Assessing the address data harmonisation process and interoperability in European Union

MSc Thesis final version

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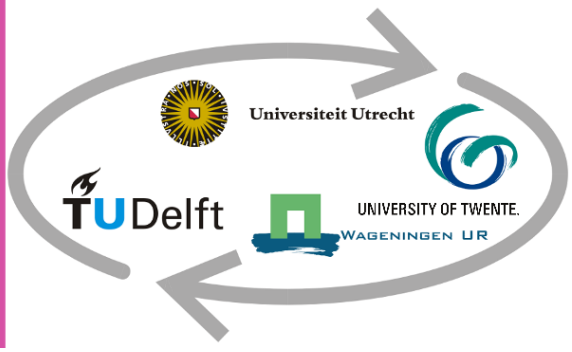

Acknowledgements

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Abstract

Addresses are used every day. They are used when sending a letter, finding a new restaurant, or locating a person to rescue. They serve as one of the basic facilitators of communication between people, public service institutions, and businesses. Each country maintains their addresses by following their own standards, using country specific data models, and formatting and maintaining their own identifiers. This makes the data heterogeneous, and it is therefore difficult to exchange and re-use address data. Technical, like schematic, syntactic, or non-technical, like organizational, legal, social, and semantic, problems might occur. The European Union (EU) has the INSPIRE initiative to order member states to harmonise address data. Within INSPIRE it is made legally-binding that member states have to make address data interoperable via web services. There is neither an overview of address data systems in the EU, nor knowledge on how is address harmonization process moving towards. By filling these gaps, the overall objectives of this research are to assess the progress of address data harmonisation in the EU and to investigate if and to what extent current systems are in line with INSPIRE. The following research questions are answered: **How are addresses in all EU member states managed, accessed and supported by tools and services? How has the compliance with INSPIRE technical requirements of address systems developed between 2014 and 2017? To what extent are the address systems interoperable in non-technical aspects in 2016?**

By using different characteristics, the addresses in the EU were described. To find the characteristics' values, various written materials, reports and presentations were used, as well as intensive Internet searches are used. The research focused on technical and non-technical aspects of interoperability. Technical compliancy was tested by using a tool called SoapUI and a framework which had been developed during the European Spatial Data Infrastructure with a Best Practice Network (ESDIN) project. A web survey was used to find out to what extent address systems are in line with the INSPIRE requirements with regard to non-technical aspects.

During this research, 28 European Union member states were described. Twenty-five different address dataset were characterised. Analysis revealed that European address systems are heterogeneous. They have different data owners, managers, responsible bodies, content information, formats, access policies, tools and services. The variation between countries is remarkable. This means that harmonisation is needed to make addresses in the EU interoperable.

Fortunately address systems in EU are moving towards better harmonization. The compliance with INSPIRE technical requirements of address system between 2014 and 2017 has been positive from all angles. Address datasets and their metadata are more compliant. Countries have made more web services available, which have had positive impact on access to address data. All web services have become more compliant with INSPIRE technical specifications. Countries, who have added completely new services, fail less technical compliancy checks, then services that existed already 2 years ago.

Despite of positive progress there is still work to do. While some countries are quite organised, then other countries do not have an official address data system. The results of this research show that there is a list of technical issues, which still need to be resolved and harmonised, but the larger gaps

are in licensing, legal issues, and organizational management. INSPIRE helps mainly to overcome technical interoperability issues, but there should be more attention and support for legal and organizational issues.

Results of this research should be useful for address data practitioners across the EU. It will give insight into the situation in other countries. For the academic world, the importance is in a developed methodology, which could be used to research other INSPIRE themes. Furthermore, overview of address harmonization progress has, to the best of researcher knowledge, not been done before.

Table of Contents

Abbreviations

API	Application Programming Interface
ARE3NA	A Reusable INSPIRE Reference Platform
CC BY 4.0	The Creative Commons Attribution 4.0 International
CEC	Commission of the European Communities
CSW	Catalogue Service Web
DIS	Draft International Standard
EC	European Commission
EFTA	European Free Trade Association
EIF	European Interoperability Framework
ELF	European Location Framework
ELISE	European Location Interoperability Solutions for e-Government
ESDIN	European Spatial Data Infrastructure with a Best Practice Network
ETF	ESDIN Test Framework
EU	European Union
EULF	European Union Location Framework
EURADIN	European Addresses Infrastructure
GIS	Geographic Information System
GML	Geography Markup Language
GPS	Global Positioning System
ICT	Information and Communication Technology
INSPIRE	Infrastructure for Spatial Information in the European Community
IPR	Intellectual Property Rights
ISA	Interoperability Solutions for European Public Administrations
ISO	International Organization for Standardization
JRC	Joint Research Centre
NMCA	National Mapping and Cadastral Authority
OASIS	Organization for the Advancement of Structured Information Standards
OGC	The Open Geospatial Consortium
PSI	Public Sector Information
SDI	Spatial Data Infrastructure
UPU	Universal Postal Union
UN	United Nations
VGI	Volunteered Geographic Information
WFS	Web Feature Service
WMS	Web Map Service
XML	Extensible Markup Language

1 Introduction

The introduction is divided into two parts. In the first part, the general background of addressing is introduced. In the introduction, a list of fields and areas is given, where addresses are used. The introduction also includes a description of problems that occur in addressing systems and ways to solve them. Subsequently, number of positive outcomes of address harmonisation are explained. The second part concludes the main objectives of this study and research questions.

1.1 Addresses around us

Addresses are used every day. They are used when sending a letter, finding a new restaurant or locating a person to rescue. Addresses have a special place in society's infrastructure. They serve as one of the basic facilitators of communication between people, public service institutions and businesses. Addresses are used in an numerous fields (Figure 1): cartography, cadastre, postal services, health and risk management, rescue services, navigation tools, transportation and logistics, emergency situations management, telecommunications and tourism (European Commission, 2010b). Address data are a central component in GIS products and services (Lind, 2000) and are used in numerous IT applications by the public and private sector. It is generally believed that addresses are part of as many as 80% of the digital solutions which a modern society makes use of (Denmarks Adresser, 2015).

Figure 1. Use of addresses (BEV, 2015; Colas et al., 2013; European Commission, 2010b)

Numerous objects have addresses. Usually land parcels and buildings (including flats and apartments) have addresses, but in some countries street furniture, water pumping stations, mooring places, car parks and agricultural barns also have addresses. Addresses are critical for services that are not necessarily performed at the address, such as for rates and taxes, opening bank accounts, buying on credit, obtaining a passport, voting and obtaining employment (Coetzee & Cooper, 2007). In urban planning and decision making, it is important to know where people live and go to work, and where factories and businesses are located. Addresses are in thousands of registers and databases. They are key elements for the governments, as addresses are often included in Population Registers, Health Insurance Registers, Vehicle Registers, Business Registers and Building Registers.

Address data has a special place in the spatial data infrastructure (SDI) as reference data. Address data fulfils requirements by: providing an unambiguous location for an user's information; enabling the merging of data from various sources and providing context to allow others to better understand the information that is being presented. It means that address data can be used as reference data to link different information systems together in order to transform billions of text-based records into spatial information (Lind, 2003). In practice, problems often arise by linking datasets and exchanging data as address data are expressed differently. If addresses are text-based, then misspellings might affect the exchange. For an information system it would be problematic to link together addresses. In Table 1 all rows are referring to the same address, but the text is different; therefore, computer algorithms and perhaps humans as well, could not identify them as the same address.

Table 1. Address example from Poland (Brzezińska, 2014)

Street name	Address number	Town name
Stefana Batorego	50C	Kędzierzyn – Koźle
Batorego Stefana	50 C	Kędzierzyn Koźle
Batorego	50c	Kedzierzyn- Kozle
S. Batorego		Kędzierzyn –Koźle
St. Batorego		Kędzierzyn – Koźle
Batorego S.		
Batorego St.		

From time to time municipalities (re)name streets, houses, plots, and reorganise the numbering. After those changes, it is important that new addresses reach everyone. For businesses, it is important that clients can find them, therefore countries have invested time and money to develop tools and services to keep address data up-to-date. Often it might be problematic for different information systems to communicate with each other, because of a lack of common identifiers, data models and formats. Estonia has developed a tool to overcome those difficulties by using web Application Programming Interface (API) named "In-ADS". It can be used in web-based information systems to harvest up-to-date address data in machine-readable JSON format, which includes unique identifiers of addresses. Later on, by using those identifiers, up-to-date addresses can be imported in XML format to various information systems via X-Road. In Estonia and other countries as well,

information systems exchange address updates using unique identifiers, but between countries, those identifiers are not in line.

Wrong or not updated addresses can lead to numerous problems. It can even cause demolition of a wrong house. One house in Texas house was torn down by mistake, and the demolition company blamed Google Maps (Figure 2). It was not the first case this has happened and it not even the first time in Texas (Lawler, 2016). This case shows how important addresses are, and how essential a well-maintained and up-to-date address system is.

Figure 2. Article in Engadget

Several issues in addressing stem from the fact, that address standards and systems are different in each country. Addresses vary from country to country because they are closely associated with geographical location, culture, race, religion, and language (Coetzee et al., 2010). They can vary from street-based addressing to numbered houses in a neighbourhood. Official addresses of some countries include an apartment number, a number of the floor and the entrance; others are limited to only the house number and street. Addresses can be owned and managed by private parties, the public sector, or both. Data models and maturity of the address systems between countries sometimes differ significantly. While some countries give full access to address data without any fees, others offer data according to a price list. Countries manage their addresses according to their own standards. Often there are different address standards even within the same country.

In the EU, thanks to an open job and business market, mobility is made easy. This also affects address management and increases the need for a common address framework. Citizens can easily switch countries and conduct business across borders, which might lead to a need to record foreign addresses in national databases or manage international clients' addresses in one database. This openness must be supported by cross-border public services. Cross-border cooperation of addresses is also needed in environmental planning and in cross-border emergency services, disaster management and fire protection management. Unfortunately, address services are heterogeneous across EU member states because of different legislations, a lack of common standards and multilingual challenges. These issues might complicate the exchange of data and lead to semantic interoperability conflicts.

Harmonised data could help to exchange information seamlessly and make it interoperable. Data harmonisation is a process of modifying semantics and data structure to facilitate compliance with

agreements (specifications, standards or legal acts) across borders and/or user communities (INSPIRE Drafting Team Data Specifications, 2007). Data harmonisation aims to create the possibility to combine data from heterogeneous sources into integrated, consistent and unambiguous information products (THESEUS, 2013). Common standards and frameworks could help in data harmonisation.

Until now, several countries (e.g. South Africa, Australia, UK, Denmark, etc) and organizations (ISO, OASIS) have been developing their own standards. According to Coetzee et al. (2008) address systems are mature enough to create an international address standard. Nevertheless it has to be mentioned that addressing cannot be fully standardised because addresses have a strong cultural association. Additionally, addressing is governed by the laws of a particular country (Coetzee, 2010). Still there are benefits of having an international address standard, such as, making addresses understandable for different users, facilitating interoperability, and promoting reusability. Developing countries could build their address systems according to this standard.

The EU is making steps towards interoperable and harmonised address data as part of the Infrastructure for Spatial Information in Europe (INSPIRE) directive. Lind (2003) states that an address system is a core component in spatial infrastructures therefore addresses are also part of INSPIRE Directive Annex I. INSPIRE offers a framework on how to share address data among EU countries. INSPIRE aims to create an EU spatial data infrastructure and ease public access to spatial information. Common principles of INSPIRE are: to combine spatial information seamlessly across Europe and share it with many users and applications; to collect data once at one level and share with all levels (European Commission, 2015); and to make spatial information compatible and interoperable. Within INSPIRE, an address data specification has been created which suggests common approaches to address data. To ease interoperability, INSPIRE technical guidelines have been developed which give suggestions on how directives could be fulfilled. These guidelines apply to all themes, including addresses.

A successful implementation of European address infrastructure would have a great positive impact on EU. European countries need more harmonised addresses to integrate their economies. Interoperability would improve public service delivery to citizens and businesses by facilitating the one-stop-shop delivery of public services and would lower costs for public administrations, businesses and citizens due to the efficient delivery of public services (European Commission, 2010a). In the EU potential benefit of delivering point addresses to the European market, taking into account social and economic benefits, is estimated overall in a total of about 63 million euros worth of improved efficiency every year, including 43 million on possible cost savings and 20 million on new possible opportunities (EURADIN, 2010a). The benefit would come from less unnecessary duplicated efforts, faster response times, the saving of life and property, more tax collected, and intangible socio-economic benefits affecting the welfare of the state. EURADIN (2010c) envisioned how it should be in 2020: When a person changes addresses he/she just needs to communicate it once, and his/her new address is updated in all databases where he/she has provided this information before (e.g. health services, Town Hall, bank, etc.). For this vision to become a reality European Union countries have to cooperate and invest their time and money into the European address infrastructure.

1.2 Research problems, objectives and questions

Addresses were chosen as a theme because they are important and are heavily used. Countries follow their own standards, use country specific data models and formats, and maintain their own identifiers. Therefore it is difficult to exchange and re-use address data. A lot of work and effort has been put into harmonizing address data: lists of projects have been made, numerous participants have been involved, and voluminous documentation and specification has been created. The European Union has the INSPIRE initiative to order member states to harmonise address data. Within INSPIRE it is made legally binding that member states have to make address data interoperable via web services. In the past ten years, member states have been working on it and their efforts were projected to be completed by 2012. Addresses were the most popular subject during Annex I testing period with 25 reports (JRC INSPIRE Data Specifications Team, 2011). This indicates again how important addresses are.

This research will focus on the following gaps that currently exist in the EU address context for INSPIRE. Firstly, there is no up-to-date overview of addressing which describes the situation in all EU member states. In previous EU projects, only a number of EU member states have been involved. This indicates that the status of address data in the EU needs research. An overview could assist further research in addressing and could ease cooperation between countries. It can help to spot weaker countries and can encourage more successful countries to help with their expertise.

Secondly, there is no overview that describes the compatibility of address data in the EU. Academic research investigating, if and how addresses are in line with INSPIRE specifications, was not found. Researchers have studied interoperability of other data domains (e.g. land-use, natural hazard and air quality) and their accordance with INSPIRE specifications, but not addresses. INSPIRE collects different types of reports, which focus on all data themes and general information. These reports are produced by countries themselves. No overview specifically for address theme nor address data harmonisation progress in the EU was found. This overview of address systems can also give insight into the sustainability and success of INSPIRE.

By taking into account all of the above, the following questions arise: How are addresses systems managed in the EU? How far is the implementation process of the INSPIRE? How fast is the harmonization process? How successful have member states been in fulfilling the INSPIRE requirements? Have all member states made their address data available through services? Are these services in line with INSPIRE specifications?

The overall objective of this research is to assess the progress of address data harmonisation in the EU and to investigate if and how the current systems are in line with INSPIRE. This thesis focuses on all INSPIRE requirements, including those, which are not legally-binding. The focus is only on addresses, because the aim is to investigate addresses profoundly and in detail.

Research questions

1. How are addresses in all EU member states managed, accessed and supported by tools and services?

2. How has the compliance with INSPIRE technical requirements of address systems developed between 2014 and 2017?

3. To what extent are the address systems interoperable in non-technical aspects in 2016?

This thesis is divided into six chapters. The first chapter introduces this topic. The second chapter presents literature review. The third chapter explains which methods and tools were used during this study. In addition reasoning of chosen methods is presented. Subsequently, the fourth chapter contains results and collected data. This is followed by discussion and reflection on the research process, methods and findings. The last chapter contains conclusions of the thesis and recommendations for further research.

2 Literature review

In the previous chapter, an introduction to this research was given and research questions were presented. This chapter gives an overview of the address theme in existing literature. Firstly, addresses as a concept are described, explaining what it consists of and its importance. The second section describes European Union projects related to addresses and this research. Subsequently, interoperability issues and problems are presented. This is followed by an introduction to standards, which are used to harmonise address data and overcome interoperability problems.

2.1 Addresses

The term "address" is used in everyday life. Dictionaries and encyclopaedias have described addresses as *"A description of the location of a property"* (Wiktionary, 2015, July 24) or, in more detail *"the place or the name of the place where a person, organization, or the like is located or may be reached"* (Dictionary.com, 2015). Another group of descriptions refer to the structure of an address as *"the conventional form by which the location of a building is described"* (Dictionary.com, 2015). Institutions handling and working on addresses have also defined addresses for themselves. The INSPIRE Directive defines the spatial data theme *Addresses* as the *"Location of properties based on address identifiers, usually by road name, house number, postal code"* (CEC, 2007). The INSPIRE address specification goes into more detail: *“An identification of the fixed location of a property, e.g. plot of land, building, part of building, way of access or other construction, by means of a structured composition of geographic names and identifiers”* (INSPIRE Thematic Working Group Addresses, 2014). All these definitions have the term "location" in common; they refer to a location in space, which demonstrates that addresses are spatial data.

As also mentioned in the INSPIRE definition, addresses are structured, and often an address consists of a number of hierarchical components and identifiers. These are important for identifying addresses unambiguously and to define their locations within a specific geographic area. These components might be a set of names, such as country, region, town, district, street name, and house number. According to INSPIRE, five subclasses of address components are defined: administrative unit name, address area name, thoroughfare name, address locator, and postal descriptor.

Normally, addresses consist of a network of named streets and ordered house numbers. House numbers are important to distinguishing one location from neighbouring addresses. It can be a systematic designator, such a number or a name. Addresses can have other locators, such as an entrance number or flat number. In addition, an address often has a unique identifier, possibly an alternative identifier, a status attribute, and a number of life cycle attributes. Two types of temporal life-cycle information can be included: 1) the content specific life–cycle information describing the real world address (i.e. when this version of the real world address is valid); and 2) the temporal information on the changes in the database or spatial dataset (i.e. when the item was inserted, superseded, or retired). In addition, nowadays, address data information systems contain addresses along with their geographic coordinates.

There are three types of reference systems that are used to identify any location on the surface of the Earth: coordinate reference systems, linear reference systems and geographic identifier reference systems. According to Coetzee et al. (2008), addressing could fall into all three types of reference systems, or can be considered to be a fourth type of reference system because there are many-to-many relationships between an address and what is being addressed. Addressing is a geographic identifier reference system because address components refer to locations. Addressing can be a linear reference system if address numbers are assigned according to the distance. Addressing can even be a coordinate reference system. For example, in South Africa, addresses in remote rural areas are captured as "dots" either with GPS devices or from aerial photography. Each of these dots represents an address. According to Lind (2003), address systems are separated from other name-based reference systems by a number of characteristics:

- It is well-known and widespread – the most common format to change information on a geographic location;
- It is practical and it is simple to understand the structure, which consists of a street name and house number, and it is therefore easy to find your destination;
- It is visible with posted street and house number signs.

Addresses can be a part of information systems or have an entirely separate system. In Denmark (Figure 3), each address has a unique identifier based on municipality, street, house, floor, and door number. The Danish experience shows that common data formats do not give a sufficient guarantee of consistency between different registers. The problem lies in the conceptual data model: if address-identifiers should be an attribute or should be an entity itself. In Denmark, the experience has shown that an attribute approach will result with a slightly different definition of an address in each system. Therefore, a shift from an attribute approach to an entity approach is common, which means separate public address registers are developed.

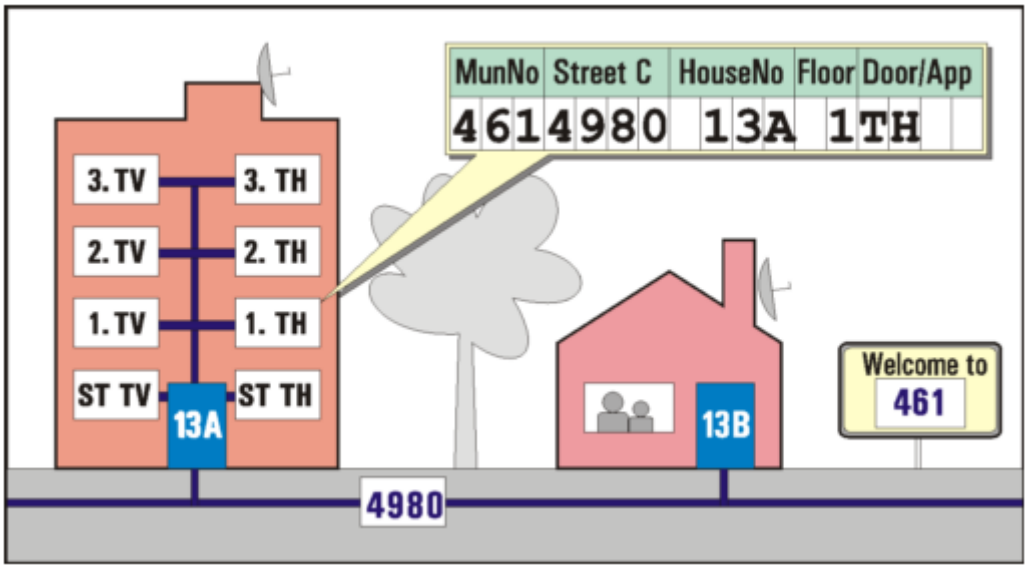

Figure 3. Unique address identifier components in Denmark (Lind, 2003)

2.2 EU projects

2.2.1 INSPIRE

As addresses are usually maintained by public organizations, they are often part of an SDI. From the beginning of the 1990s, Spatial Data Infrastructures (SDIs) have been a concept and have been primarily used in the public sector. The aim of SDIs is to facilitate a framework which enables to discovery, sharing and use of spatial data among different user communities. Rajabifard et al. (2002) focused on five components of SDIs: people, data, access network, policies, and standards. In the context of this research, data is addresses, policies are INSPIRE Directives, and standards are OGC (The Open Geospatial Consortium) and ISO (International Organization for Standardization).

Collecting spatial data, including addresses, is expensive and time-consuming, and therefore it is attractive to reuse the same data several times in different applications (Aalders & Moellering, 2001). This is also what the SDIs try to stimulate, to “collect once, use many times”. As for data-storage Rajabifard et al. (2002) presents a hierarchy structure where data is stored and maintained at the nearest level of the source in many cases, the municipality. Next, this data is aggregated to a higher level the province, by means of searching for metadata and harvesting the data. Theoretically, this process can continue until the data is available in a global SDI. In the case of addresses this structure should be followed as well.

In the European Union, there is also an initiative to establish an SDI. In 2007, European Parliament and Council announced a directive which aims to establish an Infrastructure for Spatial Information in the European Community (INSPIRE) for environmental policies, or policies and activities that have an impact on the environment. INSPIRE will make relevant, harmonised, and high-quality geographic information available to support the formulation, implementation, monitoring and evaluation of policies and activities, which has a direct or indirect impact on the environment. INSPIRE is based on the infrastructures for spatial information established and operated by the 28 member states of the European Union. Based on the deadlines, INSPIRE will be fully implemented by 2021, and Annex I should be fully implemented by 2017 (Figure 4). The Directive includes 34 spatial data themes needed for environmental applications. Data themes are divided into three Annexes. Annex I contains the priority spatial references datasets, which also includes Addresses.

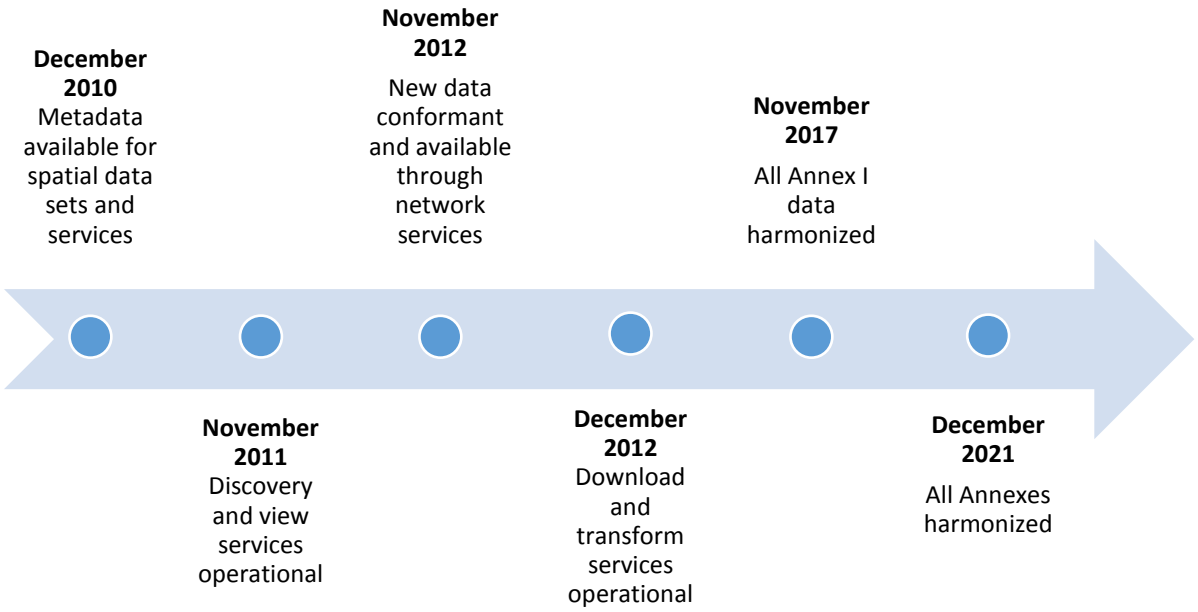

Figure 4. INSPIRE Implementation Roadmap for Annex I (INSPIRE, 2015)

To ensure that spatial data is compatible and usable among member states, a list of documentation is created. Some are legally-binding and some are not. Member states must implement the INSPIRE Directive and INSPIRE Implementing Rules. In addition to the Implementing Rules, Technical Guidance and Data Specifications define how Member States might implement the requirements and are not legally-binding. Technical Guidance documents describe detailed implementation aspects and relations with existing standards, technologies, and practices. Data, including Addresses, are made interoperable by changing (harmonizing) and storing existing datasets or transforming them via services for publication.

There is a specification for addresses as well. Address data specification gives the basis for the development of the part of Implementing Rules related to the spatial data theme of Addresses. It aims to provide a general structure, so it becomes possible to exchange addresses in the EU. Specifications are prepared by the Thematic Working Group on Addresses, which consist of international experts from different parts of the European Union. Data specification does not require additional data capture by member states and is designed to minimise the effort required to supply conformant spatial data.

In the INSPIRE Directive, it is recommended to harmonise the data and distribute it by a central node in each member state. At the same time, authorities should remain in charge of managing and updating the data which they are responsible for. This recommendation should be followed for addressing as well. The aim of the central node is to make sure that the data coming from the member states is not duplicated. Next to the European level, the central node is also the contact point for the local and regional levels. Distribution should be flexible enough for both the public and private sectors. In some countries, the central node can be a node of centralised information, and in others, the node can be established as a network of distributed services.

2.2.2 EURADIN

The project EURADIN (EURopean ADdresses INfrastructure) in 2008-2010 was aimed at constituting a Best Practice Network in order to promote the European Addresses harmonisation regarding the definition, registration, and access to the European Addresses Data and aimed to propose a solution to achieve address data interoperability (EURADIN, 2010a). The EURADIN project had a close cooperation with INSPIRE. The EURADIN outputs were used to develop newer versions of the INSPIRE Address specifications.

The EURADIN project consisted of eight Work Packages, which covered topics such as: Analysis of the current situation in Europe regarding Addresses; Data Model on Addresses; Metadata; Address data flow; Business Models; and developing a European Gazetteer. A survey among 41 EU partners was carried out. Thirty-nine address systems were described. Address systems in different levels were included: national, regional, and local. The survey included questions about General parameters, Data, Metadata, Data flow, Business models and users' requirements.

2.2.3 ESDIN

ESDIN (European Spatial Data Infrastructure with a Best Practice Network) was an eContentplus sister project of EURADIN. It lasted from 2008 to 2011. Its aim was to help prepare the data of Member States, candidate countries, and EFTA States for INSPIRE Annex I themes (ESDIN, 2011). Results of the project contained practical guidance and best practices to such processes as transformation, generalisation, and edge-matching. ESDIN developed a Test Framework (ETF), which enables it to test web services (WMS, WFS, ATOM) and checks, if they are in line with INSPIRE Technical specifications. In this research, the Testing Framework developed by ESDIN is used.

2.2.4 ELF

The follow-up project of ESDIN is a European Location Framework (ELF) with a duration of 2013-2016. The goal of ELF project was to provide up-to-date, authoritative, interoperable, cross-border geo-information for use by the European public and private sectors. It helped to supply a platform of INSPIRE compliant geo-information, harmonised at a cross-border and pan-European level. One of the focuses of the ELF project was addresses (European Location Framework, 2016a).

During this project a survey was carried out regarding core reference data and 12 data themes, including addresses. The survey is still ongoing, and preliminary results on addresses are based on 22 National Mapping and Cadastral Authorities (NMCAs) from 18 different countries. Records about address data were collected during 2014-2015, and some were amended in 2016. NMCAs filled following questions in Excel:

- Country;
- NMCA Data theme;
- ELF Regional (Answers: Yes, Partly (non NMCA), Third party (non NMCA));
- ELF Master LoD2 (Answers: Yes, Partly (non NMCA), Third party (non NMCA));

- ELF Master LoD1 (Answers: Yes, Partly (non NMCA), Third party (non NMCA));
- ELF Master LoD0 (Answers: Yes, Partly (non NMCA), Third party (non NMCA));
- Webservice (Answers: WFS, WCS, AtomFeed, WMS);
- Is the data content in the service INSPIRE-compliant? (Answers: Yes, No, In preparation)
- Free (no charge) to users (Answers: Yes, No, Partly);
- Does the web service support Web Mercator projection?
- Does the web service support Lambert Azimuthal Equal Area projection?
- Responsible third party authority if not NMCA (Title of organisation, website);
- Comments

Preliminary results regarding addresses in EU countries show that the most popular web service is WMS, followed by WFS (Figure 5). The least common web services are WCS, WMTS, and the option to download data in CSV format. Figure 6 shows that almost half of the address data content is not compliant with INSPIRE, while 37% of data content is INSPIRE-compliant. Figure 7 demonstrates that, in most of the cases address data can be accessed free of charge. 23% of the datasets can be accessed with paying a fee.

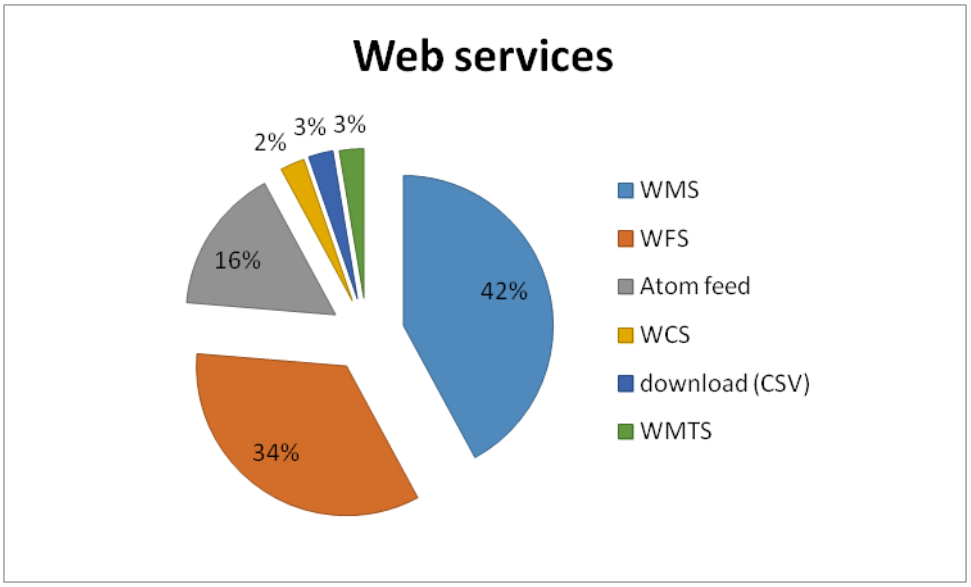

Figure 5. Address web services (European Location Framework, 03.10.2016)

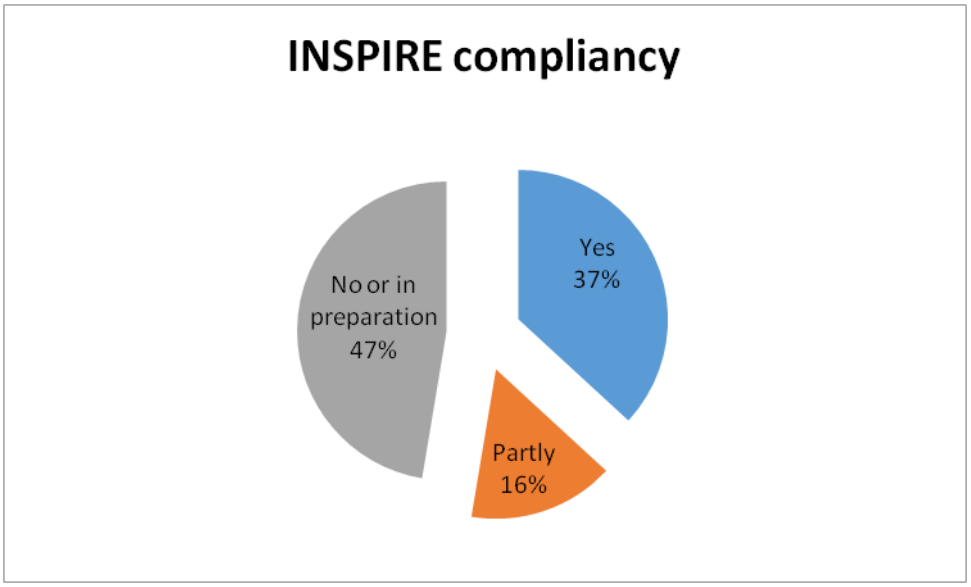

Figure 6. INSPIRE compliancy of addresses (European Location Framework, 03.10.2016)

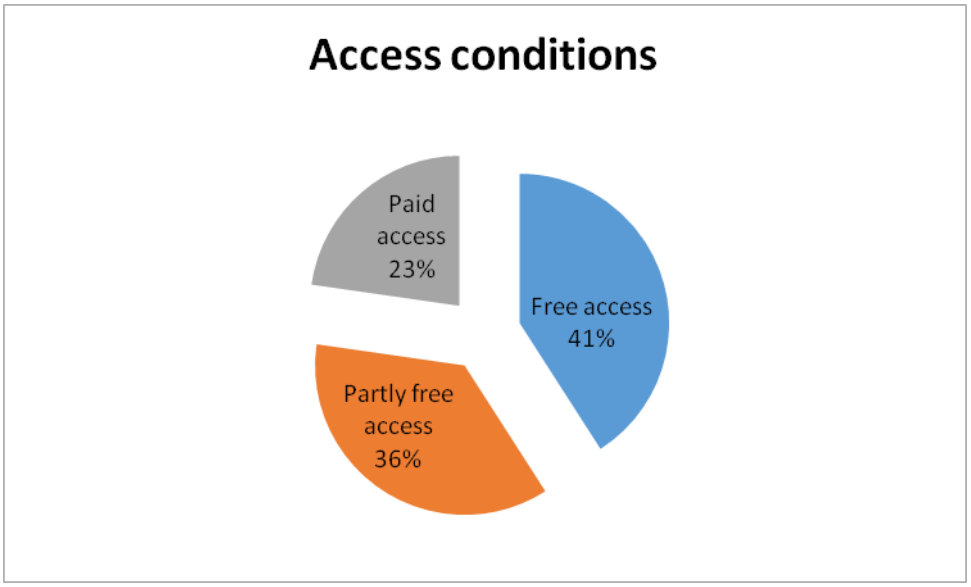

Figure 7. Access conditions of addresses (European Location Framework, 03.10.2016)

2.2.5 ELISE

The newest EU project related to addresses is European Location Interoperability Solutions for e-Government (ELISE). It is a five year project from 2016 to 2020 (European Commission, 2017). ELISE builds on the principles of the INSPIRE and continues the work of the European Union Location Framework (EULF) and A Reusable INSPIRE Reference Platform (ARE3NA) Actions in the ISA programme. One of the aims of ELISE is to run a pilot for an EU dictionary of geo-names (EU gazetteer) service, which would contain geographic names, administrative units and addresses. By end of the pilot, EU gazetteer should be integrated to 10 public or private applications/portals (ELISE, 2016).

2.3 Interoperability and address harmonisation

As mentioned previously, addresses are spatial data and have also been influenced by changes in spatial data management. Furthermore, addresses share the problems with interoperability as other spatial data. According to the European Commission (2004), interoperability is the ability of information and communication technology (ICT) systems, and of the business processes they support, to exchange data and to enable the sharing of information and knowledge. INSPIRE helps mainly to overcome technical interoperability issues, and it has been used as a framework in different themes to achieve harmonisation, and therefore, interoperability. Within INSPIRE, agreed standards are used to reach it.

For historical reasons a major portion of current geographic data is created by the public sector to fulfil their public tasks, e.g. addresses. A hundred years ago, addresses were mostly used for correct and unambiguous postal delivery and land administration (Coetzee & Bishop, 2009). From the 1950s, when developments in computer science, digital cartography, and GIS were enhanced, the process to replace analogue mapping began (Aalders & Moellering, 2001). It opened up new range of possibilities for the use of addresses, such as routing and vehicle navigation, spatial demographic analysis, geomarketing, service placement, and delivery (Coetzee & Bishop, 2009).

