sectors, as it facilitate building national geospatial competence and provides value added in future. Using spatial data by public administration in decision making is not satisfying yet.

Before the INSPIRE Directive entered into force the Polish scene of spatial information was much diversified. Spatial data collected by public administration were strongly fragmented, of diversified and unknown quality, stored in different coordinate reference systems. Access to these data was often unidentified. Poland was not an isolated country facing difficulties in access and reuse of spatial data. These problems are profoundly described in the literature (Ryan et al., 2004; Kok and Van Loenen, 2005; Masser, 2009; Klein and Müller, 2012). Building a SDI requires parallel actions, including: policy, legislation, organizational issues, as well as semantic and technical aspects of interoperability. Poland implements the INSPIRE Directive in separate Act, like many European countries (e.g. Bulgaria, Croatia, the Czech Republic, Italy, Portugal, Slovenia, Sweden). In parallel, a few amendments to selected law were made, e.g. to the Geodesy and Cartography Act. These allow for substantial changes in spatial resources maintained by the Surveyor General.

The development of PSDI is a stepwise approach. Starting from establishment of the hierarchical three-level organization structure, identifications of source resources, establishment of rules for data integration, and then performing transformation and publishing spatial data sets. Such a way of achieving interoperability is suggested by Report EUR 25280 (Toth et al., 2012), and implemented by the Member States (Vandenbroucke et al., 2013).

More efforts are made to achieve data interoperability, which could be encapsulated in three words: collect, harmonise and share. Hence, the concern for interoperability in the European SDI goes beyond conversion between different data formats. As stated by Annoni and Smits (2003) as well as Bernard and Craglia (2005) the need for harmonised data is a fundamental issue in the spatial infrastructure in Europe and the Member States. Undoubtedly, heterogeneities related to conceptual schemas are the most important and the most difficult (Friis-Christensen et al., 2007; Moeller, 2010). It comprises issues related to: syntax (diversified data formats), structure (differences in conceptual schemas), and semantics (differences in content definitions). The syntax heterogeneity could be dealt using ISO and Open Geospatial Consortium standards like Web Feature Service (WFS). Structure of data sets could be adjusted by many software and applications, some of them available on open source licenses (Wlodarczyk-Sielicka and Stateczny,

2016; Fichtinger et al., 2011). Semantic harmonisation needs adjustment (or changing) of objects and attributes definition, leading to a profound change in the source registers. In such cases, the off-line transformation is always recommended (Craglia and Campagana, 2009; Klein and Müller, 2012). Poland made a big effort to harmonised national spatial data managed by the SG. They are modernized in such a way that harmonisation with INSPIRE implementing rules is possible without manual intervention. This can be perceived as a good practice in the Polish geoinformation scene. Still, the biggest challenge of Polish SDI is achieving interoperability between all sectors, stakeholder and themes. Consistency of data referring to the same location presented in the different scales remains unsolved, yet. This is a threat not only of Polish SDI but also in other Member States (COM, 2016).

Despite the great effort put in regulating the geoinformation scene in Poland, the establishment of appropriate inter-institutional arrangement, legal and social mechanisms that facilitate data interoperability are still a major threat to the effective further development of SDI in Poland. Key challenges for SDIs defined by (Moeller, 2010) such as: incorporating new technologies, dealing with differing quality of data, expand Infrastructure into business, as well as putting in place financing and governance mechanisms that will promote and sustain SDIs over time are also of utmost importance in Poland.

5. Conclusion

Polish SDI is established according to INSPIRE rules and national needs. The goals and mission of the Infrastructure are written in the 'Strategy for data harmonisation'. This document, however, should be renewed, and its adaptation for technology development, digital maturity as well as local drivers for national social and economic development is necessary. SDI in Poland is relating to more than one branch of knowledge. It covers broad thematic content, involves all levels administration bodies, which collaborate with each other. So, it constitutes the interdisciplinary, inter-sectoral and multi thematic project. As PSDIs is complex and dynamic, it requires constant interaction among parties involved in order to be effective.

In general, spatial data sets exist and provide a basis for coverage of the INSPIRE data themes and components. Much of the spatial data is held by public administration, both governmental and self-governmental, in which data collected and maintained by the Surveyor General play considerably role. The quality issue still remains insufficiently covered. There is a documented data quality control procedure but applied only for selected data sets and quality elements. The challenge to better reuse of spatial data depends mainly on awareness and GIS skills of public administration. On the other hand wider use of spatial data by the private sector and citizens depends on data availability via spatial services and data charges. That is why moving from paid data to free and open data of the infrastructure is considered as a big challenge for future development of PSDI. The SDI envisioned by Poland is still under construction, and as such is evolving according to financial, political, and technical issues. As seen by the EU Commission

PSDI is in half a way of being fully operational and in the line with INSPIRE. This is generally viewed as a positive challenge.

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