Leveraging BIM for the LADM Part 4 - Valuation Information Model: the case study of Cyprus

Pavlos DEMETRIADES (Cyprus), Eftychia KALOGIANNI (The Netherlands) and Efi DIMOPOULOU (Greece)

Key words: Building Information Model (BIM), Land Administration Systems (LAS), Land Administration Domain Model (LADM), Valuation Information Model, data interoperability, data circularity, property valuation

SUMMARY

Building Information Model (BIM) is a powerful tool for managing and utilizing data throughout the lifecycle of buildings and infrastructure. This paper explores the options, and considerations, of using BIM data for the Land Administration (LA) domain. The ISO19152 Land Administration Domain Model (LADM), as a widely recognized international standard for Land Administration domain, is currently undergoing revision. The new Edition will be multipart, with 6 Parts, including Part 4 (ISO19152-4) about Valuation Information, specifying the characteristics and semantics of valuation registries maintained by public authorities. This valuation part may include incorporating advancements in the representation and management of property-related information, as well as aligning with the architecture, engineering, and construction (AEC) industry. BIM has a significant impact on the AEC industry, since its adoption transforms traditional processes, enhancing among others, visualization, lifecycle management and facility operation. By integrating information from BIM models into the LADM Part 4, several benefits can be achieved, such as: more accurate 3D property representation, dynamic and realistic assessment of property value, automation of valuation processes and compliance with industry regulations. Therefore, this paper investigates how to integrate BIM data with the LADM, particularly in the context of Cyprus. The mapping between the existing Valuation Model of Cyprus and the basic concepts of LADM Part 4 takes place and a proposed valuation information model for Cyprus based on LADM Part 4 is designed. This model is further enriched by the integration of data derived from a real-world mixed-use buildings. Additionally, we presented the primary objective of this paper along with its significance within the context of the Cyprus Land Registry system, with particular focus on its relevance to the Valuation Department.

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1 INTRODUCTION

Cities have undergone rapid expansion, evolving into larger, denser, and more complex due to continuous population growth and the need for efficient use of limited space (Dimopoulou, 2015). Urban areas often feature intricate constructions both above and below the surface. This global trend has given rise to new demands for sustainable land development to preserve and protect property. To meet this objective, continuous and accurate information about land ownership, rights, restrictions, and responsibilities, in conjunction with its valuation and utilization is indispensable.

In this scene, Land Administration Systems (LAS) serve as the foundational framework for managing land information, facilitating land tenure procedures, as well as registration, and transaction processes (Oguzhan Mete et al., 2022). The Land Administration Domain Model (LADM) has emerged as an international standard (ISO 19152:2012) to foster efficient interoperability, communication, and data exchange among various land administration systems.

Although the LADM Edition I is extensively used (Kalogianni et al., 2021) and is applicable for various use cases and purposes, ISO rules prescribe periodic revision (Lemmen et al., 2023) and therefore, the revision of the standard is currently ongoing. LADM Edition II is being developed as multi-part, with 6 parts, covering a wider scope of land administration (Kara et al., 2023). One of those, LADM Part 4: Valuation Information, specifies the characteristics and semantics of valuation registries maintained by public authorities and to reveal the interrelations between valuation registries and other land administration registries (Kara et al., 2021).

On the other hand, much is going in the Architecture, Engineering, Construction, Owner Operator (AECOO) sector and its modernisation, with Building Information Model (BIM) and specifically Industry Foundation Class (IFC) playing an important role. These standards, LADM and IFC, are vital to achieving communication and interoperability between AEC and LAS sector.

In Cyprus, the valuation of immovable property plays a pivotal role in the dynamic landscape of land development. With its strategic location and stunning natural beauty, Cyprus has become an attractive destination for real estate investment. Investors and developers rely on meticulous property valuations to make informed decisions about their ventures. The

valuation process ensures that the potential of each piece of land is accurately assessed, considering its unique characteristics and development prospects. As the demand for land development projects continues to rise, a precise understanding of immovable property valuation in Cyprus remains essential for sustainable and profitable ventures in this flourishing real estate market.

The scope of this paper is the optimization of the valuation procedure of the immovable property in the context of the land administration systems, using international standards like BIM/IFC and LADM-Part4. At the same time, another scope is the implementation of the valuation model of Cyprus, based on the LADM – Part 4, and the implementation of valuation information in a BIM/IFC.

The rest of the paper is structured as follows: first the background information is presented in Section 2. In Section 3 the methodological framework for the development of the valuation information model for Cyprus based on ISO19152-4 is presented, including the current valuation model of Cyprus and the detailed presentation of the modelling procedure. Following, the paper demonstrates the integration of valuation information in an IFC model based on the proposed Valuation Model of Cyprus which developed in Section 3, and visualises this information based on IFC's entities. Lastly, Section 5 presents final conclusions and Recommendations.

2 BACKGROUND INFORMATION

This Section provides all the necessary background information crucial to understanding the objective of this paper. The Land Administration Domain Model is one of the key concepts analysed at this paper and the current developments of the second edition of the standard are introduced, focusing on Part 4, which addresses valuation information. Moreover, the significance of BIM/ IFC for Land Administration Systems and property valuation applications is highlighted, while developments and innovations in this filed are also presented.

2.1 ISO 19152 Editions and ISO19152-4: Valuation Information

The first version of the Land Administration Domain Model (LADM) was adopted as an international standard by the International Organization for Standardization (ISO) in 2012, making it the most significant standardization in the field of land administration systems to date at the international level (Dimopoulou E., 2015). The main objective of LADM is to organize information about rights, restrictions, and responsibilities (RRRs) attached to land (including the space below and above it), as well as their geometric characteristics (ISO, 2012). This facilitates communication between involved organizations and systems within a country or between different countries through a common terminology (Lemmen et al., 2015).

2.1.1 ISO 19152 Edition II

All standards issued by the ISO Organization are subject to a revision process at regular intervals. In this context, the LADM revision process started in 2019 and is currently ongoing, with the second edition of the standard now having 6 parts under development, as the range of

information modelling it will cover is wider than that of the first edition (Kalogianni et al., 2023). The development of these parts is carried out by the LADM committee (LADM Editors), which are discussed and evaluated by the participants in ISO Technical Committee ISO/TC 211, Geographical information/Geomatics. To date, the first five parts are under development, following the ISO revision process, while the sixth is expected to be developed in close collaboration between ISO and the Open Geospatial Consortium (OGC) in the near future. The standardization process by the ISO follows several stages and votes, until a candidate standard is voted as an international standard. To date, none of the 5 -under-development-parts of ISO19152 Edition 2 has been voted as an international standard, while ISO19152-1: Generic Conceptual Model is expected to be the first to be voted within 2024 (Lemmen et al., 2021).

The following figure shows the six parts of the second edition of the LADM. It is noted that the first five concern conceptual models (Kara et al., 2023).

1. Part 1 – Fundamentals: will form the core of the new standard supporting the rest of the parts, defining the basic concepts, packages and interrelationships.
2. Part 2 – Land Registration: will include in detail all information for recording information in land management systems.
3. Part 3 – Marine Space Georegulation: based on the concepts of Part 1 it will concern the modeling of information about marine space.
4. Part 4 – Valuation Information: based on Part 1 & Part 2 will concern the modelling of the information related to the valuation of land values.
5. Part 5 – Spatial Plan Information: based on Part 1 & Part 2 will concern the modelling of the information related to spatial planning.
6. Part 6 – Implementations: alternative technical implementations of the above parts will be developed.

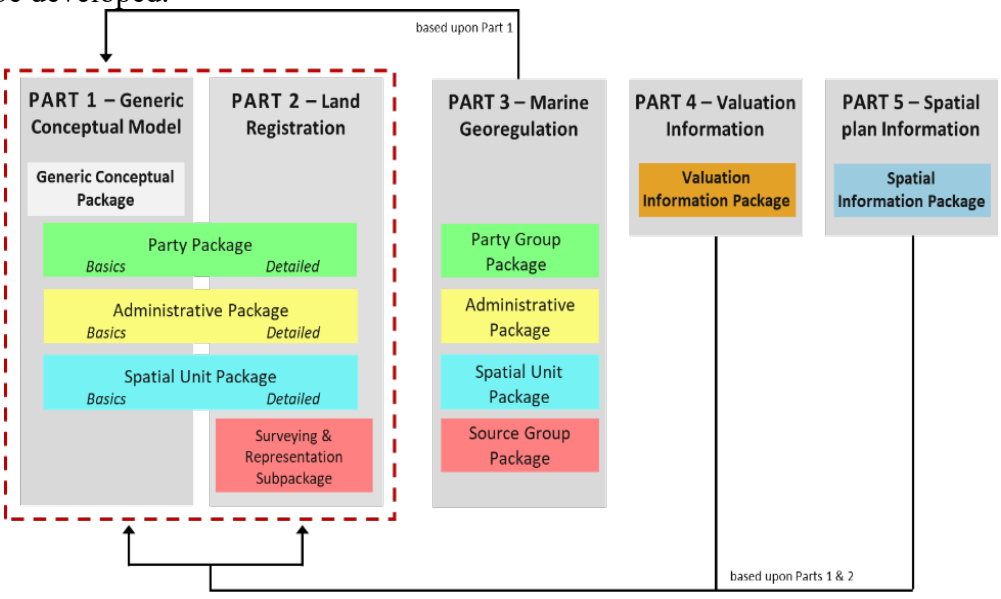

Figure 1 – Investigation of the Parts of the LADM – Edition II which are under development (Kalogianni et al., 2023)

2.1.2 ISO 19152 – Part 4: Valuation Information

ISO19151-4 - Valuation Information has a key objective of establishing a standardized way for communication among stakeholders within and between countries (Kara et al., 2021). It does so by defining a common vocabulary and terminology through its model. However, this standard does not seek to replace existing asset valuation systems; instead, it aims to provide a consistent and shared structure for describing these systems while considering their unique characteristics. Moreover, it strives to offer a scalable foundation for the development and enhancement of efficient real estate valuation systems, adopting the Model Driven Architecture (MDA) approach (Kara et al., 2021).

