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HARMO-DATA Project – cross border spatial data harmonization using INSPIRE model*

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Abstract

HARMO-DATA is an ongoing project, funded by EU in the framework of the INTERREG V-A Italy-Slovenia 2014-2020 Programme. It involves different stakeholders, target groups and end-users in three regions: Friuli-Venezia-Giulia (Italy), Veneto (Italy) and Slovenia. The main purpose of this project is to develop common solutions for more efficient cross-border spatial data management – by harmonizing the existing spatial data, implementing a cross-border spatial data platform, and developing a common protocol for the harmonization of territorial data. It will provide an instrument to define the specific obligations and rights of the involved parts – in terms of data harmonization, exchange, use and maintenance. Five pilot case studies were identified by the project partners – in cooperation with public and private end-users, and additional stakeholders. The core use cases of the project relate to spatial data search, view and download, and the harmonization model for spatial datasets applies the INSPIRE data specifications. A joined common spatial data platform was established as an extension of the existing search-view-download platforms (metadata systems), upgraded and improved to better enable open data access by users from both Italy and Slovenia. The common spatial HARMO-DATA data platform, as well as, a joint protocol for cross-

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border spatial data harmonization, have been formalized in an official bilateral agreement.

Keywords: INSPIRE, cross-border, data harmonization, Italy, Slovenia, Interreg

1. INTRODUCTION

The HARMO-DATA project, funded under the Interreg V-A Italy-Slovenia 2014-2020 Program, was officially launched in September 2017. The partnership consists of the Geodetski Inštitut Slovenije (Ljubljana, Slovenia) as coordinator, Geodetska Uprava Republike Slovenije, Igea S.r.l. (Ljubljana, Slovenia), Insiel S.p.a. (Trieste, Italy), GeoSNav Lab - Department of Engineering and Architecture, University of Trieste (Italy), and Terre S.r.l. (Mestre, Italy). There are also three associate partners involved in the project. Namely, the Region of Veneto, the Region Friuli Venezia Giulia, and the Slovenian Ministry for the Environment and Territory.

The general objective of the project is to strengthen the cross-border institutional cooperation between public authorities and spatial planning operators, and implementing shared solutions for coordination and effective land management. It builds on previous and complementary work in the European context, from projects, such as, Plan4All (PLAN4ALL; 2019; Camarata et al., 2011), Habitats (HABITATS, 2018), Humboldt (Čerba et al., 2008; Fichtinger et al., 2011), HLANDATA (Goñi, 2011), ALCOTRA (Noardo et al. 2016) – that already treated data harmonization needs for spatial management in the context of INSPIRE Directive (European Parliament, 2007).

The project applies the following strategy:

- Creation of a regional cross-border platform with harmonized data and services that allow search, consultation and download of Italian and Slovenian spatial data.
- Drafting and provision of a cross-border spatial management protocol that supports the implementation of the cross-border data harmonization platform. This protocol includes commitments and rights for all involved parties in terms of harmonization, exchange, use of data and their maintenance The importance of the cross-border platform for viewing and accessing harmonized territorial data is also highlighted. Article part 1 and 2 define the purpose of the protocol, the mutual goals and responsibilities of all the involved parties. Article part 3 and 4 define implementation and duration of the protocol. Termination, voluntary disassociation of the parties, and commitment to sustainable maintain, manage and monitor common cross-border platform with harmonized data - also after the termination of the project - are defined at the end of the protocol.

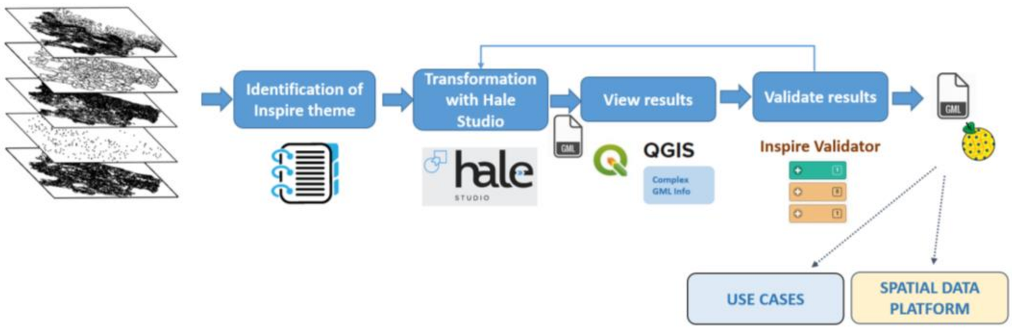
- At the same time, the protocol will promote the continuity of the cross-border infrastructure by ensuring that the spatial data will be harmonized even after the completion of the project.
- Organization of joint cross-border training courses and workshops in Italy and Slovenia, including the exchange of good practices and needs on the topics of land management, data and metadata knowledge, as well as, information and instructions on the use of the cross-border spatial data platform (PTTC).

