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CityGML Urban Planning ADE for i-Urban Revitalization

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i. Abstract

This OGC Discussion Paper introduces the CityGML Urban Planning Application Domain Extension (ADE) published by the Japanese government for the "i-Urban Revitalization" (i-UR).

The i-UR is an information infrastructure dedicated for urban planning to contribute to data-driven urban development and urban revitalization. OGC KML has been utilized more than 10 years for i-UR, however, there were huge requirements for use of application-specific semantics information for urban planning and multi-scale structured information by LOD (Levels of Detail).

By using CityGML ADE mechanism, the Urban Planning ADE provides application-specific semantics information integrating with 3D geometry data to visualize and analyze the urban situation. Additionally, the Urban Planning ADE introduces newly extended LOD, LOD-1 (minus one) for nationwide city models and LOD-2 (minus two) for a worldwide city model to visualize global urban activities and study urban structure by integrating geospatial information and statistical grid information.

This paper describes a brief introduction of i-Urban Revitalization, data model of the Urban Planning ADE and data experiment examples to discuss further utilization of the Urban Planning ADE in urban planning applications.

ii. Keywords

ogcdocs, CityGML, urban planning, urban revitalization, LOD, level of detail, statistical grid, geostatistics

CityGML Urban Planning ADE for i-Urban Revitalization

1 Introduction

1.1 Scope

This OGC® document introduces the CityGML Urban Planning ADE published by the Japanese government as “i-UR 1.2” in Feb 2020 [1]. This Discussion Paper consists of three parts:

- Brief introduction of i-Urban Revitalization
- Data model of the Urban Planning ADE
- Data experiment examples of the Urban Planning ADE

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1.3 Forward

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2 References

The following documents are referenced in this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

OGC: OGC 06-121r3, *OGC® Web Services Common Standard*, 2010

NOTE This OWS Common Standard contains a list of normative references that are also applicable to this Discussion Paper.

OGC: OGC 12-019, *OGC City Geography Markup Language (CityGML) Encoding Standard*, 2012

3 Terms and definitions

For the purposes of this report, the definitions specified in Clause 4 of the *OWS Common Standard* [OGC 06-121r3] and in the *CityGML Encoding Standard* [OGC 12-019] shall apply. In addition, the following terms and definitions apply.

4 Conventions

4.1 Abbreviated terms

The following abbreviated terms are used in this discussion paper:

ADE Application Domain Extension

i-UR i-Urban Revitalization

4.2 Contributions from other documents

This document uses significant parts of the specification document "i-UR 1.2" published by the Japanese government [1]. To reduce the need to refer to that specification, this document copies some of parts of the i-UR 1.2 specification with small modifications.

5 i-Urban Revitalization

5.1 Introduction on i-Urban Revitalization

Urban planning has been contributing to the formation of healthy urban environments, preventing disorganized urban sprawl and encouraging infrastructure development, in Japan. However, urban areas in Japan, which is facing depopulation and an aging society, are at a major turning point. New social issues, such as a rapid increase of empty apartments and lands and non-universal design of facilities, weigh heavily on sustainable development, especially in regional area. Efficient urban management is required and municipalities recognize the significance and importance of compact urban development from the perspective of administrative costs.

The "i-UR" is an information infrastructure for urban revitalization. i-UR allows people to analyze and visualize the situation and problems of urban areas according to the future vision of each area using geospatial information and virtual reality technologies. The quantitative analysis and visualization clearly show the cash-flow and spatial plan of the city and promotes understanding and encourages consensus building among relevant players, e.g., investors, citizens, and developers.

5.2 Structure of the i-UR Data

The data for i-UR (which is called "i-UR Data") is the combination of following data (Figure 1):

- a) 3-dimensional city objects and city model;
- b) Detailed information of city objects for analysis;
- c) Constraints/conditions (e.g., regulation) related to urban revitalization; and
- d) Statistical grid data for regional and global analysis and visualization.

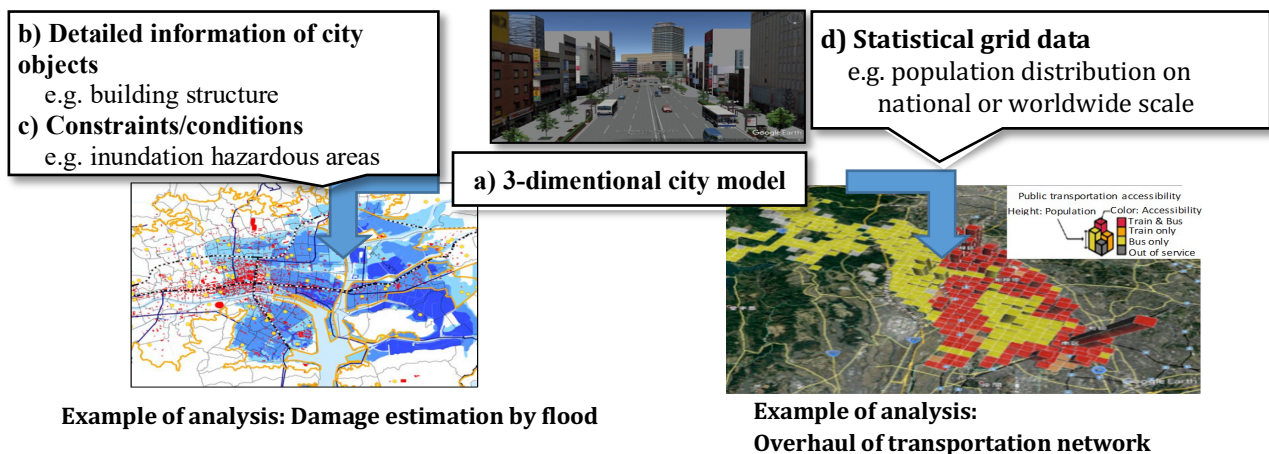


Figure 1 — Structure of i-UR Data

5.3 Data Encoding Specification Activities for the i-UR Data

OGC KML has been utilized for more than 10 years for i-UR and contributed to provide a visual representation of information for consensus-building among stakeholders and successfully encouraged citizen participation in urban planning [2]. OGC KML continues to be used for important parts of urban modeling efforts in Japan and elsewhere.

