

**IMPLEMENTATION OF THE INSPIRE DIRECTIVE**  
**ON ROAD INFRASTRUCTURE IN PORTUGAL**

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## Table of Contents

1	Introduction .....	1
2	Objectives.....	3
3	The role of standardization in the implementation of INSPIRE Directive .....	4
4	Implementation of INSPIRE Directive on the Portuguese national road infrastructure .....	6
4.1	The regulator of the Portuguese national infrastructure and its role in the implementation of INSPIRE Directive.....	7
4.1.1	Brief framework analysis.....	8
4.1.2	SWOT Analysis.....	9
5	Case Study .....	12
5.1	Description of the application schema Road Transport Network.....	12
5.2	National Road Transport Network .....	13
5.2.1	National Road Code.....	14
5.2.2	European Road Code.....	16
5.3	Road Nodes .....	16
5.3.1	Form of Road Node .....	16
5.4	Properties of Road Transport Network.....	18
5.4.1	Number of Lanes .....	19
5.4.2	Road Width.....	19
5.4.3	Form of Way.....	19
5.4.4	Functional Road Class.....	19
5.5	Extension of INSPIRE concepts to the Transport Services .....	20
5.6	Web Service.....	22
6	Conclusions .....	24
7	Bibliography .....	27

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

## 1 Introduction

Nowadays, information plays a major role in the quotidian of societies. We live in an "Information Society", where the access, storage, processing, valorization, transmission and sharing of the information are essential to stimulate wealth creation, improve the quality of life and for the development of the Society (MSI, 1997).

The true, complete and relevant information is essential in all stages of the development and implementation of a competitive strategy. According to Moniz & Kovács, (2001), the economy and society grow and develop themselves around information. The information represents the central core of the new Society.

In particular, the geographic information represents about 80% to 90% of the information in the universe, so the information society is no longer than the geographic information society (Julião, 1999).

The need for quality and harmonized information is more frequently felt in the public sector. This type of information is highly important for the development of successful public policies and measures.

The public authorities represent the biggest producers of information in Europe. The Green Paper on Public Sector Information in the Information Society (European Commission, 1998) states that information plays a fundamental role in the proper functioning of the internal market and the free circulation of goods, services and people. The provision of information is

a primordial condition for the competitiveness of the European industry.

In every EU countries, the most part of the investment performed by the public sector in information goes to the geographical sector (European Commission, 2000). Geographic information is an important component in the public sector information, constituting in more than half of its total investment.

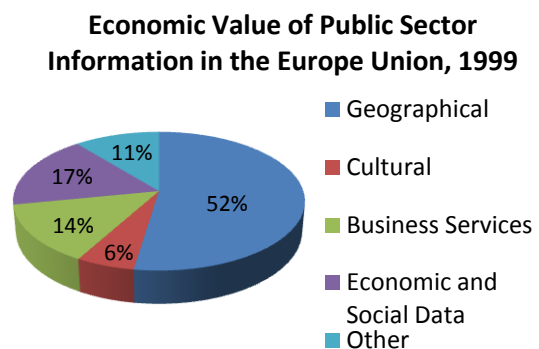


Figure 1 – The importance of the various types of information in European Public Sector  
Font: adapted from (European Commission, 2000)

However, it is common that information is fragmented, duplicated and unavailable, being difficult to identify, access and use. This is often a result of the separate legislation which is practiced in several Member States (MS) and how it's possible to access this information, due to the existence of multiple and repetitive practices that prevents the availability of data.

The existence of different sets of databases, which follow different internal structures, makes the process of integration of information difficult, as well as the existence of different languages in Europe makes it a barrier for information sharing in the European Community.

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

The same applies to the data related with European road infrastructure. According to Sandgren (2004), this situation can be characterized as follows:

- Road administrators capture and maintain road and traffic information, and have agreed on some information exchange standards, although there is still a lack of a common system to make all this wealth of information available;
- National mapping agencies capture and maintain road geographic data, but once again despite the existence of data exchange standards, there is a lack for a content standard and no global system is there to make all this data available in an interoperable way;
- Private sector players, data brokers and service providers have to find around the different EU countries agencies and authorities the data they need, and have to also invest in order to integrate the information they obtain into their own information systems. This effort is duplicated every time a “new player” wants to set up an information based system that has to rely on road data.

A well-functioning infrastructure for spatial road information on a pan-European level is fundamental for the development within areas of intelligent transport systems, mobility management, traffic and management, as well as traffic safety, environmental and society planning and many other areas.

In order to solve most of the problems related to geographic information in Europe, the European Commission has met efforts to create one of the most ambitious projects ever developed in the EU.

Initially called INSPIRE Initiative, this enterprise has as its purpose the provision of relevant and harmonized geographic information for the implementation, monitoring and evaluation of Community policies with a direct impact on the environment and territory (Architecture and Standards Working Group, 2002).

On the 15<sup>th</sup> May 2007 entered in force the Directive 2007/2/CE of the European Parliament and of the Council, which establishes an Infrastructure for Spatial Information in the European Community – the “INSPIRE Directive”.

This Directive aims to provide the users with integrated spatial information services. These services should allow the users to identify and access, locally and globally, spatial or geographical information from a wide range of sources, in an interoperable way and for a variety of uses. In addition, the Directive should help the citizen to access spatial information, whether it is local, regional, national or international.

The creation of a successful infrastructure for spatial information is a fundamental prerequisite for the development and implementation of policies which stimulate the growth of the public sector and provide better services to citizens in general (Land, 2003).

The scope of INSPIRE Directive focuses on the infrastructures for spatial information established and maintained by the 27

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

Member States, covering 34 topics arranged in three annexes, required for sustainable environmental development and containing several “key” components specified through the implementing rules.

The implementation of the INSPIRE Directive follows a phased approach. In the first stage, the MS should unblock the existing information and infrastructures for spatial information, with relevance for the different themes. This whole process ends with the harmonization of datasets and services, allowing its seamless integration at different levels, in a single and consistent infrastructure for spatial information in Europe.

With regards to the road infrastructure information, the INSPIRE Directive foresees the existence of an interoperable geographic datasets and services. On the one hand this service will be commonly used as a part of the supporting data for decision-making in planning, building and maintenance of roads, and on the other hand, used for services that aim to enhance the usage of roads considering security and accessibility, as well as to reduce the traffic’s negative environmental effects – including more and more the ITS systems at the operational level.

Although the INSPIRE Directive has been developed in an environmental perspective, its applicability on the transport networks is clear, particularly in the road network. The creation of an infrastructure for spatial road information is fundamental for the development and management of road infrastructures in each EU countries, and the global EU context (TEN-T), but its extension to local road networks, including public transport systems is also essential.

## 2 Objectives

The present work intends to contribute to the better understanding of the framework and the conditions and consequences of the implementation process of INSPIRE Directive, on the Portuguese National Road Infrastructure.

The main objectives are:

- Understanding the INSPIRE Directive and comprise the reasons that led to the creation of a European Spatial Data Infrastructure (ESDI);
- Analyze the application of the Directive to the Portuguese national road infrastructure, including understanding the role that the national regulator should play in the implementation process;
- Identify the benefits and obstacles in the implementation process, as well as the roadmap of tasks that must be applied to the measures to the existing data structures so that they meet the INSPIRE specifications;
- Develop a pilot-project of a web view service for the provision of INSPIRE data on road infrastructure;
- To assess the potential use of the INSPIRE Directive in further standardization process of the Portuguese transport systems.

The establishment of an infrastructure for spatial information, where information is standardized, interoperable and capable of being shared, is very important for social and economic development of Member States. The understanding of this ambitious

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

project was considered the main reason for the elaboration of the present work.

The preparation of this work was possible thanks to the close cooperation between the academic institution where I am finishing graduation and the national regulator for the infrastructure road sector. This successful cooperation has allowed the application of skills and abilities acquired through the academic training to an institutional context. The curricular traineeship performed at the national regulator, with constant monitoring of the academic institution, allowed the development of an innovative pilot-project, which represents an added value for the INSPIRE processes that the regulator has to come to develop. This pilot-project of a web view service, following the patterns of INSPIRE specifications and related standards was the first to be developed in Portugal in the context of road infrastructure.

### **3 The role of standardization in the implementation of INSPIRE Directive**

The INSPIRE Directive aims to establish rules for the implementation of an infrastructure for spatial information in Europe, where the geographic datasets and services can be understood and analyzed by any European citizen.