The target groups of these activities include policy makers, national, regional and local authorities, small and medium enterprises (SMEs), institutions responsible for civil protection, organizations that work in the prevention and management of environmental risks, managers of protected areas, and universities and research centres in Italy and Slovenia.

2. METHOD

The publication and harmonization of cross-border spatial data is addressed by developing a joint model for open access spatial database management. The methodologies and technologies comprising this model have been identified, shared, and tested with geographical data from selected sample areas (Figure 1).

Figure 1: Spatial data transformation and validation process



The harmonization of data and models within the HARMO-DATA project was carried out in two phases. In the first phase, based on an analysis of the existing databases and the sharing of good practices, the different database management models have been compared with each other, and semantically analysed. On this bases, a proposal for the cross-border platform was presented to the project partners. The next phase was focused on data model harmonization. It provided a bilingual objects catalogue, instructions relative to the geometric connection of cross-border objects, and a plan to integrate the harmonized data models into an interoperable cross-border platform.

The data model specified by the INSPIRE data specifications (INSPIRE, 2018) provided the baseline for the data harmonization in cross-border areas. The harmonization is implemented during data distribution, which is also a basic principle how to implement INSPIRE (INSPIRE, 2018) This implies the implementation of corresponding network services, including metadata services, data download services, and data viewing services.

The implementation of these services is the responsibility of each data provider. In the case of HARMO-DATA, the majority of main data providers are project partners (the Surveying and Mapping Authority of the Republic of Slovenia or associate partners (the Region of Veneto and the Region Friuli-Venezia Giulia). Responsible institutions that are not directly involved in in the project were invited to implement the services with the extensive assistance of the project partners. All preparatory work for metadata generation and improvement, and for service implementation was provided by HARMO-DATA project partners.

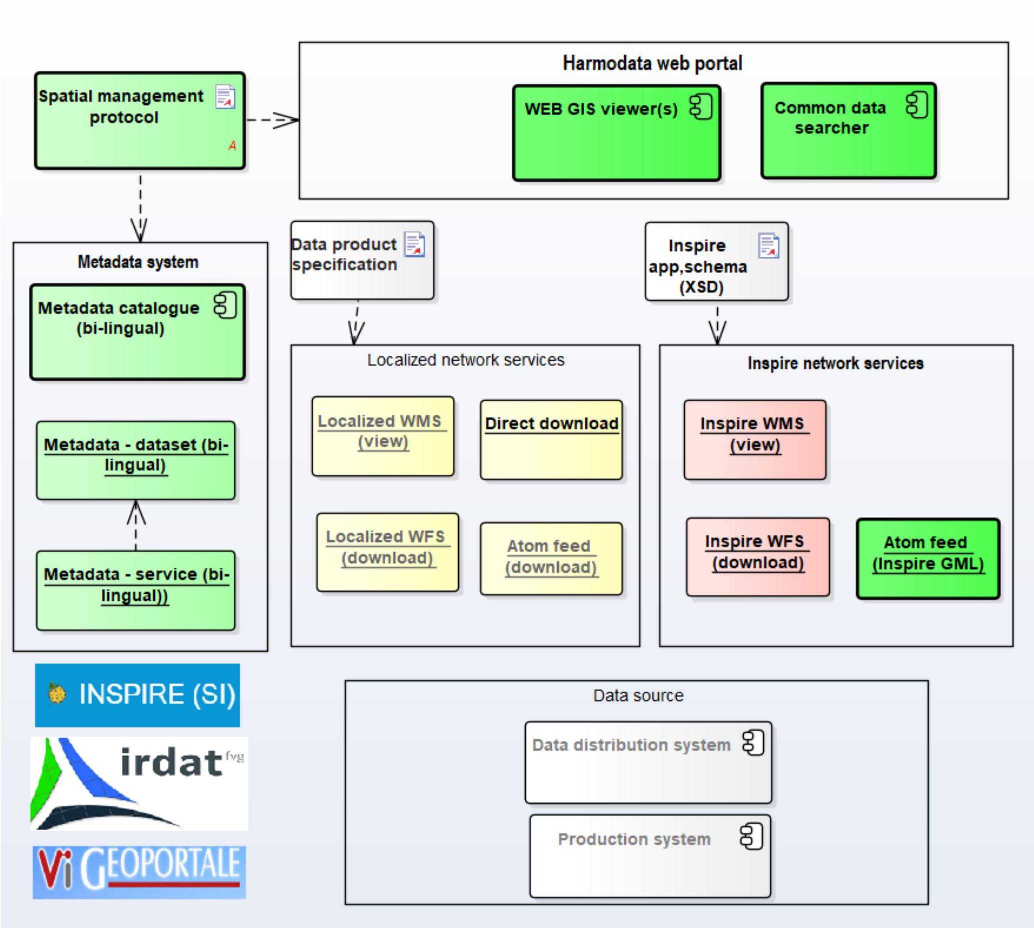
Hale Studio (Hale Studio, 2018), was used as the software to transform the existing geodata into INSPIRE-compliant data sets, and to create INSPIRE-compliant data formats. The Open Source GIS software used to visualize the results was QGIS. The results were verified using the INSPIRE Validator tool (Hale Studio, 2018). For detailed verification description see Section 3.