With time, however, i-UR participants identified requirements to use application-specific semantics information for urban planning and multi-scale structured information by LOD (Level of Detail) that could not be easily supported with OGC KML. To meet these requirements, the data encoding specification for i-UR named as the "Urban Planning ADE" was published by the Japanese government as "i-UR v1.0" in May 2019. Adapting additional needs of users such as municipalities, the ADE has been updated as "i-UR v1.1" in November 2019 and the latest version "i-UR v1.2" in February 2020 [1].

As an encoding specification for i-UR Data, the Urban Planning ADE targets data from items b), c), and d) in the list in Section 5.2; item a) is already defined in CityGML. The ADE is composed of three modules listed below. Each module is tied to each item in Section 5.2 and is an extension of CityGML according to the rules of the CityGML ADE mechanism to ensure data interoperability. Thus, i-UR Data aims to be utilized in various application fields such as disaster prevention, tourism, and to carry out urban revitalization.

Part 1: Urban Object Module

This module targets *b) Detailed information of city objects for analysis* and defines the information as properties of CityGML object.

Part 2: Urban Function Module

This module targets *c) Constraints/conditions related to urban revitalization* and defines constraints and conditions as subclasses of the root class in CityGML.

Part 3: Statistical Grid Module

This module targets *d) Statistical grid data for global analysis and visualization* and defines a statistical grid as subclasses of the root class in CityGML and new Levels of Detail (LOD) for a broad description of city models. This module extends LODs to describe rough city models which do not have to be detailed but should be described with a unified unit among cities. This enables users to analyze and visualize cities under the same conditions.

6 Data Model of the Urban Planning ADE

This chapter describes the data model of each module of the Urban Planning ADE [1][2]. The XML schemas and code lists for each module are already published and can be accessed via the URLs in Annex A and Annex B, respectively.

6.1 Urban Object Module

6.1.1 Overview

Detailed information of buildings, roads, and other objects which constitute urban areas are necessary for the quantitative assessment of the current situation and problems in urban areas. This module defines additional information of urban objects which is necessary for urban assessment as attributes of urban objects and specifies the encoding format of the information. This module is the extension of the existing modules for city objects such as *building*, *land use*, *transportation*, and *cityObjectGroup*.

6.1.2 Object definition

6.1.2.1 Extended properties of Building

Figure 2 shows a part of this module, which extends *bldg::_AbstractBuilding*. A *uro::buildingDetailsProperty* contains detailed information of a building, and a *uro::largeCustomerFacilitiesProperty* contains detailed information for large customer facilities, such as shopping malls, hospitals and universities.

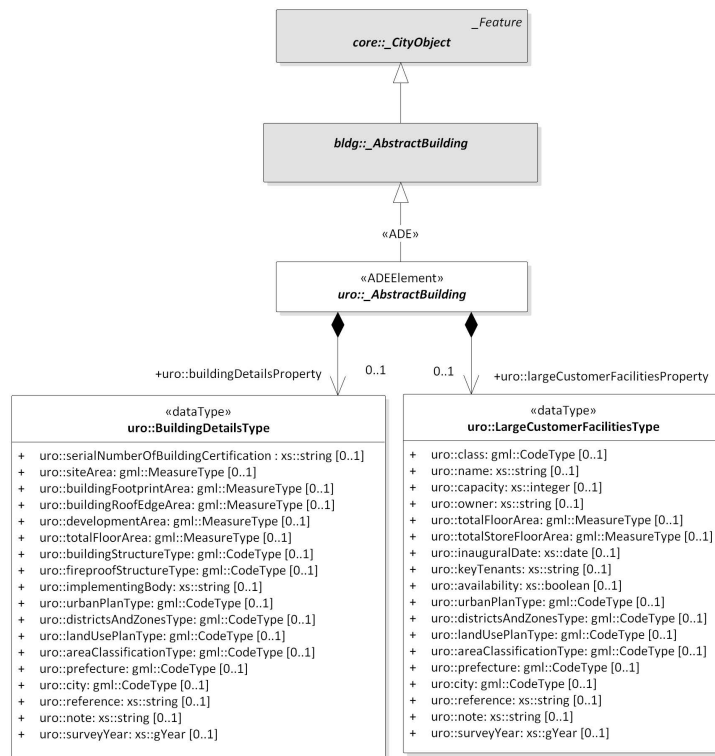


Figure 2 — UML diagram of extended properties of AbstractBuilding. Element names with the prefix *uro* are defined within this module.

6.1.2.2 Extended properties of LandUse

This module defines one extended attribute of *luse::LandUse* as a member of the substitution group *luse::_GenericApplicationPropertyOfLandUse*. Figure 3 shows the extended properties for LandUse module.

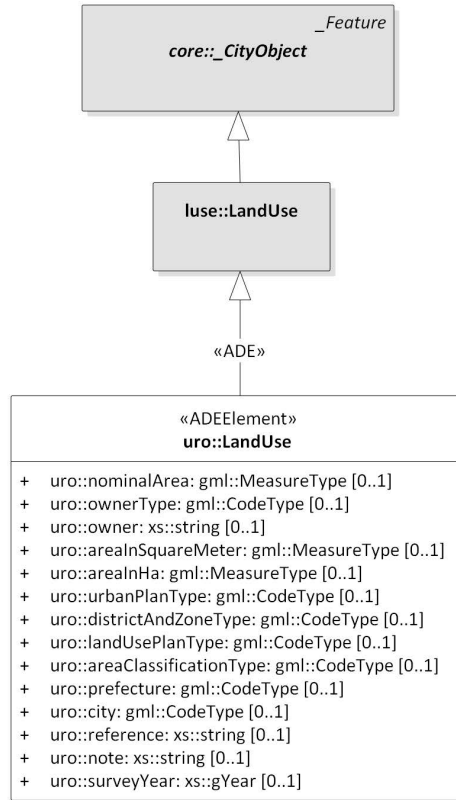


Figure 3 — UML diagram of extended properties of LandUse.

6.1.2.3 Extended properties of Transportation

Transportation objects in i-UR describe a linear network of transportation. Therefore, transportation features in the CityGML Transportation module with LOD0 geometry are applied. Some elements are added as members of the substitution group *tarn::_GenericApplicationPropertyOfRoad* and *tran::_GenericApplicationPropertyOfRailway* to describe detailed information of roads and railways. The data structure of the transportation objects is shown in Figure 4.

