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**Geographic information — BIM to GIS  
conceptual mapping (B2GM)**

*Information géographique — Cartographie conceptuelle de BIM à  
GIS (B2GM)*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## 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.

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.

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*

### 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.]

#### 3.4 complex feature

*feature* (3.6) composed of other features

[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.]

### 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]

### 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.]

### 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.]

## 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

### 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.

## 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.

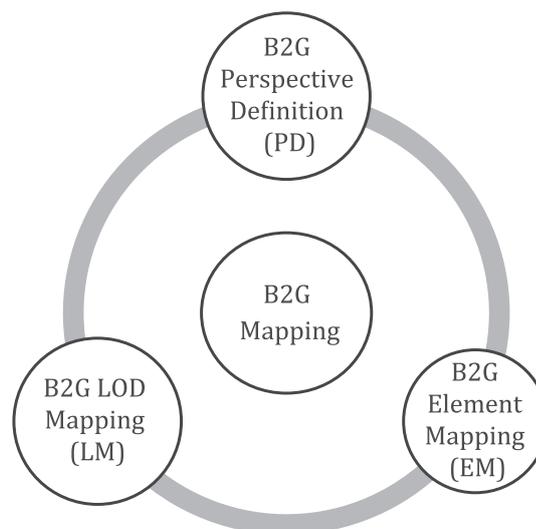
B2G CM considers the following:

- 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.

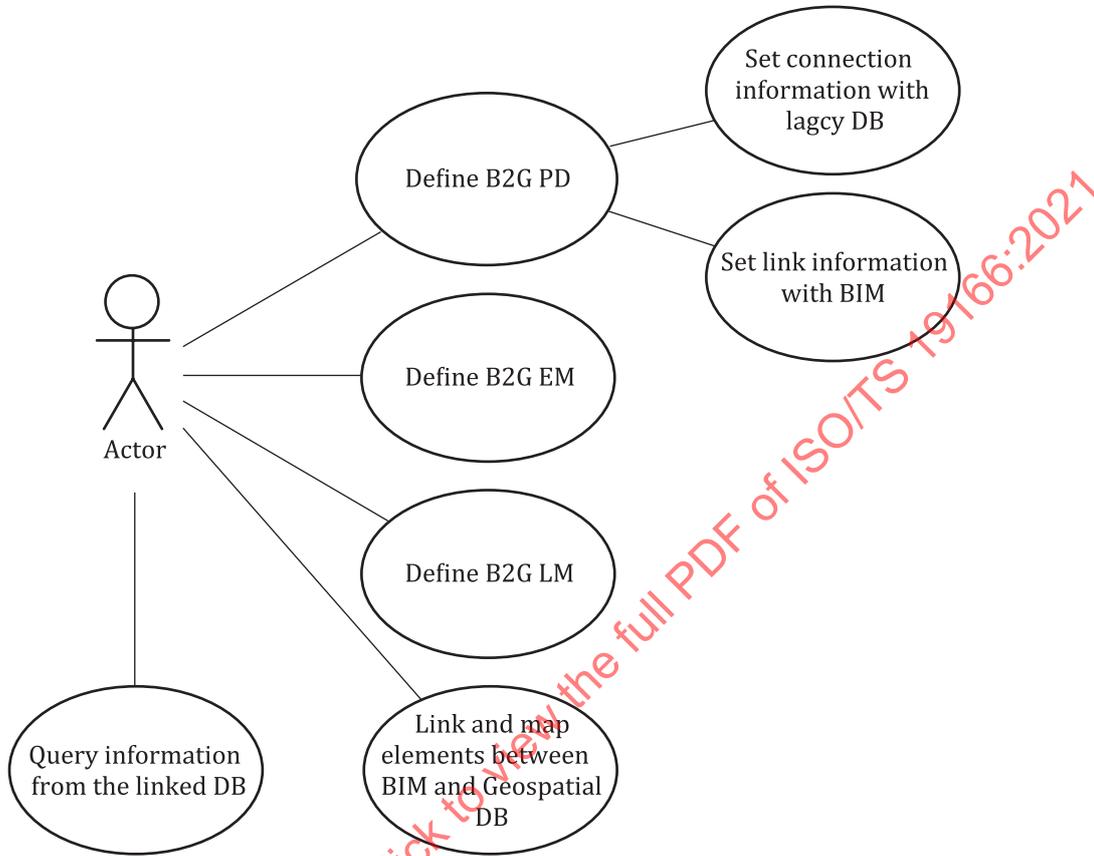
- Perspective definition for data view. Perspective information representation depending on the specific use-cases such as user facility management. "Perspective" is dependent on the use-case to extract the needed data. PD consists of three mechanisms to extract the external data needed.
- Element mapping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

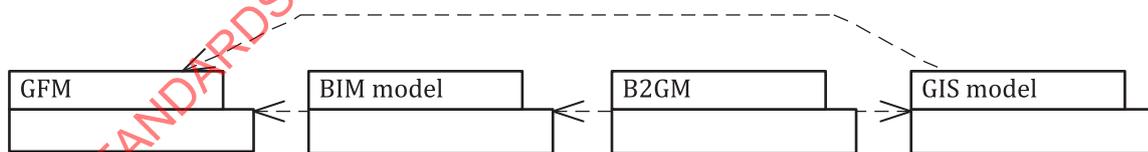
### 6.3 Mechanisms

Using the mapping framework defined in this document, it is possible to query the information from the linked database that utilizes the BIM information. [Figure 2](#) shows use cases of querying information from an integrated database that includes both GIS and BIM information elements.