LADM Part 4 comprehensively represents all stages of immovable property valuation, encompassing ownership recognition, various valuation processes, transaction price recording, statistical sales representation, and handling of appeals. The model's versatility is expected to enable relevant institutions to develop local or national information models and databases while facilitating communication and possible integration of these databases into existing land administration systems (Kara et al., 2021). It is important to note that LADM - Part 4 is specifically tailored to improve administrative valuations of immovable property, such as property taxation, compensation for expropriation, land readjustment, and insurance assessments, but it is also intended for broader evaluative purposes. LADM Part 4 consists of only one package, the Valuation Information Package, which is shown in the next figure.

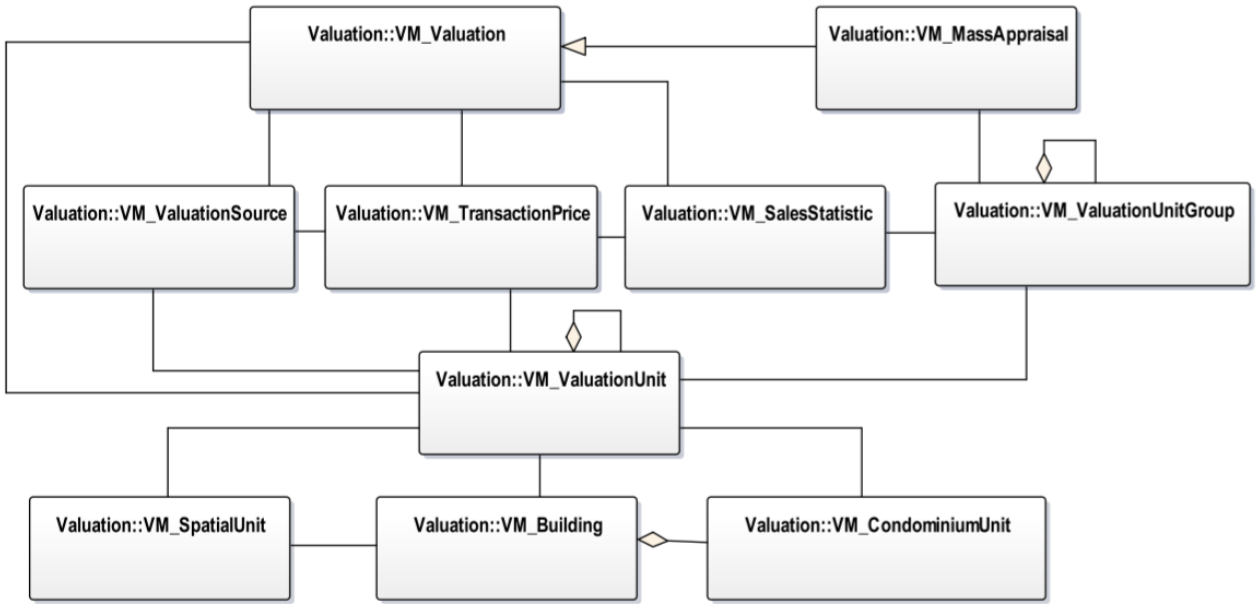

Figure 2 – Main Classes of The Valuation Information Package – Source: (Kara et al., 2023)

2.2 BIM/ IFC for Land Administration Systems and Property Valuation

The primary purpose of the development of BIM models was the modelling of buildings, but due to the complexity of other constructions, such as these of infrastructures, BIM was also adopted by them. The result of this was the increase in applications using BIM and the

parallel increase in the need for richer geometric and semantic information, this led to the increase in the dimensions of BIM (urban dimension) (Hajji et al., 2021). Since establishing the relationships between urban items is its primary priority, managing the urban component is not a simple procedure. Due to its intricate geometry, it may also serve as a physical representation of abstract notions, such as the construction's maximum allowable height, that need to be translated into language that humans can comprehend. As can be shown, many issues with real property rights can be resolved by integrating BIM models into land management systems. Additionally, limits on ownership may be seen due to the discovery of criminal activity.

Atazadeh et al. (2021) mention that the use of BIM/IFC for land administration purposes based on LADM can be achieved through two approaches. The first approach involves extending IFC based on LADM data, while the second approach involves extending LADM itself based on the physical characteristics of IFC. From the research it is concluded that the second approach is not that the optimal, as LADM is a conceptual model that addresses jurisdictional aspects in each country and when attempting to extend it with physical objects would lead to complexity. Additionally, IFC contains hundreds of entities related to building modelling, making it difficult to identify and correlate them with new entities that would serve as extensions of LADM. Therefore, at this study, the first approach, is considered the most suitable for integrating three-dimensional physical and legal information into BIM models.

Moreover, in the work of Su et al. (2021) a novel approach to property valuation is discussed, utilizing data from BIM/IFC models and machine learning methods. It is noted that machine learning methods have advantages over other approaches, as they can take both objective and subjective factors into consideration for valuation. Additionally, they are capable of handling vast volumes of data and providing measures of accuracy and reliability in the outcome. As a result, property valuation can be determined with the most accurate and reliable way. Regarding BIM models, they can store data related to property value, such as material costs, construction timelines, geographical location, energy efficiency, and more. So, utilization of BIM data for the process of the property valuation may be a potential – powerful tool in the future for property valuation.

3 VALUATION INFORMATION MODEL FOR CYPRUS BASED ON ISO19152-4

This Section examines the extent to which the current Cyprus's General Valuation Model can be adapted to the principles, concepts and structure of ISO19152-4, in accordance with the goals of the Valuation Department which belongs to Department of Surveyors (DLS) of Cyprus. To achieve this objective, a mapping is conducted between Cyprus's existing model and ISO19152-4, and the outcomes are then illustrated using UML diagrams. This process leads to the creation of the proposed ISO19152-4: Valuation Information Model for Cyprus.

3.1 Methodological framework

The methodological framework followed for the development of the proposed model of ISO19152 – 4 for Cyprus consists of two main steps. The first step is the analysis of existing

valuation model of Cyprus, and the second one concerns the modelling of the valuation model for Cyprus based on LADM – Part 4.

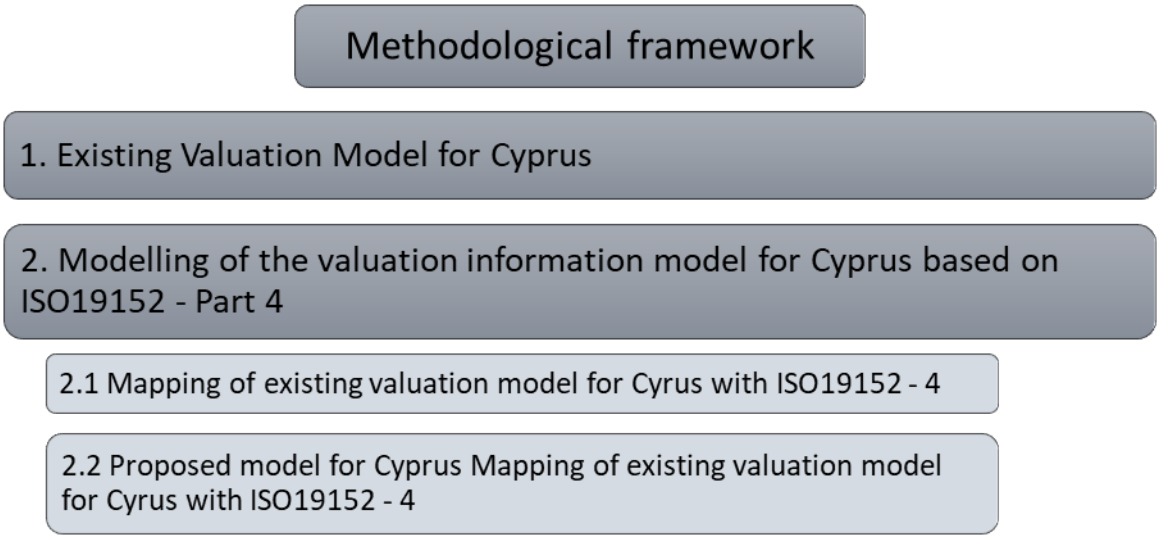

Figure 3 – Methodological framework for the creation of Valuation Model of Cyprus based on ISO19152-Part4

