European
Commission

ISA Action 1.17: A Reusable INSPIRE Reference Platform

(ARE3NA)

The use of INSPIRE data models in the realization of a cross-border database

Massimo Migliorini

Federico Stirano

Chris Schubert

Robin S. Smith

Paul Smits

Joint
Research
Centre

This publication is a Deliverable of Action 1.17 of the Interoperability Solutions for European Public Administrations (ISA) Programme of the European Union, A Reusable INSPIRE Reference Platform (ARE3NA), managed by the Joint Research Centre (JRC), the European Commission's in-house science service.

The study contributing to this publication has been undertaken by Massimo Migliorini and Federico Stirano of the *Istituto Superiore sui Sistemi Territoriali per l'Innovazione* (SiTI) in collaboration with Chris Schubert, Robin S. Smith and Paul Smits from the EC Joint Research Centre.

Disclaimer

Copyright notice

Bibliographic Information

Migliorini M, Stirano F, Schubert C, Smith RS, Smits P. The use of INSPIRE data models in the realization of a cross-border database. 2014. JRC93509

Contents

Executive Summary

The present report describes the experience gained by SiTI (*Istituto Superiore sui Sistemi Territoriali per l'Innovazione*) during the realization of a cross-border database between Italy and France, with focus on major natural events and critical Infrastructures that can be affected by natural disaster events. This work was undertaken in the context of the PICRIT project. The database was built on the basis of European Directive INSPIRE and provides an example of how investments in INSPIRE data modelling can be reused in other sectors, a topic of interest to the ISA Programme's Action 1.17: ARE3NA.

The document is structured into 6 sections:

1. **The INSPIRE Directive**: the section represents a general introduction to INSPIRE Directive concept, describing its *main principles* and listing reference *legislations* and related *documents/annexes.*

2. **The Application Context**: the section details the context where the cross-border database was built, specifying which INSPIRE Data Themes (Data specifications) were used to map different data elements.

3. **Database design and INSPIRE data model application processes**: the section provides a description of how the database was designed according to requirements and recommendations within INSPIRE Data Specifications, focusing on technical/organizational choices and related issues.

4. **Data collection procedure**: the section contains a description on how spatial data sets and information were collected and how data collection procedures were continuously refined during the cross-border database implementation.

5. **Cost Benefit Analysis Estimation**: the section contains a quantitative estimation for a broad overview of the effort required to create the cross-border database on the basis of INSPIRE model.

6. **Conclusions and suggestions for potential INSPIRE upgrades:** the section contains a synthesis of most important results coming from the application INSPIRE approach in the Italian-French context, a series of recommendations for potential future upgrades of INSPIRE Data Specifications and INSPIRE Registry, and a description of possible synergies with the ARe3NA platform.

1 Introduction

The European Union (EU) Member States and some EFTA countries[1] are currently implementing the INSPIRE Directive and related regulations. Technical guidelines for INSPIRE's implementation, based on existing international standards, have been developed or are currently under development. However, interoperability between systems is being limited by the differing implementation of standards, the regular evolution of standards and challenges in coordinating changes between standards, alongside varying choices in the technologies being adopted.

As part of the ISA Programme, the European Commission's (EC) Joint Research Centre (JRC) is establishing A Reusable INSPIRE Reference Platform (ARE3NA) which aims to support the Member States through guidance, collaboration, sharing of best practices and approaches and a reference implementation of common open source components to aid INSPIRE implementation and the reuse of interoperability components that INSPIRE can share with other sectors.

The following presents the main activities in ARE3NA:

- Inventory of
    - Existing INSPIRE components from the Open Source community;
    - Components used within the Member States to implement INSPIRE;
    - Missing components;
- Selection of other policies and initiatives from other sectors (such as INSPIRE, Water Framework Directive[2], Digital Agenda for Europe, open data, Shared Environmental Information System (SEIS)[3] etc.;) requiring exchange and sharing and maintenance of spatial data sets and services.
- Selection of the missing components and/or functionalities. Multilingual support is envisioned where required;
- Support Open Source projects to develop the missing items and produce the related documentation (installation guides and technical documentation in several languages);
- Selection and development where required of conformance test suites;
- Set up a collaborative platform to share and maintain the components

Work presented from the *Protezione delle Infrastrutture Con Rilevanza Transfrontaliera* (PICRIT[4]) project contributes to the second point by illustrating where there initiatives in other sectors requiring the exchange and maintenance of spatial data and, potentially, related services of interest to ARE3NA. In particular, the study presents one of the first cases of reusing INSPIRE's data models in a policy context beyond a pure environmental focus, including modelling critical infrastructures and the hazards they may face. The cross-border and cross-sector context of the work is also particularly informative when considering the

[1] European Free Trade Association (EFTA) Member States: Norway, Switzerland. Liechtenstein and Iceland

[2] *http://ec.europa.eu/environment/water/water-framework*

[3] *http://ec.europa.eu/environment/seis/*

[4] *http://www.siti.polito.it/getPDF.php?id=171*

interoperability issues involved, especially at a technology and semantic level. It, therefore, also helps to illustrate how semantics assets (as defined in the ISA Programme[5]) of INSPIRE can be reused in other sectors and demonstrates the implementation of the data models in real contexts with real data. This work can, therefore, also contribute to how other missing items could be developed, such as the wider registration of core INSPIRE data models for reuse and any extensions within certain sectors.

2 The INSPIRE Directive

In Europe a major recent development has been the entering in force of the INSPIRE Directive[6] (*Infrastructure for Spatial Information in Europe)*, establishing an infrastructure for spatial information in Europe to support Community environmental policies, and policies or activities which may have an impact on the environment.

Directive INSPIRE 2007/2/EC of the European Parliament and the Council of 14 March 2007 and was published in the official Journal on the 25th April 2007. The INSPIRE Directive entered into force on the 15th May 2007.

The INSPIRE Directive is aimed at creating a European Union spatial data infrastructure, enabling the sharing of environmental spatial information among public sector organizations and facilitating public access to spatial information across Europe.

The main principles of INSPIRE Directive are:

- data should be collected only once and kept where it can be maintained most effectively;
- it should be possible to combine seamless spatial information from different sources across Europe and share it with many users and applications;
- it should be possible for information collected at one level/scale to be shared with all levels/scales; detailed for thorough investigations, general for strategic purposes;
- geographic information needed for good governance at all levels should be readily and transparently available;
- it must be easy for users/stakeholders to find what geographic information is available, how it can be used to meet a particular need, and under which conditions it can be acquired and used;

The INSPIRE Directive is based on the infrastructures for spatial information established and operated by the 28 Member States of the European Union. The Directive addresses 34 spatial data themes (see

[5] For example, through the Asset Description Metadata Schema: *https://joinup.ec.europa.eu/asset/adms/home*

6 http://inspire.jrc.ec.europa.eu/

Table 1) needed for environmental applications, with key components specified through technical implementing rules. This makes INSPIRE a unique example of a legislative “regional” approach to Spatial Data Infrastructure (SDI) development. JRC is the technical coordinator for development and maintenance of INSPIRE Regulation and Data Specification on behalf of the European Commission.

Annex I	Annex II	Annex III	
Coordinate reference systems	Elevation	Statistical units	Area management/restriction/ regulation zones & reporting units
Geographical grid systems	Land cover	Buildings	Natural risk zones
Geographical names	Ortho-imagery	Soil	Atmospheric conditions & Meteorological geographical features
Administrative units	Geology	Land use	Oceanographic geographical features
Addresses		Human health and safety	Sea regions
Cadastral parcels		Utility and governmental services	Bio-geographical regions
Transport networks		Environmental monitoring facilities	Habitats and biotopes
Hydrography		Production and industrial facilities	Species distribution
Protected sites		Agricultural and aquaculture facilities	Energy resources
		Population distribution – demography	Mineral resources
plus Generic Conceptual Model, Observations & Measures			

Table 1 – INSPIRE Spatial Data Themes

To ensure that the SDIs of the Member States are compatible and usable in a Community (i.e. European-level) and cross-border context, the Directive requires that common Implementing Rules are adopted in a number of specific areas (Metadata, Data Specifications, Network Services, Data and Service Sharing and Monitoring and Reporting). These Implementing Rules are adopted as Commission Decisions or Regulations, and are binding in their entirety. The Commission is assisted in the process of adopting such rules by a regulatory committee composed of representatives of the Member States and chaired by a representative of the Commission.

The INSPIRE Directive their implementing rules will be implemented in various stages, with full implementation required by 2019 see Annex A.

3 The Application Context

3.1 The Cross-border database and INSPIRE Data Specification

The cross-border geo-referenced database was implemented in 2011/2012, as part of working package of PICRIT a European Regional Development Fund project. The set up database contains a series of relevant information about natural events that have occurred and the most vulnerable infrastructures in the cross-border area between Italy and France, with a focus on the Provinces of Torino and of Cuneo, on the Italian side, and of the *Département des Alpes de Haute Provence,* on the French side.

During the data collection phase, it was observed that a lot of different data sources with different structures had to be consulted. This variety, complexity and heterogeneity of data sources made it very difficult to organize any cross-boundary intervention when emergencies occurred. One of the goals of this work was, therefore, to develop joint intervention protocols between Italy and France, so that data could be shared in a quick and easy way as a basic element to enable an efficient cooperation between French and Italian Civil Protection Units. A geo-referenced database was, thus, designed and realized, bringing together data coming from heterogeneous sources from over the cross-border study area.

The first issue that the cross-border database faced was the development of a common data framework that can be easily understood by potential users (in this case civil protection departments, police forces, firefighters, etc.). There were two possible approaches: the first was using one of the already existing data frameworks which used in France or Italy as a master template, while the second one consisted of building a completely new framework. The first approach was simpler, but it would have greatly limited the opportunities to replicate the approach in other European cross-border areas, so the second approach was chosen.

The INSPIRE Directive and their Implementing rules as legally binding regulations for data sharing between public authorities was chosen as the starting point to develop the architecture of the database. The idea was to use an approach able to provide a broad spectrum of application opportunities and, at the same time, ensure data were compliant with the European standards.

Furthermore, this approach provided an opportunity to build one of the first prototype application as real use case for INSPIRE in a cross-border area. This use case offered the European Commission, DG JRC valuable feedback to facilitate the diffusion of INSPIRE data models across different European territorial contexts and foster the implementation of improvements and extensions to INSPIRE, on the basis of a bottom-up approach.

The process starts with the identification of potential relations between the information contained by the cross-border database and INSPIRE data models to be used during the design of the database.

The database focused on four INSPIRE-related categories:

1. Transport networks
2. Energy production sites (with particular reference to renewable energy sources)
3. Major natural events
4. Administrative layers

Transport networks have been developed in a dedicated INSPIRE thematic working group (TWG), which prepared the document "*D2.8.I.7 – INSPIRE Data Specification on Transport Networks – Guidelines*" that provides the schemas for roads, railroads and the other transport links, including aerial and naval.

Energy production sites are described in different data specifications, with a distinction between the production centres and the power lines. Production centres are described in the document "*D2.8.III.8 – Data Specification on Production and Industrial Facilities – Draft Guidelines, Version 3.0rc3*" that aims at providing specification for all industrial plants, including energy generation. Power lines description is included in the document "*D2.8.III.6 – Data Specification on Utility and Governmental services- Draft Guidelines, Version 3.0rc3*", together with the description of pipelines and other utility networks (water, sewer, etc.). INSPIRE Data Specifications also include a specific document describing energy sources, "*D2.8.III.20 – Data Specification on Energy Resources, Version 3.0rc3*".

Major natural events occurred in the last years was an important category that need to be taken into account in the cross-border database, so that the possible impacts of events in the area could be better understood and that proper intervention protocols could be defined. This topic is fully described in the document "*D2.8.III.12 – Data Specification on Natural Risk Zones – Draft Guidelines, Version 3.0rc3*". Importantly, by applying the data model to real data, the work has illustrated INSPIRE's validity in helping to develop approaches to managing and sharing data for cross-border risk management.

Finally, a common **administrative layer** was required to provide a better understanding of where infrastructures are located and events took place. It is covered by the INSPIRE Theme for Administrative Units.

3.1.1 Transport networks

As already mentioned above, Transport Networks are described in the document *"D2.8.I.7 – INSPIRE Data Specification on Transport Networks – Guidelines*".

The specification defines a generic Network object that is then applied to five different transport infrastructures: Road Transport Network, Railway Transport Network, Cable Transport Network, Water Transport Network and Air Transport Network. In addition, specific objects regarding Common Transport Elements are defined, with a specific focus on the connection between the different networks. Roads were identified as the main cross-boundary transport infrastructure item between Italy and France in the selected area, thus only these spatial objects defined for the Road Transport Network were considered.

Roads are described as a sequence of links, connected to each other through nodes. Primarily, nodes represent junctions and roundabouts, but they are also used for other elements, such as service stations. Each link is described by a geographical attribute using a *line* that is associated with other geographical objects describing the whole road surface area and the area particularly reserved for vehicles. Moreover, nodes are characterized by a geographical attribute. Each node is identified by a *point* or a *polygon*. If it describes the intersection of two roads, a point is the only geometry required, while if the node refers to other objects, the definition of the coverage area is required to increase the quality of the data.

Beyond the geographical properties, each road link also has various parameters mainly related to the management of the road, such as the direction of travel, speed limits, traffic restrictions, etc. All these parameters are described through defined attributes, providing a very detailed description of the entire Road Transport Network.

The level of detail provided by INSPIRE Data Specifications for Transport Network is very high and over-sized with regards the requirements (in particular coming from local Authorities and Institutions) addressed during the realization of the cross-border database. Furthermore, available data in the cross-border context were not as complete as the specifications asked. However, the database section about road networks has been developed taking into account all the aspects noted above, even if some fields was not feasible to fill. This means the database is already prepared to deal with other European contexts where more detailed data are available.

3.1.2 Energy production sites

Energy production sites are described in the document “D2.8.III.8 - Data Specification on Production and Industrial Facilities”.

This specification describes all the production facilities through a hierarchical approach. The highest level is represented by the Production Site. Inside the Production Site there can be one or more Production Facilities. The facilities are then composed of buildings, plots and installations. A production building is an artificial construction, part of the production facility that is useful to host productive activities. Conversely, A Production Plot is a piece of land part of a facility destined to functional purposes (even though no “artifacts” are in it). Installations are further divided into parts in order to describe the specific components of each installation. Each object is geographically represented using either points or areas, depending on the available data.

A specific attribute in the production site object refers to a code list table, allowing differentiation between different production typologies, with one of these typologies being electricity. Thus, if the typology attribute assumes the electricity value, the production site is a power plant. The specific type of electrical production is determined through attributes detailed in the other tables.

The INSPIRE data model is very accurate and provides a lot of details about a production site. However, the energy sector is quite complex. There are big power plants, usually based on mineral resources (oil, gas, etc.) that can be perfectly described through INSPIRE data specification. On the other hand, the proliferation of renewable sources has led to the installation of smaller power plants based on other forms of energy production, including photovoltaic panels and wind turbines that do not fit with INSPIRE Specification, because they are not inside. For these plants, the schemes provided by the specifications can be a bit too complex, and in some cases even redundant.

When the database was realized, one of the main purposes was collecting data on renewable energy plants located in the Italian-French cross-border area. As there are hydropower plants in the area, the full structure of production plants was implemented in the database. Moreover, additional parameters were added to the production site and production facility objects, making the search for specific plants easier.

