Technical Specification

ISO/TS 19144-3

Geographic information — Classification systems —

Part 3:
Land Use Meta Language (LUML)

Information géographique — Systèmes de classification —
Partie 3: Métalangage d'affectation des sols (LUML)

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Foreword

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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 document 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).

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This document was prepared by Technical Committee ISO/TC 211, *Geographic information/Geomatics,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 287, *Geographic Information,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement), and in collaboration with the Food and Agriculture Organization of the United Nations (UN FAO).

A list of all parts in the ISO 19144 series can be found on the ISO website.

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.

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Introduction

There is a tremendous diversity in how people establish a built infrastructure on land or over water, or otherwise make use of the surface of the earth. This diversity in use also means that there is a great diversity in how Land Use is described. Land Use data (even more so than Land Cover) are closely linked to national and regional customs, legislation, or economic factors, and are therefore necessarily quite different from one country or region to another. Within one country or region there can also be different Land Use classifications in operation, serving different administrative and management purposes. It is not meaningful to try to standardize this multitude of classifications, but it is meaningful to develop a meta-language that can assist in the comparison of systems, assist translation between the systems and help international and other organizations when they need to extract comparable data from many different data sources.

The aim of this document is to enable the comparison of information from existing classification systems in a meaningful way without replacing them. The aim is to complement the development of future classification systems that can offer more reliable collection methods for particular national or regional purposes by allowing them to be described in a consistent manner.

A critical factor in implementing such global activities is the availability of a common, umbrella Land Use classification system structure. This then provides a reliable basis for interaction without replacing the increasing number of national, regional and global Land Use mapping and monitoring activities. This enables comparisons of Land Use classes to be made regardless of mapping scale, Land Use type, data collection method or geographic location.

This document provides a metalanguage expressed as a UML model that allows different Land Use classification systems to be described. This document establishes a metalanguage for a set of objects and rules (language) to describe Land Use features that can be part of different Land Use legends (nomenclature). This provides a framework for comparing different systems and nomenclatures. This document is not a description of a nomenclature nor is it a description of a specific set of classes.

The design concepts are described as follows.

— A classification process deals with the structuring of a specific knowledge domain in order to create consistency, stability and common understanding in communication between the users, therefore its main function is the capability to be a valid reference system for a larger community of users.

— However, a classification is a dynamic process. Definitions can change over time and in relation to the prevalence of other cultures, evolving user needs and new scientific advances.

— No classification system can fully reflect either the social or the natural world completely accurately.

— There are always multiple ways to conceptualize and communicate knowledge, thus there can be an inherent ambiguity in any categorization.

— The way to create consistency in this complex and dynamic domain is the establishment of a metalanguage that defines the framework of elements and rules with which any user can define their own specific ontology.

— The system needs to be documented through a rigorous definition of a generative grammar explicated using a graphic modelling language (UML class diagram).

The metalanguage needs to ensure migration from "human language" to a "machine representation" of the "elements, rules and conditions" with which a particular category (or set of categories) has been generated.

Additional parts of the ISO 19144 series are defined to describe the classification of other aspects of the environment, such as Land Cover (ISO 19144-2). These other parts appear in separate documents, but may be used in conjunction with classifications systems described using the Land Use Meta-Language specified in this document.

There is a requirement for registration of some characteristics and code lists to be used with the classes in this metalanguage and in any instantiation of this metalanguage. Registration is also desirable for a set of instantiated schemas that correspond to the many existing Land Use classification systems in broad

use. A section on registration existed in the previous edition of ISO 19144-2:2012. This content has now been separated into another part of the series, in order to generalize the registration process, allowing it to support Land Use as well as Land Cover and any other future parts of the ISO 19144 series. In addition, this new part on registration will also address implementation issues.

The present document (ISO/TS 19144-3) is a new part of the ISO 19144 series. Some of the content of this document addressing Land Use was originally contained in ISO 19144-2:2012. The description of these Land Use elements has been moved to this document. In addition, there have been changes to the classes LC_ GrowthFormCharacteristic, LC_CultivatedAndManagedVegetation, and LC_BuiltUpSurfaces to clarify the differences between Land Cover and Land Use. Details relating to backward compatibility are described in Annex C.