**Figure 2 — Link database and integrated query based on B2G CM use cases**

B2G CM supports BIM model-to-GIS model mapping under the BIM and GIS model requirement scope in [Table 1](#). The geometry of the BIM and GIS models should be able to define the B-rep by referring to ISO 19109 GFM (general feature model) and ISO 19107 spatial schema, as shown in [Figure 3](#).



**Figure 3 — BIM and GIS model requirement**

The minimum information requirements for BIM model-to-GIS model mapping by model package are defined in [Table 1](#).

**Table 1 — Package Requirements**

Package	Requirements
BIM model	<p>A BIM model shall define the following object information.</p> <p>BM1. BIM_element: capability to define the runtime of construction components, geometry, property, and relationship.</p> <p>BM2. runtime: capability to identify the types of BIM element. The types are building information components such as walls, doors, and rooms.</p> <p>BM3. geometry: capability to contain the solid information including B-rep (boundary representation) based on GM_Solid. The B-rep information must include the topology such as the vertex, edge, loop and faces.</p> <p>BM4. property_set: capability to categorize the attributes of the BIM elements and to define the {name, value type, initial value} pairs.</p> <p>In addition, the system properties of the property information shall be defined. The system properties are automatically created when creating a BIM model. The system properties are the BIM element name and the GUID.</p> <p>BM5(Optional). relationship: capability to contain the relationships between the BIM elements. The relationships follow the UML relationships. The relationships covered in this document are Association, Dependency, and Generalization.</p>
GIS model	<p>A GIS model shall define the following object information.</p> <p>GM1. GIS_element: capability to define the runtime, geometry, property and relationship, which are the GIS model components.</p> <p>GM2. runtime: capability to identify the types of GIS element. The types include the site, building and room, which are the same architectural information components.</p> <p>GM3. geometry: capability to contain the LOD and Solid information based on GM_solid. The B-rep information shall include the topology such as the vertex, edge, loop and faces.</p> <p>GM4. property_set: capability to categorize the attributes of the GIS element and to define the {name, value type, initial value} pairs.</p> <p>In addition, the system properties of the property information shall be defined. The system properties are automatically created when creating a GIS model. The system properties are the GIS element name.</p> <p>GM5(Optional). capability to contain the relationships between the GIS elements. The relationships follow the UML relationships. The relationships covered in this document are Association, Dependency, and Generalization.</p>

The BIM model class structures reflecting the requirements defined in [Table 1](#) can be expressed in UML as shown in [Figure 4](#).

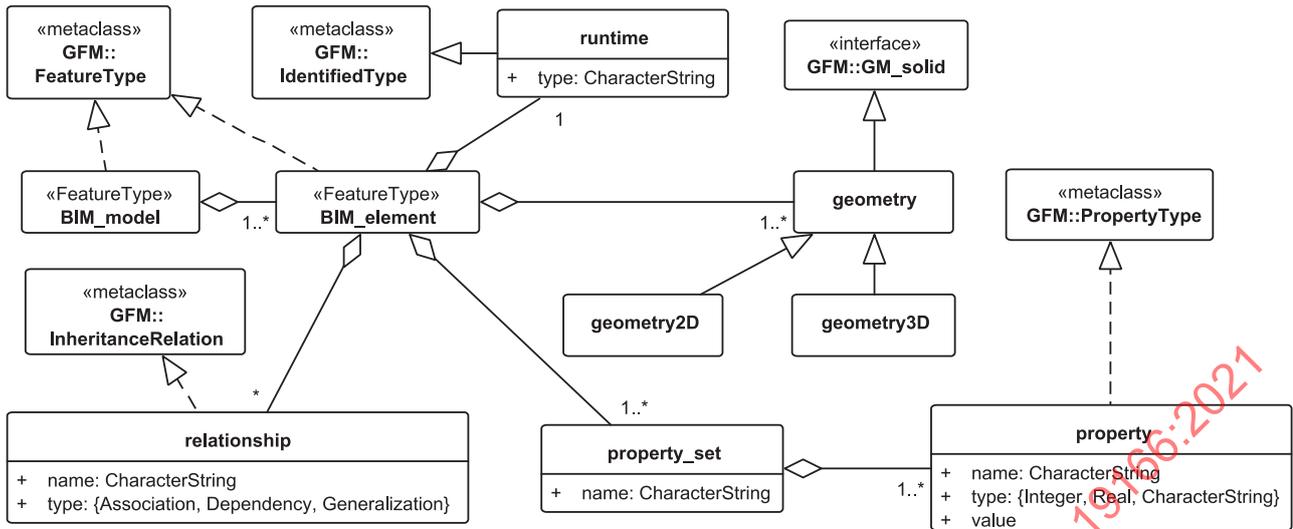


Figure 4 — BIM model conceptual diagram in UML

Similarly, the GIS model class structures reflecting the requirements defined in Table 1 can also be expressed in UML as shown in Figure 5.