Energy related infrastructures also include the transmission and distribution grid, to transfer the generated energy from power plants to consumers. These utility networks are described in the document “D2.8.III.6 – Data Specification on Utility and governmental services”. Utility networks are described as a sequence of links, in a similar way as the transport networks already described above. In this case, each link can describe an overhead or underground power cable, which makes up the entire transmission or distribution electrical network. Moreover, there are network nodes that identify the primary and secondary substations of an electrical grid. Each object is then characterized by a series of attributes to better detail the actual parameters of the lines.

The data collection in this field was focused on the Italian and French transmission networks, due to the high complexity of the distribution grids. However, the whole structure was considered in the database implementation, as the two networks can be represented in the database by two different utility networks but with the same attributes.

3.1.3 Major natural events

Major natural events in INSPIRE are described in the document "*D2.8.III.12 – Data Specification on Natural Risk Zones*". This specification introduces four main objects (observed events, exposed elements, hazard areas and risk zones) providing a conceptual framework for risk assessment protocols and mechanisms.

The four objects perfectly fit the requirements of the activity and were, therefore, fully implemented in the database. In particular, the object "Observed Events" was very useful to describe the natural and catastrophic events that occurred in the territorial context under analysis. This object is characterized by a geographical attribute that identifies the area where the event occurred and temporal information about the date and duration of the event.

However, during the data collection procedure phase, some issues arrived. In particular, an innovative classification of the events was defined (to merge Italian and French classification criteria) and, in many cases, it was not possible to identify the exact exposed area where an event occurred, due to a lack of availability of geographical data. Sections 5.2 and 5.3 show how these issues were addressed.

The other three objects (exposed elements, hazard areas and risk zones) were also included in the cross-border database, since they represented a valid starting point for the development of a cross-border risk assessment methodology (one of the primary goals following the implementation of the database).

3.1.4 Administrative Layers

The administrative units for INSPIRE are described in the document "*D2.8.I.4 – INSPIRE Data Specification on Administrative Units*".

In the specification, two different geographical objects are used to define the administrative units. The first object describes the unit itself, with attributes related to the name, country, residence of authority (indicating where the responsible authority is located), hierarchical level inside the country, NUTS region and other parameters related to the data validity and life cycle in the data set. The second object relates to the boundaries of each administrative unit.

Boundaries implementation in compliance with INSPIRE specifications is a complex task. The boundaries need to be split in different segments depending upon the number of inter-connected areas (different lines and thus different records must be used to delimit a single polygonal area. It requires a great effort to follow the recommendation of the INSPIRE Data specifications (see Section 6, "Cost Benefit/Analysis Estimation"). The prototype implementation takes place with a lot of manual work. For an operational process, software should be used or developed**.**

In the area of investigation there is a little number of administrative units, especially for units on the upper hierarchical levels. For some data fields in the developed database structure a simplification treatment was necessary. For example, the ResidenceOfAuthority attribute, is defined as INSPIRE Data Type. It requires a geographical name and a geometry, in this case a point of the position of the authority, see figure below.

Only the attribute of GeographicalName was applied, in order not to create a too complex structure that could be difficult to properly manage.

ResidenceOfAuthority	
Definition:	Data type representing the name and position of a residence of authority.
Stereotypes:	«dataType»
Attribute: name	
Value type:	GeographicalName
Definition:	Name of the residence of authority.
Multiplicity:	1
Attribute: geometry	
Value type:	GM_Point
Definition:	Position of the residence of authority.
Multiplicity:	1
Stereotypes:	«voidable»

Figure 1: INSPIRE attributes for Residence of Authority

4 Database design and INSPIRE data model application processes

4.1 Software tools description

To organize and to share data, a Geographic Information System (GIS) was implemented using open source software.

The use of open source solutions increase interoperability because the different software components can easily communicate and exchange data without format encoding issues, and the open-source enables the continuous creation and diffusion of new features and operational functionalities.

Another advantage deriving from the use of open source software is that they usually do not require license costs, so can be more easily diffused across the different private and public stakeholders taking part to territorial data management processes.

Three main open source software packages have been used to build the cross-border database:

- PostgreSQL 9.2 with the PostGIS 2.0 extension
- SpatiaLite GUI 1.7.1
- Quantum GIS 1.8

The features and benefits deriving from their use are described below.

PostgreSQL / PostGIS. PostgreSQL is the open source object-relational database system used to build the cross-border database. It runs on all major operating systems, including Linux, UNIX and Windows. It is fully ACID (Atomicity, Consistency, Isolation, and Durability) compliant and has full support for foreign keys, joins, views, triggers, and stored procedures (in multiple languages). It includes most SQL data types, including INTEGER, NUMERIC, BOOLEAN, CHAR, VARCHAR, DATE, INTERVAL, and TIMESTAMP. It also supports storage of binary large objects, including pictures, sounds, or video. PostGIS is a spatial database extension for PostgreSQL and supports geographic objects that allow location queries to be run in SQL.

This software was used since it allowed the database to be shared with different users and the possibility to manage remote multi-connections.

Spatialite GUI. Spatialite GUI is an open source Graphical User Interface (GUI) tool supporting Spatialite, which is an open source library, intended to extend the SQLite core to support Spatial SQL capabilities. Spatialite uses a GIS file format which is based on SQLite, which itself uses a single file to store multiple layers and data tables. This format offers an alternative to ESRI Shapefiles, which have several legacy issues (such as storage types and lengths of column names, etc.). The software is an embedded SQL database engine that does not have a separate server process. SQLite reads and writes directly to ordinary disk files and it is a complete SQL database with multiple tables, indices, triggers, and views, but is contained in a single disk file. The file format is also cross-platform.

This software was used to exchange and to re-organize data, without the necessity to modify the main database.

Quantum GIS. Quantum GIS (QGIS) is a Free and Open Source GIS that allows geospatial information to be created, edited, visualized, analysed and published. QGIS currently runs on most Unix platforms, Windows, and OS X. With QGIS it is possible to overlay vector and raster data in different formats and projections without conversion to an internal or common format. Supported formats include: Spatially-enabled tables and views using PostGIS, Spatialite and MSSQL Spatial, Oracle Spatial; vector formats supported by the OGR library, including ESRI shapefiles, MapInfo, SDTS, GML and many more. The raster and imagery formats are supported by the installed GDAL (Geospatial Data Abstraction Library), including GeoTiff, Erdas Img., ArcInfo Ascii Grid, JPEG, PNG and many more.

This software was used mainly to visualize/edit data, to connect to Spatialite and PostgreSQL interfaces and to perform geocoding.

The joint use of all three software packages together granted a series synergies during the realization of the cross-border database, including the possibility to develop a complete and operative GIS environment able to harmonize and organize data according to INSPIRE’s schemas.

4.2 Database design

This section provides a detailed description of the cross-border database, including the entity relationship diagrams. Furthermore, a matching comparison between the data structures defined in the INSPIRE Data Specifications and the database entities is provided.

4.2.1 Database general structure

The cross-border database is divided into three main sections, as shown in Figure 2. The first section contains the data on the mapped infrastructures that stores information on cross-border elements with a particular focus on the transport systems and energy generation plants that are based on renewable sources. The second section is related on the natural events that have occurred in the last 30 years that have been putting the various infrastructures at risk. Information on the exposed areas is also included in the database. The third section provides a common baseline for the previous two categories, being dedicated to the administrative units of the territory.

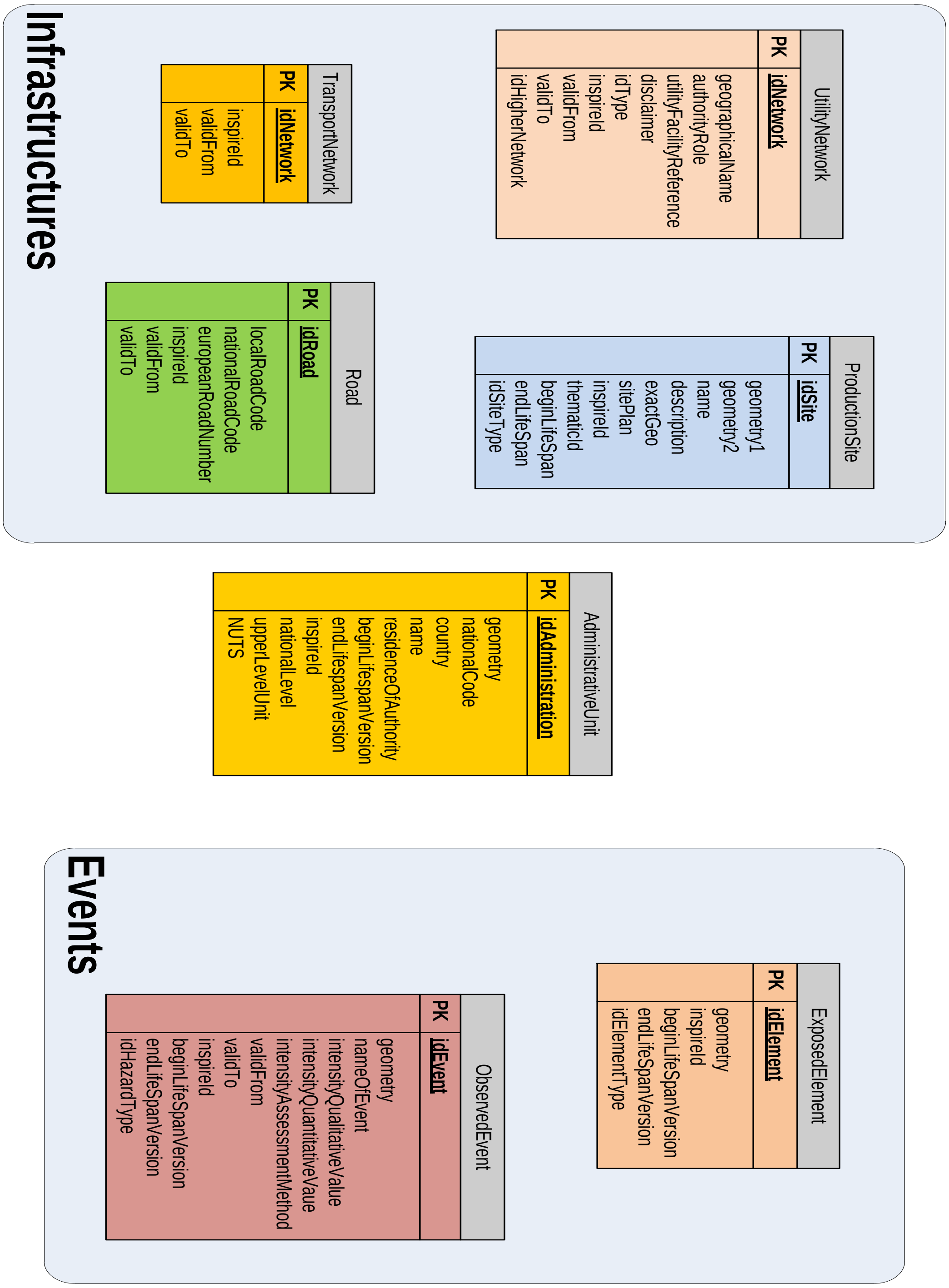

Figure 2 – General schema of the cross-border database.

4.2.2 Transport networks

Figure 3 describes the entity relationship diagram showing the database section for transport networks. As already described in the previous sections, the analysis focused on roads, so only this kind of transport networks was implemented in the database.

The structure is very similar to the diagrams included in the INSPIRE Data Specification. Each entity in the diagram is nearly an exact match of an object in the INSPIRE model, following the same hierarchical structure.

The first level in the hierarchy is represented by the TRANSPORTNETWORK entity, which characterizes the complex set of roads managed by different authorities within the same road transport network. The second entity in this representation is ROAD, which summarizes the main information that characterizes a road. A road is geographically described as a sequence of links, thus two additional entities needs to be defined, ROADLINK and ROADLINKSEQUENCE. Then there is the ROADNODE entity which describes a junction between two different links, including possible structures located near the road (e.g. a service area). Finally, the ROADAREA entity describes the parameters related to the road surface.

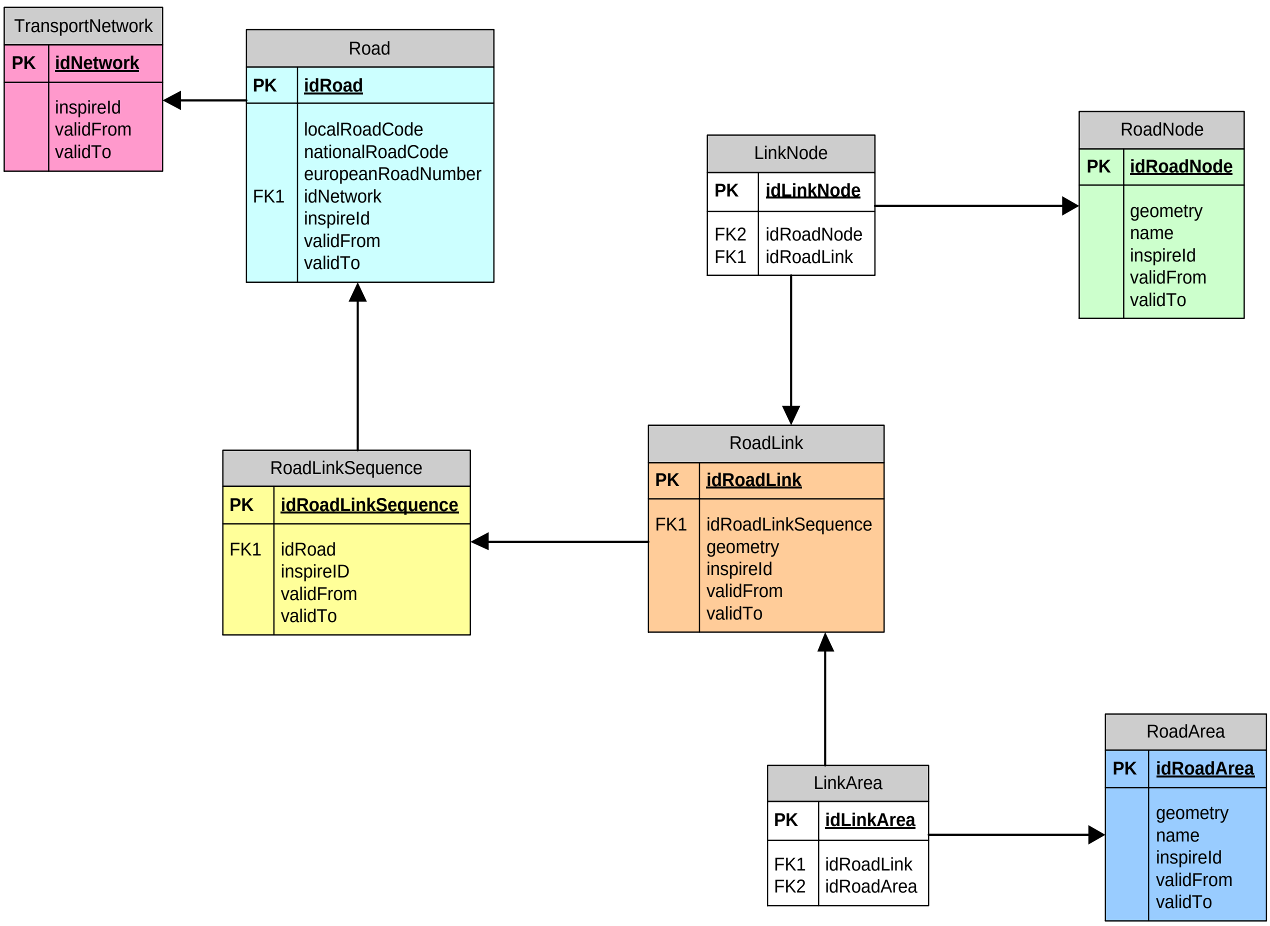

Figure 3 – Transport section

Transport Network

As shown in Figure 4, the TRANSPORTNETWORK entity is very simple, including only some parameters that are common to all the INSPIRE-based objects, plus a relationship describing which type of transport can be performed in that network.