There is a need amongst some users of this document for an expression of Land Cover and or Land Use information in XML, as well as a need for an XML Schema (XSD). This document describes a reference metamodel for the description and comparison of classification systems. Any classification system described using this metamodel is not implicitly an ISO standardized classification system. An XML expression of this document is an XML expression of a metamodel and therefore such an XML Schema is a metaschema. An XML expression of Land Cover and/or Land Use information needs to be at the Application Schema level, which is one level of instantiation lower than the metaschema and defined in terms of a particular classification system. The use of metamodels and the subsequent instantiation into models, including the instantiation into an XML Schema that can be used to encode data is an implementation issue that is not addressed in this document.

Appropriate references to externally managed lists or listed items established particularly for the ISO 19144 series can be registered. In addition, whole classification systems described using the Land Cover or Land Use parts of the ISO 19144 series can be registered. The name and contact information of the maintenance agency for this document can be found at www.iso.org/maintenance_agencies.

This document is a joint deliverable with the UN Food and Agriculture Organization (UN FAO). Permission has been granted to ISO by the UN FAO to make a derived work based on any material developed or copyright UN FAO. The EAGLE concept has also provided input to the process of developing this document.[21]

In this document UML attributes names are given in *italics*.

In accordance with the ISO/IEC Directives, Part 2, 2018, Rules for the structure and drafting of International Standards, in International Standards the decimal sign is a comma on the line. However, the General Conference on Weights and Measures (Conférence Générale des Poids et Mesures) at its meeting in 2003 passed unanimously the following resolution:

"The decimal marker shall be either a point on the line or a comma on the line."

In practice, the choice between these alternatives depends on customary use in the language concerned. In the technical areas of geodesy and geographic information it is customary for the decimal point always to be used, for all languages. That practice is used throughout this document.

Geographic information — Classification systems —

Part 3:
Land Use Meta Language (LUML)

1 Scope

This document specifies a Land Use Meta Language (LUML) expressed as a UML metamodel that allows different Land Use classification systems to be described. This document recognizes that there are a number of Land Use classification systems in existence. It provides a common reference structure for the comparison and integration of data for any generic Land Use classification system, but does not intend to replace those classification systems. This document complements ISO 19144-2 on Land Cover Meta Language (LCML) and can be used independently to describe Land Use or together with ISO 19144-2 to describe a combined Land Cover Land Use.

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 19123-1, *Geographic information — Schema for coverage geometry and functions — Part 1: Fundamentals*

ISO 19144-1, *Geographic information — Classification systems — Part 1: Classification system structure*

ISO 19144-2, *Geographic information — Classification systems — Part 2: Land Cover Meta Language (LCML)*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19144-1 and ISO 19144-2 and the following apply.

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

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

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

NOTE   The term "class" is used in the ISO 19144 series to represent a construct in a classification system. However, the term has several meanings in other contexts, including in the UML modelling language. Where possible, attributes or other identifiers are needed to distinguish between the various uses of the term "class".

3.1.1
class
<UML> classifier of a set of objects

Note 1 to entry: Adapted from UML 2.5.1, 11.8.3.1.[22]

[SOURCE: ISO 19103:—,[1] 3.14]

3.1.2
coverage
function which returns values from its range for any direct position within its domain

[SOURCE: ISO 19123-1:2023, 3.1.9]

3.1.3
discrete coverage
coverage that returns value for the direct positions within its domain

Note 1 to entry: Discrete coverages have values only for their direct positions, whereas continuous coverages can be interpolated, thereby providing values between direct positions in addition.

[SOURCE: ISO 19123-1:2023, 3.1.15]

3.1.4
feature
abstraction of real world phenomena

Note 1 to entry: A feature can occur as a type or an instance. Feature type or feature instance will be used when only one is meant.

[SOURCE: ISO 19101-1:2014, 4.1.11]

3.1.5
register
set of files containing identifiers assigned to items with descriptions of the associated items

[SOURCE: ISO 19135-1:2015, 4.1.9]

3.2   Abbreviated terms

ATS	abstract test suite
IUCN	International Union for the Conservation of Nature
LCML	Land Cover Meta Language
LUML	Land Use Meta Language
NLUD	UK National Land Use Database
UML	unified modelling language
UNEP	United Nations Environment Programme
UN FAO	United Nations Food and Agriculture Organization
UN FCCC	United Nations Framework Convention on Climate Change
XML	Extensible Markup Language
XSD	XML Schema

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1)   Under preparation. Stage at the time of publication: ISO/FDIS 19103:2024.

4 Conformance

4.1 Conformance requirements and testing

Conformance to this document consists of alignment with the requirements established in 4.2, 4.3, 4.4, 10.2 and 10.3. The abstract test suite (ATS) given in Annex A describes a methodology which shall be applicable for testing conformance to these requirements.