The interlinking between national and/or regional spatial data infrastructures (SDI) will be achieved only if the individual SDIs which will comprise the ESDI can communicate with each other via a common global infrastructure. So, the adoption of standards is essential in the implementation process of the Directive,

contributing for the interoperability of datasets and services that integrate its architecture (Architecture and Standards Working Group, 2002).

The Directive claims the need to, whenever possible, resorting to international specifications and standards for the formulation of the implementing rules. According to point (28) of the Directive, in order to take greater advantage of technology and expertise within the existing spatial data infrastructures it is desirable that the necessary measures to implement the Directive are based on international standards adopted and developed by the European standardization bodies.

Bearing in mind that one of the most important objectives in the Directive is the establishment of the interoperability between geographic datasets and services, the use of standardization initiatives like ISO/TC211, CEN/TC 287 and *OpenGIS Consortium Ltd* (OGC) must be considered crucial in all the implementation processes.

The initiative ISO/TC 211 Geographic Information/Geomatics defines standardization in the field of digital geographic information. It aims to establish a set of standards for structuring information about objects or phenomena that are directly or indirectly associated with a location on the Earth (ISO/TC 211, 2012). The standards produced by this initiative intends to specify the methods, tools and services for georeferencing, acquisition, processing, analyzing, accessing, presenting and transferring of data in digital form, between users of different countries.

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

This is a series of standards developed by the technical committee ISO/TC211, to ensure the definition, description and management of the geographic information, making it possible to define profiles in order to simplify the development of geographic information systems and applications.

The European Committee for Standardization CEN is a multi-sectorial organization and develops European Standards for most areas. CEN contributes to the objectives of the European Union and European Economic Areas with voluntary technical standards, which promote free trade, the safety of workers and consumers, interoperability of networks, environmental protection, exploitation of research and public procedures (INSPIRE, n.d.).

In particular, CEN/TC 287 produces a structured framework of standards and guidelines, which specify a methodology to define, describe and transfer geographic data and services. This work is carried out in co-operation with ISO/TC 211 in order to avoid the duplication of work. The standards developed aims to support the consistent usage of geographic information across Europe in a manner which is compatible with international usage.

CEN/TC 287 is involved in the INSPIRE standardization activities, since it is completing the European “profiling” of the ISO standards (Longhron, 2006).

The OGC is an international consortium constituted by 429 companies, government agencies and universities related to geographic information, which together promote the development of specifications

based on consensus among its members. OGC’s vision covers the complete integration of spatial data and geoprocessing resources in a computing system.

OGC’s mission is the development and free sharing of specifications for a global use. The interfaces and protocols established by the specifications promote the interoperability between different geographic information access technologies.

It’s through application schemas that interoperability tools, compliant with OGC technical specifications, will enable the easy connection between the spatial datasets from various sources.

The creation of a standardized metadata catalogue is essential for the proper functioning of the ESDI. Metadata is the information and documentation, which makes data understandable and sharable for users over the time (European Commission, 2008). In this context the use of international standards, such as ISO standards or OGC technical specifications, is fundamental for the correct establishment of the metadata catalogues, as well as promoting the interoperability of the spatial data infrastructure.

The technical specifications provided by OGC were essential in the development of the case study presented in this work.

In short, the implementation of an infrastructure for spatial information should follow the technical specifications and guidelines published and maintained by standardization specifications developed at European level. This implementation process must be

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

supported by technical teams whose mission is assisting the Member States to transpose the INSPIRE Directive into specific national contexts. The guidelines and specification should allow Member States to complete the implementation process before the end of deadlines for the various uses and services.

Nowadays it is required the exchange of public transport information between Member States in order to provide the travelling public with information that would enable them to make efficient travel choices. It is of great interest to the expansion of INSPIRE to the public transport network, taking advantage of the work developed by standards bodies, including the initiative CEN Transmodel, CEN 278 and IFOPT that over the years have gathered efforts to resolve the problems of standardization inherent to this subject.

## 4 Implementation of INSPIRE Directive on the Portuguese national road infrastructure

The INSPIRE Directive is constituted by 34 themes, grouped in three annexes. The present work deals essentially with one theme - Transport Networks, described in the Annex I of the Directive.

The Transport Networks theme is defined within the INSPIRE Feature Concept Dictionary as: *“the transport component should comprise an integrated transport network, and related features, that are seamless within each national border. In accordance with article 10.2 of the Directive, national transport networks may also be seamless at European level, i.e. connected at national borders.*

*Transportation data includes topographic features related to transport by road, rail, water and air. It is important that the features from network where appropriate, and that links between different networks are established, i.e. multi-modal nodes, especially at the local level, in order to satisfy the requirements for intelligent transport systems such as location based services and telematics. The transport network should also support the referencing of transport flow to enable our navigation services”* (INSPIRE Thematic Working Group Transport Networks, 2010).

With this work we intend to help in the identification of the most appropriate framework and procedures to be performed by the Portuguese national road infrastructure regulator, within the implementation process of INSPIRE on the national road network.

To substantiate this approach a critical SWOT analysis was performed, which aims to highlight the main institutional key points related to the implementation of the Directive at the national road network level. The development of this analysis is the result of the daily contact with the reality of the Portuguese national road regulator, provided by a 6 months traineeship. During this period issues related to road infrastructures, and also with the implementation of the INSPIRE Directive by the Portuguese Institute responsible for this thematic were deeply analyzed, both from the academic and the pragmatic implementation perspectives, resulting on the referred SWOT analysis and the production of the pilot-project posed as a case study.

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

## 4.1 The regulator of the Portuguese national infrastructure and its role in the implementation of INSPIRE Directive

The success of any infrastructure for spatial information is directly dependent on active participation and commitment of producers and users of geographic information (Furtado, 2006).

The mission of the national regulator for the road infrastructure sector consists mainly on the supervision and the oversight of the management and operation of the road network. The regulatory powers imply the monitoring of compliance with laws, regulations and concession contracts and subsidiary agreements. They also imply the duty to ensure the development and completion of the National Road Plan. The efficiency, equity, quality and safety of road infrastructure and the upholding of the users' rights are also in the sphere of the competences of the Portuguese national regulator. So, the regulator was appointed by the Portuguese State as the responsible entity for the theme of Road Transport Network, included in the INSPIRE Directive.

To comply with the INSPIRE "obligations", firstly it proceeded to the survey of the geographic information with the possible relevance to the theme of the Transport Network. The process of collecting information was based on the knowledge of implementing rules as well as the data specifications, which contained the elements and attributes require for the characterization of the network.

Of all the geographic features specified in INSPIRE Data Specifications on Transport Networks, presently the regulator has only

some of them available. Once INSPIRE does not require the collection of new data (it only looks at the datasets available) it must be submitted a number of measures in order to making information interoperable that will be collected in the future.

After the identification of all geographic datasets, the national road regulator proceeded to the creation of metadata for these datasets, using the software "*Metadata Creator*" available on SNIG<sup>1</sup> website.

The development of the pilot-project for a "view service" presented within this paper is possible and rests on the metadata work previously carried out by the staff of the national road regulator. Over that initial work and after the detailed analysis of the INSPIRE Directive and the assimilation of the data specifications, it was possible to build a network service prototype – the pilot-project presented here - as the basis for the development of a formal service for the whole road network. This service will be launched, by the regulator, in a near future as part of her obligations regarding the enforcement of INSPIRE Directive.

The institutional process of harmonization and availability of all geographic information, in particular of that related with transport networks, is still far from over, being necessary in the near future, to restructure the working methods for collecting, editing and analyzing geographic information. The need to respond to the demands related to the implementation of the Directive can be seen as an opportunity to develop new working methods and

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<sup>1</sup> Portuguese National Geographic Information Infrastructure

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

routines, to fill gaps and avoid errors from the past.

## 4.1.1 Brief framework analysis

Some of the main obstacles found in the process of data collection of the geographic information, carried out by the regulator correspond to the partial absence of some needed datasets of information and the unsuitable format in which the information is available. These problems need to be solved quickly.

In some cases, the concessionaires don't provide the necessary information, although this is provided for in contractual terms (for example, detailed traffic information), because the contractual terms are somehow ambiguous and give room for maneuver to the concessionaires. In other cases, the information exists but due to the unsuitable formats and lack of standardization, sometimes it is difficult to understand and/or time consuming to analyze.

In order to fulfill his obligations near the European Commission and contribute to a complete and harmony infrastructure for spatial information, the regulator must establish certain necessary procedures and standards.