3.2 Current Valuation Model of Cyprus

The responsible organisation for the management and dissemination of the cadastral data in Cyprus is the Department of Land and Surveys (DLS), which consists of twelve departments. The DLS is one of the most important socio-economic pillars of development of Cyprus since the immovable property it is one of the leading factors of progress, prosperity, and development of the country. Its main purpose is the implementation of legislation and procedures for the management of rights, responsibilities and restrictions that connect persons (natural or not natural) with the immovable property. To achieve this, it undertakes the record of the characteristics (geometrical and semantical) of the real property. DLS it

The Department of DLS, responsible for valuation is the General Valuation Department – Valuation's Department. The general valuation in Cyprus, according to the general annual report of DLS (Department of Land and Surveyors, 2021) is conducted every three years, starting from 2018. General valuation/mass appraisal is defined as "*the process of estimating the value of a group of properties on a specific date using common data, standardized methods, and statistical controls*" (Department of Land and Surveyors, 2022). The mass appraisal is implemented through an automated system called the Computer Assisted Mass Appraisal System. Therefore, the value resulting from the general valuation is the general valuation value. As defined by (Department of Land and Surveyors, 2022): *"General Valuation Value" in relation to immovable property means the amount resulting from the conduct of the general valuation or revaluation or revision of the general valuation, which is as close as possible to the value.*

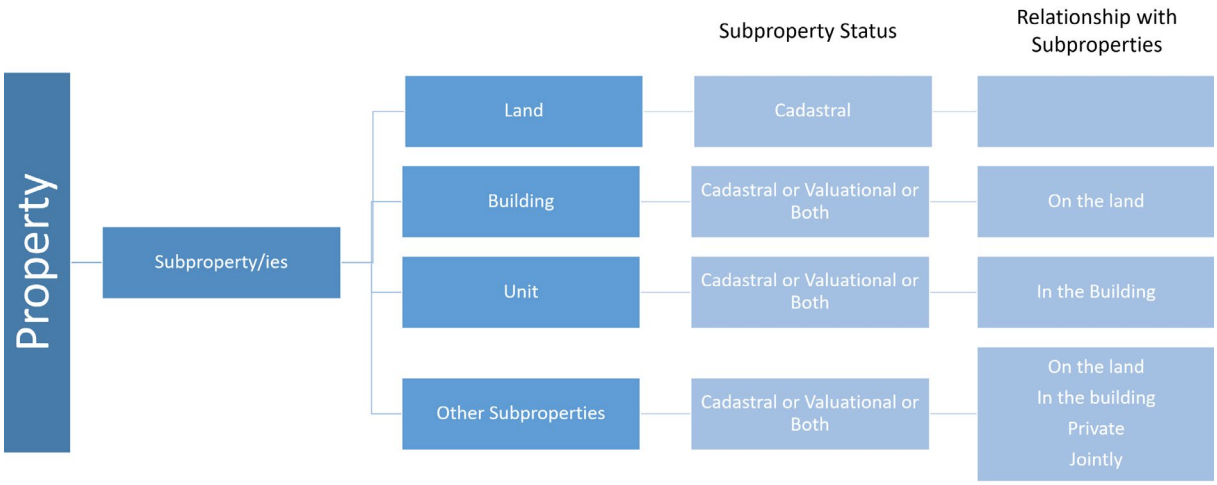

Figure 4 – Types of properties in the existing Valuation Model of Cyprus

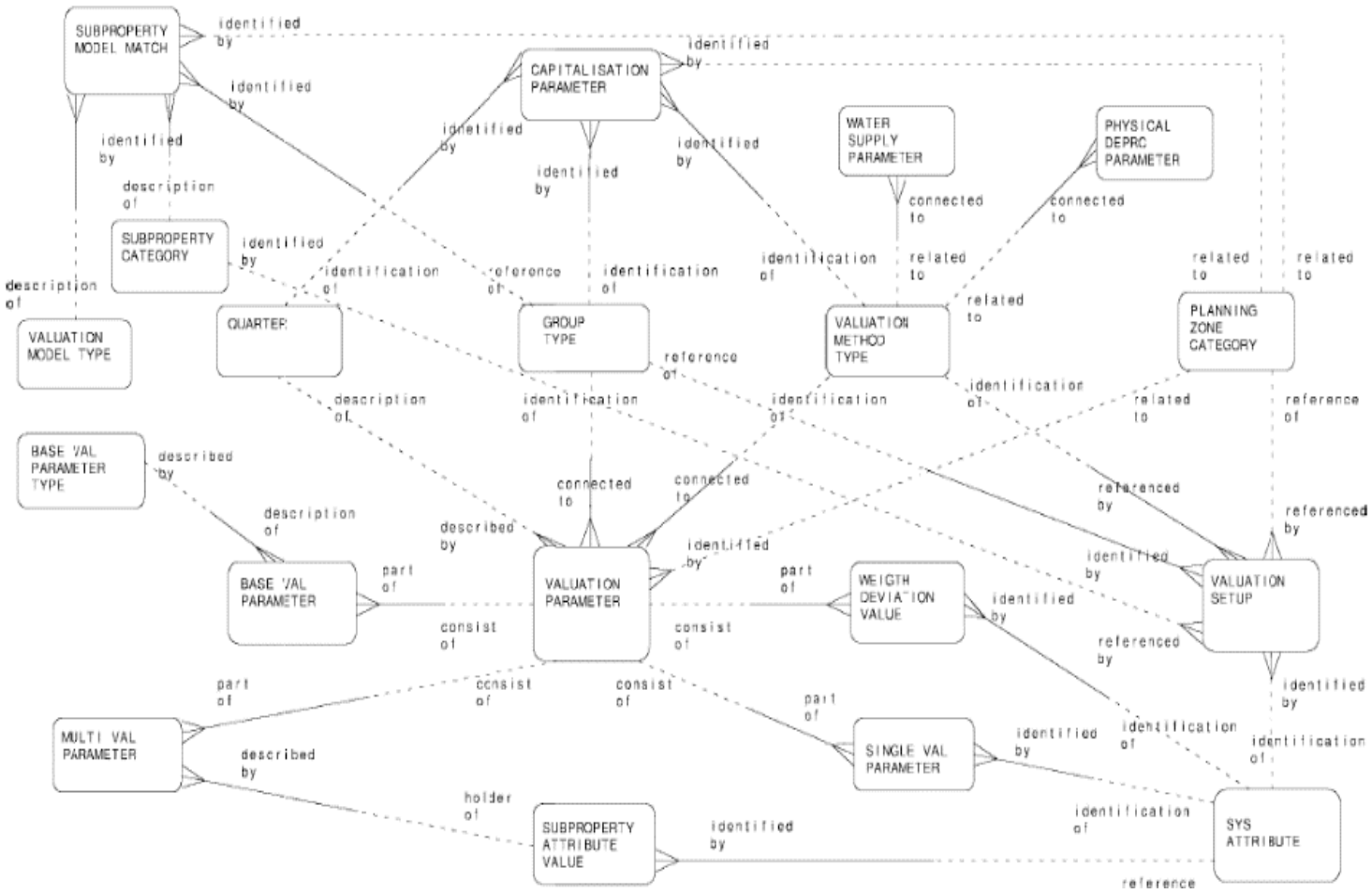

Figure 5 – Existing Valuation Model of Cyprus (DLS)

Figure 5 shows the entity-relationship diagram of the current Valuation Information Model of Cyprus. As it shown, there are plenty entities which consists of the model, denoting the complexity of the model, as well as the high number of parameters related to valuation that shall be considered. The main classes are described in the following paragraphs.

The Subproperty Category within the context of the land registry of Cyprus plays a crucial role in property categorization. These categories encompass various sub-properties, including land parcels, buildings, units within buildings, and other sub-properties like pools and parking spots. Each sub-property type is defined to ensure accurate and comprehensive property assessments. Furthermore, these categories serve as a foundation for valuation models, helping to determine the appropriate valuation approach for each unique subproperty.

The Valuation Model Type class distinguishes between two primary valuation models: Basic Models and Cost Models. These models are integral to the property valuation process, with Basic Models covering land, units, and other sub-properties, while Cost Models specifically apply to units. The choice of valuation model depends on factors like the type of sub-property, the assessment group it belongs to, and the planning zone category. By categorizing properties and selecting the appropriate valuation model, the valuation process becomes more efficient and tailored to the specific characteristics of each property.

Additionally, the Valuation Method Type, Base Val Parameter Type, Base Value Parameter, Valuation Parameter, Valuation Setup, Multi Val Parameter, and Single Val Parameter entities collectively define the methodology, parameters, and procedures used in property valuation. These elements ensure a systematic and comprehensive approach to property appraisal, considering factors such as location, property type, and valuation method. While entities like Sys Attribute, Subproperty Attribute Value, Water Supply Parameter, Quarter, Capitalization Parameter, Physical Depro Parameter (Statistics) and Weigh Deviation Value have become obsolete in the Existing Valuation Model.