3. COMMON SPATIAL DATA PLATFORM

Then main purpose of the common cross-border spatial data platform (www.harmo-data-geoportal.eu) is to enable easier data search and download, especially for datasets that were processed and harmonized within the HARMO-DATA project. The platform is supposed to be used by different stakeholders of spatial datasets in a cross-border area, as well, as other users.

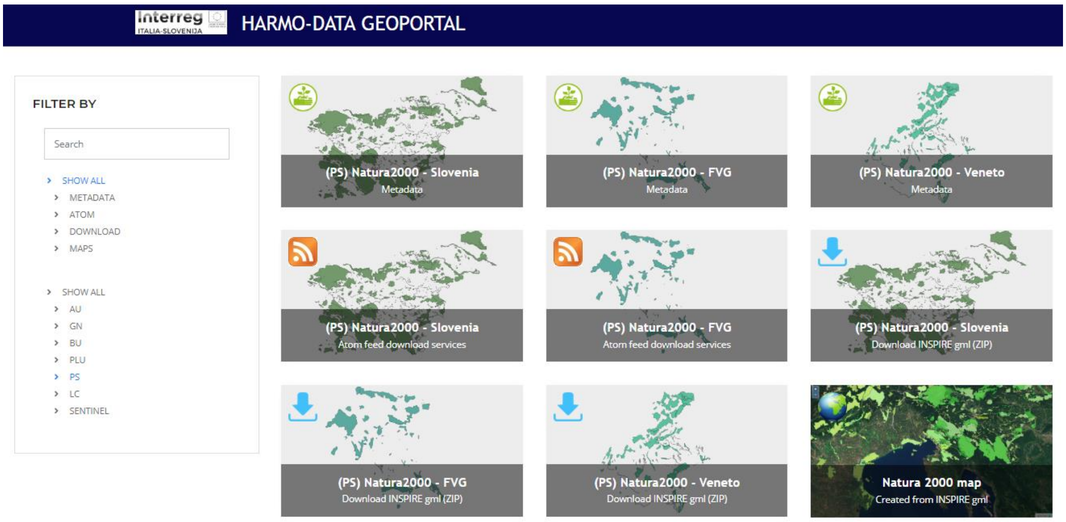
The common cross-border spatial data platform (see also Figure 2) was not designed as a new (project dependent) physical platform. This was because the development of totally new platform for metadata maintenance, data searching and data download would have caused problems related to long-term sustainability and maintenance. Instead, the common cross-border spatial data platform is based on spatial data platforms that already exist in each participating region. These existing platforms were upgraded in order to enable the implementation of INSPIRE-compliant metadata (especially supporting multiple languages), and the implementation of corresponding network services. An entirely new component, encompassing an advanced data search (the ‘data searcher”) and several thematic web GIS viewers, was developed and integrated within the project.

Figure 2: Common spatial data platform structure



The "data searcher" component (www.HARMO-DATA-geoportal.eu) (see also Figure 3) is a kind of one-stop-shop for the harmonized datasets on a cross-border area. Its maintenance and further development are also intended to be a part of common management protocol. The "data searcher" component includes three main capabilities: (1) access to metadata, (2) direct download of harmonized "project" datasets and (3) access to download services (as atom feeds) provided by responsible institutions. Additionally, several web GIS maps present harmonized datasets, and different case-specific usages of the harmonised data (pilot case studies of the HARMO-DATA project) are presented.

Figure 3: HARMO-DATA “data searcher” (example search for Natura 2000)



4. PILOT CASE STUDIES

The main purpose of the pilot case studies is to verify semantic, technical, organizational, and sustainable aspects of the proposed harmonization solution. They were also introduced as a tool to improve the communication between the project and its target user groups, and as a way to test and verify the real potential of the harmonized spatial data model.

The common question for each case study was: *Is it possible to provide harmonized data systematically in all three regions and can such harmonized datasets be used in everyday practice?*

The main side effect related to the use of harmonized data is the improvement of common understanding of cross-border datasets and good-practice example that can be further used and improved in the future cross-border cooperation.