Firstly it is essential to strengthen the absolute need to guarantee the consensus and interconnection between the various departments of the Institute. It is fundamental the existence of an internal database, equal for all users, in order to avoid incompatibilities and inconsistencies in the daily work and analyses. The information that the various departments need should be known, allowing that the information collected, analyzed and

produced by the Institute, satisfy in an efficient way the internal needs of operating, as well as the new challenges that the Directive involve.

Secondly, there is the need to guarantee that the provision of geographic information by the concessionaires accordingly to INSPIRE data specifications (but not only) become a legal duty, specified contractually in a clear way and with penalties for failure.

The concessionaires hold value-added information about the road infrastructure. However information like the type and condition of the pavement, intervention dates, services offered in services areas and road signs aren't specified by the Directive, but this kind of Transport information allows for the development of high quality information services to the users, which could have a direct bearing on their level of satisfaction.

Even though the information is extremely important, the way it is provided is also a determinant factor. The adoption of a standard pattern to provide information based on a common protocol, which contributes to the harmonization, usability and cost savings associated with it falls within the jurisdiction of the regulator.

Thus, information from different producers (concessionaires) must arrive at the regulator structured in a similarly way, allowing that the staff spend less time and resources in the management, analysis and evaluation of the operational data, helping also in this way to improve the effectiveness of supporting strategic and tactical tools for the decision making.

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

Regarding the requirements and obligations as Portuguese national regulator for the implementation of the INSPIRE Directive, the regulator institute has the duty to respond to the European Commission on issues related to road infrastructures under their jurisdiction (all national and regional roads, highways and motorways – only the municipal road networks, including urban roads and other municipal roads are excluded from the jurisdiction of the national regulator). However the effort to fulfill these responsibilities is not only dependent on the work of the Institute. It requires the effective cooperation of the concessionaries and other stakeholders, to create a spatial data infrastructure, which in one hand covers the external needs (the main focus of the INSPIRE) and on the other hand understand and contain the necessary information to internal users.

The regulator for the national road infrastructure should take a position of manager and regulator of road geographic information. It is his role to establish and qualify the levels of information, proceed to its analysis, to the creation of a metadata and further harmonization, according to his internal specifications and the INSPIRE data specifications for general use.

## 4.1.2 SWOT Analysis

As a corollary of the traineeship studying the implementation of the INSPIRE and based on the experiences (and difficulties) felt, we decided to perform a SWOT analysis. This analysis is focused on the implementation process of the INSPIRE Directive within the Portuguese regulator for the national road infrastructure, giving emphasis to its role in the implementation

process. The SWOT analysis allows the characterization, in an integrated way of the strategic position of the Institute (the regulator) regarding the adoption of provisions defined by the Directive.

### Strengths

As a strength we can point out the opportunities represented by the development of a network service (of which the pilot-project is the first experience) that allows the visualization and search. In the future it is also expected the download of datasets related to road infrastructure, including features and attributes. This kind of tool is a valuable asset for the management, decision support and usage of information.

Another strong point is the establishment of linkages and working groups with other public entities, public sector and much more disposal of information to the citizens in general.

To create an infrastructure for spatial information it is essential the cooperation of all the entities involved. It is extremely important the articulation of the various entities responsible for the Transport Networks theme, in order to develop an organized structure, where the various modes of transportation (and actors) are interconnected with each other. Thus, another strong point is the promotion of the dialogue between the various entities with responsibilities for this theme.

Internally, the regulator has excellent staff and technical skills to implement the Directive, particularly in terms of equipment and software. This is a key factor for the success of the process, since

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

without resources it would become impossible.

The reduction of costs associated with obtaining and combining the geographic datasets and services represent another kind of strength. The standardization of datasets, as well as metadata, enables users to access and use only the information that they really need and combine it with other datasets from other sources.

Since the INSPIRE Directive is assumed as a tool for decision support, a strong point of this process is to improve the quality of the decision made. The provision of geographic information related with transport networks and all the other issues that the Directive covers, such as hydrography, administrative units, territorial, among others, allows a better understanding of the relationship between them, supporting a wide range of activities related to the implementation of environmental policies and the interaction between the transport system and urban and regional planning.

## **Weaknesses**

Among the weaknesses inherent to the process of implementing the Directive on the national road infrastructure we have: lack of information about the road infrastructures, lack of standardization in the process of providing information by the concessionaires, which makes the regulator spend a lot of time in the harmonization of the information, and finally, little knowledge and understanding about the INSPIRE Directive.

## **Opportunities**

One of the most obvious opportunities is the presentation to stakeholders of the work done by the regulator related to geographic information. For example, the provision of information on traffic accidents, on the characteristics of infrastructures, concession maps, tolls, and so on.

The implementation of the Directive in the transport sector involves some institutions responsible for the spatial datasets and services, as explained above. This interconnection, which was considered strength, can provide the opportunity to the creation of an infrastructure for spatial information specifically directed to the transport sector. Additionally to the information specified by the Directive, each entity can provide more information to build knowledge over the base spatial data to help in sectorial operation, management and decision process. Fields like pavement management, accidents databases, transport planning or economic assessment of assets can be developed at the light of the INSPIRE principles and rules, as an extension of the initial standardization process.

As mentioned before, a successful infrastructure for spatial information is the result of a joint effort of users and producers of geographic information. The geographic information should be provided correctly by the concessionaires, in a standardized and complete way.

On the other hand, the failure to supplying information can contribute to a poor spatial data infrastructure. It is essential that concessionaires adhere to the

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

implementation of the Directive, contributing actively to this process.

The use of the infrastructure by citizens or other geographic information users is also extremely important, since they may contribute with comments and suggestions, giving added value to the INSPIRE initiative.

## Threats

The inappropriate governmental support may constitute a threat, because the existence of an inefficient legislation can lead to failure of the process. The publication of poorly understood information, may allow that the entities take their political decisions according to their own convenient way. It is necessary to create a strong and concise legislation framework, easy to understand and to apply.

The governmental support is critical for public bodies, allowing the creation of the necessary conditions for the proper

implementation of the Directive, whether economic, technical or political.

The adjustment to new situations is sometimes a difficult problem to overcome. One of the risks inherent to the implementation process of any directive is related to its acceptance, as well as the degree of voluntary with which the rules and standards are supported and promoted by the staff of public bodies and other institutions.

In a situation of economic crisis, the costs associated with implementing and maintaining these systems may represent a threat to their viability, even though the indirect benefits may be much higher.

Additionally, the ongoing institutional and governmental restructuring, with the extinction and merge of some institutes, represent also a threat, extending the duration of the whole process and running the risk that Portugal does not fulfill its obligations to the European Commission.

<p style="text-align: center;"><b><u>STRENGTHS</u></b></p> <ul style="list-style-type: none"> <li>• Sharing information with a wide range of users;</li> <li>• Workgroups between public authorities, private sector and citizens;</li> <li>• Cooperation between the various entities responsible for the theme;</li> <li>• Excellent staff and technical skills;</li> <li>• Improve decision support;</li> <li>• Reduction of costs associated with obtaining info.</li> </ul>	<p style="text-align: center;"><b><u>WEAKNESSES</u></b></p> <ul style="list-style-type: none"> <li>• Lack of information;</li> <li>• Lack of standardization in the provision of info by the concessionaires;</li> <li>• Little knowledge and understanding of INSPIRE.</li> </ul>
<p style="text-align: center;"><b><u>OPPORTUNITIES</u></b></p> <ul style="list-style-type: none"> <li>• Present to stakeholders the work performed;</li> <li>• Creation of a spatial data Infrastructure including its expansion for the Transport sector (INSPIRE-T).</li> </ul>	<p style="text-align: center;"><b><u>THREATS</u></b></p> <ul style="list-style-type: none"> <li>• Little acceptance and the degree of voluntary;</li> <li>• Little governmental support;</li> <li>• The costs associated with implementation.</li> </ul>

Figure 2 – SWOT Analysis

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

Finally, the present SWOT analysis must be interpreted in a broad manner, since it corresponds to the interpretation of reality acquired and assimilated over a period of roughly four months, in which the master's final traineeship took place at the national regulator for infrastructures road sector.

## 5 Case Study

This chapter presents a case study framed in the implementation process of INSPIRE Directive to the Portuguese national road transport network.

In article 11, the INSPIRE Directive refers to the need that Member States should establish and operate a network of services for the spatial datasets and services for which metadata has been created (European Commission, 2007). According to the roadmap provided by INSPIRE, the view and discovery services should be available until November 2011. To make this possible, the involved entities should direct their efforts towards meeting timely deadlines.