The INSPIREID attribute provides a unique identifier for all the geo-referenced objects in an INSPIRE-based database. The VALIDFROM and the VALIDTO attributes indicate the timeframe associated to different records reliability. Beyond assessing if the information is still valid or not, this approach allows a history of the information stored to be created. As these three attributes can be found in almost all the entities in the database, they are not described again. The TYPEOFTRANSPORT is an enumeration table containing the possible values defined in the INSPIRE data specifications (*air*, *cable*, *rail*, *road* and *water*).

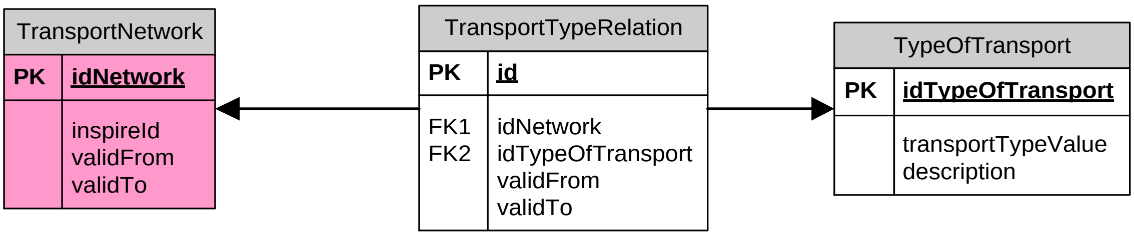

Figure 4 – Detail of transport network entity

Road

A detailed schema of the relationships about the Road entity is provided in Figure 5. The entity itself is characterized by a set of attributes about the road codes identifying the road at local, national and European levels. In some cases, one or more values of these can be void, if the corresponding road has no codes associated. The road name is included in a separate entity to have a better compliancy with the INSPIRE directive, which also defines how names should be used.

The Road entity is connected to another two tables. The FUNCTIONALROADCLASS is an enumeration table providing information on the class of the related road. The INSPIRE Directive defines up to nine classes for the different roads. On the contrary, MARKERPOSTS is an entity that describes the various posts that could be found along a road, including the information on their vertical position through the VERTICALPOSITION enumeration table. The vertical position values used in the database are the same as those defined in INSPIRE Directive: *onGroundSurface*, *suspendedOrElevated* and *underground*.

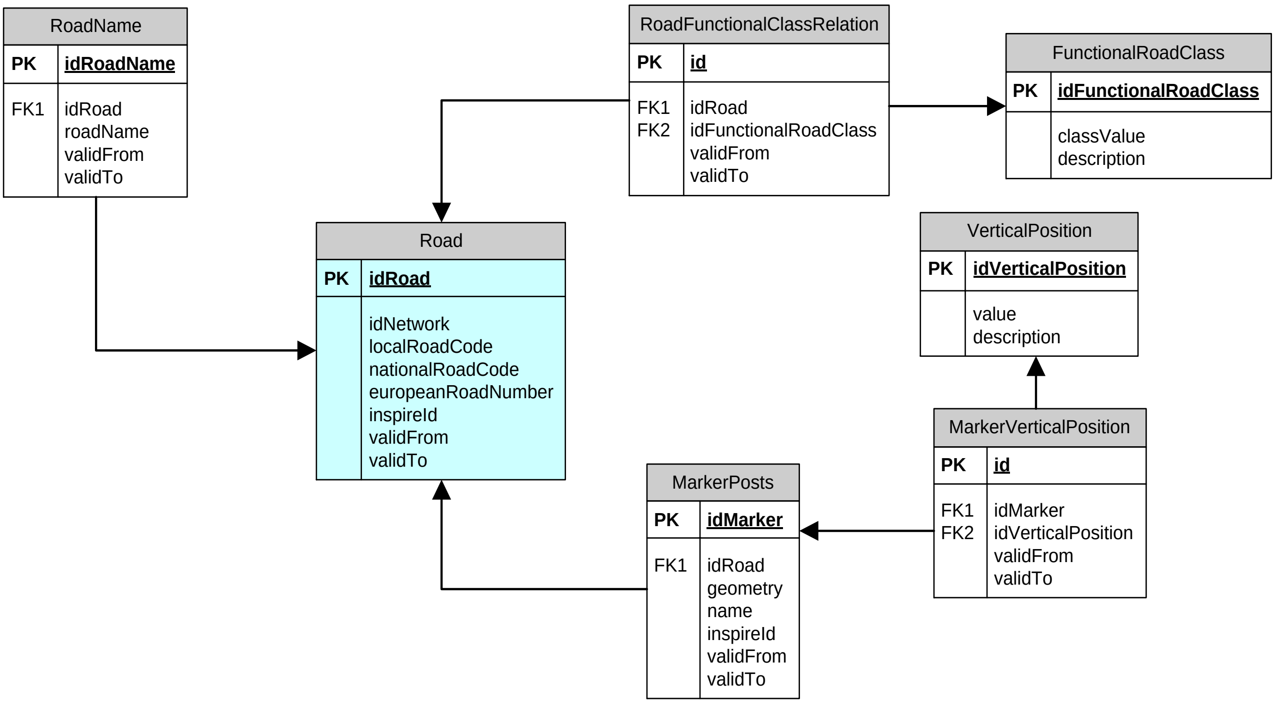

Figure 5 – Detail of road entity

Road Link

The ROADLINK entity is the base element for describing a road infrastructure and, consequently, it has to be described with a high detail degree. First of all, this is the main geo-referenced object to describe a road, using a line. There are several other entities connected to this one that are needed in order to provide data on the different parameters characterizing a single segment of a road.

Figure 6 shows the entity-relationship schema belonging to the ROADLINK section.

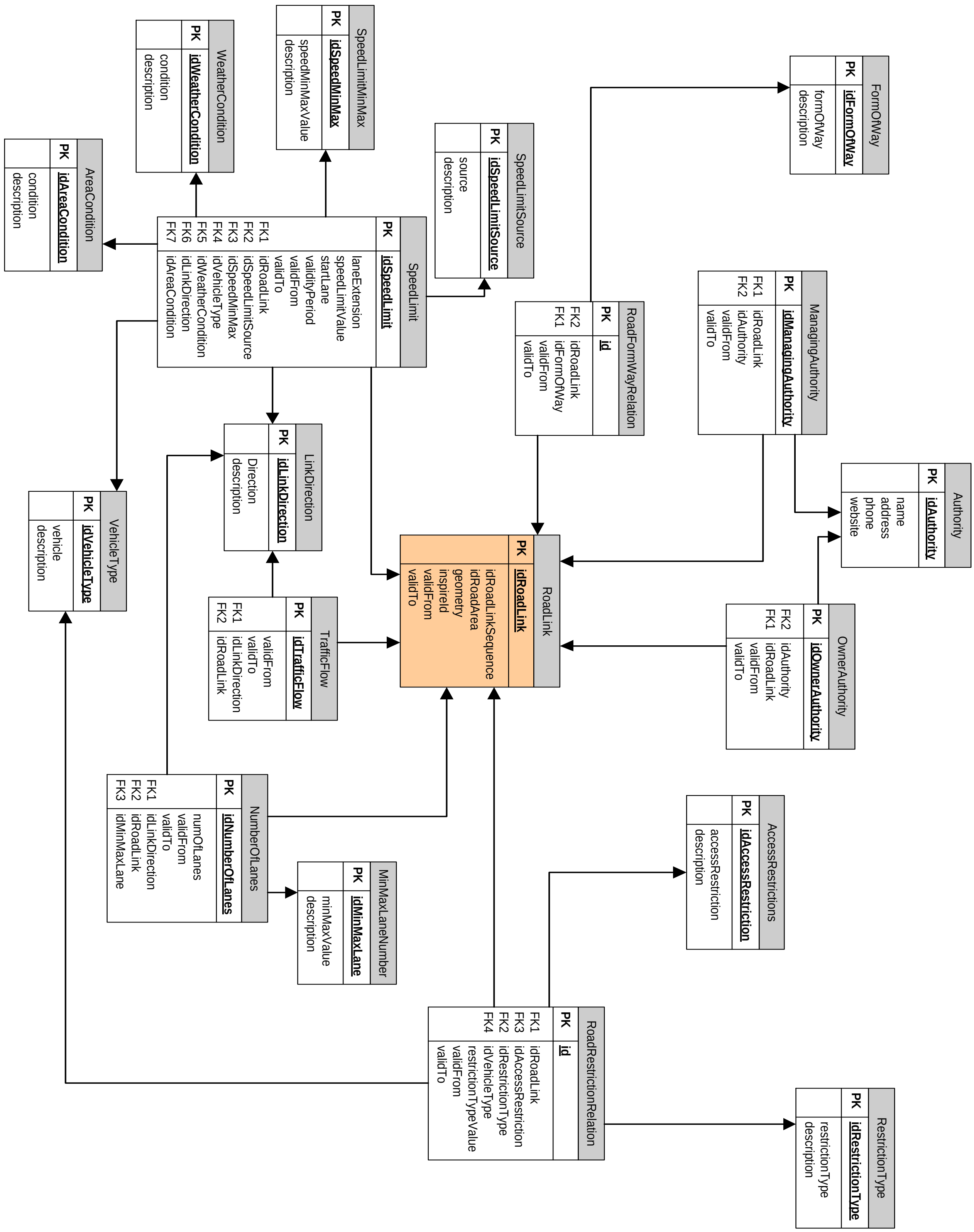

Figure 6 – Details on RoadLink entity

The first parameter is related to who is responsible for the management of the road, splitting the data into the owner authority (OwnerAuthority) and the managing one (ManagingAuthority), as there could be cases when a road is owned by an authority but managed by another. Another relevant parameter is described by the SpeedLimit entity. This entity has several attributes and additional relationships in order to manage the various differences in the speed limit definition, including the weather conditions, the type of vehicle and who defined the limit.

Furthermore, there are entities to manage information regarding other physical parameters, such as the total number of lanes and, for each one, the direction of travel, the direction, the surface, the road width and possible restrictions on the road, including data about which vehicles may use the road and in which conditions these restrictions may apply.

INSPIRE Data Specifications provide several enumeration and code list tables to support a standard classification of the data. All these tables were fully implemented in the database in the various ancillary tables that can be seen in the schema pf Figure 6. These values are connected to the specific objects through multi-multi relationships, including time information that is used to create a record.

Road Area

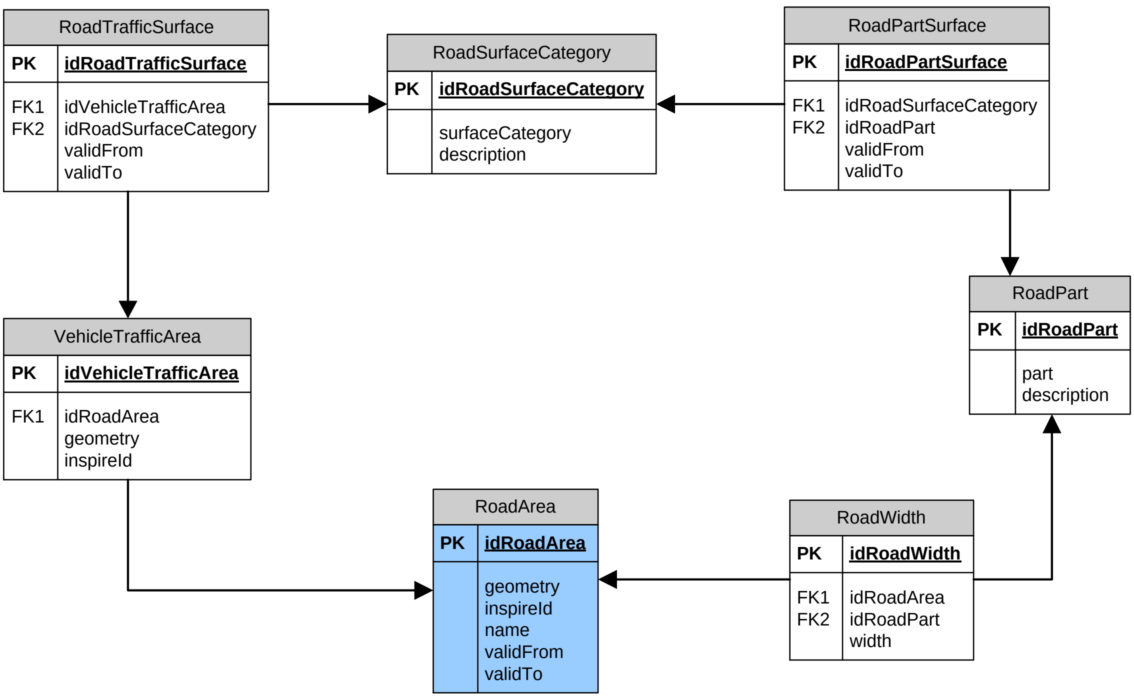

Figure 7 – Details on RoadArea section

RoadArea section, whose scheme is illustrated in Figure 7, stores the information related to the area occupied by the road. In particular, the RoadArea entity contains a geometry attribute. Another relevant entity is VehicleTrafficArea which contains information on the traffic area and the area where vehicles are authorized to pass, including information on the road surface. There is an additional entity, RoadPart, which distinguishes different parts of a road so that separate surface information details can be detailed, as in the traffic area case.

Road Node

The last section relating to transport infrastructures is centred on the ROADNODE entity (Figure 8). This entity provides information on junctions between different links, such as a roundabout or information on service areas that can be found along a road.

The FORMOFROADNODE entity is a table that defines the type of road node (junction or a service area) using values defined in the corresponding code list of the INSPIRE Data Specification. In contrast, the ROADSERVICEAREA entity contains information related to the nodes that provide services to users. This entity has a geometry attribute to identify the area covered by the node and two multi-multi relationships to specify which kind of service and facilities are present. As previously noted, the ROADSERVICEFACILITY and ROADSERVICETYPE tables contain code lists defined in the specifications.

