Lecture Notes in Geoinformation and Cartography

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Alias Abdul Rahman
Pawel Boguslawski
François Anton
Mohamad Nor Said
Kamaludin Mohd Omar *Editors*

Geoinformation for Informed Decisions

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Alias Abdul Rahman · Pawel Boguslawski
François Anton · Mohamad Nor Said
Kamaludin Mohd Omar
Editors

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Editors
Alias Abdul Rahman
Pawel Boguslawski
Mohamad Nor Said
Kamaludin Mohd Omar
Faculty of Geoinformation
and Real Estate
Universiti Teknologi Malaysia
Skudai
Malaysia

François Anton
National Space Institute
Technical University of Denmark
Copenhagen
Denmark

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Preface

This book is a compilation of the best papers among the papers presented at the International Symposium and Exhibition on Geoinformation 2013 (ISG 2013), which was held at the Universiti Teknologi Malaysia, Kuala Lumpur campus on 24–25 September 2013. The papers have been reviewed by experts (at least two blind-reviews for each paper) in the field of Geoinformation, including Geomatic Engineering, GPS, Photogrammetry, Cartography, Remote Sensing, LiDAR, GIS, etc., and they formed major discussions in the conference. The conference received around 80 full papers and only 20 % were accepted for this book.

We would like to thank all the reviewers from Australia, Canada, China, Denmark, France, Germany, Greece, Italy, Malaysia, The Netherlands, Poland, Trinidad and Tobago, Turkey, and the United Kingdom. Their great effort in the paper reviewing process is greatly acknowledged.

Last but not least, many thanks go to all local organizing committee members who have contributed significantly to the success of this conference.

We hope this book triggers more advanced ideas for the near future research within Geoinformation.

Enjoy!

Alias Abdul Rahman
Pawel Boguslawski
François Anton
Mohamad Nor Said
Kamaludin Mohd Omar

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The Interoperable Building Model of the European Union

Gerhard Gröger and Lutz Plümer

Abstract The INSPIRE initiative of the European Union (EU) aims at developing a huge spatial data infrastructure (SDI) for authoritative spatial data in Europe. The member states are obligated to provide a large amount of their spatial data in this SDI. The building model is an important aspect among the 34 themes which are covered by INSPIRE. To cope with the heterogeneity of use cases and of data availability in the EU, the model consists of two normative profiles: a 2D and 3D profile. In addition, two non-normative extended profiles are provided. The chapter describes the use cases for buildings and the normative part of the building model in detail, as well as the relation to the standard CityGML for 3D city models, which has influenced the INSPIRE building model significantly. Although the regional scope of INSPIRE is the EU, it presumably will function as a role model also for other regions in the world.

1 Introduction

Currently, a new huge, widespread and multi-faceted spatial data infrastructure (SDI) is developed and build-up in the European Union. This initiative is called *INSPIRE* (Infrastructure for Spatial Information in the European Community)[1] and

[1] See http://inspire.jrc.ec.europa.eu/

G. Gröger (✉) · L. Plümer
Institute for Geodesy and Geoinformation, University of Bonn,
Meckenheimer Allee 172, 53115 Bonn, Germany
e-mail: groeger@igg.uni-bonn.de

L. Plümer
e-mail: pluemer@igg.uni-bonn.de

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was initiated by the European Parliament and the Council.[2] INSPIRE addresses 34 spatial data themes which are needed for various applications of spatial data. However, the focus is set on environmental applications. The aim of INSPIRE is to provide metadata and spatial data in an interoperable way across country and system boundaries. In particular Geo-Web-Services such as Web Feature Services (WFS) (Vretanos 2010) will be employed.