3.3 Modelling of the valuation information model for Cyprus based on LADM Part 4

A mapping was made between the entities of the Existing Valuation Model of Cyprus and those of ISO19152-4 Valuation Information both at class and attribute level. At the tables that follow the schema mapping is presented, along with some general comments about the fundamental modelling decisions taken during both the mapping and the development of the proposed model presented in the next subsection:

- The first column of the tables below pertains to the attributes of each respective class in the existing Valuation Model of Cyprus. The first row displays the class name as it exists in the current model.
    - Classes written in **green letters** remain as entities in the proposed model.
- The second column concerns the attributes of each respective class in the under-development ISO19152-4 standard. The first row of this column displays the class name as it exists in the standard and for this reason, all of them start with the prefix "VM."
    - Attributes aligned in the middle already exist in ISO19152-4.
    - Attributes aligned to the left do not exist in the standard, but since they serve the needs of land value estimation in Cyprus, they are added and presented in the proposed model with the same names as they have in the existing Cypriot model.
    - For each attribute, the data type and the code list, where necessary, are provided.
- The third column represents the class in the proposed model for Cyprus to which the attribute in the second column belongs. The first row of this column displays the name

of the class in the proposed model and for this reason, all of them start with the prefix "CY_VM.".

- External classes: The implementation of LADM based on a country's needs can be executed flexibly, adapting to local conditions. Constructing external databases with data such as addresses, land uses, building permit details, etc., falls outside the structure of LADM. However, the possibility of linking LADM with external sources is provided through external entities.
- Code lists: Code lists are used to describe flexible coding and can be expanded by adding new values that are tailored to the country's needs.

3.3.1 Mapping of existing valuation model for Cyprus with ISO19152-4

The schema mapping of the entities of the Existing Valuation Model of Cyprus and ISO 19152-4 is as follows.

Table 1 – Schema Mapping between entities of Existing Valuation Model of Cyprus and ISO 19151-4

Existing Valuation Model of Cyprus	**ISO 19152-4 Valuation Information**
Parcel	**VM_SpatialUnit & VM_ValuationUnit**
SubpropertyCategory	**VM_ValuationUnit**
Unit	**VM_CondominiumUnit & VM_Building**
Building	**VM_Building & VM_SpatialUnit**
OtherSubproperties	**VM_CondominiumUnit**
ValuationModelType	**VM_Valuation**
Group Type	**VM_SpatialUnit & VM_Building**
Planning Zone Category	**New Class (CY_VM_Planning Zone)**
Subproperty Model Match	**VM_Valuation**
Valuation Method Type	**VM_Valuation**
Base Val Parameter Type	**New Class (CY_VM_Planning Zone)**
Base Val Parameter	**New Class (CY_VM_Planning Zone)**
Valuation Parameter	**VM_ValuationUnit**
ValuationSetup	**VM_Valuation**

At the following tables the detailed schema mapping of the attributes of the classes of the Existing Valuation Model of Cyprus and ISO 19152-4 are presented.

Table 2 – Schema Mapping Table of the Parcel class of the existing model with ISO19152-4 respective classes and attribute

Parcel	**CY_VM_SpatialUnit & CY_VM_ExtAddress & CY_VM_ValuationUnit**	
idParcel	vsUID	CY_VM_SpatialUnit
roadRelation	roadRelation(CY_VM_RoadRelation"Code List")	CY_VM_SpatialUnit
typeAccessStreet	roadAccess (CY_VM_RoadAccess "CodeList")	CY_VM_SpatialUnit
relationStreetLevel	relationRoadLevel(CY_VM_RelationRoad Level "CodeList")	CY_VM_SpatialUnit
facade	facade	CY_VM_SpatialUnit

shape	shape	CY_VM_SpatialUnit
view	parcelView (CY_VM_View "CodeList")	CY_VM_SpatialUnit
environment	environment	CY_VM_SpatialUnit
obstacles	obstacles(CY_VM_Obstacles "CodeList")	CY_VM_SpatialUnit
nuisances	nuisances(CY_VM_Nuisances "CodeList")	CY_VM_SpatialUnit
locationValuation	locationValuation	CY_VM_SpatialUnit
slope	slope	CY_VM_SpatialUnit
influencedBeachProtectionZone	influencedAreaFromBeachProtectionZone	CY_VM_SpatialUnit
area	suArea (LA_AreaValue "DataType")	CY_VM_SpatialUnit
sheet	sheet	CY_VM_ValuationUnit
plan	plan	CY_VM_ValuationUnit
plot	plotNumber	CY_VM_ValuationUnit
town	town	CY_VM_ExtAddress
quarter	quarter	CY_VM_ExtAddress
postalCode	postalCode	CY_VM_ExtAddress
registrationCode	registrationCode	CY_VM_ValuationUnit
parcelRegistryValuePrevious	parcelRegistryValuePrevious	CY_VM_ValuationUnit

Table 2 pertains to the mapping of the "Parcel" class from the existing model to the "VM_SpatialUnit" and "VM_ValuationUnit" classes of the standard. As observed from the table, the attribute "idParcel" corresponds to the attribute "vsUID" (aligned in the middle) of the "CY_VM_SpatialUnit" class. Conversely, the attribute "typeParcel" (aligned to the left in the second column) remains as is in ISO19152-4, as there is no corresponding attribute in it. In this specific table, an external class (CY_VM_ExtAddress) is presented with details regarding the Contact Address.

The attributes "sheet" (gender number), "plan" (cadastre plan number), "plotNumber" (Plot Number), "registrationCode" (Land Registry Number), and "parccelRegistryValuePrevious" (previous estimated property value) correspond to the "CY_VM_ValuationUnit" class. It should be noted that the registration code of the parcel (registrationCode) is not the unique parcel number in the cadastre; it is the unique number for each property in this specific registration section (Hajdimina N. 2018)

Table 3 – Schema Mapping table of Building class of the existing model with ISO19152-4 respective classes and attribute

Building	**CY_VM_SpatialUnit & CY_VM_Building & CY_VM_ExtAddress**	
nameOfBuilding	nameOfBuilding	CY_VM_Building
numberOfBuildings numberOfUnits	numberOfBuildings	CY_VM_SpatialUnit
address	address	CY_VM_ExtAddress

Table 3 concerns the mapping of the "Building" class to the "VM_SpatialUnit" and "VM_Building" classes of the standard. In this case, the attributes of one class correspond to attributes of two different classes. Specifically, the attribute "nameOfBuilding" belongs to the "CY_VM_Building" class, and the attribute "numberOfBuildings" belongs to the "CY_VM_SpatialUnit" class.

Table 4 – Schema Mapping table of Unit class of the existing model with ISO19152-4 respective classes and attribute

Unit	**CY_VM_CondominiumlUnit & CY_VM_Building & CY_VM_ExtBuildingPermit**	
Building Permit Number	buildPermitID	CY_VM_ExtBuildingPermit
Date of Issuance of Building Permit	permitIssuanceDate	CY_VM_ExtBuildingPermit
Construction Permit Number	constructionPermitID	CY_VM_ExtBuildingPermit
Date, Construction Permit Number	constructionPermitIssuanceDate	CY_VM_ExtBuildingPermit
File Number of Construction Permit	constructionPermitFolderID	CY_VM_ExtBuildingPermit
Final Approval Certificate Number	finalApprosvalCertificateID	CY_VM_ExtBuildingPermit
Date of Issuance of Final Approval Certificate	finalApprovalCertificateIssuanceDate	CY_VM_ExtBuildingPermit
buildingID	buID	CY_VM_Building
RealUse	buCurrentUseType	CY_VM_Building
	cuCurrentUseType	CY_VM_Condominium Unit
groupType	useType: VM_Building/CondominiumUseType "CodeList"	CY_VM_Building
	useType: VM_Building/CondominiumUseType "CodeList"	CY_VM_Condominium Unit
typeStructure	constructionMaterial: VM_ConstructionMaterialType "CodeList"	CY_VM_Building
ageStructure	dateOfConstruction:	CY_VM_Building
ageRenovation	dateOfRenovation:	CY_VM_Building
typeRenovation	typeRenovation	CY_VM_Building
floorNumber	numberOfFloor	CY_VM_Building (Number of floors in the building)
floorNumber	floorNumber	CY_VM_Condominium Unit (The floor number

		of the condominium unit)
numberGate	cuNumber	CY_VM_Condominium Unit
-	cuID	CY_VM_Condominium Unit (The identifier of the condominium unit)
orientation	buOrientation:CY_VM_Orientation	CY_VM_Building
orientation	cuOrientation:CY_VM_Orientation	CY_VM_Condominium Unit
view	cuView: CY_VM_ViewType "CodeList"	CY_VM_Condominium Unit
categoryLuxury	categoryLuxury	CY_VM_Building
statusStructure	constructionQuality:CY_VM_ConstructionQuality "CodeList"	CY_VM_Building
issuesUnit	constructionIssues	CY_VM_Building
closedArea	area = CY_VM_AreaValue "DataType"	CY_VM_Building
closedArea/ parkingArea/ poolArea/ basementArea/ auxiliarySpace/ externalBuildings	condominiumArea: CY_VM_AreaValue "DataType"	CY_VM_Condominium Unit
openedBalconyArea	openedBalconyArea	CY_VM_Condominium Unit
closedBalconyArea	closedBalconyArea	CY_VM_Building & CY_VM_Condominium Unit
numberParikingSpots	numberParikingSpots	CY_VM_Building
if useType= 62 or 63, then complete the dimensionsShopsUnit, heightShop, relationShopsWithStreet		
dimensionsShopsUnit	dimensionsShopsUnit	CY_VM_Building & CY_VM_Condominium Unit
heightShop	heightShop	CY_VM_Building & CY_VM_Condominium Unit
relationShopsWithStreet	relationShopsWithStreet	CY_VM_Building & CY_VM_Condominium Unit