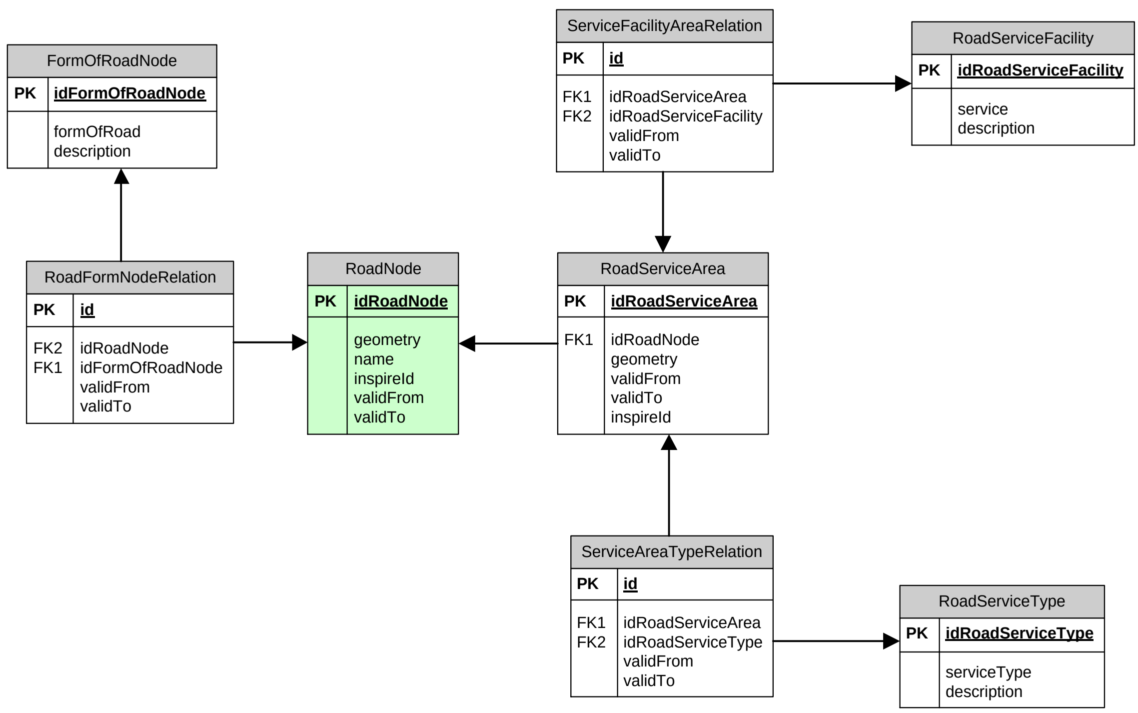

Figure 8 – Details on RoadNode section

4.2.3 Energy production sites

Beyond road networks, energy production centres, transmission and distribution grids represent the second type of infrastructure that is modelled inside the cross-border database. Figure 9 shows the entity-relationship schema of the database section for energy production centres.

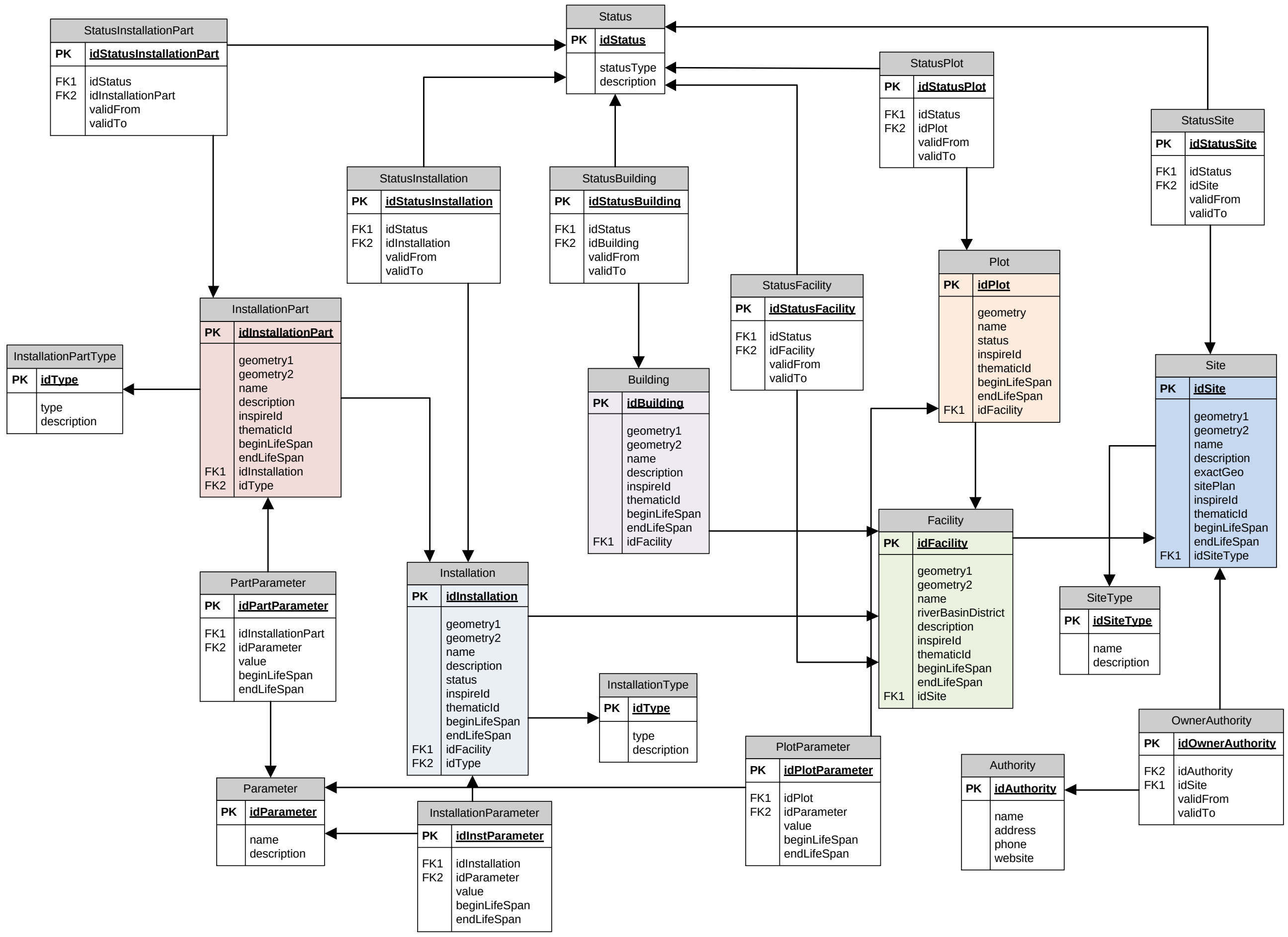

Figure 9 – Details on Energy production entities

The main entities are SITE, PLOT, FACILITY, BUILDING, INSTALLATION and INSTALLATIONPART, which describe all the elements of a power plant using the structure defined in the INSPIRE Data Specification. All these entities have two geometry attributes to locate their position. The first one is a polygonal type, representing the whole area covered by the plant, while the other is a point to be used when only the address or the coordinates are known but not the whole area covered by the production plant.

Furthermore, all the entities have an attribute relating to their status: *planned*, *building*, *operating*, *dismissed*[7] and *notUsed*. These values are connected to the infrastructures through a multi-multi relationship in order to introduce the concept of time, as the same element could have a different status at different points in time. Moreover, different parts of the same installation can be in different stages of development at the same time.

The PLOT, INSTALLATION and INSTALLATIONPART are connected to the PARAMETER table through a multi-multi relationship. This table contains a list of parameters that can be used to better describe the characteristics of the power plants. The list is left open, so that new parameters can be added if necessary, while the

[7] An entity which was operational in the past, but now it is not operating any more, and needs refurbishment work to be reactivated is indicated as *dismissed*

connection tables are useful to provide both the parameter values and the temporal information to create a record over time. Usually parameters should be connected to Installation and InstallationPart elements only but, in this database, they are also used for elements in Plot entity in order to deal with smaller power plants (such as solar panels installed on roofs) and to better identify the general characteristics of a power plant.

In addition, the Site entity contains information on the owner authority of the entire production site. The related Authority entity has the same structure as the one introduced when describing transport networks.

Another subsection of the infrastructures is represented by the utility networks, which also describe the electricity distribution and transmission networks. They are responsible for delivering power from the production facilities to consumers, creating a strategic infrastructure. Figure 10 shows the entity-relationship scheme for describing this kind of infrastructures.

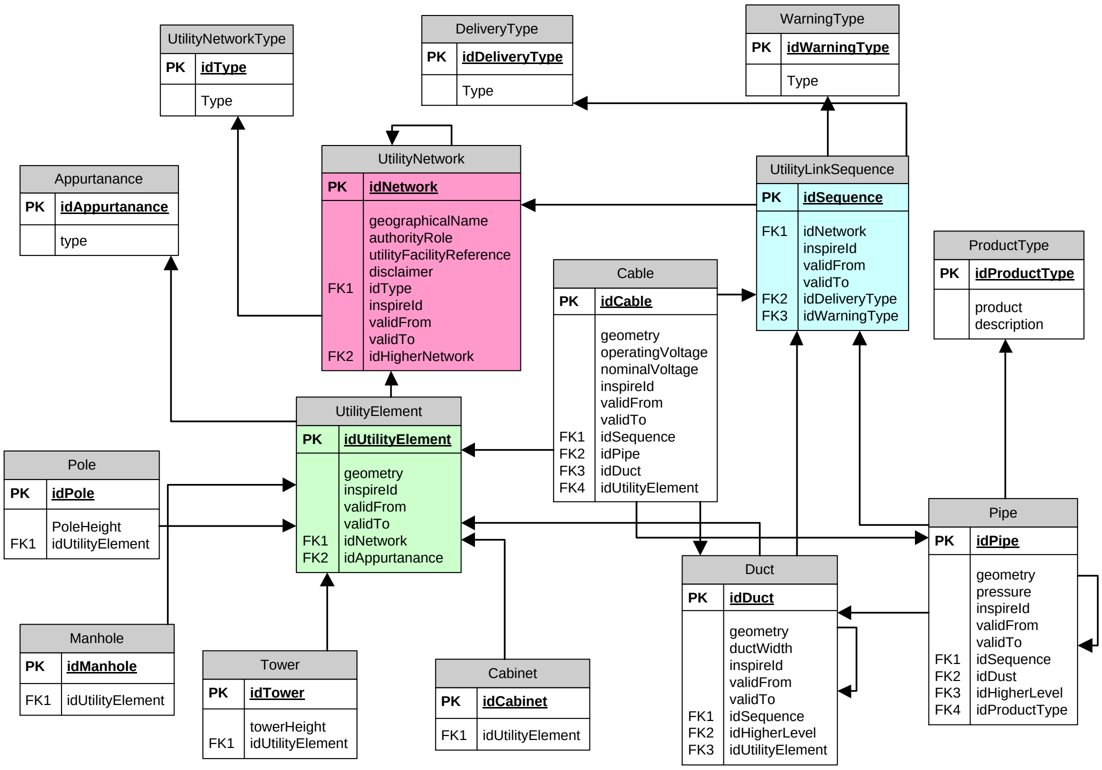

Figure 10 – Utility networks database scheme

The general schema is similar to that of the Transport Network data specifications, with the network represented as sequence of links. The main entity is UtilityNetwork, which provides the main information on the network typology and its management.

The other two more relevant entities are UtilityLinkSequence, which is linked to the geographical linear objects that compose the grid, and the UtilityElement, which is used to describe primary and secondary substations in the networks, which also provide an interface between two different electricity networks. Single lines are described in the Cable entity, with information related to nominal and operating voltage values. In order to provide a more comprehensive description of an electricity network, other parameters could have been added (including ampacity, cable material, the presence of overhead or underground cabling, etc.). However, these parameters were not considered during the implementation, as such information was not relevant to the initial scope of the cross-border database but these will be added in a future release.

Beyond electricity grids, this schema is also used to describe other utility networks, including gas pipelines and sewer systems. For these other utility networks, dedicated entities like PIPE and DUCT were defined and the UTILITYELEMENT is also used to describe elements such as manholes or pumping stations.

4.2.4 Major natural events

An important section of the database is dedicated to the collection of previous natural events that happened in the cross-border territory under analysis. Figure 11 shows the entity-relationship diagram for these objects.

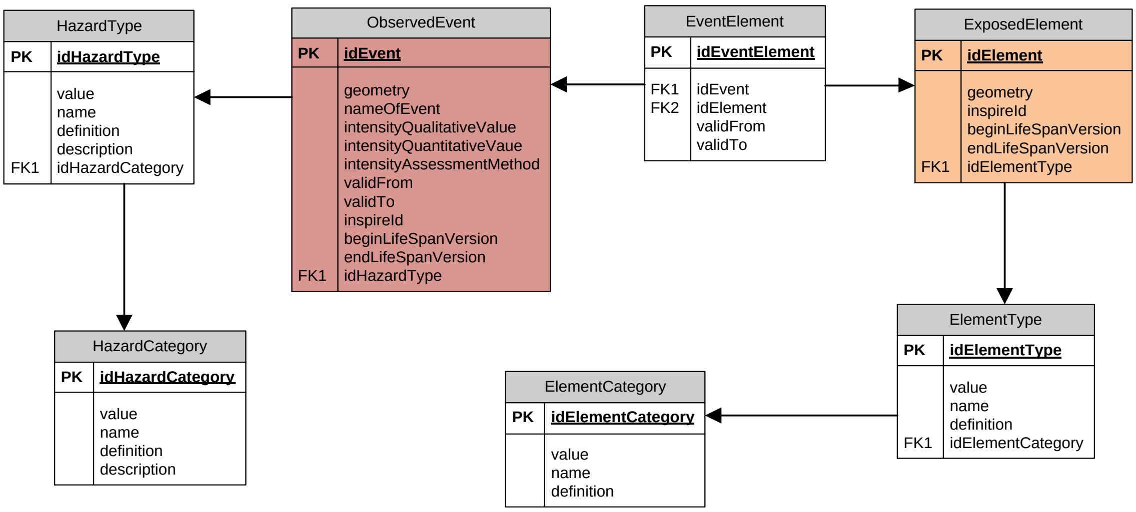

Figure 11 – Database section on events.

The main entity in this section is the table OBSERVEDEVENT which contains all the events that have occurred in the past accordingly to the data collection process. One of the main parameters is represented by the GEOMETRY, in order to provide a geographical reference. This attribute is usually a polyline, as it aims at describing the area where the event occurred. If only the city name is the only information about where the event occurred, the value of the geometry attribute is defined as the whole area of the city hit by the event, with reference to the administrative layer geometry. Other relevant attributes are represented by the field INTESITYQUANTITATIVEVALUE and INTENSITYQUALITATIVEVALUE, which contain an evaluation of the gravity of the event, either quantitatively or qualitatively. The attribute INTENSITYASSESSMENTMETHOD provides information on how the intensity values are evaluated. The remaining attributes in the entity provide temporal information about the occurrence of the event.

Another important entity in this schema is the EXPOSEDELEMENT table that contains information on the elements that were exposed to past events or that could be at risk in the case of a new event. The possible exposed elements are identified through proper risk and assessment methodologies. There are two more entities in the schema that are responsible for the classification of element and hazard categories. In chapter 5.3, a description on how the categories were defined is provided.

4.2.5 Administrative layer

In order to provide a common reference between infrastructures and events, a specific section of the database is dedicated to describe the administrative units. The entity-relationship schema is represented in Figure 12.