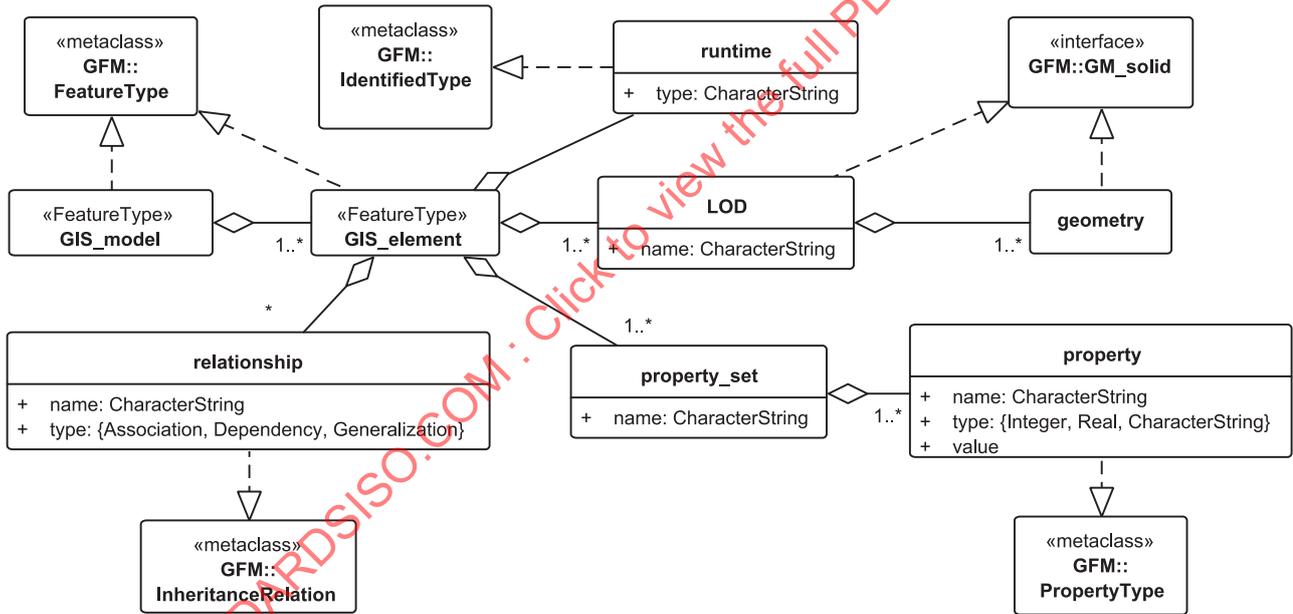


Figure 5 — GIS model conceptual diagram in UML

Package relationships for the B2G CM are shown in Figure 6.

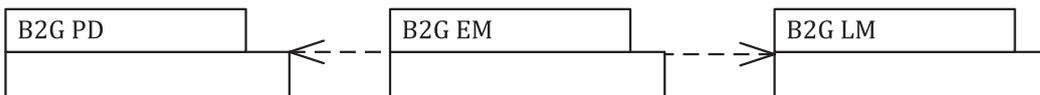


Figure 6 — B2G CM package relationships in UML

To perform the mapping function each package shall meet the requirements specified in Table 2.

**Table 2 — B2G CM package requirements**

Package	Requirements
B2G PD	<p>External data associations and views that require BIM from a use case perspective shall be supported. The external data required for B2G CM shall be capable of being uniquely linked to the PK (primary key), such as the BIM element GUID.</p> <p>The data view shall define an external data item to link to the BIM model element.</p> <p>The value of the associated data item shall enable change into a format that can be used in the use case.</p> <p>A more detailed definition of this operator is defined in <a href="#">Clause 7</a>.</p>
B2G EM	<p>The following mapping operators shall be defined for element mapping. Predefined operators can be used to create mapping rules. The mapping rules can be configured differently depending on the use case.</p> $EM(E_B \rightarrow E_G)$ <p>Where</p> <p><math>E_B</math> is an element of BIM</p> <p><math>E_G</math> is an element of GIS</p> <p>A more detailed definition of this operator is defined in <a href="#">Clause 8</a>.</p>
B2G LM	<p>The following mapping operator shall be defined for LOD mapping.</p> $LM(L_B \rightarrow L_G, LOD_{name})$ <p>Where</p> <p><math>L_B</math> is the LOD of BIM</p> <p><math>L_G</math> is the LOD of GIS</p> <p><math>LOD_{name}</math> is the name of LOD</p> <p>A more detailed definition of this operator is defined in <a href="#">Clause 9</a>.</p>

## 7 BIM to GIS perspective definition

### 7.1 General

B2G PD supports the method for perspective information representation depending on the specific use cases. To define the information perspective for binding and using BIM, GIS and external data sets, B2G PD includes the methods specifying:

- what data is needed related to BIM model use cases,
- how to extract and integrate the data between BIM, GIS and external data sets, and
- how to represent the integrated information.