An essential prerequisite for interoperable access are unified, harmonized data models. To cover the applications targeted by INSPIRE, manifold data models are needed. For 34 themes, corresponding data models have been developed. In a first phase (called Annex I) which was completed in 2010, unified models for the following basic themes have been designed: Administrative Units, Cadastral Parcels, Geographical Names, Hydrography, Protected Sites, Transport Networks, Addresses, Coordinate Reference Systems, and Geographical Grid Systems. Based on these models, a second phase (Annex II & III) is conducted which covers themes such as Agricultural/Aquaculture and Production/Industrial Facilities, Buildings, Elevation, Energy Resources, Environmental monitoring Facilities, Geology, Human health and safety, Land cover and use, Natural risk zones, Oceanographic geographical features, Orthoimagery, Population distribution, Soil, Statistical units, and Utility and Government Services. The specifications of the second phase have been completed in 2013.

The theme *Buildings* plays a crucial role for a large number of relevant spatial applications from many fields such as simulation of noise, of water flood or of air circulation, for the computation of population for statistical units, for communication and construction purposes, risk assessment and management, to mention only a few applications. Hence, the model for buildings is one important part of the INSPIRE specifications. The model has been developed since 2010 by the *Thematic Working Group on Buildings (TWG BU)*, in which 15 experts from cadastral, mapping and other agencies as well as from universities cooperate.[3] In a first step of the modeling process, the group analyzed various use cases for buildings in the European Union and collected the corresponding requirements for the model. Afterwards, existing models for buildings—either national models such as the German cadastral model (AAA) (AdV 2009) or international standards such as CityGML (Gröger et al. 2012; Gröger and Plümer 2012), Industry Foundation Classes (IFC) (buildingSMART 2007), Land Administration Domain Model (LADM) (ISO TC 211 2012), ISO 6707 (Building and Civil Engineering) (ISO/TC 59/SC 2 2004) and DGIWG Feature Data Dictionary (DFDD) (DGIWG 2010) were analyzed in order to check whether the models or particular concepts are suitable for the INSPIRE building model.

The INSPIRE building model consists of a normative part (profiles *Core 2D* and *Core 3D*) which are included in the Implementing Rules and will be legally

[2] INSPIRE was initiated by the Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007.

[3] The first author of this chapter is member of the TWG BU.

binding for the member states. The extended profiles (*Extended 2D* and *Extended 3D*) are in contrast optional. It should be noted that INSPIRE covers only spatial data which is already available in the member states or which can be derived from existing data at reasonable costs. The gathering of new data is not required by INSPIRE.

This chapter provides a detailed description of the normative part of the building model (profiles *Core 2D* and *Core 3D*) and of the intended use cases of the model. Furthermore, an overview on the extended profiles is given. Current version of the building model is v. 3, release candidate 3, see INSPIRE TWG BU (2013).

The rest of this chapter is organized as follows: In Sect. 2, the results of the analysis of use cases for buildings are presented, as well as the resulting requirements for the building model. Section 3 is devoted to the description of the building model. The normative profiles are presented in Sects. 3.1–3.3 and the non-normative, extended profiles in Sect. 3.4. The chapter ends with concluding remarks, an outlook on the further development of SDIs in Europe and a discussion of the relation to the international standard CityGML for 3D city models.

2 Use Cases

A detailed and widespread analysis of use cases of building data in the member states of the European Union was conducted by the TWG BU. Aim of the analysis was to explore what building data is used for the use cases and what the requirements for the building model with regard to geometry and attributes are. The results of the use case analysis are as follows (for a detailed description of the use cases see INSPIRE TWG BU 2013):

- **Modeling of buildings as physical phenomena**, which influences air circulation, air pollution, wind, water flood, noise, etc. Building data is used as input for corresponding simulation and propagation models. Mostly, a 3D model of buildings is required, the shape of the roof, information about architecture, and the material of the roof and of the façade.
- **Computation of population for statistical units**, to estimate the number of inhabitants of a building. Required are the footprint area of a building, the current usage (residential, office, etc.), the number of floors or alternatively, the height of the building to estimate this number.
- **Large scale 2D mapping for city maps (tourism, business, …) and medium scale mapping for topographic and land use/cover maps.** The 2D geometry of buildings (often in addition the geometry of building parts), the building nature, and the name of the building are required. Constructions which are not considered as buildings are important for this use case as well.
- **3D models for communication and construction purposes**. For this use case, the three-dimensional geometry of the building has to be provided, as well as the

positions of walls, roofs surfaces, and openings. In addition, the material of the roof, of the façade and of the building's structure and textures for walls and roofs are required.

