

# CONCEPT FOR BUILDING LICENSING BASED ON STANDARDIZED 3D GEO INFORMATION

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## ABSTRACT:

The increasing use of neutral semantic data models in the areas of spatial data and architectural design suggest a need to perform building licensing automatically or semi-automatically. Building licensing requires that different types of spatial data be integrated into a single model without losing semantic information. During the checking process it may not be possible to compare and check all data parameters directly. Therefore, models must be evaluated and semantically and geometrically transformed when necessary. This paper introduces a potential workflow concept for building licensing. An approach on how to use data from different models and how to transform data for parameter checking is presented, and a brief outlook is given.

## 1. INTRODUCTION

With the introduction of E-Government processes, an increasing number of services provided by public administration will use the support of Internet technology. Due to the EU Services Directive (EU 2006) this trend will even increase within upcoming years. Urban land-use planning and building licensing are two sectors of public administration in which Internet based procedures are rarely used. This is mainly due to the many different legal provisions on federal, state and municipal levels. Additionally, the data involved are very complex and heterogeneous. Most of these data have a spatial context and can be provided via standardized interfaces. Among these are:

- 3D Building Information Models (BIM) in IFC (IFC 2008) or DXF CAD data representing a planned building;
- virtual 3D City Models based on OGC® (Open Geospatial Consortium) CityGML for the existing buildings surrounding the planned construction or the relief of the construction site (Gröger, G., et. al., 2008);
- semantic data models for preparatory or legally binding land-use plans in the XPlanGML format (Benner, J., et. al., 2008).

This paper outlines the concept for a software system that integrates these types of geo information with additional, non-geometric information of the building project. The main function of this software will be to automatically check a “digital” building application for its consistency with legal regulations.

A geometric/semantic data model of the planned construction as well as a formalization of the relevant legal regulations is required for the automatic checking of building applications. With XPlanGML, a semantic data model exists for urban planning documents, which is based on German federal planning law (Baugesetzbuch (BauGB), Baunutzungsverordnung (Bau-VO)). An appropriate formalization does not yet exist for other building laws and building bylaws. Therefore, the first stage of the project will concentrate on checking building applications against the regulations of a XPlanGML-based, legally binding land-use plan.

## 2. RELATED DATA MODELS

### 2.1 Industry Foundation Classes (IFC)

The Industry Foundation Classes (IFC, ISO/PAS 16739), developed by the international alliance buildingSMART, are an open standard for building models representing different domains like architecture, building services and facility management. The model is intended to support the complete life cycle of the building (buildingSMART 2008).

The IFC model consists of objects, properties and relations. The building structure is hierarchically subdivided into spatial elements like projects, sites, buildings and building storeys. All building elements like walls, slabs and roofs, are contained within the spatial elements. Spatial elements do not usually have a geometry (Eastman ,C.M., 1999).

Figure 1 shows an example of a complete IFC model with 4 storeys, 21 spaces and the corresponding building elements.

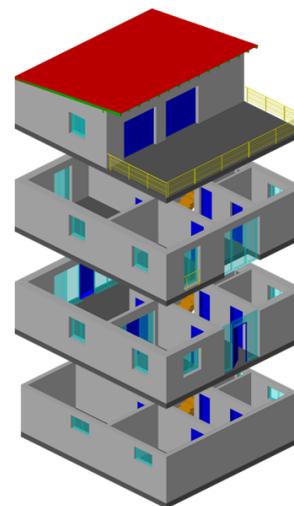


Figure 1. A complete IFC model with building elements (walls, slabs etc.) and building structure information (storeys, spaces etc.)

## 2.2 City Geography Markup Language (CityGML)

CityGML, an international OGC (Open Geospatial Consortium) Standard, is an open data model for the storage and exchange of virtual 3D city models. The model represents features like buildings, water bodies, traffic infrastructure, vegetation and city furniture with their 3D geometry, semantic definition and basic attributes.

CityGML differentiates five Levels of Detail (LoD 0 – LoD 4). Each LoD is related to a certain accuracy and complexity in the geometric and semantic representation. With increasing LoDs the models will become more detailed and semantically enriched (Gröger, G., et. al., 2008). Figure 2 shows a building in four different levels of detail. LoD 1 represents a simple block model. Beginning with LoD 2 the outer shells of buildings are more detailed and are described with boundary surfaces (WallSurface, RoofSurface etc.). In LoD 3 the outer shell has the highest level of accuracy, including door and window classes. Additionally, the building's interior is added in LoD 4.