In total, five pilot case studies have been developed:

1. Cross–border Data Usage using Earth Observation data (Sentinel-2),
2. Urban 3D Modelling – Interactive 3D Zoning,
3. Mapping and Assessment of Ecosystems and their Services,
4. Disaster Management, and
5. Public Infrastructure Cadastre.

This selection represents different types of case studies. Some important for “cross-border” situations at regional level, others more important locally (municipality level). In the following sections, two of these pilot case studies will be described, along with a presentation of the obtained results.

4.1. Urban 3D Modelling – Interactive 3D Zoning

The pilot case study “Urban 3D Modelling – Interactive 3D Zoning” was tested in the urban planning process of local municipalities. The study tested the placement and 3D modelling of new buildings according to the zoning regulations and key parameters defined by municipality spatial plans. The first test case involved the municipality of Nova Gorica, a Slovenian municipality near the Italian border. In particular, the study examined the 3D modelling of a new building, the “Zdravstveni dom”, located in the Nova Gorica city centre, taking into account the town planning rules (see also Figure 4).

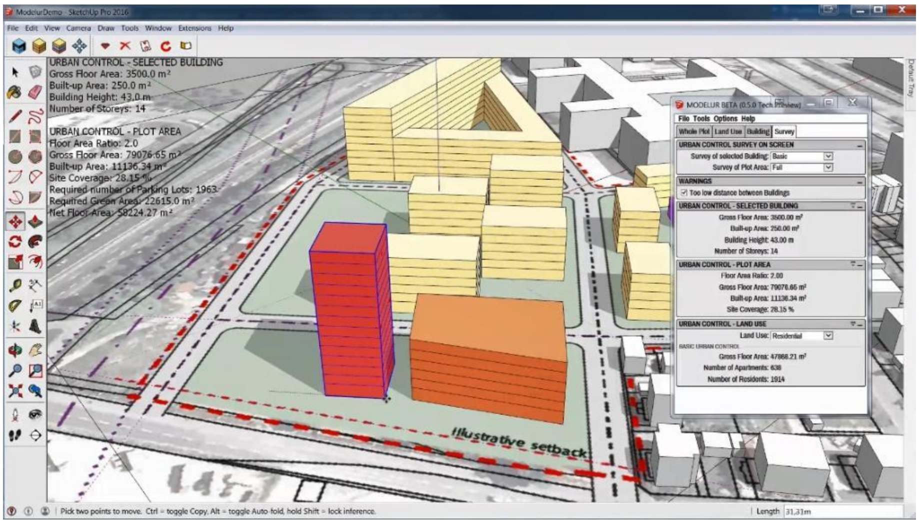
Interactive real time visualization of alternative models in a 3D environment has been possible thanks to Modelur (Modelur, 2019),, a specialized tool provided by the Slovenian startup AgiliCity. Modelur is a SketchUp (SketchUp, 2019) based application dedicated to conceptual urban planning, that enables on-the-fly calculations of the urban control parameters defined in the urban planning documents.

Modelur uses 3D models of existing or new buildings including information on their height, number of floors, number of apartments, number of parking lots etc. and enables automatic checking of these attributes against control parameters, like gross and net floor area, floor area ratio and site coverage specified in the urban planning documents (that must be available in digital format).

Using such an approach, the verification of existing conditions, preparation of new zoning ordinances or creation of new design proposal is estimated to be 2.4x faster, 4.5x more accurate and 3.5x less prone to errors. This enables decision makers at a municipality/city level to evaluate more design alternatives, to be better informed on the new designs and to make less mistakes when new urban planning documents are prepared.

The Modelur software is already implemented and used in different municipalities and larger cities all around the world. One of the main challenges of such tool are the different data models usable as input data. The test of a harmonized data model based on INSPIRE opens the possibility for Modelur to use INSPIRE compliant infrastructure and data services across the EU countries, and to promote the HARMO-DATA project as a good practice of using such infrastructure.

Figure 4: A modelling example: red colour indicates that one urban control parameter is exceeded



The source data used for the test included the building models extracted from the official building cadastre (managed by the Surveying and Mapping Authority of the Republic of Slovenia) and the planned land use layer from planned land use database (managed by the Ministry for Environment and Spatial Planning of the Republic of Slovenia). Two INSPIRE themes are included in this case study: Buildings (bu-core2d) and Planned Land Use (plu). The Buildings model was used for the buildings input data since the original dataset enables only a 2.5D model (currently only the height attribute is present in the original building cadastre database).

Transformations to the INSPIRE model for Planned Land Use and Buildings for Friuli Venezia Giulia and Veneto have been prepared within the project. The transformation for buildings in Slovenia was already provided by Surveying and Mapping Authority of the Republic of Slovenia.

In addition to the above described Modelur, the software used for the study included the open source Quantum GIS version 2.18.27 (QuantumGIS, 2018), for data preparation, Hale Studio, for transformation into the INSPIRE model, and the INSPIRE Validator online tool, for transformed data validation.