- **Safety: Buildings as obstacles for air navigation and as landmarks to support marine navigation**. The geometry and height/elevation of buildings and other constructions (chimneys, antennas, wind turbines, ...) and their qualification as landmark are needed for this use case.
- **Risk assessment/management: Assessment of risks in order to take protection and rescue measures**. Risks may be caused by floods, earthquake, landslides, and fire. Required is information on the current usage of buildings, in particular the service type (schools, hospitals, rescue services, ...) or the qualification as residential building. Furthermore, the material of the structure and of the façade, the number of floors, the description of floors, openings, and the height above ground are needed. The dates of construction and of last renovation help to assess the vulnerability of the building, and the external reference to corresponding representations of the building/construction in other data sets is useful to obtain further information on the building/construction. For risk management, constructions such as tunnels and bridges, open air pools, buildings with flat roofs (helicopter landing), addresses, the 3D representation of openings, internal and external installations (stairs, lifts), rooms and building units are needed in addition.
- **Urban Expansion/Urban Atlas:** For this use case, the classification of buildings or constructions as industrial site, sewage plant, farming industries, public service (school, university, church, ...), dam, bunker, acoustic fence, leisure facility is needed.
- **Urban monitoring (demography, energy, water, ...) and urban planning:** For buildings, the detailed 2D geometry, the height above ground, the material of roof/façade, the official area are required.
- **Environment (noise, soil, air quality, energy/sustainability, ...)**: For noise simulation, the 2D geometry, the height above ground (alternatively the coarse 3D geometry), the roof type, the material of roof/facade, the service type (school, hospital, ...), and the number of dwellings are required. For estimating the energy performance of buildings[4], the 2D geometry, the official area, the usage, the number of floors, the date of construction and the external reference are needed. The result of the estimation should be represented as attribute of the building (energy performance). In order to promote the reduction of CO_2 emissions, the indoor model of a building (LoD4 in CityGML)—geometrical descriptions of rooms and building units—along with information on the material of the roof and of the façade, the heating source, the heating system, installations such as air conditioning units, solar panels or wind turbines) have to be provided.

[4] Energy Performance of Building Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010.

- **Infrastructure planning (planning the location of a new service, …):** For example, for planning a new wind farm, the current use and the 2D geometry of buildings are needed (to exclude, for example, locations in a 500 m buffer around residential buildings), as well as the locations of constructions such as castles, churches or other protected sites which might generate constraints for wind farms.

The result of the use case analysis was the starting point for the design of the building model. In the following section the building model is introduced which was designed to meet these requirements.

3 The INSPIRE Building Model

The scope of the building model is given by the following definition, which is more or less used in all member states: 'A Building is an enclosed construction above and/or underground, used or intended for the shelter of humans, animals or things or for the production of economic goods. A building refers to any structure permanently constructed or erected on its site.' (INSPIRE TWG BU 2013). Civil engineering constructive works which are not enclosed such as self-standing antennas are not considered as buildings, but as *OtherConstructions*. Those objects are covered by the extended profiles (see Sect. 3.4).

Due to the heterogeneous data availability in the EU member states and due to heterogeneous requirements of the use cases for buildings, one single model would not be appropriate. Instead, four profiles are provided:

- *Core 2D* profile: feature types for buildings and building parts, basic attributes such as year of construction, external reference, and usage. The geometrical representation is 2D or 2.5D.
- *Core 3D* profile: same semantics as *Core 2D*, but 3D representation from CityGML (Gröger et al. 2012; Gröger and Plümer 2012) in four Levels-of-Detail (in addition to 2D/2.5D geometry).
- *Extended 2D* profile: based on *Core 2D*, feature types for building units and constructions which are not considered as buildings have been added, as well as a rich set of attributes and relations.
- *Extended 3D* profile: the geometry of *Core 3D* is combined with the semantics of *Extended 2D* and with 3D feature types (CityGML version 2.0) for boundary surfaces, building installations, rooms and textures.

