SUPPORTING FISCAL ASPECT of LAND ADMINISTRATION THROUGH a LADM-BASED VALUATION INFORMATION MODEL

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Abstract

This paper presents an information system artifact for the fiscal aspect of land administration, a valuation information model for the specification of inventories or databases used in valuation for recurrently levied immovable property taxes. The information model is designed as an extension module of ISO 19152:2012 Land Administration Domain Model (LADM), which is an international standard for land administration. LADM Valuation Information Model is supposed to facilitate all stages of immovable property valuation, namely the identification of properties, assessment of properties through single or mass appraisal procedures, generation and representation of sales statistics, and dealing with appeals. Therefore, it enables the recording of data concerning the parties that are involved in valuation practices, property objects that are subject of valuation, their characteristics and other datasets used for and produced within single and mass appraisal procedures. Moreover, it enables development of valuation maps, and property price records needed to assess changes in property values, as addressed by the New Urban Agenda which is as an extension of 2030 Agenda for Sustainable Development for urban areas (cf. Clause 104). The ultimate purpose of this research is to provide governments with a common basis for the development of local or national databases, enable integration of valuation databases with cadastral databases, and guide the private sector in the development of information technology products.

Key Words: Immovable property valuation and taxation, ISO 19152:2012 Land Administration Domain Model (LADM), LADM Valuation Information Model

1. Introduction

Valuation and taxation of land and immovable property are related to the several processes of land management for achieving Sustainable Development Goals (Plimmer and McCluskey, 2016). As indicated by the Voluntary Guidelines on the Responsible Governance of Tenure, appropriate systems are needed for fair and timely valuation of tenure rights for land and property taxation, and other public and private sector activities, such as expropriation, land re-adjustment and land consolidation, real estate financing, investment analysis, and further property transactions (VGGT, 2012, 18.1). Moreover, the New Urban Agenda, which is as an extension of 2030 Agenda for Sustainable Development for urban areas, supports initiatives regarding the fiscal aspect of land administration, such as the development of valuation maps, and land and housing price records needed to assess changes in land values (cf. Clause 104), and the use of digital platforms, such as geospatial information systems (cf. Clause 156).

Recurrent taxes on immovable property covers taxes levied regularly in respect of the use or ownership of immovable property. These taxes are levied on land and buildings, in the form of a percentage of an assessed property value based on a national rental income, sales price, or capitalised yield; or in terms of other characteristics of real property (e.g., size or location) from which a presumed rent or capital value can be derived (OECD, 2010). According to Grover et al. (2016), the credibility of these taxes depends on the quality of the data used, both of the market prices used and the attributes or characteristics of properties recorded in property inventories. Such inventories, which accommodate regular data maintenance and the updating of property characteristics, ownership details and rental and sales information, is one of the most fundamental element underpinning value-based taxation (Thang et al., 2011).

Traditional cadastral systems, which could be seen prototypical form of the above-mentioned property inventories, provide geographical and legal datasets concerning the legal objects required for valuation. However, they may not be sufficient for today’s complex valuation practices (e.g. computer aided mass appraisal). More specifically, they only provide two-dimensional geometry and legal information about property units, whereas valuation practices also require detailed physical, geographic, economic, and environmental characteristics related to components of property units. Moreover, information produced through valuation activities and market indicators should be recorded for further market analysis, dispute resolution and quality control processes. These requirements call for the development valuation registers or databases which record input and output data used and produced in single or mass appraisal processes.

Some countries have already developed special registers or databases for storing information about property transactions (e.g. Purchase Price Collections in Germany, Sales Price Register in Slovenia, Real Estate Market Database in Latvia) and providing statistics about property market (e.g. Sales

Statistics in Denmark, House Price Index in the United Kingdom, and the Price Index for existing houses in the Netherlands). These registers serve valuation sector for different requirements, e.g. estimating property values for property taxation, expropriations, and monitoring price trends. An efficient land administration infrastructure, which aims to enable the management of information concerning the ownership, value and use of land, is expected to link mentioned databases with other land information systems (e.g. cadastre, land registry, and building and dwelling registries). Such an integration or link between distributed databases maintained by different organizations can be achieved through spatial data infrastructures (SDIs). The domain-independent standards that specify the spatial and temporal aspects of geographical information (e.g. ISO 19107:2003 Geographic information - Spatial schema), and domain-specific standards that specify the semantics of a domain (e.g. ISO 19152:2012 Land Administration Domain Model) are one of the main components of the SDI (Lemmen et al., 2011).

There are several international standards related to procedural aspects of immovable property valuation, prepared by the European Group of Valuers' Associations (TEGoVA), The International Valuation Standards Council (IVSC), International Association of Assessing Officers (IAAO), and The Royal Institution of Chartered Surveyors (RICS). Moreover, there are some international measurement standards that specify semantics and rules for measuring the area and volume of land, buildings and building parts, such as Performance Standards in Building, International Property Measurement Standards, RICS Code of Measuring Practice, and Area and Space Measurement in Facility Management. In addition to these procedural standards, the geospatial community has facilitated the development of a number of domain specific data standards that define the two dimensional (2D) and three dimensional (3D) geographical aspects of property units, such as ISO 19152:2012 Land Administration Domain Model (LADM), INSPIRE Data specifications on Cadastral Parcels, Buildings and Land Use, CityGML, IndoorGML and InfraGML. Despite the existence of these standards, there is no international standard that defines the semantics of valuation registers or databases, such as the entities, attributes/properties, relationships, constraints of the information model.

A recent initiative which is carried out by a Joint Working Group established under International Federation of Surveyors (FIG) Commission 9 (Valuation and the Management of Real Estate) and FIG Commission 7 (Cadastre and Land Management) has started development of an information model which could be used for constructing valuation databases or information systems. In this initiative, LADM has been taken as the basis for the development of the valuation information model, since LADM is an international standard for the domain of land administration, which is related to management of information concerning the ownership, value and use of land. The current version of LADM mainly focuses on the legal and administrative aspects, but it has been extended to cover valuation and taxation related datasets with this research.

This paper describes LADM based valuation information model, namely LADM Valuation Information Model for the specification of inventories used in immovable property valuation made for public purposes. LADM Valuation Information Model has been designed to facilitate recording information in relation to all stages of property valuation applied for recurrently levied immovable property taxation, namely the identification of properties, assessment of properties through single or mass appraisal procedures, generation and representation of sales statistics, and dealing with appeals. It enables the recording of data concerning the parties that are involved in valuation practices, property objects that are subject of valuation, as well as their geometric, legal, physical, economic, and environmental characteristics. It is supposed that LADM Valuation Information Model will provide public bodies a common basis for the development of local or national databases, enable integration of valuation databases with cadastral databases, and can act as a guide for the private sector to develop information technology products. It is foreseen that LADM Information Valuation Model is going to be part of LADM 2.0, the revised version of LADM according to ISO's periodic maintenance procedure.

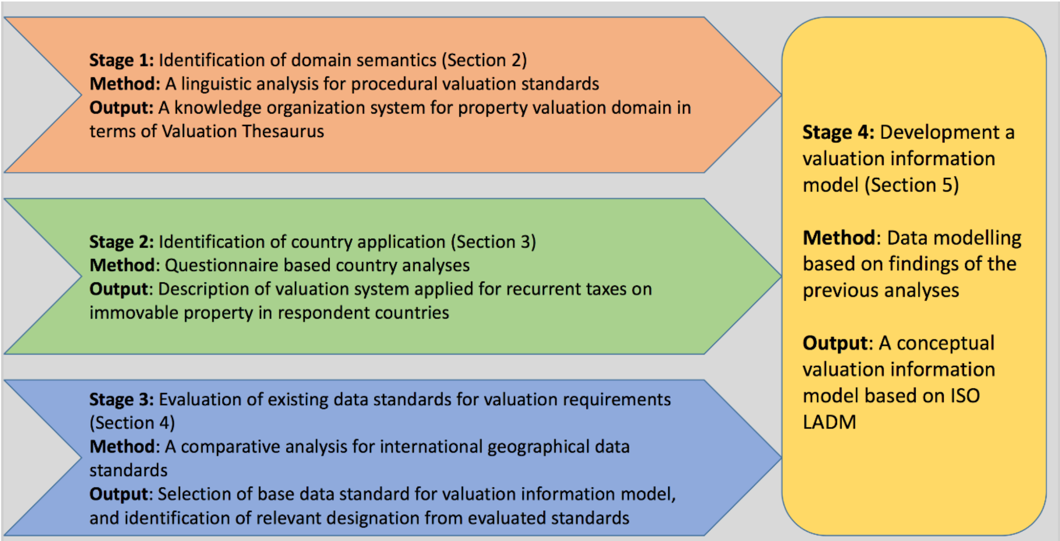

Figure 1 Research methodology

This research is carried out according to the following methodology which is illustrated in Figure 1, above. In the first stage, international procedural valuation standards issued by IVSC, TEGOVA, and IAAO are analyzed from linguistic point of view. This analysis resulted with a knowledge organization system (KOS), namely Valuation Thesaurus which reveals the core semantic of the valuation domain, and therefore supports the identification of candidate classes, class attributes and relationships for the elaboration of the valuation information model. Section 2 presents narrative description of the valuation domain with the terms of the developed thesaurus. In the second stage, international valuation approaches are investigated to reveal commonalities and differences among valuation systems used for recurrently levied immovable property taxes. For this investigation, a questionnaire is prepared and circulated among the members and delegates of FIG Commission 7 and FIG Commission 9. Section 3 describes country applications based on questionnaire responds. In the third stage, relevant geographic data models (e.g. LADM, CityGML, IndoorGML, InfraGML, INSPIRE data specifications) that would provide a framework for the specification of valuation information model are evaluated. Section 4 outlines the content of these standards, and assesses to what extent these standards represent valuation objects and their characteristics needed for valuation procedures. In the final stage, a valuation information model, LADM Valuation Information Model is designed through an iterative process according to the findings of the analyses made in the previous stages. The developed LADM Valuation Information Model is described in Section 5. The final section concludes the present paper.

