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Transnational Planning Support by the European Geodata Infrastructure INSPIRE

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1 ABSTRACT

In the INSPIRE initiative of the European Union a common spatial data infrastructure is being developed, which in a few years will support the Europe-wide, standardised access to spatial data from different thematic areas. In this context, a special activity is the specification of various data exchange formats, based on the OGC standard GML. Though INSPIRE primarily aims at environmentally relevant data, many of the themes are also relevant for spatial and urban planning. In this context, the paper presents the two INSPIRE data formats for “Buildings” and “Planned Land Use”.

2 INTRODUCTION

In the INSPIRE (Infrastructure for Spatial Information in the European Community) initiative (EU 2007), a pan-European spatial data infrastructure is being developed. In a few years the service-based access on geodata from different functional areas will be possible. This not only comprises visualisation services like Web Map Service (WMS), the pan European exchange of geographic vector data via Web Feature Services (WFS) or Download Services shall be possible as well. For this purpose, standardised data exchange formats based on Geography Markup Language (GML 3.2.1) are being developed for a number of thematic areas.

Though INSPIRE primarily aims at the environmental area, this development is also highly relevant for supporting transnational urban planning or spatial planning. Spatially related planning in any case needs a suited representation of the actual state. For this, it is not sufficient only to provide a suited visualisation model, an automatic interpretation of the data in simulation or analysis tools should also be possible. The semantically enriched, two- or three-dimensional INSPIRE data model for buildings (INSPIRE BU) facilitates the trans-border exchange of information on a city’s building stock. It is expected that such data in future will be an important basis for computer based, spatially related planning processes.

The INSPIRE data format for the planned land use (INSPIRE PLU) aims at representing the results of planning processes in Europe-wide standardised, semantically enriched data format. It is intended that this format facilitates different governmental levels. The range of the supported planning instruments goes from Construction Plans at the development area level (i.e. a few km2), over Zoning Plans at the area of a municipality or a group of municipalities (i.e. several hundreds of km2), up to Structure Plans at regional, state or country level (i.e. several thousands of km2).

The paper first of all will give an overview of history, actual status and time schedule of the INSPIRE initiative. Afterword, the main emphasis will be placed on presenting and discussing the two data formats INSPIRE BU and INSPIRE PLU. The structure of the data models will be presented, and the spectrum of the considered planning-relevant data is discussed. In this context, a number of Europe-wide standardised classification schemata for, e. g. land use categories are of special importance. Finally, the relation of the INSPIRE data formats to comparable international standards (CityGML) or German national standards (XPlanGML) is addressed.

3 THE EUROPEAN INITIATIVE INSPIRE

The European initiative INSPIRE aims “at the establishment of the Infrastructure for Spatial Information in the European Community (...) for the purposes of Community environmental policies and policies or activities which may have an impact on the environment” (EU 2007). This European directive, which meanwhile has been adopted as national legislation in all European Community (EC) Member States, lists 34 relevant thematic fields, segmented into three packages (Annex I – Annex III). Legal basis for the initiative, ensuring that the spatial data infrastructures of the Member States are compatible and usable in a community and trans boundary context, are five Implementing Rules in the areas:

- Metadata – Description of data and services;
- Data Specification – Interoperability of spatial data sets and services;
- Network Services – Specification of performance criteria for download, discovery, transformation and view services;
- Data and Service Sharing – Regulations on access to spatial data sets and services;
- Monitoring and Reporting – Definition of indicators for quality management of spatial data and services, and specification of common provisions for monitoring and reporting.

Though the development of the Implementing Rules is not yet finished, it is obvious that many areas of public administration are affected by INSPIRE. The INSPIRE directive does not require collecting new spatial data, but under special conditions spatial data have to be delivered "INSPIRE-conform" in future. These conditions are: The data are available in digital form, a national law imposes the responsibility of a public authority to collect and distribute the data, and the data can be assigned to one of the relevant thematic areas. This especially means that the specified visualisation and download services have to be supported, and that the data must be delivered in the corresponding data format.