The normative core profiles are based on the data which is widely used, widely available and whose harmonization is required at European level (for reporting on Environmental Directives, for example). The non-normative extended profiles are based on data that is widely required but whose harmonization in the EU is not easily achievable at short term. The relations between the four profiles and the application schemas of the INSPIRE building model are illustrated in Fig. 1.

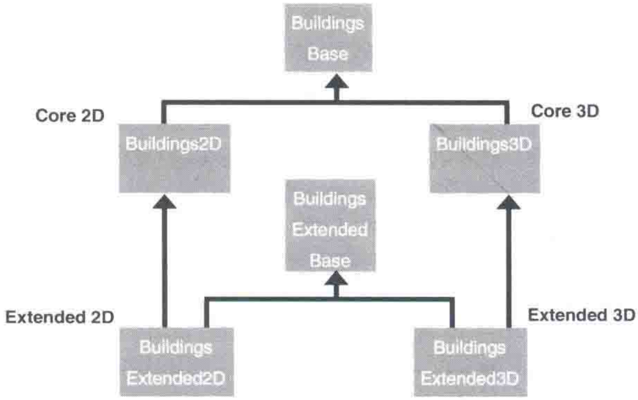

Fig. 1 Structure of the building model. It consist of six application schemas (*grey boxes*) which define four profiles (depicted *black*). An *arrow* denotes a dependency between application schemas: the schema on the *backside* of the *arrow* uses and extends the schema the *arrow* points to (INSPIRE TWG BU 2013)

3.1 The BuildingsBase Schema

The *BuildingsBase* schema collects all types, attributes and relations which are common to all profiles. It defines two feature types: *Building* and *BuildingPart*. The scope of *Building* has already been defined in the preceding paragraph. A Building can be partitioned in different *BuildingParts*. This concept has been taken from CityGML and accommodates the fact that components of a building may differ with regard to geometry (different heights, for example) or thematic properties (different years of construction, different usages, …). However, a *BuildingPart* potentially might be considered itself as a building. In particular, it must rest on the ground. This excludes dormers or towers on *Buildings* from being *BuildingParts*. The UML diagram for the *BuildingsBase* application schema is given in Fig. 2 and the (complex) data types used in the schema are provided in Fig. 3.

Buildings and *BuildingParts* potentially have the same spatial and non-spatial attributes. The attribute values of a part apply only to that part, whereas attribute values of a building refer to all parts. Care should be taken that no contradictions are introduced (for details, see Stadler and Kolbe 2007). If parts are present, the building geometry should be represented for the parts only. The attributes of *Building* and *BuildingPart* are provided by two super classes *AbstractBuilding* and *AbstractConstruction* (the differentiation into two classes is due to the usage in the extended profiles, where constructions inherit from *AbstractConstruction* only). The *inspire id* (the type of this attribute is complex, see INSPIRE Drafting Team Data Specifications 2010) is the unique object identifier published by the responsible body, which may be used by external applications to reference the spatial object. Date and time a spatial object was inserted or changed in the data set, and date and time is was removed are defined by the attributes *beginLifespanVersion* and *endLifespanVersion*: Both attributes are common for all INSPIRE objects (for details see INSPIRE Drafting Team Data Specifications 2010). The *conditionOfConstruction* of a building can take one of the values ‘declined’, ‘demolished’, ‘functional’, ‘projected’, ‘ruin’, or ‘under construction’. The dates