Table 4 deals with the attributes of the "Unit" class in the existing Cyprus model, which correspond to two different classes in ISO19152-4, specifically "VM_Building" and "VM_CondominiumUnit." Due to the presence of several attributes in the "Unit" class related to building permit details captured in the current Cyprus model, an external class was created for the proposed model to store and connect them to an existing external database. This external class is named "CY_VM_ExtBuildingPermit." Regarding the

"VM_CondominiumUnit" class, it pertains to co-dominant units such as apartments, pools, parking spaces, etc. For optimal modeling, attributes such as "closedArea,"parkingArea," "poolArea," "basementArea," "auxiliarySpace", and "externalBuildings" present in the existing Cyprus model are captured under a single attribute "area," as their differentiation is handled through another attribute. One particularity in this case is the constraint related to recording the attributes "dimensionsShopsUnit," "heightShop," and "relationShopsWithStreet," where their recording must be applicable only if the unit's use is categorized as a shop or industry.

3.3.2 Proposed ISO19152-4: Valuation Information Model for Cyprus

Based on the mapping of entities and attributes from the existing General Valuation Model of Cyprus to the corresponding elements of the ISO19152-4 Valuation Information standard, the proposed valuation model for Cyprus has been developed, customized to meet the needs of Cyprus. The goal is to create a flexible model that retains the essential characteristics of the existing Valuation Model of Cyprus while incorporating necessary additions to fully serve the country's requirements.

During the modelling process, where necessary, additional attributes are introduced that are not described in the ISO19152-4 model but are deemed essential to fulfilling the country's needs. It's noted that the nomenclature is retained for reused ISO19152-4 entities and attributes, while newly added components are named in English. Throughout the final model, all classes, data types, and code lists are prefixed with "CY_VM." Below, a detailed presentation of the classes, their attributes, and code list values of the proposed model is presented, while at the end of the Section, the proposed model is presented.

Figure 3 presents the class "CY_VM_SpatialUnit" along with its attributes. This class pertains to the parcel accompanied by attributes derived from the form (DLS, 2021). The parcel serves as the subject of the valuation unit. Code lists refer to predefined values of specific attributes based on the specifications of the existing Valuation Model of Cyprus. For example, the code list of "CY_VM_ViewType" adopts values like limited, regular, privileged, sea, and panoramic. This is because in the existing Valuation Model of the attribute "view" takes default values such as limited, regular, privileged, sea, and panoramic view (DLS., 2021).

