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Geographic information — BIM to GIS conceptual mapping (B2GM)

Information géographique — Cartographique conceptuelle de BIM à GIS (B2GM)

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Contents

Page

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Document Preview
ISO/TS 19166:2021
https://standards.iteh.ai/catalog/standards/iso/f686f00c-77a3-4dde-81da-ab0677ff1ade/iso-ts-19166-2021

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Introduction

Building Information Modelling (BIM) contains rich information related to building elements such as doors, walls, windows, MEP (mechanical, electrical, and plumbing) and others. In addition, BIM models may include information about other features than buildings, which are relevant to GIS. From the viewpoint of GIS, there are many benefits related to using BIM information in GIS applications. Some examples are:

a) Indoor service implementation such as emergency management (routing, evacuation path finding under fire situation).

b) Outdoor - indoor linkage service, such as seamless navigation.

c) Effective facility/energy/environment management considering objects related BIM based on GIS.

Although there have been some attempts to harvest the rich information contained in BIM models and use it in GIS, there is no established way to map the information elements between the two modelling worlds. A proper mapping method is clearly required. Before the implementation of the information mapping, however, mapping mechanisms for linking appropriate information elements from BIM to GIS need to be clearly defined. In addition, for the mapping mechanisms to work together, a conceptual framework for the mapping process based on open standards between BIM and GIS needs to be established.

This document provides the conceptual framework for BIM to GIS information mapping and required mapping mechanisms.

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A brief explanation of each mapping mechanism follows:

— BIM to GIS Perspective Definition (B2G PD): supports perspective information representation depending on the specific requirement such as the urban facility management (UFM). "Perspective" depends on the use-case. For example, to manage the urban facilities, the required data should be collected from the various data sources, including BIM model, and transformed to represent in user-specific perspective. PD defines a Data View to extract the data required and transform the information from the various data sources.

— BIM to GIS Element Mapping (B2G EM): supports the element mapping from BIM model to GIS model. As the BIM and GIS model schemas are different, B2G EM requires a mapping rule specifying how to transform from a BIM model to GIS model element.

— BIM to GIS LOD Mapping (B2G LM): supports the LOD mapping from BIM model to GIS model. LOD (levels of detail) in GIS is a deliberate choice of data included/excluded from a model to satisfy certain use cases including visualization. The relevant geometric and other information for the LODs required in the target GIS model need to be extracted/or queried from the BIM model. This can be defined by the LOD mapping ruleset.

This document is applicable to information query services such as urban facility management operation. BIM object visualization in GIS and other application services that require query processing depending on the relationship between BIM and GIS objects, either in the real or virtual world, will be able to use the mechanisms defined in this document for mapping the required information elements between the two systems. Although this document describes mapping information elements from BIM to GIS in general, the primary concern of this document is mapping BIM models to GIS models for visualization.

The conceptual mapping mechanism defined in this document uses existing international standards such as Geography Markup Language (GML) (ISO 19136-1) and Industry Foundation Classes (IFC) (ISO 16739-1). The Open Geospatial Consortium (OGC)'s Land and Infrastructure Conceptual Model Standard (LandInfra) (OGC 15-111r1) defines the information model of infrastructure such as roads. As LandInfra has been designed with a common conceptual model between the BIM and GIS communities, transferring information from LandInfra BIM models to LandInfra GIS models should be reasonably straight forward. This document, therefore, concentrates on mapping from BIM models not based on LandInfra.

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Geographic information — BIM to GIS conceptual mapping (B2GM)

1 Scope

This document defines the conceptual framework and mechanisms for mapping information elements from Building Information Modelling (BIM) to Geographic Information Systems (GIS) to access the required information based on specific user requirements.

The conceptual framework for mapping BIM information to GIS is defined with the following three mapping mechanisms:

— BIM to GIS Perspective Definition (B2G PD);

— BIM to GIS Element Mapping (B2G EM);

— BIM to GIS LOD Mapping (B2G LM).

This document does not describe physical schema integration or mapping between BIM and GIS models because the physical schema integration or mapping between two heterogeneous models is very complex and can cause a variety of ambiguity problems. Developing a unified information model between BIM and GIS is a desirable goal, but it is out of the scope of this document.