A *uro::serviceProperty* describes the operation and service status of transportation. This element works as a type of *uro::serviceProperty*, which is a member of the substitution group *tran::TransportationComplex*. A type *uro::TrafficVolumeType* is a class which describes the number of vehicles crossing a section of road per unit time.

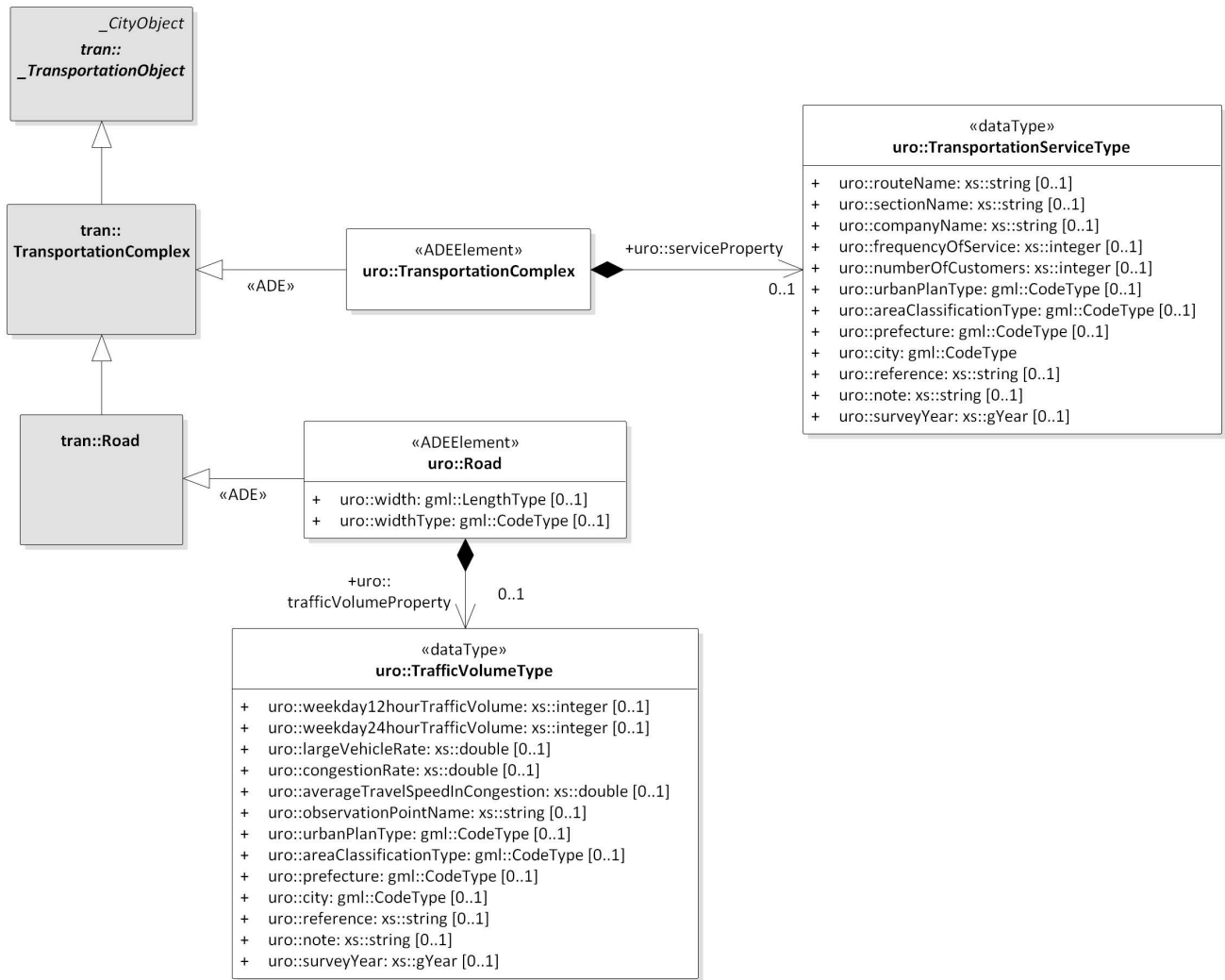


Figure 4 —UML diagram of Transportation.

6.1.2.4 Extended properties of CityObjectGroup

CityObjectGroups are defined as special *CityObjects* and aggregate *CityObjects* as shown in Figure 5. A *grp::CityObjectGroup* inherits attributes from the parent class *core::_CityObject*. The attribute *core::creationDate* shows the date of dataset creation.

Two elements, *uro::fiscalYearOfPublication* and *uro::language* are added as members of the substitution group *grp::_GenericApplicationPropertyOfCityObjectGroup*. A *uro::fiscalYearOfPublication* is used to describe the year when the result of data collection has been published and a *uro::language* clarifies the language used in the city objects.

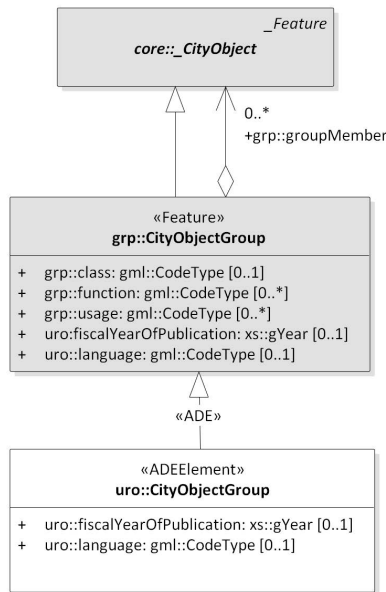


Figure 5 — UML diagram of extended properties of City Object Group.

6.2 Urban Function Module

6.2.1 Overview

Plans and regulations are important information in urban development, landscape preservation, and disaster management. Information related to plans and regulation, such as administrative boundaries and zoning works, are conditions or constraints for spatial planning and are conceptual and virtual objects in urban areas. This module defines conceptual and virtual objects in urban areas as “urban function objects,” which give a meaning to specific area, boundary or position (e.g., Administration area, Urban planning area), and specifies the encoding format of these objects.