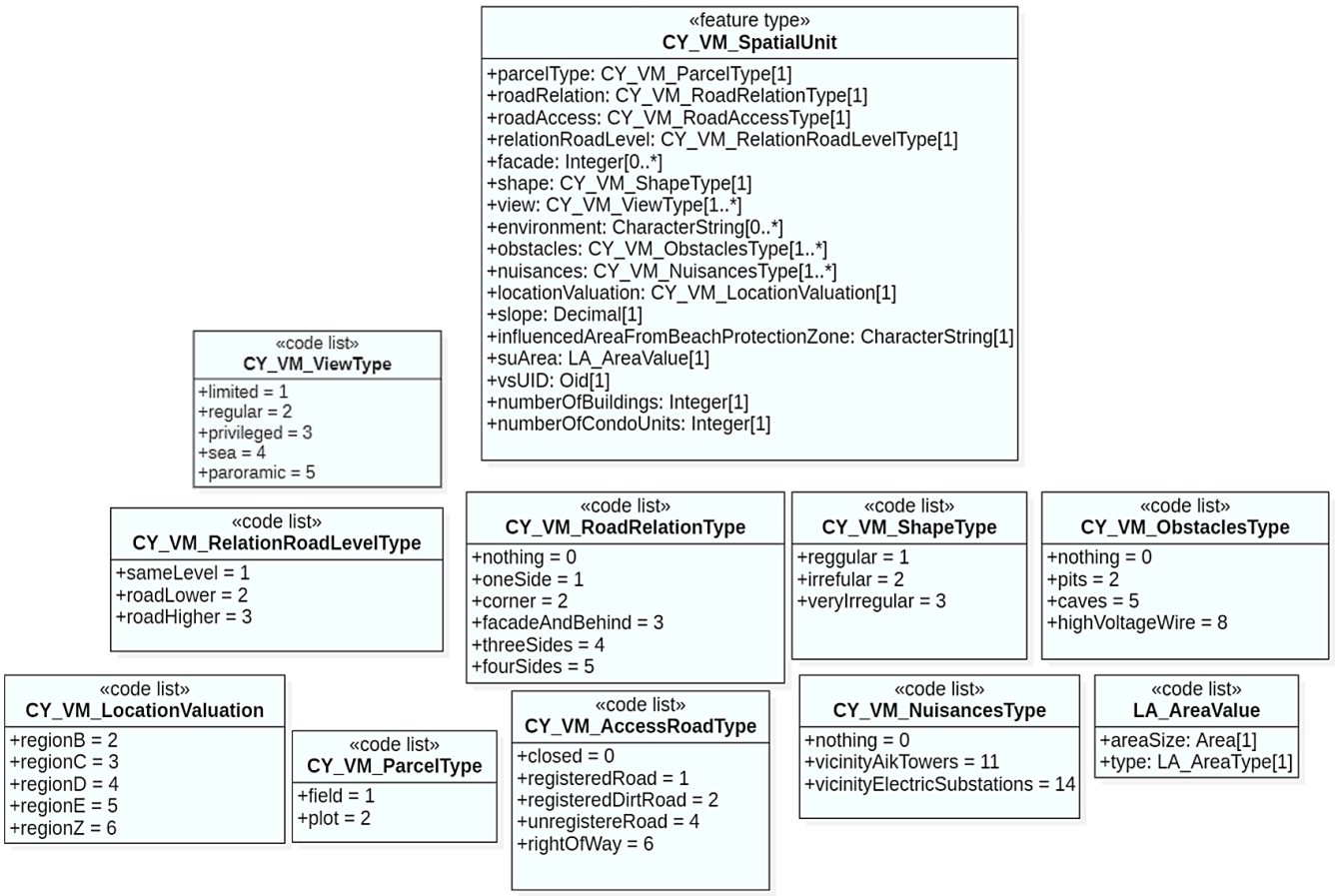

Figure 6 – Proposed class CY_VM_SpatialUnit with its code lists

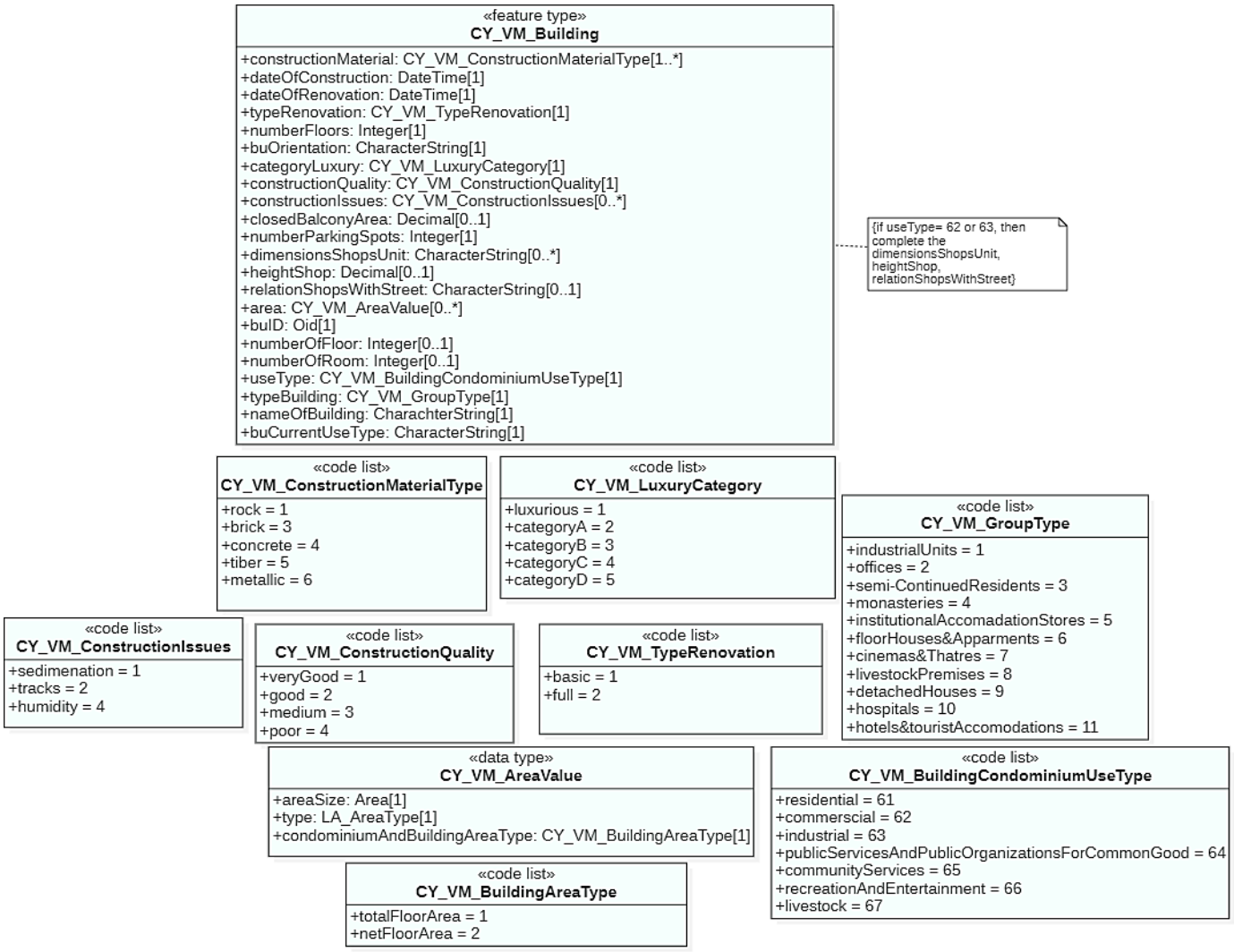

Figure 7 - Proposed class CY_VM_Building with its code lists and data type

Figure 7 illustrates the class "CY_VM_Building with attributes", some of which are taken into consideration during the valuation process. This class encompasses various types of buildings, including condominiums. In this case, a constraint is introduced in the form of a comment, which is derived from the General Valuation Methodology (Department of Land and Surveyors 2022). This constraint pertains to recording the dimensions of the shop, its height, and its relationship to the road in cases where the building's usage type is either commercial or industrial. Value lists created align with the General Valuation Methodology and the form (Department of Land and Syrveors 2021).

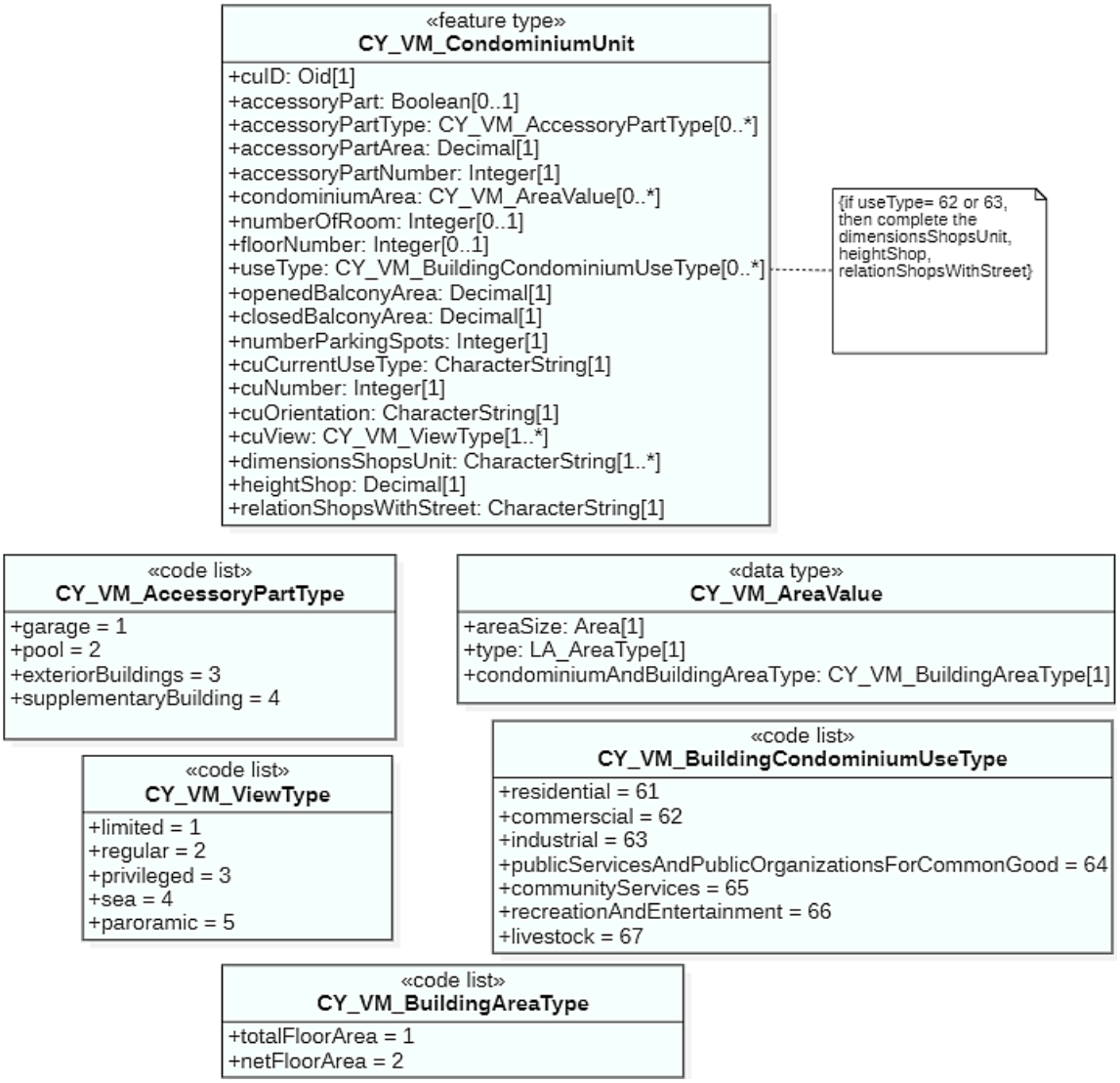

Figure 8 - Proposed class CY_VM_CondominiumUnit with its code lists and data type

Figure 8 corresponds to the class "CY_VM_CondominiumUnit", where, according to the ISO19152-4 standard, even storage spaces, pools, external buildings, and auxiliary areas are recorded. Certain attributes of "CY_VM_CondominiumUnit" are repeated in the "CY_VM_Building" class, as is the case in the standard. One key difference is that this class includes the attribute "view," unlike "CY_VM_Building". This distinction arises because in cases where the building is a single-family home, the view is recorded as an attribute in the "CY_VM_SpatialUnit" class. As for the attribute-class (data type) "condominiumArea," it captures the type and size of the area to be estimated.