Practical results from this test environment show that, for the purpose of the study, the geoJSON format (GeoJason, 2018) is more practical than GML (GML, 2018). The main problem is that standard GIS tools hardly manage large amount of data in INSPIRE output formats (GML). In addition, there are also practical problems for users to handle elements in the INSPIRE format that present referencing to code list (using “href” - hypertext reference). It was necessary to add a textual attribute into the INSPIRE format to enable easier work in the GIS environment. The geoJSON encoding (prepared by exporting from GML to geoJSON using Quantum GIS) seems to be more practical, since it is also supported by standard web GIS libraries (such as openlayers (Similar Tech, 2018), leaflet Similar Tech, 2018). It is also already supported by Modelur, while encodings in GML are not yet supported. Another practical problem arose from Planned Land Use model, and is related with the source data. Attributes describing regulations are transformed into the “Dimension Indication” set of attributes in the INSPIRE plu schema, but they are rarely populated in existing data sources.

The HILUCS (Hierarchical INSPIRE Land Use Classification System) (HILUCS, 2018) classification in the Planned Land Use theme enabled very practical comparison of different classification of planned land use in all three participating regions (Slovenia, Veneto and Friuli Venezia Giulia). It was also used for creating a planned land use comparison table for different classifications used in different regions. Table 1 presents only part of the comparison between national planned land use and HILUCS classifications. Although only Primary production and Residential Use section were included, this work clearly shows two main practical problems of mapping to HILUCS land use classification:

a) more national classes must be mapped into one HILUCS class, and
b) some HILUCS classes are not covered by national planned land use classifications at all.

A national planned land use classification is in fact also included in the INSPIRE format, and in practice it appears more useful than the HILUCS classification. According to the INSPIRE technical rules each code list should be available as a unique identifier published as an URL, and included into services in an ‘href’ format. Some practical work must still be done for the inclusion of such national land use classifications to national code list registries. In Italy this registry already exists, whereas in Slovenia the registry is still in the development phase.

Table 1: Part of Planned Land Use comparison table (HILUCS – SLO – Veneto – Friuli Venezia Giulia)

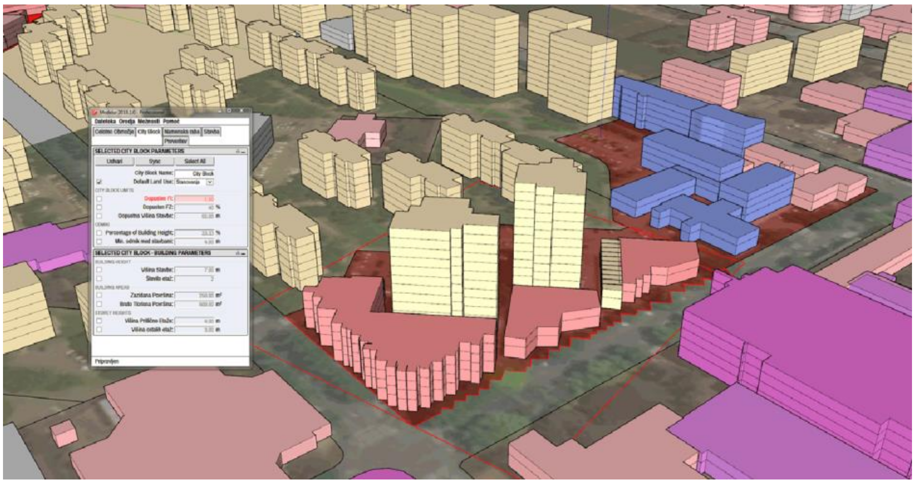
HILUCS Code	***HILUCS Value***	***Planned Land Use SLO***	***Planned Land Use Veneto***	***Planned Land Use FVG***
1	PrimaryProduction		E	
1_1	Agriculture	K1, K2	E2	E.4a A, E.4 ne, E.5, E.6
1_1_1	Commercial Agricultural Production	K1, K2	E3	E.4
1_1_2	Farming Infrastructure	SK	E3	
1_1_3	Agricultural Production For Own Consumption	IK	E4	
1_2	Forestry			E.2
1_2_1	Forestry Based On Short Rotation			
1_2_2	Forestry Based On Intermediate Or Long Rotation			
1_2_3	Forestry Based On Continuous Cover			
1_3	Mining And Quarrying			
1_3_1	Mining Of Energy Producing Materials	E		
1_3_2	Mining Of Metal Ores	LP		
1_3_3	Other Mining And Quarrying	LN		
1_4	Aquaculture And Fishing			
1_4_1	Aquaculture			
1_4_2	Professional Fishing		D5	
1_5	Other Primary Production		D5	
1_5_1	Hunting			
1_5_2	Management Of Migratory Animals			
1_5_3	Picking Of Natural Products			
…	…	…	…	…
5	Residential Use	SS	A*	A, B.1, B.2, B.3, B.4, B.5, B.6, B.7, B.8a, B.8b, B.8c, B.9, B.10
5_1	Permanent Residential Use	A	A1*-A2*-A3*-S	
5_2	Residential Use With Other Compatible Uses			
5_3	Other Residential Use	SP		VP
6	Other Uses		B*-C*	
6_1	Transitional Areas	SB	B1*-B2*-C1*-C2*-PN	AT, C.1, C.2