The development of this case study during the traineeship at the national regulator had a twofold valued added. First, to enrich the more theoretical study of the Directive initially produced. And second, to help the national regulator to fulfill his duties under the terms of INSPIRE.

A web view service was developed which enable the visualization of information over the internet. The case study aims to develop a web application that allows the visualization of geographic information, regarding part of the Portuguese national road network, available in a map server and accessible via a web browser. The

public information is presented in a format according to the INSPIRE data specifications. As already stated, it is intended that the development of this project contribute to the work performed by the national regulator in the implementation process of the Directive.

The work began with analyze of the INSPIRE data specification for road transport networks and the implementing rules. These documents are essential for the comprehension of the needs and objectives which the Directive wants to accomplish.

In first place, the development of the pilot project focuses on searching and processing the necessary data to construct the road network model, in particularly the INSPIRE attributes, required for its characterization. The next step was the creation of the database which stores all the information specified in the implementation rules and other (complementary) information useful for the road network management and transport planning.

Finally, we proceed to the establishment of the view service, using the software ESRI ArcGIS Server, which makes it possible for the publication of maps over the internet, and allows the safely and easy sharing of information with any user.

### 5.1 Description of the application schema Road Transport Network

Nowadays it is easy to understand the obvious need to ensure standardization, updating and the quality of information in an infrastructure for spatial information in Europe, to serve as a base for developing

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

areas such as intelligent transport systems, mobility management, traffic and road infrastructure management, road safety and other areas (Sandgren, 2004).

The *Road Transport Networks application schema* is a structure of links and nodes interconnected. Its main purpose is the representation of a road system used for the transportation of vehicles in the form of a linear network (INSPIRE Thematic Working Group Transport Networks, 2010).

The Directive aims to develop an integrated transport network, where spatial objects establish relationships with each other without barriers, allowing its use at Pan-European level. Thus, it is essential linking transport network through “intermodal nodes especially at a local level, in order to meet the requirements of an intelligent transport system” (European Commission, 2007).

The applications schema inherits road class diagrams of common transport application schema and also contains their own classes, with the specific objective of describing the properties of road transport network, as well as the attributes applied to sections of the network elements or subsections represented by liner referencing.

The aspects modeled for transport network elements are the spatial aspects, the geometric representation of various elements that are parts of a network, the temporal aspects, the validity of elements, and the thematic aspects, where the links, nodes and areas can be characterized through various types of attributes.

It is essential that consistency is achieved between data, in order to promote the

smooth functioning of the ESDI. According to the INSPIRE data specification for road transport networks, is necessary to ensure the consistency of spatial datasets and services at three levels: the consistency of the spatial datasets and services which belong to the same topic, regardless of the level of detail; consistency between the different objects existing within the same geographic area; and finally, ensure the consistency of spatial objects across borders or boundaries of the Member States.

According to the Generic Conceptual Model, all spatial objects must have a unique identifier. This unique identifier, as the name implies should be unique in the infrastructure, allowing that any object can be found by his geographic identifier. The unique identifier follows the guidelines presented in documents D2.5 and D2.7.

The main mechanisms used to describe the transport network are defined in the Generic Network Model (INSPIRE Thematic Working Group Transport Networks, 2010). The GNM contains an application schema for the networks, where it includes: the relationship between the nodes, links, link sequences and link sets; the network properties; the different ways as they relate to the network elements; and mechanisms for cross-border links and intermodal nodes.

## 5.2 National Road Transport Network

As mentioned at the beginning of this chapter, according to article 11 of the Directive, the Member States shall establish and operate a network of services for spatial datasets and services for which metadata has created (European

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

Commission, 2007). Although the national regulator for the road infrastructure has created metadata for a set of objects representing the National Road Network<sup>2</sup> in its entirety, after analyzing the data specifications for road transport networks, we chose to analyze and use the National Motorways Network<sup>3</sup> (NMN), due to the limitations imposed by the traineeship duration and the resources available to do the job (mainly the author). The NMN is composed by 31 motorways, has a length of 2 735 km, corresponding about 20% of the National Road Network (InIR, 2010).

For the development of this project was used the *ArcGIS Desktop*<sup>®</sup> software, which allows to manage and integrate the available data, create spatial data structures according to INSPIRE specifications, create maps for future publication, advanced analyzes, automation models and processes. Such functionalities are required for the development of the view service.

In first place, we proceeded to the design of a personal geodatabase with the use of *ArcCatalog*<sup>®</sup>, as the purpose of storing spatial datasets needed to produce the maps that will be available in the web application. Thus, from the internal database of the regulator, which stored the spatial objects related to the National Road Network, it was possible to extract only the

NMN and import it directly to a new database called “INSPIRE.mdb”.

According to the INSPIRE specification, a road can be defined as a set of sequences of individual links or links representing the axis of the road, characterized by one or more thematic identifiers or properties.

For the representation of attributes and properties of the road transport network *linear referencing* was used, since it allows the georeferencing of “properties” and “events”, using the definition of its position on a linear feature called *route*, normally corresponding to the distance from its origin (Ferreira, 2010).

This method is essential for the storage process of “information” through relative positions along the linear elements. The linear referencing is also used to associate different sets of attributes to the same geographical element, without it being necessary the segmentation of this when there is a change in the values of the attribute. For example, the most effective way to represent the speed variations along a road is through this method, without the need to “break” the links to represent different values of the attribute.

To carry out the *linear referencing* it is necessary to create *routes* because it is where these events are projected and moreover it is necessary to calibrate the network.

## 5.2.1 National Road Code

The National Road Code represents an attribute of the road transport network, which indicated the identification number of the road, committed nationally, according to the national plan in force.

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<sup>2</sup> The National Road Network is formed by the national fundamental network and for the national complementary network. The national fundamental network integrates the main itineraries (IP). The complementary network is formed by the complementary itineraries (IC) and the national roads (EN).

<sup>3</sup> The National Motorways Network is formed by elements of the National road Network, namely IPs and ICs, specifically designed and built for motor traffic.

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

Firstly we proceeded to create the event table called “NationalRoadCode”. The creation of this table is essential for the representation of this attribute using the *linear referencing*. The table “NationalRoadCode” is composed by five columns, where the first represents the primary key, followed by the column *IdRoute* whose function is to allow the association of this table with the *routes* of the NMN.

Using the tool “Dissolve”, available in *ArcToolbox*®, it was possible to associate all the geographic features of NMN (all links within the network) which have the same national road code.

Then it is necessary to project the information obtained by the process previously explained, on the layer containing the route already calibrated.

For such the tool “*Locate Features Along Routes*” was used. This tool calculates the spatial intersections of the elements on each *route*, generating an event table.

In order to make the process as automatic as possible, minimizing the errors and reducing the time spent, we proceeded to the creation of a “*Query Design*”, directly in the database.

This type of query allows adding, changing or deleting data from one or more existing records. The “*Query Design*” allows the new event table automatically fills the “NationalRoadCode” table created.

After filling the table “NationalRoadCode” it is possible to attach the events on calibrated *routes* through the command “*Display Route Events*”, indicating the route identifier (*IdRoute*) and the respective fields of initial (*FromM*) and final (*ToM*) measurement.