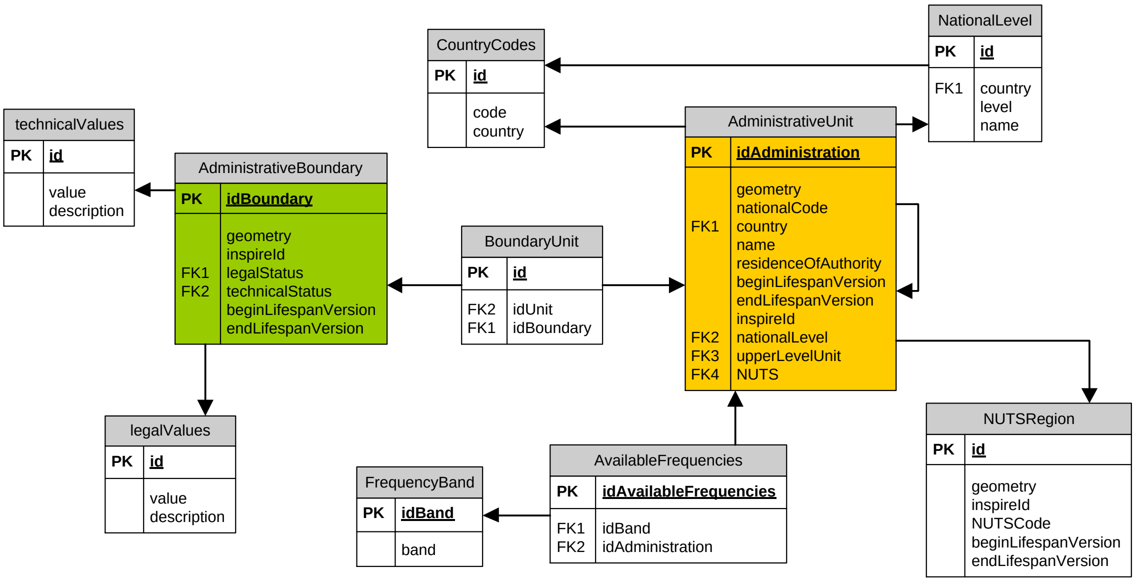

Figure 12 – Administrative Unit scheme

The main entity is the ADMINISTRATIVEUNIT table which describes all the administrative layers that can be found in a territorial context (countries, provinces, cities, etc.). It provides also information regarding the NUTS Region related to that unit. The Nomenclature of Territorial Units for Statistics (NUTS) is a geocode standard defined by Eurostat to have a consistent means to reference administrative areas for statistical purposes across the EU. In INSPIRE the RESIDENCEOFAUTHORITY is defined as an external object. In this implementation, however, it was defined as a simple attribute of the entity since, in this specific application context, no more information was needed.

The other relevant entity is the management of information on boundaries between units. Boundaries are defined as a single record for each couple of neighbouring countries (or at respective hierarchical levels). With this approach, the full boundaries of a single unit are defined as the union of different segments, adding some complexity to the whole data management process. Boundaries data are recorded in the ADMINISTRATIVEBOUNDARY entity.

In the INSPIRE Specification for Administartive Units no items of information for the radio frequency bands were specified, this needed information on the radio frequency bands have to be added to the database. For this purpose, the table FREQUENCYBAND was introduced. As each administrative unit can have more bands available, a multi-multi relationship between the ADMINISTRATIVEBOUNDARY and the FREQUENCYBAND entities was defined.

4.2.6 Information Redundancy

The cross-border database was designed taking into account the specific requirements of a proper risk management methodology, trying to include all the relevant parameters to define such an approach. On the other hand, the database was built in order to be as much compliant as possible with the INSPIRE Data Specifications. However, INSPIRE Data Specifications were defined in a generic framework, to be applied in a wide range of application contexts. For this reason, some objects or attributes defined by INSPIRE were redundant in the context of our cross-border database. In the transport section, for example, the description of a road is very detailed requiring data on speed limits for each vehicle category, presence of marker posts along the road and so on. These elements were included in the data base structure, but they weren't filled as data were not available. In other cases, a simplification were introduced, in particular when INSPIRE define a reference to other objects, not included in the Specifications considered for the cross-border database. A simple text field was defined to fill the information without adding too much complexity on the whole structure.

The first section of the database is represented by the transport network. INSPIRE Data Specifications provide a highly detailed description. Basically, in case of an event, Civil Protection Authorities need to know if a road is damaged (and consequently which possible effects descend from the closure of the road) and which is the best path to have a quick intervention. Thus, the most important information required is the geographical one. Furthermore, data on the authority managing the infrastructure and the possible presence of obstacles hindering the passage of emergency vehicles are fundamental. Following this approach, information on speed limits for each single road link and on the existing service areas can be redundant or unnecessary.

As already stated, energy production centres are considered as industrial sites. Even if this characterization is suitable for big power plants, it can be too detailed when dealing with photovoltaic panels or wind turbines. Also for mini and micro hydro power plants the full description provided by the INSPIRE Data Specifications can be redundant. At first sight, these small and medium size plants (they are able to provide less than 1 MW of peak power) could not be considered relevant at national and international level. However, the diffusion of renewable energy sources plants is moving the electricity generation paradigm to a distributed one, and each installation, even if it is medium sized, assumes a great relevance and it is necessary to understand how these plants can be damaged in case of an event. To fully describe these plants and possible consequences coming from their damage or disruption, it is important to know their positions, their technical characteristics (orientation, technology, etc.), their generation capacity (both in terms of power and energy) and how they are connected to the grid. Thus, for the purposes of our cross-border database, a more simplified structure would have been sufficient.

With regard to the remaining cross-border database sections (Natural Events and Administrative Units), the structures described by the INSPIRE Data Specifications provides all the necessary information without including data that may be redundant in the analysis. This is particularly true for the Natural Event section. Also the administrative units are well described without any redundant information.

4.3 Data Transfer Model

The model used to develop the cross-border database involves the use of all the software presented in paragraph 3.1. As previously stated, the combined use of these three software packages granted a series synergies during the realization of the cross-border database, including the possibility to develop a complete and operative GIS environment able to harmonize and organize data according to INSPIRE's schemas. In particular, the software provides the possibility to enable a multi-user filling procedure (users can fill database tables on their own and integrate them afterwards, just by sharing their work on the Spatialite platform).

As previously mentioned, the core of the GIS is the PostgreSQL database. SpatiaLite GUI and Quantum GIS were mainly used to harmonize data originating from different data sources and to perform spatial screening as: data visualization, coordinate transformation or spatial selection of a subset of the data before filling the cross-border database (Figure 13).

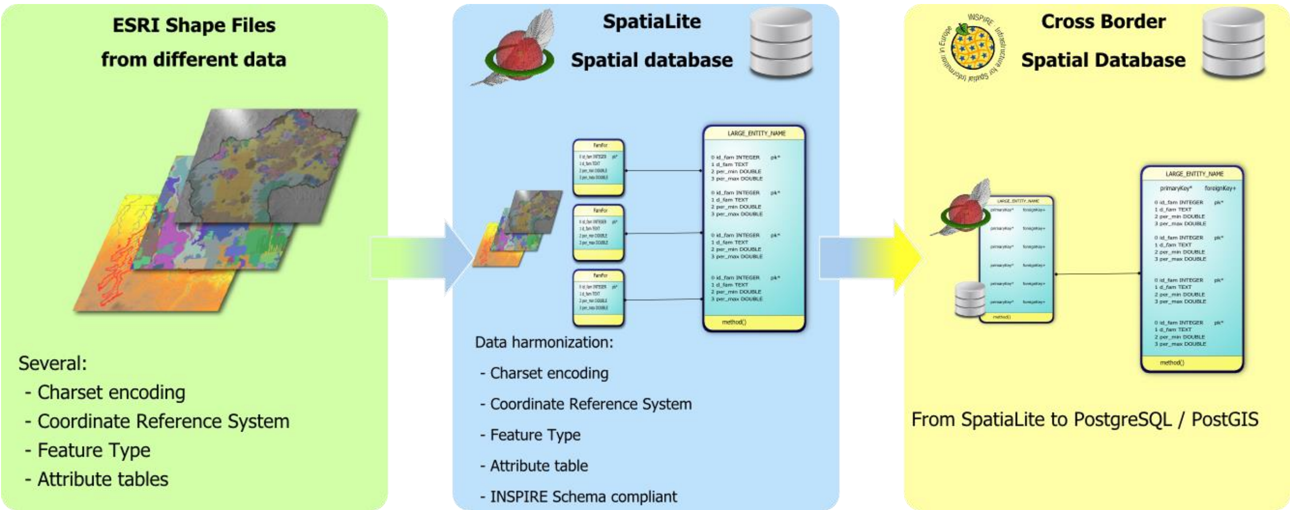

Figure 13 – Data transfer model schema

In more details, the SpatiaLite GUI was used to harmonize vector files derived from the data sources and to match them with the INSPIRE schemas. The tool enables the possibility to:

- identify and harmonize the same charset-encoding (UTF-8, CP1252, CP850 etc.) derived from the different shape-files, in order to correct the errata font visualization. For this operation, the UTF-8 encoding was chosen because it was recognized as the most adequate for the cross-border database's main purposes (such as offering a replicable approach);
- transform data in the same Coordinate Reference System and map projections. WGS 84 / UTM zone 32N (EPSG:32632) was chosen for this operation because it covers all the French/Italian cross-border territory, as shown in *http://spatialreference.org/ref/epsg/32632/*;
- define and to convert data into the same geometry types;
- organize attributes to be compliant with INSPIRE UML models: this operation was performed using an SQL function to optimize time efforts;

- dump Spatialite database into the PostgreSQL schema, allowing data to be transferred between software interfaces.

One of the most relevant challenges while building the cross-border database was the inclusion of a series of infrastructures that did not have any geo-referenced data. In order to solve this issue, a Quantum GIS plugin called "GeoCoding" was used, allowing data to be simply geo-referenced, starting from an address or postcode. This plugin supports data geocoding and reverse geocoding using Nominatium (a tool used to search OpenStreetMap's data by name and address) and Google web services.

4.4 Usability and Feasibility

The design process of the cross-border database according to the INSPIRE Data specifications took complex conceptual and technical procedures for implementation.

First of all, it was necessary to correctly identify the right Data Specifications for all the sections required by the database. Transport networks, utility grids, administrative units and natural events have a dedicated Data Specifications, so it was quite simple to identify the sections describing those objects. Identify the Energy production sites was a different matter. Inside INSPIRE power plants are described as a specific instance of an industrial production site This approach can be valid for traditional power plants, but it can be too detailed for power plants based on renewable sources, such as photovoltaic panels or wind turbines, which require a much simpler structure without division into buildings, installations and installation parts.

After the identification of the INSPIRE Data Specifications to be used, the actual objects for each database section were selected. The main issues arose for the transport infrastructures. The related Data Specification introduces a quite complex structure to describe road networks[8] with several objects connected to each other. This makes it quite difficult to readily identify the connections between the different objects, in order to implement the same structure in the database. In addition, this high detail level increases the difficulty of completing the database, since the identification of each single road and the data collection of all its properties represents a relatively time consuming process (not all original data sets were always immediately available).

Moreover, the addition of practical examples on how to manage the various objects of a road transport network could be very useful to better understand the whole structure. For example, INSPIRE Data Specifications on natural events are very well described making them easy to understand due to the examples and diagrams provided in the document. Adopting a similar approach for transport networks and other related themes could greatly improve the usability of INSPIRE Specifications.

Another issue related to the usability of INSPIRE Data Specifications is the management of boundaries between different administrative units. The approach followed is not intuitive, with the risk of generating confusion to the people that have to deal with data. The design and implementation of automatic tools able to adapt data to the correct format could be particularly useful.

[8] Also the other transport networks presented a similar structure to roads, with a similar degree of complexity, thus the issues for road networks are applied to the other networks.

For the prototypical implementation of the cross-border database no conformance testing was performed and no feedback on an actual testing experience was gathered. Any testing procedure should take into account that users start from not being familiars with the mechanics of INSPIRE: a user-friendly interface based on a wizard approach, and features like a customizable library/glossary or an interactive embedded communication tool, together with an helpdesk to be consulted in case of questions/doubts/troubles, could relevantly contribute to increased INSPIRE data model adoption at EU level.

5 Data collection procedure

5.1 Background to data collection

The first step to evaluate the vulnerability of a territory is to understand its geospatial features. It is extremely important to have a clear and precise idea of which kinds of infrastructures are situated in the analysed context, and where they are located according to a geo-referenced system. In order not to disperse research efforts, criteria must be defined to classify infrastructures and critical events according to a shared viewpoint between cross-border countries.

Natural disasters usually have social and economic impacts on a territory, damaging critical infrastructures such as power plants or transport networks and interrupting/altering primary services for citizens. This is even more problematic in a cross-border context, where emergency intervention and response procedures are managed by different countries with different regulations and emergency protocols. In order to enhance preparedness and response to such situations that mitigate potential consequences, emergency management procedures and protocols must be harmonized at the European Level, granting Member States the possibility to co-operate synergy strictly to maximize response effectiveness and optimize the resources engaged.

Information is key to successful co-operation in civil protection matters. A proper distribution of information is needed during emergencies. Without information-sharing the whole co-operation structure would simply collapse. Community co-operation also calls for the rapid mobilisation of intervention teams, experts and other resources on request in the event of major emergencies in order to alleviate the effects of a disaster during the first days.

These processes can be strongly supported by developing shared geodatabases between different countries, but in order to properly develop them a “common language” is required to foster the development and usage of common maps. For example, hazard maps are the basic tools to assess impacts, and each European country uses its own maps with different protocols and procedures. These differences can significantly reduce the capability to address emergency situations and to diffuse experiences/knowledge/best practices in the field of Civil Protection across Europe.

This is why harmonised methods, terminologies and a description for producing hazard maps are needed. Thus if maps from different regions are synchronised, the risk become easier to compare, creating a solid foundation for reliable support of decisions maker.

The development of a spatial data infrastructure under the INSPIRE initiative could resolve problems related to data availability and access of spatial information, but also it may to reduce mistakes deriving from different vocabularies or impact assessment procedures across borders.

5.2 Data Sources

5.2.1 Data Sources Classification

Different data sources have been used to collect data: official data catalogues, research project results, company web sites, interviews and the mass media, etc.

All the consulted data sources have been classified with criteria that are shared by both the French and Italian Civil Protection Authorities (*Protezione Civile Piemonte* and *Service Départemental et de Secours des Alpes de Haute-Provence*). Four categories of data sources were identified:

- **Institutional sources**: this category includes data derived from institutional catalogues and used by the institutional entities to build laws, regulations, directives, etc.
- **Scientific sources**: this category includes data derived from research projects, university studies, pilot cases, best practices, etc.
- **Private sources:** this category includes different case studies contained in data owned by utilities for (private) energy production and its distribution, transportation, etc. (collected mainly through websites or interviews).
- **Mass Media:** this category includes data derived from Internet sources, newspapers, television, etc.

All data provided by local utilities and institutions in the Piedmont Region, in particular were vectors. The only raster data we got in contact were orthophotos related to regional WMS services which were used as background maps. In the following paragraph a detailed description to data sources used for each different data model is reported.