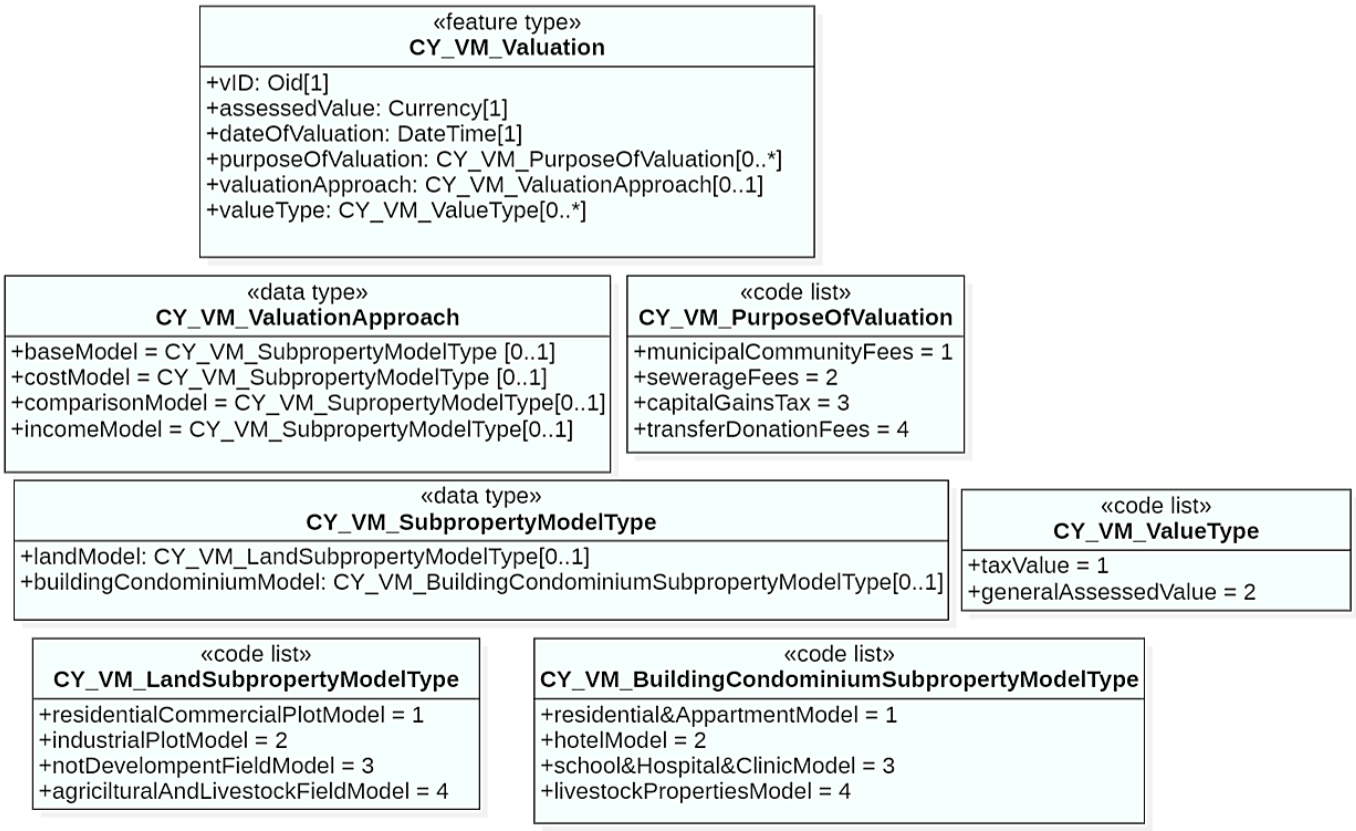

Figure 9 - Proposed class CY_VM_Valuationt with its code lists and data type

Figure 9 illustrates the class "CY_VM_Valuation", which pertains to the class involved in the valuation process. The attribute-class (data type) "CY_VM_ValuationApproach" represents all the valuation models referenced in the analysis of the current state of Cyprus's valuation model. This specific attribute-class consists of individual attribute-classes, taking the value "CY_VM_SubpropertyModelType". This data type value encompasses the subproperty valuation models. It would be beneficial to provide a specific example of how the appropriate valuation model is selected for a particular valuation unit. For instance, if the unit to be valued is a residential building, then the "valuationApproach" value might be the "baseModel" or the "costModel" (depending on the chosen system method). Following that, the "buildingCondominiumModel" with a value of 1 (residential & apartment model) would be selected.

Moreover, Figure 10 presents the class "CY_VM_ValuationUnit", which pertains to the class of the valuation unit. As shown, the valuation units comprise land, building, and condominium units. The attribute "sbpiID" is visible here, referred to as the unique property identification number (for either a unit or a parcel) (Hajdimina N. 2018)

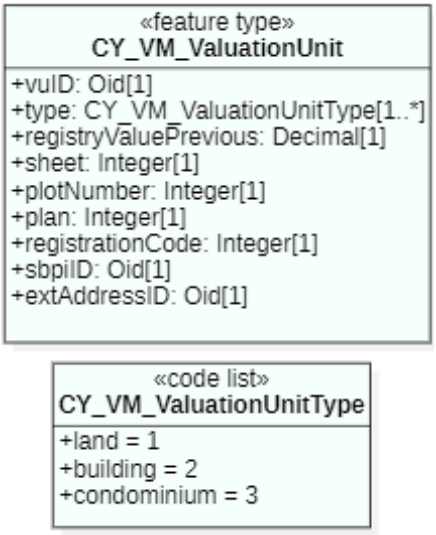

Figure 10 - Proposed class CY_VM_ValuationUnit with its code list

Figure 11 presents the class "CY_VM_PlanningZone" along with its code list. This class pertains to urban planning regulations. The unique code list presented here pertains to the value per square meter when the valuation unit is a parcel, and the cost value when the valuation unit is a building or a condominium unit. The values that these two codes can take are determined based on the category of the planning zone.

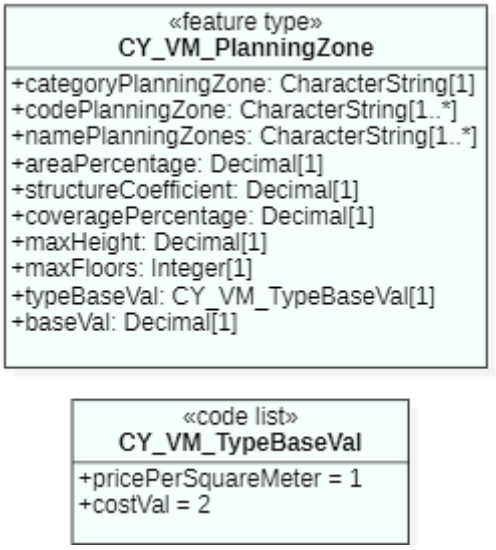

Figure 11 - Proposed class CY_VM_PlanningZone with its code list

The classes "CY_VM_ValuationUnitGroup" and "CY_VM_MassAppraisal" were not present in the existing model of general valuation in Cyprus but were added to the proposed model to ensure completeness and compatibility with theISO19152-4. It is noted that their characteristics are the same as those defined in the standard.

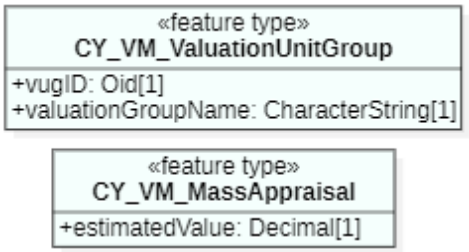

Figure 12 - Proposed classes CY_VM_ValuationUnitGroup and CY_VM_MassAppraisal

The external class "CY_VM_ExtAddress" is implemented in the proposed model, since some of its characteristics are appeared in Table 2 and Table 3 of the existing model of Cyprus.

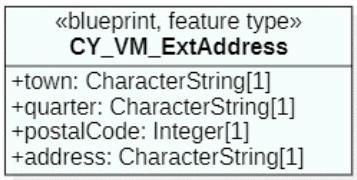

Figure 13 - Proposed class CY_VM_ExtAddress

The external class " CY_VM_ExtBuildingPermit " is introduced in the proposed model due to the presence of certain characteristics within it that appear in the Building table *Table 3* of the existing Cyprus model. As previously mentioned, it is believed that this class can be linked to an existing database of building permits.

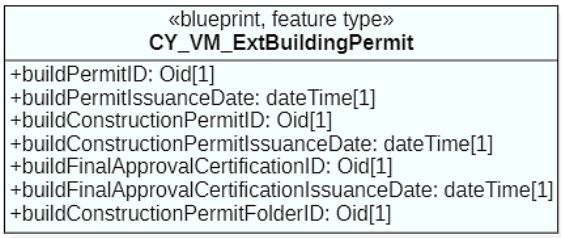

Figure 14 - - Proposed class CY_VV_ExtBuildingPermit

Figure 15 presents the proposed valuation model for Cyprus based on the ISO19152-4 standard. The relationships between classes are predefined by the ISO19152-4 standard. It would be beneficial to explain the relationships between classes using some examples. One specific relationship is between the Building class (CY_VM_Building) and the Condominium Unit class (CY_VM_CondominiumUnit), referred to as "composition." In this relationship, Condominium Units can inherit information from Buildings, and if a Building class is deleted, the associated Condominium Units will also be deleted. Another notable relationship is the one between Valuation (CY_VM_Valuation) and Mass Appraisal (CY_VM_MassAppraisal), named "inheritance." In this case, Mass Appraisal entities inherit characteristics from Valuation entities. This is referred to as a "parent-child" relationship.