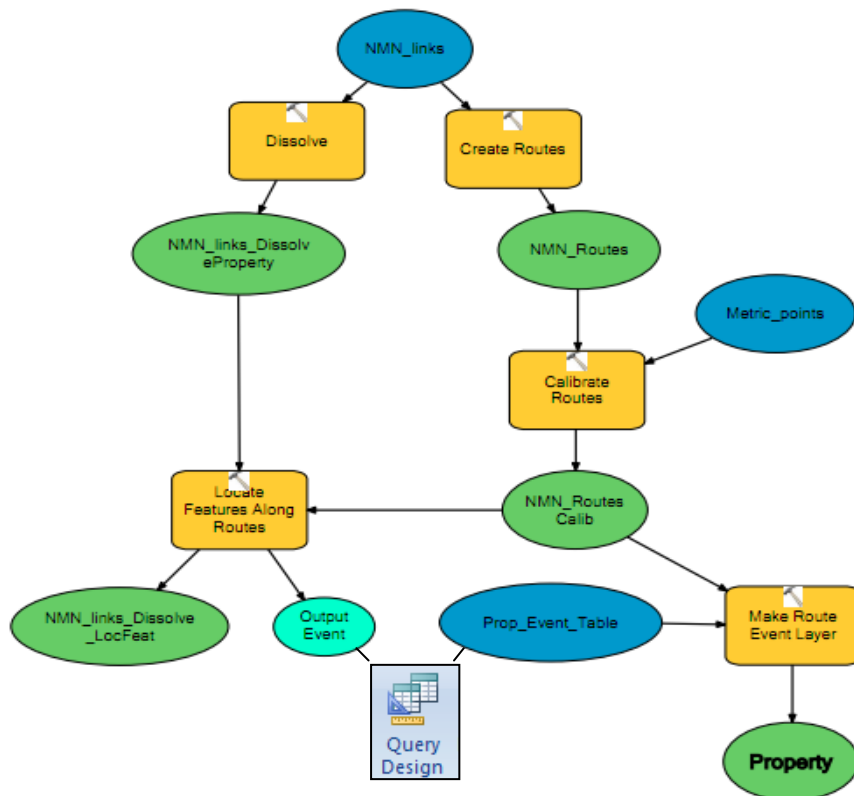


Figure 3 – Schematic process of representation the properties and attributes  
Font: scheme developed with the use of *Model Builder* in *ArcGIS Desktop*®

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

The use of this working method allows automation (as much as possible) the process of representation of the transport network properties and attributes. Its use also allows that whenever any data change occurs or new data is added, the staff can quickly proceed to its introduction in the database, and they don't need to repeat the whole process again.

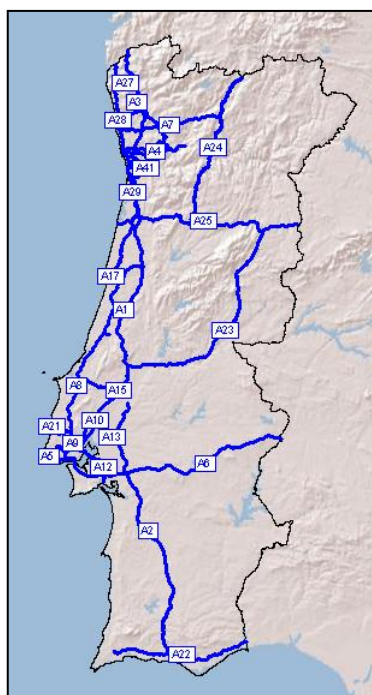


Figure 4 – National Road Code

## 5.2.2 European Road Code

In Portugal the corridors that make up the network of roads with the European classification coincide with most existent motorways. However, not all roads in the NMN are part of this network. According to the national regulator, the European Roads has an extension of more than 1 570 km. The procedure followed for the classification of the network is the same procedure explained for the national road code.



Figure 5 – European Road Code

## 5.3 Road Nodes

As previously mentioned, a road transport network is essentially composed of an interconnected set of links, which represent the axis of the road, and points or nodes at the ends of these links.

The intersections, or Road Nodes, are represented geometrically by point with the aim of establishing a connection between two links or represent an important geographic object as a service station or a roundabout (INSPIRE Thematic Working Group Transport Networks, 2010).

### 5.3.1 Form of Road Node

The road nodes should be characterized by the attribute "Form of Road Node". This attribute describes the role of a road node in the road transport network (INSPIRE Thematic Working Group Transport Networks, 2010).

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

The approach taken on this attribute required also the study of other data specifications, such as the initiative EuroRoadS-project<sup>4</sup>, in order to adapt appropriately to the context of this work (for a better understanding, details can be consulted in Figure 15).

Analyzing the possible form of road node values present in the INSPIRE Data Specifications and the information available internally at the national regulator, we considered that in NMN the form of road node values are: junction, road service area, roundabout and boundary.

- Junction:

According to INSPIRE Data Specification, value Junction is classified as an intersection of three or more roads at some point.

After analyzing all the options available on the “codelist”, it was considered that none of them fits into the existing intersections. The INSPIRE Directive does not explain which methodology to adopt in this situation. Therefore we resorted to EuroRoadS Data Specification, which served as one of the sources for the development of INSPIRE Data Specifications.

The EuroRoadS Data Specifications define Junction as a crossing of two roads belonging to a transport network. Although in motorways the intersections occurred at

different levels. In the EuroRoadS specifications, the grade separated crossings are crossing between two roads in a planar network that cross each other in different levels.

We considered as Road Nodes the crossings in the NMN where there is traffic interchange. Thus, as a way to circumvent this situation it was decided to assign the classification Junction at all grade separated crossings, complementing this classification with the relative position of the roads involved in the intersection. The projection of the road nodes and their attributes followed the procedure outline above.

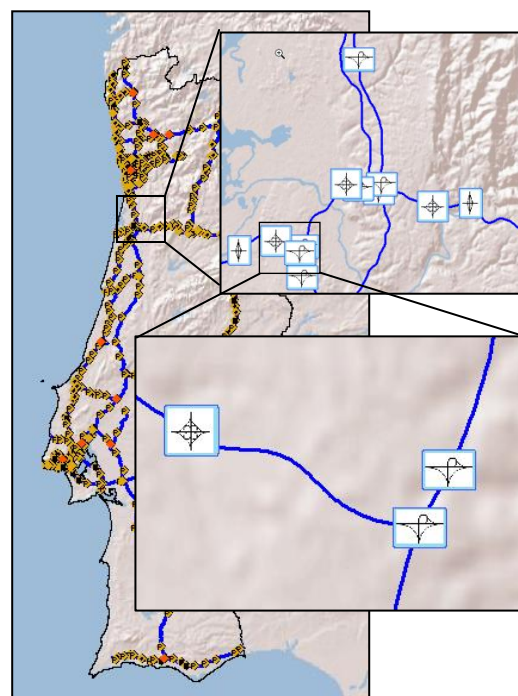


Figure 6 - Road Nodes: Junction

- Road Service Area

The INSPIRE Data Specifications define “Road Service Areas” as a surface annexed to a road and devoted to offer particular

<sup>4</sup> The EuroRoadS-project, starting in March 2004 and finished in 2006, aimed the establishment of a platform to provide solutions to problems related to road information through the development of specifications, description of the contents of data, mechanisms for sharing data, promoting the interoperability.

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

services for it, like gas station, rest area and toll area (INSPIRE Thematic Working Group Transport Networks, 2010). In view of this definition and the data provided by the national regulator it was possible to classify as road service areas the road nodes that represent the gas station and tolls.

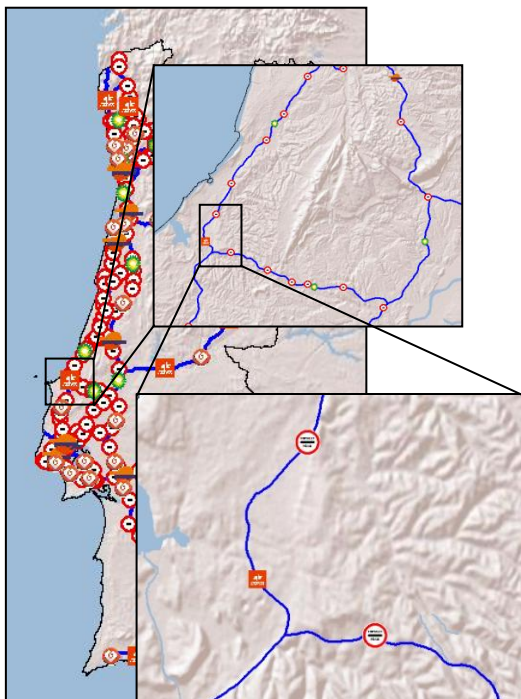


Figure 7 - Road Nodes: Road Service Areas

- Roundabout and Boundary:

It was considered essential the representation of boundaries, although this value is not present on the “codelist”, since the Directive stresses the extreme importance of perfect coordination between the transport networks, namely at the country’s borders. This is an informative data, but in future this type of information will have great importance for the homogenization of transport networks from Portugal and Spain.