Standardised data formats for the Europe-wide, interoperable exchange of spatial data are being developed for all INSPIRE themes. The formats for the 9 themes in Annex I have already been published at the end of 2010, and the development of the remaining data specifications for Annex II and Annex III is nearly finished. It is expected that the corresponding Implementing Rules will be adopted in October 2013. Based on this decision, the following roadmap for the implementation of INSPIRE in the Member States can be expected:

- From October 2015, all spatial data sets affected by INSPIRE, which have been created or significantly changed after adoption of the Implementing Rules, must be facilitated INSPIRE-conform.
- From October 2020, all spatial data sets affected by INSPIRE have to be facilitated INSPIRE-conform.

The implementation of the INSPIRE directive will surely have a strong impact on the activities of public authorities in Europe, and it will cause high personal and financial efforts. On the other hand, the possibility for a Europe wide, interoperable access to spatial data provides a high potential for improved or even new public services, especially in the area of trans-border urban or spatial planning. The spatial data infrastructure which will be available in a couple of years potentially can be used for several purposes in spatially related planning processes:

- Provision of restrictions or constraints influencing the planning process. This thematic area is e.g. tackled by the INSPIRE topics "Natural Risks Zones" (INSPIRE-NZ 2012), "Elevation" (INSPIRE-EL 2012) and "Protected Sites" (INSPIRE-PS 2009).
- Provision of data on the actual state of the build-up environment. This thematic area is supported by the INSPIRE topics "Buildings" (INSPIRE-BU 2012), "Transport Networks" (INSPIRE-TN 2009) and "Production and Industrial Facilities" (INSPIRE-PF 2012).
- Provision of spatially related planning documents and corresponding cartographic representations, which is supported by the INSPIRE topic "Planned Land Use" (INSPIRE-PLU 2012).

The paper is focusing on the two thematic areas Buildings (chapter 5) and Planned Land Use (chapter 6). The central goal is to present the two corresponding data formats, in order to show which planning relevant information in future is provided by the European spatial data infrastructure.

4 COMMON PROPERTIES OF THE INSPIRE DATA FORMATS

It was a central goal of INSPIRE that the data formats cannot only be used stand-alone, also a problem-suited combination must be possible. Furthermore, in order to facilitate implementation, a common basic structure for all data formats is intended. Therefore, all data models are specified as conceptual models in form of UML class diagrams, based on a common Generic Conceptual Model (INSPIRE-GEN 2012). This generic model itself is based on the family 191xx of ISO norms.

From the conceptual models, encodings in form of XML-schemata are automatically generated using common encoding rules (INSPIRE-Encoding 2012). These rules internally use the GML 3.2 (OGC 2007) and GML 3.3 (OGC 2012) encoding rules for the UML to XML-Schema transformation, and define a few INSPIRE specific rules. The latter mainly concerns the classification of attributes as "mandatory", "optional" and "voidable". While a mandatory attribute must be specified and an optional one may be specified or not, a "voidable" attribute is a mixture of both. Normally, voidable attributes must be specified at least once, but if the corresponding information is not available or unknown, the value may remain empty, but the reason for this has to be stated explicitly.

5 THE INSPIRE DATA FORMAT FOR BUILDINGS

In the INSPIRE specification, buildings are defined as "constructions above and/or underground which are intended or used for the shelter of humans, animals, things, the production of economic goods or the delivery of services and that refer to any structure permanently constructed or erected on its site" (INSPIRE-BU 2012). The specification mentions a number of important use-cases which were considered during the development process. Among these are statistics and census, safety (natural risks, human risks, rescue management), environment (air, noise or soil pollution, energy efficiency, preservation of national heritage), and infrastructure planning or management. A building may be composed of building parts, defined as "a sub-division of a building that might be considered itself as a building" (INSPIRE-BU 2012). Because the modelling of building and building part is identical, only the term "building" is used subsequently.