HILUCS Code	***HILUCS Value***	***Planned Land Use SLO***	***Planned Land Use Veneto***	***Planned Land Use FVG***
6_2	Abandoned Areas			
6_3	Natural Areas Not In Other Economic Use			d, d/r, dE6
6_3_1	Land Areas Not In Other Economic Use	O, N, G	F7	
6_3_2	Water Areas Not In Other Economic Use	VM, VC,		
6_4	Areas Where Any Use Allowed			
6_5	Areas Without Any Specified Planned Use			
6_6	Not Known Use	BD, ZV, F, OO		

Ultimately, the INSPIRE models (plu and bu-core2d schema) have been evaluated as fitted for this purpose. The entire process in the Modelur software was performed on the base of INSPIRE data model (however exported to geoJSON format) and extensions to these two models were not needed.

The modelling of the existing city centre buildings (Figure 5) allowed the identification of "problematic" areas where the existing buildings do not follow the prescribed regulations and planning rules. For this, three attributes describing regulation (net floor area, build-up area, maximum height of the buildings) could be used. This methodology can allow an easy verification of municipality spatial plans.

Figure 5: Analysis of a 3D parametrical model in the city center of Nova Gorica



This case study has been extended within the HARMO-DATA project on the neighbouring Municipality of Gorizia and Mira (near Venice, Italy). The potential to use this technology has been estimated as positive in all three municipalities, especially for the controlling of “problematic” areas. Modelling of new buildings is estimated as less attractive. All three municipalities will have the possibility to use and test the Modelur in one year period.

Case studies that are oriented to workflows at the local level (especially, Urban 3D modelling, and partially Mapping and Assessment of Ecosystems) are also identified to be important “cross-border” topics. It is expected that typical local level workflows, for example, related to spatial planning and constructions design, will became more and more relevant “cross-border” collaborations. There are already some good practices related with common infrastructure investments on the cross-border region between Gorizia (Italy) and Nova Gorica (Slovenia), including a cross-border city bus line, cross-border cycling routes, cross-border walking paths and common cross-border healthcare services. The municipalities of Gorizia and Nova Gorica, together with the municipality of Šempeter-Vrtojba, are also joined into the EGTC GO (European Grouping of Territorial Cooperation), which is a legal entity based on the Regulation (EC) no. 1082/2006 of the European Parliament. Recently the three mayors expressed the intent to work on the proposal for a single regulatory plan and the design of common services.

4.2. Underground Utility Infrastructure Cadastre

Usually this topic is referenced as Public Infrastructure Cadastre and it includes transport data (i.e roads, railways, bike paths, etc.), energy data (i.e. electricity, gas, oil, district heating, etc.), public utility data (i.e. water supply, waste water, etc.), electronic communication networks data (i.e. fiber optic networks, network communication points, etc.) and generic ducts data.

These data assets are hardly available (especially with information about geolocation). Owners or managers of underground utility infrastructure often ‘know’, at a different level of accuracy, where their infrastructures are located and their characteristics. It is also very difficult to manage this data and to keep it up-to-date. Moreover, the technical methods available to acquire missing information, such as Ground Penetrating Radar (GPR), Artificial Intelligence (AI), Radio Frequency (RF), are expensive and hardly applicable with good results.

This HARMO-DATA pilot case study highlights the main importance of the public infrastructure cadastre availability, describing the following needs of four main stakeholders (all belonging to telecommunication environment):

- Considering the omnipresent need for a high capacity telecommunication network (broadband) due to the large and increasingly growing demand for high speed connectivity (especially in digital divided zones), operators would build up new infrastructures with fast delivery times while minimizing realization costs. This could be implemented with intense re-use of existing infrastructure of any type, as long as, it is known where the existing infrastructure is located.
- In order to increase wide geographical telecommunication networks and to make them more reliable, national operators are planning to identify new redundancy paths for the main lines. This means that in cross-border zones, these paths could also use existing infrastructure belonging to different countries.
- Aiming to decrease the digital divide using public funds (i.e. EU financing programmes), national authorities - such as Infratel, the Italian technical and operational entity connected to Ministry of Economic Development to act the development of broadband and ultra-broadband plans in Italian territory - need to map the territory identifying zones where public funds can be used (and where not). Again, this depends on the presence of existing telco infrastructure.
- Considering a local use of a public infrastructure cadastre, public workers and construction companies may take advantage of an harmonised general view of existing infrastructure on a particular zone (maybe offered by an on-line service) in order to prevent damage reducing risks of accidental damages.