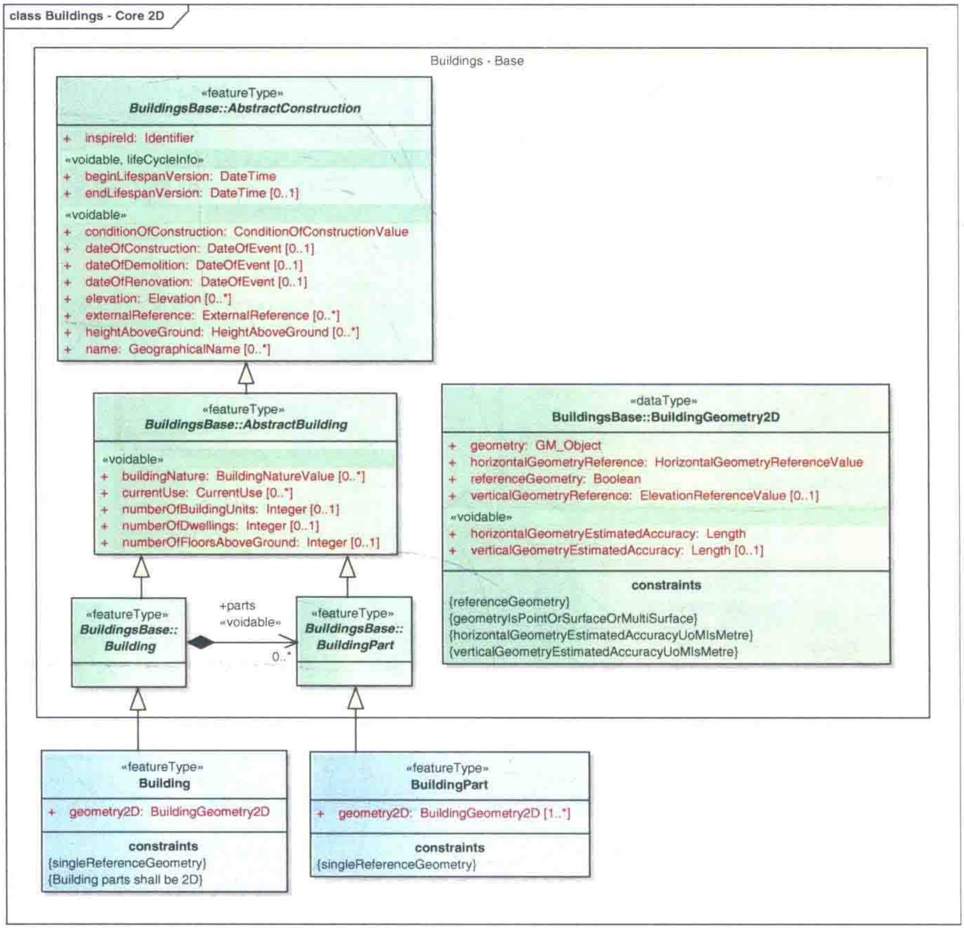

Fig. 2 UML diagram of the *Core 2D* profile. This profile mainly consists of the *BuildingsBase* package (classes enclosed by the *box*). The stereotype ≪voidable≫ for attributes and associations means that a reason for a missing value must (multiplicity at least 1) or can (multiplicity at least 0) be given. For specifying the reason, the following options are provided: 'Unpopulated' (value not part of the dataset maintained by the data provider), 'Unknown' (value is not known to data provider or not computable by the data provider), and 'Withheld' (value is confidential), see INSPIRE Drafting Team Data Specifications (2010)

of construction, of demolition and of renovation can be provided in addition. The *elevation* of a building is defined as the (absolute) z-coordinate of a specific point of the building. The height level of this point is defined by a value of an enumeration data type *ElevationReferenceValue* (see Fig. 3). Some values are *topOfConstruction*, *lowestGroundPoint*, *bottomOfConstruction*, see Fig. 4 for an illustration of all values.

In contrast to the absolute elevation, the *heightAboveGround* denotes the relative height of a building. This concept is often used in 2D and 3D data models (CityGML, for example), but mostly this relative height is not defined precisely