At first, spatial data processing and its methods run by GIS were done locally. Each community used to have their own rules. From the early 1990s the growing need to combine and share geographic data between public bodies, companies, and organisations and across borders has guided the movement from GIS to spatial data infrastructure (SDI) (Janssen & Crompvoets, 2012). In time, there has been rapid growth in the amount and availability of spatial data. The availability of GPS devices, Web 2.0 and free GIS software has led to the era of Volunteered Geographic Information (VGI). With VGI the focus has shifted from software and technology towards data (Kalbasi et al., 2014). This means that data is created in large volumes and great variety. Nowadays, anyone can retrieve spatial data using the Internet and combine it from anywhere in the world. The same trends affect addresses as well. The Addresses theme is managed by different countries, organizations, user communities, languages, terminologies, and perspectives. If a user wants to gather address data from different providers, then most probably spatial data integration is needed to some extent at different levels.

One of the most important characteristics of usable datasets is its readiness to be integrated with other datasets (Mohammadi et al., 2009). However, it is usually quite difficult to integrate datasets from different sources. Multiple issues can arise, such as diversity of data standards. For example, data can be stored in a different format, or the data models may be different. Business processes and organizational funding may also affect spatial data management. Spatial data integration issues can be divided into technical and non-technical aspects. In many cases, the technical inconsistency arises from non-technical problems and occurs as a result of other marginal issues. Technical integration and interoperability of multi-sourced spatial data have received a considerable amount of attention, but in addition, institutional, social, legal, and policy requirements must also be taken into account in order to achieve effective integration (Mohammadi, Binns, et al., 2006). Non-technical issues seem to be more problematic (Mohammadi, Rajabifard, et al., 2006), and research and practice on legal aspects has still not achieved a sufficient level of maturity (Janssen & Crompvoets, 2012).

Subsequently, both technical and non-technical interoperability issues and challenges are described in more detail.

2.3.1 Integration issues and challenges

Hereby, two different classifications of integration issues are presented. Firstly, a more general version from "European Interoperability Framework (EIF) for European public services" and secondly, a more specific version for spatial data made by Mohammadi et al. (2009).

The purpose of European Interoperability Framework is to promote and support the delivery of European services, while also focusing on cross-border and cross-sectoral interoperability. It is an umbrella framework for all public services and is therefore, related to the exchange of spatial data, including addresses. European Interoperability Framework describes four levels of interoperability (Figure 8): legal, organisational, semantic and technical. All levels need attention when cross-sectoral public services are established.

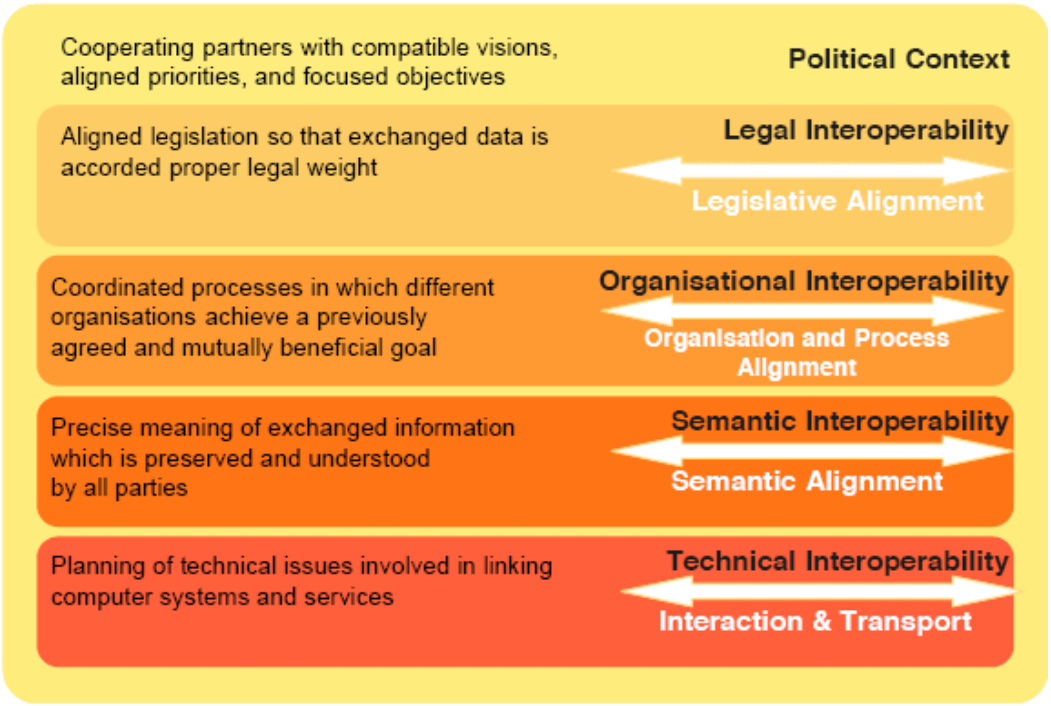

Figure 8. Levels of interoperability (European Commission, 2010a)

Another classification, which takes into account spatial data specially, is described by Mohammadi et al. (2009). In general, context address integration issues are not different from other spatial data; they share similar issues and challenges. Mohammadi et al. (2009) investigated the issues and barriers of spatial data integration in several different countries, together with possible solutions and enabling tools. As a result, challenges were divided into five groups: technical, institutional, social, legal, and policy (Figure 9). Often, these categories cannot be separated as they affect each other and SDI components including data, policy, network, standards, and people. They also pointed out the importance of spatial data validation and an integration tool, which should assess and ease multi-source spatial data for integration.

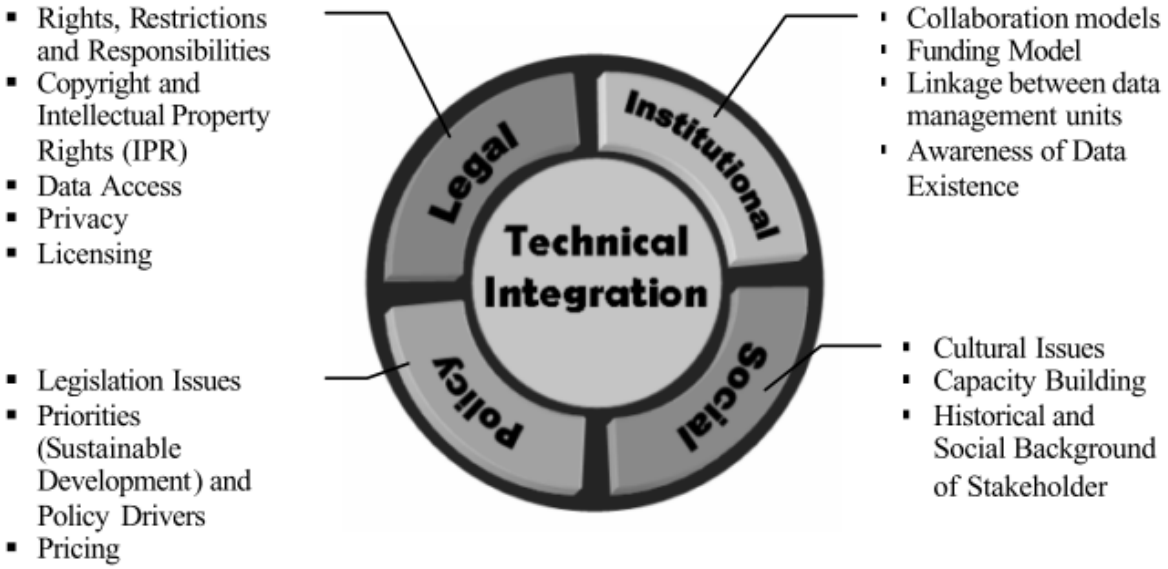

Figure 9. Integration issues (Mohammadi, Binns, et al., 2006)

These classifications are similar and show that integration issues are complex, cross-disciplinary, and have different sides, such that all need to be considered. Both classifications have technical and institutional/organizational issues in common. EIF has legal interoperability class, and Mohammadi et al. (2009) have divided it into legal and policy issues. EIF separates semantic interoperability from technical integration. Mohammadi et al. (2009) also points out social issues, which are not mentioned in EIF.

In this research integration issues are divided into two major categories: technical and non-technical. In Figure 10, categories are divided into sub-classes: schematic, syntactic, organizational, legal, social, and semantic.

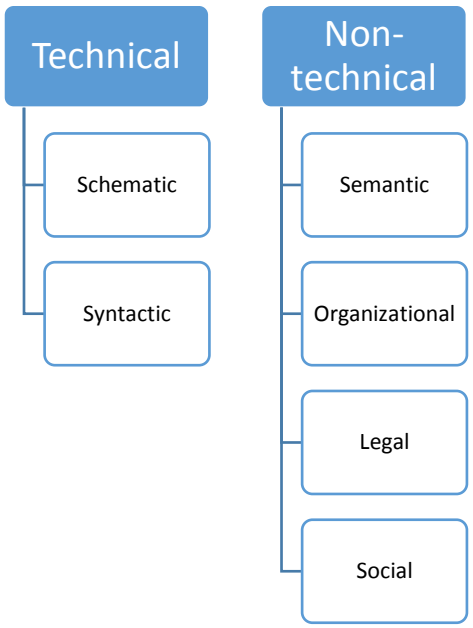

Figure 10. Integration issues

Technical

Schematic and syntactic

Mohammadi, Binns, et al. (2006) recognise that most major technical issues are related to standards, interoperability, vertical topology, semantic, reference system, data model, metadata, format, and data quality. Bishr (1998) classified those issues into schematic heterogeneity, syntactic heterogeneity, and semantic heterogeneity. Syntactic means that database systems use different query languages, for example, if some addresses are saved in the Oracle database, while others are saved in Postgres; or one dataset is saved in SHP format, and another in MIF format. Schematic means that different information systems store their data in different structures, for example, if data models of two address datasets differ. The OGC focuses on syntactic and schematic interoperability (Janowicz et al., 2009; Lutz & Klien, 2006). Solving technical differences are crucial for interoperability. If data types and names for their inputs, outputs, and functions is established, then the challenge is to assure semantic interoperability (Janowicz et al., 2009).

Non-technical

Semantic

Bishr (1998) classifies semantic issues as technical issues. This is debatable, as it depends on the context. In this research, there are other non-technical issues taken into account, thus semantic issues are considered rather non-technical. Semantic conflicts refer to problems in which systems do not use the same interpretation of information. Semantic interoperability is seen as major challenge in spatial data sharing and data interoperability (Bishr, 1998). The term "semantics" refers to the meaning of expressions in a language (Kuhn, 2005). Semantic interoperability allow systems to combine received information with other information resources, and to process it in a meaningful manner (European Commission, 2010a). Semantic heterogeneity can occur at different levels: metadata, schema, and data content level (Lutz et al., 2009). Semantic heterogeneity can be caused by naming or conceptual heterogeneity. The first refers to a problem, when the same objects are named differently; the latter refers to a situation, when the same names are given to different objects in real world (homonyms) (Bishr, 1998). In the case of addresses, naming heterogeneity can happen if a different field name is provided for ThroughtfareName (which is used in INSPIRE Address specification). For example, in Estonian databases, "Road name" is used, while in the UK, "Street name" is used. They are all referring to the same object, but the name is different. Conceptual heterogeneity might occur if, for example, in the UK and Estonia, an apartment is indicated to be on the 1st floor. In reality, they refer to different things. In the UK, for example, usually the street level floor is the ground floor and above it is 1st floor. But in Estonia, the 1st floor indicates a floor on street level, and above it is the 2nd floor.

Organizational

Institutional interoperability issues can be related to different business models, funding models, work processes, change management, awareness of data existence (Mohammadi, Rajabifard, et al., 2006), business goals, internal structures (European Commission, 2010a), and also to coordination, know-how, resources, and partnerships.

Business models, business goals, and funding models affect data pricing and data access. If the institution relies largely on money from data sale and less on public funding, then probably the data is not provided for free. Work processes can influence the quality and updating. If the work process involves several partners, and if the agreements between stakeholders are not clear, then it can affect data quality and how up-to-date it is. Experience and awareness of the data existence can affect the content and quality of the services. If there is not enough experience and resources to create services that disseminate address data, then data cannot be accessed and acquired.

Even if one considers all different issues that can occur, then harmonizing all of processes, models, and goals is idealistic. The European Commission (2010a) points out that it is unrealistic to hope that administrations from different Member States will be able to harmonise their business processes because of pan-European requirements. The steps and processes that are internal to a particular Member State can remain unchanged, if “entry and exit points” to these processes are made transparent and interoperable with the other Member States involved.

Legal

Legal issues are connected to rights, restrictions and responsibilities, copyright and intellectual property rights (IPR), data access, privacy, personal data protection, and licensing (Mohammadi et al., 2009). As legislation is different at a national level and regional level, then by combining address data this has to be considered. Legal issues are also associated with Public Sector Information (PSI) legislation on a national and an EU level. Licenses are also a problem as, firstly, they can be carried out differently, e.g. e-mail, a non-transactional statement on a webpage, a click licence, or a licence agreement signed by all the parties involved (INSPIRE Drafting Team Data and Service Sharing, 2013b). Secondly, the content of licenses can vary to a great extent. In a derivative data product or database, the strongest restriction(s) will control (Uhlir, 2013).

Policy issues can come from different pricing models, access policies, and use restrictions. Different pricing models can make acquiring data more difficult. The user needs to put time and effort into understanding the details. Data owners can define how data can be used, e.g. for academic use, research use only, or for research and commercial use. If a user wants to combine address data to make an added value product, only commercial datasets can be used. Access limitations can also be problematic. The data owner can limit access only for corporate users and cannot allow access to individuals.

Social

As people are part of SDI, interoperability issues can rise due to social issues. Cultural issues, capacity building, historical background, and social background can also affect interoperability. If data owners or managers have a siloed mindset, meaning they are not open to sharing information or knowledge to others (Investopedia, 2016), then it takes more time or it is even impossible to share address data and make it accessible. In the case of EU and INSPIRE, members have to make data open because it is forced by the law. With a siloed mentality, it can take more time, and data owners can make access as restricted as possible. Giuliani (2011) states that "to ensure effective interoperability, it is not only a matter of technology but also and often it requires a change of philosophy, of spirit to go “open”". Different understandings and knowledge about SDI and its missions can also make the process time- and resource-consuming.

2.3.2 Standards

Heterogeneity of address datasets makes the re-use and combining of data from different sources difficult. The data might have differences in data types, attributes, definitions, and formats. Translations are very labour-intensive and time-consuming. To ease this problem, different international organizations, such as the International Standardization Organisation (ISO) and Open Geospatial Consortium (OGC) are developing common standards to make datasets interoperable (Lutz & Klien, 2006). Other international standard generators for addresses are UPU and OASIS. These standards are also a foundation for SDI. Harvey et al. (1999) stated that, despite standardization efforts, cross-standard data sharing issues will always remain. Existing standards are great to solve technical issues, but even when datasets are translated according to the standards or common framework, the non-technical problems remain. This means that there is still a long road ahead, and that there are different heterogeneity problems that still need to be solved.

Subsequently, a generalization is made and standards are divided into technical and non-technical sections.

Technical

The ISO (International Organization for Standardization) is the world's largest developer of voluntary International Standards. Since 1947, ISO has published more than 19500 International Standards covering almost every industry, including, technology, agriculture, and healthcare. The ISO 19112 "Geographic information - spatial referencing by geographical identifiers" is related to addresses, as addresses are geographical identifiers. Other ISO standards directly related to addresses are under development: ISO/DIS 19160-1 (Addressing - Part 1: Conceptual Model) and ISO/DIS 19160-4 (Addressing - Part 4: International postal address components and template languages). the ISO 19160 Project Team has been reviewing a number of existing national and international address standards. The review included the scope, terminology, conceptual model, addressing schemes, address metadata, processes, and procedures for maintenance of the address data, encoding, and address rendering (Coetzee, 2010). The results will serve as input to formulate standards.

Another initiative is Addressing the World, An Address for Everyone by the Universal Postal Union (UPU), which focuses on creating address-related synergies between United Nations (UN) agencies, intergovernmental organisations, and any other interested parties. Universal Postal Union (2012) also published a white paper about it. It was pointed out that in most industrialised countries, having a physical address is something that is taken for granted. However, in many developing countries, as well as in some emerging economies, the majority of people do not have an address.

OASIS (Organization for the Advancement of Structured Information Standards) has published a set of XML specifications for defining, representing, interoperating, and managing "Party Centric Information" (Coetzee et al., 2010). Name and addresses information is the most complex of this data. Specifications represent the data independent of any culture, geographical location, application, or industry at an abstract level or detailed level. Google Earth/Maps implements the OASIS data model for addresses because until now, the OASIS Technical Committee has not yet come across an address that cannot be presented in its address data model.

The most novel initiative is what3words. They have covered the world with 57 trillion 3mx3m squares, and for each square, a fixed and unique three-word address has been pre-allocated (what3words, 2015). For example, the address of the ITC Building in Enschede based on what3words is "rapport.itself.slate". The aim is mainly to help create addresses for developing nations, which are currently poorly addressed. The three-word address system is available in nine languages: English, French, Spanish, Portuguese, Swahili, Russian, German, Turkish, and Swedish.

INSPIRE also recommends using specific standards for addresses. INSPIRE technical specifications require using OGC and ISO standards for web services. OGC standards are technical documents used by developers to create open interfaces and encodings (OGC Standards, 2015). These standards are also used to disseminate address data via WMS, WFS and CSW. A Catalogue Service Web (CSW) is used for Discovery Services to publish and search collections of descriptive information, i.e. metadata (OGC, 2007). A Web Map Service (WMS) is able to dynamically generate a map of spatially referenced data as an image file, often in pictorial format such as PNG, GIF, or JPEG. The ISO 19128 standard is also used to develop an in-line WMS. WFS (Web Feature Service) is a service for the creation, exchange, and modification of geographic information encoded in Geography Markup Language (GML) over the web. The WFS offers access to geographic information on the feature and feature property level. Instead of using FTP services, WFS can be used (OGC, 2005). In addition, ISO 19139 is used in data types, ISO 19119 is used for services, and ISO 19115 is used for metadata.

Another service used to fulfil INSPIRE Download Service requirements as an alternative to WFS are ATOM feeds. They are used to share frequently-updated content. Users can subscribe to a feed and automatically have access to the most up-to-date data (Safe Software Inc, 2015). ATOM is in an XML-based format and was designed to be a universal publishing standard for blogs and other websites where content is frequently updated. INSPIRE data download requirements can be met by using ATOM feeds. This incurs minimal implementation costs and complexity (Wilson, 2013), therefore a number of organizations are using this option.

Several countries have developed their own address standards. One of the leading countries is Denmark. Denmark’s address format is based on digit codes, which can avoid misspellings and incorrect abbreviations. Digit codes are also easier to handle by a computer. In Denmark, digit code systems have been used for 37 years, and they have helped to save a considerable amount of money (Lind, 2003). Common identifiers can help to link together various administrative public systems, which handle personal taxes, property taxes, health insurance, wages, pensions, and benefit payments.

Non-technical

In addition to technical standards agreements and standards establishing interoperability on an organisational or legal level are also important. Licensing is one of the issues, which arises and is amplified when users wants to re-use, combine, and/or re-disseminate different datasets. Licenses can be long, can be written in "legalese", can be different in the level of detail, and can make re-dissemination difficult. The need for harmonised geo-licences is growing, and several licensing

initiatives are found in the United States, Europe, Italy, the Netherlands, and Australia (Loenen et al., 2012).

One of the sources of regulations on non-technical aspects in the European Union also related to addresses is the CEC (2010b) INSPIRE Regulation on Data and Service Sharing. This regulation establishes harmonised conditions of access to spatial data sets and services. It is companioned with two documents: guidance on the "Regulation on access to spatial data sets and services of the Member States by Community institutions and bodies under harmonised conditions" (INSPIRE Drafting Team Data and Service Sharing, 2013b) and a summary of "Good practice in data and service sharing" (INSPIRE Drafting Team Data and Service Sharing, 2013a). These two documents cannot be used to interpret or explain the obligations in the INSPIRE Directive. They are not legally-binding.

Guidelines contain clarification on the Regulation and general guidance, which aims to assist Member States and their public authorities, as well as the Community institutions and bodies, in complying with or applying the Regulation on Data and Service Sharing. The guideline introduces two different licence types: Basic and Specific. The Basic INSPIRE Licence applies when spatial data sets or services can be used free of charge under the conditions in the INSPIRE directive without further restrictions or conditions. The Specific INSPIRE Licence template can be used when a Member State public authority wishes to grant the Community institution or body specific additional rights of use or wants to impose specific additional conditions on that use and/or charges (INSPIRE Drafting Team Data and Service Sharing, 2013b, p. 16). The Good Practice document includes examples of data and service sharing practices that can improve sharing and help to solve the issues related to establishing a data and service sharing policy for a particular area or data domain.

The INSPIRE Drafting Team Data and Service Sharing (2013b) points out a problem that the INSPIRE legislation does not provide any implementing rules for the standards for accessing interoperability, and, as a result data, publishers will implement their own solutions. This might lead to a decrease in the interoperability of services. Fortunately, it is addressed as part of the Interoperability Solutions for European Public Administrations Programme (ISA Programme). Additionally, INSPIRE has not adopted any specific standards for machine-readable licences, but is monitoring development in ISO19149. The standards cannot help solve all problems. Even if international geo-licenses existed, challenges would remain. For example, interoperable electronic licensing would still be problematic in situations like categorizing user groups (public, private or non-profit use) (Loenen et al., 2012). Categorizing is important when use restrictions apply.

During the EURADIN project, a survey was made on different topics. Based on that, best practices and recommendations were created. To some extent, these conclusions can be considered a standard that can help to improve organizations and help to make them and their address data more interoperable. Based on how partners defined their data flow, a best practice workflow was created. In Figure 11 workflow for state organization, in Figure 12 workflow for federal organization and in Figure 13 workflow for state special practice are presented. The figures explain in which level (local, regional, national or European) address registration, georeferencing, harmonisation and distribution should take place. The appropriate level depends on the type of the organization. The presented workflow is generalised, but all partners agreed that, in general, the workflow meets the workflows of the different EURADIN members. The exact flow depends on the size of member states and their

political form of organization. The workflow should be used to implement or improve their current existing flow.

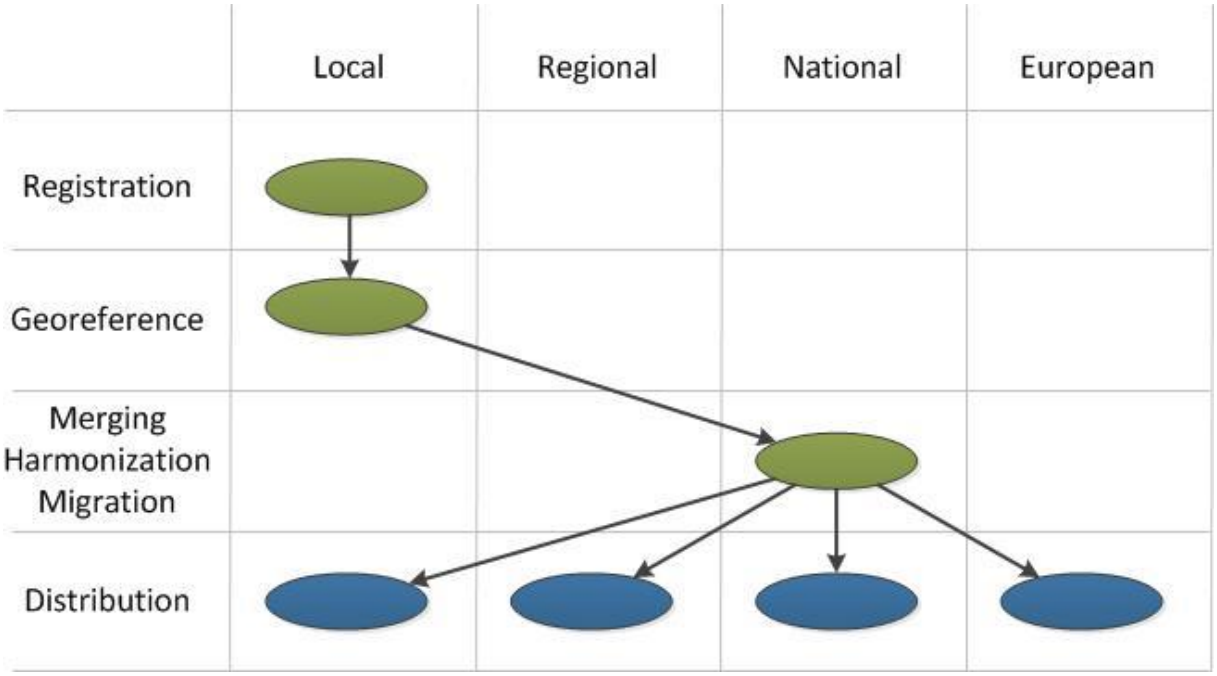

Figure 11. State organization best practice workflow (adapted from EURADIN (2010b, pp. 11-12))

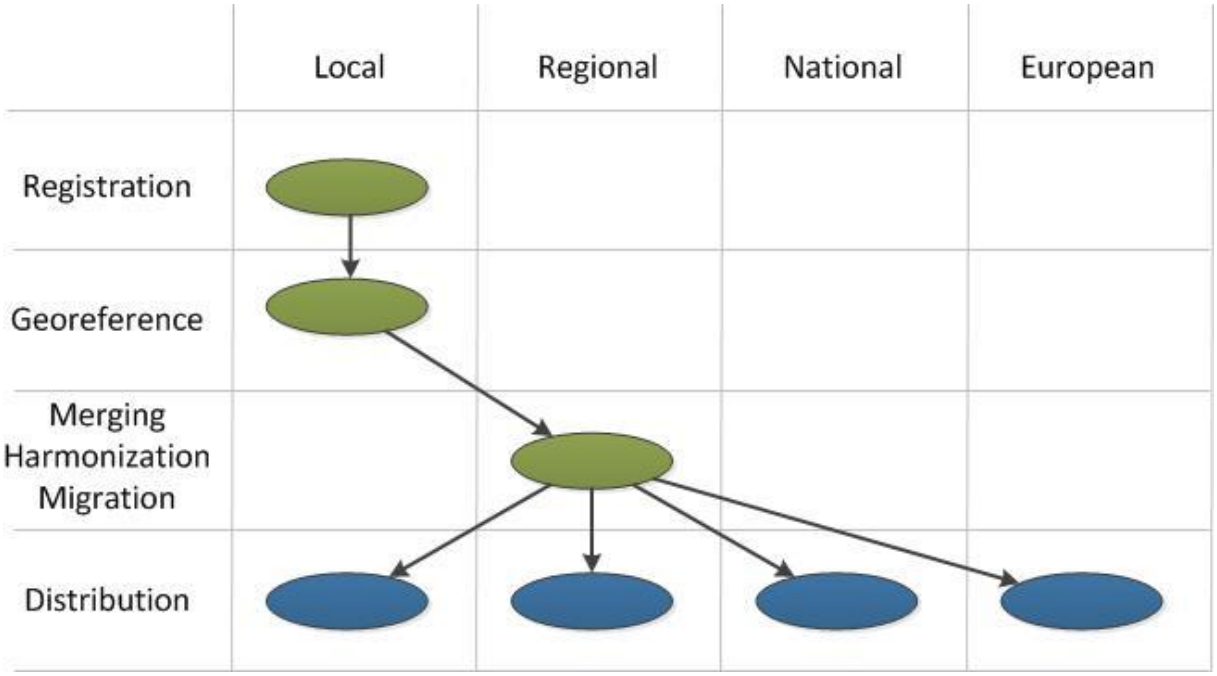

Figure 12. Federal organization best practice workflow (adapted from EURADIN (2010b, pp. 11-12))

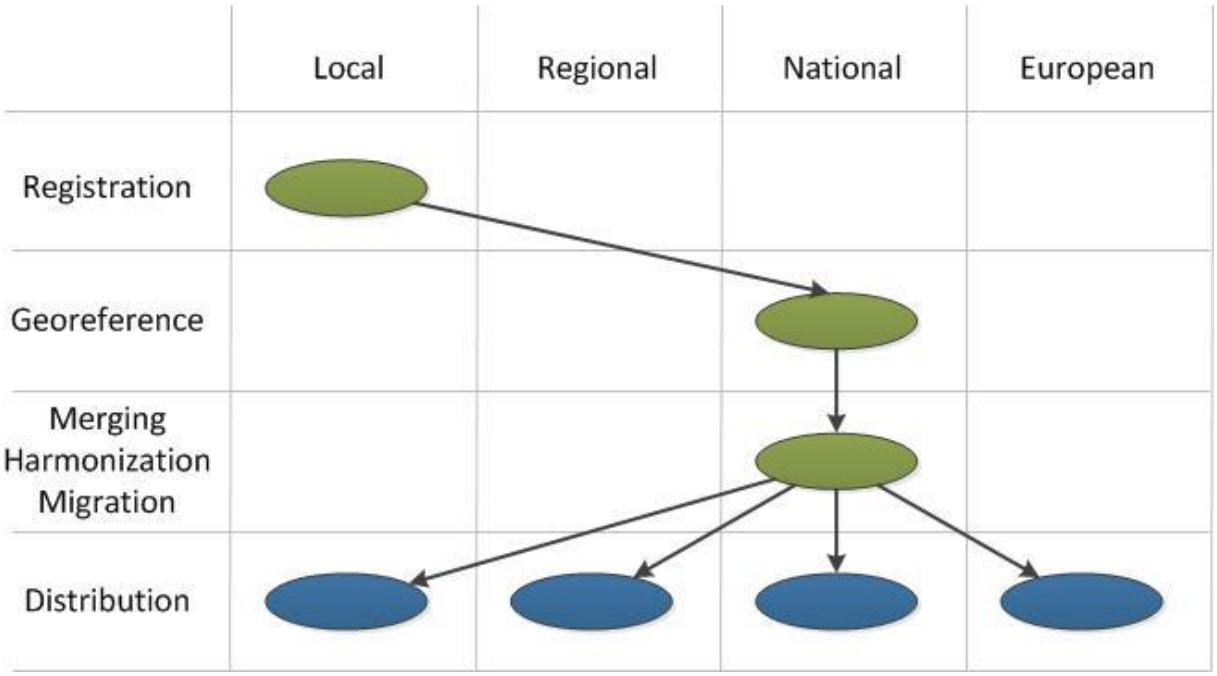

Figure 13. State organization special practice workflow (adapted from EURADIN (2010b, pp. 11-12))

EURADIN concluded the following recommendations as part of Best Practice. These should be used in addressing (EURADIN, 2010b, pp. 15-16):

1. There should be a single national “official” address reference database.
2. The process should be sponsored and controlled by the Public Sector.
3. The data should be owned by the Public Sector and probably the State.
4. The dataset must be comprehensive, up-to-date, and fit for the purposes of central and local government.
5. If such datasets are created at a regional or local level, then they must be capable of national integration and of following the INSPIRE standard for subsequent Pan-European integration.
6. There should be an integrated creation and maintenance process.
7. The primary “official” creators of address data should be identified.
8. Those bodies involved in the creation process should be encouraged to participate, preferably by law or possibly by binding contract with associated funding where necessary.
9. The basic data should be free or available at a marginal cost of distribution.

3 Methodology

In the previous chapter the theory underlying the research questions were discussed. In this chapter the research methodology, to answer the research questions, is presented. This is done for each question in a separate paragraph. First the overall approach is presented, which is followed by a short justification of selected approach and the steps are described in more detail.

3.1 How are addresses in all EU member states managed, accessed and supported by tools and services?

The aim of this research question is to characterize the address systems of each 28 European Union member states using a number of characteristics. The approach consists of five steps (Figure 14).

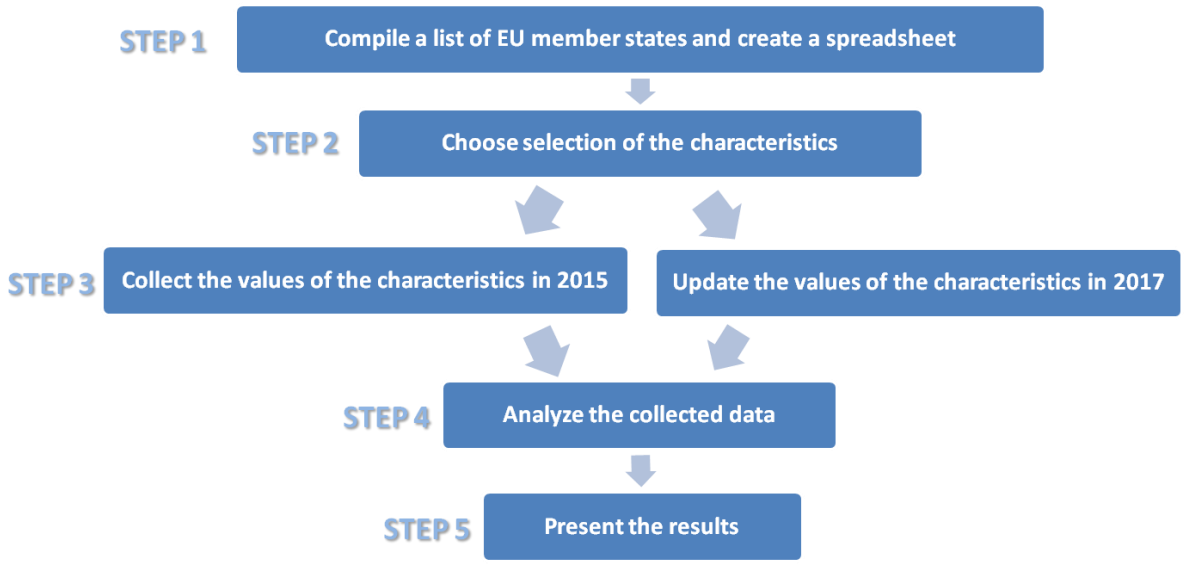

Figure 14. Steps used in the approach of first research question

STEP 1: All current European Union member states were included to have a complete overview of current situation and status of addressing in EU. List of 28 European Union member states with year of entry to EU can be found in Appendix A.

STEP 2: For choosing characteristics to describe address data systems of each country, the attributes from EURADIN project are used, but modification are made. From 17 EURADIN's characteristics three (Name, Year, Responsible Authority) are included and another eight are added by the researcher. The aim is to have characteristics that can be compared and acquirable by using public materials. In Table 2 list of chosen characteristics and their description is given.

Table 2. Characteristics and their description

Characteristic	Description
Number of address systems	Number of systems per country. Country can have no address system, one central system, number of regional systems or local systems.
Name of the address system	Name of the system in English and when applicable, abbreviation of the name.
Year created	The year, when current address data system was created
Content of the address system	Next to addresses, which kind of other data is stored in the system
Ministry in charge of the system	Name of the ministry in charge of the system
Data owner	Owner of the address data system
Data manager	Establisher of address data
Full address example of apartment	Example of an address based on fictional setting in Appendix B
Number of entries	Number of address entries
Access to the data	How address data can be accessed, is it free, free (restrictions), free/price list, price list, no access or no dataset
Tools, Services	Which kind of address web services and tools are offered

STEP 3: During this step values of the characteristics are researched. Values are inserted into a spreadsheet and overall description of each country is composed to bring out interesting facts about each country.

In 2015

The aim is to find for each member state one central dataset, which is a digital, owned and managed by public sector and covers the whole country. These limitations are chosen, because of the nature of INSPIRE, where only digital datasets can be shared and cooperation is taking place mainly between public sector.

To investigate each country the following steps are taken:

1) Firstly, INSPIRE Monitoring from 2014 and 2013(if 2014 is not present) are used to find address dataset and responsible authority.
   a) If there is a dataset indicated, then to acquire additional information about it a web search is carried out.
   b) If there are not any indicated datasets, then a web search is carried out to check possible datasets.
2) This is followed by comparing the found results with other existing materials, like INSPIRE Reports from 2013; INSPIRE State of Play reports from 2011 and EURADIN report from 2008.

When a country has a number of address datasets, then to keep overview concrete, comprehensible and to fit into research timeframe the following limitations are applied:

1) If there is more than one dataset, then the first choice is to describe only that dataset, that has full coverage.
2) If there is no a singular dataset, that has full coverage, then
   a) if there are less than 5 different datasets and by summing up they have full coverage, then all are described.
   b) if there are more than 5 different datasets with no full coverage (local, thematic datasets), then they are not described, but added as a note, that several datasets are available.

To find the characteristics' values, different written materials, reports, presentations and intensive Internet search are used. In the case a website is in multiple languages, the first choice is English. After revising English, the website in local language is checked and it is translated to English by using Google Translate, because often the website content is limited in foreign languages.

To find characteristics, "Access" and "Tools and services", websites of organizations, national geoportals are used. Additionally, the INSPIRE Geoportal Discovery / Viewer is used to find services and datasets with keywords: "addresses" and *name of a country*.

In 2017
"Access" and "Tools and services" characteristic are updated.

STEP 4: First, analysis is carried out by concluding each characteristic and the aim is to find patterns and dissimilarities between countries. Possible explanations and interesting variables are pointed out. Secondly, patterns and relations between variables are explored. All possible outcomes are compared with previous work and results from other researchers and projects.

STEP 5: The most interesting results are presented by using figures and graphs. Collected characteristic "Access" in 2015 and 2017 are compared.

3.2 How has the compliance with INSPIRE technical requirements of address systems developed between 2014 and 2017?

Aim of the second research question is to investigate how are address services in line with the INSPIRE requirements in technical aspects in 2014 and in 2017 and describe the progress of address data harmonization. To answer this research question seven steps are made (Figure 15).