6.2.2 Object definition

The Urban Function Module contains constraints and conditions for urban development, which are conceptual and virtual objects, such as administrative boundaries and zoning in urban areas. These objects (hereafter called "urban function objects") are not visible in the real world, but guide and lead city objects such as land use and buildings to their intended state. These types of features are not defined in CityGML, so these feature types are extended from *core::_CityObject*, a root object in CityGML (Figure 6).

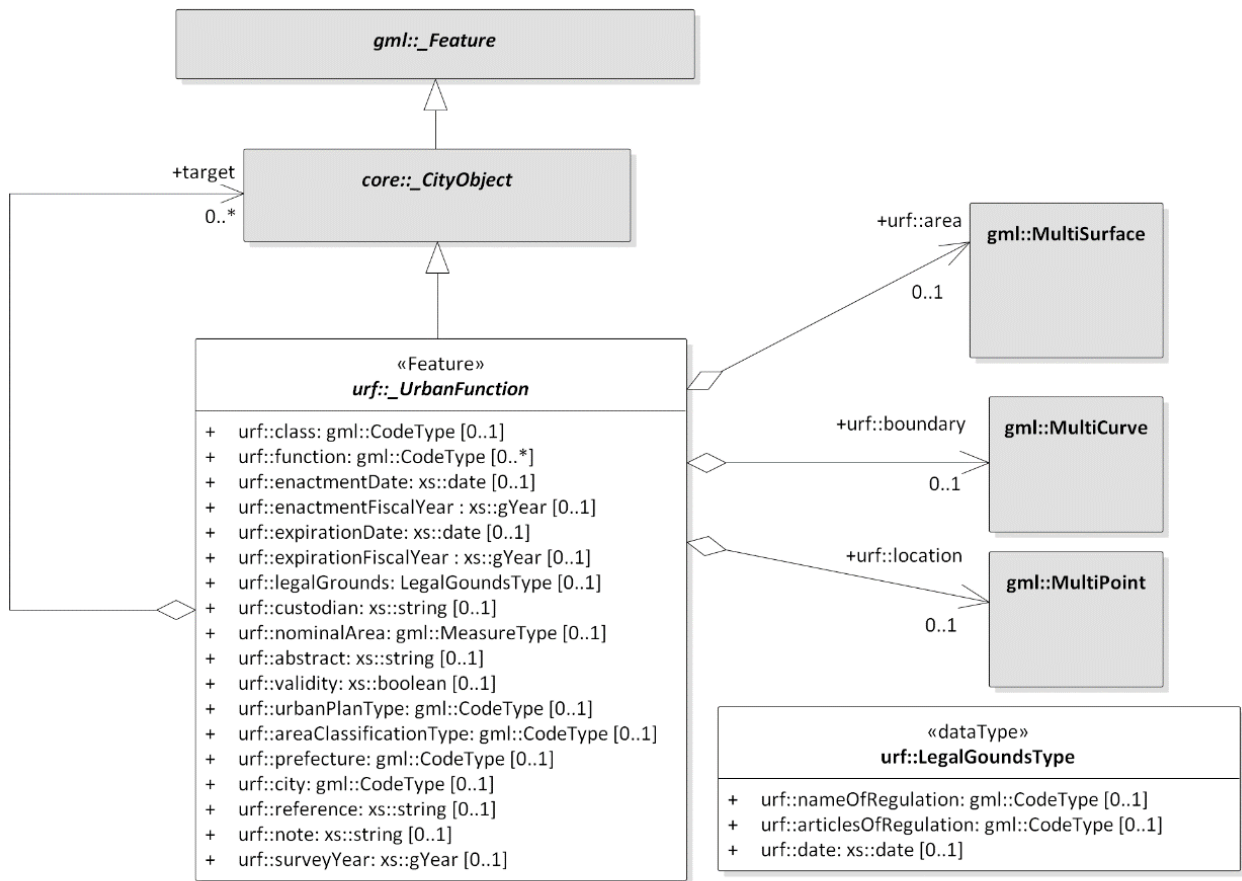


Figure 6 — UML diagram of *urf::_UrbanFunction*. Element names with the prefix *urf* are defined within this module.

Specific objects such as administrative boundary and land use regulation are defined as subclasses of *urf::_UrbanFunction* (Figure 7).



Figure 7 — Subclasses of *urf::_UrbanFunction*.

6.3 Statistical Grid Module

6.3.1 Overview

To grasp the current situation and issues of urban areas, comparisons of urban growth from the past to the present as well as comparisons between cities of the same urban scale are necessary to understand and simplify complex situations. This module defines a statistical grid for time-series comparison and regional comparison and specifies the encoding format of the statistical grid which divides specific area to grids. Each grid has its own thematic value, e.g., population and land price. Figure 8 shows an example of statistical grids describing a global city model.

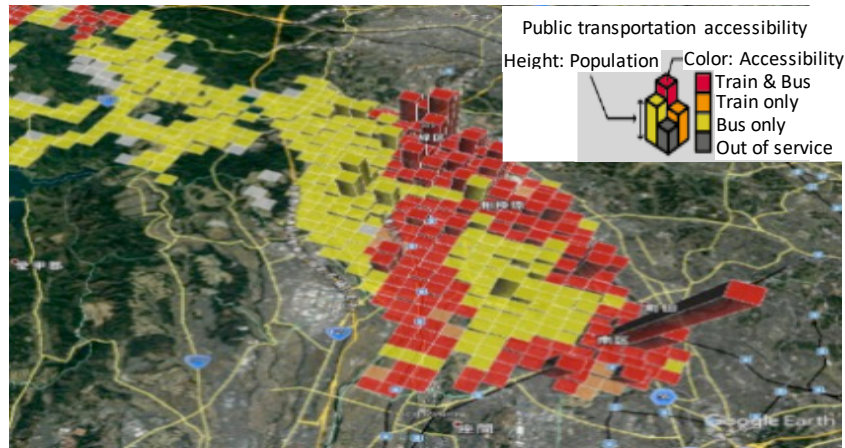


Figure 8 — Example of statistical grids describing a global city model.