### 7.2 Mechanisms

The methods listed in [7.1](#) have been divided into stages of information processing such as DataView ([7.2.1](#)) according to perspective, LogicView ([7.2.2](#)) for information conversion, and StyleView ([7.2.3](#)) for information expression in order to acquire information view per perspective.

#### 7.2.1 Data view

The data view expresses the data needed as BIM object properties. Properties are combined with BIM objects and defined with a PK such as a GUID. Properties are expressed by [Formula \(1\)](#). The property to be extracted is formalized into category, property name, property value, and property type using

metadata and scripts. The category is used to represent similar properties in group. Types are defined as integer, real, and character string.

$$\text{Property} = \{\text{Category, Name, Value, Type}\} \tag{1}$$

### 7.2.2 Logic view

The logic view extracts and converts data and is applied using an ETL concept. To process BIM-based FM data, the aggregated FM data in the dispersed database must be extracted, converted and stored in a form that can be easily used. This process is carried out using an ETL platform. Through extracting and refining data from various geospatial data sources, converting data and storing it in the database, the extracted property data can be used to extract or analyse information that supports perspectives per project stakeholder. Extracted data shall have a defined PK such as GUID to be combined with BIM objects.

### 7.2.3 Style view

The style view defines the formatting method in which the data is displayed on a user interface. Formatting can be expressed in the XML form (refer to [Annex C](#)).

[Table 3](#) describes the class requirements of B2G PD style view, data view and logic view class.

**Table 3 — B2G PD class requirements**

Class	Description
PD	PD shall manage the logic view (PD_logic_view), data view (PD_data_view) and style view (PD_style_view).
PD_data_view	The PD data view, similar to a data filter, shall define which BIM element the data set shall be linked with and imported from the external database. PD1. Elements, which are mapped into the data view, shall have a GUID. To connect external data with the BIM elements, PK for data binding shall be defined.
PD_logic_view	The PD logic view shall define how to import the data set from an external database. PD2. An external data source shall be defined as the URI of the <i>external_data_source</i> . The execution path of the operation module that extracts data from URI and loads it into the Pset database of BIM is defined in the ETL_module.
PD_style_view	The PD style view shall define how to format the data to enhance understanding and meaning. PD3. The PD_style_view shall include the formatting operation designed to convert the data value form from the user perspective, together with the unit.
PD_element	If an element to be connected in PD_data_view is defined, it shall have a PK like a GUID.
PD_category	With a property definition to map in PD_data_view, a category to group similar properties can be defined. A category has name. PD4. Category shall have unique name for mapping within PD_element.
PD_property	PD5. Properties shall have unique names for mapping within categories.
PD_propery_style	A style view can include property styles. When a property style is defined, the category and attribute name need to be defined so that the property can be identified. PD6. In this case, the formatting operator is described to represent the property value as the viewpoint of use case in formatting Operation.

Figure 7 presents the B2G PD concept.

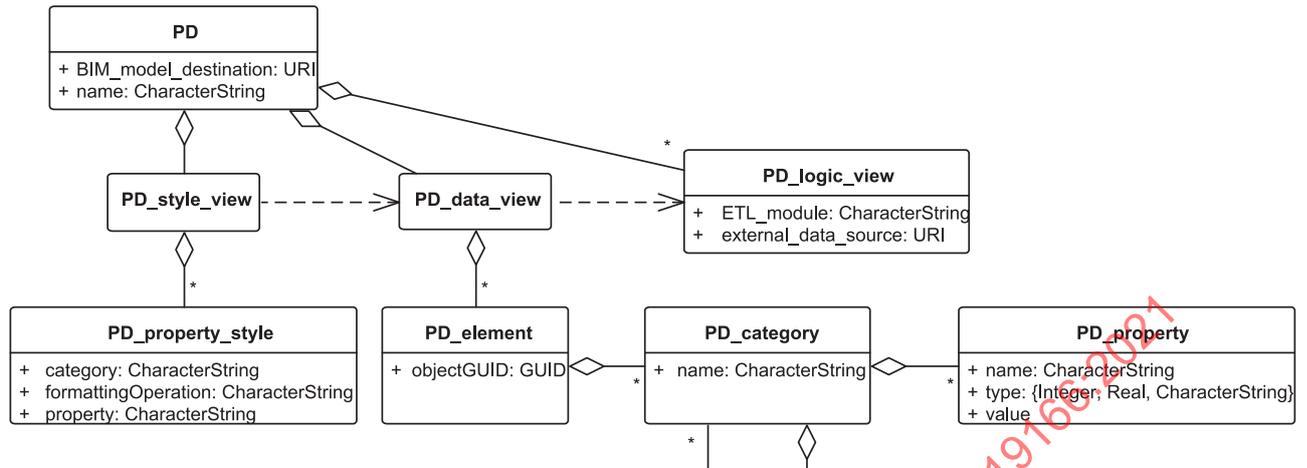


Figure 7 — B2G PD concept diagram in UML

Table 4 is the class member definition related to B2G PD.