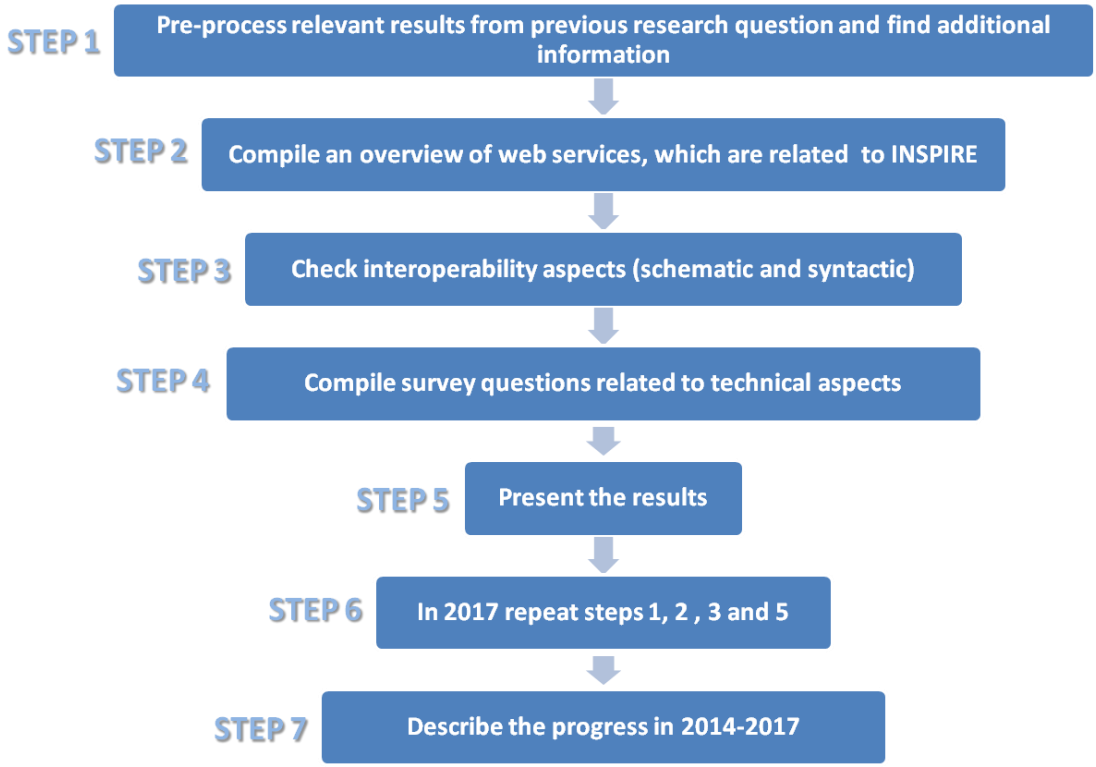

Figure 15. Steps used in the approach of second research question

STEP 1: In previous steps available tools, services and their relation with INSPIRE are mapped for each country. The results of characteristic "Tools and services" are pre-processed and used as an input.

In addition, to determine a dataset relation with INSPIRE, its metadata and dataset compliancy estimation is gathered from INSPIRE Monitoring indications. In 2015, INSPIRE Monitoring reports from 2014 and 2013 (if 2014 is not present) are used. In 2017, information is updated using INSPIRE Monitoring reports from 2016.

STEP 2: For situation in 2015 and 2017 tables with web links of WMS, WFS and ATOM services in each country are presented. These web services were chosen based on capabilities of SoapUI (the description of SoapUI can be found later in the text). Only those web services are listed, that have relation with INSPIRE. For example, it is mentioned in the web service title, WMS (INSPIRE). Only those web services are listed, which cover the whole country or if there are less than five different datasets and by summing up they have full coverage. If for a same type of service more than one web link is found, then all links are listed. To check if WMS and WFS are operable, GetCapabilities queries are made.

STEP 3: Schematic and syntactic accordance with INSPIRE is checked by using a tool named, SoapUI, and predefined Testing Framework, which was initially developed during ESDIN project. Those two aspects, schematic and syntactic, are chosen based on literature review. Validation is made against INSPIRE technical specifications. The existences of specific parameters are measured, but not the content. Similar validation methodology was used also in EURADIN project, when the European Gazetteer was developed. In EURADIN web services and WFS were tested.

SoapUI is a free and open source cross-platform for Functional Testing developed by SmartBear Software. SoapUI can be used to process test steps automatically. In this research SoapUI 4.5.2 and ESDIN Testing Framework (ETF) 1.4.1 managed by Geonovum are used. They can be downloaded from Geonovum website: http://www.geonovum.nl/validator-inspire-view-en-downloadservices. Screenshot of SoapUI graphical user interface can be found in Appendix C.

SoapUI and ETF can be used to test INSPIRE View Services (WMS 1.3.0), INSPIRE Download Services: ATOM and/or WFS 2.0.0. Tests provide detailed information about compliancy of the INSPIRE technical requirements (View Service version 3.11 and Download Service 3.1) and help to debug errors. Each predefined web service test contains Test Suites. WMS test has six Test Suites. WFS has two Test Suites and ATOM has five Test Suites. If the test is run, then it will give a result, if each Test Suite "Failed" or "Finished". Test Suites contain number of checks and if even only one check fails, then entire Test Suite fails. Most of the cases each check represents one INSPIRE requirements. More detailed explanation of Test Suits, its checks and references to INSPIRE requirements can be found in Appendix D, E and F.

Usually this tool and tests are used during the implementation stage of WMS, WFS and/or ATOM. As the INSPIRE Technical Guidance is not legally binding, therefore this tool cannot be used to test if the legal requirements have been met (Geonovum, 2014). The combination of SoapUI and ETF is used, because manual checking would be unproductive and time consuming. This tool is assessed to be the best method to check INSPIRE compliance, because it gives detailed overview and helps to diagnose problems.

For each SoapUI test run a web link of a service is used as an input. Tests are made in 2015 and 2017. Only these services are tested, which can be accessed for free.

STEP 4: To answer third research question a survey is planned. To take advantages of this opportunity some questions about technical aspects are added. It gives some extra background information and insight.

STEP 5: Results of address dataset and metadata compliance are gathered in a table and presented by using figures.

Existence of different types of INSPIRE web services is presented for each country. If there is a web service, which covers the whole country, then it is indicated with "yes". If there is not a web service, then "no". If the web service only covers part of the country, then "partly" is used.

Results of the SoapUI tests in are presented in tables, where it is indicated which Test Suites failed and which were finished. If for a same type of service more than one web link is tested, then the results of the most successful service are presented. In the end, an overall estimation is given how interoperable these web services are according to INSPIRE.

The results of the survey related to technical aspects are described.

STEP 6: In 2017, steps 1, 2, 3 and 5 are repeated. Updated characteristics from research question 1 are used, new INSPIRE Monitoring reports are used to check metadata and dataset compliance. Web services are tested again using SoapUI and results are presented.

STEP 7: Results of metadata and dataset compliance in 2014 and 2016 are compared and changes are described. Results of INSPIRE services and their test results in 2015 and 2017 are compared and changes are described. Overview of harmonization progress of address in 2014-2017 is compiled.

3.3 To what extent are the current address systems interoperable in non-technical aspects in 2016?

Aim of the third research question is to investigate non-technical aspects of address harmonization. Six steps are taken to find answer to this question (Figure 16).

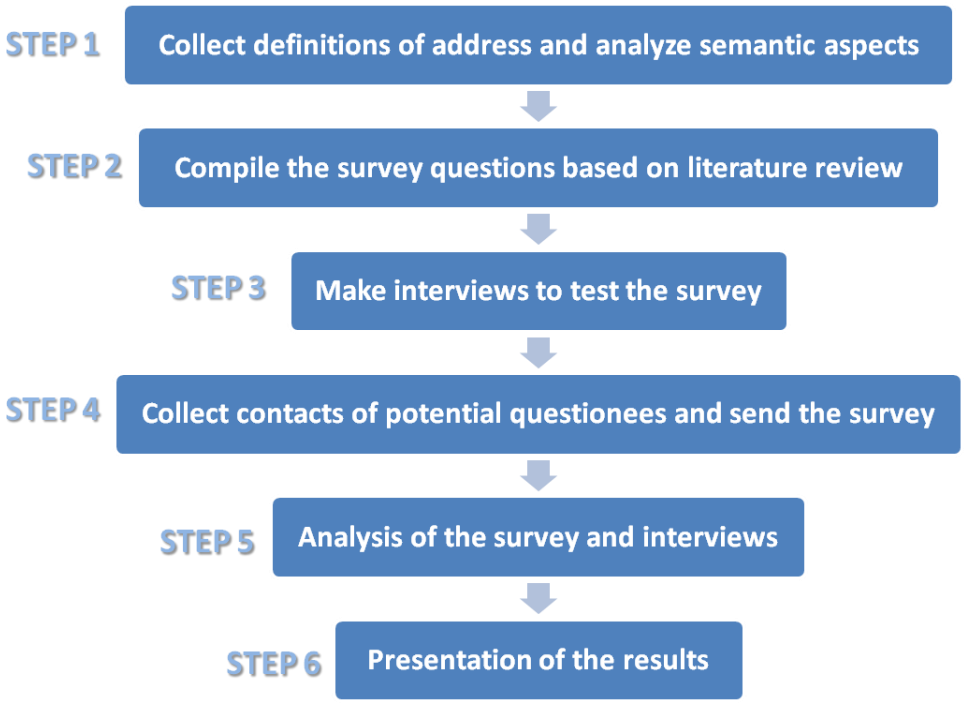

Figure 16. Steps used in the approach of third research question

STEP 1: During this step address definitions of different countries is compared with INSPIRE definitions (INSPIRE Directive and INSPIRE Address Specification). Aim is to find similarities, overlaps and possible dissimilarities between countries and INSPIRE definitions. Results are presented in a

table by using three classes: yes, no, partly. "Yes" indicates definitions, that are compliant with specific INSPIRE definition. "Partly" indicates definitions, which are partially compliant. "No" indicates definitions, which are not semantically compliant. One of the sources, to collect definitions in different countries, is EURADIN report. Within project EURADIN, only a number of project partners gave their definition on "address".

STEP 2: Questionnaire questions are compiled based on Mohammadi (2008) International Case Study Integration Template, INSPIRE Drafting Team Data and Service Sharing (2013a), CEC (2010b), INSPIRE Drafting Team Data and Service Sharing (2013b), EURADIN (2010b), Loenen et al. (2012), Cho (2012), Mohammadi et al. (2009) and Uhlir (2013). Main aim is to focus on non-technical aspects, legal and organizational interoperability issues, which are difficult to research by using secondary data. In addition, the survey focuses on technical aspects as well. Survey questions related to technical aspects were compiled during second research question STEP 4.

Questionnaire is put together using Google Forms. It consists of 49 sections and has skip logic built in, which directs to different branches based on answers. Link to the survey is https://goo.gl/forms/I3Befh4SdTr8ZrdE3. Questionnaire template is presented in Appendix G.

STEP 3: Aim of the interview is to collect survey answers from Estonia, to test the survey itself and to have feedback on the survey content. Interview questions are the same as in questionnaire, but extra follow up questions can be asked. Based on interview experience and feedback content of survey is modified.

STEP 4: To approach specialists of address data and its harmonisation a multiple channels are used (Appendix H). Main approach is to send an e-mail with introduction and web-link to survey. PDF and Word formats of the survey are added as attachments. Attachments help to get an overview and to understand the scope of the questions. If possible cross-posting is avoided.

Channels:

1. Interview is made with employees of the Estonian Land Board on 6th July, 2016. Interviewees are Sulev Õitspuu, Keiti Pärn and Andre Kaptein. Interview is carried in Estonian. Estonia is the only country where interviews are carried out, because author of this thesis is located in Estonia and it gives the opportunity to have face-to-face interaction also.
2. Contacts were collected from websites of the address dataset owners (see also Appendix H). Most of the cases general contact e-mail was chosen for survey recipients. In some cases, contact form of the website was used. E-mails were sent and contact forms are filled on 1st October, 2016. Deadline was 21st October, 2016.
3. Members of INSPIRE Thematic Cluster Topographic and Cadastral Reference Data sub-cluster Addresses received a message via INSPIRE Thematic Cluster website (INSPIRE Thematic Clusters, 2016). Messages were sent on 8th October, 2016. Deadline was 21st October, 2016.
4. National Contact Points e-mail addresses were collected from INSPIRE website (European Commission, 2016b) and all receive an e-mail. E-mails were sent on 16th October, 2016. Deadline was 28th October, 2016.
5. The survey was sent to contact e-mails in INSPIRE State Reports (European Commission, 2016a). E-mails were sent on 16th October, 2016. Deadline was 28th October, 2016.

6. E-mail was sent by Sulev Õitspuu to INSPIRE MIG-T e-mail list (inspire-mig-t@jrc.ec.europa.eu). E-mail was sent on 17th October, 2016. Deadline was 28th October, 2016.
7. Reminding e-mail to National Contact Points. E-mails were sent on 14th January, 2017. Deadline is 31st January 2017.

STEP 5: Qualitative and quantitative analysis of the survey answers are carried out.

STEP 6: Main conclusions from the analysis are pointed out. Results related to technical aspects are combined with results of second research question.

In the next chapter the described methodology is implemented and the most interesting results are presented.

4 Results

In this chapter the results are presented. Results are presented using the order of research questions. First section gives overview of characteristics of address systems in EU. Second section focuses on to what extent address systems are in line with INSPIRE requirements in technical aspects. Third section focuses on non-technical interoperability of address dataset.

4.1 How are addresses in all EU member states managed, accessed and supported by tools and services?

The data collected for all member states is presented in a table in appendix I. For all EU countries individual country reports were produced, they are presented in appendix J. Subsequently most interesting results are introduced.

4.1.1 Number of address datasets

In Figure 17 the number of address datasets in a country is presented. From the 28 EU countries 13 (47%) have only one central dataset. In the second biggest group are eight countries (28%), who have either one central dataset and list of regional datasets or no central datasets, but small amount of regional datasets that form together complete coverage.

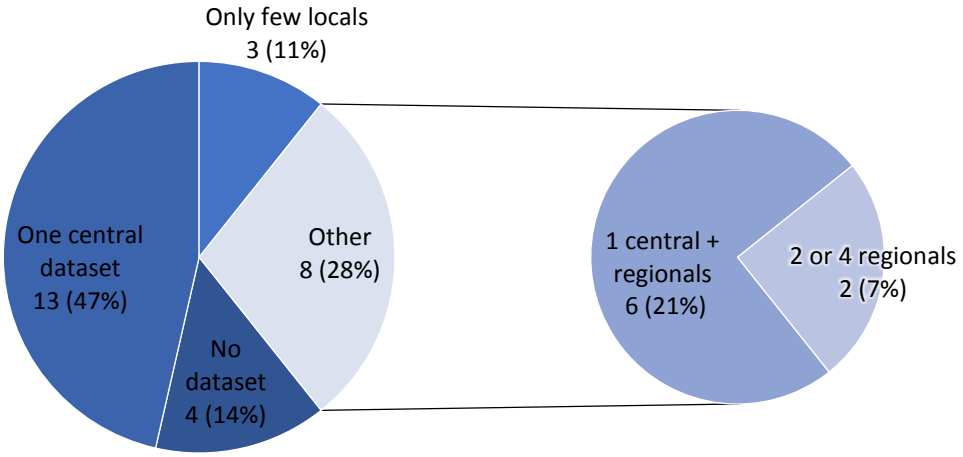

Figure 17. Number of datasets in a country

Three countries (11%) (Cyprus, Greece and Portugal) have indicated that they have some address datasets, but these do not cover the whole country. In some cases, these datasets are municipal dataset or dataset just covers addresses of a specific topic, like fire departments. In case of four countries (Bulgaria, Hungary, Malta and Romania) no indication of public address dataset was found. This means that 21 EU countries have public address datasets, which cover the whole country,

another seven have not indicated any dataset or they have indicated just a few local/regional datasets.

4.1.2 Year created

In Figure 18 the year of creation of 15 address datasets is presented. For ten other datasets the year of creation was not found. The Finnish address dataset is the oldest, founded in 1980. Probably Finland stands out with 11 year difference until to the next one, because in Finland addresses are part of Population Register. Population Register is most likely to be the first databases being digitized. In the next group are the datasets created during 1990s. This development can be explained by general emerge of digitalization of government databases (Heywood et al., 2011). Further increases in national address datasets can be observed from 2004, this might be explained by approaching INSPIRE Directive. The newest datasets are in Latvia and Czech Republic. The reason might be connected with their entry years to EU. They both became members in one of the latest entry waves, in 2004.

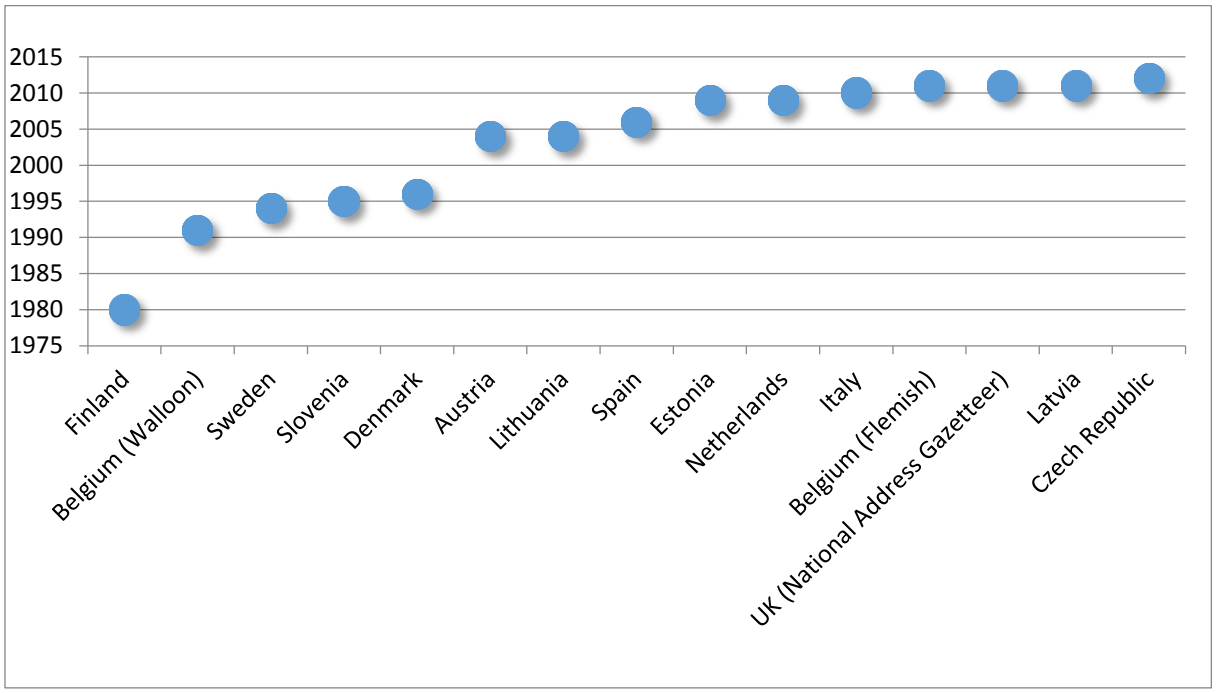

Figure 18. Year of creation of address dataset

4.1.3 Content and ministry in charge

The content of 25 address data systems was discovered. For a bit more than half, for 15 datasets, responsible ministries are indicated. In some cases a logical relation between content of address data system and ministry is found:

1) If a dataset contains mainly addresses, then the ministry in charge is related to planning or environment. This applies in Estonia, The Netherlands, Denmark, Spain and Slovenia. Table 3 shows that in those countries keywords of the ministries are development, environment, spatial planning and housing.

2) If an address dataset also contains territorial units or statistical sectors, then the ministry in charge is related to justice, public administration. This relation is present in Belgium, Latvia and Poland (Table 3). In those countries address database content goes further by including administrative borders, territorial units or other wide range of cartographical objects. The ministry in charge has focus in justice, public administration or administrating all IT related subjects.
3) If an address dataset also contains real estate data and personal data, then the ministry in charge is related to finance. Even though for this relation only one example was found, it is considered as a good and unique example. In Finland addresses are included in the Population Register and this might explain also, why it is under jurisdiction of Ministry of Finance (Table 3). For a government it is important to know, where their taxpayers live and how much of them are there.

Table 3. Content of address data system and ministry in charge

Country	**Content**	**Ministry in charge of the system**
Estonia	Addresses	Ministry of Environment
The Netherlands	Addresses, premises, their size and occupancy status, relevant dates	Ministry of Housing, Spatial Planning, and the Environment
Denmark	Addresses with coordinates	Ministry of Housing, Urban and Rural
Spain	Cities and villages (their streets and roads networks); urban areas (blocks, parcels, buildings, house numbers, street names, etc)	Ministry of Development
Slovenia	Location and attribute data on spatial units and on addresses	Ministry of Environment and Spatial Planning
Belgium (Brussels)	Several cartographical databases, including address data	Minister or the Secretary of State responsible for regional and communal IT
Latvia	Textual and spatial data about streets, buildings and administrative territory borders	Ministry of Justice
Poland	State borders, territorial units, addresses	Minister in Charge of Public Administration
Finland	Personal, building and real estate data	Ministry of Finance

4.1.4 Data owner

Address data can be owned by public or private sector. From 28 member states, in case of four countries (Bulgaria, Hungary, Malta and Romania) no indication of public address dataset was found. In all other countries address data is owned and established by public sector. For example, in Bulgaria address data is owned by the private sector.

The websites of the organizations revealed that in most cases the address data is established by the municipalities. The most common data contributor after municipalities is postal delivery, in countries such as Sweden, UK, Spain, and Ireland. This can be explained by historical background, as addressing has strong bonds with letter sending. In some cases other organizations are also involved, such as Statistical office, Building authorities in Czech; Swedish Tax Agency in Sweden.

Some examples were found, where municipalities are not establishing data, like in Spain and Ireland, Slovenia. In those countries data owner and establisher is the same organization. It means they establish and manage the data and none of the local authorities are included.

4.1.5 Full address example of apartment

By collecting full address examples, some similarities were discovered and some insight was gathered to understand addressing issues. These full address examples are composed based on fictional setting, which can be found in Appendix B.

In Baltic States, Estonia, Latvia and Lithuania, apartments are divided by using "-". These examples are presented in Table 4. The similarity can be explained, by the fact, that those countries are spatial close together and have similar historical background. All of them were part of Soviet Union and became independent in the beginning of 1990s.

In Belgium, France, Poland, Italy, Poland, Romania and Spain the type of the throughway (road, highway) is listed as an abbreviation or as a word in front of the street name (Table 4). It could be explained by language similarities, as all of them belong to same Indo-European languages families. Most of them (except polish) belong to Romance subfamily. Polish belongs to the Slavic subfamily. There are other languages in the EU, which belong to Slavic subfamily, like Bulgarian, Croatian, Czech, Slovak, and Slovene (Wikipedia, 2015a), but these countries do not use the type of the throughway in front of the street name.

Romania also stands out by being the most detailed, all possible information are indicated: the house number, floor, apartment and entry.

The Netherlands stand out by not separating house number and apartment number. In the Netherlands, if a house has several apartments, than each apartment has its unique number. In Table 4, in case of The Netherlands, Mainstreet 24 is indicated. The number 24 refers to an apartment. If number 360 would be used, then it would refer to the whole house, which does not have any apartment.

These examples and others indicate that developing a European address standard and INSPIRE address specification is complex, as different countries indicate and interpret addresses in their own way. In addition, it was discovered that the language has a notable influence on addressing.

Table 4. Full address examples of some EU countries

Country	Address example
Estonia	Mainstreet 360-24 13422 Tallinn Estonia
Latvia	Mainstreet 360-24 Rauda Tukuma novads LV-3456
Lithuania	Mainstreet 360-24 Ariogala 60249 Raseiniu r.sav.
Belgium	street Main 6 bus 3 2140 Antwerpen
France	24 360 STREET MAIN 75014 PARIS
Italy	360, 1, 24 Street Main 81055 Santa Maria Capua Vetere CE
Poland:	strt. Main 360/24 (or 360 m. 24) 00-902 Warszawa
Romania:	str. Main bl. 360, sc. 6 et. 1, ap. 24 București, sector 6, 313988
Spain	Street Main 6 left 1 1 (or 360, 1°, 24) Cortijo del Marqués 41037, Écija (Sevilla)
The Netherlands:	Mainstreet 24 2500 AA Den Haag The Netherlands

4.1.6 Access in 2015 and 2017

In Figure 19 address data accessibility of 28 EU countries is displayed. In 2015, seven countries (25%) had not indicated any central address dataset. 18% can be accessed by paying a fee. In case of Sweden, there is a fee, but there is also an extra restriction, that individuals cannot access it. In their authorization system it is only possible to register corporate identification numbers.

22% of the address datasets can be accessed for free without any constraints. 21% of datasets, "free/price list", offer some services for free, but in some cases a fee applies. For example, in the

Netherlands some data and services can be access for free, but at the same time for more advanced, detailed datasets fees applies. In France data is available for free for public sector and for research purposes, but fee applies for commercial use.

Four datasets did not have any access. For example, in Slovenia and Slovakia, the potential explanation is that they are still in progress of developing the datasets and therefore access possibilities are not ready either. In case of Finland, the dataset containing addresses is part of National Population Register, as this contains also personal data, therefore it cannot be accessed.

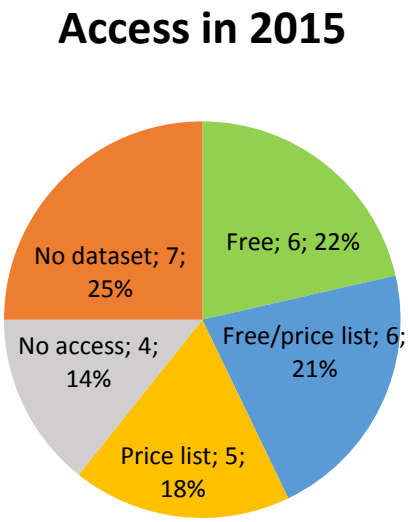

Figure 19. Address data access in 2015

In 2017, 25% of different address datasets are free to use (Figure 20). 29% of address datasets have products for free and for a fee. 14% collects a fee for accessing address data. 7% has address datasets, but no services. In seven countries there are not any address datasets.

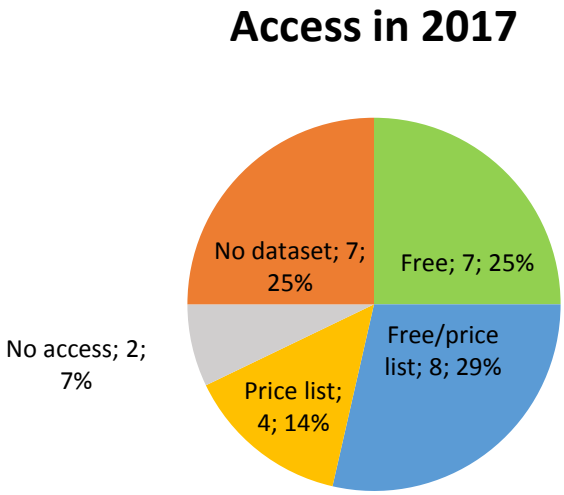

Figure 20. Address data access in 2017

Figure 21 demonstrates difference between access in 2015 and 2017. Access to one additional datasets has been made free, two more datasets can now be accessed for free or in some cases price list applies. These changes have retracted from "price list" and "no access" categories. For example, Slovenia and Finland did not have access to their address data in 2015, but in 2017 they have made services available. In 2015, Sweden was in category "price list", but during the survey it was explained, that there is an exception for educational and public sector. They can access address data for free. In conclusion, during two years positive progress has been made. There are more data for free and more address data has been made accessible.

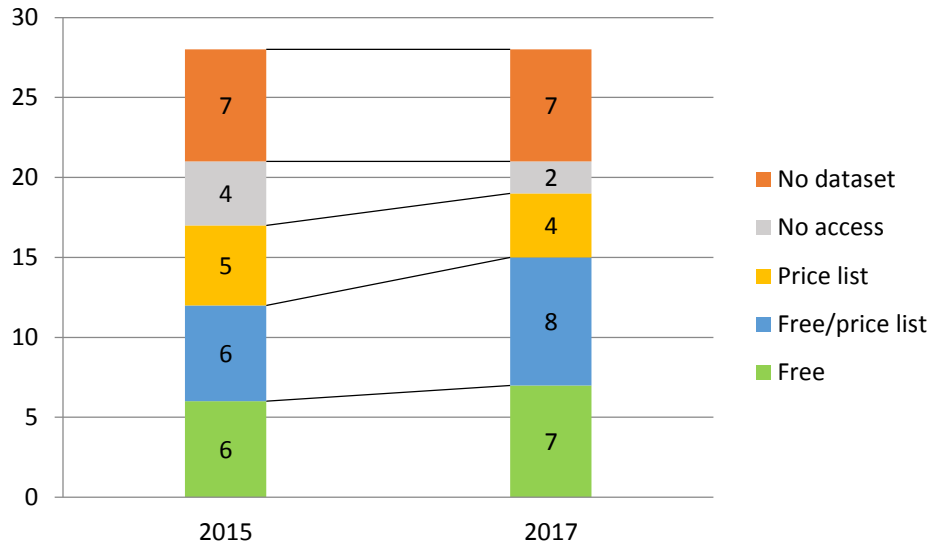

Figure 21. Changes to address data access 2015-2017

4.1.7 Tools and services

Address data distribution and access options vary between EU countries. They differ by number and existence of sub datasets, by acquirable format and, by type of available web services. Some countries have created sub-sets of their address datasets, which contain different type of data and the aim is to fulfil the needs of diverse users. For example, these countries are Belgium (Flemish region), France, Ireland, the Netherlands and UK (National Address Gazetteer). The content of sub-sets varies by including/excluding geographical coordinates, historical information, and type of address (business or residential).

One option to access address data is to download it. Often there are different formats to choose from, like XML, CSV, ASCII, DBF, JSON, SHP, FGDB, DWG, GML, MIF/MID (MapInfo). From spatial formats, ESRI SHP is the most common one. It is followed by GML, which is recommended by INSPIRE. From textual datasets, CSV is the most used. Apart from downloading directly from websites, there other channels also in use, like for example Latvia also offers as an option to access data via FTP or acquire it by ordering a CD.

Various services are offered, such as WMS, WFS, WMTS, ESRI REST, ATOM feed, WPS, WMS-C, WMS-T. The most common web services are WMS and WFS. Also often gazetteer and geocoding services

are offered within the address domain. The most unique services are in Estonia and in Denmark. They offer an API, which can easily be used in an information system. It helps a user to find searched addresses and at the same time the information system can save this address in machine readable format. Later, thanks to saved unique address ID, the information system can communicate with a central address database and keep addresses up-to-date.

4.2 How has the compliance with INSPIRE technical requirements of address systems developed between 2014 and 2017?

Subsequently, the results of the second research question are presented. Firstly, address dataset and its metadata compliance with INSPIRE in 2014 and 2016 are presented. Subsequently, existence of INSPIRE web services in 2015 and 2017 are introduced. It is followed by results of technical tests made by SoapUI and ETF in 2015 and 2017. In the last part, INSPIRE compliancy according to the survey is presented.

4.2.1 Metadata and dataset compliance in 2014 and 2016

Detailed results based on INSPIRE Monitoring reports 2014 and 2016 can be found in Appendix L. Figure 22 shows how countries themselves estimate their address data compliancy with INSPIRE in 2014. "Yes" means that all address datasets/metadata indicated in the report is compliant. "Partly" means there are a number of datasets listed and only part of them are compliant. “n/a” indicates number of countries, which did not indicate any information about addresses.

In 2014, almost half of the member states estimate their metadata to be compliant. Eight countries have indicated that their address dataset’s metadata is not INSPIRE compliant. In case of address dataset itself, more than half of the countries do not have address dataset that is INSPIRE compliant. Only four countries have INSPIRE compliant datasets.

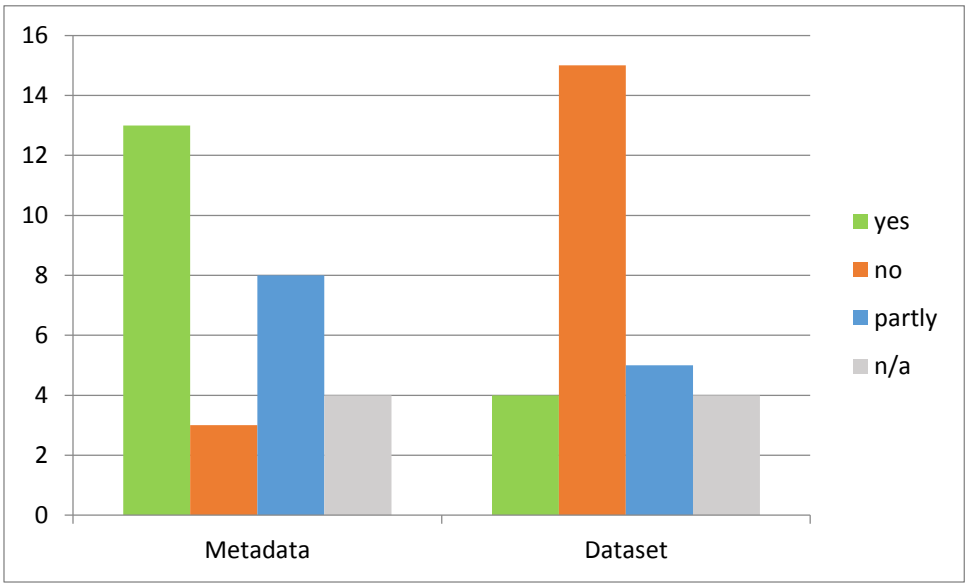

Figure 22. Metadata and dataset compliance with INSPIRE in 2014

Figure 23 shows address dataset and its metadata compliance with INSPIRE in 2016. More than half of the countries have compliant metadata. Nine countries have compliant dataset. The same amount of countries does not have compliant dataset. Metadata is more likely to be compliant than dataset itself.

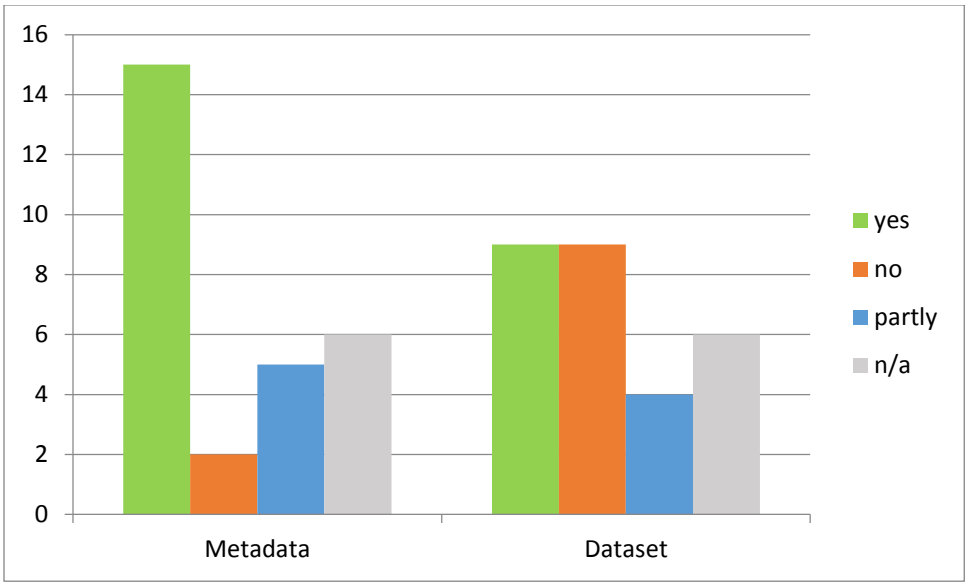

Figure 23. Metadata and dataset compliance with INSPIRE in 2016

Figure 24 shows the overall change of metadata and dataset compliance with INSPIRE. During 2014-2016 a positive trend can be detected. The most noticeable change has been with datasets. In more countries address datasets have become INSPIRE compliant. In 2016, five more countries have compliant dataset. The change has been mainly on account of datasets that before were not compliant. Positive change can be seen also with metadata of address datasets. Metadata have become more INSPIRE compliant. In 2016, two more countries have INSPIRE compliant metadata. The change has been mainly on account of metadata that was before partly compliant. In 2016, there are two more countries missing information.

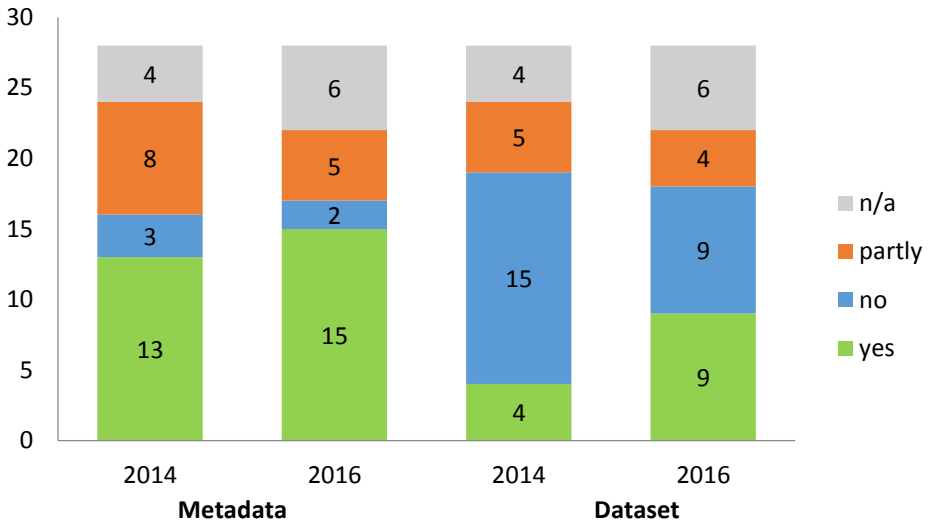

Figure 24. Change in metadata and dataset compliance in 2014-2016

4.2.2 INSPIRE web services in 2015 and 2017

In Figure 25, the number of countries with different type of INSPIRE web services in 2015 are presented. More detailed information can be found in Appendix K. "Yes" indicates countries, which have indicated such a web service. The class "partly" indicates those countries, which have number of datasets, but the spatial coverage of web services vary. In those countries, some regional datasets have web services, some have not. For example, in Germany some municipalities have CSW, WMS, but others do not have them. "No" indicates countries, which do not have any web services.