2. A description of property valuation domain through a knowledge organization system

A knowledge organization system (KOS) refers to tools that present the organized interpretation of knowledge structures (Zeng, 2004, p. 377). It covers all types of schemes for organizing information and promoting knowledge management, such as (i) term lists (i.e. *glossaries*, *dictionaries* and *gazetteers*), (ii) classifications and categories (i.e. *subject headings*, and *taxonomies*), and (iii) relationship lists (i.e. *thesaurus* and *ontologies*) (Hodge, 2000, p.4). Taxonomies, thesaurus and ontologies are most commonly used schemas for modeling of knowledge domains (cf. Shwarz, 2005; van der Meer, 2008). A taxonomy is a rough modelling scheme because it only connects terms to each other with a hierarchical relationship, whereas a thesaurus is more specific, because it also offers equivalence and associative relationships. An ontology, however, is most precise because it defines the meaning of concepts by modelling properties that constrain the possible interpretations of a concept (Schwarz, 2005, p. 19). Among these KOSs, thesauri provide a weaker semantics but they are simpler to create and bigger models are affordable (Miguel 2009, p. 13). They are also seen the core building block of ontologies (Ma et al. 2011, p. 1603). This research, therefore constructs a thesaurus for the domain of property valuation, which may reveal the core semantic of domain, and therefore may assist for the identification of candidate classes, class attributes and relationships for the elaboration of LADM Valuation Model.

The Valuation Thesaurus has been developed according to the ANSI/NISO Z.39.19-2005 'Guidelines for the Construction, Format, and Management of Monolingual Controlled Vocabularies'. Accordingly, thesaurus construction process consists of the following stages: (i) Term selection, (ii) Identification of semantic relationships, and (iii) Specification of these relationships. In the first stage, the candidate terms were derived through an empirical method from the following international valuation standards:

- Standard on Automated Valuation Models (IAAO, 2003)
- Standard on Mass Appraisal of Real Property (IAAO, 2013a)
- Standard on Ratio Studies (IAAO, 2013b)
- European Valuation Standards (TEGoVA, 2016)
- International Valuation Standard (IVSC, 2017)

In this process, a total of 522 terms which represents main valuation concepts and terms that represent factors affecting property values were derived from the glossaries and the main text of the above listed valuation standards. It should be noted that whole the suite of IAAO standards were investigated within this research but only the mostly used standards for recurrently levied immovable property taxes are listed above. The manually extracted terms were analyzed and edited from a linguistic perspective, including elimination of repeated terms, control of the grammatical forms, spelling variants, singular and plural forms, abbreviations and acronyms, punctuation and capitalization (c.f. Schneider, 2004, p. 28). Moreover, a number of terms which are related to financing, land surveying, and statistics were eliminated from the vocabulary. During the next stage, the semantic relationships between the remaining 139 terms (i.e. hierarchical, equivalency and association relationships) were specified according to the principles given in ANSI/NISO Z.39.19-2005. Finally, the developed thesaurus was encoded through the Simple Knowledge Organization Systems (SKOS) specifications developed by World Wide Web Consortium (W3C) for standardized representation of structured vocabularies. The SKOS encoding of the thesaurus is online accessible at http://cadastralvocabulary.org/IPVT.rdf. Table 1 provides an extraction from this SKOS encoding.

A narrative description of the valuation domain is given below with the terms of the Valuation Thesaurus.