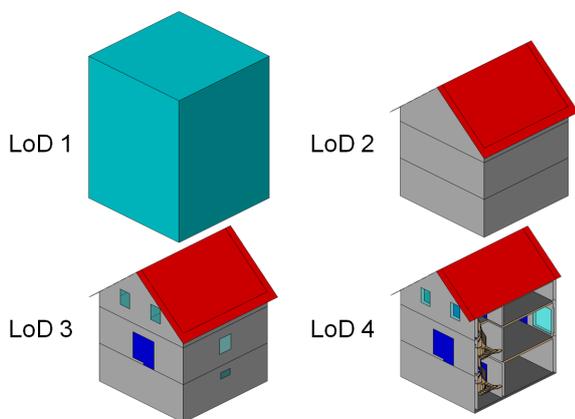


Figure 2. Different LoDs of a CityGML building

In addition, a mechanism called Application Domain Extension (ADE), allows extending the CityGML data model by additional attribute and features. With this mechanism the model can be adapted to special requirements of certain application like building licensing.

## 2.3 Semantic data model for urban planning (XPlanGML)

The national standard XPlanGML (Benner, J., Krause, K.-U., 2007) represents the planned use of a city area from a juridical point of view. The standard is based on the regulations of the German urban planning law: Baugesetzbuch (BauGB), Baunutzungsverordnung (BauNVO) and Planzeichen-verordnung (PlanzV). Objects in XPlanGML are represented as 2D geometry and with corresponding attributes (see Figure 3).

Legal restrictions and regulations may be formulated geometrically (e.g. specification of the area where buildings are allowed) and/or using attributes (e.g. specification of a maximal height, number of storeys or occupancy index of a building). If specific regulations cannot be formalized in XPlanGML by a set of attributes, it is possible to integrate the regulations as free text.

## 3. BASIC CONCEPT FOR AUTOMATIC BUILDING APPLICATION CHECKING

The automatic checking process can be roughly separated into four different steps (Figure 4):

1. Import of the digital building application data in the form of an IFC building model or DXF CAD data.

2. Semantic and geometric analysis and transformation of the imported building model / CAD data and generation of a representation suited for checking algorithms. For this, a CityGML Application Domain Extension (ADE) will be specified.
3. Provision of the municipal geo information needed for the checking process.
4. Automatic checking of the CityGML ADE model data for consistency with the regulations of the urban land-use plan.

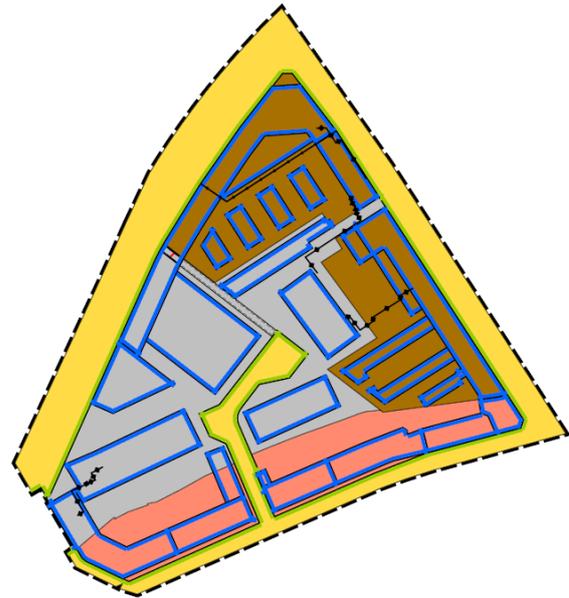


Figure 3. Visualisation of a XPlanGML based urban plan (Freie und Hansestadt Hamburg).

The import format for the digital building application may be an IFC-model or DXF data, which are both supported by most architectural CAD systems. From the imported CAD data, geometric and functional parameters relevant to the checking process must be calculated. Among others these parameters include:

- the relevant ground area of the building, and the ratio between the ground area and the plot area (site occupancy index);
- the relevant storey area of the building, and the ratio between the storey area and the plot area (floor space ratio);
- the relevant building volume, and the ratio between the building volume and the plot area (cubic index);
- the building height and the number of storeys proper;
- the intended type of use for the building and
- the roof type, roof slope and direction of the ridge.

The German planning legislation defines methods for calculating each of these parameters. For an automatic, model-based calculation the CAD data have to provide geometric and semantic information on the internal (storeys, rooms, ceilings) and external structure (balconies, oriel windows, roofs) of the building. The geometries addressed in the building and planning laws will not normally be represented as objects in an IFC or DXF model directly. Therefore, heuristics and geometric algorithms have to be developed for extracting and calculating relevant geometries and parameters from the input model. Initial findings to this affect, concerning the automatic transformation of IFC-models into LOD-1 CityGML models are already available (Nagel, C., 2007). The findings showed that reliable results can only be achieved with IFC models that have a specific structure. Therefore, specific requirements must be defined in order to

maintain a sufficient amount of semantic information and ensure correct operation of geometric algorithms. These special prescriptions may be presented in the form of an IFC Informa-

tion Delivery Manual (IFC 2008a) or a specialized DXF layer and attribute structure.