Table 4 — B2G PD class description

Class	Member	Description
PD	name: CharacterString	PD name
	BIM_model_destination: URI	URI string pointing to a BIM model destination for integrating the external data
PD_style_view	-	PD_property_style object container
PD_data_view	-	PD_element object container
PD_logic_view	external_data_source: URI	URI string pointing to an external data source
	ETL_module: CharacterString	Executable ETL module name that can transform external data to BIM model destination by using PD_data_view
PD_element	objectGUID: GUID	PK to combine with BIM object
PD_category	name: CharacterString	PD category name
PD_property	name: CharacterString	PD property name
	value	PD value
	type: {Integer, Real, CharacterString}	PD value type that can be Integer, Real, CharacterString
PD_property_style	category: CharacterString	PD property style category name
	property: CharacterString	PD property value that is displayed on a user interface
	formattingOperation: CharacterString	Formatting operation to express PD property value on a user interface

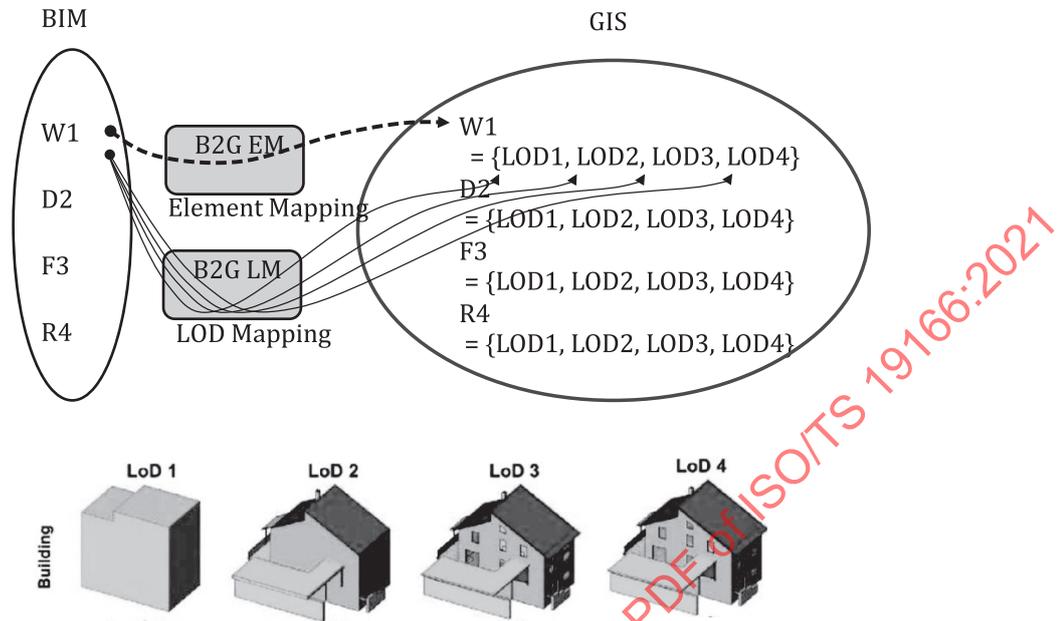
## 8 BIM to GIS element mapping

### 8.1 General

To transform the elements from the BIM model to the GIS model, the object mapping mechanism that transforms the BIM model to GIS model elements shall be defined. B2G EM can describe the mapping requirement definition related to the object mapping mechanism from the viewpoint of specific use-cases.

## 8.2 Mechanism

B2G EM defines the ruleset used to transform elements such as building, floor, wall, window, etc. from the BIM model to the GIS model. It is described in [Figure 8](#).



- Key**
- W1 Wall #1
  - D2 Door #2
  - F3 Floor #3
  - R4 Roof #4

**Figure 8 — B2G EM-based element transform mechanism concept diagram**

[Table 5](#) requirements shall be met for B2G EM.

**Table 5 — B2G EM class requirements**

Class	Description
EM_rule	EM1. The following mapping operators shall be defined for element mapping. Predefined operators can be used to create mapping rules. $EM(E_B \rightarrow E_G)$

To implement the transformation of the elements from the BIM model to the GIS model, a LOD mapping method needs to be considered. For example, a wall in the BIM database can be mapped to a wall in LOD2 or LOD3 of the GIS model depending on specific use cases. It is necessary to consider the LOD mapping method to transform LODs from BIM model to GIS model, as the LOD representation of the element can vary depending on the use case.