5.2.2 Data Sources relationships with Data Models

Natural hazards data have been obtained from *Regione Piemonte* following direct requests to the Regional Civil Protection Department. The data are currently directly downloadable by geoportal services developed by *Regione Piedmonte* and the *Arpa Piemonte* (the regional environmental agency), leading to the following official data sources:

- GeoPortale Piemonte - *http://www.geoportale.piemonte.it/*
- GeoPortale Arpa Piemonte - *http://webgis.arpa.piemonte.it/*
- Open Data Piemonte - *http://www.dati.piemonte.it/*
- *Repertorio Cartografico Tematico della Regione Piemonte* (the Thematic Cartographic Repository for *Regione Piemonte*) - *http://www.regione.piemonte.it/repcarj/welcome.do?ric=1*

Data collected for natural hazards are in ESRI shapefile format are licensed under the Creative Commons – Attribution 2.5 Italia license, and include:

- Arpa Piemonte - SIFraP - *Sistema Informativo Frane in Piemonte* (The Information System for Landslides in Piemonte),
- Arpa Piemonte - *Evento alluvionale 13-16 ottobre 2000 - Fiume Po* (River flooding event of the 13-16 October 2000 on the River Po),

- Arpa Piemonte - *Evento alluvionale 23-25 settembre 1993 Torrente Orco - tratto superiore* (River flooding event of the 23-25 September 1993 on the upper River Orco),
- Arpa Piemonte - *Evento alluvionale 23-25 settembre 1993 Torrente Orco - tratto inferiore* (River flooding event of the 23-25 September 1993 on the lower River Orco),
- Arpa Piemonte - *Sismicità in Piemonte - Classificazione sismica su base comunale* (Seismic activity in Piemonte based on the municipalities' seismic classification),
- Regione Piemonte - *Incendi boschivi - aree percorse dal fuoco* (Forest fire affected areas);
- *Sistema Informativo Valanghe in Piemonte* (SIVA) (The Piemonte avalanche information system);
- *Provincia di Cuneo - Sistema Informativo sulle Valanghe* (The Province of Cuneo's avalanche information system).

Data concerning **energy production sites** have been obtained by consulting private utilities' websites, as there is not an official data source for this kind of information. The following information was collected: power plant type, fuel typology, prime mover/turbine typologies and number, and power output, as well as the postcodes/addresses for geocoding.

The principal data sources used were:

- *Gestore dei Servizi Energetici* (GSE) web site[9]: Italian company involved in the distribution and trading of electricity. In particular, the document "*Bolettino Impianti qualificati (II semestre 2011)*" (The 2011 second semester Qualified Plant Bulletin) which contains a list of all the national Renewable Energy Sources (RES) power plants authorized at a particular point in time;
- *EDF – energies nouvelles* (Energy news) web site[10]: French company involved in the distribution and trading of electricity, which contains a list of all the currently operational national RES power plants;
- *Provincia di Torino* energy sector web site[11], where there is a list of all the authorized RES power plants;
- Other electric power companies' web sites[12], where power plants are described.

5.3 The cross-border glossary

---

[9] *http://www.gse.it/it/Qualifiche%20e%20certificati/Qualificazione%20impianti/Il%20bollettino%20informativo%20sull%20energia%20da%20fonti%20rinnovabili/Pagine/default.aspx*

[10] *http://www.edf-en.fr/nos-realisations/*

[11] *http://www.provincia.torino.gov.it/ambiente/energia/fonti_rinnovabili/impianti_387-2003*

[12] *http://it.solarig.com/instalaciones_minus_2mw/*

[12] *http://www.enelgreenpower.com/it-IT/plants/map/*

[12] *http://energie.edf.com/hydraulique/hydraulique/accueil-47693.html*

[12] *http://www.bdpv.fr/carte_installation.php*

One of the most relevant issues at the earlier design stages of the cross-border database was that Italy and France have their own classifications for *major natural events* and for *energy production sites*. The need to have a shared data framework between France and Italy required the realization of an Franco-Italian glossary which allowed natural hazards and energy-related infrastructures to be classified into a cross-border data framework. This was the first step towards the realization of matching tables to combine data coming from different sources to INSPIRE's schema.

5.3.1 Major natural events glossary

The Major Natural Event typology includes:

- hydrogeological hazards (shallow landslides, translational slides, rotational slides, landslides, complex movement, , debris flows, mud flows, floods, falls and/or topples and snow avalanches);
- seismic activity;
- extreme meteorological phenomena (extreme temperatures, extreme snow conditions, drought, lightning);
- forest fires.

Italian and French natural hazard classifications are notably different. For example, landslides classification criteria involve different discriminating factors, including the causes of landslides, movement types, morphology and the materials involved, and the two countries apply these factors in different ways in their classifications.

For this reason, a two-step process was performed in order to match the national classifications with the one defined by INSPIRE. The first step was the development of a shared glossary to match Italian and French classifications, starting from "*Progetto Damage - Développement d'Actions pour le MArketing et la GEstion post-événements*" (The Development of Actions for 'post-event' Marketing and Management), a document made by the Italian Civil Protection Department within the Interreg III B Medocc Programme.

The shared glossary grouped landslides into four categories:

- DEPLETION. The volume bounded by the main scarp, the depleted mass and the original ground surface.
- FLOW. Flows are rapid movements of material as a viscous mass where inter-granular movements predominate over shear surface movements. These can be debris flows, mudflows, or rock avalanches, depending upon the nature of the material involved in the movement.
- FALLS AND/OR TOPPLES. Falls are abrupt movements of slope material that separate from steep slopes or cliffs. Most of the movements occur due to free falls or by rolling or bouncing.
- LANDSLIDE. All the movement of a mass of rock, earth or debris down a slope, which are not included in other definition.

The final classification is:

- Hydrogeological risk
  - Snow avalanches

  - Depletion
  - Flow (debris flow - mud flow)
  - Falls and/or topples
  - Landslides
  - Flood
- Seismicity
  - Seismic zone classification
- Meteorology
  - Extreme weather conditions
  - Drought
  - Lightning

This glossary was used during the risk analysis to harmonize French and Italian data.

Then, the second step was the association with the INSPIRE hazard types and categories classification, as showing in Table 2.

INSPIRE		Cross -border database			
Hazard type	**Hazard category**	**Hazard type**	**Hazard category**	**French corre-sponding Categories**	**Italian corre-sponding Cate-gories**
ForestFireWildFire	fires	Forest Fire	Forest Fire	Feux de forêts	Incendio boschivo Incendi di interfaccia urbano-rurale
earthquake	geologicalHydrological	Earthquake	Seismicity	Séisme Tremblements de terre	Terremoto
subsidenceAndCollapse	geologicalHydrological	Depletion	Hydrogeological risk	Erosion Subsidence	Bradisismo di pendii Subsidenze sprofondamento della costa erosione
landslide	geologicalHydrological	Flow	Hydrogeological risk	Coulée de boue Crues torren-	Colamenti lenti Colate rapide di

INSPIRE		Cross -border database			
Hazard type	**Hazard category**	**Hazard type**	**Hazard category**	**French corresponding Categories**	**Italian corresponding Categories**
				tielles	detriti e fango
		Falls and/or topples	Hydrogeological risk	effondrements et affaissements Eboulement chutes de pierres et de blocs	Crollo Ribaltamenti
		Landslide	Hydrogeological risk	Glissement de terrain mouvements de terrain différentiels consécutifs à la sécheresse et à la réhydratation des sols	Scivolamenti rotazionali Scivolamenti traslativi Espansioni laterali
snowAvalanche	geologicalHydrological	Avalanche	Hydrogeological risk	Avalanche	Valanghe
flood	geologicalHydrological	Flood	Hydrogeological risk	inondations de plaine inondations par crues torrentielles	Alluvione
otherGeologicalHydrological	geologicalHydrological			inondations par ruissellement en secteur urbain Inondations consécutives aux remontées des nappes phréatiques	Processi torrentizi sulla rete idrografica minore e sui conoidi
otherMeteorologicalCli-	meteorologicalClima-			Phénomènes météorolo-	Eventi metereologici

INSPIRE		Cross -border database			
Hazard type	**Hazard category**	**Hazard type**	**Hazard category**	**French corre-sponding Categories**	**Italian corre-sponding Cate-gories**
matological	tological			gique (Neige, grêle, vent, gelée)	(Neve, grandine, vento, gelate)
lightning	meteorologicalClima-tological	Lightning	Meteorology	Orages	Tempesta di fulmini
tornadoesAndHurri-canesStrongWinds	meteorologicalClima-tological	Extreme weather conditions	Meteorology	Rafale ouragan	Tornado Uragano
extremeTemperature	meteorologicalClima-tological		Meteorology	températures extrêmes	Temeperature estreme
drought	meteorologicalClima-tological	Drought	Meteorology	sécheresse	Siccità

Table 2 – INSPIRE and cross-border database hazard type and categories matching tables.

5.3.2 Energy production sites glossary

The Energy production sites' typology includes both Renewable Energy Sources (RES) and traditional energy power plants. The final classification consists of two categories that are subdivided in nine types by fuel:

- Renewable Energy power plants
  - hydroelectric plants,
  - wind energy plants,
  - photovoltaic plants,
  - bio-energy plants,
  - geo-thermic plants,
- Traditional thermoelectric power plants
  - gas plants,
  - oil plants,
  - coal plants,
  - nuclear plants.

For the power plants classification, Italian and French conventional classifications were the same so no specific glossary was built. In the INSPIRE schema described in document *(D2.8.III.8 Data Specification on Production and Industrial Facilities – Draft Guidelines)* there is not a power plants classification that's based on fuels' use. Since this information was relevant for the purposes of the cross-border database, a new data field was added.

5.4 Matching table

5.4.1 Hazards matching table

Hazards data come from different data sources (see 5.2 Data Sources) and are organized in many shape-files. Each shapefile is related to different hazard categories and gives different information. It was not possible to organize them in an unique table compliant with INSPIRE schema.

Instead, for each hazard category the related attribute table was defined, and SQL queries to redistribute data inside INSPIRE tables were developed.

The hazard categories investigated are four, and are related to different data sources:

1. **Earthquake** (source: Municipalities seismic classification)
2. **Landslide** (source: Regional landslide inventories).
3. **Snow Avalanche** (source: Regional avalanches inventories)
4. **Flood** (source: integration of different shape-files coming from Regional geo-portals)
5. **Forest Fire** (source: Regional wild fire inventories)

The matching tables between each hazard category and the corresponding INSPIRE schema are reported in the Annex C.

5.4.2 Energy Production sites matching table

The matching table for the power plants classification was developed using different shapefiles that were collected into a Spatialite database and reorganized in a unique table named “centrElettiriche” (that stands for “electric power plants”**Error! Reference source not found.**). This allow the data reorganization to be simplified into the INSPIRE schema proposed in the document “D2.8.III.8 Data Specification on Production and Industrial Facilities – Draft Guidelines”.

The tables are described in the Annex C. They have been introduced with the objective of increasing the information related to the power plants stored in the cross-border database, as described in Section 4.2.

6 Cost Benefit/Analysis Estimation

The creation of the cross-border database was structured into the following phases:

- **Phase 1**: Analysis of previous efforts (research projects, best practices, etc.) to create shared datasets within Italian-French context.
- **Phase 2**: Definition of a common Glossary between Italy and France for strategic infrastructures and major events
- **Phase 3**: Analysis and classification of local and national available data sources
- **Phase 4**: Analysis of INSPIRE data Models and Data Specifications
- **Phase 5**: Database design
- **Phase 6**: Database validation with local French and Italian Civil Protection Authorities
- **Phase 7**: Database implementation
- **Phase 8**: Data collection and database filling
- **Phase 9**: Results diffusion and stakeholder sensitization about INSPIRE Directive

Each phase requires a specific working time effort in terms of multi-disciplinary teams and economic resources (e. g. travels costs). These efforts have been detailed in the following paragraphs.

1) **Phase 1: Analysis of previous efforts (research projects, best practices, etc.) to create shared datasets within Italian-French context.**

Activity Description: literature analysis to map previous effort to create shared datasets within Italian-French context.

Activity Type: Identifying and collecting relevant input data sets

Proportion of total workload: 5 percent

Benefits: Best Practice Benchmarking

2) **Phase 2: Definition of a common Glossary between Italy and France concerning strategic infrastructures and major events**

Activity Description: a series of meetings with Italian and French Civil Protection Authorities to define a common Glossary between Italy and France for strategic infrastructures and major events

Activity Type: Identifying and collecting relevant input data sets

Proportion of total workload: 5 percent

Benefits: Cross-border Glossary definition

3) **Phase 3: Analysis and classification of local and national available data sources**

Activity Description: a series of interaction with local stakeholders to build a map of available data sources, classifying them into four categories: Institutional Sources, Scientific Sources, Private Sources and Media Sources.

Activity Type: Identifying and collecting relevant input data sets

Proportion of total workload: 15 percent

Benefits: map of available data sources on cross-border region between France and Italy

4) **Phase 4: Analysis of Inspire data Model**

Activity Description: literature analysis of inspire data model.

Activity Type: Training / Studying the Data Specifications

Proportion of total workload: 10 percent

Benefits: Knowledge gain on INSPIRE Data Model

5) Phase 5: Database design

Activity Description: database structure design including tables, fields, relationships, geo-referenced layout, etc.

Activity Type: Creating the mapping rules

Proportion of total workload: 5 percent

Benefits: Database structure prototype

6) Phase 6: Database structure validation with local French and Italian Civil Protection Authorities

Activity Description: four meetings with Italian and French Civil Protection Authorities to share, refine and validate the cross-border database structure
Activity Type: Validating the results
Proportion of total workload: 5 percent
Benefits: Database structure final release

7) Phase 7: Database implementation
Activity Description: creation of the cross-border database and all its components (ICT and SW development competences)
Activity Type: Setting up the infrastructure
Proportion of total workload: 15 percent
Benefits: database framework

8) Phase 8: Data collection and database filling
Activity Description: Data collection on strategic infrastructures and major natural events and integration within the cross-border database
Activity Type: Setting up the infrastructure
Proportion of total workload: 25 percent
Benefits: database with data filled

9) Phase 9: Results diffusion and stakeholder sensitization about INSPIRE Directive
Activity Description: The activity includes:
a) two meetings with Italian and French Civil Protection Authorities to show the project results, including the cross-border database
b) one final conference in which the INSPIRE based cross-border database was presented
c) the creation of dissemination products presenting the cross-border database together with other results: a press publication, brochures, etc.
Activity Type: Documenting the results
Proportion of total workload: 10 percent
Benefits: Dissemination products

A further effort of 5 percent was spent on management (meetings organization, activities coordination, etc.). The overall workload is represented below (See Figure 1).

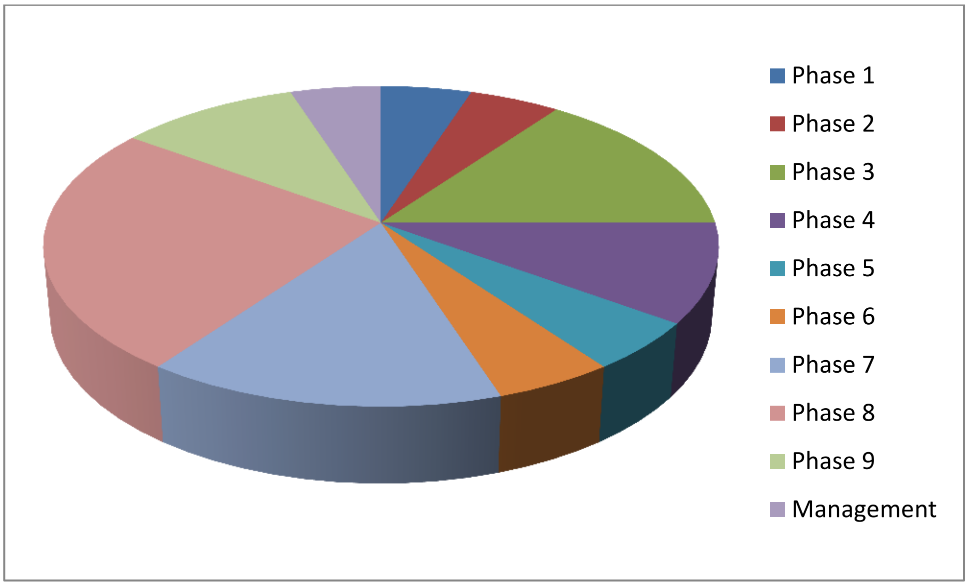

Figure 1: Overview of total workload proportion

7 Conclusions and suggestions for potential INSPIRE upgrades

The INSPIRE application case study has tested the potential of INSPIRE data models to fit end-users need in a cross-border context.