4.2 Conformance classes

Two conformance classes are identified in this document, one for the description of a land characterization classification system and the other for the comparison between two or more land characterization classification systems.

4.3 Conformance class 1 — Description of a land characterization classification system

Requirement 1: The description of Legends or Land characterization Application Schema using this document shall consist of a set of UML classes with associated attributes that correspond to instantiations of the metalanguage classes described in Clause 8 or the combined Land Cover Land Use combinations identified in 7.7, or both.

4.4 Conformance class 2 — Comparison of land characterization classification systems

Requirement 2: The process of comparison of two land characterization classification systems shall be performed by developing descriptions of the two land classification systems, each in accordance with Requirement 1, and then identifying the differences on a class-by-class basis. This can be repeated for more than two land characterization classification systems under comparison.

NOTE   The level of detail of the comparison is dependent on the type of description.

5 Notation

The conceptual schema specified in this document is described using the Unified Modelling Language (UML), in accordance with ISO 19103.

Several model elements used in this schema are defined in other ISO geographic information standards. By convention within ISO/TC 211, names of UML classes, with the exception of basic data type classes, include a two-letter prefix that identifies the standard and the UML package in which the UML class is defined. This provides a global unique name for the class. UML classes defined in this document have the two-letter prefix "LU". Examples in this document and ISO 19144-2 have the two-letter prefix EL. Table 1 lists the other International Standards and packages in which UML classes used in this document have been defined.

Table 1 — Sources of externally defined UML classes

Prefix	International Standard	Package
CL	ISO 19144-1	Classification system structure
LC	ISO 19144-2	Land Cover Meta classes
EL	ISO 19144-2 & ISO/TS 19144-3	Examples in the ISO 19144 series
CV	ISO 19123-1	Coverage geometry

The stereotype <<metalanguage>> is used throughout this document to identify metalanguage objects that compose the LC_LandCoverClassDescriptor, LU_LandUseClassDescriptor or LU_LandCharacterizationClassDescriptor. As illustrated in 7.3, LU_LandCoverLandUseRelationship and its components are at a higher level of abstraction than the LU_LandUseClass that form a Land Use Classification

System, which are at the Application Schema level. A Legend as described in ISO 19144-1 is the simplest type of Application Schema.

The stereotype <<metalanguage>> applies to a class whose instances are other classes that are described by the metalanguage class.

The term "class" is an English word with a dictionary definition. However, it also has several meanings within the ISO 19144 series, dependent upon context. Classification is a process and the result of a classification process is a "class". The term "class" (<classification>) is used in the ISO 19144 series to represent a construct in a classification system. However, the term "class" has several other meanings in other contexts. A classification system consists of a set of classes subdividing the concepts within a given topic area. There is an unavoidable conflict with the terminology when a modelling language such as UML is used to describe a classification system metalanguage such as the LCML. The UML modelling language uses the term "class" (<UML>) as a construct in an object-oriented programming or data modelling paradigm, as the template for an object. That is, a UML class describes the properties associated with the instances of the class called objects. The term "class" is used in normal practice in both modelling and classification, and it is unreasonable for either modelling or classification to avoid the term. The term "Item Class" is also used in the process of registration, identifying the item that is registered. This term occurs in other parts of the ISO 19144 series. Adjectives have been used in this document where possible to reduce this confusion. For example, UML classes can be called "UML classes" and classification system classes can be called "classification classes" or "legend classes". At times, a UML class describes a classification class and it is possible to dispense with the adjective since both meanings of "class" are equivalent in the context. The conflict results from the fact that there is a deep relationship between data modelling and classification as used in other domains.

There is a similar related potential conflict with the associated terms "attribute" and "object". Adjectives have been used where possible, but at times it is necessary to derive the meaning from the context. Other terms where there is a potential for confusion are the terms "element", "component", "characteristic" and especially "attribute". The use of these terms is potentially confusing as they have different meanings in different contexts. These terms come from different places and all that can be controlled is their usage in the ISO 19144 series. Care is taken to use adjectives with these terms to help to clarify their meaning.

Certain classes that are common to both this document and to ISO 19144-2 are defined once. The classes that describe how permitted numeric values at the metalanguage level may be instantiated to the basic number types at the type level represented by LC_ValueObject or its subtypes are described in ISO 19144-2. The basic number types defined in ISO 19103 shall apply.