The INSPIRE BU format can be used with four different profiles, whose dependencies are shown in Figure 1

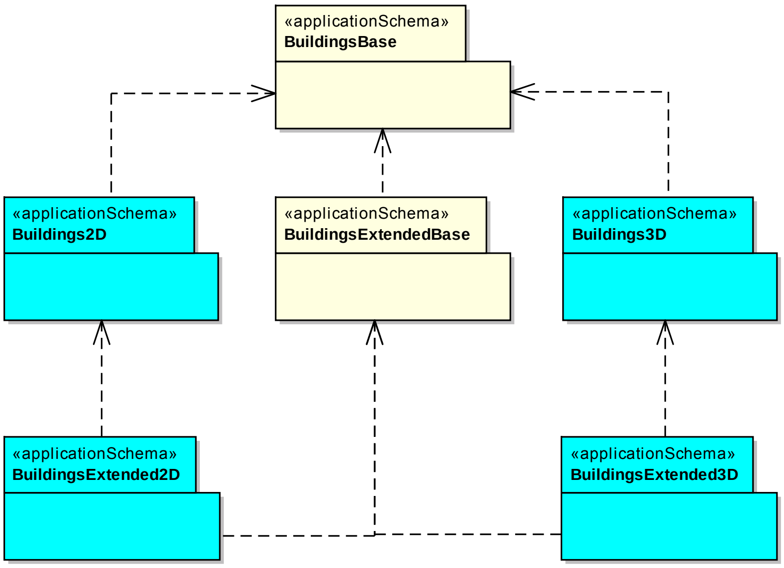

Figure 1: Profiles of the INSPIRE BU data format

The two core profiles (Building2D and Building3D) represent buildings with a reduced set of (normally optional) semantic attributes, which are provided by the (abstract) schema BuildingBase. The following information can be expressed:

- Classification of status (e.g. "functional" or "planned"), nature (e.g. "castle", "church" or "stadium") and current use of a building;
- Important dates in the building's life cycle: Date of construction, of last renovation and of demolition;
- Elevation of the building relative to a well-defined surface (e.g. geoid or water level);
- Height of the building, defined as difference between a well-defined lower reference (e.g. ground level) and a well-defined upper reference (e.g. top of construction);
- Name of the building;

- Information on the building structure: Number of storeys above ground, number of dwellings and number of building units.

The Building2D profile geometrically represents a building as 2D or 2,5D surface (see fig. 2a). A mandatory attribute specifies which element of the building (e.g. “above ground envelope” or “roof edge”) was captured by the surface. The Building3D profile additionally supports a 3D representation of the building’s exterior shell in three different Levels of Detail (LOD) (see fig. 2b). The INSPIRE specification uses the LOD concept of CityGML (CityGML 2012), which means that LOD1 represents the vertical extrusion of a horizontal surface, LOD2 a geometrically generalised representation, and LOD3 a geometrically exact representation.

In the profiles BuildingExtended2D and BuildingExtended3D, both based on the abstract schema BuildingExtendedBase, the corresponding core profiles are semantically enriched. The profiles support the representation of an OtherConstruction, which is defined as “self-standing construction not fulfilling the definition of a building”. Additional attributes are provided, regarding

- the connection of the building to public infrastructure (gas, water, electricity, sewage);
- information on the building’s energy performance and installed heating system;
- cadastral information (e.g. address or parcel);
- material information;
- detailed information on the storey structure above and below ground, including data on storey height, floor and window area, and the number of dwellings belonging to a storey;
- real estate information (official area and value).