Figure 25 shows a clear trend that most of the countries have CSW, and by that they can be discovered by the INSPIRE Geoportal. The next popular service is the View Service. The least number of services are for download. WFS and ATOM web services are combined together, because countries can implement either one of them.

Nine countries out of 28 do not have any web services and therefore their datasets are not discoverable via INSPIRE Geoportal. These nine countries are: Bulgaria, Cyprus, Greece, Hungary, Ireland, Italy, Malta, Romania, and Slovakia.

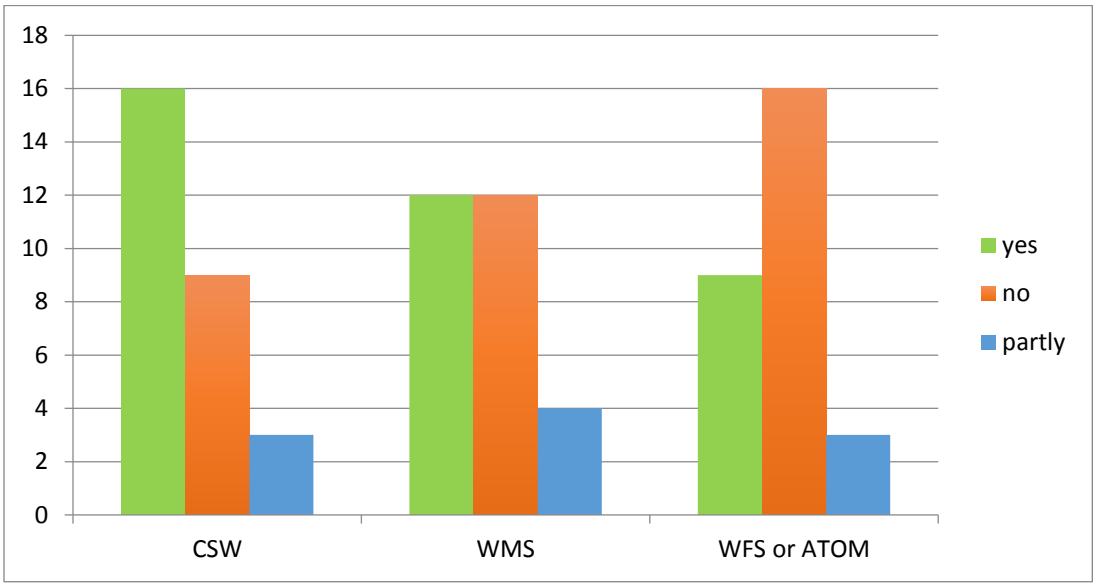

Figure 25. Number of countries with INSPIRE web services in 2015

In Figure 26 the number of WFS and ATOM are presented separately, which indicates that for Download Services the most used option is to disseminate data via WFS. Most of the cases countries have both, even if the minimum is to have only one of them.

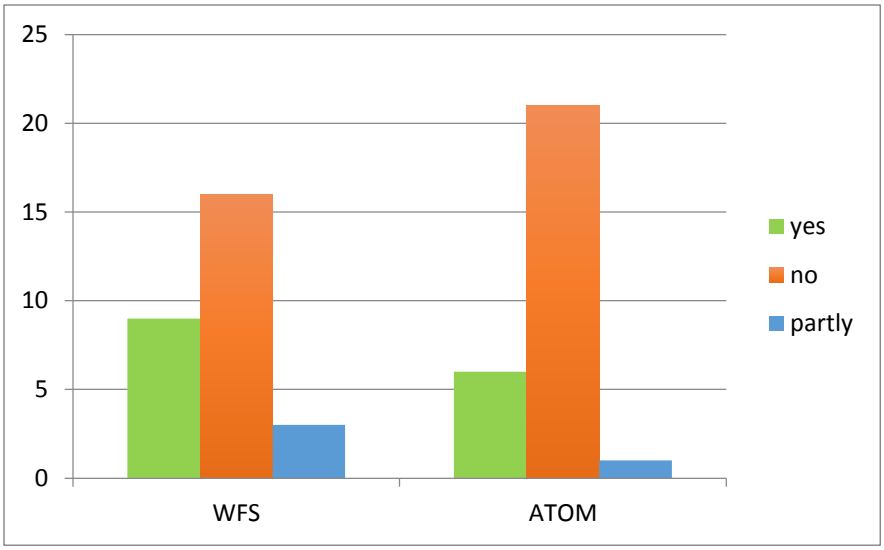

Figure 26. WFS and ATOM services in 2015

In 2017, list of available web services was updated. In Appendix K changes can be seen in blue. In Figure 27 can be seen that most popular service is still CSW. Now there are more countries, which have WMS service, than countries, which do not have WMS. Same situation is with download services, there are more countries with download service, than countries without.

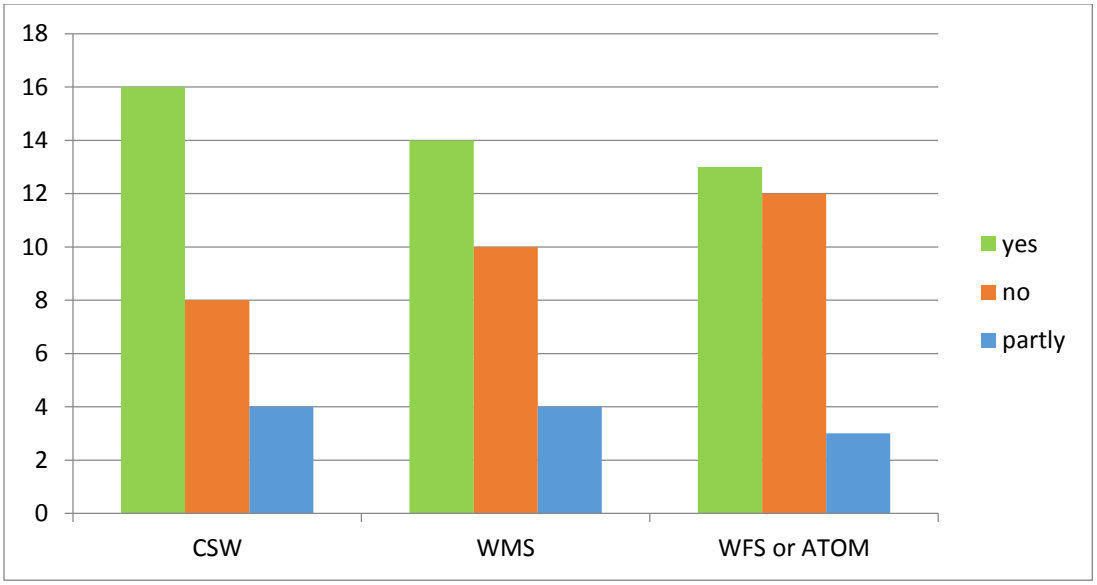

Figure 27. Number of countries with INSPIRE web services in 2017

In Figure 28 is demonstrated that from download services WFS is still more popular than ATOM service.

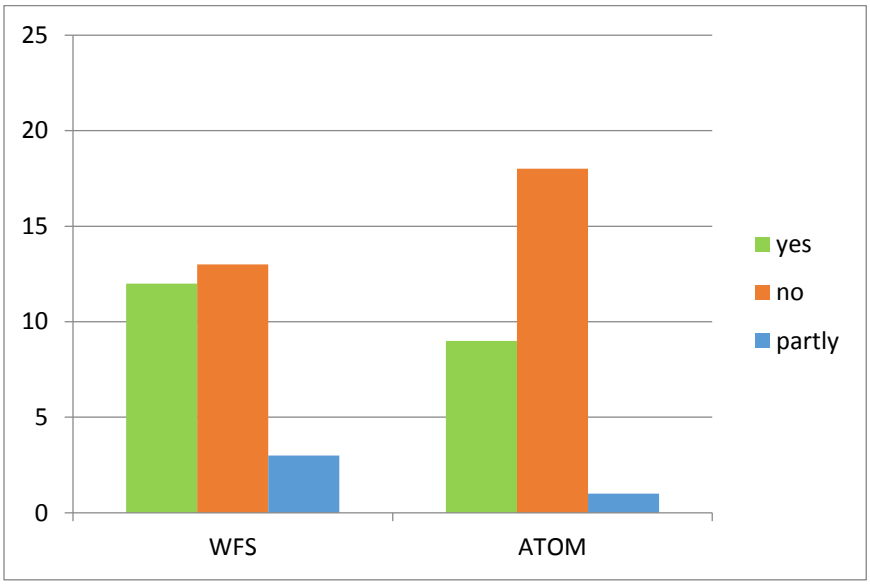

Figure 28. WFS and ATOM services in 2017

Figure 29 shows in total in how many countries and which services were added 2015-2017. There is a clear trend that countries have made address data more accessible by adding new services. In total one country has added CSW. Four countries have added WMS and WFS services. Three countries more have now ATOM services.

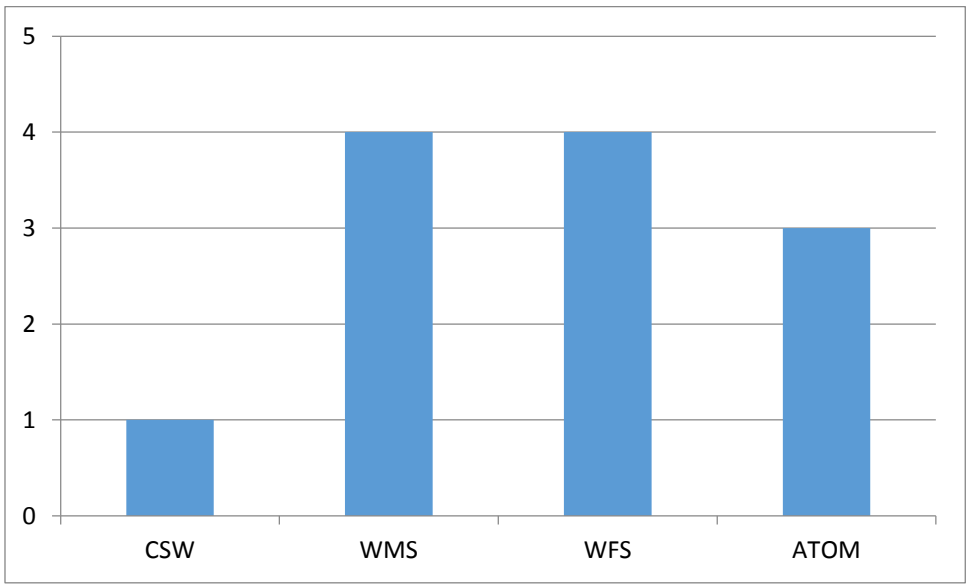

Figure 29. Number of countries, who made web new services available 2015-2017

4.2.3 Syntactic and schematic tests in 2015 and 2017

In July 2015 and in April 2017 technical tests with SoapUI and ETF were made to estimate INSPIRE compliance of web services. Results are presented in the following order, first WMS, then WFS and ATOM. Input web service links used in 2015 and 2017 can be found in Appendix M. More detailed overview of the results is in Appendix N.

The test results of WMSs in 2015 and 2017 are presented in Table 5. The test consisted of 33 checks. In 2015, fifteen WMS links were encountered. Eleven WMS were tested. Four countries had restricted access to their services. In 2015, none of the INSPIRE view services passed SoapUI tests. The number of failed checks varied between 3 and 12 and the average was 7 failed checks. Six countries had less failed checks than the average. These countries were: Denmark, Luxembourg, Lithuania, Belgium (Flemish), Czech Republic and Spain.

In 2017, eighteen WMS links were encountered. Thirteen of them were tested. Five countries have restricted access to their view services. In some cases GetCapabilities queries gave errors or in another cases it acquired authentication. In 2017, two countries, Finland and the Netherlands, passed tests 100%. The number of failed checks varied between 3 and 13 and the average was 5 failed checks. Countries with less than 5 failed checks were Finland, the Netherlands, Estonia, Denmark, Luxembourg and Slovenia. In 2015 and 2017 the most often countries failed the Test Suites *GetCapabilities Mandatory* and *Metadata URL*.

The progress of WMS services has been positive between 2015 and 2017. In eight countries have less failed checks in 2017 than in 2015 (in Table 5 presented in green). In five countries the situation has not changed. Either they have the same amount of failed checks or they were still not accessible. In five countries the situation has deteriorated, as the number of failed checks has increased or the access has restricted. In case of increased failed checks, the changes has been rather minor, the number of failed checks increased only by one. In overall, during 2015-2017, the average number of failed checks has decreased from seven to five, which means that WMS services are more compliant in 2017 than they were in 2015.

Table 5. Number of failed checks of WMS in 2015 and 2017 and progress

WMS	2015	2017	Progress
Denmark	3	3	
Luxembourg	3	4	
Lithuania	4	-	
Belgium (Flemish)	5	-	
Czech Republic	6	1	
Spain	6	7	
Estonia	7	2	
Belgium (Brussels)	9	8	
The Netherlands	10	0	
Austria	11	12	
Croatia	12	12	

Latvia	-	-	
Poland	-	8	
Sweden	-	-	
UK (Pointer)	-	-	
Finland	n/s	0	
Slovenia	n/s	4	
Belgium (Walloon)	n/s	13	
Average	7	5	

Positive progress
No change
Negative
(-) access to service is restricted.
(n/s) no service

In Table 6 the test results of WFS in 2015 and 2017 are presented. The results for WFS are divided into mandatory and optional checks. Test for mandatory requirements has 10 checks and optional has 12 checks. In 2015, nine INSPIRE WFS were encountered and tested. Two countries had restricted access to their service. In 2015, none of the services passed the test 100%. In mandatory part, number of failed checks varied from two to nine. The average was number of failed checks was four. Most of the cases, the test suite, which checked GetCapabilities failed. Specific metadata attributes from external metadata documents were not found. It is similar to the problem, which occurred with failed WMS tests. In the optional part, number of failed checks varied from two to 12. The average number of failed checks was six. In total, in 2015 the average of failed checks was 10. In total, four countries have has less failed test than the average. These countries, who are more compliant than average were Spain, Croatia, the Netherlands and Denmark.

In 2017, twelve WFS links were encountered. In two countries web services were not available. Their services' GetCapabilities query gave errors, which means that web links might be incorrect or services are down. There are countries, which pass mandatory part of WFS tests 100%. These countries are Finland, Spain, Netherlands and Slovenia. In the mandatory part the average number of failed checks is 3. In additional to countries with zero failed checks, Czech Republic had less failed checks than the average. None of the countries pass optional part of WFS tests. In the optional part, the average number of failed checks is 5. In total, seven countries are more compliant than the average services, as they have less failed checks than the average. These countries are: Spain, Croatia, The Netherlands, Denmark, Finland, Slovenia and Estonia.

Also in case of WFS a positive progress has been made in two years. If in 2015, both parts (mandatory and optional) had failed checks, then in 2017, there are countries, which passed mandatory part. The average number of failed checks has decreased in both parts. In total, the average number has dropped from 10 failed checks to 9. In two countries the progress has been negative. In both countries services should be accessible, but they returned errors. In three countries there has been no progress, the number of failed checks is the same. In other eight countries, the progress has been positive. They have less failed checks or they have entirely new services.

Table 6. Number of failed checks of WFS in 2015 and 2017 and progress

WFS	2015			2017			Progress
	Mandatory	Optional	**In total**	Mandatory	Optional	**In total**	
Spain	2	2	**4**	0	3	**3**	
Croatia	3	2	**5**	3	2	**5**	
The Netherlands	4	2	**6**	0	2	**3**	
Denmark	3	4	**7**	3	4	**7**	
Lithuania	3	7	**10**	-	-	-	
Czech Republic	6	10	**16**	2	10	**12**	
Belgium (Brussels)	9	12	**21**	9	12	**21**	
Latvia	-	-	-	-	-	-	
Poland	-	-	-	7	3	**10**	
Finland	n/s	n/s	n/s	0	3	**3**	
Slovenia	n/s	n/s	n/s	0	4	**4**	
Estonia	n/s	n/s	n/s	4	4	**8**	
Belgium (Flemish)	n/s	n/s	n/s	6	12	**18**	
Average	4	6	10	3	5	**9**	

Positive progress
No change
Negative

(-) access to service is restricted.
(n/s) no service

In Table 7 the ATOM test results in 2015 and 2017 are presented. There are 46 checks in total for ATOM service. In 2015, six ATOM service were encountered. Results for UK are absent, because testing and accessing requires paying a fee. Polish web service is restricted to use only by authorized users. None of the services passed the test. Only The Netherlands had less failed checks than the average. Other four countries failed more than half of the checks. Most of the cases Service Feed test suite failed. Mostly it failed to contain a link to itself and did not have a proper language reference (Req 7). Similar problem occurs as with previous services. The metadata links and attributes are problematic in case of ATOM services as well.

In 2017 eight ATOM services were tested. None of the service passed the test. The least number of failed checks has the Netherlands, who has only two. Other countries failed more than half of the checks. The average number of failed checks is 27. Two countries, The Netherlands and Estonia, had less failed checks than the average.

During 2015 and 2017 mostly positive progress can be witnessed. Most of the countries have made positive progress by having less number of failed checks or have made their services available. Only

two countries have not made positive progress. In case of Denmark, the number of failed checks has been increased by one. UK has still not made their service available. The only indication, that shows negative progress, is the average of failed checks. It has increased from 23 to 27.

Table 7. Number of failed checks of ATOM in 2015 and 2017 and progress

ATOM	2015	2017	Progress
The Netherlands	3	2	
Denmark	28	29	
Lithuania	30	27	
Croatia	31	30	
UK (GeoPlace)	-	-	
Poland	-	45	
Estonia	n/s	22	
Czech Republic	n/s	29	
Spain	n/s	35	
Average	23	27	

Positive progress
No change
Negative
(-) access to service is restricted.
(n/s) no service

4.2.4 INSPIRE compliancy according to the survey

In the survey, all 11 participant state that they have separate web-service(s) to fulfil INSPIRE requirements. They elaborate, that separate web-services were created to implement INSPIRE directive, because their own services did not fulfil the requirements. INSPIRE data specification differs from the national data specification, also structure of national data sets is different from INSPIRE.

Figure 30 shows if survey participants estimate their address data to be INSPIRE compliant. From 11 countries seven estimates their data content to be INSPIRE compliant. Two participants are currently working on INSPIRE compliancy and two participants do not have INSPIRE compliant address data.

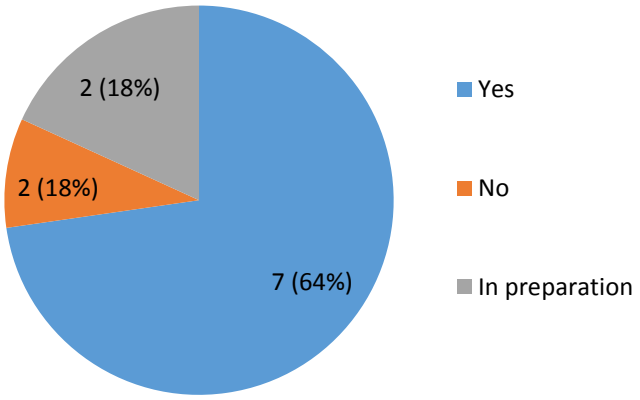

Figure 30. Is the data content (data model) in the service(s) INSPIRE compliant?

According to the survey, only one participant affirmed, that they have changed their data model because of INSPIRE regulations. Germany (Hesse) data model is now simplified, but it is not INSPIRE compliant. Most of other countries stated that their data model is already in line. Estonia mentioned that as there is a separate INSPIRE system and therefore there is no need to make changes in their own data model. France achieves compliancy through transformation of data model. Germany (Niedersachsen) has not made changes, because INSPIRE date model do not fulfil the requirement in Germany. Estonia admits, that in the data model all mandatory fields are filled, but not 100%, not in the level of detail needed and also metadata is not compliant. This contradicts with the information found in INSPIRE reports, where it is stated that metadata and dataset is compliant.

According to the survey INSPIRE data model versions vary from INSPIRE different version numbers to own data model and no data model (Table 8). Countries, which use INSPIRE data model use different data model versions, some use v3.0 and others v3.1. This issue would complicate interoperability.

Table 8. INSPIRE data model version

Version	Country
4.0	Estonia (XML Schema), Czech Republic (XML Schema)
3.1	Sweden, the Netherlands, Czech Republic (Addresses)
3.0	Spain, Denmark
Own data model	French
None	Germany (Hesse), Germany (Niedersachsen)

Organizations were asked to described how they tested if address data model is in line with INSPIRE Directive. All 11 organizations had their own testing strategy. Estonia stated that there is no test for GML structure. Spain used INSPIRE validator. In Denmark their software provider has test it. The Netherlands consulted with national address data experts to assure compliancy. Latvia relies on the fact, that the services are created based on INSPIRE Directive. France tested the compliancy with logical matrix. Germany has not tested their data model. Sweden made manual mapping. Czech Republic used XML schema validation. Based on the survey, all participants stated, that their INSPIRE web services are in line with INSPIRE Directive. They have assured the compliancy by using different validators (INSPIRE, ESDIN Testing Framework and GDI-DE Testsuite), relied on tests made by software company, used pre-made solutions to develop services or made manual mapping.

According to the survey (Table 9), the frequency how often countries update their INSPIRE services varies remarkably, from near real time to once a year.

Table 9. Updating frequency of INSPIRE web services

Frequency	Country
Daily	Denmark WMS (near real time), Czech Republic
Weekly	Denmark ATOM
Every couple of months	Estonia
Once in 6 months	Latvia, Sweden, Germany (Hesse), Poland
Yearly	Germany (Niedersachsen)

4.3 To what extent are the address systems interoperable in non-technical aspects in 2016?

In this section, results of the third research question are presented, which focuses on non-technical aspects of address harmonization. Firstly, the result of semantic compliancy is introduced. Subsequently, overview of legal and organizational aspects is given.

4.3.1 Semantic interoperability

The definition of "address"

In this section semantic compliance of definition of "address" in different countries is compared with INSPIRE definitions. The INSPIRE Directive defines the spatial data theme *Addresses* as the: *"Location of properties based on address identifiers, usually by road name, house number, postal code"* (CEC, 2007). INSPIRE address specification goes in more detail: *"An identification of the fixed location of a property, e.g. plot of land, building, part of building, way of access or other construction, by means of a structured composition of geographic names and identifiers."* (INSPIRE Thematic Working Group Addresses, 2014).

In Table 10 the results of semantic compliance is presented. Definitions in each country is showed and if it is compliant with INSPIRE Directive and INSPIRE Address Specification. "Yes" indicates that it is compliant. "Partly" means that it is partly compliant and "no" means that it is not compliant. INSPIRE Directive definitions focuses on identifiers (road name, house number, postal code) and by that gives an idea, what are address components. A similar approach is found in Finland, Austria and Latvia. They all explain components of an address. In case of Sweden, structure and textual character of an address is described, but specific components are not mentioned. Estonia, Denmark, Belgium (Flemish) and Lithuania does not mention the structure of an address.

The INSPIRE Address Specification definition of an address is more detailed if it comes to the properties. It gives examples of properties, which has an address. The structural component is mentioned as in INSPIRE Directive, however, specific structural components are not mentioned. Sweden, Finland and Latvia focus on structured characteristic and objects, which has an address. Denmark and Lithuania gives a list of objects, but no indication on structure. Austria focuses on structure and attributes, but does not focus on the objects. Estonia and Belgium does not have direct intersection with an address definition from INSPIRE Address Specification.

Table 10. Semantic compliance

	Address definition	INSPIRE Directive	INSPIRE Address Specification
Estonia	An entry or a feature of an object to discover in geographical space (Maa-amet, 2015a)	no	no
Denmark	Identification assigned as a common reference to a definite way of access from the terrain surface to a building (entrance door), a construction or to a developed or undeveloped plot of land (EURADIN, 2008)	no	partly
Sweden	Informal definition: a structured, textual definition assigned as a unique and common reference to a definite way to access to a building (or property) (EURADIN, 2008)	partly	yes
Finland	Street address of building or building project. Structure: street name and street number w/necessary suffixes, postal area code and name and municipality of location (EURADIN, 2008)	yes	yes
Austria	Address contain following attributes: municipality, hamlet, street, postal code, house number, parcel, reference point, census region (EURADIN, 2008)	yes	partly
Belgium (Flemish)	An address is an indirect localisation system. Its position is not described by coordinates, but by numbers and names of field objects. Those objects are easy to find in the field or their coordinates are known. (EURADIN, 2008)	no	no
Latvia	Address is group of address elements (name of administrative territory, village name, street name, house number etc.) with unique identification to find object in geographical area (EURADIN, 2008)	yes	yes
Lithuania	Address is a concrete residential place of a natural person, headquarters of legal entity or location of immovable object in the territory of the Republic of Lithuania. (EURADIN, 2008)	no	partly

As INSPIRE definitions are slightly different, then this is also the reason, why results vary between INSPIRE definitions. INSPIRE definitions are less detailed than countries use. The only exception to it is Estonia, who has even more abstract and broader definition. In overall, address definitions vary in level of detail and there is no exactly the same definition. They are not directly contradicting, but the emphasis is on different topics. Finland and Latvia have the closest definitions to both INSPIRE definitions.

4.3.2 Legal interoperability

From September 2015 until May 2016 a web survey was composed. From September 2016 until January 2017 a web survey was sent to potential participants. 11 responses from 10 different EU countries were received. The detailed results of the survey can be found in https://goo.gl/nzG9R1.

Participants, who filled the survey (country and organization):

1. Estonia - Maa-amet (Estonian Land Board)
2. Spain - National Geographic Institute of Spain
3. Denmark - Danish Agency for Data Supply and Efficiency
4. Latvia - The State Land Service
5. France - Ministry of Environment
6. Germany (Hesse) - Hessisches Landesamt für Bodenmanagement und Geoinformation
7. Germany (Niedersachsen) - Landesamt für Geoinformation und Landesvermessung Niedersachsen (LGLN) - Landesvermessung und Geobasisinformation - Landesbetrieb -
8. Sweden - Lantmäteriet
9. Poland - Head Office of Geodesy and Cartography
10. Netherlands - Cadastre, Land Registry and Mapping Authority
11. Czech Republic - Czech Office for Surveying, Mapping and Cadastre (CUZK)

Law and licenses

According to the survey, only in France and Sweden addressing is not regulated by the law. In other countries it is regulated by the law.

Based on the survey, if user wants to use address data/services, then six participants apply licenses and five do not use any license. Spain and Estonia state, that they do not use license, because it is open data. Czech Republic do not use license yet, because according to the Czech law, license has to be in Czech language. They are waiting for translation of The Creative Commons Attribution 4.0 International (CC BY 4.0).

From those countries, who have licensing, three (Latvia, Germany - Niedersachsen, Sweden) present it in a form of a license agreement signed by all the parties involved. France uses various types of licenses. Germany (Hesse) uses a license sent by letter or e-mail. Netherlands uses a statement on a webpage. In all cases the license is in their official languages and pre-prepared. Almost all licenses mentioned intellectual property rights, except Germany (Hesse), who do not mention them. Only in Sweden the license is based on an INSPIRE Specific license. Other participants' reasons for not using INSPIRE licenses are different: national legislation (Latvia); not known / too complicated / not adapted to French habits (France); not necessary (Germany - Hesse and Niedersachsen); it is open data, therefore uses The Creative Commons license (Netherlands).

In Germany (Hesse and Niedersachsen), Sweden, Czech Republic and Netherlands address dataset contains third party data. In Sweden and Netherlands third party has given consent of intellectual property rights.

In the survey, most of the countries state that address data is provided almost instantaneously. It takes more time in Latvia and Germany (Hesse and Niedersachsen). In Latvia it takes 2 weeks. In Germany (Niedersachsen) it takes up to 3 working days and in Germany (Hesse) it takes a few days to receive the dataset and a few hours to receive the service.

It was asked, how does your organization protect itself against legal liability issues that could come from data mistakes, which could lead to collateral damage and unintended consequences. Participants gave different explanations. Estonia stated that municipalities take responsibilities for data quality. Address data should be taken "as-is". Denmark has made "conditions for use of Danish public sector data" to protect them self. Latvia cooperates with data providers and corrects errors. France do not protect them self, as no legal issues have been reported yet. Germany (Niedersachsen) protects only by general terms and conditions. Sweden uses following mechanisms: Access rights on personal level, rules on object and controls via user interface. In Germany (Hesse) the protection is carried out by agreement. In Netherlands, neither Kadaster nor Ministry of Infrastructure and the Environment are responsible for the content of the data, only for data specifications and data distribution. In Czech Republic, the RUIAN data are authoritative reference data and there is a bona fide (“good faith”) status regarding their quality. However, there are several procedures enabling to claim and to repair possible errors. Originally, the Czech law was enabling to initialize this claiming procedure to public bodies only. Later, an on-line web services would be established and published by CUZK, which enables entering information on errors to everybody. Nevertheless, the replacement of bugs and validation of changes follows the procedures of data maintenance by relevant public bodies and is given preciously by the law.

Access

It was asked, who and how can data be accessed. Sweden said that they have a restriction that address data can be accessed only for educational use and public sector and not allowed for business purposes. Spain stated that address data and services can be accessed for free. Latvia and the Netherlands said that fees apply in case of commercial use. In France address data is for free and for a fee. France pointed out that in some cases fee is added, because some of address databases are from private sector.

The organizations stated that fees are calculated based on cost of human resources (Latvia), coverage of the workflow cost (France), derivate from fees of cadastral data and costs for third parties (Germany - Niedersachsen), the fees of the original data (Germany - Hesse) or the additional cost of distributing the data to non-government users (Netherlands). In France and Germany, there is no explanation to the user of the basis for charges and the factors taken into account. In the Netherlands and in Latvia, the basis of charges is written in the law or in the Cabinet of Ministers Regulation.

4.3.3 Organizational interoperability

Number of datasets

According to the survey made, there is a single central address reference database is in 7/11 cases. Others do not have one central database because: "History and lack of quality of existing databases", "depending on the use case and also on the administrative level there are more than one database", "legal conditions", "each federal State has the address data, but there is a central organization, that collects and distributes the different databases".

Workflow

Participants stated that the most common workflow (Figure 31) is, where merging, harmonisation and migration takes place on national level and from there data is distributed to all levels. Estonia, Denmark, Sweden, The Netherlands and Czech Republic claimed this to be their workflow. Poland also chose this flow, but in addition mentioned, that data distribution is from local to local and also from local to regional. Spain pointed out that they have a mixture of different workflows. Latvia chose a model similar to the most common, but georeferencing takes place on national level. Germany (Hesse) chose model, where merging harmonisation and migration takes place on regional and national level. Germany (Niedersachsen) chose model, where merging harmonisation and migration takes place only on regional level.

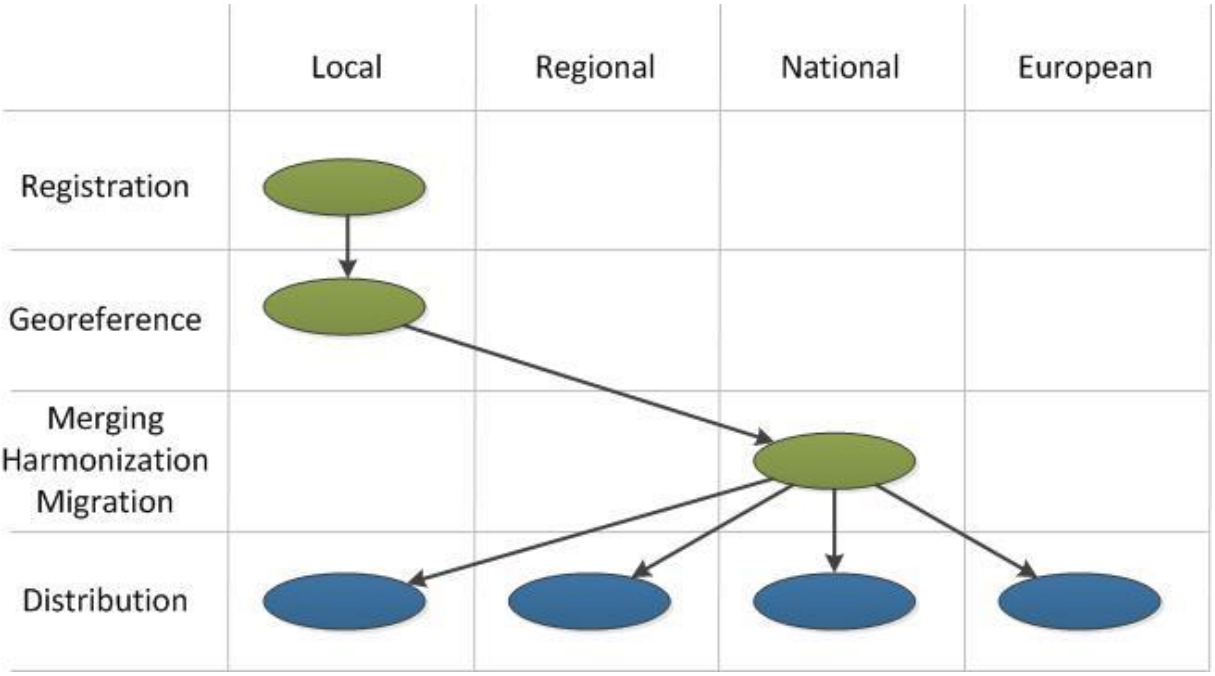

Figure 31. State workflow

Two participant told that they have changed their business processes / workflow because of INSPIRE regulations. Germany (Hesse) has defined a new workflow for INSPIRE. In Czech Republic, the INSPIRE datasets are generated via the publication database, plus specific additional arrangements related to means of publishing are needed. Those countries, which have not made changes, had different reasoning. Estonia aim is to serve public sector in Estonia. If any changes are made, then it

should be because of national need. In Spain, Denmark, Germany and Sweden business processes / workflow is already in line with INSPIRE regulations. In France changes will take place in future.

Business model

In most of the countries the organizations are sponsored by the government. Based on the survey funding/business model is in 9/11 cases 100% sponsored by the government (Figure 32). In one case it is government-owned company and in one case funding is mixed: 85% tariff based, 15% budget financed.

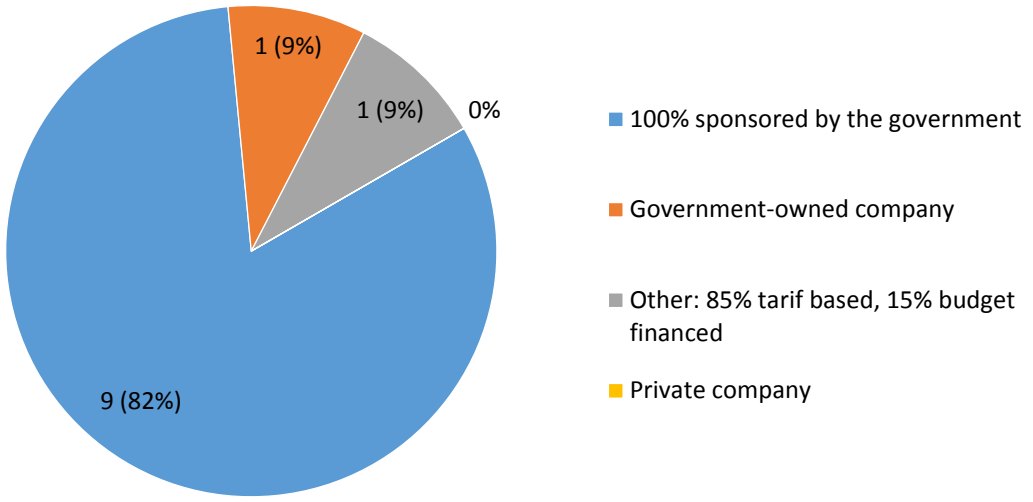

Figure 32. What is your organization's funding model/business model?

Main user of address data services

Most frequently mentioned main user of the address data products is public sector (five countries mentioned it). Other mentioned users: delivery of packages, transport of persons, rescue, geomarketing companies. Sweden describes target user in detail, The Swedish Tax Agency (Skatteverket). There were wider answers also: Denmark: "We do not know who is using INSPIRE address related services"; Latvia: "Private and public sector, anyone who is interested in to use address data".

Data owner, establisher and manager

According to the survey, 10 out of 11 responses, address data is owned by public sector. France answered that their address data ownership is "mixed". Address data is owned by organizations, which are closely related to spatial data. Common attributes are cadastre, land, surveying, mapping, geodetic (geodesy), and topography. According to survey (Figure 33), main function of the organization is related to land themes (Cadastre management, Land survey, Mapping, Topography) in

10 cases. None of the participant's organization main function is postal office. One organization's main function is related to environment - France Ministry of Environment.