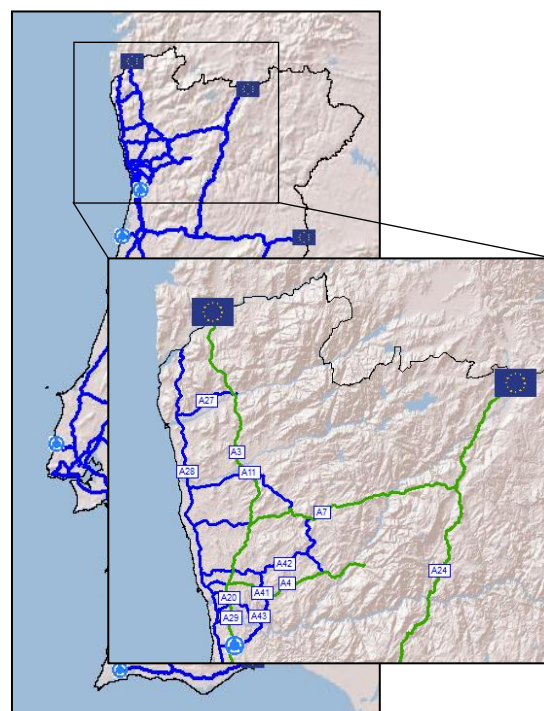


Figure 8 - Road Nodes: Roundabout and Boundary

## 5.4 Properties of Road Transport Network

The Directive INSPIRE promotes the reuse of information. The *linear referencing* is recommended by data specifications for supporting the absence of duplication of information, i.e., on a set of existing objects, such as a transport network, are projected the properties or attributes of the network.

The national regulator only has a few properties and attributes of the network referred in the INSPIRE Data Specifications, such as national and European codes (which have already been presented), functional road class, form of way, number of lanes and surface category (paved or unpaved).

We tried to provide the network with all the properties present in the specifications, and beyond these, add new properties considered essential for a complete

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

characterization of the network in transport terms.

## 5.4.1 Number of Lanes

The national regulator comprises the property “Number of Lanes” from the infrastructures that compose the National Motorways Network.

It was considered that the value of the number of lanes is an integer value corresponding to the average of the number of lanes actually existing by traffic direction.

The entire process followed to represent the attribute “Number of Lanes” is very similar to the one used to compute the “National Road Code” and previously presented.

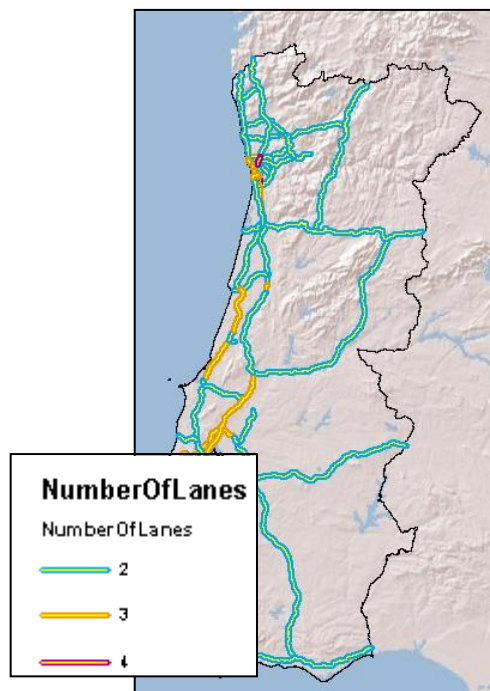


Figure 9 - Number of Lanes

## 5.4.2 Road Width

In order to meet the INSPIRE Data Specifications it was considered appropriate to present this property. This property of the network is associated with

two attributes, the effective value of the “road width” and which part of a road the value for the attribute “road width” applies.

Since the number of lanes is a known property, with the use of standards for geometric design of roads, we computed an estimated width of the road.

According to the normative provisions published by the regulator, the two-ways roads must have a minimum width of 3,5 meters. However, in order to ensure the necessary distance between the trucks, the width should be 3.75 meters in motorways and highways, and 3.5m in the remaining roads.

## 5.4.3 Form of Way

This property of the road transport network is the classification assigned to a road, based on their physical properties. The INSPIRE Data Specifications has a “codelist” for this property, which presents various types of road infrastructure for the classification of the network.

Thus, it was considered that, among all values in “codelist”, the network use should be classified as “motorway”, since the specification define this attribute as a road intended exclusively for motor vehicles, only in combination with a prescribed minimum speed, with two or more mostly physically separated carriageways and no single level-crossing.

## 5.4.4 Functional Road Class

The property “Functional Road Class” classifying the road based on the importance of the role that this road performs in the network.

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

In the present work, and considering only the network on which the regulator hold jurisdiction it was decided that the motorways are functionally classified as mainRoads, the main itineraries are classified as FirstClass, the complementary itineraries as SecondClass and finally the remaining as ThirdClass.

The remaining properties specified by INSPIRE Directive weren't considered, as explained before.

The property "Road Surface Category" indicates the state of the road surface, whether it is paved or unpaved. Since the present study is only based on the NMN, all roads are paved.

Regarding the property "Name" this turns out to coincide with the national classification of the road.

With regards to the "Road Service Type" and "Speed Limit" the regulator doesn't have all the necessary and relevant information for the characterization of these properties.

## 5.5 Extension of INSPIRE concepts to the Transport Services

It was considered extremely important in this work to elaborate a small test of the potential use of INSPIRE as a source of doctrine and structure for the eventual establishment of an infrastructure for information targeted exclusively to transport networks, which we denote as INSPIRE-T. This infrastructure should have as primary functions the standard storage and availability of network properties directly related to the planning, operation and management of the road transport systems, and the full integration of these services.

Thus, in an experimental way, we chose to complement the range of information available on National Motorways Network, with information on the "Annual Average Daily Traffic" (AADT), the "Percentage of Heavy Goods Vehicles" (%HGV) and the "Road Capacity" of the infrastructure (in uve/time unit).

These were the three properties of the network chosen for an initial analysis, because they are the key performance indicators to support the road planning and management.

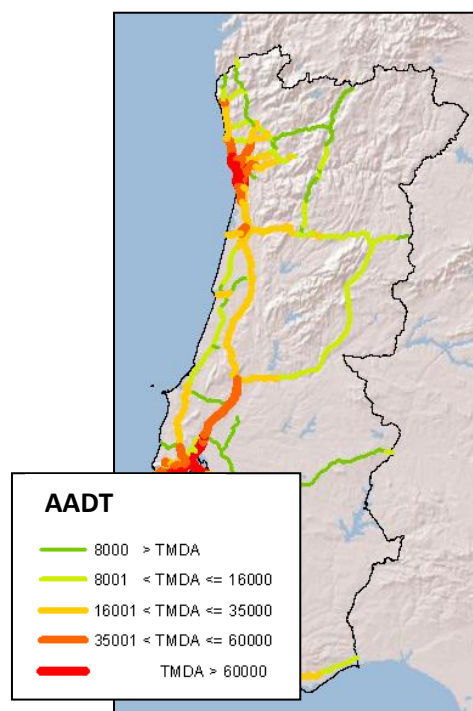


Figure 10 – Annual Average Daily Traffic

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

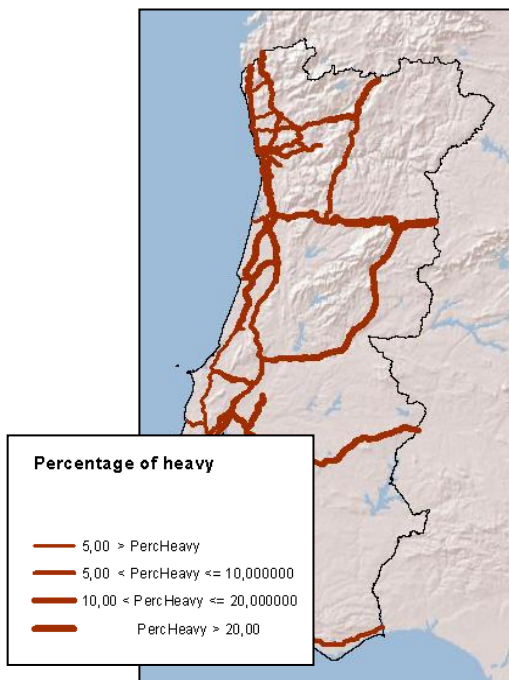


Figure 11 – Percentage of heavy goods vehicles

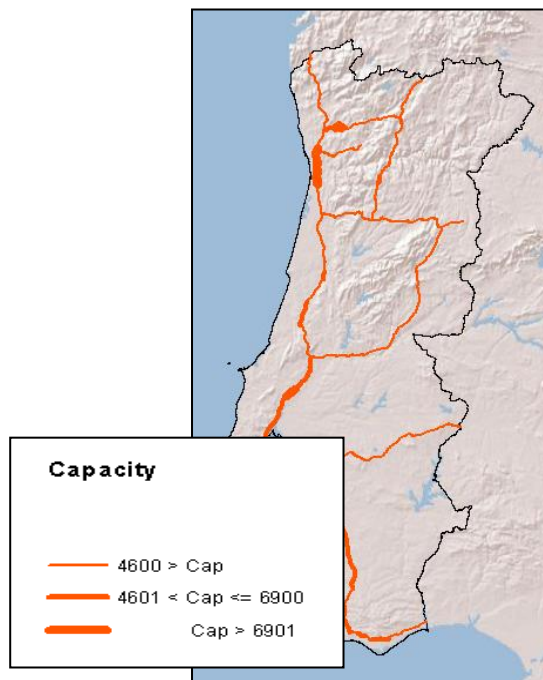


Figure 13 – Road Capacity

Experimentally, a brief UML diagram was developed where the properties related to the transport planning (INSPIRE-T) are also considered. As Figure 12 shows, in addition to the properties already presented in the INSPIRE Data Specifications, we add the three additional Transport Properties.