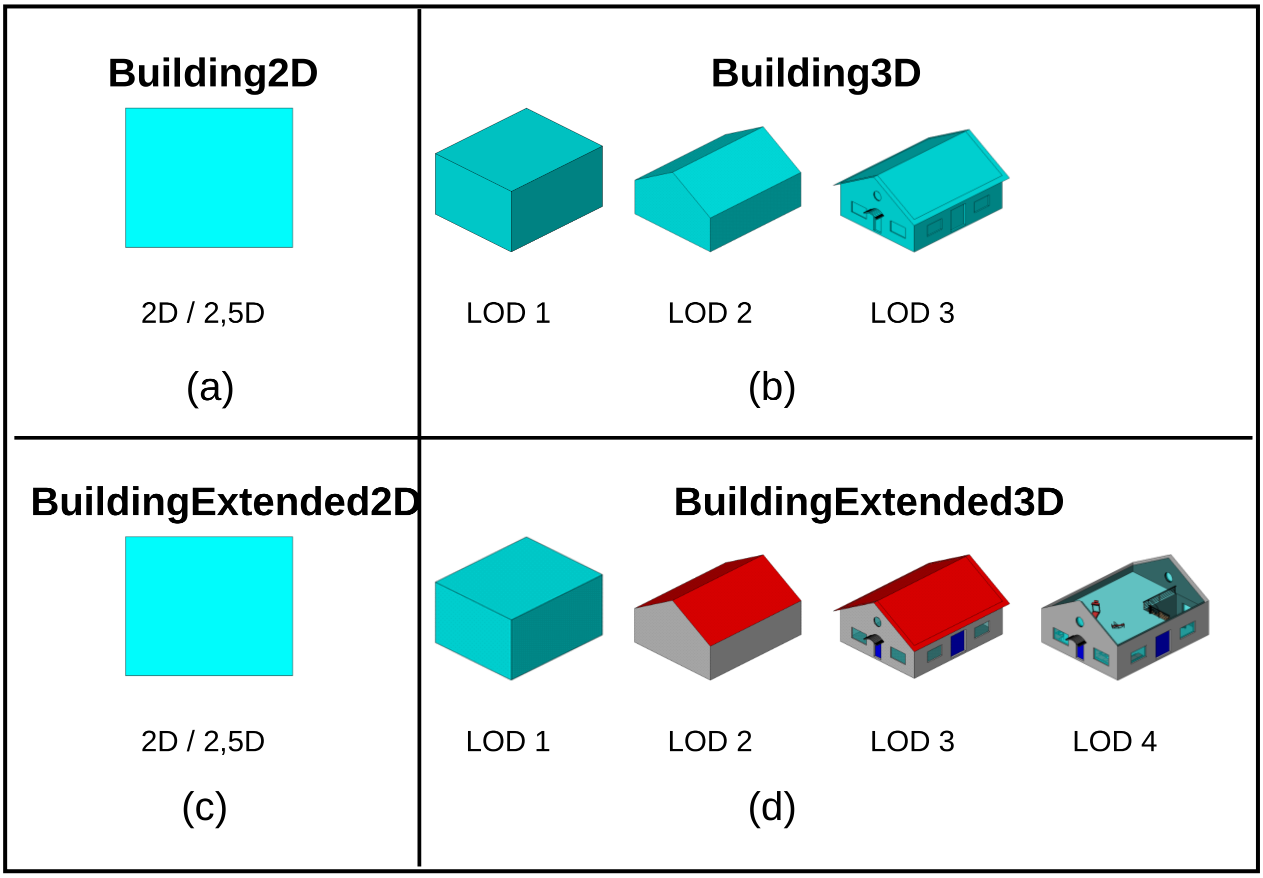

Figure 2: Representation of a building in the four INSPIRE BU profiles

Apart from the extended set of attributes, the representation of buildings in the profiles Building2D and BuildingExtended2D do not differ (see fig. 2a and 2c). This is not the case for the 3D profiles. The BuildingExtended3D profile (see fig. 2d) comprises the whole CityGML Building module and therefore provides, in addition to a purely geometric representation in four different LODs, classes for a semantic classification of the building’s exterior shell by BoundarySurfaces. This means that every part of the geometry is classified as RoofSurface (building roof), WallSurface (building facade), GroundSurface (building ground plate), OuterFloorSurface (part of the exterior shell with orientation pointing upwards) OuterCeilingSurface (part of the exterior shell with orientation pointing downwards) or ClosureSurface (virtual surface used for closing buildings which are not totally enclosed). Furthermore, external constructions or external devices attached to the building may be represented as Installation. In LOD3 or LOD4, BoundarySurfaces may refer to Openings representing doors and windows. In LOD4, also a geometrically and semantically representation of the building's interior structure is possible.

