

OGC PROJECT DOCUMENT 16-000r1

TITLE: LandInfra Executive Summary
AUTHOR: Name: Paul Scarponcini
Address: Bentley Systems, Inc.
Email: paul.scarponcini@bentley.com
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1. Introduction

OGC 15-111 is the OGC® Land and Infrastructure Conceptual Model Standard (LandInfra). It defines concepts for land and civil engineering infrastructure facilities. The concepts will be used in providing and understanding information about land and civil engineering infrastructure facilities contained in a LandInfra dataset used to exchange such information.

The target audience of 15-111 spans civil engineering (e.g., road and rail), surveying, land parcel, facility and asset management, and government information communities. It is applicable throughout the entire facility life cycle, including planning, design, construction, operations, maintenance, and removal. It represents a seminal venture into GIS-CAD-BIM integration.

Because it follows the structure of an OGC standards document, 15-111 is more easily readable by standards and software developers. This Executive Summary document therefore summarizes the content of 15-111 in a more easily readable format. It directs the reader to specific areas within 15-111 that may be of interest to the individual information communities. This 16-000r1 version aligns with the r1 version of 15-111.

2. Background

After evaluating the LandXML 1.2 schema, the OGC Land and Infrastructure Domain Working Group (LandInfraDWG) recommended the development of an alternative standard to be part of the OGC standards baseline. The Preface of 15-111 explains the advantages and approach taken by the OGC Land and Infrastructure Standards Working Group (LandInfraSWG) in developing 15-111.

With shared interest by the buildingSMART International Infrastructure Room, it was agreed that 15-111 would be a concepts-only document – encodings such as GML, IFC, and possibly others would follow as separate standardization efforts. An anticipated GML encoding will be compatible with other GML standards such as CityGML. Having a common underlying Conceptual Model across all LandInfra encodings will help insure the compatibility across multiple encoding standards.

The goal of 15-111 is therefore to establish and document a common set of concepts that spans land and civil engineering infrastructure applications. It does not attempt to redefine application-specific concepts, but merely presents a common set of concepts from and to which the application concepts can be understood and mapped. This includes information relevant to those concepts as well as relationships that exist between the concepts.

3. Summary

3.1 OGC Modular Specification

Because 15-111 is an OGC standard, it follows OGC 08-131r3 *The Specification Model — A Standard for Modular specifications*. Accordingly, the target of 15-111 is clearly enumerated: it is the subsequent encoding standards. Therefore 15-111 contains Requirements which mandate what these subsequent encodings must support in order to claim conformance to LandInfra. Requirements are grouped together into Requirements Classes (RCs). An encoding must support all of the Requirements in an RC in order to claim conformance to that RC. Each RC has a corresponding Conformance Class which explains how the encoding is to be tested for conformance.

RCs and their Requirements are presented in 15-111 Clause 7, “UML Conceptual Model”. Their corresponding Conformance Classes are presented in Annex A, “Annex A Conformance Class Abstract Test Suite”. The RCs in 15-111 are used to group concepts into subject areas: core, facilities, projects, alignment, roads, railway, surveys, survey equipment, survey observations, survey results, land features, land division, and condominiums. Therefore, when reading 15-111, one can focus on just those RCs relevant to your subject area of interest.

RCs often depend on other RCs. For example, to comply with the LandDivision RC, an encoding must support all LandDivision Requirements plus all of the Requirements in the LandInfra RC (see 15-111 Figure 1). The reader should therefore take these dependencies into account.

3.2 Unified Modeling Language (UML)

3.2.1 Use Cases

From its beginning, LandInfra was to be use case driven. Use cases relevant to each subject area were identified and described. They were constantly monitored against the LandInfra scope to insure that the concepts being developed were consistent with the purpose of the standard. These use cases are included informatively as 15-111 Annex B.

3.2.2 Class Diagrams

OGC 15-111 uses Unified Modeling Language Class Diagrams to communicate LandInfra concepts. By OGC and TC211 conventions, boxes in these diagrams (UML classifiers) represent classes, data types, enumerations, code lists, etc. In 15-111 these should all be interpreted as concepts. Attributes in the boxes (including their cardinalities and data types) therefore specify information about the concepts. Association lines connecting boxes (including their cardinalities and roles) specify relationships between concepts. Concepts are grouped into UML Packages which correspond to RCs.