In addition, a global city model of nationwide or worldwide content is necessary for comparing cities and understanding the relationships between cities through quantitative assessment. This is necessary in order to clarify the current situation and problems in urban areas. The Levels of Detail (LODs) defined in CityGML do not cover such general information, therefore this module defines the mechanism to describe the global city model and specifies the encoding format of the information.

This module extends the CityGML LOD concept and defines two extra LODs for statistical grids, LOD-1 (minus one) for nationwide city models and LOD-2 (minus two) for worldwide city models, which enables users to employ global city models for comparison and analysis of cities and maintain consistency between LOD 0 to 4 (Figure 9).

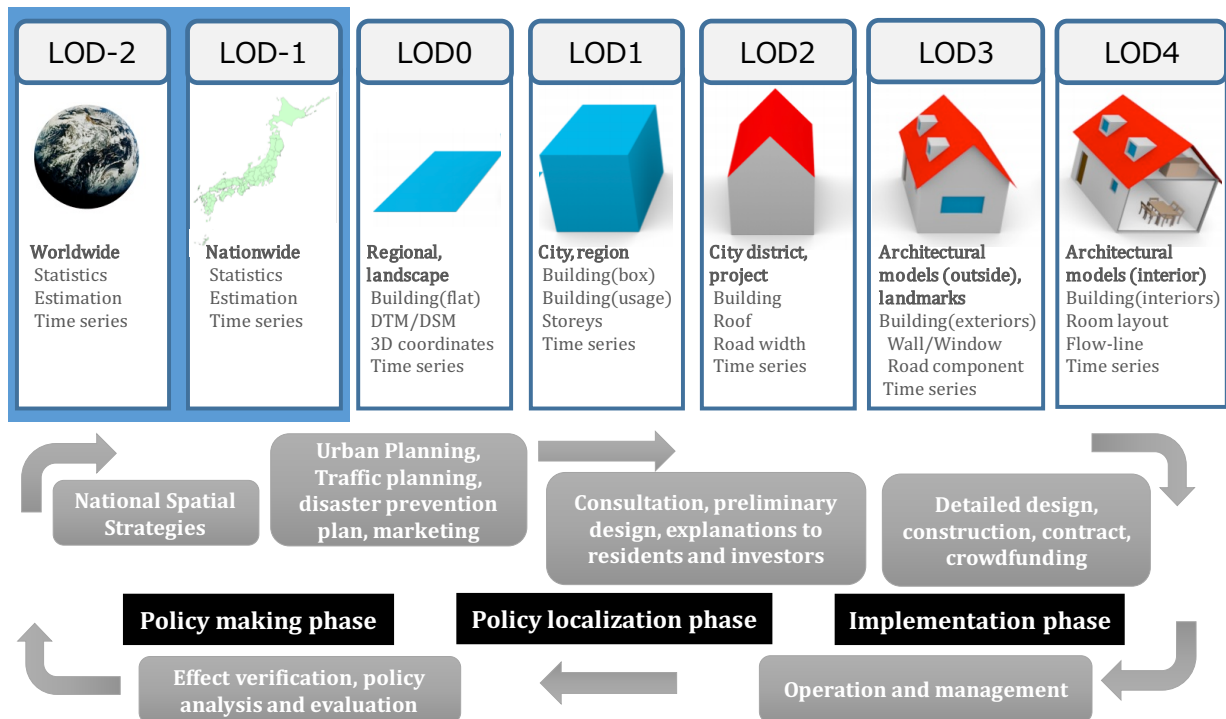


Figure 9 — Extended LOD for global city models.

6.3.2 Object definition

The Statistical grid module enables users to perform time-series analysis and regional comparison. A grid as defined in this module is a network composed of two or more sets of data curves, in which the members of each set intersect the members of the other sets in an algorithmic way, and the curves separate space into grid cells. The Statistical Grid Module gives statistical values to each grid cell.

Figure 10 shows the UML diagram of the Statistical Grid Module. A root class of this module is *urg::_StatisticalGrid*. Each statistical grid cell has its identifier and acts as a feature, and therefore *urg::_StatisticalGrid* inherits from *core::_CityObject*, a subtype of *gml::_Feature*.

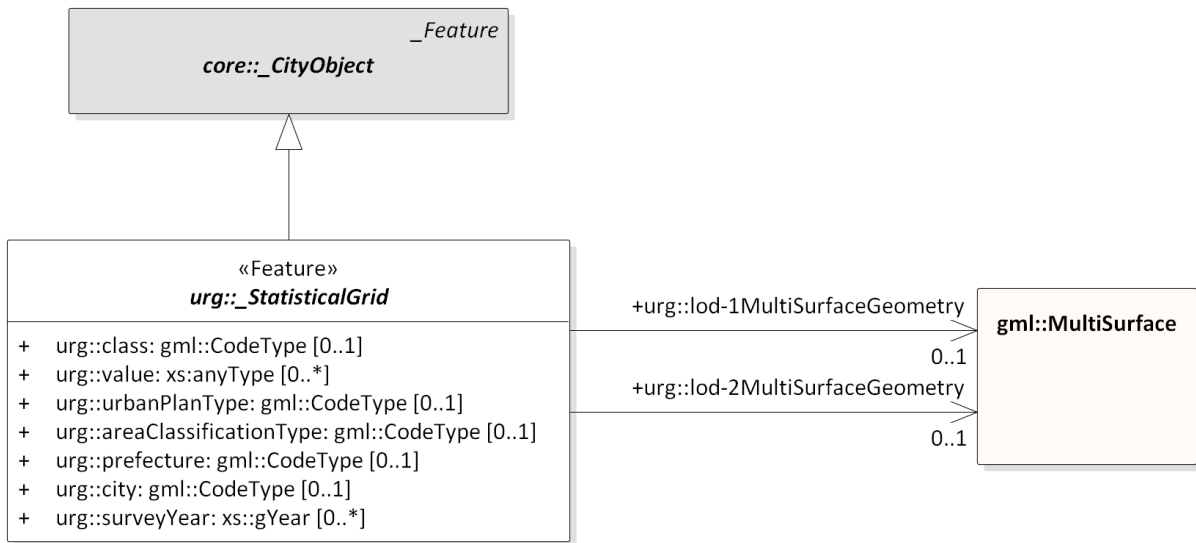


Figure 10 — UML diagram of Statistical Grid Data. Element names with the prefix *urg* are defined within this module.

urg::_StatisticalGrid is the root class of this module and is extended for defining specific statistical grid objects. Figure 11 shows subclasses of *urg::_StatisticalGrid*.