6 THE INSPIRE DATA FORMAT FOR LAND USE

In the relevant EC directive INSPIRE PLU, Land Use is defined as "Territory characterised according to its current and future planned functional dimension or socio-economic purpose (e.g. residential, industrial, commercial, agricultural, forestry, recreational)" (INSPIRE-PLU 2012). Land Use is split up into two different types: Existing Land Use, which objectively depicts the use and functions of a territory as it has been and effectively still is in real life, and Planned Land Use (PLU), which corresponds to spatial plans, defined by spatial planning authorities, depicting the possible utilization of the land in the future (INSPIRE-PLU 2012).

The scope of the INSPIRE PLU specification is giving the exact spatial dimension of all the elements a spatial plan is composed of. Spatial planning is performed at several governmental levels and the cartographic expression of the regulation differs in its graphical expression as well as the concepts that are represented. The specification distinguishes between three different types of plans (INSPIRE-PLU 2012):

- Structure Plans at a level of a wide area (several thousands of km², i.e. a country, a state, or a region), which outline the spatial structures and development in pursuance of spatial planning goals.
- Zoning Plans at a level of a municipality or a group of municipalities (i.e. several hundred of km²) cartographically representing the zoning and supplementary regulations (such as easements). Zoning refers to a partition where the planned land use is depicted. Supplementary regulations overlap the zoning where it exists and provide additional information and/or limitations to the development of the area.
- Construction Plans at a development area level (i.e. few km²) cartographically representing the actual geographical objects that will be created such as building, parking lots, gardens.

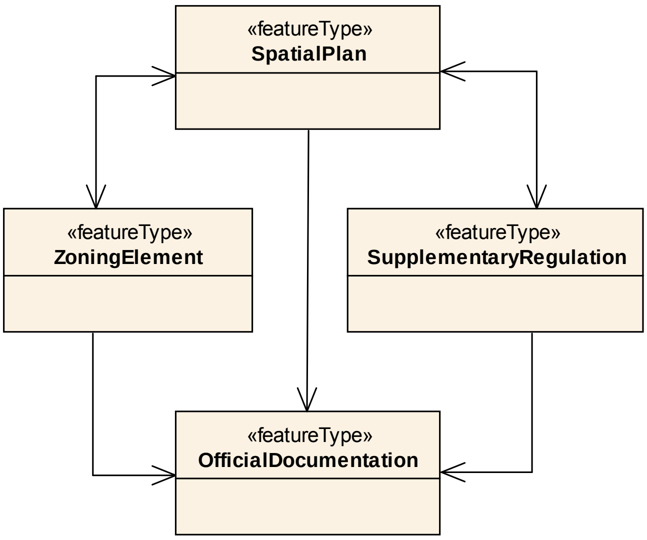

Figure 3: Basic structure of the INSPIRE PLU data model

The basic structure (without attributes) of the INSPIRE PLU data model is shown in figure 3. There are four different feature types: SpatialPlan representing a spatial plan as a whole; ZoningElements representing planning elements of the zoning layer; SupplementaryRegulation for additional planning elements overlapping the zoning layer, and OfficialDocumentation representing documents or raster images, assigned to the plan as a whole or to single elements.

6.1 Representation of a Spatial Plan – SpatialPlan

A mandatory attribute of the class SpatialPlan is the surface geometry, outlining where the planning document is valid. Additionally, every planning document must have a unique identification, an official name or title, a classification to which level of the public administration it belongs (infraLocal, local, supraLocal, infraRegional, regional, supraRegional, national)), and a classification of the plan type according to national legislation. If available, additional information can be given: Temporal restrictions on the legal validity of the plan, an indication of the status of the planning process (adoption, elaboration, legalForce, or obsolete), a reference to the background map that has been used for construction the plan, and important dates during the process of establishing the plan.