B2G EM concept can be represented by using UML as shown in [Figure 9](#).

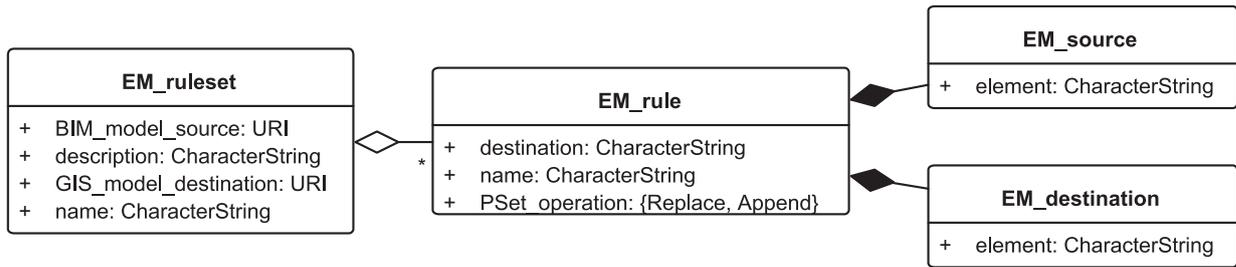


Figure 9 — B2G EM concept diagram in UML

Table 6 is the class member definition related to B2G EM.

Table 6 — B2G EM class definition

Class	Member	Description
EM_rule	name: CharacterString	Element mapping rule name
	PSet_operation: {Replace, Append}	Element mapping operation 1) Replace: when element mapping, the mapping destination is replaced by the mapping source. 2) Append: when mapping, the mapping source is added to the mapping destination.
EM_ruleset	name: CharacterString	Element mapping ruleset name
	description: CharacterString	Element mapping ruleset description
	BIM_model_source: URI	BIM model source URI for mapping from BIM to GIS model
	GIS_model_destination: URI	GIS model destination URI for mapping from BIM to GIS model
EM_source	element: CharacterString	Source element name for mapping
EM_destination	element: CharacterString	Destination element name for mapping

## 9 BIM to GIS LOD Mapping

### 9.1 General

B2G LM defines a method to transform LODs from the BIM to the GIS model, if required. In the GIS model, there may be a LOD schema for representing the LODs which are used to support a wide range of GIS use cases, including information visualization. In order to support the use cases, the geometry in the BIM model should be sufficiently complete.

Visualization can work at various LODs, but other use cases require information that can only be represented in higher LODs. If this information cannot be extracted from the BIM model it needs to be sourced from other data. For example, an early stage “visualization” BIM model cannot have geometries that are complete enough to support flood modelling or have sufficient information about textures to support noise modelling.

The GIS model LOD schema supports various LODs to represent the geometry information depending on an object on GIS. The LODs define a visualization mechanism and information which is similar to the B-Rep structure. However, there is no LOD schema in BIM model. To represent BIM object in the GIS, LOD information needs to be extracted from the BIM model. It can be defined by the LOD mapping ruleset.

## 9.2 Mechanism

Before mapping LODs from the BIM to the GIS model, a mechanism for generating LOD information from the BIM model’s geometry should be considered. B2G LM defines the mapping rule to transform LODs from the BIM to the GIS model.

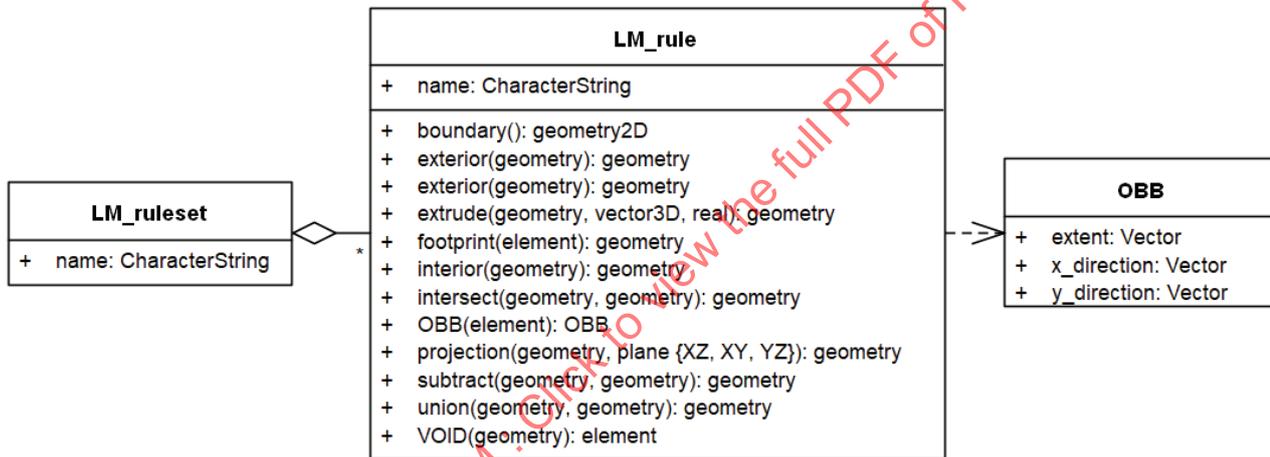
Table 7 requirements shall be met for B2G LM depending on the use case.