Table 1 The SKOS encoding of the *Immovable property valuation* term


```
<skos:Concept rdf:about="http://cadastralvocabulary.org/IPVT/ImmovablePropertyValuation">
<skos:prefLabel>ImmovablePropertyValuation</skos:prefLabel>
<skos:altLabel>RealEstateAppraisal</skos:prefLabel>
<skos:definition>(1) The process of establishing the value of an asset or liability; OR (2) The amount representing an opinion or estimate of value (Source: International Valuation Standards Counsil, 2016).</skos:definition>
<skos:changeNote>Established with version 1.0</skos:changeNote>
<skos:inScheme rdf:resource="http://cadastralvocabulary.org/IPVT"/>
<skos:narrower rdf:resource="http://cadastralvocabulary.org/IPVT/Valuer"/>
<skos:narrower rdf:resource="http://cadastralvocabulary.org/IPVT/Value"/>
<skos:narrower rdf:resource="http://cadastralvocabulary.org/IPVT/ValuationObject"/>
<skos:narrower rdf:resource="http://cadastralvocabulary.org/IPVT/ValuationActivity"/>
<skos:narrower rdf:resource="http://cadastralvocabulary.org/IPVT/ValuationRecord"/>
</skos:Concept>
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Immovable property valuation or *Real estate appraisal* is performed by *Valuer*(s) or *Appraiser*(s) employed within a public or private organization to estimate *Value* of immovable properties for several public and private purposes, such as property taxation, expropriation, real estate financing, insurance and further property transactions (see, Figure 2).

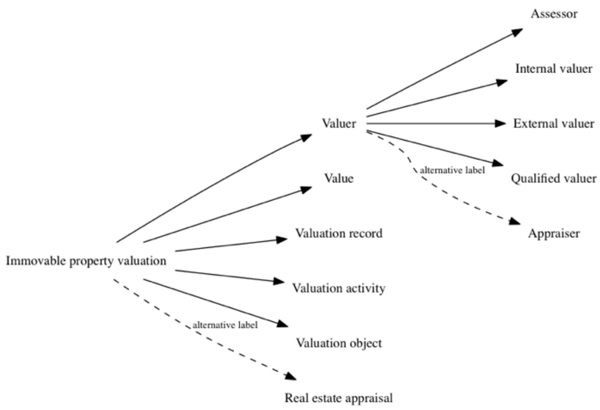

Figure 2 The Valuer concept

The term of *Value* refers to the relationship between an object desired and a potential owner (IAAO, 2013a; 2013b), and can be decomposed into several value types according to different legislations and requirements, such as *Acquisition value*, *Alternative use value*, *Appraised value*, *Market value* (see, Figure 3).

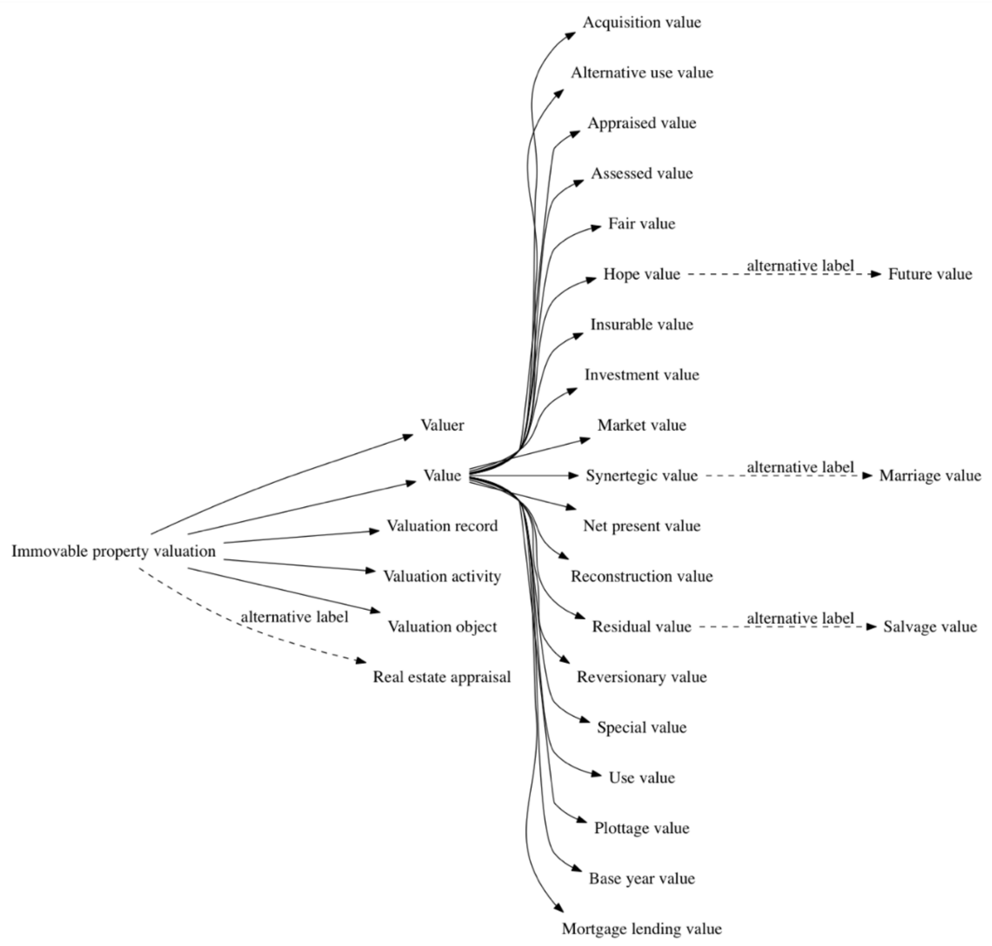

Figure 3 The Value concept

As illustrated in Figure 4, the object of valuation is the *Immovable property* or *Real estate* which consists of one or more *Parcel*(s) and the *Improvement*(s) or *Construction*(s) built on the *Parcel*(s). These objects have characteristics that should be considered in the *Immovable property valuation*, such as *Parcel area*, *Land use* and *Topography* for the *Parcel*; and *Chronological age*, *Size* and *Construction quality* for the *Construction*. Moreover, selection of the *Valuation approach* to be employed requires classification of the *Immovable property* according to its use, for instance *Residential property* and *Commercial property* (cf. IAAO, 2013a).

Figure 4 Valuation object concept

The *Valuation activity* term illustrated in Figure 5 covers *Valuation approach*es, *Single property appraisal*, *Mass appraisal* and *Valuation date*. The *Valuation approach* specifies the *Sales comparison approach*, the *Cost approach* and the *Income approach* terms that represent the traditional valuation approaches or methods, used in both *Single property appraisal* and *Mass appraisal*.

The *Sales comparison approach* compares the subject property with other similar properties that have been recently sold which are termed as *Comparable sales*. It estimates the *Value* of the subject property by making *Adjustments* in the *Sale*s *price*s of the comparable properties in terms of their differences from the subject property. *Adjustments* are usually made for the *Sale date*, location and physical characteristics (e.g. *Parcel characteristics*, *Construction characteristics*, and *Locational characteristics*) (IAAO, 1999).

The *Cost approach* provides an indication of the *Value* based on the economic principle that a buyer will pay no more for a property than the cost to obtain a property of equal utility (TEGoVA, 2016). According to this, the *Market value* of an improved parcel can be estimated as the sum of the value of the *Parcel* and the depreciated value of *Construction*s (Eckert et al., 1990, p. 205). A differentiated version of the *Cost approach*, the *Abstraction method* or *Residual method* can also be used for valuation of unimproved land in the absence of vacant land sales. The *Cost approach* requires estimation of the current *Cost* of *Construction* which covers expenses, direct and indirect, of constructing an improvement (IAAO, 2013a). Two types of *Cost* can be used: *Reproduction cost* and *Replacement cost*. The former refers to the current *Cost* of creating a replica of the asset, while the latter means the current *Cost* of a similar asset offering equivalent utility (IVSC, 2017). This method also requires determination the extent of *Obsolescence* occurred in the *Construction*. *Obsolescence*, which is also known as *Depreciation*, refers to loss in value of an object, relative to its *Replacement cost*, *Reproduction cost*, or original cost (IAAO, 2013a). It can be decomposed into *Physical obsolescence*, *Functional obsolescence,* and *External obsolescence* (IVSC, 2017).

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Income approach converts the present or prospective stream of income derived from property into capital value through *Direct capitalization* or *Yield capitalization* (Shugrue, 1963). The *Direct capitalization* can be applied with *Net income* and *Capitalization rate* or *Gross income* and *Gross rent multiplier*. The *Capitalization rate* is the ratio of net operating income to market value (IAAO, 2013a), while the *Gross income multiplier* represents the ratio of potential gross income or its effective gross income to market value. The second capitalization approach, *Yield capitalization* is used to calculate the present value of anticipated future *Cash flow*s (IAAO, 2010). Future *Cash flow*s are converted to value through *Rate of return* of the investment. A *Rate of return* is an amount of income (loss) and/or change in value realized or anticipated on an investment, expressed as a percentage of that investment (IVSC, 2017). It consists of *Internal rate of return*, *Risk free* rate and *Risk Premium. Internal rate of return* is the discount rate at which the present value of the future cash flows of the investment equals the acquisition cost of the investment. The *Risk free rate* is the rate of return available in the market on an investment free of default risk. The *Risk premium* is a rate of return added to a risk-free rate to reflect risk.

These *Valuation approach*es are employed in both *Single property appraisal* and *Mass appraisal*. The *Single property appraisal* estimates value of a particular property on a given date, while the *Mass appraisal* values a group of properties on a given date and using common data, standardized methods, and statistical testing (IAAO, 2013a; 2013b). The term of *Computer aided mass appraisal* (c.f. IAAO, 2003; 2013a) is used when *Mass appraisal* is performed by means of computer-supported statistical analyses.

The main component of *Mass appraisal* is the *Mass appraisal model* which explains the relationship between *Value* and variables representing factors of supply and demand (IAAO, 2013a). *Model specification* and *Model calibration* are distinct steps in the modeling. *Model specification* is the formal development of a model in a statement or equation, based on data analysis and appraisal theory (IAAO, 2003; 2013a). Models may be specified for group of properties that have similar characteristics, in the form of *Additive model*, *Multiplicative model*, and *Hybrid model.* Grouping of properties according to the selected variable (e.g. location, size) is called as *Stratification* and can be realized with *Cluster analysis* (see, IAAO, 2003). The specified models are supplemented through the *Model calibration* stage, which according to IAAO (2003; 2013a) is the development of adjustments, or coefficients, based on market analysis, that identifies specific factors with an actual effect on market value. Several statistical techniques can be applied in this stage, such as *Multiple regression analysis*, *Adaptive estimation procedure*, *Location value response surface analysis*, *Time series analysis*, and *Artificial network analysis*. A *Mass appraisal* may further include a performance analysis stage, the *Ratio study,* to compare the appraised values with market values for determining the accuracy of the appraisal (Gloudemans, 1999). The *Ratio study,* which also termed as *Appraisal ratio study* or *Sales ratio study,* is a study of the relationship between appraised values and market values (IAAO, 2003; 2010; 2013a). Two aspects, *Appraisal level* and *Appraisal uniformity* are analyzed in the *Ratio study* to measure the accuracy of the *Mass appraisal*. The *Appraisal level* is an indicator that shows the overall or typical ratio of the appraised values to the market values. It is ascertained by central tendency measures such as, mean, median, weighted mean. The second indicator, *Appraisal uniformity* defines appraisal consistency and equity between and within groups of properties. It could be expressed for instance, by the coefficient of dispersion, coefficient of variation, or price-related differential measures (Gloudemans, 1999).