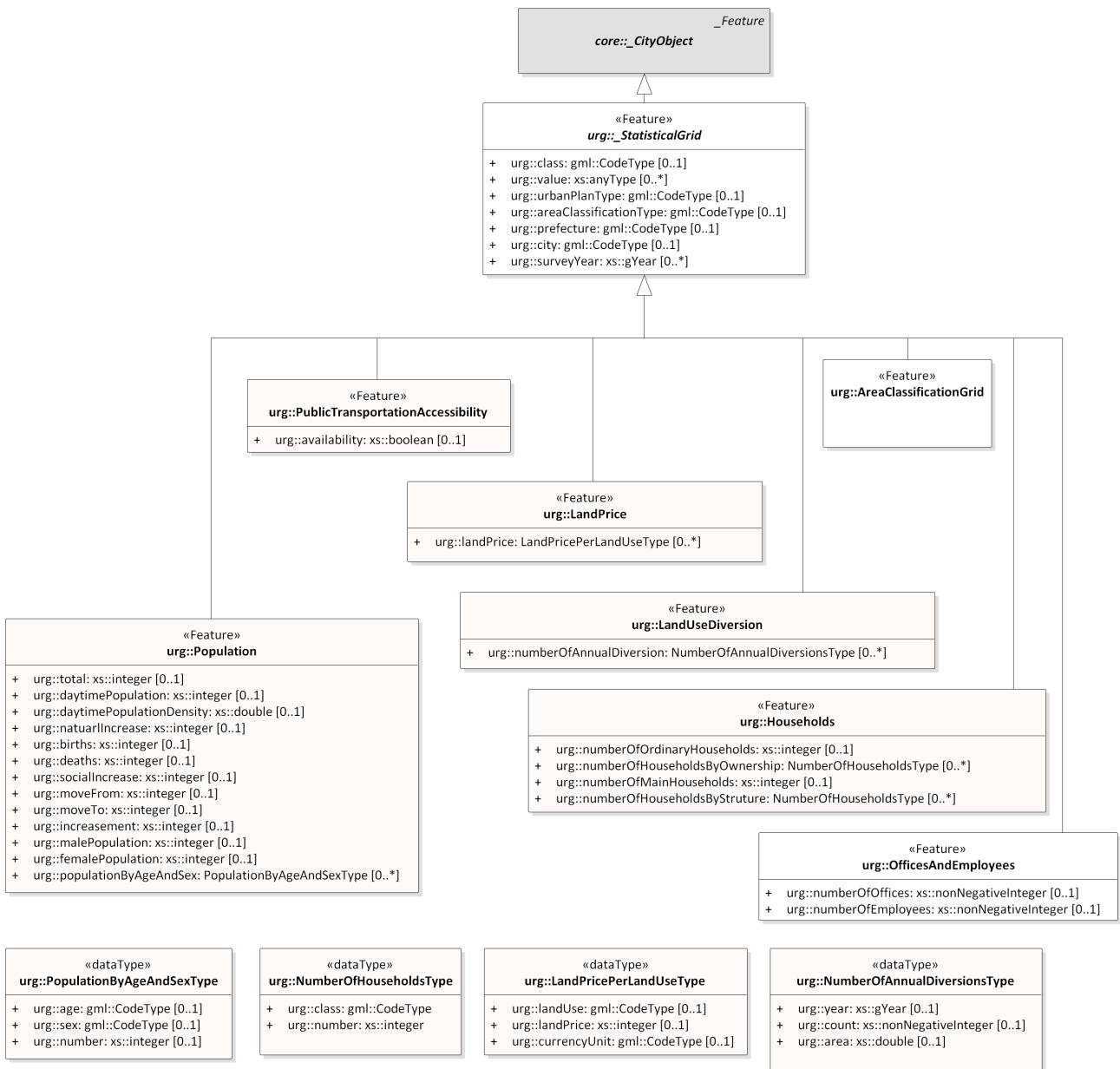


Figure 11 — Subclasses of *urg::_StatisticalGrid*

7 Data Experiment Examples of the Urban Planning ADE

This chapter introduces examples of i-UR Data in Japan [4][5][6].

Several municipalities in Japan have implemented i-UR Data by using existing 2D maps and statistics surveyed every five years [2]. Those i-UR Data have been used during the planning process such as consensus-building and the results confirmed the validity of the Urban Planning ADE for urban planning applications.

Figure 12 shows the example data of the Urban Object Module in Munakata City in Japan [4]. By using different properties, color-coded visualizations make it easier to understand urban structure and activities from various perspectives.