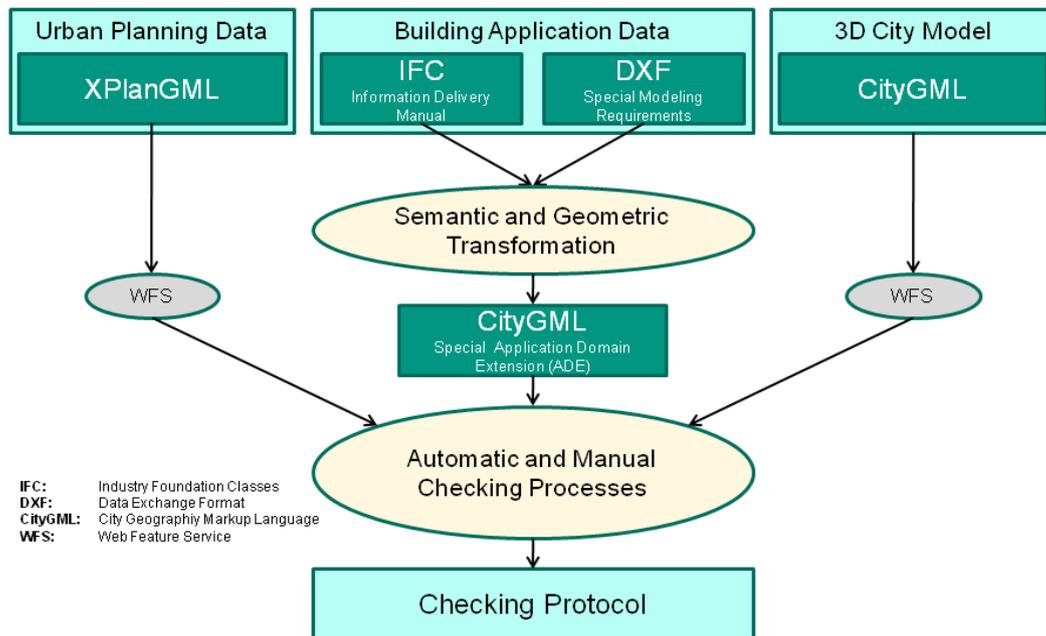


Figure 4. Building application checking process

The checking processes itself will be based on the extracted geometric objects and calculated parameters. A CityGML ADE “Building Application Checking” has to be defined in an internal representation format for the transformed building application. The structure of this ADE is still open, but it will surely extend the CityGML model with classes for building storeys, ridges and various attributes.

The checking process needs XPlanGML versions of the land-use plans valid for the construction site and a CityGML model of the surrounding building construction area. Corresponding data are already available for different areas and some are accessible via standardized Web Feature Services.

All geo data involved are represented in the international standard GML. Therefore integration into a suitable software tool like the IfcExplorer for 3D visualization and processing is easily possible (see figure 5). Geometrical algorithms have to be developed and integrated into the software to compare the 3D CityGML representation of the building application with the regulations of the digital urban plan. The geometric and semantic information of the XPlanGML model will allow the verification of whether:

- building activities are in fact allowed on the construction site;
- the location of the physical structures within the construction window is correct as defined by regulation lines and construction lines;
- the scale of land-use indicated by floor space ratio, site occupancy index and cubic index is valid;
- the building’s use is valid;
- the orientation of the ridge, the roof type and roof slope are allowed;
- the coverage type (open or closed) is correct with respect to surrounding buildings.

Besides these objective criteria that are based on federal planning law, additional regulations may exist concerning land-

use, e.g. protection of nature, monument or noise protection. Furthermore, regulations are frequently presented in an informal, textual style. Though an automatic examination of these regulations is difficult or impossible, the protocol generated as a result of the automatic checking process can summarize additional regulations for a subsequent manual checking.

#### 4. CONCLUSION AND OUTLOOK

Many technical and organizational factors must be considered throughout the realization of the automatic checking of digital building applications presented here. These factors must be resolved in a stepwise manner. Therefore, the first prototype will concentrate on checking the digital building application against the regulations of a digital legally binding land-use plan.