Classes related to the Land Cover Land Use Relationship are defined in this document in the package LU_LandCoverLandUseRelationship.

6 Context

The purpose of this document is to define a common reference structure for the comparison and integration of data for any generic Land Use classification system.

The majority of today's global biosphere is occupied by human-modified landscapes of agricultural, urban and other Land Uses. Due to the extent of the human impact, it is of fundamental importance to understand the extent and effects of human use of ecosystems, such as urban development, deteriorating environmental quality, changes in the extent and types of agricultural systems, and loss of fragile ecosystems (e.g. wetlands and steep lands) or of ecosystems with a high value in terms of biodiversity (e.g. humid tropical forests). These processes and problems need to be understood and documented in order to manage biodiversity, water security and human health. In other words, an understanding of Land Use and Land Cover is necessary if living conditions and standards are to be improved or at least maintained at the current level. For regional to national extents, Land Use is typically measured and mapped at a coarse spatial resolution (e.g. state or county unit) and for only broad categories of use (e.g. urban vs. agriculture). No unified or detailed worldwide Land Use classification exists. Some Land Cover maps depict "developed" or built-up Land Cover types that are directly related to human activities. However, that information cannot represent the full extent and complexity of human use of the land. Since every Land Use classification system is highly dependent on the purpose of the classification itself, there is a great diversity between Land Use classification systems.

In the past, many Land Use classification authors had different purposes and the result was an amalgam of classification methods to describe Land Use. As a result, today, comparison across time and space of Land Use has become very arduous. There is no agreement on any of the common classificatory principles. The metalanguage presented in this document accommodates this diversity and provides a way to describe and compare different systems. A Land Use or combined Land Cover Land Use system, described using the metalanguage specified in this document, should be able to re-examine and then make interoperable existing land-use data sets to make realistic comparisons within and between the systems used in different countries or application areas. It should also be able to collect time series information with which to analyse the dynamics of Land Use changes and therefore detect and predict trends.

7   Conceptual basis

7.1   Domain of interest

The term "Land Use" has different meanings across different disciplines and is consequently identified with a wide range of different parameters (for instance, those determined by natural, economic, institutional, cultural and legal factors). In order to develop a consistent approach to view Land Use is it easiest to start with the broad concept of "Land".

The term "Land" is inclusive of all physical elements, bestowed by nature, to a specific area. This includes fields, forests, minerals, inland water and in a broader sense, environment. Land Cover has been defined in this context in ISO 19144-2. In contrast, Land Use is defined with respect to different types of human activities that maintain or produce change to the land.

There is a clear relationship between Land Cover and Land Use. In fact, many existing older Land Use classifications are based on Land Cover information. However, the two are necessarily separate concepts. Land Cover can be considered the result of some aspects of Land Use at a certain moment in time. In this sense some Land Cover is the direct visible consequence of certain Land Use activities humans make to the bio-physical cover of the Earth. Land Use is determined by the human activities over certain periods of time, while Land Cover is determined at one moment including temporal aspects.

7.2   Model based approach

The "Object Based" ontology approach detailed in UML class diagrams represents one of the most efficient ways to represent the complexity and variety of land features.

This approach offers the following advantages:

— No predefined fixed list of categories exists, but an almost unlimited possibility of combination of well-defined attributes is allowed.

— Each Land Feature class is described or characterized by a specific UML model. This is an efficient way to represent complex land dynamics.

— The system is flexible and copes well with the advance of science in many different sectors. For instance, the use of Mark Up languages (XSD, XML) can be used to represent the instantiation of the information content.

— As the Land Use system component is built up with same "object oriented" logic of the ISO 19144-2 LCML, it is straightforward and effective to model a functional relationship between the Land Biophysical component (Land Cover) with the functions and activities (Land Use) that outline it.

Both the Land Cover and Land Use classification systems described in ISO 19144-2 and this document make use of a building block approach to the description of a classification system. Detailed elements are defined which can be combined to create a precise description of any Land Cover or Land Use class. This is described in more detail in ISO 19144-2:2023, 8.1. The background theory is given in Reference [6].

7.3 Packages

The UML model of each of the Land Use metalanguage-elements is given in Clause 8. The metalanguage objects are organized into several packages.