3.3 Terms and Definitions

Because of the broad scope of 15-111, the conventional Clause 4, “Terms and Definitions” is subdivided by subject area. These include general, facility and project, alignment, road, railway, survey, land feature, land division, and wet infrastructure.

3.4 Subject Areas

3.4.1 LandInfra Core

All readers should review 15-111 Clause 7.2, “Core Requirements Class: LandInfra”. It contains Requirements which must be supported by all other subject area-specific RCs. The LandInfra RC contains the LandInfraDataset which is where information about a dataset that contains other subject-area-specific LandInfra information is specified. Think of this as the header information of a file or document.

Concepts which span multiple subject areas are included in the LandInfra RC, including documents, survey marks, features, general purpose sets, properties, property sets, and (licensed) professionals. Data types which span multiple subject areas are also included in the LandInfra RC, including ID, state, status, percentage, side, professional type, spatial representation (geometry and location), and linearly referenced locations (at and from/to).

The LandInfra RC brings in concepts from other, OGC and TC211, standards. These include geometry types from OGC Abstract Specification Topic 1, coordinate reference system from Topic 2, linear referencing from Topic 19 plus base data types from ISO TC211 19103 and feature from 19109. Only those geometry types from Topic 1 needed to specify spatial representations in a particular LandInfra dataset need to be supported. For example, if a LandInfra dataset contains only information about survey points, then only Points need to be supported. If no spatial representations exist in a LandInfra dataset, then Topic 1 can be ignored completely.

Similarly, only that part of Topic 19 which is needed to specify linearly referenced locations in a particular LandInfra dataset need to be supported. Offsets, for example are not required if all linearly referenced locations are along (and not offset from) a linear element. If linear referencing is not used in a LandInfra dataset, then Topic 19 can be ignored completely.

3.4.2 Infrastructure Facilities

3.4.2.1 Facility

A LandInfra dataset can contain information about infrastructure facilities. Readers interested in any type of infrastructure facility need to review Clause 7.3, “Facility”, as it contains Requirements for all types of facilities. Facilities can be as simple as a single stretch of road or as complex as a campus containing roads, bridges, buildings, etc. Therefore, facilities are broken down into facility parts which can then be related back to each other.

Various facility part types are described in Clause 7.3.1.3, “Facility Part Type”. A LandInfra implementation is not required to support all of these types. In fact, only road and railway are specified in detail in the initial release of 15-111.

Facility parts can be made up of physical elements which can be located using a positioning element. Specific physical and positioning elements are specified in other RCs as appropriate so only information common across all facilities are included in the Facility RC.

3.4.2.2 Project

The information in the LandInfra dataset can be about planned, existing, or to be constructed/modified facilities. In the latter case, it may be appropriate to include information about the design/construction project itself. The Project RC in Clause 7.4 contains only a minimum amount of information about the project itself. IFCs provide a better source of Project information.

Projects can be broken down into project parts which are facility part type specific (e.g., one stretch of road). It may be necessary to further break these parts down based on some set of constraints, for example, design alternative or construction phase.

3.4.2.3 Alignment

An alignment is a positioning element which provides a Linear Referencing System for locating physical elements. It is made up of geometric segments in the horizontal plane (straight lines, circular curves, clothoids and other types of spirals) and vertical plane (straight lines, circular curves, parabolic sections), or alternatively specified as a 2D or 3D linestring.

Locations along an alignment are specified as linearly referenced locations based upon some Linear Referencing Method (LRM), as specified in OGC Topic 19, Linear Referencing. Traditionally the LRM has been limited to stationing along survey alignments, but this constraint has been eased to allow for a more general “distance along” measure of any linear element. This makes it useful during maintenance and operation as well as design/construction.

An alignment is continuous, non-overlapping, and non-branching (though it may contain intersections with other alignments). If it is used within the context of a project, it shall be for a single alternative, as specified by the project part.

The LandInfra Alignment RC (Clause 7.5, “Alignment”) was jointly developed with buildingSMART International (bSI) to help insure compatibility between all future encodings, including the bSI Industry Foundation Class (IFC) standard as well as OGC’s proposed InfraGML.