Information used in or produced through the *Valuation activity* are represented or kept in *Valuation record*s (Figure 6). These records may be in the form of *Valuation report*s or in the form of *Valuation database*s, which records the *Locational, Parcel, and Construction characteristics* of *Valuation objects*, or provides *Sale statistics* about property market.

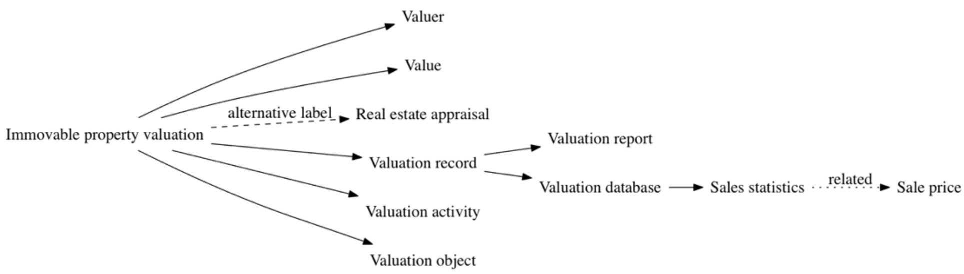

Figure 6 Valuation record concept

This section presented a formal description of property valuation domain through terms of the *Immovable Property Valuation Thesaurus* (IPVT) which is developed as a part of research methodology. In the next section, this formal description is supplemented with the descriptions of country applications.

3. Property valuation applications in several countries

After description of the domain with the Valuation Thesaurus, international valuation approaches are investigated. The purpose is to reveal commonalities and differences among valuation systems applied for recurrently levied immovable property taxes. A questionnaire is prepared and circulated among the members and national delegates of FIG Commission 7 (Cadastre and Land Management) and FIG Commission 9 (Valuation and Management of Real Estate). Respondents from 24 countries Argentina, Bolivia, Brazil, Colombia, Costa Rica, Croatia, Cyprus, Denmark, Ecuador, Greece, India, Latvia, Macedonia, the Netherlands, Poland, Singapore, Slovenia, South Africa, South Korea, Spain, Turkey and the United Kingdom have filled the questionnaire. The responses to the questionnaire can be viewed online at http://wiki.tudelft.nl/bin/view/Research/ISO19152/ValuationQuestionnaire. The questionnaire consisted of three sections. First section covers general questions related to structure of valuation systems. The second and third sections focus on mass appraisal and single property appraisal procedures, respectively. The following subsections explain international valuation approaches for recurrently levied property taxes based on information obtained from the questionnaire survey.

3.1 General structure of valuation systems

Valuation of properties for property taxation are mostly found under the responsibility of ministry of finance or taxation, land administration authorities or municipalities. Table 2 presents the organizations responsible for valuation of properties for property taxation among the respondent countries.

Table 2 The organizations responsible for valuation of properties

Ministry of Finance / Taxation	Croatia, Denmark, Singapore
Municipalities / local governments	Macedonia, Turkey, the Netherlands, Bolivia, Brazil, Costa Rica, Ecuador, South Africa, India
Surveying and cadastral authorities	Slovenia, Cyprus, Argentina, Colombia, Spain

Other authorities	South Korea (Ministry of Land, Infrastructure and Transport), Latvia (State Land Service under Ministry of Justice)

Recurrent taxes on immovable property are generally levied on all types of properties. However, some countries only tax the land, while a few only tax the buildings. Most countries tax both land and buildings, usually together, but in some countries separately (Bird and Slack, 2002). In the respondent countries, land and improvements together are used as tax base in Cyprus, Bolivia, Brazil, Costa Rica, Ecuador, Greece, the Netherlands, Poland, South Korea, Spain and Turkey. Only ‘holiday homes’ are taxed in Croatia and ‘every type of real property’ in Macedonia. In the United Kingdom tax base is a unit of occupation, known as a ‘hereditament’. In Latvia, land, buildings, apartments and engineering structures are objects of valuation.

These objects may be taxed based on monetary value or non-monetary value based measures. In monetary value-based systems, tax assessment is based on, for example, market value, annual rental value, or the acquisition price of properties (Youngman and Malme, 1994; McCluskey, 1999; Bird and Slack, 2002; Kitchen, 2003). As appears from the questionnaire results, all respondent countries apply monetary value based systems except Poland of which the real estate tax is generally based on area other than buildings or its parts for commercial purposes (see Table 3).

A good-quality land registration system plays an indispensable role in supporting property appraisal (Thang et al., 2011). Land registry and cadastre are the common public registries that provide legal and geospatial information to valuation organizations in the surveyed countries. Valuation organizations also use information recorded at other land related registries or databases, such as Land Information System in Cyprus; Building and Dwelling Register in Denmark; base registers for buildings, addresses, inhabitants and companies in the Netherlands; Address Register in Slovenia and Turkey; National Real Estate Cadastre Information System in Latvia; and GijimaSouth African eCadastre System in South Africa. Moreover, respondent countries have declared availability of national valuation databases (see Table 4). These databases are generally used for storing transaction information (e.g. sale prices, transaction date) and property characteristics (e.g. type of property, area) for implementing mass appraisal system and producing sale price statistics.

Table 3 The value types used for property taxation

Annual value	Singapore, India
Book value	Poland (for commercial properties)
Cadastral value	Spain
Capital value	India
Commercial value	Costa Rica (for commmercial properties)

Market value	Brazil, Colombia, Croatia, Cyprus, Denmark, Ecuador, Latvia, Macedonia, Slovenia, the Netherlands, United Kingdom (for domestic dwellings)
Rateable value	United Kingdom (for non-domestic hereditaments)
Self assessed value	Bolivia
Tax value	South Korea, Turkey
Area	Poland (for properties other than commercial)

Table 4 Special valuation database for storing datasets used in or produced with valuation procedures

Yes, national level	Croatia (eProperty), Denmark (SVUR), Macedonia (Registry for Lease and Prices), Slovenia (Real Estate Valuation Database), The UK (VOA & Land Registry), Cyprus (Computerised Integrated Land Information System), the Netherlands (Basisregistratie WOZ), India (Property and Vacant Land Tax Information System), Latvia (Real Estate Market Database), Singapore, South Africa (eCadastre), Spain (Cadastre)
Yes, municipal level	Turkey, Bolivia, Costa Rica, South Korea
Yes, other	Poland (local appraisal associations)
No	Argentina, Brazil, Colombia, Ecuador

Dissemination of the information about property market to public has of vital importance for market transparency, and fair and equitable taxation. All respondent countries have some mechanisms for public information sharing. In Cyprus, property characteristics and estimated values are open to public, and sales data and GIS based analyses are open to licensed valuer through a web portal. Similarly, in Croatia, authorized users (e.g. authorized valuers and property agents) can access to valuation information, while in Slovenia sales data, market reports, property data and property values are online accessible by all citizens. In Denmark, SKAT records sales statistics in the SVUR database, and publishes every six months a sales statistic. Moreover, the Public Information Server, OIS, provides data on Danish properties. In the Netherlands, the public ‘WOZ-waardeloket’ makes available the assessed value of residential properties together with other attributes such as construction year, property function/type, and building floor size. In the United Kingdom, there are separate dissemination portals for non-domestic and domestic units in VOA website, also sales statistics are published through Price Paid Data system. In South Korea, MOLIT provides the real estate price information via Internet. In Spain, the Cadastral Observatory of Real Estate Market (OCMI) information system is open to public and it serves the cadastral value for each property to the owner, public administration and legally interested persons. In Singapore, the e-Valuation List is an online service that includes the annual value and the name of owner of a property. In Greece, the Bank of Greece since 2008 keeps regular records with the assessed values of the properties. On the other hand, valuation information is not open to the public in Argentina, Bolivia, Colombia, Costa Rica, Ecuador and Poland.