The scope of this document includes the following:

— definition for BIM to GIS conceptual mapping requirement description;

— definition of BIM to GIS conceptual mapping framework and component;

— definition of mapping for export from one schema into another.

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The following concepts are outside the scope:

— definition of any particular mapping application requirement and mechanism;

— bi-directional mapping method between BIM and GIS;

— definition of physical schema mapping between BIM and GIS;

— definition of coordinate system mapping between BIM and GIS.

NOTE For cases involving requirements related to Geo-referencing for providing the position and orientation of the BIM model based on GIS, there exist other standards such as ISO 19111 and the Information Delivery Manual (IDM) from buildingSMART on Geo-referencing BIM.

— definition of relationship mapping between BIM and GIS;

— implementation of the application schema.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 19103, *Geographic information — Conceptual schema language*

ISO 19107, *Geographic information — Spatial schema*

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ISO 19109, *Geographic information — Rules for application schema*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
application
manipulation and processing of data in support of user requirements

[SOURCE: ISO 19101-1:2014, 4.1.1]

3.2
application schema
conceptual schema for data required by one or more *applications* (3.1)

[SOURCE: ISO 19101-1:2014, 4.1.2]

3.3
class
<UML> description of a set of *objects* (3.9) that share the same attributes, operations, methods, relationships and semantics

[SOURCE: ISO 19103:2015, 4.7, modified — <UML> domain has been added to the entry.]

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3.4
complex feature
feature (3.6) composed of other features

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[SOURCE: ISO 19109:2015, 4.3]

3.5
element
<BIM> component including geometry, property, method, and relationship in a BIM or GIS *model* (3.8).

EXAMPLE In BIM, site, building, wall, door, and room are examples of elements, whereas in a GIS, site, building, wall, room with infrastructure such as road, and bridge are examples of elements.

3.6
feature
abstraction of real-world phenomena

Note 1 to entry: A feature composed of other features is called a "*complex feature*" (3.4).

[SOURCE: ISO 19101-1:2014, 4.1.11, modified — Note 1 to entry modified.]

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3.7
level of detail
LOD
alternate representations of an *object* (3.9) at varying fidelities based on specific criteria

Note 1 to entry: The levels of detail concept of CityGML is widely accepted by the market and by the scientific community. The term "LODX model" (X = {0, 1, 2, 3, 4}) is frequently used to address the complexity of existing city *models* (3.8) and their suitability for specific *applications* (3.1). Buildings are represented by non-vertical polygons, either at roof or at footprint level. In LOD1, volume objects such as buildings are modelled in a generalized way as prismatic block models with vertical walls and horizontal 'roofs'. In LOD2, the (prototypic) roof shape of buildings is represented, as well as thematic ground, wall, and roof surfaces along with additional structures such as balconies and dormers. LOD3 is the most detailed level for the outermost shape of objects. For buildings, openings are added as thematic objects. In LOD4, interior structures (rooms, etc.) are added to the most accurate outer representation, which is called LOD4 but almost identically to the LOD3 outer surface.

Note 2 to entry: It is important to note the distinction between the term LOD (levels of detail) in GIS usage and the term LOD in BIM LOD (Level of Development). LOD in GIS is a deliberate choice of data included/excluded from a model to satisfy certain use cases including visualization. LOD in BIM refers to the maturity of the planning process of the real-world object modelled.

[SOURCE: ISO/IEC 18023-1:2006, 3.1.8, modified — Notes 1 and 2 to entry modified.]

3.8
model
abstraction of some aspects of reality

[SOURCE: ISO 19109:2015, 4.15]

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3.9
object
<UML> object entity with a well-defined boundary and identity that encapsulates state and behaviour

[SOURCE: ISO 19103:2015, 4.25, modified — <UML> domain has been added to the entry.]

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3.10
package
<UML> general purpose mechanism for organizing *elements* (3.5) into groups

[SOURCE: ISO 19103:2015, 4.27]

3.11
perspective
<BIM> definition of the necessary data and behaviours for the use case context

Note 1 to entry: perspective in the construction industry in general, and construction modelling in particular, is more like the common dictionary definition: "the art of representing three-dimensional *objects* (3.9) on a two-dimensional surface so as to give the right impression of their height, width, depth and position in relation to each other".