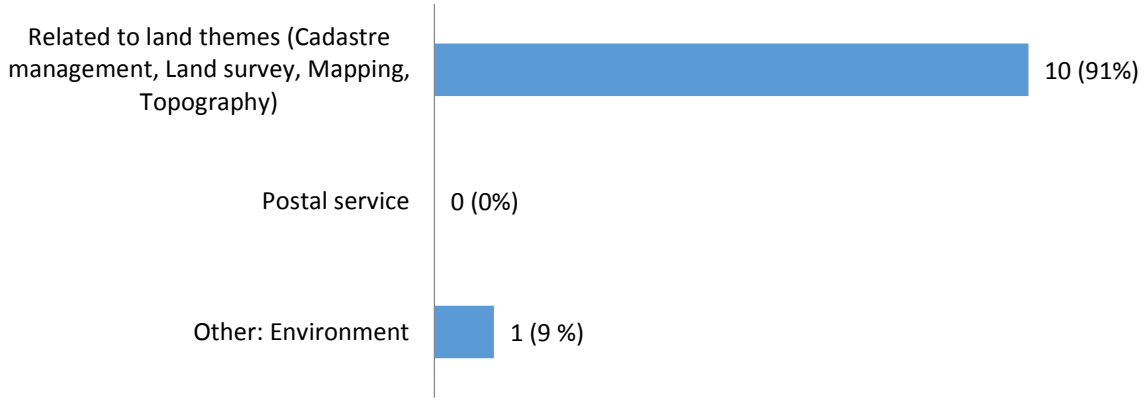

Figure 33. What is the main function of the organization?

Survey focused on different activities through address data creation: establishing, maintaining data, managing services. In this research, establish means to create new address data, maintain means to manage existing address data and manage services is to manage web services. Survey both participants from Germany establishes address data, others do not establish address data. Address data establishers in Latvia, Denmark, France and the Netherlands are municipalities. In Spain, the Councils establish address data. In addition to the municipalities, tax administration, Mail Office and national mapping agency establish addresses in France; building authorities in Czech Republic.

Those nine countries, who do not establish data, specified in the survey how is the relationship stated with the establisher (Figure 34). In most cases the relationship is stated by the law. As in France there are various establishers, there are also various types of relationships. In Sweden the relationship is stated by the contract. None of the countries have stated the relationship with a license.

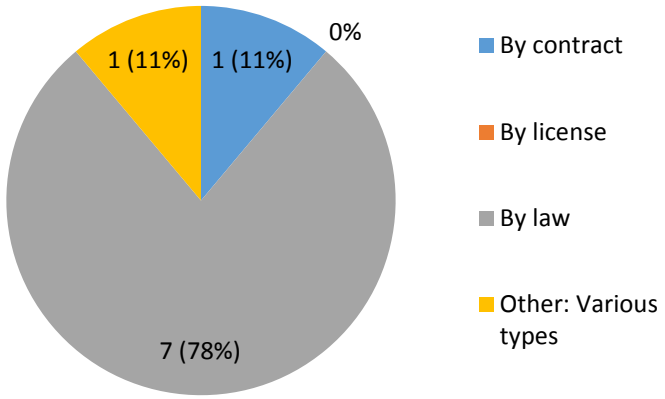

Figure 34. How is the relationship with the data establisher stated?

8 of 11 participants themselves maintain address data. In Denmark, France and the Netherlands the municipalities maintain address data. In France, in addition to municipalities, firemen, Mail Office, Tax Administration and National Mapping Agency (IGN-F) also maintain address data. In case of Denmark and the Netherlands the relationship with the manager is stated by the law. In France the relationship is stated by various types.

In the survey, the focus was also on the manager of web services and aim was to find out if participant organizations manage their web services. Four out of eleven do not manage their web services. In case of those for relationship with the manager is regulated by contract (Estonia, Germany (Hesse)), by law in Latvia and through coordination in France.

It was asked, if there is information available (e.g. on a web page, public document) on how address data are collected, processed and can be obtained. 7 participants state that this information is available. Three countries (Spain, France and Germany (Niedersachsen) tell, that this information is not available.

Organizations and INSPIRE

National contact point in charge of fulfilling INSPIRE Directive exists in all countries (Figure 35). There were two participants from Germany, one mentioned, that there is a single responsible organisation, but other marked, that there is not a single responsible organization, because of legal conditions in Germany.

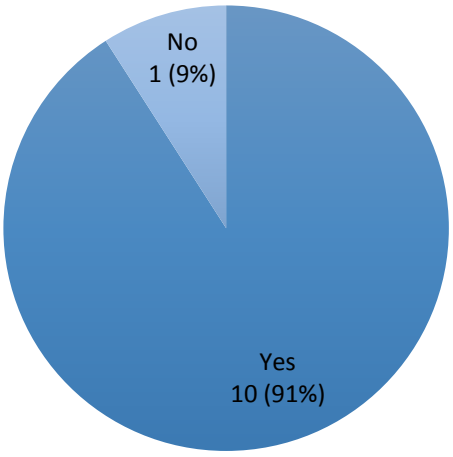

Figure 35. Do you have a national contact point or any other single responsible organisation in charge of fulfilling INSPIRE Directive?

It was asked, how participants relate with INSPIRE Directive and specifications. Not all participants were included in the early stages of INSPIRE formulation, like Estonia, Germany (Niedersachsen), Germany (Hesse) and Czech Republic. Estonia did not use this opportunity, because they did not have human resources. In Germany the central organization ("Koodinierungsstelle GDI-DE") was involved and informed participants of this survey. In Czech Republic, there was another representative from the Czech Republic participating in the Address drafting team. That representative participated in the

RUIAN (Czech address system) preparations too. Czech Republic stated that INSPIRE needs are not equal to public administration tasks (and historic continuity) in the country. These particularities go beyond the INSPIRE in the field of addresses.

Almost all participants received training regarding to INSPIRE Directive (in general context), except Germany (Niedersachsen). The number, who had raining regarding to INSPIRE Directive (about addresses data specification, data model, etc.) is smaller. Estonia, Denmark, Germany (Niedersachsen), Germany (Hesse), Netherlands, Czech Republic did not receive any training regarding to INSPIRE and addresses.

Based on survey, most of the organizations are involved with INSPIRE work groups, like TWG Addresses, TWG Geographical Names, MIG-P, MIG-T, TWG Buildings and TWG Area Management. Germany (Niedersachsen) and Germany (Hesse) do not participate in INSPIRE work groups, because the "Koodinierungstelle GDI-DE" does and informs them. Those, who participate in work groups are motivated by influence, knowledge exchange, networking, gained experience, being in charge of INSPIRE negotiation and implementation, sharing national views and expertise, learning from other countries, promoting interoperability and advocating policy decisions that are not in conflict with any country's national interests, understanding the context and common direction. Almost all participants of the survey have followed/used INSPIRE Address Specification. Only Germany (Hesse) states that the implementation of INSPIRE Address specification is required not till then 2017.

It was asked if organizations had or they are currently having difficulties with address data harmonisation related to INSPIRE Directive. Most of the organizations are not currently having difficulties. Estonia and Germany (Niedersachsen) mention, that they are having technical problems. Germany (Hesse) has not finished harmonisation.

In addition, the survey focused on issues country had in the past. During the address data harmonisation most common problems were related to technical, legal and political issues. Participant from Estonia states that the problem is that countries interpret specifications differently. Furthermore, address data is closely connected with several other topics (cadastre, administrative units) and it makes it complicated. For Germany (Niedersachsen) harmonisation is difficult because there are big differences between source data model and target model. The Netherlands had in the early beginning some technical issues in getting the service up and running and also in producing INSPIRE-compliant data. They fixed the issues and the services have been running smoothly ever since. In Czech Republic there are following problems: some of the addresses (about 2.5 %) does not have definition point. There was a long period of preparations to have the base registry (RUIAN) and the whole complex of Czech base registries defined, politically supported, formally established, legally underpinned and to gain enough financial support for this rather ambitious goal and the specific project. For Czech Republic the INSPIRE implementation was not so easy, but it was just an added value to the entire framework of Base registries in the Czech Republic.

In the survey participants had opportunity to add some extra various thoughts. France stated that postal address does not fit for digital uses. They will soon propose to work on something to give up postal address and get a grid instead. Sweden mentions that there is low use of existing services.

5 Discussion

This chapter discusses and reflects on performed research. First, the results of different interoperability aspects are discussed and findings of this research are compared with other sources. Secondly, reflection on chosen methodology is offered and limitations of this research are presented.

5.1 Results

Technical aspects

Results of this thesis indicate that technical harmonisation is rather slow process. The deadline for discovery services, view services and download services to be available in the INSPIRE geoportal was in 2012. Even though the deadlines to harmonise Annex I data and disseminate it through web services have passed, there are nine countries of the 28 do not have any web services. From web services, the most common is CSW, followed by WMS and least common WFS/ATOM. It might be explained by INSPIRE deadlines, as the deadline for view services was before download services. Also the reason might lie in a fact, that disseminating data via WMS is technologically easier, less complex than WFS. The popularity of WMS can also be explained, by the fact, that WMS protects your data and the re-use of data is more limited, than in case of WFS. Project ELF preliminary results regarding to addresses in 18 countries show, that most popular web service is WMS and it is followed by WFS. These results correspond with results of this research also.

By November 2017 all address services should be harmonized. In April 2017 only few services passed the technical tests 100%. There are few months still to improve services, but probably in the end of the year all services will not pass the technical tests. During 2015-2017 new web services were made available. Technical tests revealed that these new services had better results, than services, which had been existed already number of years. Recently added services had less failed checks than most of the “old” services. This might be evident of improvement in developing web services. Knowledge, experiences and tools are better than before and new services are from the beginning more in line with INSPIRE requirements.

Even though addresses services exist and are findable, during this research, it seemed that address data is not easily attainable. In a case an user, would like to re-use all addresses in European Union to develop a product, them several obstacles would raise. INSPIRE Geoportal Discovery can give too many responses, like it happens with German addresses. As harmonization in Germany takes place on regional level and is distributed from there, then INSPIRE geoportal search gives over 400 responses for addresses. This amount of responses makes using the data difficult and is not really usable. EURADIN gives recommendation: "There should be a single national “official” address reference database". Only 13 countries (47%) have a single national address reference database. If other countries would follow this recommendation, than INSPIRE Geoportal Discovery would find only one response for each type of web service.

There are opposite example to too many responses. INSPIRE Geoportal can give too little information or it is absent. In these cases it is wise to check countries’ geoportals. These geoportals have more up

to date information. Often there are contradictions between geoportals of the countries and INSPIRE geoportal. They refer to different web service links and in the end it is difficult to understand, which is correct. Often it seemed, that INSPIRE geoportal Discover service is not up to date. It can be result of not frequently updated CSW.

Often countries had their own address systems before INSPIRE Directive. In the INSPIRE Reports, Estonia also stated, that the current information systems were created to perform certain tasks and they do not correspond to new needs and new data models. It means that often a separate parallel system for INSPIRE is created and compliancy is achieved through transformation of data model. In recent discussion in INSPIRE Thematic Clusters Address group helped to reveal the reasoning why separate systems were created. It is because countries' current address systems are more complex than INSPIRE data model (INSPIRE Thematic Clusters, 2017). One of the survey participant stated also that INSPIRE date model do not fulfil the requirements in their country. In addition, in the INSPIRE report Spain mentioned, that the application of the scheme proposed in INSPIRE data specifications would entail a loss of information. Having a separate system means that countries have to maintain two different systems. It consumes extra financial and human resources. INSPIRE address data model should be expanded, so it would fit with needs of the EU member states and in the future, countries could maintain only one system. Countries, which currently do not have a central address systems could benefit from INSPIRE Specification. They could use it to build their system that would already be INSPIRE compliant.

EURADIN recommends that "The dataset must be comprehensive, up-to-date and fit for the purposes of central and local government". It is difficult to estimate, if datasets are up-to-date, as no timeframe is given in the recommendation. CEC (2010a) states that data should be updated in regular basis, at the latest 6 months the change was applied in the source data. The results of this research show, that the frequency how often countries update their INSPIRE services varies remarkably, from near real time to once a year. It means that probably INSPIRE Directive, regarding to update times, is not followed in all countries. In INSPIRE Reports Spain mentions this also as an obstacle, there are different times at which the data are updated and the different environments in which these data are collected in different regions/countries. By combining data from different countries the updating frequency affects data quality.

Non-technical aspects

Mohammadi, Rajabifard, et al. (2006) have stated that non-technical issues seem to be more problematic than technical issues. Unfortunately, INSPIRE helps mainly to overcome technical interoperability issues. The results of this research also show, that there are list of non-technical issues, which still need to be solved and harmonised. The biggest gap is in licensing, legal issues and in organizational management. INSPIRE should focus more on non-technical aspects. Most common barriers based on INSIPRE reports produced by countries are also related to legal and organizational issues. Less mentioned are technical and social issues.

Based on the survey, all licenses are in local languages. One participant of the survey pointed out, that because of the law the licenses have to be in local language. This might be the case in other countries as well. Aim of the INSPIRE is cross-border cooperation, but if licenses are in different

languages, then it is hard to use this data. Next to license in local language there should be one in English. Another problem with licenses is the variety. The form of license and also the content can differ. The form of the license can be from a license signed by all parties to a statement on a webpage. The licenses are based on different international standards or based on their own standards. INSPIRE has prepared licenses, which could help to harmonise licensing, but only one of the survey participants uses INSPIRE license. INSPIRE license is not used by other participants, because of national legislation or it is not known / too complicated / not adapted to local habits. Next to INSPIRE license a good option could be CC BY 4.0 license. Two participants mentioned using CC. If type of the standards would be harmonised, then less time could spent on understanding legal constraints of each license and data would be more usable and manageable.

Not all countries have one central address dataset. An observation was made, that a country is more prone to have more than one dataset, when different parts of the country have higher independency and equal responsibilities. Political systems, which have higher degree of self-governance are federations, federacies and devolved state countries (Wikipedia, 2015b). Table 11 shows countries, which are federation, federacies and devolved states and how many address datasets they have. Officially Denmark and The Netherlands are federacies, as they have parts of the country outside of European, but they have one central address data system. Austria is a bit different exception, where the whole country is in Europe and it is a federation, but has a single dataset. It might be explained by the fact, that Austria is quite small country compared with other federations and devolved countries. Croatia is also an exception, as it has one central dataset and multiple regionals and at the same time it is unitary. It can be explained by the on-going progress of harmonization. Other countries, with higher degree of self-governance, have more than one dataset. It shows a correlation between number of datasets and political system.

Table 11. Datasets per country and self-governance

		Self-governance			
		Unitary	***Federacy***	***Devolved***	***Federation***
Number of datasets	***More than 1***	Croatia	Finland, France	Italy, Spain, United Kingdom	Belgium, Germany
	One	Czech Republic, Estonia, Ireland, Latvia, Lithuania Luxembourg, Poland, Slovakia, Slovenia, Sweden	Denmark The Netherlands	-	Austria
	Less than 1	Bulgaria, Cyprus, Greece, Hungary, Malta, Portugal, Romania	-	-	-

Aim of the INSPIRE Directive is also to encourage private sector to create value added products. EURADIN (2010b, pp. 15-16) recommends also “The basic data should be free or available at the marginal cost of distribution”. Currently several countries restrict free use of address data by asking fee for data use. Or in some cases address data is available only for educational and public sector

use. Restrictions show, that using address data in by private sector is not always so welcomed. Participants of the survey explained the need for restrictions, because dataset contains third party data. Based on the survey, if a fee is applied then it is calculated based on cost of human resources, coverage of the workflow cost, derivate from fees of cadastral data or costs for third party data.

In some cases, the business model of organization can also affect existence of fees. If organization is not sponsored by the government, then they have to finance themselves by applying fees. Based on the survey not all organizations are 100% sponsored by the government. This goes against EURADIN (2010b, pp. 15-16) recommendation "The process should be sponsored and controlled by the Public Sector". In most of the countries addressing is controlled by public sector, but the financing is more complicated. According to INSPIRE Reports, Greece, Hungary and Portugal has mentioned sponsoring as a barrier to open data. In Greece, public limited liability companies are main data owners and are not willing to open data. Also some public authorities, who generate data, sell data even to other public authorities. In Hungary, land administration sector costs are covered from data sales revenues. It means that to offer address data for free, then central government should give financial resources also to the organizations, whose income depended on selling data. This recommendation was made also in INSPIRE state reports.

There are seven EU countries, which have not indicated any address data set or they have rather limited datasets. Four of the countries entered to the EU in 2004 or 2007, quite recently. It might help to explain, why they are behind. In case of three countries, the entry year to the EU seems not to be relevant. According to INSPIRE state reports most common barriers are lack of different resources (financial, human, knowledge), the spatial information is decentralised, lack of a government policy on spatial information and financial models, which expects to cover organizational costs from data sales revenues. These seven countries probably suffer under these issues as well. Countries with limited datasets might have problems (also mentioned in INSPIRE state reports) with diversity of datasets, formats and low data quality.

European Commission (2010a, p. 27) recommends that "Public administrations should lead or actively participate in standardisation work relevant to their needs". INSPIRE state reports mention that cooperation on national and international level could help to overcome barriers. According to the results of the survey, not all participants were included in the early stages of INSPIRE. This opportunity was not used, for example, lack of human resources. Additional financing could from central level could have helped with it. Fortunately, now most of the countries are actively participating in the work groups.

INSPIRE has directives, which are legally binding. To help to fulfil these laws INSPIRE has created several guidance documents (like INSPIRE Technical Guidance, Address Specification), which are not legally binding. There are no hard compliance guidelines. Based on the survey, almost all participants have followed/used INSPIRE Address Specification, which is good indication as it is not legally binding. Technical guidance documents are important to follow, because they can help to assure the interoperability, but every country makes their own modifications and interpretations to the technical guidelines. Few participants of the survey mentioned, that they have adjusted INSPIRE guidelines based on their own needs. Another participant mentioned this also as an obstacle, which could decrease the interoperability. INSPIRE gives freedom to the member states, but in the end how

can interoperability be reached, if the directions of interpretations are opposite? Recommendation for the future, after INSPIRE Directive, there should be new directive or a project, that would continue the work of INSPIRE and would help to include mandatory technical guidelines and more help with non-technical aspects.

5.2 Methodology

Involving all 28 member states made this research sometimes difficult to handle, as systems, languages, approaches varied between countries. In most cases, there was not any local insight to different EU countries. Coetzee et al. (2010) mention that addresses vary from country to country, because they are closely associated with the geographical location, culture, race, religion and language. Based on that statement and this research experience, a note can be made, that to understand the addressing accurately in different countries, then one should understand culture, religion and language. This indicates that if the most accurate overview of addresses is wanted, then a group of experts from all EU member states should be included. Current thesis did not involve experts from different EU countries.

The validity of collected data is important issue. From the collected data, the characterization of the address datasets might have shortcomings. As mentioned previously, the researcher did not have local insight to all countries. It would have helped to allocate errors and problems. The data relies on multiple sources, which can lead to interpretation mistakes and missing values. It was hard to estimate credibility of the sources. To acquire information in other languages Google Translate was used, but this is not considered a "bulletproof" tool. Some information might have been lost in translation.

Some of the countries have multiple address datasets, which have different characteristics and also their web services' compliancy vary. One of the aims was to make conclusions based on member states. To accomplish it, collected values and characteristics of multiple datasets were aggregated. Data aggregation slightly distorted the results, as after aggregation, they do not describe the situation fully. For example, in case of datasets' metadata compliancy (based on INSPIRE Monitoring), in Italy 61 datasets were indicated, 60 of them were compliant, but in statistics it was expressed in a "partly" class. In another example, if only one dataset was compliant from a list of datasets, then it was also expressed in a "partly" class. These examples show, if aggregation is used, then the values might not be equal.

11 participants from 10 different countries filled the survey. This is only a bit more than 1/3 of the EU countries. It means that quantitative analysis was not reasonable method and mainly qualitative analysis was made. Even though generalization of the results is not suitable, it still helped to give insight to different issues thanks to open questions. It helped to answer questions, which were difficult to answer using only secondary sources.

The survey had questions about topics, which were already collected in previous research stages (e.g. question about available web services). These questions were needed to give context to the participant and to validate previously collected data. Participants were not aware, what data has been collected already. Another weakness of web survey is that participants could have been

interpreted some questions differently. Interviews might have helped to avoid this by elaborating questions. Survey structure was quite complex, it consists of 49 sections and ha skip logic built in, which directed to different branches based on answers. Certain questions leaded to next questions, which asked to elaborate previous answer. It definitely helped to reveal extra information, but it was still a strict structure and it could not foresee all possible answers. This effect would also be avoided by human contact and interviews. In the introduction of the survey, it was mentioned that it takes approximately 20 minutes to fill. One of the participants said it was not accurate time estimation, it took longer.

To estimate the progress of metadata and dataset compliance INSPIRE Monitoring reports from 2014 and 2016 were used. In some cases Monitoring reports from 2016 were missing or in the reports there was information missing about address datasets, which might have distorted the results. The reason, why there are missing reports, might be that INSPIRE Monitoring changed the format from Excel to xml and all countries have not adopted yet.

For testing the web services SoapUI and ETF were used. During ESDIN project ETF was developed for this specific reason, to help to validate web services during the development process. In some cases countries use it also. The use of SoapUI might not have been common, because it is not intuitive and at first, it is not easy to use. The tests showed only, if specific Test Suite failed or not. If it fails, the reasoning has to be made by the user, as the tool does not highlight, what exactly is wrong. This issue is currently being addresses as part of another EU project, European Location Framework (ELF). For testing, a web based environment is being developed. Hopefully, it will be used more frequently and then simple human errors could be avoided. There are other limitations with this testing tool. It tests the existence of metadata and how web services fulfil certain technical requirements. It does not test the compliancy of the data model, output GML structure. SoapUI and ETF tests are against the INSPIRE Technical Guidance. As it is not legally binding, then results of these tests cannot be used to make conclusions about fulfilling the INSPIRE Directive. The results show how compliant the web services are according to INSPIRE Technical Guidance. SoapUI gives also an opportunity to test INSPIRE performance requirements. These were not carried out, because usually they are run with permission of the organizations. During performance tests numerous requests are made, which can choke the service.

By comparing results with other projects, ELF and EURADIN, in some cases differences are found. ELF reports that 41% of address data can be accessed free of charge and 36% of address data is partly free. 23% of the datasets can be accessed with paying a fee. These results are more optimistic than outcomes of this research, where in 2017, 25% can accessed for free, 29% is partly free, 14% with paying fee, 7% has no access at all and 25% do not have any dataset. Main reason for the difference might be the methodology. In ELF project 18 countries were involved, but this research focused on all 28 countries. Those countries, who had less to share, probably would not participate in ELF project. This research included also countries to the statistics, which do not have access at all.

6 Conclusions and recommendations

In this chapter, the research questions are presented and based on previous chapters, conclusions for each questions are drawn. In the last part, the recommendations for further research and practitioners are made.

6.1 Conclusions

1. **How are addresses in all EU member states managed, accessed and supported by tools and services?**

The European address systems are heterogeneous. They have different data owners, managers, responsible bodies, content, formats, access policies, tools and services. Variations between countries are remarkable.

In European Union member states addresses are managed in zero to multiple dataset. From 28 member states, in case of four countries (Bulgaria, Hungary, Malta and Romania) no indication of public address dataset was found. Three countries (Cyprus, Greece and Portugal) have only regional datasets, which do not cover the whole country. 13 countries have a single central dataset. Eight countries have multiple datasets (the UK, Germany, Croatia, Finland, France, Italy, Spain, and Belgium) that cover the whole country. An observation was made that country is more prone to have more than one dataset, when different parts of the country have higher independency and equal responsibilities. Address data is mostly owned by public organizations, which are closely related to spatial data collection and management. Common attributes in the titles of the organizations are: cadastre, land, surveying, mapping, geodetic (geodesy) and topography.

Access to address dataset varies between countries. In 2015, seven countries (25%) had not indicated any central address dataset. Four datasets (14%) did not have any access. 18% can be accessed by paying a fee. 21% of datasets offer some services for free, but in some cases a fee applies. 22% of the address datasets can be accessed for free without any constraints. The access has improved in two years. In 2017, 25% of different address datasets is free to use. 29% of address datasets have products for free and for a fee. 14% can be used for a fee. 7% have no access and 25% have no dataset. By comparing access to address datasets in 2015 and 2017 positive progress has been made. There are more data for free and there is more address data has been made accessible.

Address data is offered in different formats and via different services. Next to basic address dataset, sub-sets are offered for the private and public sector. The content varies by including or excluding geographical coordinates, historical information, and type of an address (business or residential). Often there are different formats to choose from, like XML, CSV, ASCII, DBF, JSON, SHP, FGDB, DWG, GML, MIF/MID (MapInfo). From spatial formats, ESRI SHP is the most common. It is followed by GML, which is recommended by INSPIRE. Different web services are used, such as WMS, WFS, WMTS, ESRI REST, ATOM feed, WPS, WMS-C and WMS-T. The most unique service found was an API, which helps a user to find searched address and at the same time information system can save this address in machine readable format.

2. How has the compliance with INSPIRE technical requirements of address systems developed between 2014 and 2017?

The compliance with INSPIRE technical requirements of address system between 2014 and 2017 has been positive from all angles. Address datasets and their metadata, existence of INSPIRE web services and technical compliancy of INSPIRE web services has improved.

Address datasets and their metadata are more compliant. During 2014-2016 five more countries have compliant dataset. The change has been mainly on account of datasets that before were not compliant. Positive change can be seen also with metadata of address datasets. Metadata have become more INSPIRE compliant. In two years, two more countries have INSPIRE compliant metadata. The change has been mainly on account of metadata that was before partly compliant.

During 2015-2017 countries have made more web services available, which have had positive impact on access to address data. Some countries have expanded available services, added ATOM next to WMS and WFS or in another cases made first steps to make address data publicly available with WMS and WFS services. In total, one country has added CSW. Four countries have added WMS and WFS services. Three countries more have now ATOM services.

During 2015-2017 web services have become more compliant with INSPIRE technical specifications. Countries, who have added completely new services, fail less checks, then services that existed already 2 years ago. In case of WMS, eight countries have less failed checks in 2017 than in 2015. In five countries the situation has not changed. Either they have the same amount of failed checks or they were still not accessible. In five countries the situation has deteriorated, as the number of failed checks have increased or the access to WMS has restricted. In case of increased failed checks, the changes has been rather minor, the number of failed checks increased only by one. In overall, during 2015-2017 the average number of failed checks has decreased from seven to five, which means that WMS service are more compliant in 2017 than they were in 2015.

Also in case of WFS a positive progress has been made in two years. If in 2015 both parts, mandatory and optional, had failed checks, than in 2017 there are countries, which passed mandatory part. The average number of failed checks has decreased in both parts. In total, the average number of failed checks has dropped from 10 failed checks to 9. In two countries the progress has been negative. In both countries services should be accessible, but they returned errors. In three countries there has been no progress as the number of failed checks is the same. In other eight countries, the progress has been positive. They have less failed checks or they have entirely new services.

With ATOM services mostly positive progress can be witnessed. Most of the countries have made progress by having less number of failed checks or have made their services available. Only two countries do not have positive progress. Either the number of failed checks has been increased by one or they have not made their service publicly available. The only indication, that shows negative progress, is the average of failed checks. It has increased from 23 to 27.

3. To what extent are the address systems interoperable in non-technical aspects in 2016?

European Union member states have non-technical (semantic, legal and organizational) issues, which keep address systems from being interoperable. The biggest gap is in licensing, legal issues and in organizational management.

The semantics of address definitions were compared with INSPIRE definitions. The definitions vary in the level of detail. INSPIRE definitions are less detailed than countries use. The only exception to it is Estonia, who has an even more abstract and broader definition. The definitions are not directly contradicting, but the emphasis is on different topics. None of the definitions are entirely the same as INSPIRE definitions. Finland and Latvia have the closest definitions to a definition in INSPIRE address specification.

Not all countries apply licenses to use address data. Those countries, which have licenses, have them in local languages. The form of the license varies between countries, from a license signed by all parties to a statement on a webpage. The licenses are based on different international standards or are based on local standards. The usage of INSPIRE license and CC BY 4.0 license was mentioned. INSPIRE license is not used by other participants, because of national legislation, it is not known, too complicated or not adapted to local habits.

Not all organizations in charge of address data distribution protect themselves against legal liability issues that could come from data mistakes, which could lead to collateral damage and unintended consequences. Participants gave different explanations. One participant stated that there is no direct protection and data should be taken “as-is” or another explained, if mistakes are found, they will be corrected. Some of the countries have protected themselves with conditions in the licenses.

Organizations in charge of managing addresses are different. They have different business models and workflows. The most common workflow is, where merging, harmonisation and migration takes place on national level and from there data is distributed to all levels. In most of the countries, the organizations are sponsored by the government, but there are cases, where organizations are government-owned companies or their income comes partially from selling data. This can directly affect existence of fees. If organization is not sponsored by the government, then they often finance themselves by applying fees to data access.

6.2 Recommendations

Recommendations for further research

More research could be performed to test how compliant EU addresses are according to the INSPIRE requirements. In cooperation with partners, performance tests of INSPIRE web services could be made. Further investigation can be made on address databases and data models, to check if they are compliant with INSPIRE address data specifications. To make test results of SoapUI more understandable, the web services could be checked with desktop software, like QGIS, ArcMap. This

would help to translate failed test suites into possible problems, which might occur when the services are actually combined.

One of the participant of the survey mentioned that there is low use of existing services. This topic can be researched further. How frequently are INSPIRE web services used? In case they are under used, what might be the issue?

Recommendations for practitioners

The results of this research show, that there are many technical issues, which still need to be solved and harmonised. The biggest challenge is licensing, legal issues and in organizational management. INSPIRE helps mainly to overcome technical interoperability issues, but there should be more focus and help on legal and organizational issues.

Actions, which could help to overcome barriers to data sharing, are cooperation on national and international level. National work groups focusing on different topics and themes, like adapting the need of INSPIRE Directive to local legislation, agreements between stakeholders, strong help and guidance from central level would help to overcome barriers. If adapting INSPIRE Directive requires additional and new tasks from public authorities, then additional financing should be supported from central level.

There is a need for harmonised geo-licences. Using INSPIRE licenses or CC BY 4.0 could be one of the solution. First step is to have a license for data owners to protect themselves. Second step, the license should be translated to English (or to more widespread languages) and finally harmonise the form of license, for example, a statement on web page.

Multiple sources indicated that there are problems with INSPIRE address data model. Current data model do not fulfil the needs of member states country, it can entail a loss of information. INSPIRE address data model should be expanded, so it would fit with needs of the EU member states.

Maybe it is impossible task to create a data model, which would fit for all EU countries. Maybe on European level totally different system and standard should be used. France stated in the survey that postal address does not fit for digital use. They will soon propose to work on something to give up postal address and get a grid instead. Maybe the classical postal address time is over and new initiatives, like what3words, will take over or postal addresses will be used together with grid approach.

Another possible direction towards harmonised addresses is to create The European Gazetteer Service API. During EURADIN project The European Gazetteer Service was made as a pilot project. In the most recent EU project, ELISE, one of the aims is to create an EU gazetteer. Gazetteer Service API would be similar to the ones in Estonia and Denmark, only it would contain all EU official addresses. Gazetteer Service is based on web services from different countries. This API could be used by information systems, where European addresses are processed and saved. User of the information system inserts his/hers address in free format, system offers existing addresses, user chooses the correct and system saves the address in standardized format.

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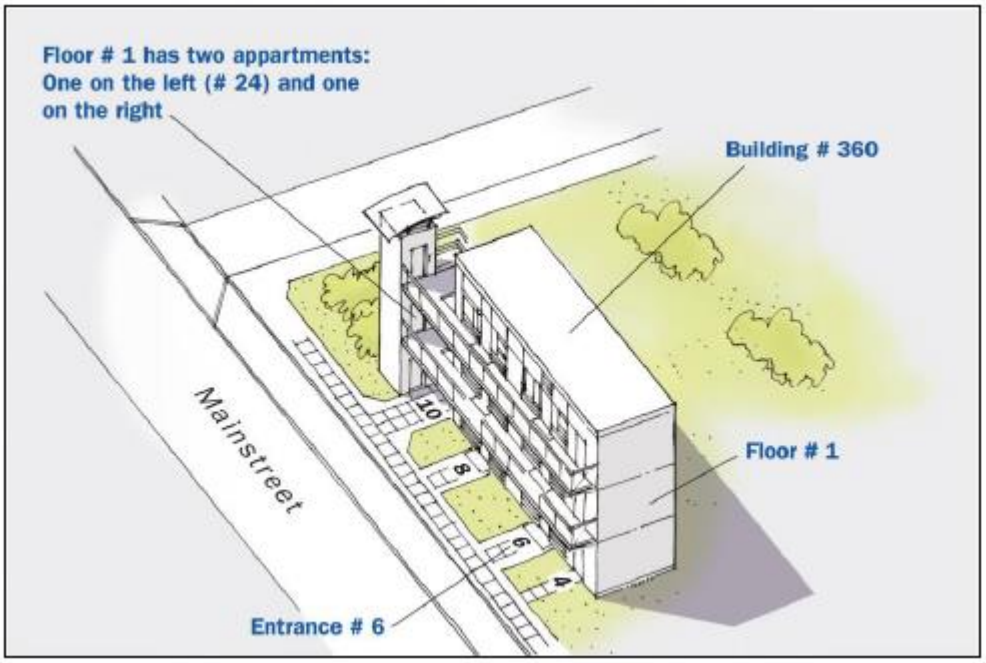
Appendices

Appendix A: 28 members states of EU

	Country	Year of entry to EU
1.	Austria	1995
2.	Belgium	1958
3.	Bulgaria	2007
4.	Croatia	2013
5.	Cyprus	2004
6.	Czech Republic	2004
7.	Denmark	1973
8.	Estonia	2004
9.	Finland	1995
10.	France	1958
11.	Germany	1958
12.	Greece	1981
13.	Hungary	2004
14.	Ireland	1973
15.	Italy	1958
16.	Latvia	2004
17.	Lithuania	2004
18.	Luxembourg	1958
19.	Malta	2004
20.	Netherlands	1958
21.	Poland	2004
22.	Portugal	1986
23.	Romania	2007
24.	Slovakia	2004
25.	Slovenia	2004
26.	Spain	1986
27.	Sweden	1995
28.	United Kingdom	1973

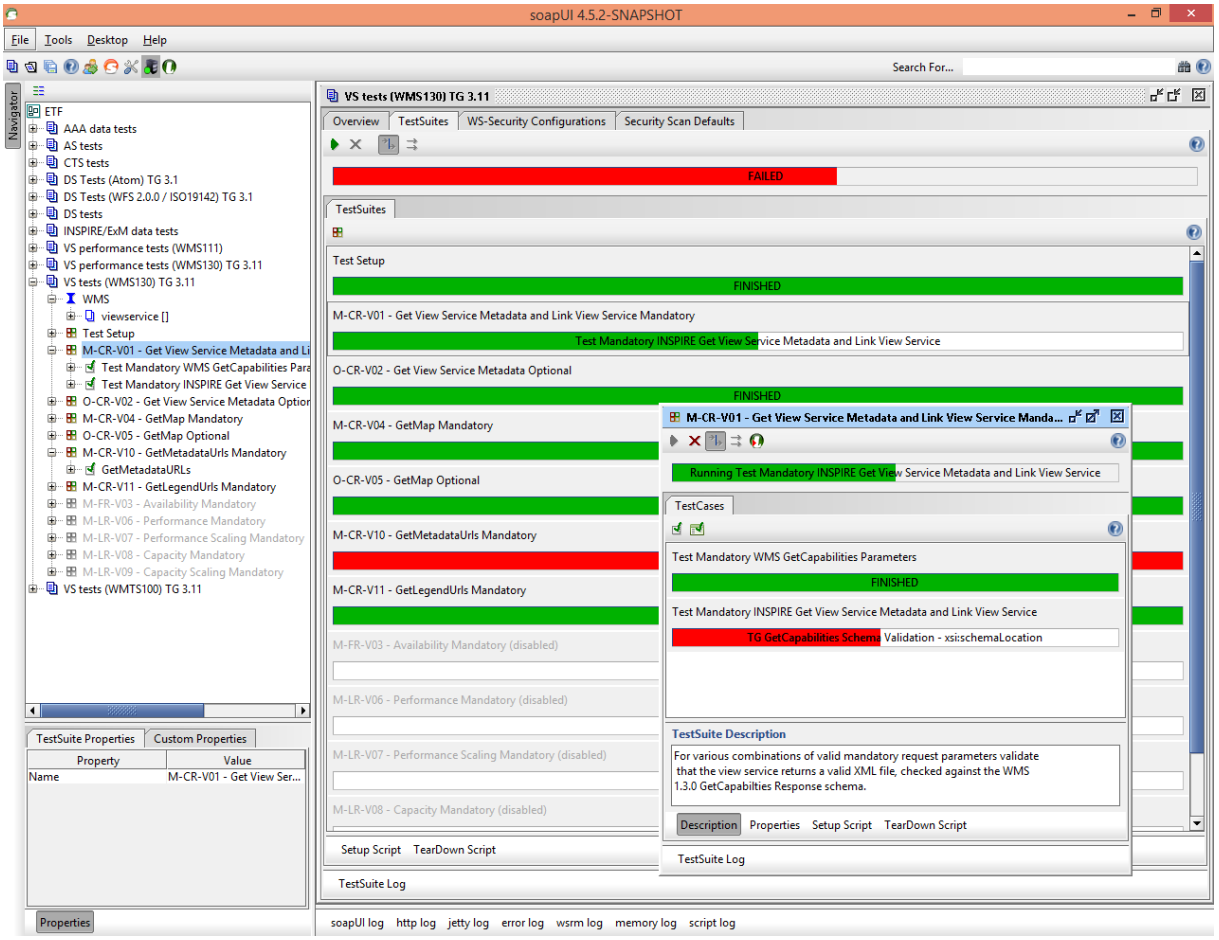
(European Union, 2015)

Appendix B: Fictional setting for address example



Adopted from INSPIRE Thematic Working Group Addresses (2014)

Appendix C: Screenshot of SoapUI



Appendix D: ETF WMS 1.3.0 SoapUI checklist

1. **Test 1** – GetCapabilities Mandatory (M-CR-V01)
   - 1.1. Test Mandatory GetCapabilities Parameters
     - 1.1.1. Response SLA: Capabilities response in time (within 5000 ms)
     - 1.1.2. Capabilities claim to be WMS version 1.3.0
   - 1.2. Test Mandatory INSPIRE GetCapabilities Parameters
     - 1.2.1. Response SLA: Capabilities response in time (within 5000 ms)
     - 1.2.2. Capabilities validate to INSPIRE Schema View Services (the XSD). Note that INSPIRE elements from INSPIRE schemas are checked by schema validation to the XSD: req 11, 12, 15, 20 & 21, 22 & 23, 27 & 28, 29.
     - 1.2.3. Req 18: INSPIRE MandatoryKeyword infoMapAccessService is present
     - 1.2.4. Req 31: INSPIRE GetMap Supports PNG or GIF
     - 1.2.5. Req 32, 33: INSPIRE Resource Title: all Layers with a Name have a Title
     - 1.2.6. Req 32, 34: INSPIRE Resource Abstract: all Layers with a Name have an Abstract
     - 1.2.7. Req 32, 35: INSPIRE Resource Keyword: all Layers with a Name have at least one Keyword
     - 1.2.8. Req 32, 36: INSPIRE Ex_GeographicBoundingBox: all Layers with a Name have a EX_GeographicBoundingBox
     - 1.2.9. Req 36: INSPIRE BoundingBox: all Layers with a Name have BoundingBoxes for all advertized CRSes
     - 1.2.10. Req 37, 38: INSPIRE Resource Identifier: all Layers with a Name have an Identifier and a declared Authority for that Identifier
     - 1.2.11. Req 41, 46: INSPIRE Styles: all Styles have a Name and Title
     - 1.2.12. Req 70: INSPIRE ResponseLanguage present
     - 1.2.13. Req 71: INSPIRE DefaultLanguage present
     - 1.2.14. Each Layer has a Style.
   - 1.3. Scenario 1 for service metadata: if an external Service Metadata record is mentioned in the Capabilities, this is fetched and check if an ISO metadata root-element is available in the response document. Note that this service metadata document is not entirely validated by the ETF. This should be done separately, since the ETF is not an ISO metadata validator.
   - 1.4. Scenario 2 for service metadata: if no external service metadata record is provided, the service metadata elements are checked in the Capabilities document:
     - 1.4.1. Req 10: WMS Title present
     - 1.4.2. Req 10: WMS Abstract present
     - 1.4.3. Req 11: INSPIRE Resource Type
     - 1.4.4. Req 16, 18: INSPIRE MandatoryKeyword infoMapAccessService
     - 1.4.5. Req 24: INSPIRE Conditions for Access and Use (wms:Fees)
     - 1.4.6. Req 25, 26: INSPIRE Responsible Organization present (wms:ContactOrganization and wms:ContactPosition)
     - 1.4.7. Req 33: INSPIRE Theme is mapped to a Keyword

2. **Test 2** - GetCapabilities Optional (O-CR-V02): NOTE: this is an optional test, since the underlying assertions are based on recommendations or cannot be mandated at this moment. If this test fails,

this does not mean the WMS is not compliant to INSPIRE View Services.