The Alignment RC is only required if the physical elements of a facility part are to be linearly located using an alignment type of linear element. Annex C contains more information about linear referencing.

3.4.2.4 Road

The Road RC (Clause 7.6) supports information about road facility parts. The information is typically about an existing or fully designed road. It is not intended to support the more complex road designer to road designer information exchange such as would exist when a designer other than the original designer takes over to complete the design. (This may be in scope for the next phase of LandInfra, but is certainly more relevant as IFCs.) Consequently, the Road RC includes several alternative ways for representing a designed road, such as road elements, 3D stringlines, 2D cross sections, and 3D surfaces and layers, as well as collections of any of these.

Road elements (Clause 7.6.2) can include pavement, shoulder, barrier, median, curb, walk, side slopes, or more specific types of any of these. These can be physically located: both with spatial representation in

accordance with OGC Abstract Specification Topic 1 and linearly referenced location in accordance with Topic 19 are optional.

A 3D string line (aka long section, longitudinal breakline, or profile view) is a 3D longitudinal view of a position in the road construction, such as the right outside edge of pavement, as you travel along a road (Clause 7.6.4). Any number of string lines may be specified for a road, either individually or in string line sets.

A Surface representation of a road (Clause 7.6.6) is a triangulated irregular network (TIN) at a particular level within a road cross section. For example, it can represent the top surface of the constructed road or the subgrade level of the finished earthwork which supports the actual road elements, such as pavement and sidewalk.

A cross section (Clause 7.6.8) describes how a Road looks (or will look), in a 2D cross section view, at some specific location along the length of the road. Cross sections are typically an output of the road design, rather than a set of requirements like a design template. They may include just the resultant top surface (early design output) or may include subsurface information as well. RoadCrossSection is a separate Road-dependent RC to make cross sections optional for encodings wishing to only support the three other methods of representing the Road design.

3.4.2.5 Railway

The Railway RC (Clause 7.7) supports information about railway facility parts. The information is typically about an existing or fully designed railway. It is not intended to support the more complex railway designer to railway designer information exchange such as would exist when a designer other than the original designer takes over to complete the design. (This may be in scope for the next phase of LandInfra, but is certainly more relevant as IFCs.) Consequently, the Railway RC includes railway elements and cant specifications.

Railway elements can include ballast, switches, rail, fastenings, sleepers, etc. These can be physically located: both with spatial representation in accordance with OGC Abstract Specification Topic 1 and linearly referenced location in accordance with Topic 19 are optional.

The cant of a railway track (also referred to as superelevation) is defined in 15-111 as the difference in elevation (height) between the two rails. A cant event specifies a cant value at a linearly referenced location along a railway. A cant specification includes a cant event at the beginning of the railway, one at its end, and any number of cant events in between – wherever the cant value changes.

3.4.3 Land

A LandInfra dataset can contain information about land. Those interested in land features should look at Clause 7.9, “Land Feature”. Those interested in land division should look at Clauses 7.10, “Land Division” and 7.11, “Condominium”.

3.4.3.1 Land Features

The LandFeatures RC (Clause 7.9) provides information about land features, specifically land elements, land surfaces, and land layers (Clause 7.9.1). Features of the land, such as naturally occurring water features and vegetation are specified as land elements (Clause 7.9.2). Man-made interventions to the land such as the construction of an embankment or the planting of landscape material are considered to be part of site features and are therefore included as facility parts in section 7.3.1 above.

Land surfaces (Clause 7.9.3) are spatially represented using a triangulated irregular network (TIN) and include the top ground terrain surface and any sub-terrain surfaces which separate the underground into layers (e.g., differing soil layers). The TIN model used in 15-111 is the version which appears in GML 3.3 and SQL/MM Part 3: Spatial. More efficient and robust than the OGC Abstract Specification Topic 1 TIN, it includes TIN elements of the following types: random points, group spot, boundary, breakline, soft break, control contour, break void, drape void, void, hole, stop line, and user defined.