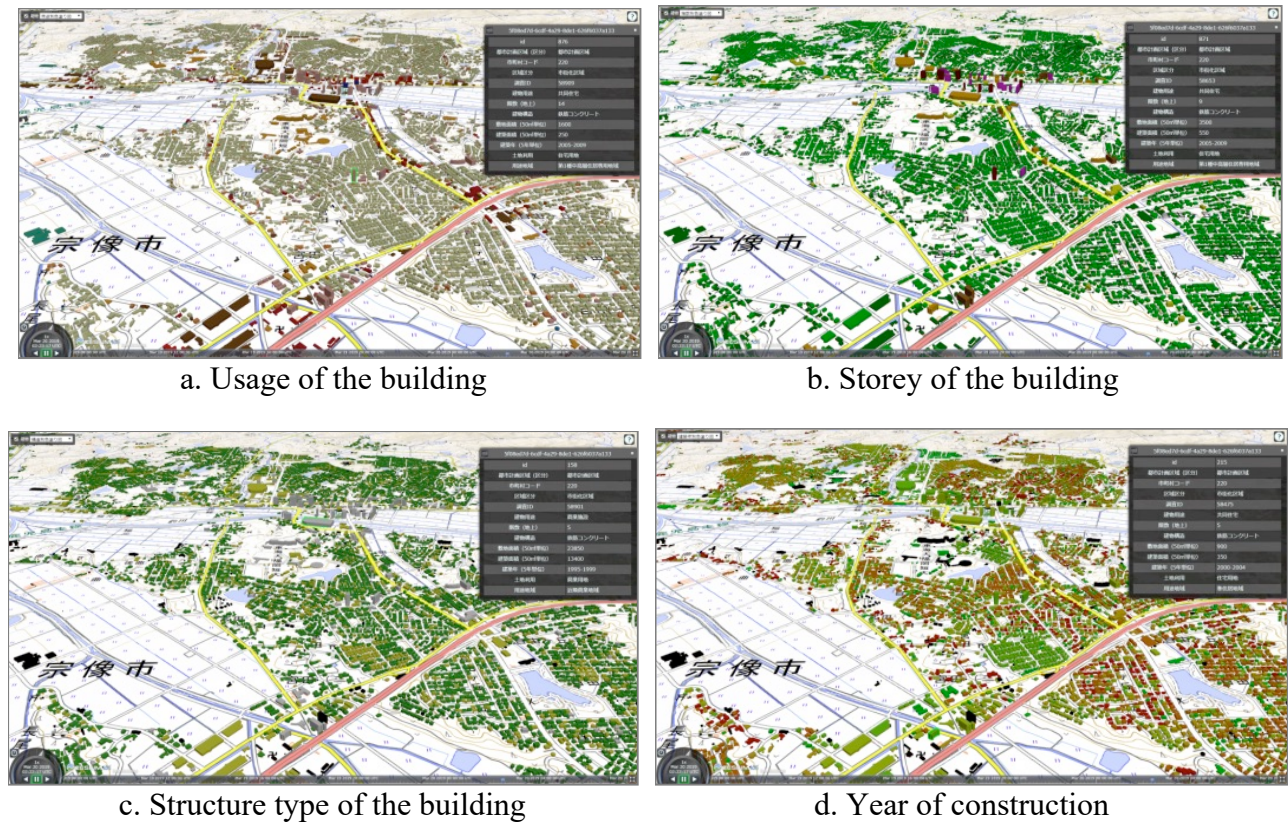
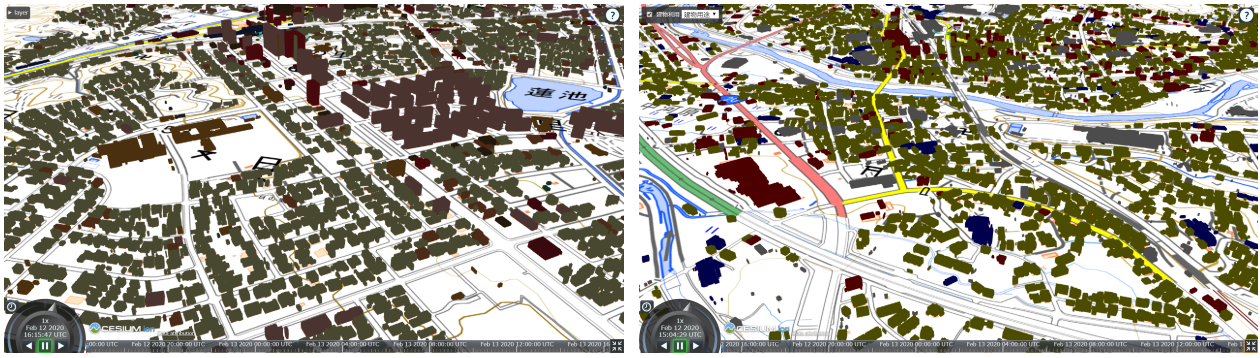


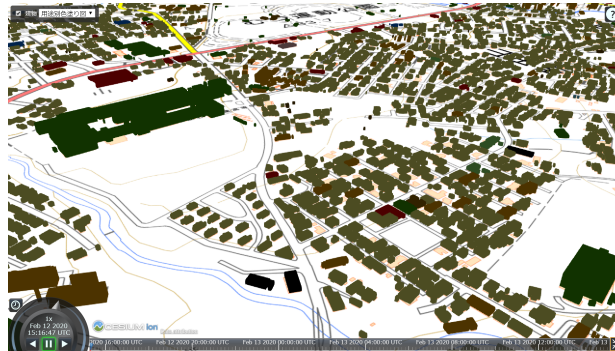
Figure 12 — Example of the Urban Object Module in Munakata City

Figure 13 shows a comparison of example data of the Urban Object Module in Munakata City [4], Chino City [5], and Mutsu City [6] in Japan. By using same color, the building usage visualization makes it easier to compare the urban structures of different cities.



a. Munakata City

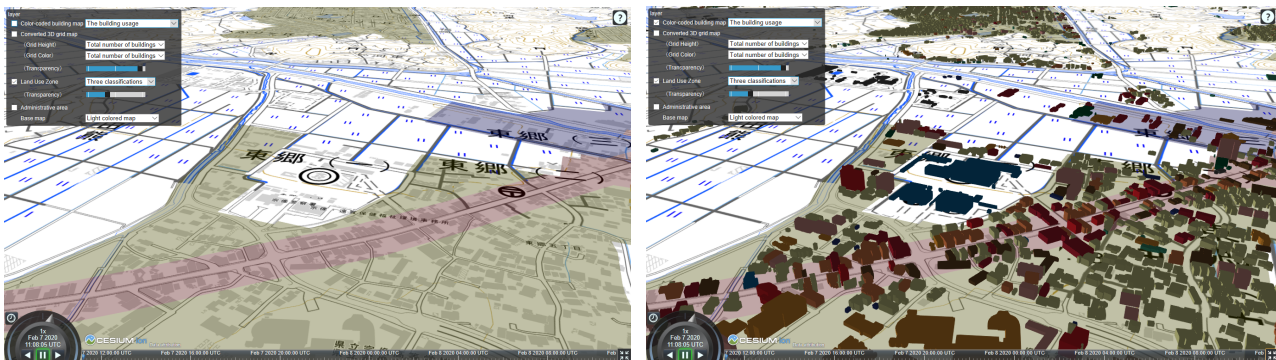
b. Chino City



c. Mutsu City

Figure 13 — Comparison of example data of the Urban Object Module in three municipalities

Figure 14 shows a comparison of example data of the Urban Object Module and the Urban Function Module in Munakata City in Japan [4]. The color-coded visualization of zoning and building usage confirmed that the buildings in this region generally correspond well with the zoning plan.