Note 2 to entry: the use of 'perspective' in this document is similar to the BIM concept of 'model view', where 'Model View Definition' is "A specification which identifies the properties and specifies the exchange requirements" – i.e. what the customer wants/needs in the *model* (3.8) at that stage.

3.12
runtime
<BIM> *element* (3.5) consisting of code and data produced by the compilation of a source element

[SOURCE: ISO/IEC 1989:2014, 4.168, modified.]

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3.13
system
applications (3.1), services, information technology assets, or other information handling components

[SOURCE: ISO/IEC 29134:2017, 3.13]

3.14
system property
customized *system* (3.13) settings used when automatically creating a model

EXAMPLE GUID

4 Abbreviated terms and notation

4.1 Abbreviated terms

B2G EM	BIM to GIS element mapping
B2G LM	BIM to GIS LOD mapping
B2G PD	BIM to GIS perspective definition
B2G CM	BIM to GIS conceptual mapping
BIM	Building Information Modelling
BIM model	Building Information Model
B-rep	boundary representation
ETL	Extract/Transform/Load
FM	facility management
FK	foreign key
GIS	Geographic Information System
GIS model	Geographic Information System Model
GUID	Globally Unique Identifier
OBB	oriented bounding box
PD	perspective definition
PK	primary key
PSet	property set
UML	Unified Modelling Language
URI	Uniform Resource Identifier
XML	Extensible Markup Language

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Document Preview
ISO/TS 19166:2021
https://standards.iteh.ai/catalog/standards/iso/f686f00c-77a3-4dde-81da-ab0677ff1ade/iso-ts-19166-2021

4.2 UML Notation

In this document, conceptual schemas are presented in the Unified Modelling Language (UML). The user shall refer to ISO 19103 for the specific profile of UML used in this document.

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5 Conformance

This document defines the requirements classes in Clauses 7, 8, and 9.

6 Conceptual Framework for BIM to GIS mapping

6.1 General

The BIM to GIS conceptual mapping (B2G CM) is the conceptual framework for object mapping from a BIM model to a GIS model which includes the transform ruleset related to class elements, LODs, and geometries.

B2G CM considers the following:

— The way for users to design, predict and check the results of model integration explicitly.

— The way for users to define, connect and integrate the data they need from a user perspective.

— The way for users to exclude unnecessary data and determine the amount of data needed.

6.2 Conceptual overview

Figure 1 presents a conceptual overview of B2G CM as defined in this document and presents the relationship of the mapping mechanisms.

— Perspective definition for data view. Perspective information representation depending on the specific use-cases such as user facility management. "Perspective" is dependent on the use-case to extract the needed data. PD consists of three mechanisms to extract the external data needed.

— Element mapping from BIM to GIS model. To transform the elements from the BIM model to the GIS model, it is necessary to define the element mapping mechanism that transforms the BIM to GIS model elements. Element Mapping describes the mapping requirement definition related to the element mapping mechanism from the viewpoint of specific use cases.

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— LOD definition and mapping from BIM model to GIS model. The LOD models define a visualization mechanism. However, there is no LOD schema in BIM objects defined in the BIM model, ISO 16739. To represent BIM geometry in a GIS, LOD information can need to be extracted from the BIM model.

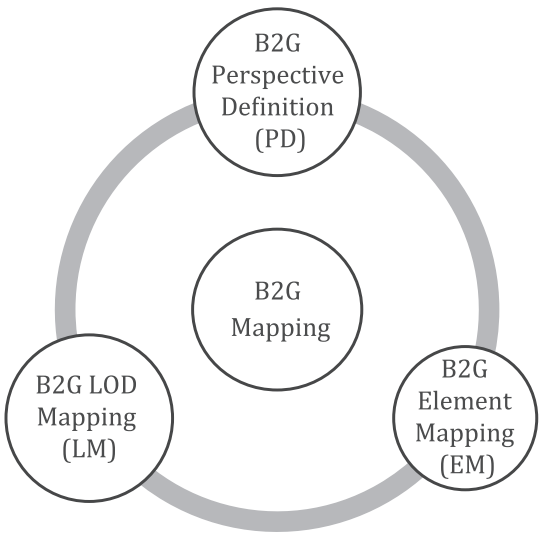

Figure 1 — B2G CM Conceptual Overview

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