Fair and productive property taxes require not only a good initial valuation but also periodic revaluation to reflect changes in property values (Bird and Slack, 2002). Among the respondent countries, general revaluations are made every year in the Netherlands, Singapore, South Korea; every two year in Ecuador and Latvia; every three year in Costa Rica; every four years in Slovenia and Turkey, and every five years in Cyprus, and the United Kingdom for non-domestic hereditaments. In Denmark, general revaluations were made every fourth year of the most 20th century, and every second year in 2002-2012 period. A new revaluation is expected to be made after 2018 when a new appraisal system is operational. In Macedonia, general revaluations are very rare, and in most of the municipalities general revaluations have not been made for more than 20 years. The revaluations are not made regularly in Argentina, Brazil, Greece and South Africa. There is no revaluation in Poland

3.2 Mass appraisal procedures

Among the respondent countries, Bolivia, Brazil, Cyprus, Denmark, Greece, India, Latvia, the Netherlands, Singapore, Slovenia, South Africa, South Korea and Spain have computer aided mass appraisal systems. These systems are maintained by Department of Lands and Surveys in Cyprus; municipalities in Bolivia, Brazil and South Korea; municipalities partly with the support of private companies in the Netherlands; Ministry of Taxation in Denmark, the Surveying and Mapping Agency in Slovenia and cadastral authority in Colombia and Spain. The mass appraisal systems are mainly used for estimating property values for property taxation, but also for analyzing trends in property market, and other administrative processes.

All the systems applied multiple regression analysis except for Bolivia which did not use any statistical analysis method. While in Slovenia also GAMLSS (Generalized Additive Models for Location, Scale and Shape) is additionally used, in Singapore artificial neural networks analysis is also utilized. The Additive Multiple Regression Model (AMRA) is used in India and South Korea. In the Netherlands, most systems use clustering as the main methodology, while some systems use linear regression and clustering methods. Slovenia and the Netherland used in-house developed CAMA/GIS software. The systems are generally used spatial data such as property area recorded at Cadaster, construction information recorded at Building and Dwelling Register and permitted land use recorded at PlansystemDK in Denmark; cadastral, and land use information recorded at Land and Building Cadasters and other public organizations in Slovenia; cadastral information recorded at Digital Cadastral Database in Cyprus; property area, property address and taxpayer information recorded at Cadastre and other registers, as well as large scale base maps in combination with aerial photos and street view pictures in the Netherlands.

In general, parcel characteristics, construction characteristics, and locational characteristics are used as explanatory variables in mass appraisal models. As for parcel characteristics, parcel area and permitted or planned land use are utilized in all countries. But in the Netherlands both planned (or allowed) and effective use is considered. As for construction characteristics, about 150 variables, including the use of building/unit, building material, installations, and dates for building permits are used in Denmark. In Slovenia, depending on the valuation approach different kind of construction characteristics are considered. In sales comparison models, size, year of construction, year of renovation, number of floors, number of apartments in condominium, and availability of elevator, balcony, terrace, garage in the building are used as variables for the valuation of residential properties. In income models, building type, size, micro location characteristics are used as attributes for commercial immovable properties. In cost models, building type and size are used as variable for the valuation of agricultural, industrial and public properties. In Cyprus, age, condition, property type, construction type, building category and area are used as construction characteristics. In the Netherlands, type of property, size of property, building year, annexes of the property (e.g. garages), quality of the property, maintenance condition are used. As for locational characteristics, distance from electrical power lines, highways and railways are used in Slovenia, while distance from the point of interests are employed in Brazil, Cyprus, Ecuador, Greece, India, Singapore and South Africa. In the Netherlands, positive and negative locational characteristics are combined into a 'school mark' for the quality of the location.

Three-dimensional (3D) data is not used in mass appraisal processes in Cyprus, Denmark and Slovenia. In Denmark, valuation objects include condominiums, and these condominiums are described by floor plans recorded at the Land Registration Court. Appraisal of condominiums is based on data only, e.g. floor number and area. Similarly, in Slovenia building parts (i.e. apartments) are included in the mass appraisal system on the base of attribute data. Apartments are part of the Building Cadastre and are used in Mass Valuation System, but are not registered as 3D, but as a 'part of the building'. In the Netherlands, the use of 3D data is limited to some pilot projects. This data is mostly derived from large scale base map in combination with height information (such as AHN, Actual Height Netherlands) and sometimes combined with a picture. In Greece, India, Latvia and South Africa floor plans are used as 3D data in mass appraisal procedures.

3.3 Single property appraisal procedures

Traditional sales comparison, income capitalization and cost approaches are used in Argentina, Croatia, the Netherlands, Turkey, South Korea and the United Kingdom. In Cyprus, sales comparison, investment method (income approach), and 'base method' is applied. Only sales comparison approach is used in Bolivia. Interestingly, only the cost approach is used for every type of property in Macedonia.

Since the ambition is to follow market practice, object dependent valuation methods are applied in Denmark.

Geographical or spatial datasets used in single property appraisal include cadastral plans, land use plans in Croatia and Turkey, and Ordnance Survey large scale (1:2.500 and 1:1.250) maps are used in the United Kingdom. Moreover, legal information recorded at land registry, and land use information represented by land use planning documents and building permits are taken into consideration in all respondent countries that use single property appraisal even if as complementary part of mass appraisal. Considering the locational characteristics, some environmental risks, e.g. contaminated site recorded in the Danish Natural Environmental Portal, flood risk depicted on maps by Danish Agency for Water and Nature Management are taken into account in Denmark. In Croatia, locational characteristics are available through web services, but they are mostly not considered. In Macedonia and Cyprus, distance from point of interests is used, while in the United Kingdom and the Netherlands, locational factors are taken into account but reflected in the analysis of comparable evidence. In South Korea, Urban Planning Information System and field surveys are used for obtaining distance from road and waste management. Construction characteristics used in single property appraisal are mainly derived from national registries in the respondent countries. But in Croatia, these are examined by the valuer on the site. In Denmark, information from the Building and Dwelling Register may be supplemented by a 'Tilstandsrapport' (Building Quality Status Report) prepared by certified engineers according to statutory rules. While construction characteristics are obtained from Construction Administration System that is verified through field surveys in South Korea; on site visit, owner, manager of the building and local authorities are the information sources in Greece. In the Netherlands, cost data for non-marketable properties is collected by the union of municipalities and is available for all municipalities for their valuations. Also municipalities have to collect all income related data for commercial real estate themselves. Mostly they send out questionnaires to owners of users of these properties for this purpose.

4. An evaluation of geographical data standards according to valuation requirements