In future stages, the functionality of the system will be extended. For example, consider cases in which no land-use plan exists within the area of a building project, as is common in small municipalities. In these cases the German planning law (§34 BauGB) mainly demands that “a development project is only permissible where, in terms of the type and scale of use for building, the coverage type and the plot area to be built on, the building proposal blends with the characteristic features of its immediate environment”. A semantic and geometric analysis of the building environment represented by a CityGML Model could help to make a more objective evaluation.

In the building licensing process, state building laws and bylaws must be considered in addition to the general planning law. These laws contain regulations concerning such as fire protection, escape routes, thermal insulation, etc. The model-based checking of such regulations will only be possible on detailed BIM models.

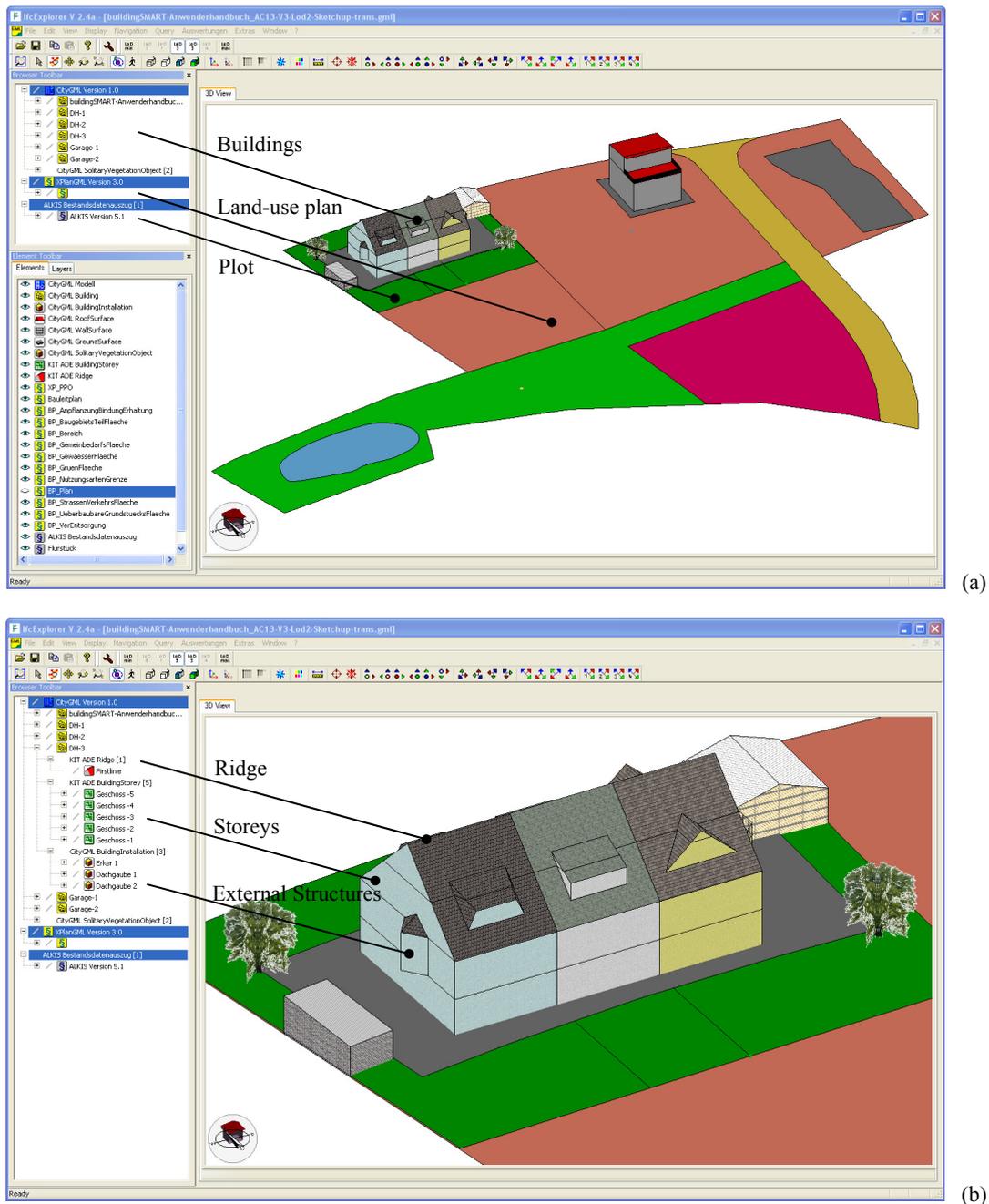


Figure 5. Overlay of the building application geometry with the digital land-use plan. (a) shows the construction window, (b) in a magnification the construction site.

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