**Table 7 — B2G LM class requirements**

Class	Description
LM_ruleset	LM1. The following mapping operator shall be defined for LOD mapping. $LM(L_B \rightarrow L_G, LOD_{name})$

To generate a BIM model LOD, we should define LOD information and transform it to a LOD of the GIS model element. This LOD information definition method can be a ruleset including simple solid operators such as extrusion, projection, and others such as B2G LM ruleset operator.

Figure 10 shows the UML class diagram that defines the LOD mapping (LM) rule.



**Figure 10 — B2G LM concept diagram in UML**

Table 8 shows the operator required for the definition of the B2G LM ruleset. LODs, extracted from BIM, are created from the perspective of the LOD required for GIS, using the LM ruleset operator.

**Table 8 — B2G LM class definition**

Class	Member	Description
LM_ruleset	name: CharacterString	Ruleset name definition
LM_rule	footprint(el: element): geometry	Returns the footprint geometry of Building element <i>el</i>
	OBB(el: element): OBB	Returns OBB (oriented bounding box) of Building element <i>el</i>
	projection(el: element, base: enum plane{XZ, XY, YZ}): geometry2D	Returns the 2D-geometry ( <i>geometry2D</i> ) mapped onto the reference surface that designates the geometry of Building element <i>el</i> in the enumeration plane type
	boundary(g: geometry, base: enum plane{XZ, XY, YZ}): geometry2D	Creates the 2D-geometry <i>g</i> boundary on the reference surface designated in the base, and returns the <i>geometry2D</i>

Table 8 (continued)

Class	Member	Description
	extrude(g: geometry2D, v: vector3D, height: real): geometry	Returns geometry2D <i>g</i> to the geometry protruded as much as the height, using the vector direction <i>v</i>
	exterior(g: geometry): geometry	Extracts only the outside surface of geometry <i>g</i> , then returns to geometry
	interior(g: geometry): geometry	Extracts only the inside surface of geometry <i>g</i> , then returns to geometry
	VOID(e: element): element	Returns only the VOID-type elements of the Building element. The VOID-type elements refer to the windows, doors, and other openings.
	union(g1: geometry, g2: geometry): geometry	Returns the results of the union operation of geometry <i>g1</i> and <i>g2</i> to geometry
	subtract(g1: geometry, g2: geometry): geometry	Returns the results of the geometry <i>g1</i> and <i>g2</i> subtraction operation to geometry
	intersect(g1: geometry, g2: geometry); geometry	Returns the results of the geometry <i>g1</i> and <i>g2</i> intersection operation to geometry
OBB	x_direction: vector3D	Member that defines OBB's X axis
	y_direction: vector3D	Member that defines OBB's Y axis
	extent: vector3D	Member that defines OBB's width, depth and height
vector3D	v[3]: Real	Defines the 3D vector elements

By using the ruleset and operators, the method to generate LODs for each GIS element from the geometry representation of the BIM model can be defined.

To define LODs from the BIM to GIS model semantically, a set of mapping rules is required. The ruleset for B2G LM consists of rules including operators such as simple Modelling functions and set operators (union,  $\cup$ , and intersect,  $\cap$ ).

## Annex A (normative)

### Abstract test suite

#### A.1 B2G CM package requirement satisfaction

##### A.1.1 BIM model

- a) Test purpose: Verify that an application schema or profile instantiates BIM\_model, element, property\_set, relationship and geometry with B-rep data structure as a conceptual model. If the application schema or profile also instantiates property\_set, verify that it includes the property with attribute name and value (refer to [Table 1](#) and [Figure 4](#)).
- b) Test method: Inspect the documentation of the application schema or profile.
- c) Reference: ISO 19166:2021, Table 1, Requirement BM1 — BM4.
- d) Test type: Capability.

##### A.1.2 GIS model

- a) Test purpose: Verify that an application schema or profile instantiates GIS\_model, element, property\_set, relationship, LOD and geometry with B-rep data structure as a conceptual model. If the application schema or profile also instantiates property\_set, verify that it includes the property with attribute name and value (refer to [Table 1](#) and [Figure 5](#)).
- b) Test method: Inspect the documentation of the application schema or profile.
- c) Reference: ISO 19166:2021, Table 1, Requirement GM1 — GM4.
- d) Test type: Capability.