2.1. Test Optional GetCapabilities Parameters

2.1.1. Response SLA: Capabilities response in time (within 5000 ms)

2.1.2. Req 39: INSPIRE there is a harmonisedLayer Name available

2.1.3. Req 40: INSPIRE Coordinate Reference System 4258 in Layer or group Layer

3. **Test 3** - GetMap Mandatory (M-CR-V04)

3.1. GetMap Mandatory Parameters: send a GetMap request, using the properties as found in the Capabilities.

3.1.1. The response has a content type for a PNG image

3.1.2. the response size is bigger than 100 bytes, to check if the PNG is not empty

3.2. GetMap INSPIRE Parameters send a GetMap request valid for INSPIRE, using the properties as found in the Capabilities and with Transparency set to true.

3.2.1. The response has a content type for a PNG image

3.2.2. the response size is bigger than 100 bytes, to check if the PNG is not empty

3.2.3. If an Exception is returned, the service supports Exceptions in the XML-format.

4. **Test 4** - GetMap Optional (O-CR-V05), these tests are optional, since they are based on recommendations

4.1. GetMap Optional Parameters

4.1.1. BGCOLOR is supported

4.1.2. EXCEPTIONS with the INIMAGE-format are supported

5. **Test 5** - GetMetadataUrls Mandatory (M-CR-V10): check if all MetadataURLs provided for Layers refer to an online available ISO Metadata document, for a dataset.

5.1. GetMetadataURLs:

5.1.1. check if at least for one Layer a MetadataURL is available;

5.2. For each MetadataURL in the Capabilities document fetch the document and check:

5.2.1. Metadata has root element MD_Metadata

5.2.2. Metadata fileIdentifier exists

5.2.3. The MD_Identifier exists in the ServiceMetadata. Note: this is important since the Service Metadata as provided through the Capabilities (in tests M-CR-V01 – GetCapabilities Mandatory) shall contain the dataset identifiers (MD_Identifier) of the Layers

6. **Test 6** - GetLegendUrls Mandatory (M-CR-V11): check if all LegendURLs provided for Layers refer to an online available image.

6.1. GetLegendURLs

6.1.1. INSPIRE Styles: all Styles have a LegendURL

6.1.2. All LegendURLs refer to an image

Appendix E: ETF WFS (2.0.0 / ISO19142) SoapUI checklist

1. PredefinedWFS (M-01)
   - 1.1. SimpleWFS - HTTP GET - Mandatory
     - 1.1.1. Capabilities support HTTP GET
     - 1.1.2. WFS supports GML 3.2 output format as "application / gml + xml; version = 3.2 "
     - 1.1.3. The DescribeFeatureType response is an XML Schema element
   - 1.2. SimpleWFS GetFeatureById support - Mandatory
     - 1.2.1. The StoredQuery for GetFeatureById is listed
   - 1.3. Query support - Mandatory
     - 1.3.1. The Capabilities document advertizes support for ImplementsQuery (Query support)
     - 1.3.2. DescribeStoredQueries contains more StoredQueries (with parameters CRS/DataSetID/Language) besides the StoredQuery GetFeatureById Mandatory INSPIRE GetCapabilities
   - 1.4. INSPIRE GetCapabilities - Mandatory
     - 1.4.1. Capabilities refer to the INSPIRE download Services schemas in the xsi: schemaLocation
     - 1.4.2. Validating Capabilities against the declared schema, xsi: schemaLocation
       In Service Metadata in the Capabilities (Scenario 2):
     - 1.4.3. INSPIRE Keyword InfoFeatureAccessService exists
     - 1.4.4. Capabilities contain a Title and Abstract
     - 1.4.5. Capabilities include the INSPIRE ResourceType
     - 1.4.6. Capabilities include the INSPIRE ResourceLocator
     - 1.4.7. Each FeatureType has a MetadataURL
     - 1.4.8. Capabilities include INSPIRE SpatialDataServiceType with value 'Download'
     - 1.4.9. Capabilities include for each FeatureType a WGS84BoundingBox
     - 1.4.10. Capabilities include INSPIRE TemporalReference
     - 1.4.11. Capabilities include INSPIRE Conformity
     - 1.4.12. Capabilities contain Fees and AccessConstraints
     - 1.4.13. Capabilities include the ServiceProvider, Provider Name and Contact Info
     - 1.4.14. Capabilities include INSPIRE MetadataDate
     - 1.4.15. Capabilities include INSPIRE MetadataPointOfContact
     - 1.4.16. Capabilities include the INSPIRE Unique Resource Identifier
       Metadata for all Urls by Feature Type: Metadata
     - 1.4.17. The document is available at the specified URL
     - 1.4.18. The Metadata document contains fileIdentifier
       Service Metadata is in an external document (Scenario 1):
     - 1.4.19. The Service Metadata is available at the specified URL
     - 1.4.20. The Service Metadata contains the element MD_Metadata
       For all URLs Dataset Metadata in the Metadata Service: Metadata
     - 1.4.21. The document is available at the specified URL
     - 1.4.22. The Metadata document contains fileIdentifier
     - 1.4.23. The MD_Identifier exists in the Service Metadata

2. DirectAccessWFS. (O-02)
    2.1. BasicWFS - GetFeature and GetPropertyValue- Optional
        2.1.1. Capabilities advertise ImplementsBasicWFS
        2.1.2.GetPropertyValue response contains ValueCollection
    2.2. BasicWFS - Minimum Spatial Filter - Optional
        2.2.1.Capabilities advertise SpatialOperator BBOX
    2.3. Resource Identification and Ad Hoc Query - Optional
        2.3.1.Capabilities advertizes fes:ResourceId (ResourceIdentification)
        2.3.2.Response with non-existing identifier does not contain any Features
    2.4. Minimum Standard Filter - Optional
        2.4.1.Capabilities advertise ImplementsMinStandardFilter
        2.4.2.Capabilities advertise all ComparisonOperators
        2.4.3.Capabilities advertise the logical operators
        2.4.4.A GetFeature request with PropertyIsEqualTo delivers a properly filtered result
    2.5. Minimum Temporal Filter - Optional
        2.5.1.Capabilities advertise ImplementsMinTemporalFilter
    2.6. Minimum XPath - Optional
        2.6.1.Capabilities advertise ImplementsMinimumXpath
        2.6.2.GetFeature request with a XPath number predicate works correctly in Filter

Appendix F: ETF ATOM SoapUI checklist

1. Service Feed (M-01)
   1.1. Feed Elements Mandatory
      1.1.1. Service Feed Title exists (Req 5)
      1.1.2. Feed service refers to a service metadata document, with the right type (Application / xml + vnd.iso.19139) (Req 6)
      1.1.3. Feed Service contains a link to itself and has proper language reference (Req 7)
      1.1.4. Service Feed refers to an OpenSearch Description document (Req 8)
      1.1.5. Feed Service id refers to self URL (Req 9)
      1.1.6. Feed Service contains legal information (Req 10)
      1.1.7. Feed Service contains update information (Req 11)
      1.1.8. Service Feed contains author name and email address (Req 12)
      1.1.9. Each entry in the service feed contains an INSPIRE identifier code (Req 13)
      1.1.10. Each entry in the service feed contains an INSPIRE namespace element (Req 13)
      1.1.11. Each entry has a valid Dataset metadata link, referring to a file of "application / xml" (Req 14)
      1.1.12. Each entry has exactly one Dataset Feed link (Req 15)
      1.1.13. Each entry has an id and id has an URI (Req 16)
      1.1.14. Each entry has a title (Req 17)
      1.1.15. Each entry has an element updated (Req 18)
      1.1.16. Each entry has an element category, including a term and label, which refers to CRSs (Req 19)
2. M-02 Service Feed Service Metadata
   2.1. Mandatory Service Metadata
      2.1.1. The metadata document contains information on ServiceIdentififcation
      2.1.2. The service metadata contains at least one dataset reference (via the XML element operatesOn)
3. M-03 Service Feed Dataset Metadata
   3.1. Dataset Metadata Mandatory
      As specified Dataset metadata document:
      3.1.1. The metadata is ISO metadata, as root element MD_Metadata
      3.1.2. The metadata contains a fileIdentifier
      3.1.3. The dataset identifier exists in the Service Metadata, as defined in the Feed Service
      3.1.4. Conversely: any Dataset Identifier specified in the service metadata is also called Metadata Dataset to which the service refers
4. M-04 Dataset Feed
   4.1. Feed Elements Mandatory
      As specified Dataset Feed:
      4.1.1. Feed contains a link to itself and has proper language reference
      4.1.2. Feed dataset contains a title (Req 20)
      4.1.3. Feed dataset id refers to self URL (Req 21)
      4.1.4. Feed dataset contains legal information (Req 22)
      4.1.5. The Atom feed contains updated information (Req 23)

4.1.6. Feed contains author name and email address (Req 24)

4.1.7. The Atom feed contains at least one entry for data, with a link to the dataset and length set or a section link in case of multiple files (Req 25, 28, 31)

4.1.8. Dataset feeds contains separate entries for each format/combination of CRS. Each entry link for download has one/the same media type, CRS category element (Req 26)

4.1.9. Dataset Feeds contains at least one link to a Spatial Object description in Feature Catalogue (in HTML) (Req 27)

4.1.10. If a section link is provided (for multiple files) then there should be more than 1 section link (Req 31)

4.1.11. Each entry has a category element for CRS (Req 35)

4.1.12. Only media types listed in the INSPIRE media-types register at http://inspire.ec.europa.eu/media-types/ shall be used (Req 34)

4.2. ResolveDatasetLink Mandatory

For each link to a file for download:

4.2.1. Response starts within 30 seconds (using HTTP HEAD)

5. M-05 OpenSearch Description

5.1. OpenSearch Mandatory

5.1.1. The OpenSearch Description contains a URL reference to itself (Req 39)

5.1.2. The OpenSearch Description contains a template URL for generic searches queries (Req 40)

5.1.3. The OpenSearchDescription contains a Url element that describes a template URL for the Describe Spatial Dataset operation (Req 41)

5.1.4. The OpenSearchDescription contains a Url element that describes a template URL for the Get Spatial Dataset operation (Req 42)

5.1.5. The OpenSearchDescription contains 'Query' examples with 'spatial_dataset_identifier_code' and 'spatial_dataset_identifier_namespace' attributes (Req 43)

5.1.6. The described dataset URL response is an Atom feed with at least one category with a CRS

5.1.7. Valid HTTP Status Codes: 200, 206, 301, 302, 303

Appendix G: Questionnaire template

The address data harmonisation process and interoperability in European Union

Aim of this survey is to collected data and information about address system and services in each European Union country.

As the number of EU countries are limited and the goal is get a response from each country, therefore each response is crucial and has high value.

Aims of the survey are to find out:

- how interoperable are address systems in EU
- how are address services in line with the INSPIRE requirements in nontechnical aspects and
- what are the main challenges in address data harmonisation.

Filling the survey takes approx. 20 minutes.
The deadline to submit the response: 31st January, 2017.

Responses will be used in the master thesis to compare EU countries and to make conclusions on the address harmonisation process.

Title of the thesis „Assessing the address data harmonisation process and interoperability in European Union".
Study program: Geographical Information Management and Applications (www.mscgima.nl), Utrecht University (the Netherlands).

Should you need any further information, please do not hesitate to contact me (maarja.mahlapuu@gmail.com).

Thank you for your time!

Maarja Mahlapuu

*Required

1. Country *

2. Name of the organization *

3. Name of the officer and position *

4. Email *

5. Phone number

Organisational interoperability

6. What is the main function of the organization?
   Tick all that apply.

   - [ ] Related to land themes (Cadastre management, Land survey, Mapping, Topography)
   - [ ] Postal service
   - [ ] Other: _____

7. What is your organization's funding model/business model?
   Mark only one oval.

   - ◯ 100% sponsored by the government
   - ◯ Government owned company
   - ◯ Private company
   - ◯ Other:

8. Do you have a national contact point or any other single responsible organisation in charge of fulfilling INSPIRE Directive?
   Mark only one oval.

   - ◯ Yes
   - ◯ No Skip to question 10.

9. What is the name of the organisation in charge of fulfilling INSPIRE Directive?

   _____

Skip to question 11.

10. Why there is not a single responsible organization?

    _____

    _____

    _____

    _____

    _____

11. Does your country has a single central address reference database?
    Mark only one oval.

    - ◯ Yes Skip to question 14.
    - ◯ No Skip to question 12.

12. Why your country has more than one central address database?

13. Describe address data system in your country
Number of separate systems, content of separate systems, who are the owners, who establishes data in each system

14. Is address data owned by public sector?
Mark only one oval.

- Yes
- No
- Other: _____

15. Does your organization establishes address data?
Mark only one oval.

- Yes Skip to question 18.
- No Skip to question 16.

16. Who establishes the address data?

17. How is the relationship with the data establisher stated?
Mark only one oval.

- By contract
- By license
- By law
- Other: _____

18. Does your organization maintains address data?
Mark only one oval.

- Yes Skip to question 21.
- No Skip to question 19.

19. Who maintains the address data?

20. How is the relationship with the data manager stated?
Mark only one oval.

- By contract
- By license
- By law
- Other: _____

21. Do you have any kind of address data products (WMS, WFS, direct download, etc)?
Mark only one oval.

- Yes Skip to question 22.
- No Skip to question 41.

22. Which kind of address products do you have?
Tick all that apply.

- [ ] WMS
- [ ] WFS
- [ ] WCS
- [ ] ATOM feed
- [ ] Other: _____

23. Who is the main user of the created address data products?

_____

24. Do you have separate webservice(s)to fulfill INSPIRE requirements?
Mark only one oval.

- Yes Skip to question 25.
- No Skip to question 31.

25. Which kind of services were created especially for INSPIRE?

26. Why separate INSPIRE webservice(s) was/were created?

27. How often do you update your INSPIRE address service(s)?

28. What INSPIRE data model version(s) is applied?

29. Is the data content (data model) in the service(s) INSPIRE compliant?
Mark only one oval.

- Yes After the last question in this section, skip to question 36.
- No After the last question in this section, skip to question 35.
- In preparation After the last question in this section, skip to question 35.
- Other: After the last question in this section, skip to question 36.

30. How have to tested/assured address data model is in line with INSPIRE Directive?

Skip to question 35.

31. How often do you update your address service(s)?

32. What INSPIRE data model version(s) is applied?

33. Is the data content (data model) in the service(s) INSPIRE compliant?
Mark only one oval.

- Yes After the last question in this section, skip to question 36.
- No After the last question in this section, skip to question 35.
- In preparation After the last question in this section, skip to question 35.
- Other: After the last question in this section, skip to question 36.

34. How have to tested/assured address data model are in line with INSPIRE Directive?

35. What is data model missing from being INSPIRE compliant?

36. Are your (INSPIRE) services in line with INSPIRE Directive?
In technical aspects
Mark only one oval.

- Yes After the last question in this section, skip to question 39.
- No After the last question in this section, skip to question 40.
- Other: After the last question in this section, skip to question 40.

37. How have to tested/assured address services are in line with INSPIRE Directive

38. What is/are service(s) missing from being INSPIRE compliant?

39. Do you manage your (web)services related to addresses?
On the technical point of view
Mark only one oval.

- Yes Skip to question 41.
- No Skip to question 40.

40. How is the relationship with service manager stated?
Mark only one oval.

- By contract
- By license
- By law
- Other:

41. How does the workflow of address data looks like (Figure 1-6)?
Columns are levels, European level is INSPIRE. Rows are processes.
Mark only one oval.

- Figure 1
- Figure 2
- Figure 3
- Figure 4
- Figure 5
- Figure 6
- Other:

Figure 1

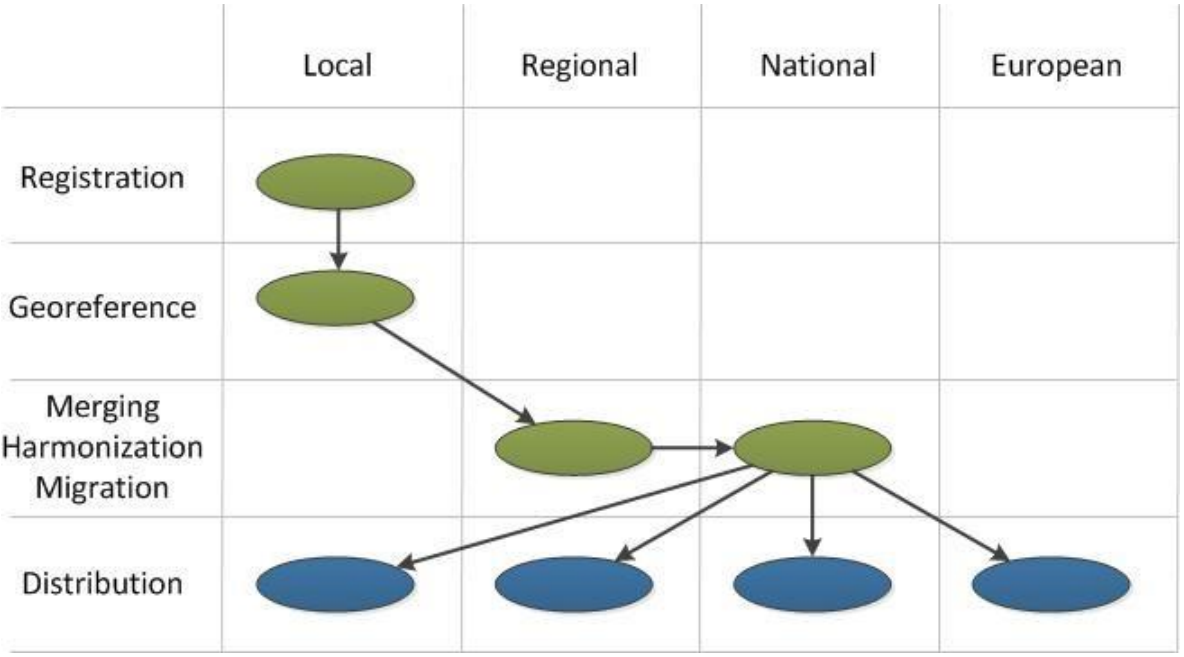


Figure 2

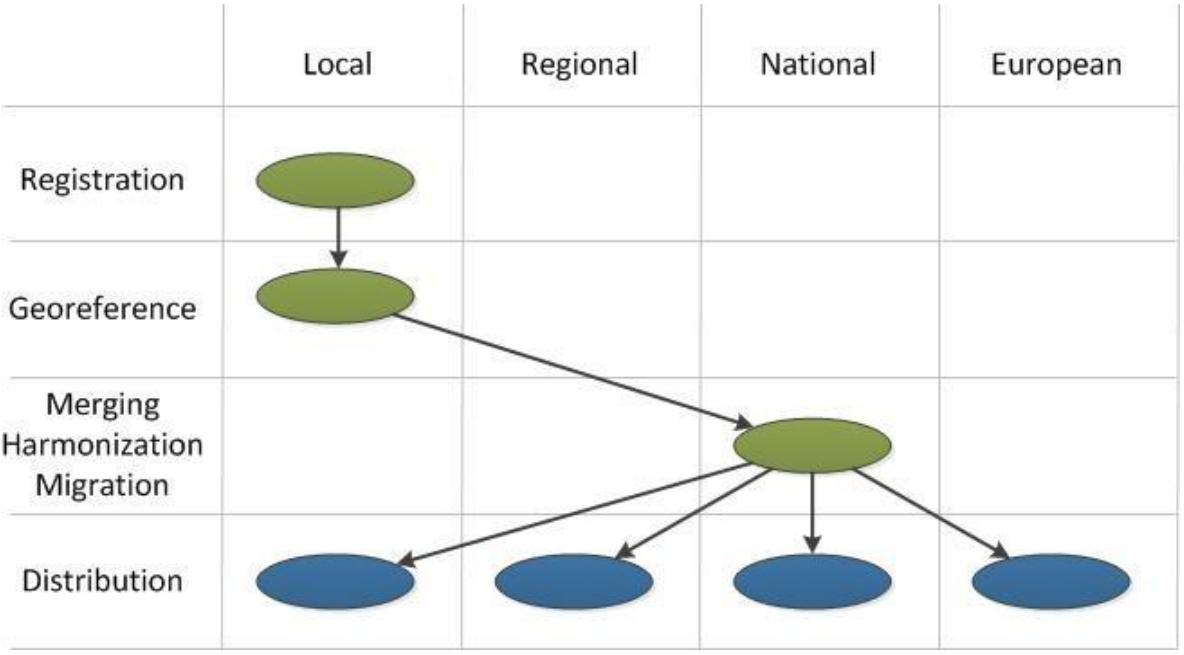


Figure 3

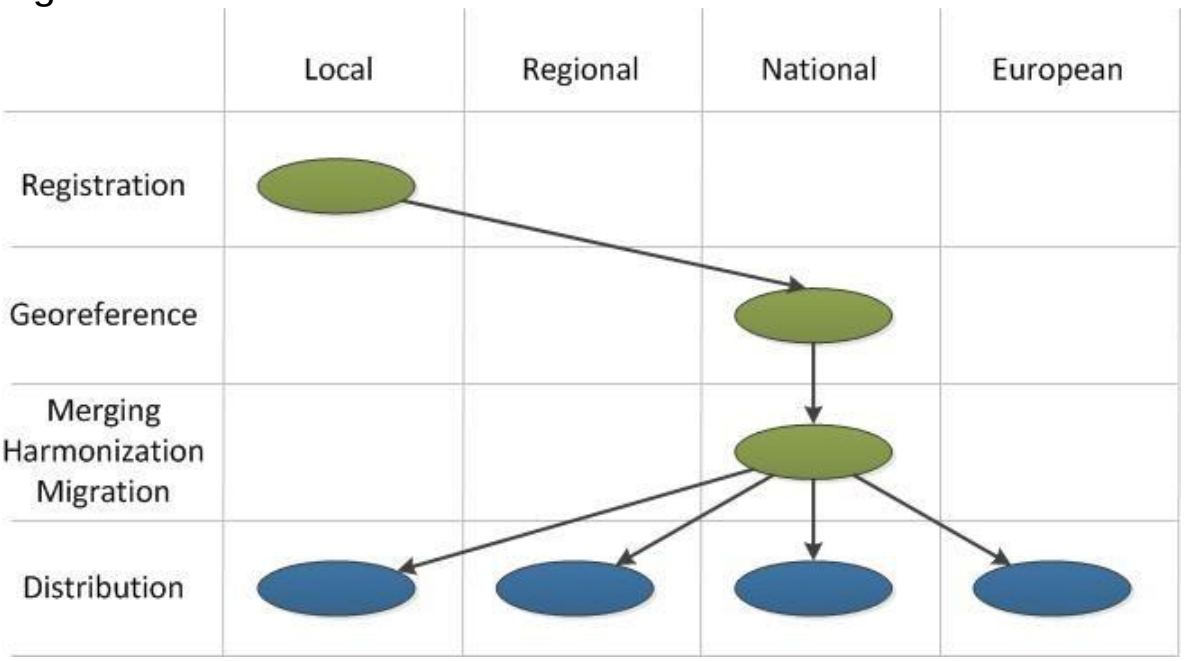


Figure 4

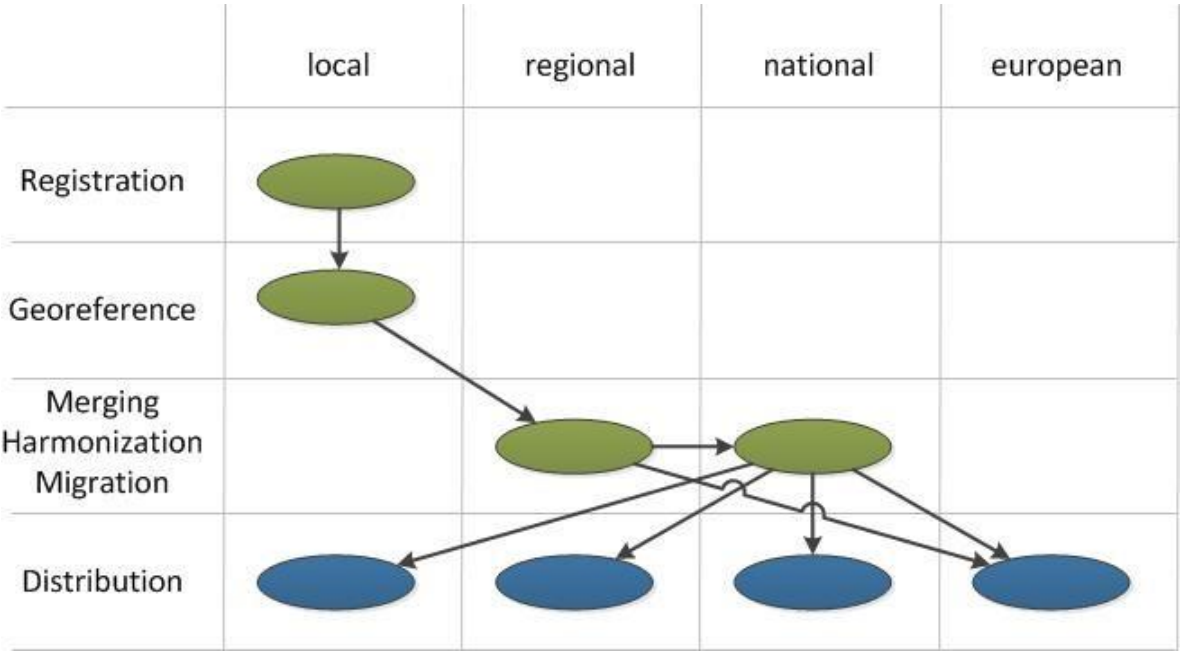


Figure 5

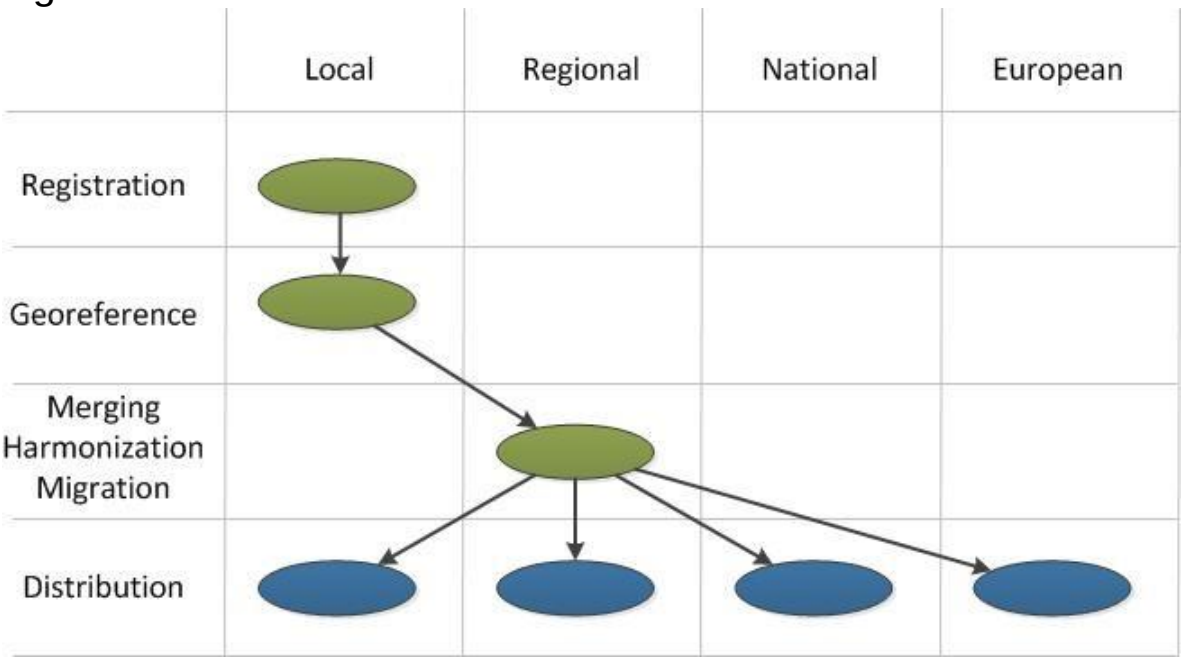
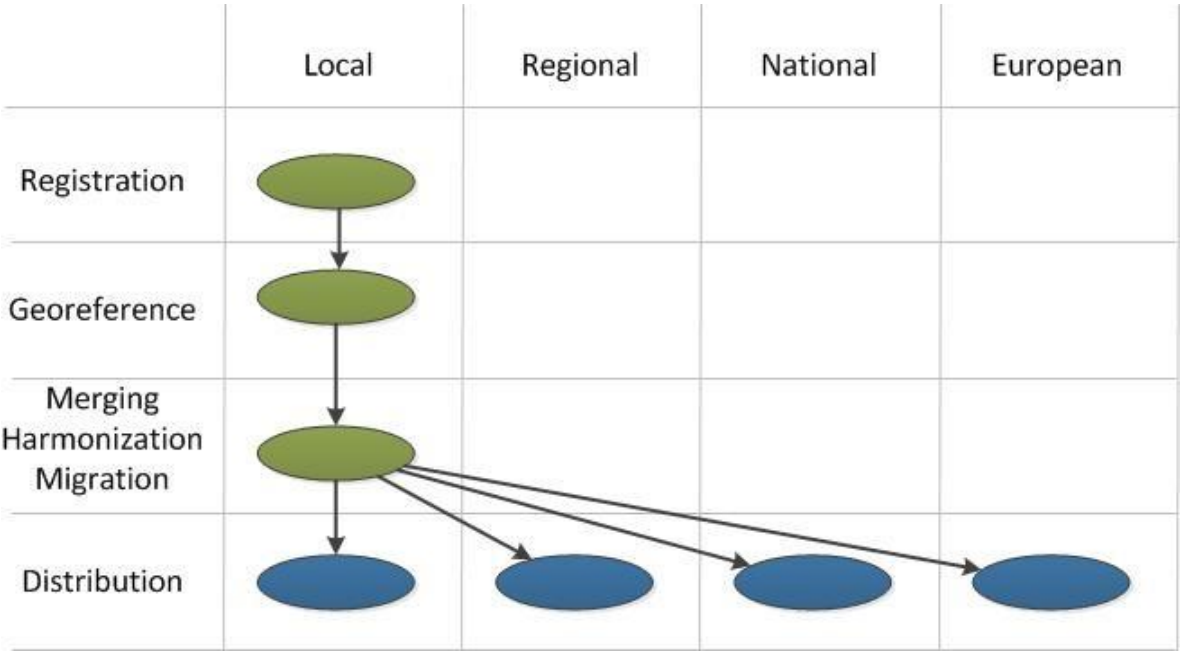


Figure 6



42. Is information available (e.g. on a web page, public document) on how address data are collected, processed and can be obtained?

Mark only one oval.

- Yes
- No

43. Have you changed your business processes / workflow because of INSPIRE regulations?

Mark only one oval.

- Yes Skip to question 44.
- No Skip to question 45.

44. In what extent have you changed your business processes / workflow?

Skip to question 46.

45. Your organization has not made any changes in workflow, because
Mark only one oval.

- Everything was already in line
- Changes will take place in future
- Other:

46. Have you changed your data model because of INSPIRE regulations?
In the main address database
Mark only one oval.

- Yes Skip to question 47. No
- Skip to question 48. Other:
-

47. In what extent have you changed your data model?

Skip to question 49.

48. Your organization has not made any changes in data model, because
Mark only one oval.

- Everything was already in line
- Changes will take place in future
- Other:

Legal interoperability

49. Is addressing in your country regulated by law?
Mark only one oval.

- Yes
- No
- Other: _____

50. How can address data and services be accessed?
These data and services that are the most compliant with INSPIRE
Mark only one oval.

- All for free Skip to question 58.
- For free, but with restrictions (eg. only for educational use, only for public sector and/or not allowed for business purposes) Skip to question 51.
- There is a fee Skip to question 55.
- Both, for free and for a fee Skip to question 55.
- No access Skip to question 53.
- Other: _____

51. Which restrictions apply (eg. only for educational use, only for public sector and/or not allowed for business purposes)?

_____

_____

_____

_____

52. For which purposes restrictions are applied ?

_____

_____

_____

_____

Skip to question 58.

53. For which purposes the restrictions are applied ?

_____

_____

_____

_____

54. Are there procedures in place to obtain address data in case of emergency?
Eg. by law enforcement in case of natural disaster
Mark only one oval.

- Yes
- No
- Other:

Skip to question 72.

55. For which purposes a fee is applied ?

56. Based on what you have calculated the charges?

57. Do you include explanation to the user of the basis for charges and the factors taken into account? And where?

58. When user wants to use address data/services, is there any license used?
Mark only one oval.

- Yes
- No Skip to question 66.

59. In what form the license agreement is presented?
Mark only one oval.

- Sent by email
- A statement on a webpage
- A click licence
- A licence agreement signed by all the parties involved
- Other:

60. In what language is the licence?

Mark only one oval.

- Official language(s)
- English
- Other: _____

61. Is the license...

Mark only one oval.

- Preprepared
- Developed for every query
- Other:

62. Is in the license mentioned how and where intellectual property rights appear?

Mark only one oval.

- Yes
- No

63. Is the license based on an INSPIRE license?

Mark only one oval.

- Yes Skip to question 65.
- No Skip to question 64.

64. Why INSPIRE licenses are not used?

_____

Skip to question 67.

65. Which INSPIRE license is used?

Mark only one oval.

- Basic
- Specific
- Other: _____

Skip to question 67.

66. Why there is not any license used?

_____

_____

_____

_____

67. Does address dataset contain third party data?

These data and services that are the most compliant with INSPIRE
Mark only one oval.

- Yes Skip to question 68.
- No Skip to question 69.

68. Has third party given consent of intellectual property rights?

Mark only one oval.

- Yes
- No

Skip to question 69.

69. Is data provided (can be used, downloaded) almost instantaneously?

These data and services that are the most compliant with INSPIRE
Mark only one oval.

- Yes Skip to question 71.
- No Skip to question 70.

70. How much time it would take to require address data?

71. How does your organization protect itself against legal liability issues, that could come from data mistakes, which could lead to collateral damage and unintended consequences?

Political context

72. Have your organization had opportunity to share visions on INSPIRE, when address part was compiled?

Mark only one oval.

- Yes Skip to question 74.
- No Skip to question 73.

73. Why your organization was not been involved when INSPIRE was compiled?

74. Was there training regarding to INSPIRE Directive (in general context)?
Mark only one oval.

- Yes
- No
- Other: _____

75. Was there training regarding to INSPIRE Directive (about addresses data specification, data model, etc.)?
Mark only one oval.

- Yes
- No
- Other: _____

76. Has the organization been involved in any INSPIRE work groups?
Mark only one oval.

- Yes Skip to question 77.
- No Skip to question 79.