The package LU_LandUseClassStructure contains the definition of the basic Land Use classes. The LU_LandUseClassStructure package also relates to the LU_LandUseFunctionsElement package which is related to the LU_LandUseActivities package. The LU_LandCoverLandUseRelationship package contains classes that define the relationship to the Land Cover classes defined in ISO 19144-2. All of these classes contain numerical attributes related to the LC_ValueObjectTypes package that is defined in ISO 19144-2. This is represented in Figure 1.
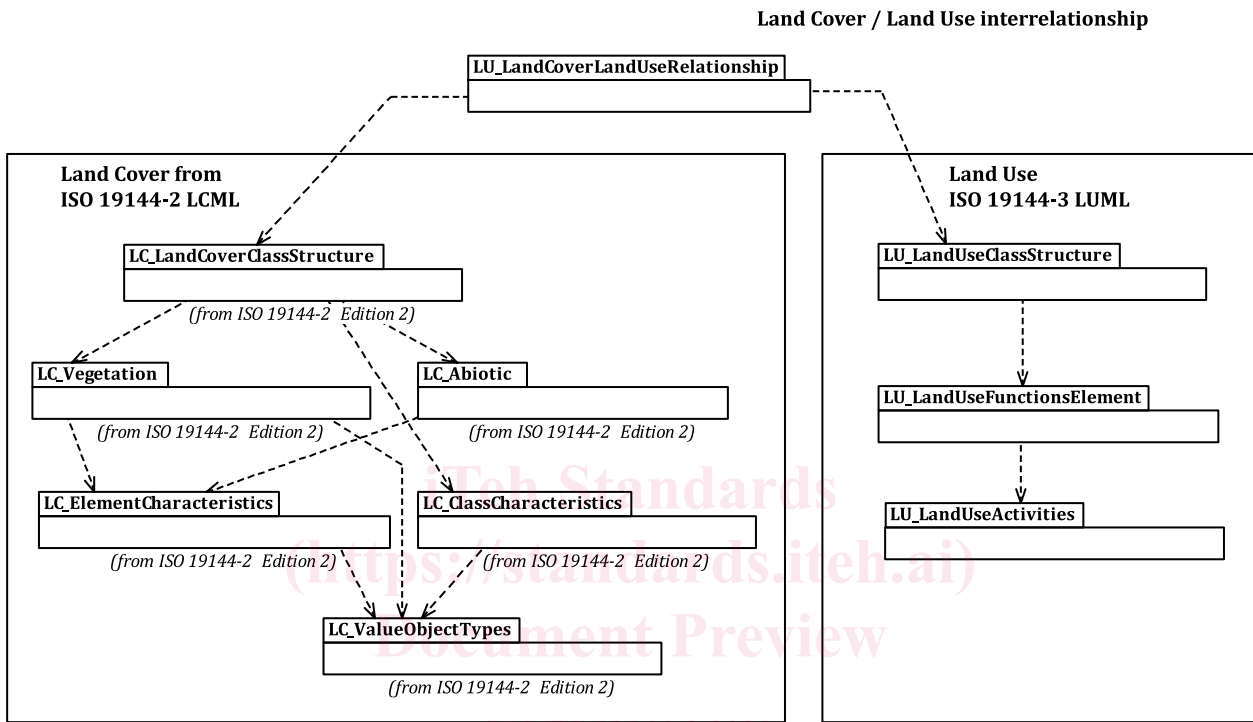

Figure 1 — LUML packages

7.4 Relation to ISO 19144-1

The LUML metalanguage is used to describe a Land Use classification system which is itself a UML model of classes that is then used to generate a legend (or nomenclature) or schema.

A classification system consists of a set of Land Cover or Land Use Classes that are established to exhaustively represent a particular aspect of the reality. The totality or a subset of these classes can be selected to describe a particular geographic area establishing a legend or nomenclature. The Land Use metalanguage described in this document has the same relationship to ISO 19144-1 as ISO 19144-2. The relationship between a classification system and legend is described in ISO 19144-1.

There are two separate semantic levels of abstraction involved. A legend (or nomenclature) is concrete in that it defines legend classes, instances of which can exist within a particular geographic area. A classification system is a semantic level of abstraction above a legend that characterizes the functional relationship of a set (finite or infinite) of possible classes and defines their descriptive criteria. The LUML metalanguage is another semantic level of abstraction higher. The metalanguage provides the structure so that a classification system can be described.

As indicated in ISO 19144-1, a classification system subdivides any geographic area into smaller units that have a unique type, and that result is represented as a "discrete coverage". The definition of coverages provided in ISO 19123-1 shall apply. This approach is used as the basis for both ISO 19144-2 and this document (see ISO 19144-2:2023, 7.2).