The respective “codelists” were also considered. It’s intended that in the near future other properties can be addressed essential to promote the spread of INSPIRE successful practices to the management and regulation of the road network.

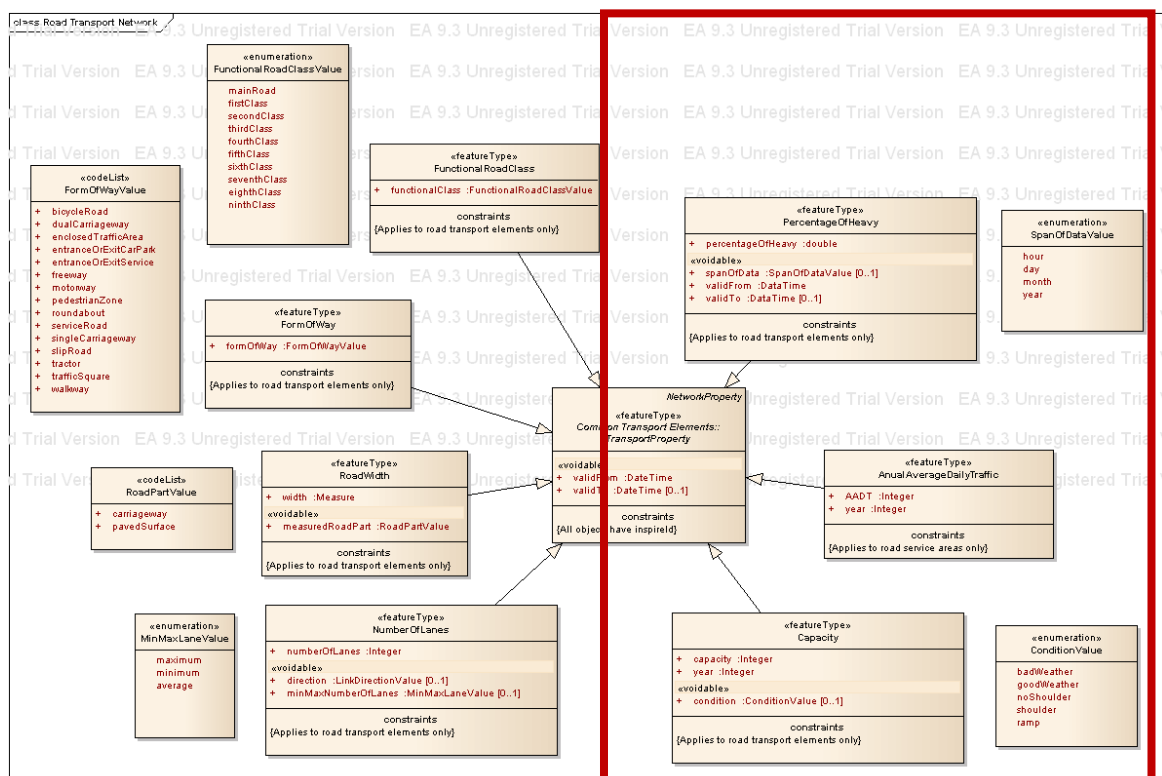


Figure 12 – UML diagrams for the INSPIRE-T properties

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

## 5.6 Web Service

According to the INSPIRE Directive the View and Discovery services must be operable until November 2011. The main objective of the INSPIRE Network Services is to promote and facilitate the use of geographic information from the Internet (Initial Operating Capability Task Force Network Services, 2011).

The national regulator for the road infrastructure, as the responsible for the theme Road Transport Networks, has the obligation to provide a network service where users can access geographic information related to national road infrastructures via internet.

So, the last step in this case study was the development of an innovative prototype for a view service, with the goal also of providing the national regulator a pilot-project for the development of future work.

The design of a web service with the use of the software *ArcGIS Server*<sup>®</sup> allows actions such as distributing maps, models or tools inside or outside organizations. This software enables the creation, management and distribution of geographic information services via web (ESRI, n.d.).

The established view service enables the sharing of the INSPIRE data on the road transport network specified in the preceding sections through a web map application.

The service publishes the developed map, where all information released by the regulator and related to the national road network is presented, according to the INSPIRE Data Specifications and previous descriptions.

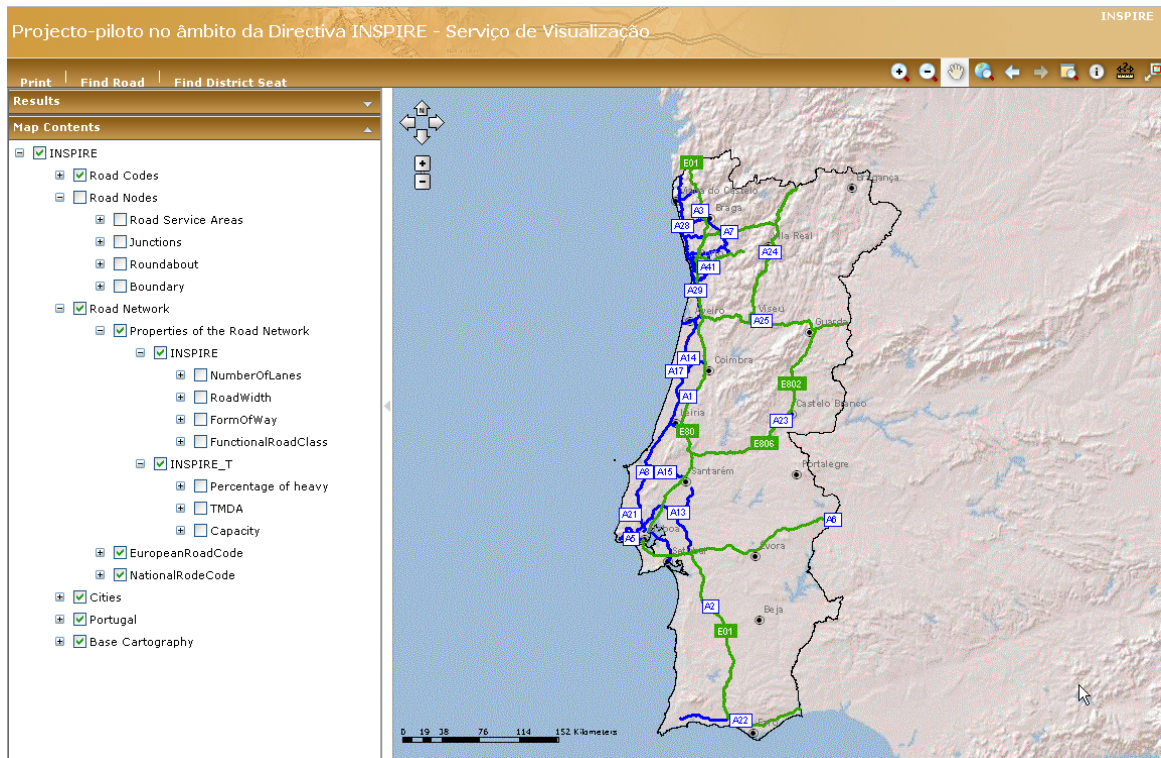


Figure 14 – INSPIRE web service for the Portuguese National Road Infrastructure

<http://sig.inir.pt/InIR>

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

After the establishment of the new INSPIRE map service, some operating parameters were defined, as the map which contain all the information, skills, time, etc.

The next step was the development of a web application that supports the map service created. As mentioned, it is this application that allows users to visualize the information in the map service, offering at the same time some interaction options on the map.