77. In which work groups?

_____

_____

_____

78. What motivates you organization to participate in work groups?

_____

_____

_____

_____

Skip to question 80.

79. Why your organization has not been involved with any INSPIRE work groups?

_____

_____

_____

80. Have you followed/used INSPIRE Address Specification?
Mark only one oval.

- Yes Skip to question 82.
- No Skip to question 81.

81. Why your organization has not followed/used INSPIRE Address Specification?

82. Do you currently have any difficulties with address data harmonisation related to INSPIRE Directive in your country?
Mark only one oval.

- Yes After the last question in this section, skip to question 85.
- No After the last question in this section, skip to question 86.
- Other:

After the last question in this section, skip to question 85.

83. Which kind of problems you have/had with address data harmonisation related to INSPIRE Directive in your country?
Tick all that apply.

- [ ] Technical
- [ ] Legal
- [ ] Political
- [ ] Institutional
- [ ] Social
- [ ] Other:

84. Could you specify last answer in more detail

Skip to question 86.

85. If you are not currently having any difficulties, how did you overcome those difficulties?

Finish

86. Remarks:

87. If you would like to receive the results of this research, then fill your email address:

Appendix H: Recipients of the survey

Blue cell indicate e-mail recipients

	Country	E-mail	INSPIRE Address Cluster	National Contact Points	Notified body of the EU
1.	**Austria**	benannte.stelle@bev.gv.at		wolfgang.fahrner@bmlfuw.gv.at	wolfgang.fahrner@lebensministerium.at
2.	**Belgium**	contactpunt@agiv.be	Liesbet DE WOLF, Hendrik VAN HEMELRYCK, Ziggy VANLISHOUT	ouns.kissiyar@agiv.be	Leen.detemmerman@agiv.be
		customer@bric.brussels			
		helpdesk.carto@spw.wallonie.be			
		http://www.ngi.be/NL/NL5.shtm			
3.	**Bulgaria**	-unavailable		ksimonski@esmis.government.bg	istanev@mtitc.government.bg
4.	**Croatia**	info@dgu.hr		ljerka.maric@dgu.hr	-unavailable
5.	**Cyprus**	-unavailable		ahadjiraftis@dls.moi.gov.cy	ahadjiraftis@dls.moi.gov.cy
6.	**Czech Republic**	https://helpdesk.cuzk.cz/ehd/vytvorPozadavek	Veronika KUSOVA, Michal MED	Jitka.Faugnerova@cenia.cz	inspire@cenia.cz
7.	**Denmark**	adresser@gst.dk		ukm@gst.dk	inspire@gst.dk
8.	**Estonia**	sulev.oitspuu@maaamet.ee		Peep.Krusberg@maaamet.ee	maaamet@maaamet.ee
9.	**Finland**	kirjaamo@vrk.fi	Tarja MYLLYMÄKI, Lena Hallin-Pihlatie	Antti.vertanen@mmm.fi	antti.vertanen@mmm.fi
10.	**France**	http://professionnels.ign.fr/contact	Dominique LAURENT	point-de-contact-inspire-France.dri.cgdd@developpement-durable.gouv.fr	Point-de-contact-inspire-france.dri.cgdd@developpementdurable.gouv.fr
11.	**Germany**	hauskoordinaten@bezreg-koeln.nrw.de	Heinrich GEERLING, Anja HOPFSTOCK	inspire@gdi-de.org	martin.lenk@bkg.bund.de
12.	**Greece**	-unavailable		e.grigoriou@prv.ypeka.gr	support@okxe.gr

13.	**Hungary**	-unavailable		tamas.koos@vm.gov.hu	tamas.koos@vm.gov.hu
14.	**Ireland**	https://www.geodirectory.ie/Home/Contact.aspx		helen.mcgrath@environ.ie	inspire@environ.ie
15.	**Italy**	http://wwwt.agenziaentrate.gov.it/servizi/form_mail/form.php?id=1	Andrea DEIANA, Giacomo MARTIRANO, Stefania MORRONE, Fabio VINCI, Karen Fullerton	annunziata.fabio@minambiente.it	NCP.Inspire@minambiente.it
16.	**Latvia**	vzd@vzd.gov.lv	Jurijs HOLMS	valdis.berzins@lgia.gov.lv	valdis.berzins@lgia.gov.lv
17.	**Lithuania**	info@registrucentras.lt		audrius.petkevicius@zum.lt	jurgita.spuraite@nzt.lt
18.	**Luxembourg**	info@act.public.lu		francis.kaell@act.etat.lu, francis.kaell@sip.etat.lu	-unavailable
19.	**Malta**	-unavailable		martin.j.saliba@gov.mt	-unavailable
20.	**Netherlands**	https://www.kadaster.nl/web/formulier/BAG-formulieren/BAG-contactformulier.htm	Frank KOOIJ	Noud.hooyman@minienm.nl	Noud.hooyman@minienm.nl
21.	**Poland**	prg@codgik.gov.pl	Mirosław MIGACZ	pol-inspire@gugik.gov.pl	ewa.surma@gugik.gov.pl
22.	**Portugal**	-unavailable	Marlene Antunes, Raquel MEDEIROS	mario.caetano@dgterritorio.pt	mvale@dgterritorio.pt
23.	**Romania**	-unavailable		gabriela.dragan@ancpi.ro	gabriela.dragan@ancpi.ro
24.	**Slovakia**	http://www.minv.sk/?kontakty-23&kontakt=3655&od=8886		marek.ziacik@sazp.sk, inspire_eu@sazp.sk	martin.tuchyna@sazp.sk
25.	**Slovenia**	gurs@assist.si		tomaz.petek@gov.si	Tomaz.petek@gov.si
26.	**Spain**	cartociudad@ign.es	Ana VELASCO TIRADO, Maria CABELLO, Alicia GONZALEZ, Jose Manuel VAZQUEZ, Josué Díaz Jiménez, Jordi ESCRIU	smas@fomento.es	-unavailable
27.	**Sweden**	lantmateriet@lm.se		christina.wasstrom@lm.se	christina.wasstrom@lm.se
28.	**United Kingdom**	support@geoplace.co.uk	Peter PARSLOW	UK-INSPIRE-NCP@defra.gsi.gov.uk	-unavailable

Appendix I: Address datasets of the EU countries (a table)

No	Country	Number of datasets	Name of the main(s) dataset	Year created	Content of address dataset	Ministry in charge of the system	Data owner
1	**Austria**	1	Austrian Address Register	2004	addresses	Federal Ministry of Science, Research and Economy	Federal Office of Metrology and Surveying
2	**Belgium**	4	Central Reference Address Database	2011	street names, house numbers and geographical positioning of addresses	n/a	Geographic Information Agency Flanders
			UrBIS	n/a	several cartographical databases, inc. address data	Minister or the Secretary of State responsible for regional and communal IT	Brussels Regional Informatics Centre
			Information Mapping Project Continues (PICC)	1991	Basic Digital Topographic, including address data	n/a	Public Service of Walloon
			Top10Vector-Streetnames	n/a	road segment data, including references to the identifiers and street names of the Civil Register	Minister of National Defence	National Geographic Institute
3	**Bulgaria**	0	n/a	n/a	n/a	n/a	n/a
4	**Croatia**	1+ regionals	Register of Spatial Units	n/a	spatial units for post office, buildings with house numbers	n/a	State Geodetic Administration
5	**Czech Republic**	1	Register of Territorial Identification, Addresses and Real Estate	2012	buildings, address nodes, real estate	prime minister of the Government	Czech Office for Surveying, Mapping and Cadastre (COSMC)
6	**Cyprus**	regionals	n/a	n/a	n/a	n/a	n/a
7	**Denmark**	1	Building and Dwelling Register (BBR)	1996	addresses with coordinates	Ministry of Housing, Urban and Rural	Ministry of Housing, Urban and Rural
8	**Estonia**	1	Address Data System	2009	Addresses with coordinates	Ministry of Environment	Estonian Land Board
9	**Finland**	1+ regionals	The Population Information System (Building and Dwelling Register)	1980	Personal, building and real estate data	Ministry of Finance	Population Register Centre

Country	Data manager	Full address example of apartment	Entries	Access	Tools, Services
Austria	the municipalities and cities	Mainstreet 360/6/24 1014 Wien	n/a	Price list	download (CSV, relational tables), WMS
Belgium	Municipalities	rue Main 6 bus 3 2140 Antwerpen	3 million	free	WMS, GetCRABMatch, GetAddressLocation, GetStreetLocation, Geolocation, CRAB WS-T, WFS
	Municipality		n/a	free	WMS, WMTS, WFS, REST, Geolocation services
	Regional		219 000	Free/price list	WMS, ESRI REST, distribution (SHP, DWG, fgdb)
	National		n/a	price list	data (shp, dwg, gml, fgdb)
Bulgaria	n/a	360 Main Str. Ent 6 Apt 24 Dobrich 9300 Bulgaria	n/a	n/a	n/a
Croatia	Municipalities	Mainstreet 360 24 1 31225 BREZNICA NAŠIČKA CROATIA	n/a	Price list	WMS, WFS
Czech Republic	COSMC, Municipal offices, Building authorities, Czech statistical office	Mainstreet 360/6 Chodov 149 00 Prague 41	address points: 2 910 000 (2014)	free	Remote Public Access, download (VFR (GML), CSV), INSPIRE WMS, INSPIRE WFS, INSPIRE ATOM
Cyprus	n/a	360 Mainstreet 3035 LEMESOS CYPRUS	n/a	n/a	n/a
Denmark	Municipalities	Mainstreet 6 1 TV 2400 København NV Denmark	2,3 million (2015)	free	INSPIRE WMS & WFS, AWS WFS, download (~~xml~~, CSV, JSON, GeoJSON), DAWA (API), AWS Autocomplete, INSPIRE ATOM
Estonia	Municipalities	Mainstreet 360-24 13422 Tallinn Estonia	2,44 million (nov 2014)	free	WMS, X-Road (xml), In-ADS, Gazetteer Service, Geocoding, WFS, ATOM
Finland	municipalities, public authorities	Mainstreet 360 (as. 24) 00100 Helsinki Finland	n/a	no access	WMS, WFS

No	Country	Number of datasets	Name of the main(s) dataset	Year created	Content	Ministry in charge of the system	Data owner
10	**France**	1+ regionals	ADRESSE® POINT	n/a	address points	n/a	National Geographic and Forest Information Institute
11	**Germany**	1+ regionals	The Official House Coordinates Germany	n/a	buildings with addresses	n/a	Working Committee of the Surveying Authorities of the Laender of the Federal Republic of Germany
12	**Greece**	regionals	n/a	n/a	n/a	n/a	n/a
13	**Hungary**	0	n/a	n/a	n/a	n/a	n/a
14	**Ireland**	1	GeoDirectory	n/a	geocoded addresses of buildings	n/a	An Post and Ordnance Survey Ireland
15	**Italy**	1+ regionals	The national archive of urban street numbers	2010	street names, house numbers, Street Code, Sections for Census	Ministry of Economy and Finances	the Italian Revenue Agency and ISTAT
16	**Latvia**	1	State Address Register data	2011	textual and spatial data about streets, buildings and administrative territory borders	Ministry of Justice	State Land Service
17	**Lithuania**	1	Address Register of the Republic of Lithuania	2004	administrative units, residential areas, local administrative districts (neighbourhoods), streets, buildings and premises	n/a	State Enterprise Centre of Registers
18	**Luxembourg**	1	National Address Register	n/a	georeferenced and not georefereced addreses	n/a	Administration of the Cadaster and Topography, The Information Technology Center of State
19	**Malta**	0	n/a	n/a	n/a	n/a	n/a

Country	Data manager	Full address example of apartment	Entries	Access	Tools, Services
France	local governments and their partners	24 360 STREET MAIN 75014 PARIS	26 million	free (restrictions)	Shapefile, MIF / MID
Germany	cadastre authorities	Mainstr. 6 67 433 Kelkheim	21 million	price list	WFS-G
Greece	n/a	Mainstreet 360 546 42 THESSALONIKI	n/a	n/a	n/a
Hungary	n/a	Budapest Mainstreet 360, I. em/24 2806	n/a	n/a	n/a
Ireland	An Post and Ordnance Survey Ireland	360 Mainstreet CO DUBLIN	1.87 million buildings and 2.2 million addresses.	price list	CSV, Access Oracle Dump (XML)
Italy	Municipalities	360, 1, 24 Street Main 81055 Santa Maria Capua Vetere CE	26 millions	no access	n/a
Latvia	Municipalities	Mainstreet 360-24 Rauda Tukuma novads LV-3456	1354737 (2014)	Free/price list	WMS, ArcGIS Server service, CD or FTP (dgn, shp, gml, csv), INSPIRE WMS and WFS
Lithuania	municipal councils	Mainstreet 360-24 Ariogala 60249 Raseiniu r.sav. Lithuania	547,000 buildings and land plots addresses	price list	WMS, WFS
Luxembourg	Municipalities	360 Mainstreet 7456 Lintgen Luxembourg	n/a	free	WMS, REST API, SHP, CSV
Malta	n/a	360 Mainstreet Mellieha MLH 1021	n/a	n/a	n/a

No	Country	Number of datasets	Name of the main(s) dataset	Year created	Content	Ministry in charge of the system	Data owner
20	**The Netherlands**	1	Key Register Addresses and Buildings	2009	addresses, premises, their size and occupancy status, relevant dates	Ministry of Housing, Spatial Planning, and the Environment	The Netherlands' Cadastre, Land Registry and Mapping Agency
21	**Poland**	1	National Registers of Borders (PRG)		state borders, territorial units, addresses	Minister in charge of Public Administration	Head Office of Geodesy and Cartography
22	**Portugal**	regionals	n/a	n/a	n/a	n/a	n/a
23	**Romania**	0	n/a	n/a	n/a	n/a	n/a
24	**Slovakia**	1	Address registry (in progress)	n/a	addresses and points addressable residential and non-residential buildings	n/a	Ministry of Interior
25	**Slovenia**	1	Register of Spatial Units	1995	location and attribute data on spatial units and on addresses	Ministry of Environment and Spatial Planning	The Surveying and Mapping Authority of the Republic of Slovenia
26	**Spain**	1+ regionals	CartoCiudad	2006	cities and villages and their streets and roads networks, urban areas data (blocks, parcels, buildings, house numbers, street names, etc)	The Ministry of Development	National Geographic Institute of Spain
27	**Sweden**	1	Real Property Register	1994	the General part (the Cadastre), the Land Register, the Tax Assessment Part, the Address part, the Buildings part	Minisetry of Health and Social Affairs	Lantmäteriet

Country	Data manager	Full address example of apartment	Entries	Access	Tools, Services
The Netherlands	Municipalities	Mainstreet 24 2500 AA Den Haag	n/a	free/price list	WMS, WFS, BAG Extract (XML), BAG Compact, BAG Digilevering, BAG Bevragen, BAG Geocodeerservice
Poland	local authorities	str. Main 360/24 (or 360 m. 24) 00-902 Warszawa	n/a	free	WFS, WMS, API
Portugal	n/a	Street Main 360, 1, 24 2775-153 PAREDE PORTUGAL	n/a	n/a	n/a
Romania	n/a	str. Main bl. 360, sc. 6 et. 1, ap. 24 București, sector 6, 313988	n/a	n/a	n/a
Slovakia	n/a	Mainstreet 360 851 01 Bratislava	n/a	no access	n/a
Slovenia	branch offices, regional surveying and mapping authorities and the Main Office of the Surveying and Mapping Authority of the Republic of Slovenia	Mainstreet 360 2241 Spodnji Duplek	523 363 house numbers (2013)	price list	dbf, acsii, SHP (sample data), WMS, WFS
Spain	General Directorate of Cadastre, Statistical Office, Post Office, National Geographic Institute	Street Main 6 left 1 1 (or 360, 1°, 24) Cortijo del Marqués 41037, Écija (Sevilla)	99% of the Spanish population	free	WMS, WMS-C, WMS-T, WFS, WPS (Proximity area, Routing), download (SHP), ATOM
Sweden	municipalities, Swedish Post, Swedish Tax Agency	Mainstreet 6 1101 12345 Farsta	3,6 million (2013)	price list	Adress Direkt (GML), Referens Uppslag Adress, Adress Visning Inspire (WMS), Adress Nedladdning Inspire (GML)

No	Country	Number of datasets	Name of the main(s) dataset	Year created	Content	Ministry in charge of the system	Data owner
28	**United Kingdom**	2	Pointer (Northern Ireland)	n/a	addressable buildings	n/a	Land & Property Services
			National Address Gazetteer (England, Wales, Scotland)	2011	unique identifiers for the definitive street name and number with postcode and with a link to the map base	No ministry	GeoPlace (Local Government Association and Ordnance Survey)

Country	Data manager	Full address example of apartment	Entries	Access	Tools, Services
United Kingdom	local councils and Royal Mail	Flat 1A 6, Mainstreet Fairfield Wandsworth London SW18 1ED	n/a	price list	WMS, download (CSV), restricted Pre-Defined Download (fgdb)
	local authorities, Ordnance Survey, Royal Mail		40 million	price list	AddressBase Premium, AddressBase Plus, AddressBase, Atom feed (INSPIRE Download service)

n/a - no answer

Changed during 2015-2017

(AGIV, 2015f; Aigars, 2014; Andreasson, 2008; Ažman & Petek, 2011; Bačina, 2014; Benetton, 2014; BEV, 2015; Brzezińska, 2014; CartoCiudad, 2016; CIRB, 2015a, 2015b; Colas et al., 2013; Croatian State Geodetic Administration, 2015; Cyprus Ministry of Interior, 2014; DATECS GIS Center, 2015; Denmarks Adresser, 2015; Deutsche Post, 2015; EuroGeographics, 2015; European Location Framework, 2016b; GeoDirectory, 2016a, 2016b; GeoPlace, 2015b; Goorman, 2010; Guide-Spain.Com, 2015; Informatica AddressDoctor, 2015; INSPIRE Thematic Working Group Addresses, 2014; A. González Jiménez et al., 2012; Alicia González Jiménez et al., 2009; Kadaster, 2016a, 2016b; Lantmäteriet, 2015a, 2015b, 2015d; Lind, 2008; Maa-amet, 2015a; Main Geodetic and Cartographic Documentation Centre, 2015, 2016; Ministry of Economy and Finances, 2015; National Geographic and Forest Information Institute, 2015a, 2015b, 2015c; National Land and Property Gazetteer, 2015; National Land Survey of Finland, 2015b; NGI, 2014, 2015; OpenStreetMap Wiki contributors, 02.03.2014; Pauknerova, 2012; Permanent Committee on Cadastre in the European Union, 2015; Petek, 2013; Population Register Centre, 2016a, 2016b, 2016c, 2016d; Roos, 2014; Slovak Ministry of Interior, 2015; SPW, 2015; State Enterprise Centre of Registers, 2016a, 2016b; State Land Service, 2016; The Administration of Cadastre and Topography, 2015; The Czech Office for Surveying, 2015a; The Surveying and Mapping Authority of the Republic of Slovenia, 2015a, 2015b, 2016; Vandenbroucke & Biliouris, 01.09.2010; Working Committee of the Surveying Authorities of the Laender of the Federal Republic of Germany, 2016; Young, 14.01.2013)

Appendix J: Address datasets of the EU countries (an overview)

Subsequently address datasets and related information for all 28 EU countries' are presented. Countries are listed in an alphabetical order. For each country, first, information found in INSPIRE Monitoring Report about theme Addresses is given. Second, overview of existing address system is given, who is the owner, what services are offered and other interesting facts. Finally, findings from INSPIRE Geoportal Discovery about Address theme are presented. More detailed information is found in Appendix I as a table. In 2017 information about changes and improvements was added.

Austria

Austrian dataset is named Address register (Österreichisches Adressregister). It is managed by Federal Office of Metrology and Surveying (BEV - Bundesamt für Eich- und Vermessungswesen). Central database is managed by the municipalities and cities. Each address has an unique key (7-digit address code) and spatial coordinates (BEV, 2015). Product has a price list and the prices are set per object. Delivery format is in .csv. In INSPIRE Geoportal only INSPIRE discovery service is found. In INSPIRE Monitoring they indicate WMS and WFS also. Only web link for WMS was found.

Belgium

AGIV (2014) indicates in INSPIRE monitoring five different datasets and four different providers. Three of the providers are regionals (Walloon, Brussels and Flanders) and one is national. Regional datasets owners are Public Service of Walloon, Geographic Information Agency Flanders, Brussels Regional Informatics Centre. National dataset is owned by National Geographic Institute.

Central Reference Address Database (Centraal Referentieadressenbestand - CRAB) is owned by Geographic Information Agency Flanders (AGIV - Agentschap voor Geografische Informatie Vlaanderen). This database contains street names, house numbers and information about the geographical positioning of addresses (AGIV, 2015h). The 308 Flemish municipalities are responsible for address detail management on their territory. The AGIV in charge of technical management of the CRAB databank (AGIV, 2016). CRAB has applications and downloading, management and view services. Municipalities use web application, Lara (Loket voor Authentieke Registratie), to manage addresses. Other management tools help also municipalities to manage addresses.

It is possible to download different datasets from https://download.agiv.be for free. In case of customized data is wanted then registration is needed. Metadata of downloadable datasets is INSPIRE compliant (AGIV, 2015c, 2015d, 2015e, 2015i):

- "CRAB address positions", which contains house numbers and their position and is distributed in dBASE , AccessDB , Shapefile , GML (2.1.2) format;
- "CRAB address list" list of addresses up to house number an sub address level and is distributed in Shapefile and GML;
- "CRAB street list" street names in Belgium without geographical coordinates dBASE, AccessDB;
- "xGRAB" is only for CRAB managers, contains all CRAB-entities relevant for decentralised working managers of the CRAB (AGIV, 2015a, 2015g)

Services:

- The CRAB Tools (GetCRABMatch, GetAddressLocation, GetStreetLocation) service contains methods that help to clean up their own mailing lists and enriching it with geographical information;
- Geolocation service converts addresses to geographic coordinates which can then be used to indicate a position on a map;
- WS-CRAB - helps to consult CRAB entities through operations;
- WMS addresses - INSPIRE compliant
  (AGIV, 2015b)

From INSPIRE Geoportal Discovery/Viewer AGIV's WMS can be discovered.

National Geographic Institute (NGI - Nationaal Geografisch Instituut / IGN - Institut géographique national) is the owner of TOP10vector dataset, which contains roads, railways, hydrography, height, land cover and vegetation. The geometry of the data of all these themes is described by x, y, z coordinates. This dataset has subset called TOP10vector - Street names (Segment de route/wegsegment), this contains street names associated with the road segments (NGI, 2014). It is possible to request data with price of EUR 30 / km² in ESRI File Geodatabase, ESRI shapefile, GML , AutoCAD DWG (CAD Version) format via DVD or File Transfer System (NGI, 2016). Other options, to access the data, were not discovered.

Public Service of Walloon (SPW - Service public de Wallonie) is the owner of spatial data "Information Mapping Project Continues" (PICC - Projet Informatique de Cartographie Continue). It is Digital Topographic 3D data of all the Walloon Region. Also contains addresses with roads. Next to Addresses INSPIRE theme is connected to Elevation, Buildings, and Transport networks. It is possible to request dataset by filling the form and paying according to price list. Distribution formats are ESRI shapefile, AutoCAD DWG and ESRI File Geodatabase. Also there are WMS and REST services (SPW, 2015). In 2015-2017 WFS service has been added.

Brussels Regional Informatics Centre (CIRB- Centre d'Informatique pour la Région Bruxelloise / CIBG - Centrum voor Informatica voor het Brusselse Gewest) owns UrbIS solutions. It is a set of geographical databases of the Brussels-Capital Region. There are three different options to access the dataset: data, tools and application. Data is accessible free of charge. BRIC offers several cartographical databases: Aerial photomaps, Orthophotomap, topographic data, administrative database, base map, database of parcels and buildings. Data can be downloaded via UrbIS Download (http://urbisdownload.gis.irisnet.be/en/dimension) in DGN (Microstation), DWG (AutoCAD), MDB (Database Access), SHP (Shapefile), TAB (MapInfo), TAB (MapInfo Non-Earth) formats. UrbIS contains also points of addresses and streets. Addresses can be accessed through WMS, WMTS, WFS and Geolocation service (CIRB, 2015b). Also ESRI REST services are offered.

Apart from described datasets Belgium Civil registry contains also official addresses of natural person. It is managed by Federal Public Service Interior (Federale Overheidsdienst Binnenlandse Zaken - IBZ) and doesn't have a public access (IBZ, 2015).

Bulgaria

In Ministry of Transport (2014) INSPIRE Monitoring Responsible authority and spatial dataset of Annex I, 5. Addresses are not indicated. Also from INSPIRE Geoportal Discovery Service no datasets, services were found. From private sector one of the address data owners were found: DATECS GIS Center (DATECS GIS Center, 2015).

Croatia

In Croatia (2014) INSPIRE Monitoring f datasets are indicated, three regionals: City of Umag, City of Knin and City of Split; and one national: Register of Spatial Units (RPJ - Registar prostornih jedinica) owned by State Geodetic Administration (DGU - Državna Geodetska Uprava).

RPJ contains data of spatial units for statistics levels, city, municipality, town, post office delivery area, units of local government, protected areas, cadastral municipality, cadastral area at sea, statistical and census districts, streets, square and buildings with house numbers (Croatian State Geodetic Administration, 2015). Register of Spatial Units consists of regional registers and the central register of spatial units. Local government is responsible for the establishment and management of original records of settlements, streets and house numbers.

On INSPIRE Geoportal DGU services are found and based on metadata INSPIRE conformance:

Service/INSPIRE	**INSPIRE Data Specification on Geographical Names**	**INSPIRE Data Specification on Addresses**	**INSPIRE Directive on interoperability of spatial datasets and services**
WMS	Is conformant	Is not conformant	Is not conformant
WFS	Is not conformant	Is conformant	Is conformant
ATOM	Is conformant	Is conformant	Is conformant

Czech Republic

According to EURADIN (2008) survey results OKsystem s.r.o. was in charge of UIR-ADR - Territorial Identification Register of Addresses, but this changed in 2012, when the old database was replaced by RUIAN.

Czech Environmental Information Agency (2014) indicated in INSPIRE Monitoring two Annex I Addresses datasets: RÚIAN and INSPIRE Adresy (AD) by The Czech Office for Surveying, Mapping and Cadastre - COSMC (ČÚZK - Český úřad zeměměřický a katastrální).

RUIAN is a basic register of territorial identification, addresses and real estate. It is the largest Basic Register within the eGovernment. Register does not contain any personal data. RUIAN is an unique data resource of addresses for state administration (Bačina, 2014). RUIAN contains: territorial features and units, purpose territorial features, address nodes, buildings registered in Czech Cadastre, real estate links among data (OpenStreetMap Wiki contributors, 02.03.2014). RUIAN is

edited by RUIAN Administrator (COSMC), Municipal offices, Building authorities (Local, specialized), Czech statistical office.

RUIAN data can be downloaded from Remote Public Access (http://vdp.cuzk.cz/) for free in RUIAN exchange format (VFR) in GML 3. 2. 1. format and from Cadaster Consultation (http://nahlizenidokn.cuzk.cz/StahniAdresniMistaRUIAN.aspx) in CSV format (The Czech Office for Surveying, 2015b).

Development of RUIAN was co-funded by the European Union - European Fund for Regional Development. INSPIRE and European Interoperability Framework (EIF) were used as baseline/framework in the development (Pauknerova, 2012). In 2015 from INSPIRE Geoportal it is discovered that Czech Republic has INSPIRE compliant WMS, WFS and downloadable zipped GML files. In 2015-2017 ATOM service option was added.

Cyprus

Ministry of Interior of Cyprus (2014) has indicated in INSPIRE Monitoring seven different datasets related to INSPIRE theme Addresses:

Dataset	**Responsible Authority**
Road axes (1:500 - 1:5000)	The Department of Lands and Surveys
Postal sectors	
Road axes	Municipalities and communities
Addresses	Agia Napa Municipality
Roads	Paralimni Municipality
Postal code	Postal Services
Addresses	Fire Service

In 2015 no Address services, datasets, series were found on INSPIRE Geoportal. In 2017 INSPIRE Geoportal retrieved WMS and WFS services, but they only cover 4% of Cyprus.

Denmark

According to Danish Geodata Agency (2014) INSPIRE monitoring Denmark's address dataset is Building and Dwelling Register (BBR - Bygnings- og Boligregisteret), owned by Ministry of Housing, Urban and Rural. It was originally constructed in 1978, was improved in 1980-90. During 1996 - 2001 spatial content (address coordinates) was added. Lately, was under modernization (data model, IT-platform, interfaces, services) (EURADIN, 2008).

In Denmark according to law, addresses assigned to individual dwellings must be unique, which means that residential buildings with more than one main entrance door are have individual address for each entrance door or stairway. In case of two or more dwellings have access through same stairway then each dwelling must be assigned information about floor number and door. Every street has unique three-digit municipality code and four-digit street code (Lind, 2003).

In international level Denmark cooperates with Nordic Address Forum, ISO Addressing, INSPIRE. In accordance with INSPIRE Denmark has made address data available in a format that is common to the whole EU. Also Denmark has actively participated in designing the common rules and guidelines (Ministry of Housing, 2015).

In 2002 the official Danish address data was made available free of charge. Now the goal is to have single cohesive register of correct addresses by 2017. When the addresses are complete the annually revenues for the Danish society are expected to be approx. 33,5 million euros annually (24 million euros in the public sector)(Munkstrup, 2015).

From website http://www.aws.dk/ everyone can access the data for free in different formats. They offer Denmark Address Web API, which provides a service-based access to data and helps to consume it in machine readable way. From web services AWS4 WMS supports various styles, which helps to find best fit with different backgrounds. Denmark also offers WFS and download option in CSV, GeoJSON and JSON format.

In 2015 in INSPIRE Geoportal following services are indicated: WMS INSPIRE, WFS INSPIRE, Download Inspire GML (but no links are provided), API (GeoCodingAddressService and GeographicSearchAddressService). 2015-2017 WFS and ATOM services were added.

Estonia

In Maa-amet (2014) INSPIRE Monitoring Report an Address INSPIRE dataset is indicated with responsible authorities of Estonian Land Board (Maa-amet) and local governments. Estonia has Address Data Information System (ADS), which a central address data management system and is conformant with INSPIRE metadata, services and interoperability Directive, but it is not conformant with INSPIRE Address Specification. According to Estonian law all national and municipal information systems have to linked with ADS (Maa-amet, 2015b). Estonian official address data is used by both, private and public sector.

Estonia offers address data via WMS service, Gazetteer Service and In-ADS API. Data is also downloadable in CSV format. In-ADS can be used in web-based information systems to harvest up to date address data in machine readable JSON format. To transfer address information between Estonian information systems X-Road is use to exchange updates in XML formats.

In 2015 INSPIRE Geoportal Estonian INSPIRE WMS is findable.

Finland

National Land Survey of Finland (2014) indicates in INSPIRE Monitoring Report 75 datasets for Addresses. Building and residence addresses in population information system owned by Population Register Centre is the only national dataset, others are municipal level datasets. None of them is compliant with INSPIRE.

Building and Dwelling Register (BDR) contains addresses, building codes and centre point coordinates of buildings and forms nationwide address information system. Building information is maintained

and checked by municipalities and local register offices. Since 1969 the population information system is computerized. From 1988 Address System subset is continuously updated (EURADIN, 2008). Using building and apartment codes, persons registered in the Population Information System can be linked with the centre coordinates of buildings and, using identifiers, buildings can be linked with other national base registers used in Finland. This enables the utilisation of the Population Information System in various geographical data applications (Population Register Centre, 2016a).

The data model of Finnish population register is:
Person >> Apartment (apt. number) >> building (street name and street number)

The most address related web service is Building data query service (WFS). Through this service it is possible to access the Population Information System construction data. The service can inquire the buildings identifying information, attribute information, as well as the owner of the information (National Land Survey of Finland, 2015a).

In 2015 111 services and datasets can be discover from the INSPIRE geoportal. Most of them are municipal level services and datasets. No national address services were found. 2015-2017 new national level services were added, WMS and WFS. With these services was a note: *The service is in beta and as such accessibility and full operationality is not guaranteed. During the beta phase the service is free to use and there are no access constraints. Beta phase will continue until 30th June 2017.*

France

In France (2014) INSPIRE Monitoring Report 8 different datasets containing Addresses are found. Six of them are regional or municipal datasets, one is related to water management and one is national address dataset called POINT ADRESSE®.

POINT ADRESSE® is owned by National Geographic and Forest Information Institute (Institut national de l'information géographique et forestière - IGN-F). Available formats are Shapefile, MIF / MID, GML. From IGN (2015) information about INSPIRE download service is found. It can be downloaded in GML format. For public use and research it is for free, but registration is needed. For private sector a price list applies.

POINT ADRESSE® has different extensions and their content and formats vary:

- BD ADRESSE® - addresses point, a road network (2D) including all roads with place names, administrative boundaries. Formats: Shapefile, MIF / MID
- ROUTE ADRESSE® - 2D road network, street names and addresses at the intersections. Formats: Shapefile, MIF / MID
- ADDRESS PREMIUM - ability to link the address to other objects or cut-outs. Formats: CSV, DBF, TXT, SHP

From INSPIRE Geoportal 65 datasets and series were found. Mainly they were regional datasets, but no address related services were found.

Germany

Koordinierungsstelle GDI-DE (2014) indicated 129 datasets in theme Addresses. Most of them are regional and municipal datasets. It is hard to determine, if any of them is national wide. Dataset INSPIRE Adressen NRW by GDI-NW: Geobasis NRW, Bezirksregierung Köln stands out by being the only dataset with conformant metadata.

The Official House Coordinates Germany (HK-DE) is a dataset that defines spatial position of buildings with addresses across Germany owned by Working Committee of the Surveying Authorities of the Laender of the Federal Republic of Germany (Arbeitsgemeinschaft der Vermessungsverwaltungen der Länder der Bundesrepublik Deutschland). HK-DE contains: key for the Land, administrative district, district/independent city, municipality, location or municipality part, street - structured according to a nationally valid statistic key; Street name, house number, address supplement; Post code, postal location name, supplement to postal location name, postal district. Data format is ASCII and updates are made once a year (Working Committee of the Surveying Authorities of the Laender of the Federal Republic of Germany, 2016).

German Geoportal finds 39 datasets and services related to theme Addresses and INSPIRE. Some datasets contain only specific types of addresses: schools, pharmacies, kinder gardens. In INSPIRE Geoportal over 130 services and dataset are discovered including regional INSPIRE compliant and non-compliant services.

Greece

Ministry for Environment (2014) has indicated in INSPIRE Monitoring Report 4 datasets for theme Addresses:

Dataset	**Responsible authority**	**Ministry in charge**
Roads Attica (1: 5000)	Office ETI and EEA - D / Division of Environmental Planning	Ministry of Environment, Energy and Climate Change
Roads Thessaloniki (1: 5000)	Office ETI and EEA - D / Division of Environmental Planning	Ministry of Environment, Energy and Climate Change
Police Departments Locations	Office GIS - Division - Greek Police Headquarters -	Ministry of Public Order and Citizen Protection
Road Axes	Greek Post Office	Ministry of Infrastructure, Transport and Networks

None of them can be identified a central address dataset. In INSPIRE Geoportal no address related dataset, service were found.

Hungary

In Hungary (2014) INSPIRE Monitoring Report no address dataset is indicated. In INSPIRE Geoportal no address related dataset, service were found.

EURADIN (2008) indicates in the partners' survey, that Hungary has the Hungarian Land Registry System called TAKAROS. The Land Registry contains the addresses of parcels. The main attribute is the parcel number. In every case the addresses are not up-to-date also the land registry system is not established for public search of the addresses.

Ireland

Department of Environment, Community and Local Government of Ireland (2013) indicates in the INSPIRE Monitoring Report that addresses' dataset is GeoDirectory and responsible authority is Ordnance Survey Ireland/An Post.

GeoDirectory is Ireland's most authoritative electronic register of addresses matched precisely to their geographical locations. It is updated constantly, due to population or business migration up to 600,000 changes every year. Benefits of using GeoDirectory are: capture addresses in standardised format, helps to clean up address database, remove duplicates (GeoDirectory, 2016b).

GeoDirectory gives each property a standardised eight digit code, classifies each building as being either residential or commercial and had coordinates to each building within metre accuracy. Can be downloaded in following formats: CSV (Excel compatible), Access, Oracle Dump, XML (GeoDirectory, 2016a).

GeoDirectory's different products:

- GeoAddress Locator - The essential directory of every Irish address with coordinates
- GeoAddress - The directory of every Irish address
- GeoBusiness Locator - the comprehensive business to business database with coordinates
- GeoBusiness - comprehensive database of Ireland's businesses
- GeoBuild - helps businesses to target new customers, helps to reach new residents at precisely the time when they are most likely to purchase products
- GeoForecaster - marketing tool with details of future building developments and advance knowledge of future addresses

In the INSPIRE Geoportal no address related dataset or service were found.

Italy

ISPRA (2014) indicates in INSPIRE Monitoring Report 61 regional datasets and no central dataset for addresses.

From 2012 the Italian Revenue Agency (Agenzia delle Entrate) and The National Institute for Statistics (Istituto nazionale di statistica - ISTAT) is developing The national archive of urban street numbers (Archivio nazionale dei numeri civici delle strade urbane - ANNCSU) (Italian Revenue Agency, 2015). It

contains now street names, house numbers, street code, sections for Census. At the later stage will contain: zip codes, road graph, and spatial coordinates.

Need for central database was influenced by different stakeholders. The municipalities, in charge of holding street names' registers, sometimes did not use a single street name register, but used multiple, which were not perfectly consistent with each other and were managed independently by individual offices. With increase of digitalization of archives and need for integration between them resulted with a cooperation between different database holders.