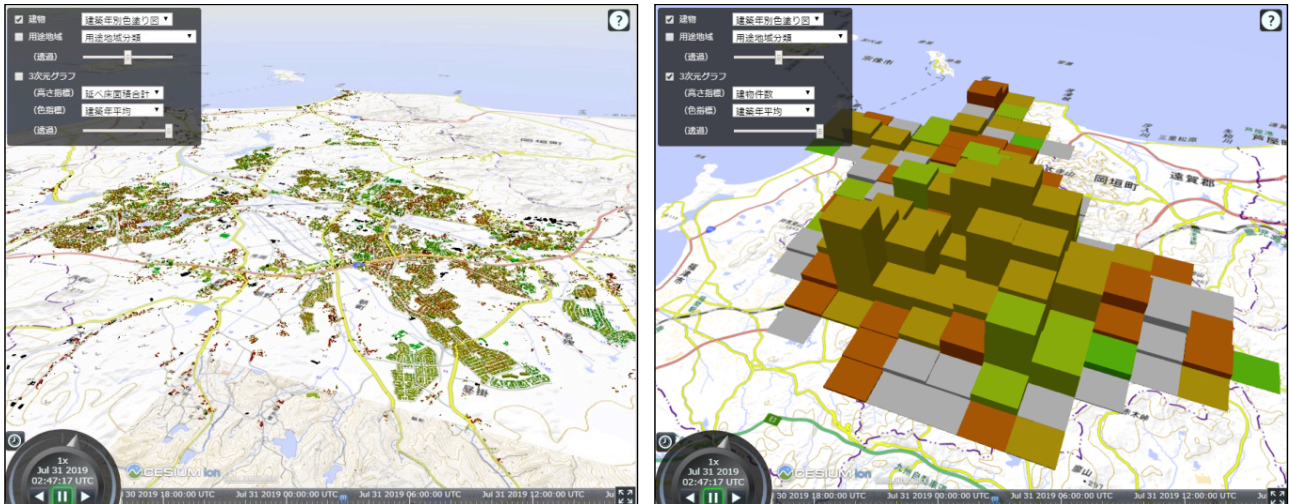


a. Zoning plan

b. Overlaid buildings (Color: Usage of the bldg.)

Figure 14 — Comparison of example data of (a) the Urban Function Module and (b) overlaid the Urban Object Module in Munakata City

Figure 15 shows a comparison of example data of the Urban Object Module and the Statistical Grid Module in Munakata City in Japan [4]. Figure 15-a shows individual buildings in detail, while Figure 15-b shows aggregated statistical grids that visualize distribution of number and age of buildings in an easy-to-understand manner.



a. Distribution of individual buildings
(Color: Year of construction)

b. Aggregated statistical grids
(Height: Number of buildings,
Color: Average of year of construction)

Figure 15 — Comparison of example data of (a) the Urban Object Module and (b) the Statistical Grid Module in Munakata City

Annex A

XML Schema Documents

The XML schema files of the CityGML Urban Planning ADE for each i-UR module are provided by the Japanese government as below.

A.1 Urban Object Module

XML namespace identifier	http://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/uro/1.2
XMLSchema location	http://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/schemas/uro/1.2/urbanObject.xsd
Recommended namespace prefix	uro
Description	This module defines additional thematic and spatial aspects of city objects which enables users to examine and to analyze current situation and issues of urban areas. This module is the extension of the existing modules for city objects such as <i>building</i> , <i>land use</i> , <i>transportation</i> and <i>cityObjectGroup</i> .

A.2 Urban Function Module

XML namespace identifier	http://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/urf/1.2
XMLSchema location	http://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/schemas/urf/1.2/urbanFunction.xsd
Recommended namespace prefix	urf
Description	This module defines conceptual or virtual objects in the urban areas which give a meaning to specific area, boundary or position. (e.g., Administration area, Urban planning area)

A.3 Statistical Grid Module

XML namespace identifier	http://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/urg/1.2
XMLSchema location	http://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/schemas/urg/1.2/statisticalGrid.xsd
Recommended namespace prefix	urg
Description	This module defines statistical grid which divides specific area to grids. Each grid has its own thematic value, e.g., population, land price.

Annex B

Code Lists

The code lists for enumerative attributes of type *gml:CodeType* in the Urban Planning ADE are provided by the Japanese government as below. Please note that this annex is non-normative and the presented code lists are neither mandatory nor complete.

Common	https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Common_urbanPlanType.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Common_districtsAndZones.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Common_landUsePlanType.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Common_areaClassification.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Common_prefecture.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Common_localPublicAuthorities.xml
Urban Object Module	https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Building_buildingStructureType.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Building_class.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Building_fireproofStructureType.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/LargeCustomerFacilities_class.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/LandUse_function.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/LandUse_ownerType.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Road_function.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Road_widthType.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/CityObjectGroup_usage.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Common_language.xml
Urban Function Module	https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Agreement_class.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/DevelopmentProject_class.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/DevelopmentProject_function.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/DevelopmentProject_status.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/DevelopmentProject_usage.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Households_houseType.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Households_ownershipType.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/DisasterDamage_class.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/DisasterDamage_function.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/DisasterPreventionBase_class.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Pollution_class.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Recreation_class.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Recreation_function.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/HubCity_class.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/LandUseDiversion_class.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/Urbanization_class.xml
Statistical Grid Module	https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/LandPricePerLandUseType_landuse.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/PopulationByAgeAndSexType_age.xml https://www.kantei.go.jp/jp/singi/tiiki/toshisaisei/itoshisaisei/iur/codelists/1.2/PopulationByAgeAndSexType_sex.xml

Annex C

Revision History

Date	Release	Editor	Primary clauses modified	Description
Feb 13, 2020	0.9	Nobuhiro Ishimaru, Chikako Kurokawa, Yuichi Tanaka, Tomohisa Oishi, Kentaro Akahoshi	All	Original
Feb 19, 2020	0.9.1	Nobuhiro Ishimaru, Chikako Kurokawa, Yuichi Tanaka, Tomohisa Oishi, Kentaro Akahoshi	Chapter 6, 7 Annex	Revision

Annex D

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