Land layers (Clause 7.9.4) can be defined either as a solid layer, a surfaces layer, or a linear layer. A solid layer (Clause 7.9.5) is defined by a 3D solid polyface mesh geometry collection of bounding triad or quad faces defined by 3 or 4 indexed points, respectively. A surfaces layer (Clause 7.9.6) is defined by a top and bottom surface. A resultant solid shape is implied between these two surfaces, within the boundary of the surfaces layer’s extent, having vertical sides where the surfaces do not connect. A linear layer (Clause 7.9.7) is a layer defined by 2D cross sectional areas along a linear element.

3.4.3.2 Land Division

A LandInfra dataset may contain information about parts of the land surface separated by boundaries delimiting ownership in the land or in alternative terms: boundaries of real estate, of real property or of immovable property (land parcels). Land parcels are not the only division of the surface of the Earth, as the sovereign State which protects ownership is bordered and furthermore divides its territory according to political, judicial, or executive points of view (administrative division). Finally, ownership in land is not confined to the surface of the Earth as buildings may be subdivided into condominiums, aka strata title, through a condominium or strata title scheme and jurisdictions may attribute ownership to subsurface structures like tunnels. The LandDivision RC (Clause 7.10) addresses all of these except condominiums which are covered by the Condominium RC (Clause 7.11).

LandDivision (Clause 7.10.1) is separated into interest in land and administrative division. Spatial units are used to define their boundaries.

Interest in land (Clause 7.10.2) includes property units and easements. A property unit is a unit of ownership in land. It can be either a condominium (see 3.4.3.3 below) or a land property unit. Land property units can be made up of individual contiguous land parcels. In some jurisdictions, land ownership is of a single, contiguous area of land. In other jurisdictions, a single land ownership may be defined across several disjoint areas of land. To accommodate this difference, LandInfra considers each separate contiguous area to be a land parcel. For the former case, the land property unit contains a single land parcel. For the latter case, the land property unit is a collection of multiple land parcels.

An easement grants a beneficiary party right to a certain use, e.g. right of way, as specified by easement type, across one or more instances of what is called a servient land parcel. Also supported are superficie objects which comprise a building or other construction, including pipes, cables or tunnels, established and owned by a party (other than the owner of the LandParcels on which the superficie object is constructed) according to a granting Statement.

Administrative division (Clause 7.10.3) addresses land divided according to political, judicial, or executive points of view. 15-111 supports the ISO 3166-2 defined codes for the names of the principal (political) subdivisions (e.g., provinces or states) of all countries coded in ISO 3166-1. Normally, the division is hierarchical, e.g. in terms of a court hierarchy, or regional and local units of the central executive power, e.g. in terms of police or health and safety bodies.

Also included in the LandDivision RC are statement, statement type, signatory, signing role, survey monument, and survey monument type. A statement (Clause 7.10.4) documents the establishment or acquisition of an interest in land or a survey monument in accordance with a specific statement type. A statement document is signed by one or more signatories, each with a specific signing role. A survey monument (Clause 7.10.5) is a physical object, the location of which is stable and by its form defines a point on the surface of the Earth.

Spatial unit (Clause 7.10.6) is a contiguous geometrical entity used to define the boundary of an interest in land or an administrative division of land. A spatial unit is delimited and located on or close to the surface of the Earth through its bounding elements.

Bounding element (Clause 7.10.7) provides all or part of the boundary of a spatial unit. Because of the diverse manner in which spatial units may be delimited, boundary elements can take the form of either text, point, string (structured, unstructured, topological, partial, or ring types of curve), face (extruded, explicit, or implicit surface or extruded, explicit, or implicit topological surface), or solid.

3.4.3.3 Condominium

The 15-111 Condominium RC (Clause 7.11) describes condominium units (Clause 7.11.1). These represent concurrent ownership of real property that has been divided into private and common portions. The privately owned part is made up of clearly demarcated parts of a condominium building (Clause 7.11.3), as specified by a condominium scheme (Clause 7.11.6). Condominium unit owners are members of a mandatory owners' association. Moreover, each condominium unit has a share in the common parts of the property which are also clearly demarcated.

3.4.4 Survey

A LandInfra dataset can contain information about surveys. Anyone interested in information about a survey should review Clause 7.8, “Survey”. Core information about the survey itself can be found in subclause 7.8.1. Further information about survey observations, equipment, and results can be found in further subclauses of 7.8.