6.2 Representation of zoning objects – ZoningElement

The class ZoningElement represents elements of the zoning-layer, which specify a unique dominant land use for all parts of the planning region. The elements therefore must have a geometrical representation by one or more non overlapping surfaces. For classifying the dominant land use, two schemata represented as hierarchical CodeLists are used: The Europe-wide standardised "Hierarchical INSPIRE Land Use Classification System" (HILUCS), and additionally an EC Member State specific classification schema (LandUseClassificationValue). Additional attributes of class ZoningElement indicate, whether the regulation is legally binding or not, and support the formulation of numerical values or texts, explicitly restricting the indicated land use. By this, e.g. a maximal value for the floor space ratio or a certain roof type may be stipulated.

The HILUCS schema is one of the standard's central components, being used for existing as well as planned land use. It has a hierarchical structure with 98 entries on maximum three levels of hierarchy. Due to the definition of "Land Use", mostly economic classification criteria are used. The first level contains the six categories

- Primary Production: Agriculture, forestry, production of raw materials;
- Secondary Production: Manufacturing industry;
- Tertiary Production: Services, including culture, recreation and sports;
- Transport Networks, Logistics and Utilities;
- Residential Use;
- Other Use, including economically unused land and water areas.

On the next two levels of hierarchy, these categories are refined. As an example, urban parks or other areas used for recreation purposes have to be assigned to the Tertiary Production area, sub-category Culture, Entertainment and Recreation Services, and sub-sub-category Open Air Recreational Areas.

For the HILUCS-classification of zoning information, there are multiple possibilities:

- The specification of one or more HILUCS-values without priority or weighting;
- The specification of several values with specified priorities;
- The specification of several values with quantitative weighting.

The specification states that always the most detailed classification or classifications, which are consistent with the intended land use, must be used.

6.3 Representation of additional information and limitations: SupplementaryRegulation

Any other spatially related content of the plan not belonging to the zoning layer is represented as SupplementaryRegulation. The attributes of this class mostly correspond to ZoningElement attributes. In particular, there are two hierarchically structured classification schemata for the semantic meaning of a SupplementaryRegulation: A Europe-wide standardised schema (SupplementrayRegulationValue), and a specific schema for every EC Member State (SpecificSupplementaryRegulationValue). Geometrically, a SupplementaryRegulation may be represented by points, lines or surfaces either.

In comparison to HILUCS, the SupplementaryRegulationValue schema is more complex and contains 159 categories on 4 levels of hierarchy. The top-most categories differentiate regulation into the themes

- Impact on environment;
- Risk exposure (natural and technological risk areas);
- Heritage protection;
- General interest (this category e. g. comprises easements);
- Land property right (restriction on the usage rights of land property owners);
- Regulations on buildings (restrictions on position, orientation and size of buildings);
- Local, regional, state development policies;
- Social health choices;
- Regulated activities (permitted, restricted and prohibited activities);
- Other supplementary regulations.

6.4 Representation of additional documents and raster images: OfficialDocumentation

As only class of the INSPIRE PLU data model, OfficialDocumentation has no explicit spatial relationship. It is used for assigning textually formulated regulations, raster images, official documents, or legal texts to a plan (SpatialPlan) or to specific elements of a plan (ZoningElement, SupplementaryRegulation).

7 GENERATION OF INSPIRE PLU ON BASE OF THE GERMAN STANDARD XPLANUNG

In the project XPlanung (Benner et al. 2007), the GML-based standard XPlanGML (Benner et al. 2010) has been developed, supporting the exchange of planning documents like Bebauungsplan (BPlan), Flächennutzungsplan (FPlan) or Regionalplan (RPlan), based on German national legislation (BauGB, BauNVO, ROG). On national level, XPlanGML thus supports the same type of information as INSPIRE PLU on European level. Implementation and usage of XPlanung are under way (Krause 2010) and on the technical level there are strong similarities between both standards. Therefore, it is obvious to use XPlanung for the implementation of the INSPIRE directive.

Spatial planning documents are generated with many different software systems. An effective way for producing INSPIRE-conform versions of spatial planning documents is to proceed in two steps (fig. 4): First to produce a XPlanGML version of the plan, which is automatically transformed into INSPIRE PLU in a second step. In order to proceed in this manner, transformation rules between XPlanGML and INSPIRE PLU need to be defined, ensuring that a valid, INSPIRE-conform data can be generated, representing the central content of the plan.