There are several international geographical standards that may provide a technical framework for the specification of valuation databases, such as LADM issued by ISO, LandInfra, CityGML, and IndoorGML issued by OGC and INSPIRE data specifications on cadastral parcel and buildings. This section briefly outlines the content of these standards, and evaluates to what extent these standards represent valuation objects and their characteristics needed for single and mass appraisal procedures.

4.1 ISO 19152:2012 LADM

The first standard, ISO 19152:2012 LADM is an abstract conceptual model that focuses on the legal and geographical aspects of land administration. It aims to standardize cadastral systems, but also has capabilities to cover other land-related public registries (e.g., address, land use and land cover, property taxation, and valuation databases). The conceptual data model of LADM consists of the following three packages: (1) Administrative Package, (2) Spatial Unit Package, and (3) Party Package. The Administrative Package defines the recording units of land administration; and rights, restrictions, and responsibilities established on basic administrative units. The Spatial Unit Package and its Surveying and Representation sub-packages deal with spatial units (e.g. cadastral parcel, legal space building units, and legal space utility networks), and their geometric/topological representation based on ISO and OGC standards. Finally, the Party Package represents natural and legal people, and the groups consisting of a number of parties that play a role in land administration (Lemmen, 2012, p. 96). LADM also provides external classes which relate cadastral information systems with the other property related databases, such as address, taxation, land use, land cover, valuation, physical utility network, and archive databases.

4.2 OGC LandInfra

Next standard, the OGC LandInfra is a conceptual data model focusing on land and civil engineering facilities. It consists of a core LandInfra package, and special packages for Facilities, Project, Alignment, Road, RoadCrossSection, Railway, Survey, Equipment, Observations, SurveyResults, LandFeature, LandDivision and Condominium. Among these, LandDivision and Condominium are important since they specify the representation of property units, land parcels, and condominium units. LandInfra is not concerned with land recording and database storage unlike LADM, since the scope is limited to activities in respect to civil engineering infrastructure facilities. Therefore, attributes assigned to mentioned classes are mainly related to determination and surveying of boundaries divisions of land (OGC, 2016b).

4.3 OGC CityGML

The other OGC standard, CityGML is an open data model with an XML-based format for the storage and exchange of virtual 3D city models. It consists of a core module and thematic modules including Appearance, Bridge, Building, CityFurniture, CityObjectGroup, Generics, LandUse, Relief, Transportation, Tunnel, Vegetation, WaterBody, and TexturedSurface. Among these modules, Building module has specifications for the representation of building and building parts, and their physical features, such as building installations (e.g. chimneys, stairs, balconies), rooms and interior building installations (e.g. stairs, railings, radiators) (OGC, 2012, pp. 67–82). It also provides rich semantics for representing physical characteristics of the objects.

4.4 OGC IndoorGML

IndoorGML is related to specification of interior space of buildings from geometric, cartographic, and semantic viewpoints. It specifies indoor space (e.g. rooms, corridors, stairs) bounded by architectural components (e.g. roofs, ceilings, walls), and the relationships between indoor spaces. IndoorGML has limited capabilities for the representation of valuation objects, since the focus is to provide description of indoor space and GML syntax for encoding geoinformation (geometry, network or path) for indoor navigation (OGC, 2016a). A recent research by Zlatanova et al. (2016) provides new insights for linking IndoorGML and LADM, but at this moment IndoorGML is considered out of scope for the further investigation.

4.5 INSPIRE Data Specification on Cadastral parcels and Buildings

The final two data models which are relevant to the specification of valuation objects are INSPIRE Data Specification on Cadastral parcels (INSPIRE CP) and Buildings (INSPIRE BU). They are application schemas in GML published as annexes of the INSPIRE directive which aims at establishing an SDI for the European Union for cross-border access of geographical information for environmental purposes. The INSPIRE CP is concerned with the spatial aspect of immovable properties, including basic property units and cadastral parcels. It is consistent with LADM, but does not cover the legal aspect, namely property rights and right holders, like the LandInfra. The other, INSPIRE BU is a rich data model for the specification of constructions, buildings, building parts, and their features. It provides four profiles for multiple representations of buildings and constructions with different levels of detail both in geometry and semantics. The normative core profiles describe buildings and building parts, and a limited set of attributes mainly related to temporal aspects (e.g. construction, renovation and demolition dates), physical information (e.g. height, number of floors, elevation) and the classification of buildings according to their physical aspect and current use. The extended profiles contain additional feature types (i.e. other constructions, building units and installations) and additional thematic attributes (e.g. material of construction, official area or value) (INSPIRE D2.8.III.2).

4.6 Discussion on Data Standards

Concluding this section it is seen that LADM and LandInfra specify of all types of valuation units with different designations, from the legal and the surveying point of views. LA_SpatialUnit and LA_LegalSpaceBuildingUnit classes in LADM enable spatial representation of cadastral parcels and legal space of building units, respectively. They are further used to form the immovable properties represented with the LA_BAUnit class, such as one or more parcels with/without buildings and fixtures, and condominium units. Similarly, LandInfra provides a set of classes to represent property units and their components, i.e. LandParcel, Building, CondominiumBuilding, BuildingPart and CondominiumUnit for cadastral parcels, condominium buildings, parts in condominium buildings, and condominium units, respectively. But LADM and LandInfra has limited attributes for the physical aspects of valuation objects.

INSPIRE CP and INSPIRE BU specify cadastral parcels, buildings and other constructions. INSPIRE CP includes BasicPropertyUnit and CadastralParcel for the specification of immovable properties and cadastral parcels, while INSPIRE BU provides AbstractBuilding, BuildingPart, AbstractBuildingUnit, Room, AbstractConstruction, AbstractOtherConstruction classes for buildings, building parts, rooms and constructions, respectively. INSPIRE initiative, which focuses on environmental purposes, applies a minimalistic approach for the specification of cadastral parcels, but exhaustive for the physical description of buildings, building parts and constructions.

OGC CityGML, is similar to INSPIRE BU and provides a comprehensive data model for the representation of buildings and their parts for 3D visualization purposes with _AbstractBuilding, Building, BuildingPart, Room classes.

The current research considers LADM as the most relevant basis for the development of a valuation information model, as LADM is conceptually the most relevant standard and emphasizes the relationship to other property related databases, which is outside the scope of LandInfra. LADM is an ISO standard for the domain of land administration, which is related to management of information concerning the ownership, value and use of land. The current version of LADM mainly focuses on the legal and administrative aspects, but can be formally extended to cover valuation, taxation and land use planning related datasets. Moreover, its abstraction approach provides a flexible framework for the further development of country specific data models. Thus, in this research LADM is taken as the basis for the development of the proposed valuation information model.

5. A valuation information model based on ISO LADM

This section describes the LADM-based valuation information model. LADM Valuation Model was developed through the specification of the ExtValuation classes of LADM (and model classes are labelled with the prefix VM_ in diagrams). In addition to the new classes, class attributes, and relationships, and the constraints were also introduced. It provides a base model for managing data regarding the parties involved in the valuation practices, valuation units that are the objects of valuation, and their characteristics required in valuation applications. It is noted that the model focuses on only administrative valuations in relation to property tax assessments, and excludes other public and private sector valuation activities.