The development started with House numbers and street names' national register (*Archivio nazionale degli stradari e dei numeri civici* - ANSC) in 2010, which collected data from municipalities about House numbers and street names. ISTAT added street numbers, archive of addresses of individuals/ families in the population and archive of addresses of buildings collected during the census (Benetton, 2014). Combined dataset is called ANNCSU.

In the INSPIRE Geoportal no address related dataset or service were found.

Latvia

Latvijas Ģeotelpiskās informācijas aģentūra (2014) indicates in the INSPIRE Monitoring their address dataset as State Address Register data (Valsts adrešu reģistra informācijas sistēma - VARIS) with responsible authority of State Land Service (Valsts zemes dienests- VZD) and Ministry of Justice

Address register was founded at 2001 by combining together following registers: Cadaster, Population register, Social Security system, State Revenue Service, State Enterprise Register. Register covers whole country and is 100% digital. It is used regularly by 119 Municipalities, 23 Government institutions,31 Companies (Aigars, 2014).

For a price data can be accessed via WMS, ArcGIS Server service, CD or FTP (dgn, shp, gml, csv). Also it is possible to browse data with and without contract via Cadaster portal (State Land Service, 2016). Price depends on the browser (public or private sector) and how detailed data is needed.

EURADIN (2010b) describes in Good Practice Catalogue Latvian Address classifier. In State Address Register of Latvia each addressing object has a unique code of addressing object and all the addressing objects are classified in Address classifier. All the addressing objects are registered on-line in central database.

In INSPIRE Geoportal five Latvian address related services, datasets are found. Has INSPIRE WMS, WFS and dataset.

Lithuania

Lithuania National Land Service (2014) indicates in the INSPIRE Monitoring Report existence of Address Register of the Republic of Lithuania and responsible authority is State Enterprise Centre of Registers (SE "Registru centras"). The Address Register is a one of the base state registers and single official address data source in the Republic of Lithuania. All state (municipal) registers and cadastres

information systems must use only the Address Register data. Private sector is recommended to use the Address Register data. Each address registered in the Address Register has a unique number, which becomes very useful when Address Register data is used in other information systems. Data from the Address Register are provided for a fee (except for cases when it is by law made mandatory) (EURADIN, 2010b, p. 85).

The function of the Address Register is to:

- collect and store data of residential areas, neighbourhoods, streets, buildings and premises addresses, including geographical data components;
- provide registry data for public authorities, other public registers, businesses and residents

Data can be acquired by completing and signing a contract.

In INSPIRE Geoportal four INSPIRE services and datasets are found. Lithuania has INSPIRE WMS and ATOM service.

Luxembourg

In Luxembourg (2014) INSPIRE Monitoring Report two datasets that contain addresses are indicated: Official file of the georeferenced addresses of the Grand-Duchy of Luxemburg and INSPIRE - Annex I Theme Addresses - Layer Addresses, both owned by Administration of the Cadaster and Topography (l'administration du cadastre et de la topographie - ACT).

Luxembourg also has centralised database of the Luxembourg official addresses, named National Register of localities and streets (Registre national des localités et des rues). It is set up by Administration of the Cadaster and Topography (ACT) and the Information Technology Center of State (le centre des technologies de l'information de l'Etat - CTIE). This register contains addresses, that are not georeferenced (The Administration of Cadastre and Topography, 2015). It contains:

- Administrative District Name
- Name of canton
- Town
- Name of locality
- Street name
- House number (or home number)
- Zip code of the building

In INSIPRE Geoportal two services and one dataset is discovered. Luxembourg has INSIPRE Address WMS.

Malta

Malta Information Technology Agency (2014) indicates in INSPIRE Monitoring no dataset for Addresses. INSPIRE Geoportal do not discover any Malta's datasets or services, that are related with addresses. In 2015-2017 Malta Geoportal has been added, but it does not contain address data yet.

Netherlands

Ministry of Infrastructure and the Environment (2014) indicates dataset for addresses, named Key Register Addresses and Buildings (Basisregistraties Adressen en Gebouwen - BAG) and its responsible authority is Dutch Land Registry Office (Kadaster).

BAG is one of the base registers in the Netherlands. Kadaster makes data available to different buyers. Public bodies are obliged to use BAG data. All services are free for public sector, in most cases private sector has to pay minimum cost. Address data can be used via number of services:

- BAG Extract - Collection of XML files. The geometric data of the BAG objects are supplied in GML files.
- BAG Compact - XML files, contains the addresses of the Netherlands on a fixed date
- BAG Digilevering - delivers changes to ensure up to date registers
- BAG Bevragen - offers web services option to request BAG data by object ID, address
- BAG Geocodeerservice - geocoding service, helps to geocode addresses from text queries
- WMS - free of charge
- WFS - free of charge
- BAG Viewer - an online map, free of charge
  (Kadaster, 2016a)

During EURADIN project the Netherlands made a prototype, which concerned addresses content transformation and INSPIRE-compliant data delivery from a source database with Dutch national geodata conform BAG. Hemmatnia et al. (2010) transformed The Key Registers for Addresses and Buildings (BAG) and parcel data from Cadastral registration (BRK) into INSPIRE-compliant geodata and exposed through a Web Feature Service (WFS) using “Combined Transformation” (CT). Firstly, data according to the Dutch local model was transformed offline into a (database) data model close to the INSPIRE data specification. It included coordinate transformation, from the Dutch "Rijksdriehoeksmeting" (RD) CRS into ETRS89. Secondly, the resulting data from the first step was subsequently transformed, on-the-fly, into INSPIRE-compliant data (GML) during execution of a web Download (WFS) or View (WMS) service.

INSPIRE Geoportal discovers seven address dataset/service from the Netherlands. Data can be access via INSPIRE WMS, ATOM.

Poland

Main Geodetic and Cartographic Documentation Centre (2014) indicates in INSPIRE Monitoring two address datasets for addresses: Database of Topographic Object - Adresses Points (Baza danych obiektów topograficznych - punkty adresowe) and INSPIRE Addresses, both owned by Surveyor General of Poland - GGK.

INSPIRE Geoportal finds 728 datasets, services related to addresses. INSPIRE WMS, WFS, WMTS, ATOM are offered. Most of the discovered findings are referring to smaller area datasets.

Portugal

National System Information Geographic (2014) indicates in INSPIRE Monitoring three datasets:

- GeoIndex Addresses (Endereços), Postal Services of Portugal (CTT,S.A.)
- Addresses of Region Of Azores (Endereços da Região Autónoma dos Açores), Region of Azores (Região Autónoma dos Açores - RAA)
- Police in Santa Cruz das Flores (Números de Policia do concelho de Santa Cruz das Flores), RAA

GeoIndex Addresses contain vector data of addresses (entrances). The dataset supports the postal code of Portugal, helps to automate processing of postal delivery, optimizes postal services' delivery routes (The National Geographic Information System, 2011). It is offered also as a tool for geomarketing, which helps businesses to identify new opportunities, clients, area for potential consumption (Postal Services of Portugal, 2015). It visualizes economical and socio-economical parameters of a specific location. Two other datasets are regional dataset.

EURADIN (2010b) initiated Tavira's Pilot project (region Algarve). Its aim was to test and adapt the specifications of INSPIRE to the address, considering the input of the project EURADIN and aspects of the Portuguese reality. Five years later hints of a successful implementation on national were not found.

In EURADIN (2008) partner survey the National Statistics Institute (Instituto Nacional de Estatística - INE) was indicated as a owner of a dataset, that contains addresses for statistical production.

INSPIRE Geoportal discovers one Portuguese dataset, Police in Santa Cruz das Flores.

Romania

National Agency for Cadastre and Land Registration (2014) indicates in INSPIRE Monitoring report no address dataset.

In the INSPIRE Geoportal no address related dataset or service were found.

Slovakia

Slovak Environment Agency (2014) indicates two dataset for addresses:

- Address points (Adresné body), Ministry of Interior (Ministerstvo vnútra SR)
- Address points (Adresné body), Žilina Region (Úrad Žilinského samosprávneho kraja)

With a help from European Regional Development Fund Slovakia is developing Address registry (Register adries), which would contain addresses of residential and non-residential buildings with spatial coordinates. The duration of the project is from 12/2011 to 07/2015 (Slovak Ministry of Interior, 2015).

In the INSPIRE Geoportal no address related dataset or service were found.

Slovenia

The Surveying and Mapping Authority of the Republic of Slovenia (2014) indicates Register of Spatial Units (Register prostorskih enot) as address dataset by The Surveying and Mapping Authority of the Republic of Slovenia (SMA).

Register of Spatial Units is a database that contains spatial and descriptive data. Content can be divided into three mayor categories: basic spatial units, additional spatial units and codes (The Surveying and Mapping Authority of the Republic of Slovenia, 2015a).

- basic spatial units - house number, spatial district, statistical district, settlement, municipality, administrative unit, country.
- additional spatial units - street, district, village community, local community, the polls for local elections, polling stations for parliamentary elections, the electoral unit for the local elections, electoral district for the general election, the electoral unit for the election, school district.
- codebooks - codes for spatial units, street code list, and others.

Data can be ordered by filling the form and price list applies. The Surveying and Mapping Authority of the Republic of Slovenia offers free data also, but not addresses. Addresses can be ordered in dbf, and ACSII format, example dataset is in SHP. Online services are accessible by registered users (The Surveying and Mapping Authority of the Republic of Slovenia, 2015b).

In 2015 the INSPIRE Geoportal Register of Spatial Units is found as a dataset. 2015-2015 new web services were added, WMS and WFS.

Spain

Instituto Geográfico Nacional (2014) indicates 13 address datasets. 12 of them are different regional datasets. The widest coverage, national level, has CartoCiudad by National Geographic Institute of Spain.

CartoCiudad started its work in the land of Valencia in 2006 and year by year has expanded the coverage (EURADIN, 2010b).

CartoCiudad contains data about:

- Continuous road network
- Urban cartography and toponymy
- Postcodes
- Districts and census tracts

Services available and in accordance with OGC (2015):

- WMS
- WMS INSPIRE
- WMS-C

- WMTS
- WFS-INSPIRE addresses
- WPS

(CartoCiudad, 2016)

2015-2017 ATOM services has been added.

In INSPIRE Geoportal 350 dataset/services can be found under keyword "addresses". Most of them are regional datasets and large part are related to CartoCiudad.

In the survey, Spain explained their complex address system: "The local governments (in Spain there are more 8.000 municipalities) are in charge of creating the addresses; after that they have to send the addresses data by law (within the electoral census and the register of inhabitants) to the National Statistic Office so that it can gather the data all over Spain (so far these addresses data do not have coordinates). In addition, Cadastre department also gather addresses data as they are linked to the real state owners and the cadastral parcels. Moreover, IGN-Spain has created a street map whose addresses data come from a matching process between Statistic Office and Cadastre."

Sweden

Lantmäteriet (2014) indicates that there is a dataset named Dataset for Addresses INSPIRE, owned by Lantmäteriet.

The Real Property Register includes information on all real property units. Contains data in five main groups (Andreasson, 2008):

- the General part (the Cadastre)
- the Land Register
- the Tax Assessment Part
- the Address part
- the Buildings part

In Sweden mainly municipalities are responsible for updates. In 2015 15 municipalities use service - base solutions for updating. In 2014, about 3,8 million euro were paid to the municipalities to update address register. In towns street names and house numbers have been assigned by council over 100 years (Roos, 2014). In rural areas, cadastral names and place names are most common. There was not any official registration of addresses until 20 years ago. Swedish address standard exists from 1998, currently the revision is going on and new version will be expected in 2015. It will contain, for example, rules about how addresses on the minority language for the sami people should be handled. Addresses are directly georeferenced since 2002. Five years ago the apartments were linked to the addresses.

It is not possible for individuals to gain access to Lantmäteriet geodata services. It is only possible to register corporate identification numbers in Lantmäteriet's authorization system. Currently, Lantmäteriet and the municipalities prepares for open geographical data and addresses.

Lantmäteriet has requested funding (about 100 million Skr) to open data, but nothing is decided yet (Lantmäteriet, 2015c).

In INSPIRE Geoportal INSPIRE dataset, ATOM service and view service are presented.

United Kingdom

Department of Environment, Food and Rural Affairs of UK (2014) indicates 17 different address datasets:

NI Councils Licensed Sports Stadiums and Stands (Pre-defined Downloads)	Ballymena Borough Council (owner)
NI Councils Licensed Sports Stadiums and Stands (Metadata)	Ballymena Borough Council (owner)
LPS OSNI Pointer (Metadata)	Land & Property Services (owner)
LPS OSNI POINTER (Download)	Land & Property Services (owner)
LPS OSNI Pointer Lite (Metadata)	Land & Property Services (owner)
NIEA - Land Use - Historic (Metadata)	Northern Ireland Environment Agency, Land and Resource Management (owner)
NIEA - Land Use - Historic (Pre-defined Download)	Northern Ireland Environment Agency, Land and Resource Management (pointOfContact)
OS MasterMap Address Layer 2	Ordnance Survey, Great Britain (publisher)
Code-Point Open	Ordnance Survey, Great Britain (publisher)
OS MastermapÂ® Address Layer	Ordnance Survey, Great Britain (publisher)
Code-Point®	Ordnance Survey, Great Britain (publisher)
Code-Point® with polygons	Ordnance Survey, Great Britain (publisher)
AddressBase	Ordnance Survey, Great Britain (publisher)
AddressBase Plus	Ordnance Survey, Great Britain (publisher)
AddressBase Premium	Ordnance Survey, Great Britain (publisher)
Police Stations of Northern Ireland (Metadata)	Police Service of Northern Ireland (owner)
One Scotland Gazetteer	The Improvement Service (resourceProvider)

Currently UK has gathered together three different datasets from England, Wales and Scotland and named it the National Address Gazetteer. This dataset is not mentioned in the Monitoring Report. Geoplace is the name of the company, who is in charge of the National Address Gazetteer. Dataset contains unique identifiers for the definitive street name and number with postcode and with a link to the map base. Data sources are local authorities, Ordnance Survey and Royal Mail PAF (GeoPlace, 2016).

GeoPlace previous body was The National Land and Property Gazetteer (NLPG). Until 2011 NLPG wasn't the only address dataset produced and maintained by the public sector. GeoPlace was created as a joint venture partnership. It brings together local government's address and streets gazetteers; the National Land and Property Gazetteer (NLPG) and the National Street Gazetteer

(NSG), with all of Ordnance Survey's addressing products (The National Land and Property Gazetteer, 2015).

The national address gazetteer supports the Location Strategy's concept of a 'Core Reference Geography' and the key principles of the INSPIRE directive. Addressing data will be published through the national address gazetteer meeting the requirements of the INSPIRE technical framework. It helps to reduce the burden to local authorities to meet those requirements themselves (Geoplace, 2015a).

GeoPlace offers following services:

- AddressBase Premium - the most detailed view of an address and its lifecycle. It contains all the AddressBase Plus information and functionalities. Formats: GML, CSV
- AddressBase Plus - contains current properties and addresses sourced from local authorities, Ordnance Survey and Royal Mail. It has more records than AddressBase. Formats: GML, CSV
- AddressBase - Contains Royal Mail PAF addresses, both commercial and residential matched to the local authority Unique Property Reference Number (UPRN) and structured in a flat file model. Formats: CSV
  (GeoPlace, 2016)

There is price list for mentioned products with price for full dataset from £129,950 to £189,370 (Ordnance Survey, 2015). For all previous datasets there are Atom feed (INSPIRE Download service) with closed license (DATA.GOV.UK, 2015)

EURADIN (2010b) describes in Good Practice Catalogue a project named "Extending the accessibility of address information across England and Wales". It started in 2009-2010 and aimed to make the National Land and Property Gazetteer (NLPG) available to both public and private sector organisations.

Northern Ireland has its separate dataset, called Pointer. It is maintained by Land & Property Services (LPS), with input from local councils and Royal Mail (NIDirect, 2016). Pointer is spatial address database with full Northern Ireland coverage. To access the data price list applies, price for all data is £7,049.70 (NIDirect, 2015).

Pointer has Pre-Defined Download in File Geodatabase format, which is restricted dataset and it is download is available to The Northern Ireland Mapping Agreement (NIMA) users only.

With INSPIRE Geoportal only one dataset is discovered, Code-Point®, which contains postcode units in the United Kingdom.

Appendix K: Existence of INSPIRE web services

Country	CSW	WMS	WFS	ATOM
Austria	yes	yes	yes	no
Belgium	yes/no	yes/no->yes	yes/no	no
Bulgaria	no	no	no	no
Croatia	yes	yes	yes	yes
Czech Republic	yes	yes	yes	No->yes
Cyprus	no->yes/no	no->yes/no	no->yes/no	no
Denmark	yes	yes	yes	yes
Estonia	yes	yes	no->yes	no->yes
Finland	yes	yes/no->yes	yes/no->yes	no
France	yes	no	no	no
Germany	yes/no	yes/no	yes/no	no
Greece	no	no	no	no
Hungary	no	no	no	no
Ireland	no	no	no	no
Italy	no	no	no	no
Latvia	yes	yes	yes	no
Lithuania	yes	yes	yes	yes
Luxembourg	yes	yes	no	no
Malta	no	no	no	no
Netherlands	yes	yes	yes	yes
Poland	yes	yes	yes	yes
Portugal	yes	no	no	no
Romania	no	no	no	no
Slovakia	no	no	no	no
Slovenia	yes	no->yes	no->yes	no
Spain	yes	yes	yes	no->yes
Sweden	yes	yes	no	yes
United Kingdom	yes/no	yes/no	no	yes/no

Changed during 2015-2017

Appendix L: Metadata and dataset compliance

Country	Datasets' metadata INSPIRE compliant		Dataset INSPIRE compliant	
	2014	2016	2014	2016
Austria	yes	yes	no	no
Belgium	yes/no	yes/no	yes/no	yes/no
Bulgaria	-	-	-	-
Croatia	yes/no	yes	no	no
Czech Republic	yes	yes	no	yes
Cyprus	no	no	no	no
Denmark	yes	yes	yes	yes
Estonia	yes	yes	yes	yes
Finland	yes/no	yes/no	no	no
France	yes/no	-	yes/no	-
Germany	yes/no	yes/no	yes/no	yes/no
Greece	yes/no	no	no	no
Hungary	-	-	-	-
Ireland	no	-	no	-
Italy	yes/no	yes/no	yes/no	yes/no
Latvia	yes	yes	no	no
Lithuania	yes	yes	no	yes
Luxembourg	yes	yes	no	yes
Malta	-	-	-	-
Netherlands	yes	yes	yes	yes
Poland	yes	yes	no	no
Portugal	yes	yes	no	no
Romania	-	-	-	-
Slovakia	no	yes	no	yes
Slovenia	yes	yes	no	yes
Spain	yes/no	yes/no	yes/no	yes/no
Sweden	yes	yes	yes	yes
United Kingdom	yes	yes	no	no

(-) no information

Appendix M: INSPIRE web services in 2015 and 2017

In 2015

	Country	WMS
1.	Austria	http://wsa.bev.gv.at/GeoServer/Interceptor/Wms/AD/?
2.	Belgium (Brussels)	http://geoserver.gis.irisnet.be/geoserver/ows?
3.	Belgium (Flemish)	http://geo.agiv.be/inspire/wms/Adressen?
4.	Croatia	http://cgn.dgu.hr/deegree//services/wms?
5.	Czech Republic	http://services.cuzk.cz/wms/inspire-ad-wms.asp?
6.	Denmark	http://kort.aws.dk/geoserver/inspire/wms? http://kort.aws.dk/geoserver/aws4_inspire/wms?
7.	Estonia	http://inspire.maaamet.ee/arcgis/services/public/ad/MapServer/InspireViewService?
8.	Latvia	http://geometadati.viss.gov.lv/arcgis/services/AddressesInspireViewService/MapServer/InspireViewService?
9.	Lithuania	http://www.geoportal.lt/inspire-services/rest/services/INSPIRE/Addresses/MapServer/exts/InspireView/service?
10.	Luxembourg	http://wsinspire.geoportal.lu/ad?
11.	Poland	http://mapy.geoportal.gov.pl/wss/service/INSPIRE_AD/guest?
12.	Spain	http://www.cartociudad.es/wms-inspire/CARTOCIUDAD/CARTOCIUDAD?
13.	Sweden	http://maps.lantmateriet.se/inspire/ad/wms/v1?
14.	The Netherlands	http://geodata.nationaalgeoregister.nl/inspireadressen/wms?
15.	UK (Pointer)	https://www.spatialni.gov.uk/wss/service/LPS_OSNI_Pointer-WMS-I-LIC/WMS?

	Country	WFS
1.	Belgium (Brussels)	http://geoserver.gis.irisnet.be/urbis/wfs?
2.	Croatia	http://cgn.dgu.hr/deegree///services/wfs?
3.	Czech Republic	http://services.cuzk.cz/wfs/inspire-ad-wfs.asp?
4.	Denmark	http://kort.aws.dk/geoserver/aws4_wfs/wfs?
5.	Latvia	http://geometadati.viss.gov.lv/arcgis/services/AddressesInspireFeatDown/MapServer/InspireFeatureDownloadService?
6.	Lithuania	http://www.geoportal.lt/inspire-services/rest/services/INSPIRE/Addresses/MapServer/exts/InspireFeatureDownload/service

7.	Poland	http://mapy.geoportal.gov.pl/wss/service/INSPIREG2/httpauth/rest/services/INSPIRE/INSPIRE_AD/GeoDataServer/exts/InspireFeatureDownload/service?
8.	Spain	http://www.cartociudad.es/wfs-inspire/direcciones?
9.	The Netherlands	http://geodata.nationaalgeoregister.nl/bagviewer/wfs?

	Country	**ATOM**
1.	Croatia	http://geoportal.nipp.hr/atom/gazetteerRoCAtomServiceFeed.en.xml
2.	Denmark	http://file.aws.dk/inspire/AtomInspireAddresses.xml
3.	Lithuania	http://www.geoportal.lt/inspire-services/rest/directories/arcgisforinspire/INSPIRE/Addresses_MapServer/serviceatoma1.xml
4.	Poland	http://mapy.geoportal.gov.pl/wss/service/ATOM/httpauth/atom/Adresy
5.	The Netherlands	http://geodata.nationaalgeoregister.nl/atom/index.xml
6.	UK (GeoPlace)	http://www.ordnancesurvey.co.uk/xml/atom/AddressBasePremium.xml

In 2017

	Country	**WMS**
1.	Austria	http://wsa.bev.gv.at/GeoServer/Interceptor/Wms/AD/?
2.	Belgium (Brussels)	http://geoserver.gis.irisnet.be/geoserver/ows?
3.	Belgium (Flemish)	http://geo.agiv.be/inspire/wms/Adressen?
4.	Belgium (Walloon)	http://geoservices.wallonie.be/arcgis/services/TOPOGRAPHIE/PICC_VDIFF/MapServer/WMSServer?
5.	Croatia	http://cgn.dgu.hr/deegree//services/wms?
6.	Czech Republic	http://services.cuzk.cz/wms/inspire-ad-wms.asp?
7.	Denmark	http://kort.aws.dk/geoserver/inspire/wms? http://kort.aws.dk/geoserver/aws4_inspire/wms?
8.	Estonia	http://inspire.maaamet.ee/arcgis/rest/services/public/ad/MapServer/exts/InspireView/service?
9.	Finland	https://inspire-wms.maanmittauslaitos.fi/inspire-wms/AD/ows?
10.	Latvia	http://geometadati.viss.gov.lv/arcgis/rest/services/INSPIRE/AddressesInspireViewService/MapServer/exts/InspireView/service
11.	Lithuania	http://www.geoportal.lt/inspire-services/rest/services/INSPIRE/Addresses/MapServer/exts/InspireView/service?
12.	Luxembourg	http://wsinspire.geoportal.lu/ad?

13.	Poland	http://mapy.geoportal.gov.pl/wss/service/PZGIKINSP/guest/services/G2_EMUIA_WMS/MapServer/WMSServer?
14.	Slovenia	http://prostor4.gov.si/ows2-ins-m/inspire_ad/ows
15.	Spain	http://www.cartociudad.es/wms-inspire/CARTOCIUDAD/CARTOCIUDAD?
16.	Sweden	http://maps.lantmateriet.se/inspire/ad/wms/v1?
17.	The Netherlands	http://geodata.nationaalgeoregister.nl/inspire/ad/wms?
18.	UK (Pointer)	https://www.spatialni.gov.uk/wss/service/LPS_OSNI_Pointer-WMS-I-LIC/WMS?

	Country	**WFS**
10.	Belgium (Brussels)	http://geoserver.gis.irisnet.be/urbis/wfs?
11.	Belgium (Flemish)	http://geoservices.informatievlaanderen.be/overdrachtdiensten/Adressen/wfs?
12.	Croatia	http://cgn.dgu.hr/deegree///services/wfs?
13.	Czech Republic	http://services.cuzk.cz/wfs/inspire-ad-wfs.asp?
14.	Denmark	http://kort.aws.dk/geoserver/aws4_wfs/wfs?
15.	Estonia	http://inspire.maaamet.ee/arcgis/rest/services/public/ad/MapServer/exts/InspireFeatureDownload/service?
16.	Finland	https://inspire-wfs.maanmittauslaitos.fi/inspire-wfs/ad?
17.	Latvia	http://geometadati.viss.gov.lv/arcgis/services/AddressesInspireFeatDown/MapServer/InspireFeatureDownloadService?
18.	Lithuania	http://www.geoportal.lt/inspire-services/rest/services/INSPIRE/Addresses/MapServer/exts/InspireFeatureDownload/service
19.	Poland	http://mapy.geoportal.gov.pl/wss/service/PZGIKINSP/httpauth/rest/services/PZGIK/EMUIA/GeoDataServer/exts/InspireFeatureDownload/service?
20.	Slovenia	https://prostor4.gov.si/ows2-ins/ad/wfs?
21.	Spain	http://www.cartociudad.es/wfs-inspire/direcciones?
22.	The Netherlands	https://geodata.nationaalgeoregister.nl/inspireadressen/wfs?

	Country	**ATOM**
7.	Croatia	http://geoportal.nipp.hr/atom/gazetteerRoCAtomServiceFeed.en.xml
8.	Czech Republic	http://atom.cuzk.cz/AD/AD.xml
9.	Denmark	http://file.aws.dk/inspire/AtomInspireAddresses.xml
10.	Estonia	http://inspire.maaamet.ee/arcgis/rest/directories/arcgisforinspire/public/ad_MapServer/serviceatoma1.xml
11.	Lithuania	http://www.geoportal.lt/inspire-

		services/rest/directories/arcgisforinspire/INSPIRE/Addresses_MapServer/serviceatoma1.xml
12.	Poland	http://mapy.geoportal.gov.pl/wss/service/ATOM/httpauth/atom/Adresy
13.	The Netherlands	http://geodata.nationaalgeoregister.nl/atom/index.xml
14.	Spain	http://www.catastro.minhap.es/INSPIRE/Addresses/ES.SDGC.AD.atom.xml
15.	UK (GeoPlace)	http://www.ordnancesurvey.co.uk/xml/atom/AddressBasePremium.xml

Changed during 2015-2017

Appendix N: Results of web service tests

WMS (2015)	GetCapabilities Mandatory	GetCapabilities Optional	GetMap M	GetMapO	Metadata URL	Legend URL	Failed in total
Denmark	Failed (1/17)	Approved	Approved	Approved	Failed (2/4)	Approved	3/33
Luxembourg	Failed (1/17)	Approved	Approved	Approved	Failed (2/4)	Approved	3/33
Lithuania	Failed (1/17)	Approved	Approved	Approved	Failed (2/4)	Failed (1/2)	4/33
Belgium (Flemish)	Failed (2/17)	Failed (1/3)	Approved	Approved	Failed (2/4)	Approved	5/33
Czech Republic	Failed (3/17)	Failed (1/3)	Approved	Approved	Failed (2/4)	Approved	6/33
Spain	Failed (2/17)	Approved	Approved	Approved	Failed (4/4)	Approved	6/33
Estonia	Failed (3/17)	Approved	Approved	Approved	Failed (4/4)	Approved	7/33
Belgium (Brussels)	Failed (6/17)	Failed (1/3)	Approved	Approved	Failed (2/4)	Approved	9/33
The Netherlands	Failed (4/17)	Failed (1/3)	Failed (3/5)	Failed (2/2)	Approved	Approved	10/33
Austria	Failed (3/17)	Failed (1/3)	Failed (2/5)	Failed (2/2)	Failed (2/4)	Failed (1/2)	11/33
Croatia	Failed (8/17)	Approved	Approved	Approved	Failed (4/4)	Approved	12/33
Latvia	-	-	-	-	-	-	-
Poland	-	-	-	-	-	-	-
Sweden	-	-	-	-	-	-	-
UK (Pointer)	-	-	-	-	-	-	-

WFS (2015)	Predefined WFS				
	HTTP GET	GetFeatureById	Query	GetCapabilities	Total
Spain	Approved	Approved	Approved	Failed (2/4)	2/10
Croatia	Approved	Approved	Approved	Failed (3/4)	3/10
The Netherlands	Approved	Approved	Failed (1/2)	Failed (3/4)	4/10
Denmark	Approved	Approved	Failed (1/2)	Failed (2/4)	3/10
Lithuania	Approved	Approved	Approved	Failed (3/4)	3/10
Czech Republic	Failed (2/3)	Failed (1/1)	Failed (1/2)	Failed (2/4)	6/10
Belgium (Brussels)	Failed (3/3)	Failed (1/1)	Failed (2/2)	Failed (3/4)	9/10
Latvia	-	-	-	-	-
Poland	-	-	-	-	-

WFS (2015)	Direct Access WFS (optional)							In total
	GetFeature, GetPropertyValue	Minimum Spatial Filter	Resource Identification	Minimum Standard Filter	Minimum Temporal Filter	Minimum XPath	Total	
Spain	Approved	Approved	Approved	Failed (1/4)	Failed (1/1)	Approved	2/12	**4/22**
Croatia	Approved	Approved	Approved	Approved	Failed (1/1)	Failed (1/2)	2/12	**5/22**
The Netherlands	Approved	Approved	Approved	Approved	Approved	Failed (2/2)	2/12	**6/22**
Denmark	Failed (1/2)	Approved	Approved	Failed (1/4)	Approved	Failed (2/2)	4/12	**7/22**
Lithuania	Failed (1/2)	Approved	Failed (1/2)	Failed (4/4)	Approved	Failed (1/2)	7/12	**10/22**
Czech Republic	Failed (1/2)	Failed (1/1)	Failed (2/2)	Failed (3/4)	Failed (1/1)	Failed (2/2)	10/12	**16/22**
Belgium (Brussels)	Failed (2/2)	Failed (1/1)	Failed (2/2)	Failed (4/4)	Failed (1/1)	Failed (2/2)	12/12	**21/22**
Latvia	-	-	-	-	-	-	-	
Poland	-	-	-	-	-	-	-	

ATOM (2015)	Service Feed	Service Metadata	Dataset Metadata	Dataset Feed	OpenSearch Description	Total
The Netherlands	Failed (1/17)	Approved	Failed (2/3)	Approved	Approved	**3/46**
Denmark	Failed (7/17)	Failed (2/2)	Failed (3/3)	Failed (7/15)	Failed (9/9)	**28/46**
Lithuania	Failed (3/17)	Failed (2/2)	Failed (1/3)	Failed (15/15)	Failed (9/9)	**30/46**
Croatia	Failed (3/17	Failed (1/2)	Failed (3/3)	Failed (15/15)	Failed (9/9)	**31/46**
UK (GeoPlace)	-	-	-	-	-	
Poland	-	-	-	-	-	

WMS (2017)	GetCapabilities Mandatory	GetCapabilities Optional	GetMap M	GetMapO	Metadata URL	Legend URL	Failed in total
Finland	Approved	Approved	Approved	Approved	Approved	Approved	0/33
The Netherlands	Approved	Approved)	Approved	Approved	Approved	Approved	0/33
Czech Republic	Approved	Failed (1/3)	Approved	Approved	Approved	Approved	1/33
Estonia	Failed (2/17)	Approved	Approved	Approved	Approved	Approved	2/33
Denmark	Failed (1/17)	Approved	Approved	Approved	Failed (2/4)	Approved	3/33
Luxembourg	Failed (2/17)	Approved	Approved	Approved	Failed (2/4)	Approved	4/33
Slovenia	Approved	Approved	Failed (3/5)	Failed (1/2)	Approved	Approved	4/33
Spain	Failed (3/17)	Approved	Approved	Approved	Failed (4/4)	Approved	7/33
Belgium (Brussels)	Failed (6/17)	Failed (1/3)	Approved	Approved	Approved	Failed (1/2)	8/33
Poland	Failed (3/17)	Failed (1/3)	Approved	Approved	Failed (3/4)	Failed (1/2)	8/33
Austria	Failed (3/17)	Failed (1/3)	Failed (3/5)	Failed (2/2)	Failed (2/4)	Failed (1/2)	12/33
Croatia	Failed (8/17)	Approved	Approved	Approved	Failed (4/4)	Approved	12/33
Belgium (Walloon)	Failed (7/17)	Failed (1/3)	Approved	Approved	Failed (4/4)	Failed (1/2)	13/33
Belgium (Flemish)	-	-	-	-	-	-	-
Latvia	-	-	-	-	-	-	-
Lithuania	-	-	-	-	-	-	-
Sweden	-	-	-	-	-	-	-
UK (Pointer)	-	-	-	-	-	-	-

WFS (2017)	Predefined WFS				
	HTTP GET	GetFeatureById	Query	GetCapabilities	Total
Finland	Approved	Approved	Approved	Approved	0/10
Spain	Approved	Approved	Approved	Approved	0/10
The Netherlands	Approved	Approved	Approved	Approved	0/10
Slovenia	Approved	Approved	Approved	Approved	0/10
Croatia	Approved	Approved	Approved	Failed (3/4)	3/10
Denmark	Approved	Approved	Failed (1/2)	Failed (2/4)	3/10
Estonia	Approved	Approved	Approved	Failed (4/4)	4/10
Poland	Failed (1/3)	Failed (1/1)	Failed (1/2)	Failed (4/4)	7/10
Czech Republic	Failed (2/3)	Approved	Approved	Approved	2/10

Belgium (Flemish)	Failed (3/3)	Failed (1/1)	Failed (2/2)	Approved	6/10
Belgium (Brussels)	Failed (3/3)	Failed (1/1)	Failed (2/2)	Failed (3/4)	9/10
Latvia	-	-	-	-	-
Lithuania	-	-	-	-	-

WFS (2017)	Direct Access WFS (optional)							**In total**
	GetFeature, GetPropertyValue	Minimum Spatial Filter	Resource Identification	Minimum Standard Filter	Minimum Temporal Filter	Minimum XPath	Total	
Finland	Approved	Approved	Approved	Failed (1/4)	Failed (1/1)	Failed (1/2)	3/12	**3/22**
Spain	Approved	Approved	Approved	Failed (1/4)	Failed (1/1)	Failed (1/2)	3/12	**3/22**
The Netherlands	Approved	Approved	Approved	Approved	Approved	Failed (2/2)	2/12	**3/22**
Slovenia	Failed (1/2)	Approved	Approved	Failed (1/4)	Approved	Failed (2/2)	4/12	**4/22**
Croatia	Approved	Approved	Approved	Approved	Failed (1/1)	Failed (1/2)	2/12	**5/22**
Denmark	Failed (1/2)	Approved	Approved	Failed (1/4)	Approved	Failed (2/2)	4/12	**7/22**
Estonia	Failed (1/2)	Approved	Failed (1/2)	Failed (1/4)	Approved	Failed (1/2)	4/12	**8/22**
Poland	Failed (1/2)	Approved	Approved	Failed (1/4)	Approved	Failed (1/2)	3/12	**10/22**
Czech Republic	Failed (1/2)	Failed (1/1)	Failed (2/2)	Failed (3/4)	Failed (1/1)	Failed (2/2)	10/12	**12/22**
Belgium (Flemish)	Failed (2/2)	Failed (1/1)	Failed (2/2)	Failed (4/4)	Failed (1/1)	Failed (2/2)	12/12	**18/22**
Belgium (Brussels)	Failed (2/2)	Failed (1/1)	Failed (2/2)	Failed (4/4)	Failed (1/1)	Failed (2/2)	12/12	**21/22**
Latvia	-	-	-	-	-	-	-	
Lithuania	-	-	-	-	-	-	-	

ATOM (2017)	Service Feed	Service Metadata	Dataset Metadata	Dataset Feed	OpenSearch Description	Total
The Netherlands	Approved	Approved	Failed (1/3)	Failed (1/15)	Approved	2/46
UK (GeoPlace)	Failed (6/17)	Failed (2/2)	Failed (3/3)	Failed (3/15)	Failed (4/9)	18/46
Estonia	Failed (2/17)	Failed (2/2)	Approved	Failed (15/15)	Failed (3/9)	22/46
Lithuania	Failed (7/17)	Failed (2/2)	Failed (3/3)	Failed (6/15)	Failed (9/9)	27/46
Denmark	Failed (7/17)	Failed (2/2)	Failed (3/3)	Failed (8/15)	Failed (9/9)	29/46
Czech Republic	Failed (1/17)	Failed (2/2)	Failed (2/3)	Failed (15/15)	Failed (9/9)	29/46
Croatia	Failed (3/17)	Approved	Failed (3/3)	Failed (15/15)	Failed (9/9)	30/46
Spain	Failed (7/17)	Failed (1/2)	Failed (3/3)	Failed (15/15)	Failed (9/9)	35/46
Poland	Failed (17/17)	Failed (2/2)	Failed (3/3)	Failed (14/15)	Failed (9/9)	45/46