In conclusion, INSPIRE data model had a good usability for the realization of the cross-border database of strategic infrastructures between Italy and France. Clearly, some improvements and adjustments were needed to make it fit the application's context specific requirements, in particular those concerning the granularity (e.g. scale level) of data fields.

It is worth to highlight that INSPIRE data models were tested only within the cross-border area within Italy and France, and only for certain typologies of data, so the results are not representative of a European Scenario. Other case studies of data model application in cross-border contexts will be needed to gain a wide-spectrum view. An interesting application case could be, for example, any other cross-border areas involving Italy or France (such as the Italian-Slovenian one), to make comparisons with the present study and see how the INSPIRE feasibility can change by switching one of the border countries involved.

Even if related mainly to a specific sub-set of INSPIRE data models, the work done highlighted strengths and weaknesses.

In particular, some possible upgrades to INSPIRE data models were spotted, and divided into three categories: potential upgrades on Data Specification, developments for the INSPIRE Registry and potential synergies with ARe3NA.

1) Potential upgrades related to INSPIRE Data Specification

INSPIRE data models do not give any information to differentiate geographic scale depending on which spatial object is taken into account. This may represent an issue when building a database that aims to integrate data related to different typologies of infrastructures that come from different data sources. For example, for power plants, INSPIRE suggests the use of the geo-referenced buildings geometry: this approach is often not coherent with geographic data scales used by local bodies and institutions. The same problem applies to the Natural Risk field, where several scales are used by data owners to describe landslides and other major critical events. The impossibility of differentiating data scale within the same dataset can lead to errors during spatial analysis or data overlapping processes. A possible solution can be to develop different tables for different data scales, or to integrate inside INSPIRE data models a "field" reporting data scale information.

Another issue worth to highlighting is that not all the attributes expected by the INSPIRE Application schema for "natural hazards" were filled, because input data sets did not have all the information requested by INSPIRE Application schemas. Power plants, some of the relevant spatial objects in the input data sets (and/or their attributes/relationships) could not be transformed into a corresponding structure of the proposed INSPIRE schema. To solve this issue, new tables were added into Production and Industrial Facilities theme.

Furthermore, the application of the INSPIRE category to describe energy objects for the Italian-French cross-border area highlighted that some upgrade is required. Energy generation infrastructures are described as production facilities, which are optimal to describe big generation plants, such as power stations burning fossil fuels or hydro power plants.

However, in the last few years, the European policies regarding the use of renewable sources promoted the diffusion of smaller plants based on photovoltaic panels, small wind turbines or mini and micro hydroelectric turbines. For these kinds of plants, the description provided by INSPIRE specifications can be over detailed, with the risk of losing the most important information about them.

The definition of a specific category related to energy infrastructures can be a valuable upgrade to current INSPIRE Specifications. This updated category can also better represent the relationships between the generation objects and all other elements that are beginning to be part of complex energy systems, like energy storage devices. Furthermore, a possible link can be created to identify if the plant has been built according to some incentive scheme or not and to understand how the produced energy is sold to the grid or if it is self-consumed.

2) Potential upgrades related to INSPIRE Registry

The "Natural Hazard Category" register requires a description of a generic classification of types of natural hazards. This registry could be integrated by further developing "landslide label". Indeed, to better understand possible impacts deriving from landslides in risk evaluation, it is important to recognize landslide types, because each hazard type has particular characteristics in different circumstances.

The category landslide could be divided in subcategories, such as:

- DEPLETION. The volume bounded by the main scarp, the depleted mass and the original ground surface.

- FLOW. Flows are rapid movements of material as a viscous mass where inter-granular movements predominate over shear surface movements. These can be debris flows, mudflows, or rock avalanches, depending upon the nature of the material involved in the movement.
- FALLS AND/OR TOPPLES. Falls are abrupt movements of slope material that separate from steep slopes or cliffs. Most of the movements occur due to free falls or by rolling or bouncing.
- LANDSLIDE. All the movement of a mass of rock, earth or debris down a slope, which are not included in other definition.

This is clearly only one of many possibilities, since there are many national and international landslide classification systems based on different criteria: type of movement (falls, slides, flows, topples, complex movements etc.); involved material (rock, debris and mud), movement velocity and activity.

3) Potential Synergies with ARE3NA

The experience gained in the implementation of the cross-border can represent a valuable case study to be included in ARE3NA.

The creation of the cross-border database identified several issues whose analysis could lead to improve the adoption of INSPIRE Directive.

First, during the cross-border database design process the analysis of the existing databases showed that the structures used in Italy and in France are very different between each other, limiting the possibility to share information between the two countries. The applied approach was based on the definition of a structure on INSPIRE Data Specifications and the use of manual procedures to adapt the existing data on the new structure (please see paragraph 4 “Database design and INSPIRE data model application processes”). This structure and related filling procedures represent an important added value to be shared with ISA community, not only because is one of the first concrete effort to tune INSPIRE a real cross-border application context, but also because it was planned in collaboration with Italian and French Institutions (in particular Civil Protection Authorities) so it already embraces, among others, policy-makers and responsible administration

Secondly, the data collection process highlighted a discrepancy between the natural events categories of France and Italy, and also with regards to INSPIRE Data Specification. A new harmonized category list was defined and implemented in order to meet the specific requirements of the *risk management* application context. This new list could be shared on the platform to help other possible implementations in similar application contexts (i.e. related with risk analysis, alert procedures, intervention and rescue procedures, etc.)

Finally, the framework has shown a need for a more detailed definition of the energy generation infrastructures, in particular concerning renewable sources power plants (e.g. photovoltaic panels and mini- or micro-hydroelectric turbines) that are assuming a more and more relevant role in the current energy market.

8 Summary and next steps

The description of the INSPIRE technical issues met during the cross-border database realization, and related improvement proposals is reported in the ANNEX F.

Following the realization of the present report, SITI will investigate other contexts in which INSPIRE team may need data collection, feedbacks, information exchange, feasibility studies and other kinds of "operational" activities, and will support JRC in performing these activities under the framework of new specific commitments.

A first set of possible activities could be:

- The integration of INSPIRE Data Specifications with Smart Cities & Smart grids related elements. (SITI is also member of the Smart Cities and Communities European Platform, Sherpa Group).
- The activation of further national and/or trans-boundary case studies for INSPIRE application, to gather further feedbacks at European level for Inspire Maintenance and Implementation.
- The investigation of potential synergies between INSPIRE team and the existing collaboration between SITI and SDIS 04 (French Civil Protection).

9 Bibliography

[DS-D2.3] INSPIRE DS-D2.3, Definition of Annex Themes and Scope, v3.0, http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.3_Definition_of_Annex_Themes_and_scope_v3.0.pdf

[DS-D2.5] INSPIRE DS-D2.5, Generic Conceptual Model, v3.4rc2, *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/D2.5_v3.4rc2.pdf*

[DS-D2.6] INSPIRE DS-D2.6, Methodology for the development of data specifications, v3.0, http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.6_v3.0.pdf

[DS-D2.7] INSPIRE DS-D2.7, Guidelines for the encoding of spatial data, v3.3rc2, *http://inspire.jrc.ec.europa.eu/documents/Data_Specifications/D2.7_v3.3rc2.pdf*

[DS-D2.8.I.3] INSPIRE DS-D2.8.I.3, INSPIRE data specification on Geographical names – Guidelines, v3.0

10 Abbreviations

EC	European Commission
EFTA	European Free Trade Association
EU	European Union
GIS	Geographical Information System
GUI	Graphical User Interface
ICT	Information and Communication Technology
INSPIRE	INfrastructure for SPatial InfoRmation in Europe
ISA	Interoperability Solutions for European Public Administrations
JRC	Joint Research Centre
NUTS	Nomenclature of Territorial Units for Statistics
PICRIT	Protezione delle Infrastrutture Con Rilevanza Transfrontaliera
SDI	Spatial Data Infrastructure
SEIS	Shared Environmental Information System
SiTI	Istituto Superiore sui Sistemi Territoriali per l’
TWG	Thematic Working Group
UML	Unified Modeling Language

UTF	Unicode Transformation Format
UTM	Universal Transverse Mercator
WGS	World Geodetic System
WMS	Web Map Service

Annex A

INSPIRE Reference Legislations with Date entry into force

Reference Legislations	***Date entry into force***
Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)	*03.12.2008*
INSPIRE Metadata Regulation	*14.03.2007*
Commission Decision regarding INSPIRE monitoring and reporting	*05.06.2009*
Commission Regulation (EC) No 976/2009 of 19 October 2009 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards the Network Services	*19.10.2009*
Corrigendum to INSPIRE Metadata Regulation	*15.12.2009*
Regulation on INSPIRE Data and Service Sharing	*29.03.2010*
COMMISSION REGULATION (EU) No 1089/2010 of 23 November 2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services	*08.12.2010*
Commission Regulation (EU) No 1089/2010 as regards interoperability of spatial data sets and services	*08.12.2010*
Commission Regulation amending Regulation (EC) No 976/2009 as regards download services and transformation service	*08.12.2010*
COMMISSION REGULATION amending Regulation 1089/2010 as regards interoperability of spatial data sets and services	*05.02.2011*
COMMISSION REGULATION (EU) No 1253/2013 of 21 October 2013 amending Regulation (EU) No 1089/2010 implementing Directive 2007/2/EC as regards interoperability of spatial data sets and services	*10.12.2013*
Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)	*14.03.2007*
INSPIRE Metadata Regulation	*03.12.2008*
Commission Decision regarding INSPIRE monitoring and reporting	*05.06.2009*
Commission Regulation (EC) No 976/2009 of 19 October 2009 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards the Network Services	*19.10.2009*
Corrigendum to INSPIRE Metadata Regulation	*15.12.2009*
Regulation on INSPIRE Data and Service Sharing	*29.03.2010*
COMMISSION REGULATION (EU) No 1089/2010 of 23 November 2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services	*08.12.2010*
Commission Regulation (EU) No 1089/2010 as regards interoperability of spatial data sets and services	*08.12.2010*

Reference Legislations	***Date entry into force***
Commission Regulation amending Regulation (EC) No 976/2009 as regards download services and transformation service	*08.12.2010*
COMMISSION REGULATION amending Regulation 1089/2010 as regards interoperability of spatial data sets and services	*05.02.2011*
COMMISSION REGULATION (EU) No 1253/2013 of 21 October 2013 amending Regulation (EU) No 1089/2010 implementing Directive 2007/2/EC as regards interoperability of spatial data sets and services	*10.12.2013*

ANNEX B

JRC feasibility template, filled:

Feasibility	
Methodology used Short description of the methodology/process used	Different data sources have been used in the data collection process, which have been derived from official data catalogues, research project results, company web sites, interviews and the mass media. The model used to develop the cross-border database involves the use of three open source software: PostgreSQL/PostGIS, SpatiaLite and Quantum GIS. The combined use of these three software packages allows to be reorganized data derived from different data sources and formats in the INSPIRE schema. In particular, the software provides the possibility to enable a multi-user filling procedure: users can fill database tables on their own and integrate them afterwards, just by sharing their work on the Geo Spatial platform
Description of software and tools used Short description of software and tools	**PostgreSQL / PostGIS. PostgreSQL** is the open source server object-relational database integrating a spatial extension. **Spatialite GUI** is an embedded SQL database engine and is a complete SQL database with multiple tables, indices, triggers, and views, but is contained in a single disk file. The file format is cross-platform. **Quantum GIS (QGIS)** is a Free and Open Source desktop GIS.
Input datasets For each dataset provide the following information: Dataset name, description, URL and URL for metadata and data	Arpa Piemonte - SIFraP - Sistema Informativo Frane in Piemonte (The Information System for Land-slides in Piemonte) ***URL***: *http://webgis.arpa.piemonte.it/elenco_servizi/serviziwebgis_iffi.htm* ***URL Metadata:*** *http://webgis.arpa.piemonte.it/geoportalserver_arpa/catalog/search/resource/details.page?uuid=ARLPA_TO_07.04.02-D_2011-03-24-11:43&title=* Arpa Piemonte - Evento alluvionale 13-16 ottobre 2000 - Fiume Po (River flooding event of the 13-16 October 2000 on the River Po), ***URL***: *http://www.dati.piemonte.it/catalogodati/dato/100510-.html* ***Metadata URL***: *http://webgis.arpa.piemonte.it/geoportalserver_arpa/catalog/search/resource/details.page?uuid=ARLPA_TO_07.03.02-D_2011-04-29_11:45&title=* Arpa Piemonte - Evento alluvionale 23-25 settembre 1993 Torrente Orco - tratto superiore (River flooding event of the 23-25 September 1993 on the upper River Orco), ***URL***: *http://www.dati.piemonte.it/catalogodati/dato/100521-.html* ***URL Metadata***: *http://webgis.arpa.piemonte.it/geoportalserver_arpa/catalog/search/resource/details.page?uuid=ARLPA_TO_07.03.11-D_2011-04-28-15.00&title=* Arpa Piemonte - Evento alluvionale 23-25 settembre 1993 Torrente Orco - tratto inferiore (River flooding event of the 23-25 September 1993 on the lower River Orco), ***URL***: *http://www.dati.piemonte.it/catalogodati/dato/100522-.html*

	URL Metadata: *http://webgis.arpa.piemonte.it/geoportalserver_arpa/catalog/search/resource/details.page?uuid=ARLPA_TO_07.03.12-D_2011-04-28-15.00&title=* Arpa Piemonte - Sismicità in Piemonte - Classificazione sismica su base comunale (Seismic activity in Piemonte based on the municipalities' seismic classification), ***URL:*** *http://www.dati.piemonte.it/catalogodati/dato/100529-.html* ***URL Metadata:*** *http://webgis.arpa.piemonte.it/geoportalserver_arpa/catalog/search/resource/details.page?uuid=ARLPA_TO_07.05.13-D_2011-06-16-12:38&title=* Regione Piemonte - Incendi boschivi - aree percorse dal fuoco (Forest fire affected areas); ***URL:*** data directly furnished by Regione Piemonte Civil Protection Sistema Informativo Valanghe in Piemonte (SIVA) (The Piemonte avalanche information system); ***URL:*** *http://webgis.arpa.piemonte.it/elenco_servizi/webgis_sigeo_valangheARPA.htm* ***URL Metadata:*** *http://webgis.arpa.piemonte.it/elenco_servizi/metadati/metadato_2012.pdf*
Source Dataset description Short description of the input dataset used in the use case	Natural hazards data have been obtained from Regione Piemonte following direct requests to the Regional Civil Protection Department. The data are currently directly downloadable by geoportal services developed by Regione Piedmonte and the Arpa Piemonte (the regional environmental agency). Data concerning energy production sites has been obtained by consulting private utilities' websites, as there is not an official data source for this kind of information.
Feasibility **Fully feasible** (It was possible to transform all relevant spatial objects in the input data sets (and their attributes/relationships) into a corresponding structure of the proposed INSPIRE schemas, and all transformed objects are compliant with the requirements of the proposed INSPIRE schemas (e.g. multiplicity, voidability of attributes). **Partly feasible** (Some of the relevant spatial objects in the input data sets (and/or their attributes/relationships) could not be transformed into a corresponding structure of the proposed INSPIRE schema and/or some of the transformed objects are not fully compliant with the requirements of the proposed INSPIRE schemas (e.g. multiplicity, voidability of attributes). **Not feasible**	Concerning natural hazards was possible to transform all relevant spatial objects in the input data sets (and their attributes/relationships). All data and attributes were transformed into corresponding structure of the proposed INSPIRE schemas. Nevertheless, not all the attributes expected by INSPIRE UML models were filled, because input data sets did not have all the information requested. Concerning power plants, some of the relevant spatial objects in the input data sets (and/or their attributes/relationships) could not be transformed into a corresponding structure of the proposed INSPIRE schema. To resolve this issue, new tables were added into the Production and Industrial Facilities theme. Also, in this case, not all the information request by INSPIRE schemas were filled, because input data sets did not have all the information the request by INSPIRE UML models.
What are the outcomes? Filled Matching Tables Other (please specify)	Italy-France cross-border database on Natural Disasters, Energy Infrastructures and Transport Infrastructures.