The Valuation Thesaurus given in Section 2, and international valuation applications given in Section 3 provide the core semantics of the valuation domain. Therefore, they are used as the main source for the identification of candidate classes, class attributes and relationships of the LADM Valuation Model. The responses to the questionnaire were cross-checked with a number of literature on property taxation such as Almy (2013), Bahl et al. (2013), Almy (2014) and Blöchliger (2015) and then used for creating the model. Moreover, relevant designations of the international geographic data standards outlined in Section 4 were also adopted.

5.1 Objects of valuation: Elements of immovable property

According to the Valuation Thesaurus, country applications and scholarly literature, the object of valuation may be (a) only land (e.g. cadastral parcel), (b) only improvements (e.g. buildings), (c) land and improvements together as land property, (d) land and improvements together as condominium property (cf. McCluskey, 1999; Bird and Slack, 2002). As explained in the previous section, the objects of valuation are related to the LA_SpatialUnit, LA_LegalSpaceBuildingUnit and LA_BAUnit classes in LADM. These designations of LADM provide a base for the specification of valuation objects; however, they should be supported from a valuation point of view. A cadastral system is generally organized to maintain legal information in relation to immovable properties (i.e., one or more parcels and attached buildings, or condominium units) whereas a valuation database is organized in a way that stores information in relation to parcels, buildings, parcels and buildings together, and condominium units since these components may, individually, be the object of valuation procedures. Therefore, as depicted in Figure 7 the developed extension model proposes a parent VM_ValuationUnit class, and VM_Parcel, VM_AbstractBuilding, VM_CondominiumUnit subclasses to represent parcels, buildings and condominium units, and their characteristics required by the valuation authorities.

VM_ValuationUnit represents the basic recording unit of valuation databases is associated with LA_BAUnit, which denotes the basic registration unit of cadastral systems. Owing to the constraints created for the valuationUnitType attribute of the VM_ValuationUnit class, the extension model enables the recording of data only for the selected units according to the selected tax base (i.e., only parcels, or only buildings, or parcels and buildings together, or condominiums). The VM_ValuationUnit class defines common characteristics for the valuation objects through attributes, such as identifier, valuation unit type, address, neighborhood type, and available utility services. Among these, the neighborhoodType attribute is used to denote the type of neighborhood where the valuation unit is located (e.g., urban, rural), and the utilityServices attribute records the available utility services (e.g., natural gas, electricity), enumerated in the VM_NeighborhoodType and LA_UtilityNetworkType code list classes, respectively.

The VM_Parcel class represents cadastral parcels, as well as sub-parcels that are the division of parcels based on official land use for taxation purposes (e.g., France and Spain). In addition to inherited attributes from VM_ValuationUnit, it has attributes for parcel identifiers recorded in the cadastral information system, area, current and planned land uses, as indicated by the Valuation Thesaurus and international valuation applications. The current land use attribute is used to denote the existing use of a cadastral parcel while planned land use is used to show the future use of a parcel indicated by spatial plans (INSPIRE D2.8.III.4). The Hierarchical INSPIRE Land Use Classification System (HILUCS) provides a code list for both existing and planned land use attributes.

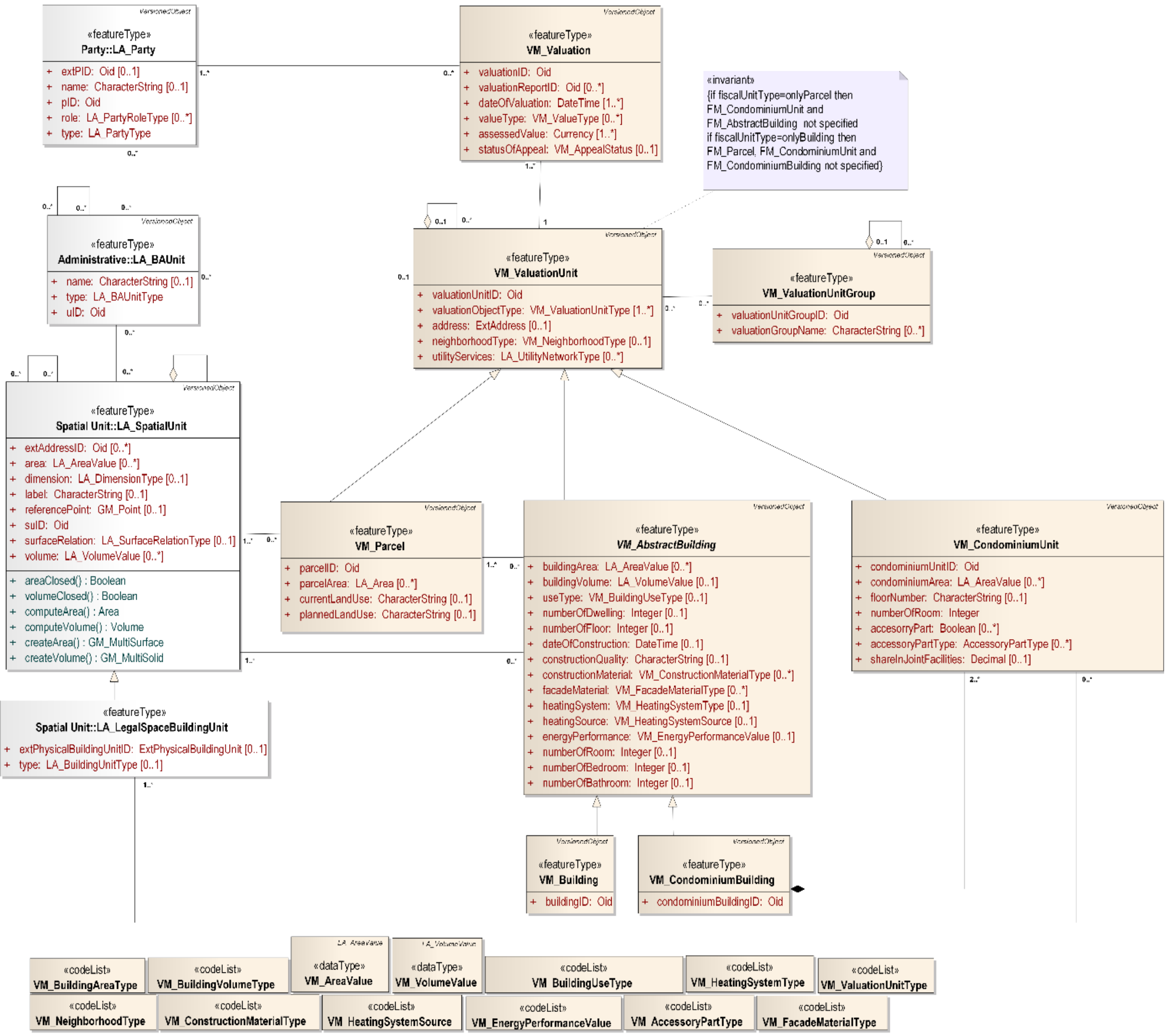

Figure 7 VM_ValuationUnit and related classes

LADM is only concerned with the legal space of buildings and building parts (e.g., individually owned apartments, jointly owned building parts), which does not necessarily coincide with the physical space of a building (ISO 19152:2012, p. 11). LADM also relates the legal space of building units with the corresponding physical building units recorded at external databases through the LA_LegalSpaceBuildingUnit class. Before-mentioned two data models, INSPIRE BU and CityGML provide a framework for the development of such external databases. Incorporating their approach, an abstract VM_AbstractBuilding class is included in the extension model to represent buildings, building parts, other constructions, and their characteristics. VM_AbstractBuilding provides a set of common attributes shared by its sub-classes, such as area, volume, type of use, building type, number of dwellings and floors of buildings. It also accommodates construction and energy performance related attributes, i.e. date of construction, construction material, facade material, heating system, heating source and energy performance, as suggested by the evidences provided in previous sections. INSPIRE BU and CityGML have also designations for the specification of building installations (e.g. balcony, winter garden, chimney), building furniture (e.g. chair, table), and interior installations (e.g. stairs, railings, radiators), especially for 3D visualization purposes. But for the sake of simplicity, these designations have not been adopted to this data model.

Figure 8 shows the code list classes that present values for the mentioned attributes, such as VM_BuildingUseType, VM_ConstructionMaterialType, VM_FacadeMaterialType, VM_HeatingSystemSource, VM_HeatingPerformanceType, and VM_EnergyPerformanceValue.

In LADM, the LA_AreaValue and LA_VolumeValue data types, and the LA_AreaType and LA_VolumeType code lists support the recording the various types of area and volume values (e.g., calculated, official) of spatial units. In the proposed model, these data types are extended with VM_AreaValue and VM_VolumeValue to specify different types of area and volume values of buildings and condominium units (e.g., total floor area, gross volume). The area and volume types defined in the ISO Performance Standards in Building (ISO 9836:2011) are adopted via the VM_BuildingAreaType and VM_BuildingVolumeType code list classes.

VM_AbstractBuilding (see Figure 7) has two concrete classes, VM_Building VM_CondominiumBuilding. The former represents buildings that are considered as complementary parts of parcels, but may be valued separately from the parcels on which they are located. The latter, VM_CondominiumBuilding, is adopted from the OGCs LandInfra standard to specify buildings that contain condominium units established according to condominium schemes (OGC, 2016b). Both classes inherit attributes from the VM_AbstractBuilding class. A condominium building consists of (i) condominium units (e.g. flats, shops); (ii) accessory parts assigned for exclusive use by specific condominium units (e.g. garages, storage areas); (iii) and joint facilities covering parcel, structural components (e.g. foundations, roofs), accession areas (e.g. entrance halls, spaces), and other remaining areas of buildings (e.g. staircases, heating rooms). Joint facilities are owned collectively by all the owners of the condominium units according to ownership shares of the condominium units, while accessory parts and the main condominium units are owned individually by the owners of these units (OGC, 2016b). The extension model proposes a VM_CondominiumUnit class to record the main condominium unit characteristics, such as area and volume, related accessory parts and shares in joint facilities.

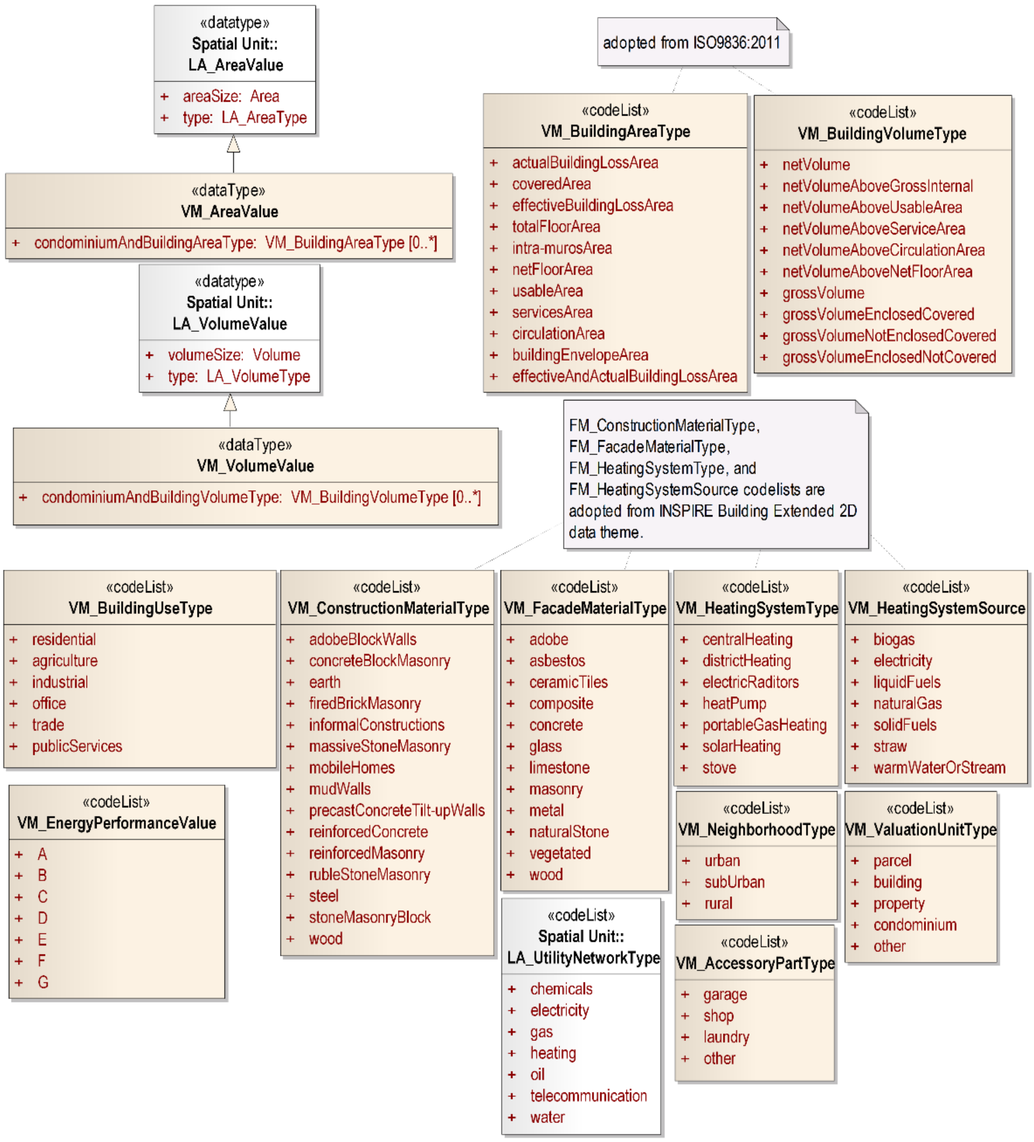

Figure 8 Data types and code list classes for the VM_ValuationUnit class and its subclasses

5.2 Categories of valuation units and zoning

As described in Section 3, valuation units may be grouped according to zones (e.g. administrative divisions, market zones) that have similar environmental and economic characteristics, or categorized according to functions and types of valuation units (e.g., commercial, residential, agricultural) that have similar physical characteristics. Moreover, mass appraisal models and ratio study analysis may be employed for such groups instead of individual units. This issue is addressed by the VM_ValuationUnitGroup class (see Figure 9) in the extension model, which includes an identifier and type attributes. VM_ValuationUnitGroup not only groups spatially related valuation units, but also spatially unrelated units that have similar characteristics, such as commercial properties.