Figure 4: Automatic transformation of spatial plans into the INSPIRE PLU format

It turned out that the transformation XPlanGML INSPIRE PLU is principally possible, and that the major part of the national planning information can also be expressed in the European data format, but the transformation rules are quite complex (Benner 2013). Figure 5 shows as example the zoning plan (FPlan) of Hamburg visualised on basis of an XPlanGML and an INSPIRE PLU model with nearly identical content. The cartographic representation of the XPlanGML model is based on the German Planzeichenverordnung, for the INSPIRE model the portrayal rules of the specification (INSPIRE PLU, 2012) were used.

However, not in any case the total content of a BPlan or FPlan can be transformed. Exceptions are restrictions on the height of buildings, which need a precise definition of the lower reference (e.g. ground surface) and upper reference (e.g. ridge height). This specification is not possible with the INSPIRE PLU syntax. For all XPlanGML Presentations Objects, supporting a problem suited, automated visualisation of a spatial plan, there also exist no counterpart in INSPIRE.

A major deficit of the INSPIRE PLU format is the fact that it does not support any relations between different SpatialPlan objects. XPlanGML supports such relations with the special semantic meaning, that a certain plan modifies, eventually only partial, another plan. This allows keeping the spatial plan and subsequently occurring modifications to be hold in separate data sets, which is common practice in German planning authorities. However, because the INSPIRE data format does not support this feature, for an INSPIRE-conform deliverable the different plan need to be integrated in one XPlanGML data set.