3.4.4.1 Survey

The umbrella RC for all survey information is the Survey RC in Clause 7.8. Clause 7.8.1 specifies the “header” information about a survey, such as the purpose, type, and surveyor. The survey may have additional information about its observations, equipment, and results. This information is contained within separate RCs.

3.4.4.2 Observations

The Observations RC (Clauses 7.8.2 and 7.8.3) contains information about the observations made as part of a survey. This includes setups which describe the place from which different observations have been measured. Survey observation information depends on the type of observation. Supported types include angular, distance, TPS, level, GNSS, image, and point cloud observations. All but the last two result in a target point.

3.4.4.3 Equipment

The Equipment RC (Clauses 7.8.4 and 7.8.5) contains information about the equipment and sensor(s) used for each observation in a survey. Additionally, attributes contain information about the controlling software that was used to steer the sensors and process the observations. Calibration of sensors may be required dependent on the sensors used. Some survey applications require calibration in the field. The calibration of remote sensing imagery sensors and the validation is covered by ISO 19159-2.

Sensor types supported include generic angle, generic distance, electronic distance meter (EDM), camera, total station, level, laser scanner, and GNSS.

3.4.4.4 Survey Results

A LandInfra dataset may contain any number of survey results that contains the estimate of the value(s) of a geometry or property of the feature of interest. The results are linked to sampling features – this would enable a later reprocessing of all observations to determine how the results have been determined. Survey result information is specified in the SurveyResults RC (Clauses 7.8.6 and 7.8.7). Types of survey results supported include: target point, string, stakeout (possibly with a design point), average (possibly with an average point), image, point cloud, and user defined. Information of the quality achieved with the processed observations for design and average point is also available.

3.5 Other Content

3.5.1 LandXML

Positioning InfraGML as an alternative to LandXML, the LandInfraDWG suggested that a mapping from LandInfra concepts to LandXML-1.2 be provided as part of the 15-111 standard. This has been done to the best of our limited ability since LandXML-1.2 has no published, underlying conceptual model and only minimal documentation. The mapping is included as LandInfra Annex D.1.

3.5.2 LADM

The ISO TC211 *19152:2012 - Geographic information - Land Administration Domain Model (LADM)* provided a constant source of inspiration for the LandInfra LandDivision and Condominium RCs.

However, it should be noted that the scope of LandInfra in this area is much more limited.

The scope of LandInfra is land development and civil engineering infrastructure facilities. The emphasis of LandInfra on infrastructure and on surveying suggests minimizing as far as possible the legal-administrative aspects of land development. This is achieved by modelling what is needed to account for the surveying related activities, including defining the legal entities, the boundary of which are measured, as well as identification of the signing parties. The primary concern for the initial release of LandInfra is the determination of land ownership as it relates to infrastructure facilities. For example, do I have enough road right of way to construct a road or do I need to acquire additional property (or easements) from adjacent property owners?

The legal/rights issues addressed by LADM are minimized in LandInfra to what is needed to know to define (and measure) the legal boundary. Similarly, the recording issue is minimized, because the broad diversity of implementations makes it difficult to achieve a consistent and understandable world-wide specification of cadastral recording. These do provide areas for future LandInfra development.

A more detailed comparison between LandInfra and LADM is provided as LandInfra Annex D.2.

3.5.3 INSPIRE

The INSPIRE directive aims to create a European Union (EU) spatial data infrastructure. The Directive addresses 34 spatial data themes needed for environmental applications, with key components specified through technical implementing rules.

In Annex D.3, the INSPIRE Annex I themes (post) Addresses, Administrative Units, Cadastral Parcels, Coordinate Reference Systems and Geographical names, and the Annex II theme Buildings are compared with LandInfra content.

3.5.4 ePlan

The ePlan Protocol - LandXML Structural Requirements, (v1, released 12-11-2010, amended 15-12-2015), is the most recent among ePlan documents. It supplements the ePlan Model (v 1.0 12-11-2010) and the ePlan Protocol - LandXML mapping (v 2.1. 6-08-2011). A LandInfra – ePlan correspondence is offered in Annex D.4

3.5.5 TIN Example

In Annex E, an example of a TIN is provided, along with a discussion on the expected behavior when TINElement constraints are added to the triangulation