This application is associated with a URL (<http://sig.inir.pt/INSPIRE/default.aspx>), from which users can access the map, and consequently the pilot-project developed as case study of this academic work.

Functionalities such as “zoom in and out”, “pan”, “measure elements”, “identify”, “full extend” and “turn on or off” the different layers are possible to run in this application. Also, the capability of running some pre-defined “queries” was incorporated in the application: one that allows the users to find the district seat where they want to do the research and other to find the desired road infrastructure.

As shown in the Figure 15, by clicking on a network element (in this example on a point) it is possible to find all the associated information, including the information referred by the Directive, and in this case, supplemented by information specified by EuroRoads (as shown in the figure).

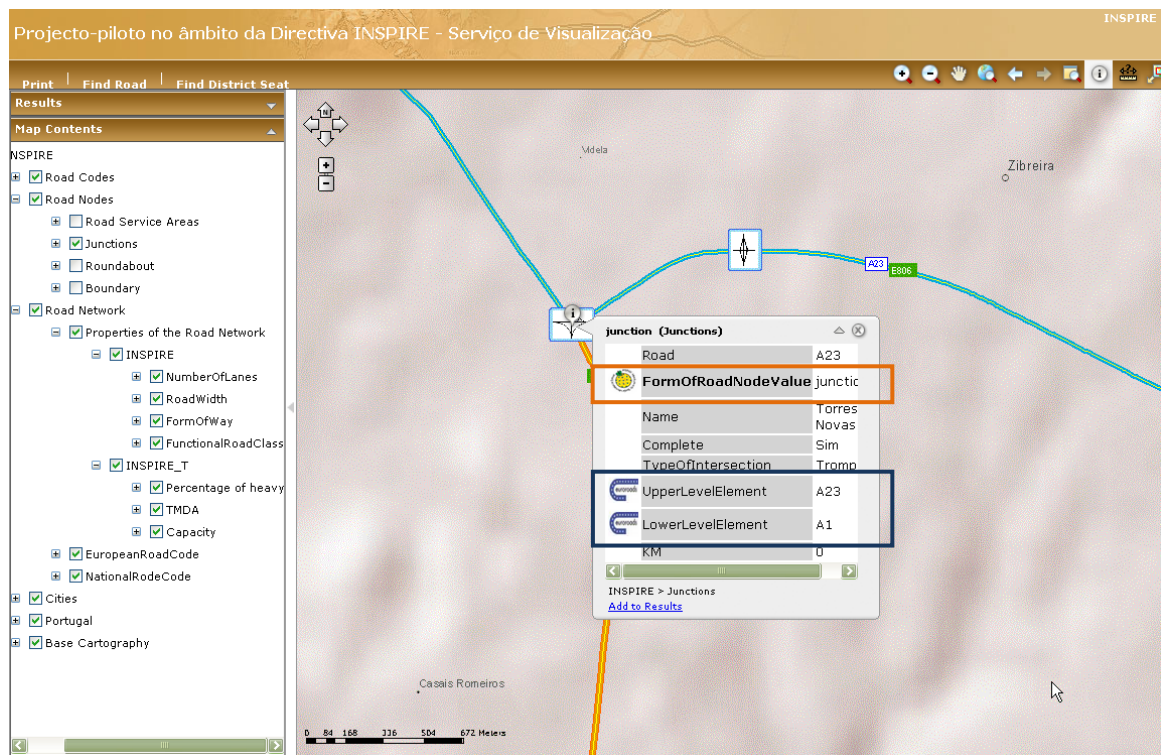


Figure 15 – Identifying a point on the road transport network

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

## 6 Conclusions

The preparation of this work allowed us to understand the evolution of the provision of geographic information in the last 20 years, and which problems such as duplication, lack of documentation and standardization, have prevented or hindered the sharing, understanding and enjoyment of this information as an indispensable requirement.

It should be noted the excellent and hard work that the European Commission and the Member States have developed in order to solve this situation. The main objective of the INSPIRE Directive is to provide a set of guidelines and good practices to Member States, setting a legal framework for the creation of an infrastructure for spatial information in Europe.

Related to the implementation of INSPIRE Data Specifications for the item 7 of Annex I – Transport Networks, the Portuguese regulator for the national road infrastructure arises as the responsible for the road transport networks. It is the responsibility of the regulator to meet the requirements of the European Commission in the INSPIRE Directive context.

The implementation of INSPIRE on the road network enables sharing information by a wide range of users, contributing to a joint effort between the public and private sector, providing support to the political decision in order to reduce the costs and difficulties in accessing information and ultimately in establishing a strong relationship between the entities responsible for the theme of the transport networks.

In analyzing in detail the objectives proposed at the beginning of this work, it is possible to conclude that:

- The problems related to geographic information, the need for standardized information to support policy decisions and the need to address certain problems rapidly, are some of the main reasons that led the creation of an “open” spatial data infrastructure in Europe. However, these problems are not exclusively European;
- In order to solve these problems, arises the INSPIRE Directive. INSPIRE’s policy vision is to produce a harmonized and high quality geographic information, available for the formulation, implementation, monitoring and evaluating community policies, allowing citizens access to information, both locally and across national borders;
- Directed towards the implementation of the INSPIRE Directive on road infrastructure in Portugal, the traineeship performed in the Portuguese national regulator allowed the development of a careful analysis of benefits and obstacles, as well as to draw some conclusions about the implementation process of the Directive. A SWOT analysis was also performed which identified the main strengths, weaknesses, opportunities and threats for the implementation process of the Directive at the level of the national regulator. Briefly, the strengths are the ability to share

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

geographic information by multiple users, cooperation between various entities responsible for the transport sector in Portugal and the reduction of costs associated with obtaining the information. The weaknesses are the lack of information, lack of standardization or poor diffusion of the Directive. The implementation of the INSPIRE Directive by the regulator can bring opportunities in the dissemination of their work promoting the skills and competences and the creation of a successful and efficient road transport network;

- The INSPIRES's vision is also essential for the provision of data by the concessionaires to become standardized and in accordance with the data specifications, reducing the analysis time and data processing.

In short, it is considered that the initially proposed objectives were successfully achieved. The involvement and understanding of the implementation of INSPIRE by the national road infrastructure, as well as the support provided by the staff allowed also the development of an innovative pilot-project for a web view service(<http://sig.inir.pt/INSPIRE/default.aspx>), the first performed in Portugal for this theme. From the web service it is available (in this case, only for display) information on the National Motorways Network according to INSPIRE data specifications.

The national regulator can use this pilot-project as a basis for drafting any INSPIRE national web service, covering the entire

road network, and thus responding to its obligations to the European Commission.

From an academic and research point of view the pilot-project developed is also useful in the bridging of geographic information, framed by the INSPIRE initiative with Transport Systems analysis. The work done allowed a better understanding of two different streams of knowledge to be further developed in the future. The first is the link and possible fit of INSPIRE with the public transport standards based on Transmodel and its extension initiatives. This link can be extended not only to data standards, but also to conceptual standardization, including ontologies, quality levels, image, etc. The conceptual standardization promoted by initiatives like START<sup>5</sup> project (INTEGRA concept), INSPIRE and Transmodel have certainly an important role in the future of a European seamless public transport system.

Secondly, but also very important, the potential extension of INSPIRE to the transport subjects not yet covered by the stable standards was also exploited in this work, in what was called the INSPIRE-T essay. Examples can be transport demand data, or transport analysis models (we refer to the data and analysis layer which are placed on top of infrastructure layers). For a beginning, only three variables were used, as this was only a first essay: road capacity (C), percentage of heavy goods

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<sup>5</sup> *Seamless Travel across the Atlantic area Regions using sustainable Transport* (START for short) is a project implemented within the European Commission's Transnational Territorial Cooperation Programme from January 2009 to May 2012 (<http://www.start-project.eu/en/Home.aspx>). It is expected that the project will give rise to the European Association INTEGRA which will continue the development of the INTEGRA concept and brand.

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

vehicles (HGV's) and Annual Average Daily Traffic (AADT). These features are very important to the tactical and strategic management of the national roads regulator. So, an UML structure was built, making a preliminary integration of these data features on the broad INSPIRE data structure. The result of this essay was included in the pilot-project, for testing. The trial was well succeeded and we conclude it can easily be extended to other transport features, like for instances road accidents (data), which in Portugal is a key performance indicator and in the past (for several reasons) has been associated to difficulties in obtaining information reliable and easy to use.

# Implementation of the INSPIRE Directive on Road Infrastructure in Portugal

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