##### A.1.3 B2G CM package

- a) Test purpose: Verify B2G PD, B2G EM and B2G LM are defined. For BIM-GIS conceptual mapping, B2G PD and B2G EM are requirements. B2G LM of each component can be an option depending on the use case (refer to [Table 2](#)). Refer to the test suites in [A.2](#), [A.3](#), [A.4](#) for detailed requirements of each component.
- b) Test method: Inspect the documentation of the application schema or profile.
- c) Reference: ISO 19166:2021, Table 2.
- d) Test type: Capability.

#### A.2 B2G PD requirement satisfaction

- a) Test purpose: Verify that an application schema or profile instantiates PD, PD\_style\_view, PD\_data\_view and PD\_logic\_view (refer to [Table 3](#)). PD\_data\_view shall define data view like data set structure and include a PK such as GUID as the viewpoint of conceptual. If the application schema or profile also instantiates PD\_logic\_view, verify that it includes ETL\_module with an external\_data\_source URI.
- b) Test method: Inspect the documentation of the application schema or profile.

- c) Reference: ISO 19166:2021, Table 3, Requirement PD1 — PD6.
- d) Test type: Capability.

### A.3 B2G EM requirement satisfaction

- a) Test purpose: Verify that an application schema or profile satisfies all the requirements of [A.1.1](#) and [A.1.2](#), and that it supports the element mapping mechanism between the BIM model and GIS model. B2G EM package shall include and define rulesets called EM\_rule, EM\_source and EM\_destination with element class name as the viewpoint of conceptual (refer to [Figure 9](#)).
- b) Test method: Inspect the documentation of the application schema or profile.
- c) Reference: ISO 19166:2021, A.1.1, A.1.2, 8.2, Requirement EM1 (refer to [Table 5](#)).
- d) Test type: Capability.

### A.4 B2G LM requirement satisfaction

- a) Test purpose: Verify that an application schema or profile satisfies all the requirements of [A.1.1](#), [A.1.2](#) and [A.3](#), and that it supports the LOD mapping mechanism between the BIM model and GIS model geometry. B2G LM package shall include and define a ruleset called LM\_rule which can generate LODs as the viewpoint of use case (refer to [Table 4](#) and [Figure 10](#) UML diagram).
- b) Test method: Inspect the documentation of the application schema or profile.
- c) Reference: ISO 19166:2021, A.1.1, A.1.2, A.1.3, 9.2, Requirement LM1 (refer to [Table 7](#)).
- d) Test type: Capability.

## Annex B (informative)

### B2G EM and LM example

[Annex B](#) presents an example to define the ruleset of B2G EM and LM using XML as shown in [Figure B.1](#).

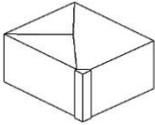
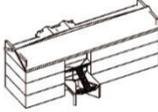
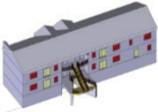
```
<LM>
  <LOD-Generation>
    ...
    <LOD Level='3'> ExteriorSurfaceExtraction(Product) </>
    <LOD Level='4'> LOD3 + IndoorSurface(Product) </>
  </LOD-Generation>
  <SemanticLODMappingRule>
    ...
    <MappingRuleSource='IfcWall*.L3' Destination='WallSurface.L3'></>
    <MappingRuleSource='IfcWall*.L2' Destination='WallSurface.L2'></>
  </SemanticLODMappingRule>
</LM>
```

IFC	CityGML
IFCBEAM,	IntBuildingInstallation OR OuterBuildingInstallation
IFCBUILDINGELEMENTPROXY,	IntBuildingInstallation OR OuterBuildingInstallation
IFCCHIMNEY,   IFCFLOWCONTROLLER,	IntBuildingInstallation
IFCCOLUMN,	IntBuildingInstallation OR OuterBuildingInstallation
IFCCOVERING,	CeilingSurface
IFCCURTAINWALL,	OuterBuildingInstallation
IFCDOOR,	Door
IFCFOOTING,	IntBuildingInstallation
IFCFURNITURE,	BuildingFurniture
IFCPLATE,   IFCRAILING,   IFCRAMP,	IntBuildingInstallation OR OuterBuildingInstallation
IFCROOF,	RoofSurface
IFCSLAB,	FloorSurface
IFCSTAIR,   IFCSTAIRFLIGHT,	IntBuildingInstallation OR OuterBuildingInstallation
IFCWALL,	WallSurface OR InteriorWallSurface
IFCWALLSTANDARDCASE,	Wall
IFCWINDOW,	Window
IFCSPACE,	Room

**Figure B.1 — B2G EM and LM example**

A result of applying the ruleset, the LOD model from IFC to CityGML can be obtained, as shown in [Table B.1](#) from the viewpoint of a specific use case.

**Table B.1 — IFC-CityGML LOD mapping results**

No.	IFC Data	LOD-1	LOD-2	LOD-3	LOD-4
1	Sample#1 (Size: 0,559 Mb)				
2	Sample#2 (Size: 2,257 Mb)				

**Table B.1** (continued)

No.	IFC Data	LOD-1	LOD-2	LOD-3	LOD-4
3	Sample#3 (Size: 28,188 Mb)				

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