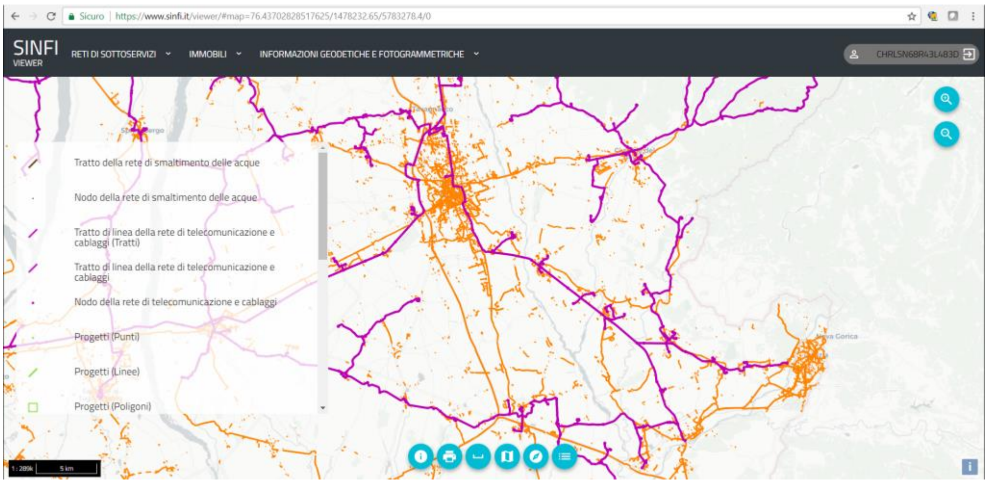
On national level, both in Slovenia and in Italy, appropriate laws and acts regulate the structure and the management of a national infrastructure cadastre in which underground utilities are also included. This cadastre gives a country-level vision of all the infrastructures existing on national territory, with the main aim to share data between all qualified stakeholders.

The Slovenian Public Infrastructure Cadastre contains transportation, utilities, energy, water infrastructure, electronic communication and several acts and laws rule the cadastre since 2002, including regulations. In Slovenia the supply of this data is mandatory and there is a high level of data completeness. Slovenia offers the users public access to data and a free data download service (see Figure 6 for an example).

Figure 6: Slovenian Public Infrastructure Cadastre – public access data

The Italian Underground Utility Infrastructure Cadastre (SINFI (SINFI, 2018), see Figure 7 for an impression) includes only elements from underground utility (generic ducts, water supply, waste water, electric network, gas network, district heating, oil pipelines, communication networks). The reference law in Italy is “DLgs 33/2016 – transposition of EU Directive 2014/61”. In the case of the Friuli Venezia Giulia Region, there is only a first partial Technical Regulation (DM 11/05/2016) available, and a local regional law (LR 3/2011) regulates the generic ducts cadastre. The technical data structure (the data model) is part of the National Geo-Topographical Database Specification (SINFI, 2018). There is a low level of data completeness, as data supply began at the end of 2017. Service development for public access to data is in progress.

Figure 7: Italian Underground Utility Infrastructure Cadastre (SINFI)



The HARMO-DATA project adopted an INSPIRE-oriented approach for data model harmonization. In order to facilitate the use in a cross-border context, the project has considered the INSPIRE data model specifications. The INSPIRE Data Model for Utility and Governmental Services (INSPIRE, 2018) provides two different profiles that can be used to model data. The first one is the Utility Network profile (derived from Generic Network Model also used for Transportation Network and Hydrography) and it is based on a node-arch structure and on the network basic component. The involved technical data are very simple and basic (for example type of carried material), and the topology constraint is not mandatory because the relationship between nodes and arches is optional. The second profile is the Extended Utility Network profile that adds to the basic profile more attributes and code lists in order to detail the description. Each profile includes an application schema for Electricity, Oil/Gas/Chemical, Sewer, Thermal, and Water. However, it does not include an application schema for telecommunication networks because the INSPIRE Implementing Rules (INSPIRE, 2018) do not include it inside the legislation.