ANNEX C

HAZARDS MATCHING TABLE

Earthquake

Cross border database schema based on INSPIRE Application Schema:Natural Risk Zones				Seismic data structure from Regione Piemonte		
Table	**Attribute**	**Attribute Description**		**Table**	**Attribute**	**Attribute / Value Description**
Ob-servedEvent	nameofevent	Name of the event		rischioSismic	ISTAT	Code to identify Municipality
	intensityqualitativevalue	Qualitative estimation of the intensity of the event			CLASS_2010	Territorial classification into seismic zones
	intensityquantitativevalue	Quantitative estimation of the intensity of the event				
	intensityassessmentmethod	Method of calculation of the intensity				
	validfrom	Start date of the event				
	validto	End date of the event				
	inspireid					
	beginlifespanversion	Start validity date of the record				
	endlifespanversion	End validity date of the record				
	geom	Multipolygon			Geometry	Polygon

Landslide

Cross border database schema based on INSPIRE Application Schema: Natural Risk Zones				Landslide data structure from Regione Piemonte		
Table	**Attribute**	**Attribute Description**		**Table**	**Attribute**	**Attribute / Value Description**
ObservedEvent	nameofevent	Name of the event		SIFraP	TIPOPOL	Landslide typology
	intensityqualitativevalue	Qualitative estimation of the intensity of the event			ATTIVITA	Classification of the states of activity of landslides
	intensityquantitativevalue	Quantitative estimation of the intensity of				

		the event			
	intensityassessmentmeth-od	Method of calculation of the intensity			
	validfrom	Start date of the event		DATA_OSS	Observation data
	validto	End date of the event			
	inspireid				
	beginlifespanversion	Start validity date of the record			
	endlifespanversion	End validity date of the record			
	geom	Multipolygon		Geometry	

Snow Avalanche

Cross border database schema based on INSPIRE Application Schema: Natural Risk Zones			**Snow avalanches data structure from Regione Piemonte**		
Table	**Attribute**	**Attribute Description**	**Table**	**Attribute**	**Attribute / Value Description**
ObservedEvent	nameofevent	Name of the event	SIVA	LOCALITA	Municipality name
	intensityqualitativevalue	Qualitative estimation of the intensity of the event			
	intensityquantitativevalue	Quantitative estimation of the intensity of the event			
	intensityassessmentmeth-od	Method of calculation of the intensity			
	validfrom	Start date of the event			
	validto	End date of the event			
	inspireid				
	beginlifespanversion	Start validity date of the record			
	endlifespanversion	End validity date of the record			
	geom	Multipolygon		Geometry	Geometry column

Flood

Cross border database schema based on INSPIRE Application Schema: Natural Risk Zones			2000 - Po River - Flood data structure from Regione Piemonte		
Table	**Attribute**	**Attribute Description**	**Table**	**Attribute**	**Attribute / Value Description**
ObservedEvent	nameofevent	Name of the event	All2000	NOM_BAC	River basin name
	intensityqualitativevalue	Qualitative estimation of the intensity of the event		DECOD	Flood effects description
	intensityquantitativevalue	Quantitative estimation of the intensity of the event			
	intensityassessmentmeth-od	Method of calculation of the intensity			
	validfrom	Start date of the event			
	validto	End date of the event			
	inspireid				
	beginlifespanversion	Start validity date of the record			Event starting data
	endlifespanversion	End validity date of the record			Event ending data
	geom	Multipolygon		Geometry	

Cross border database schema based on INSPIRE Application Schema: Natural Risk Zones			1993 - Orco River - Flood data structure from Regione Piemonte		
Table	**Attribute**	**Attribute Description**	**Table**	**Attribute**	**Attribute/ Value Description**
ObservedEvent	nameofevent	Name of the event	Orco1993		River basin name
	intensityqualitativevalue	Qualitative estimation of the intensity of the event			Flood effects description
	intensityquantitativevalue	Quantitative estimation of the intensity of the event			
	intensityassessmentmeth-od	Method of calculation of			

		the intensity			
	validfrom	Start date of the event			
	validto	End date of the event			
	inspireid				
	beginlifespanversion	Start validity date of the record			Event starting data
	endlifespanversion	End validity date of the record			Event ending data
	geom	Multipolygon		Geometry	

Forest Fire

Cross border database schema based on INSPIRE Application Schema: Natural Risk Zones			Forest Fire data structure from Regione Piemonte		
Table	**Attribute**	**Attribute Description**	**Table**	**Attribute**	**Attribute Description**
ObservedEvent	nameofevent	Name of the event	aree_percorse_fuoco	COMUNE_INT	Municipality name
	intensityqualitativevalue	Qualitative estimation of the intensity of the event		SUP_CALC	Fire area extension
	intensityquantitativevalue	Quantitative estimation of the intensity of the event			
	intensityassessmentmethod	Method of calculation of the intensity			
	validfrom	Start date of the event			
	validto	End date of the event			
	inspireid				
	beginlifespanversion	Start validity date of the record			
	endlifespanversion	End validity date of the record			
	geom	Multipolygon		Geometry	

ATTRIBUTE	VALUE TYPE	COMMENTS
IdCentrale	INTEGER	Primary key
Tipologia_centrale	TEXT	Power plant type
Nome_impianto	TEXT	Power plant name
Potenza_kW	DOUBLE	Total power generated in kilowatts
Tipo_combustibile	TEXT	Fuel type used
Fonte dato	TEXT	Data source
Gestore	TEXT	Power plant operator
Tipo_macchinario	TEXT	Machinery type
Numero_gruppo_gener	TEXT	Hydropower plant generation station number
Salto_massimo	INTEGER	Difference in height between the source and the water's out-flow, also called the hydraulic head
Geom	POINT	Power plant location
Georiferita	BOOLEAN	Status information about whether the power plant needed geo-referencing (true or false)

Table 3 – Power plants data reorganized into unique table named “centrElettriche“.

Application Schema Production and Industrial Facilities			**Application Schema Power Plants Data – "centrElettiriche"**		
Table	**Attribute**	**Attribute Description**	**Table**	**Attribute**	**Attribute Description**
Installation	name	Name of the installation	centrElettriche	Tipologia_centrale	Power plant type
	description	Description of the installation			
	beginLifeSpan	Start validity date of the record			
	endLifeSpan	End validity date of the record			
	geom1	point			
	geom2	polygon			
Site	name	Name of the site	centrElettriche	Nome_impianto	Power plant name
	description	Brief description		Power plant type	Power plant type
	siteplan	Description of the whole site		Fonte dato	
	inspireid				
	thematicid				
	beginLifeSpan	Start validity date of the record			
	endLifeSpan	End validity date of the record			
	geom2	polygon		Geom	
	exactGeo	flag to identify if the geometry is exact or not		Georiferita	Information about geo-referencing status (true or false)
InstallationParameter	value1	Numeric value of parameter	centrElettriche	Potenza_kW	Total power generated
	value 2	Textual value of parameter		Tipo_macchinario	Machinery type used for power generation
				Tipo_combustibile	
				Salto_massimo	
				Numero_gruppo_gener	
	beginLifeSpan	Start validity date of the record			
	endLifeSpan	End validity date of the record			
Authority	name	Name of the managing authority	centrElettriche	Gestore	
	address	Address			
	phone	Contact phone			

		number				
	Website	website				

Table 4 – Matching tables among production and industrial facilities INSPIRE schema and power plant data collected for the cross -border database.

ANNEX D

Costs and Benefits Estimation – Synthesis

Costs and Benefits Estimation - Synthesis	
If possible please specify the effort required for each dataset that were used Specify the effort in **percentage**	
Training / Studying the Data Specifications	**10**
Identifying and collecting relevant input data sets	**5 + 5 + 15 = 25**
Creating the mapping rules (e.g. matching tables)	**5**
Setting up the infrastructure	**15 + 25 = 40**
Validating the results	**5**
Documenting the results	**10**
Management and coordination	**5**

ANNEX E

Benefits of harmonized INSPIRE datasets

Please indicate (with X) the benefits harmonized INSPIRE datasets would have for the use case defined	
Direct user value	
Improvement of data identification	x
Increased ease of use	
Availability of the data models	x
Increased data availability	x
Speeded up data management	
Higher flexibility for further data requests	x
Improvement of data access	x
Improvement of data compatibility	
Better data sharing ability	x
Reduced cost of integrating data	
Increased data quality	x
Increased data reliability	x
The new services availability	x
Improvement the efficiency and the quality of environmental assessments	x
Institutional Financial Value	
Achieves cost avoidance (as opposed to savings)	
Overall cost savings for info management	
Institutions operational benefits	
Promotes inter-institutional collaboration	x
Promotes intra-institutional collaboration	x
Promotes re-use of existing datasets	x
Decreases cost of IT / information management	
Reduces data integration cost across institutions	
Increasing potential to run or join various kinds of projects commission of research tasks	x
Social value	
Increases public participation (raised public sector confidentiality)	x
Promotes more efficient use of (taxpayer) funds	
Increases institutional effectiveness	x
Enables better decision making	x
Reduces barriers between organizations	x
Strategic and Political Value	
Fosters closer working relationships	x
Support improved decision making	x
Supports other information infrastructure	x
eGoverment support	x

ANNEX F

Description of the INSPIRE technical issues met during the cross-border database realization, and related improvement proposals.

Issue Topic	Description	Proposal Improvement
Data models Scale	INSPIRE data models do not give any information to differentiate geographic scale depending on which spatial object is taken into account. This may represent an issue when building a database that aims integrate data related to different typologies of infrastructures that come from different data sources. For example, for power plants, INSPIRE suggests the use of the geo-referenced buildings geometry: this approach is often not coherent with geographic data scales used by local bodies and institutions. The same problem applies to the Natural Risk field, where several scales are used by data owners to describe landslides and other major critical events. The impossibility of differentiating data scale within the same dataset can lead to errors during spatial analysis or data overlapping processes	A possible solution can be to develop different tables for different data scales, or to integrate inside INSPIRE data models a "field" reporting data scale information.
Lack of an adequate data model for RES power plants	Energy generation infrastructures are described as production facilities, which are optimal to describe big generation plants, such as power stations burning fossil fuels or hydro power plants. However, in the last few years, the European policies regarding the use of renewable sources promoted the diffusion of smaller plants based on photovoltaic panels, small wind turbines or mini and micro hydroelectric turbines. For these kinds of plants, the description provided by INSPIRE specifications can be over detailed, with the risk of losing the most important information about them.	A new specific data model could be created for Renewable Energy Sources power plants (in particular biomass, photovoltaic and micro-hydroelectric) also taking into account possible useful data fields within future SMART GRID scenarios. This updated data model should also represent the relationships between the generation objects and all other elements that are beginning to be part of complex energy systems, like energy storage devices. Furthermore, a possible datafield could be created to spot if the plant has been built according to some incentive scheme or not and to understand how the produced energy is sold to the grid or if it is self-consumed.

Upgrade of landslide label for "Natural Hazard Category"	The "Natural Hazard Category" register requires a description of a generic classification of types of natural hazards. This registry could be integrated by further developing "landslide label". Indeed, to better understand possible impacts deriving from landslides in risk evaluation, it is important to recognize landslide types, because each hazard type has particular characteristics in different circumstances.	The category landslide could be divided in subcategories, such as: • DEPLETION. The volume bounded by the main scarp, the depleted mass and the original ground surface. • FLOW. Flows are rapid movements of material as a viscous mass where inter-granular movements predominate over shear surface movements. These can be debris flows, mudflows, or rock avalanches, depending upon the nature of the material involved in the movement. • FALLS AND/OR TOPPLES. Falls are abrupt movements of slope material that separate from steep slopes or cliffs. Most of the movements occur due to free falls or by rolling or bouncing. • LANDSLIDE. All the movement of a mass of rock, earth or debris down a slope, which are not included in other definition. This is clearly only one of many possibilities, since there are many national and international landslide classification systems based on different criteria: type of movement (falls, slides, flows, topples, complex movements etc.); involved material (rock, debris and mud), movement velocity and activity.
Complex Structure for Road Networks inside Transport infrastructures Data Specification	Transport infrastructures Data Specification introduces a quite complex structure to describe road networks with several objects connected to each other. This makes it quite difficult to readily identify the connections between the different objects, in order to implement the same structure in the database. In addition, this high detail level increases the difficulty of completing the database, since the identification of each single road and the data collection of all its properties represents a relatively time consuming process (not all original data sets were always immediately available).	The addition of practical examples on how to manage the various objects of a road transport network could be very useful to better understand the whole structure. For example, INSPIRE Data Specifications on natural events are very well described making them easy to understand due to the examples and diagrams provided in the document. Adopting a similar approach for transport networks and other related themes could greatly improve the usability of INSPIRE Specifications.

Difficult management of boundaries between different administrative units.	Another issue related to the usability of INSPIRE Data Specifications is the management of boundaries between different administrative units. The approach followed is not intuitive, with the risk of generating confusion to the people that have to deal with data.	The design and implementation of automatic tools able to adapt data to the correct format could be particularly useful.
Incoherence with available local data sets concerning Production and Industrial Facilities.	Some of the attributes expected by the INSPIRE Application schema for "natural hazards" were not filled, because input data sets did not have all the information requested by INSPIRE Application schemas. Power plants, some of the relevant spatial objects in the input data sets (and/or their attributes/relationships) could not be transformed into a corresponding structure of the proposed INSPIRE schema.	To solve this issue, new tables could be added into Production and Industrial Facilities theme more focused on data that are usually available to Municipalities and other local Institutions.
Critical Differences on existing terminology (including text and iconography) between different Countries, in particular concerning Natural Hazards and related warning/alert systems.	During the cross-border database design process the analysis of the existing databases showed that the structures used in Italy and in France are very different between each other, limiting the possibility to share information between the two countries. The process of developing a shared glossary must necessarily take into account the perspective of Civil Protection Authorities and local security-related bodies.	Our suggestion is to organize a series of meetings with Security Operators, Policy-makers, Civil Protection Authorities, Fire-fighters, Polices, etc. to gather systematic feedbacks and comments to improve INSPIRE Glossary in particular on Natural Hazards. This will ensure gathering the perspective of all relevant INSPIRE end-users and facilitate the reduction of the barriers between countries in terms of terminology and warning/alert procedures.