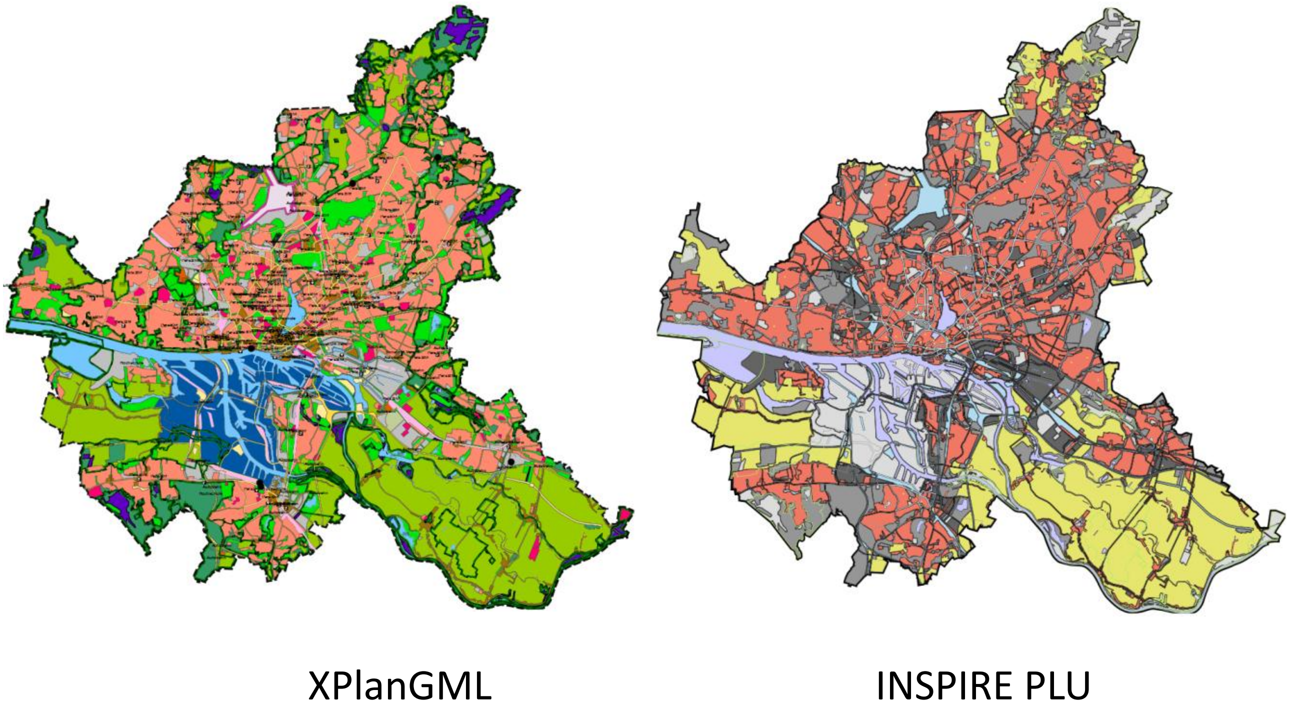

Figure 5: FPlan of Hamburg in XPlanGML and INSPIRE PLU format

8 SUMMARY AND OUTLOOK

In the INSPIRE initiative, the development of a trans-European Spatial Date Infrastructure is under way. In a few years, the Europe-wide access on spatial data from different thematic areas via standardised Internet services shall be possible, as well as the interoperable data exchange based on standardised exchange formats. Many of the thematic areas falling under the scope of INSPIRE are relevant for urban planning and should in future be used to support transnational planning activities.

During the last years, 34 different data exchange formats have been developed. Two of these, the INSPIRE data formats for modelling buildings (INSPIRE BU) and planned land use (INSPIRE PLU) were presented in the paper. The INSPIRE BU data supports four profiles with strongly varying functionality. The differences on the one hand affect the geometrical representation (two- or three dimensional), and of the other hand the amount of semantic information a building may contain. The profiles allowing a three dimensional geometrical representation of the building's geometry use central concepts of the international standard CityGML, e. g. the LOD concept or the classification of different parts of the building's exterior shell as thematic BoundarySurfaces. The main differences between the European and the international standard are that INSPIRE BU supports more non-geometrical, semantic attributes and explicit 2D geometry.

The INSPIRE data format for planned land use (INSPIRE PLU) is designed to support spatial planning documents of various governmental levels. The data format represents a spatial plan as a whole, two different types of spatially related elements of a plan (zoning elements and supplementary regulations), and elements like textually formulated regulations, raster images or legislation texts without explicit spatial representation. Central instruments for specifying the intended land use are four different classification schemata represented as hierarchical CodeLists. Two of them, the "Hierarchical Land Use Classification System" (HILUCS) for zoning elements and the "SupplementaryRegulationValue" system for supplementary regulations are Europe-wide standardised and centrally managed by the EC. As not every speciality of national planning law can be expressed with these schemata, two Member State specific schemata (LandUseClassificationValue for zoning elements and SpecificSupplementaryRegulationValue for supplementary regulations) are provided. Every regulation in a spatial plan may optionally use these schemata, in addition to the mandatory classification due to the central schemata.

The paper finally illustrated the relation of the INSPIRE PLU data format with the German national standard XPlanGML. It turned out that rules can be specified; enabling an automatic transformation of most parts of XPlanGML represented plans to INSPIRE PLU. Some concepts of XPlanGML like explicit data supporting plan visualisation have no counterpart in the INSPIRE format, the corresponding information therefore will not be available on the European level. This causes problems in the context of modifying plans. The German planning legislation and the XPlanGML standard allow that a basic plan and subsequent modifications of this plan can be stored and exchanged as separate data sets. Because the INSPIRE PLU format has no concept for this, an integration of basic plan and modifications needs to be performed prior to the XPlanGML to INSPIRE PLU transformation.

It is expected that the specification of all INSPIRE data formats will be finalised soon, and that the corresponding Implementing Rules, defining the Europe-wide legal basis for the activities, will be adopted in the second half of 2013. For the actual implementation and usage of the Spatial Data Infrastructure, still a lot of work has to be done on European as well as national level. So, registry services supporting the different CodeLists need to be implemented on European and national level. A lot of EC Member State specific CodeLists still have to be specified, and transformation rules defining the mapping between exiting standards like CityGML and XPlanGML and the INSPIRE standards need to be defined.

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