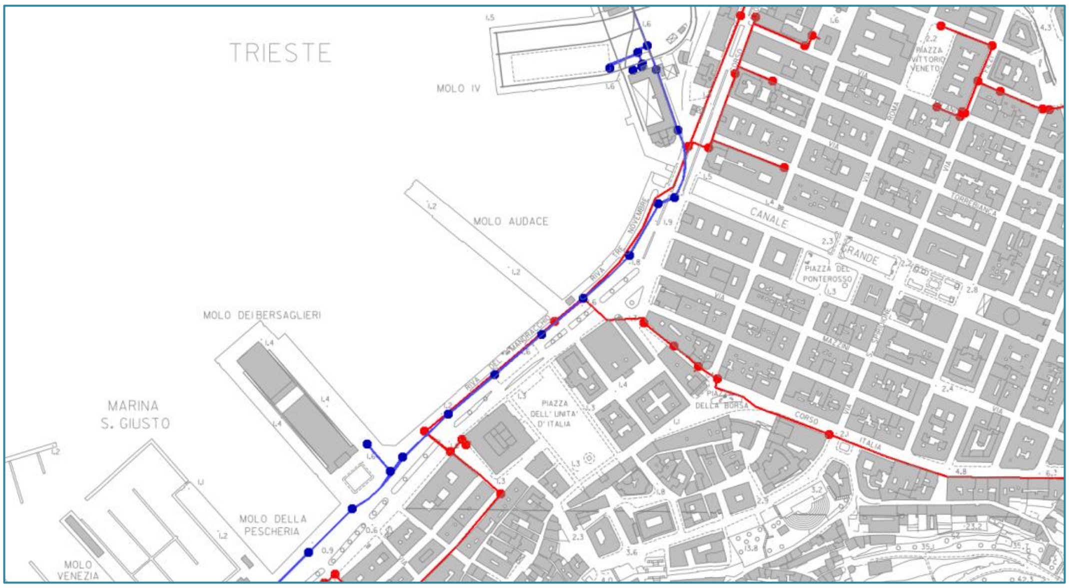
With this constraint, the Utility Network Profile model has been effectively used to model, as a test case, infrastructure elements of a telecommunication network in a cross-border environment. Figure 8 illustrates elements belonging to two different infrastructure owners in an adjacent and disjointed zone: the Municipality of Trieste and the Northern Adriatic Port Authority – which can be considered as institutions from two different countries inside the Italian territory. The Utility model was expressive enough to describe what is required: a basic not-topological network structure made up by generic nodes and links.

On the opposite, the Extended Profile is not enough expressive to properly model the telecommunications objects. Attribute elements lack descriptions and the object classification is not specific enough.

In order to model the infrastructure and optical components of a telecommunication network in detail, it is necessary to provide an additional (own) model. This needs to be sufficiently expressive to describe a country’s reality. This is, for example, the case for IMKL (Dutch information model for cables and pipes) (Dewyngaert, 2019) and the Italian SINFI, currently used to build the Italian Underground Infrastructure Cadastre.

In particular, the SINFI model is part of a bigger data specification about the contents of the Geo-Topographic Italian Database (SINFI, 2018) where the chapter regarding utilities infrastructure was added as last to complete elements like orography, hydrography, roads, buildings and addresses that can be obtained by conventional digital maps methods (survey and mapping).

Figure 8: Underground infrastructure networks belonging to different owners



5. CONCLUSIONS

5.1. Current state of implementation of the project

Three months before the end of the Project, the main objectives were reached. This includes the successful tests on the common spatial data platform and its open access to external users; the publication of harmonized territorial data (including the implementation of bilingual catalogue of geographical names and the translation into English of metadata) (www.HARMO-DATA-geoportal.eu); and the organisation of two educational workshops (one in Trieste and one in Ljubljana), which involved partners, stakeholders, professional users and students. Furthermore, all the necessary preparatory phases for the signature of the planned protocol were performed.

These activities and the pilot case studies – which have been selected in order to develop and test the outcomes of the project's operational phase – strengthened the collaboration between the members of the partnership and the involved stakeholders. Moreover, the connections with the beneficiaries of the joint actions have been strengthened, too. Numerous dissemination and promotional activities have been carried out, including the organization of seminars and workshops, the publication of leaflets, posters and articles, and the arrangement of public engagement activities involving representatives of public and private bodies, universities and research centres at local, regional and international level, professionals, private citizens and university students.

5.2. Future developments

The cross-border approach will allow to coordinate planning policies related to cross-border areas and to increase the knowledge for effective joint planning and implementation of an integrated land management model. This will be reinforced by the consolidation of relations between public authorities and the exchange of good practices among spatial data managers.

The role out of an INSPIRE-compliant spatial data platform is considered a valuable innovation for the considered geographic area, as the spatial data management in that territory is currently not coordinated. The municipalities selected for the pilot case studies are testing the functioning of the platform, thus preparing the grounds for an effective transfer of the HARMO_DATA solution for the future joint management of the cross-border area.

The involved municipalities will be supported in the future, as they are invited to take part in further meetings and workshops in order to discuss open challenges, and to share best practices on the use of harmonized spatial data.

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