5.3 Valuation methods

VM_Valuation class, as counterparts of ExtValuation external class of LADM, was created to specify valuation information. The relationships between VM_Valuation, LA_Party and VM_ValuationUnit indicate that a valuation unit may be subject of one or more valuation activities carried out by one or more valuation experts. As shown in Figure 9, the VM_Valuation class focuses on the output data produced within valuation processes for property tax assessment. It identifies valuation activities and valuation reports through valuationID and valuationReportID attributes, indicates the valuation date and value type with valuationDate and valueType attributes, and the final assessed value with the assessedValue attribute. The Valuation Thesaurus includes many value types (c.f. Figure 3), but only value types which, are used as tax base according to international applications (c.f. Section 3), are rendered in the designed model. Moreover, appealOfStatus attribute and its data type VM_AppealStatus enable tracking status of possible appeals against to assessed values.

As appears from the Valuation Thesaurus and international applications, the value of a unit may be estimated by different approaches and methods before the final assessment, such as sales comparison, cost and income approaches, through single or mass appraisal procedures. Therefore, valuationApproach attribute, and corresponding VM_ValuationApproach data type which also supported by VM_SalesComparisonApproach, VM_IncomeApproach and VM_CostApproach data types are designed for the specification information in relation to mentioned valuation approaches.

As illustrated in Figure 10, the VM_SalesComparisonApproach data type enables documentation of comparable valuation units used in the sales comparison approach, and adjustments made for the sale according to the time, physical and locational differences from comparable units to estimate value of subject unit. The VM_CostApproach data type organizes the cost method related details, such as cost type (e.g., replacement or reproduction cost), source and price of cost, chronological and effective age of improvements, and appreciated obsolescence (e.g., physical, functional, external, and total) occurring through the improvements. Finally, the VM_IncomeApproach data type renders the potential gross, effective gross and net incomes, operating expenses, capitalization and discount rates, and gross rent multipliers used in the direct and yield capitalization approaches of income capitalization procedures.

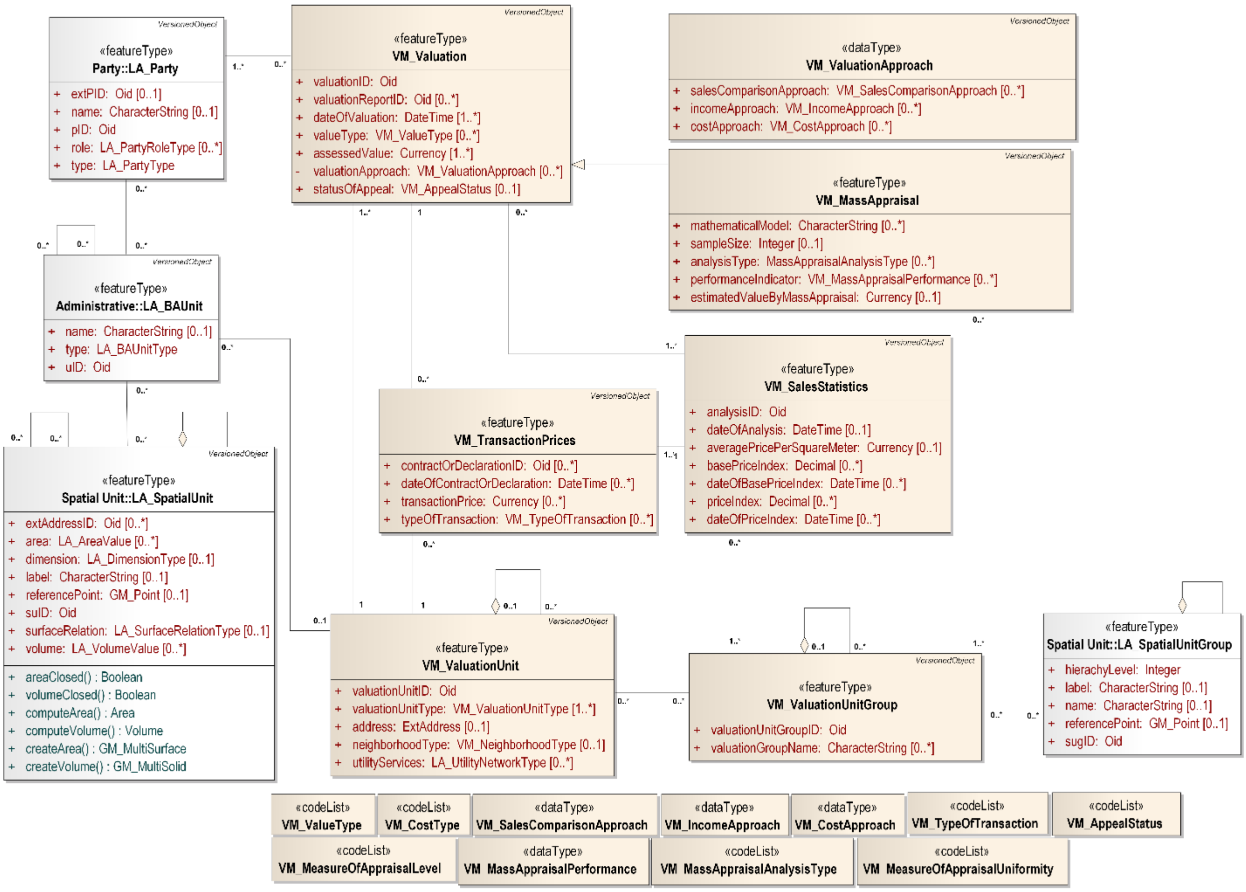

Figure 9 VM_Valuation and related classes

The extension model also enables specification of mass appraisal related information through VM_MassAppraisal class. Specifically, it describes mathematical models, mass appraisal analysis types (e.g., multiple regression analysis), and the sample size of the analysis. It also has a performance indicator attribute and corresponding VM_MassAppraisalPerformance data type. The date of performance analysis, sample size, measures for appraisal level (e.g., mean), appraisal uniformity (e.g., coefficient of dispersion), and values for the selected measurements can be recorded through the VM_MassAppraisalPerformance data type class.

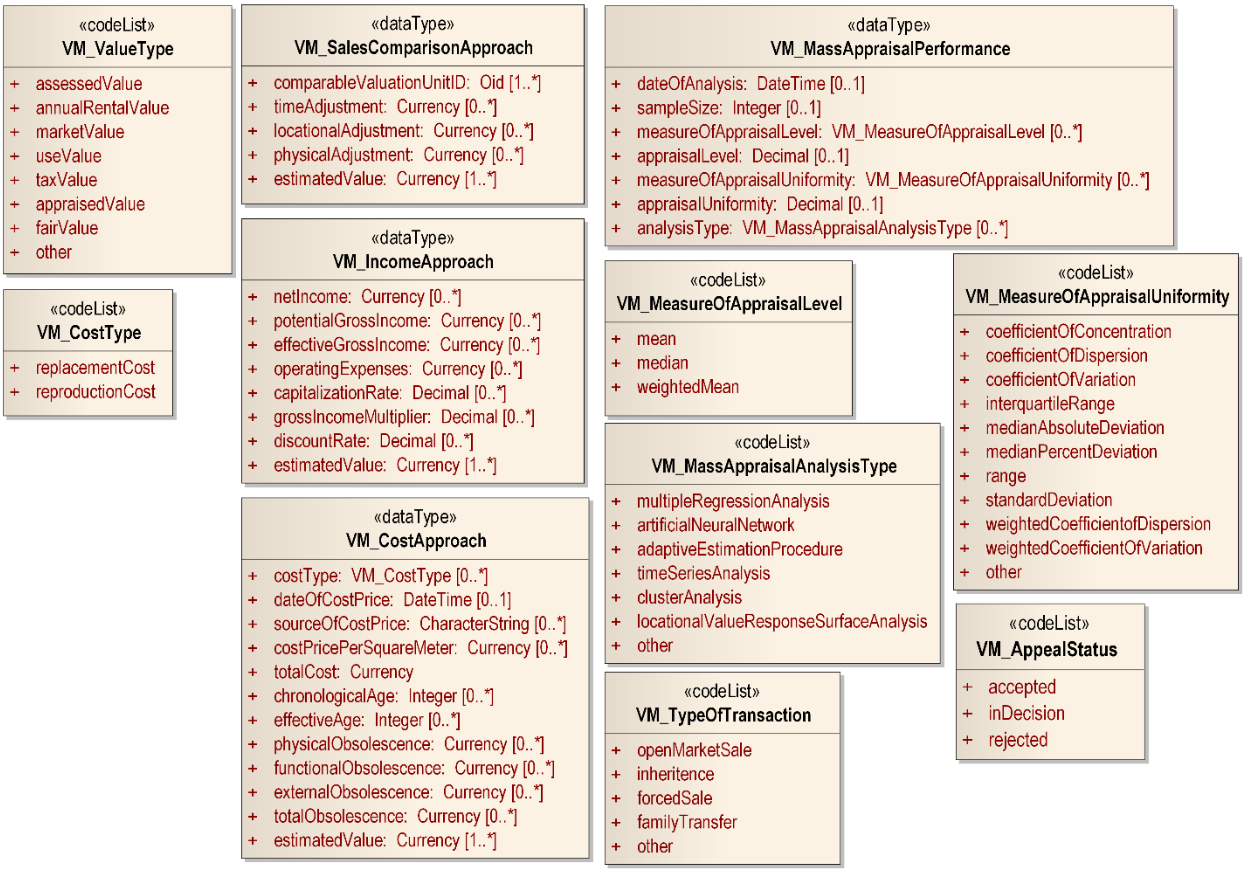

Figure 10 Code list and data type classes developed for VM_Valuation and its subclasses

5.4 Sales statistics

Many countries maintain registers or databases to record data in relation to property transactions, as mentioned in Section 3. These databases are used to produce periodic sale statistics and price indexes (e.g., House Price Index in the United Kingdom, and the Price Index for existing houses in the Netherlands) that show the total amount and type of transactions, average values, and changes in property values. Such databases are created and updated regularly by information provided from contracts or declarations submitted by the parties (e.g. buyer and/or seller) involved in the property transactions. The Valuation Model is supported by the VM_TransactionPrices and VM_SalesStatistics (see. Figure 9) classes to address information regarding transaction prices and sales statistics, respectively. VM_TransactionPrices is provided with attributes that characterize the information content of transaction contractor declarations, including the date of contract or declaration, price, date and type of transaction (e.g., sale, heritage, forced sale, and rent prices). The next class, VM_SalesStatistics, is created to represent sales statistics produced through the analysis of transaction prices. It is related to VM_ValuationUnitGroup since such analysis can be made based on spatial (e.g. parcels in a municipality) or thematic clusters (e.g., parcels used for agricultural purposes). In addition to identifier and date attributes, it has attributes to indicate the calculated average transaction prices per square meter of valuation units. Moreover, it has basePriceIndex and dateOfBasePriceIndex attributes to record the value and date for specification of base index (e.g. Base Index Value = 100 at 2015 January), and priceIndex and dateOfPriceIndex attributes to record the calculated price index at a given date (e.g. Index Value = 120 at 2016 January). Transaction prices and sales statistics are directly used in single and mass appraisal procedures, as indicated by two associations from VM_Valuation to VM_TransactionPrices and VM_ SalesStatistics.

The LA_Party class in LADM represents the natural and legal persons, and groups consisting of a number of parties both of which play a role in land administration. It can also be utilized to record information about parties that are involved in valuation procedures. The LA_PartyRoleType code list class, which provides values for the role performed by the parties (e.g., surveyor or notary) in the land administration domain, is therefore extended (see Figure 11) to cover valuation related roles according to Valuation Thesaurus (cf. Figure 2).

Figure 11 Code list developed for LA_PartyRoleType

Finally, the temporal aspect in the extension model is addressed with the VersionedObject class and a number of attributes assigned to the VM_Valuation class. In LADM, VersionedObject is the superclass of all classes either directly or indirectly, and has the beginLifespan and endLifespan attributes to specify the date and time when the object was inserted, changed, and removed from the database. In keeping with the LADM design approach, all classes in the Valuation Model are created as a subclass of VersionedObject either directly (e.g. VM_ValuationUnit, VM_Valuation) or indirectly (e.g., VM_Parcel, VM_Building, VM_MassAppraisal). Moreover, several attributes are assigned to the

VM_Valuation class (see Figure 9) to deal with other temporal issues in relation to valuation procedures, e.g., date of valuation, date of cost for valuation procedures.

6. Conclusions

This article describes development of a valuation information model for the specification of inventories or databases used in valuation for recurrently levied immovable property taxes. As an extension module of ISO 19152:2012 Land Administration Domain Model, it is designed to facilitate all stages of immovable property valuation, namely the identification of properties, assessment of properties through single or mass appraisal procedures, generation and representation of sales statistics, and dealing with appeals. More specifically, it enables the recording of data concerning the parties that are involved in valuation practices, property objects that are subject of valuation, as well as their characteristics.

The semantics of valuation information for recurrent taxes on immovable property is revealed by a Valuation Thesaurus which is prepared based on international valuation standards according to ANSI/NISO Z.39.19-2005, and information obtained from 24 respondents from 22 countries through questionnaires and scholarly literature. The formal description of the domain given in Section 2, and country applications explained in Section 3 are therefore used as the main source for the development of LADM Valuation Model. Moreover, relevant designations of the international geographic data standards outlined in Section 4 are also adopted.

LADM Valuation Information Model will help public bodies a common basis for the development of local or national databases, and can act as a guide for the private sector to develop information technology products. It is foreseen that LADM Valuation Model is going to be part of LADM 2.0, the revised version of LADM according to ISO's periodic maintenance procedure.

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