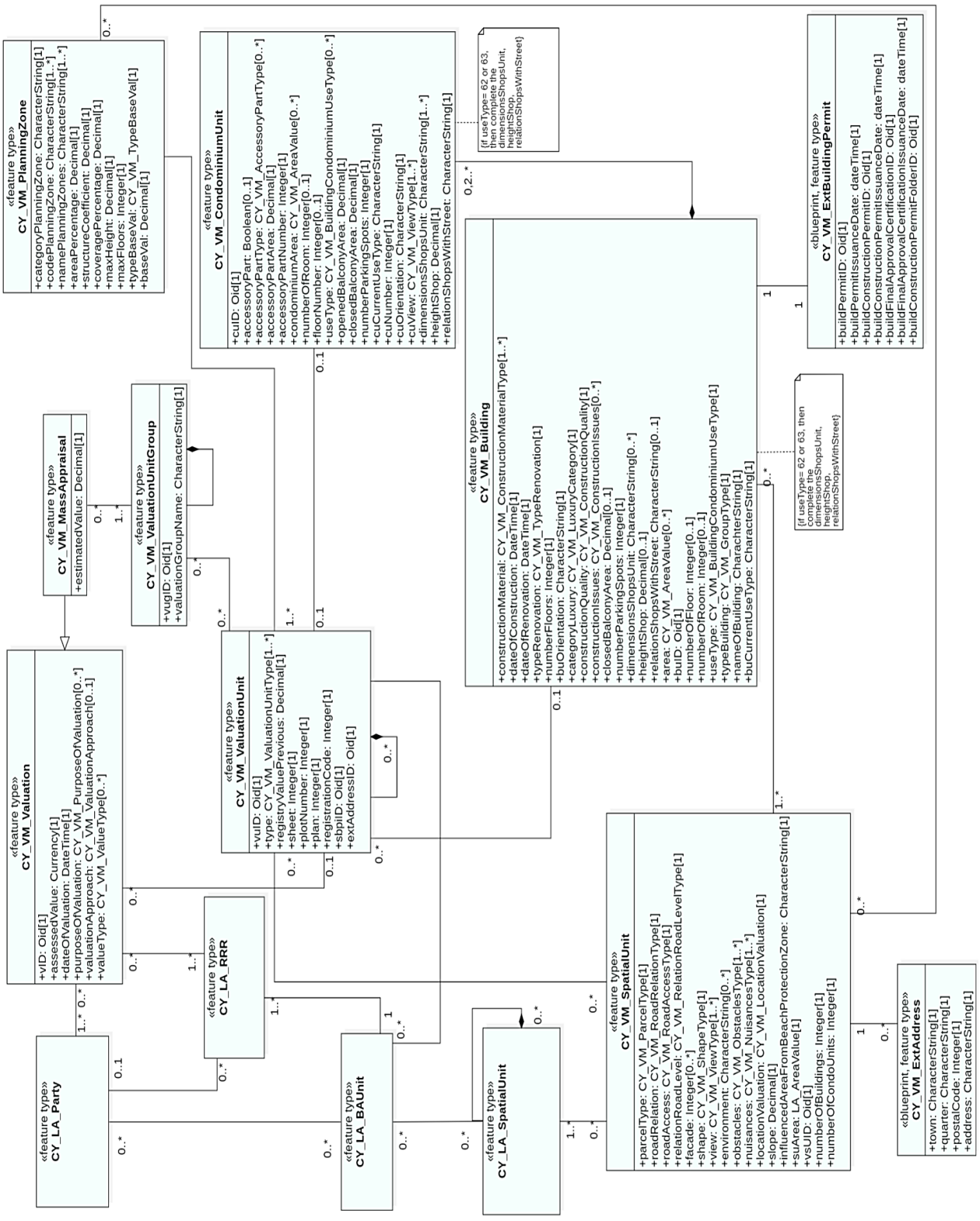

Figure 15 - The proposed Valuation Model of Cyprus based on ISO19152-4

Other relationships between classes are referred to as associations. An example of such a relationship is between Valuation Unit (CY_VM_ValuationUnit) and Valuation (CY_VM_Valuation). This relationship is translated as "a Valuation Unit can be associated with 0 to many [0..*] instances of Valuation processes, while conversely, a Valuation can be associated with 0 to 1 [0..1] Valuation Unit." Additionally, a Valuation Unit can be associated with 0 to many [0..*] transaction cases (meaning a Valuation Unit can be subject to property transactions). Furthermore, multiple Valuation Units (CY_VM_ValuationUnit) are related to 0 to many [0..*] instances of Valuation Unit Groups (CY_VM_ValuationUnitGroup) in a subdivision and in a real estate market zone.

4 CASE STUDY: APPLYING THE PROPOSED MODEL FOR A HOUSE IN CYPRUS

This Section presents the technical application exploring the utilization of data from BIM models for their reuse in land management issues, specifically the valuation of properties, within the framework of ISO19152 - 4 for the case of Cyprus. For this case, a mixed-use house has been modelled from 2D Drawings, in Revit and exported in IFC format.

4.1 Integration of valuation information in the IFC based on the proposed Valuation Model of Cyprus

The integration of valuation information based on LADM into the IFC is accomplished by storing the relevant information within the entities of IFC. The entities capable of adopting such information are IfcSpaces, IfcZones, and IfcSite (Oguzhan Mete et al., 2022). By incorporating the appropriate attributes into these entities, it becomes possible to automatically provide information for general valuation purposes from the IFC model. Furthermore, during the effort to integrate valuation information into the aforementioned entities, it was discovered that the IfcBuilding and ProjectInformation entities can also adopt relevant information for the buildings. The characteristics of the entities of the proposed Valuation Model of Cyprus, will be stored as follows in the IFC entities:

Characteristics which IfcZone will adopt are:

- CY_VM_CondominiumUnit
- CY_VM_ValuationUnit

Characteristics which IfcSite will adopt are:

- CY_VM_SpatialUnit
- CY_VM_ValuationUnit

Characteristics which IfcSite or Project Information will adopt are:

- CY_VM_Building

Table 5 – Mapping the entities of Revit & IFC – Integration characteristics CY_VM

Entity in Revit	Entity in Ifc	Attribute
HVAC Zones (Analyze Tab) or ZoneName (Shared Parameters)	IfcZone	• CY_VM_CondominiumUnit • CY_VM_ValuationUnit
Space	IfcSpace	• CY_VM_CondominiumUnit
Toposurface (Massing & Site)	IfcSite	• CY_VM _SpatialUnit • CY_VM_ValuationUnit
Project Information	IfcBuilding ή Project Information	• CY_VM_Building

4.2 Visualization of the CY_VM characteristics in the IFC entities

This section refers to the visualization of the characteristics of the entities of the Proposed model of Cyprus.

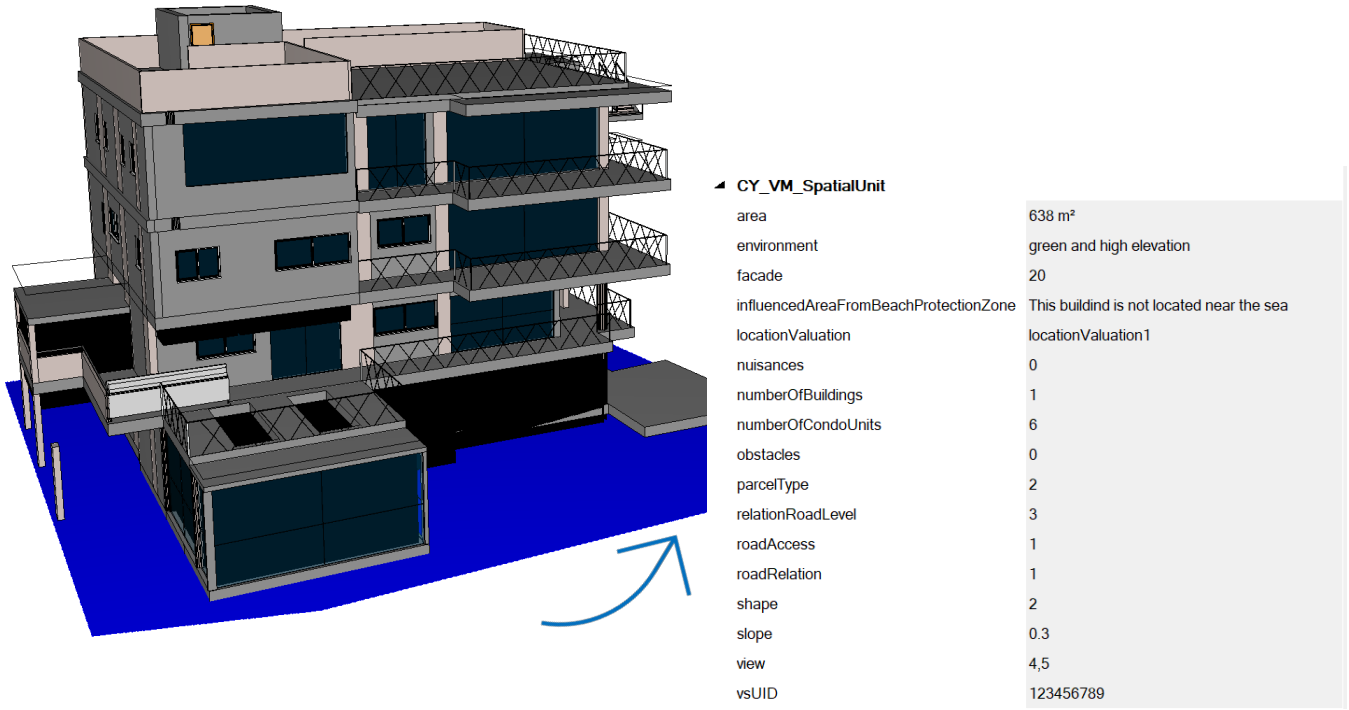

Figure 16 – Visualization of the characteristics of the CY_VM_SpatialUnit in IFC format – DDScad viewer

Figure 16 shows the characteristics of the class CY_VM_SpatialUnit. Highlighted in blue is the IfcSite entity. Also, characteristic's value is based on the CY_VM_SpatialUnit code lists Figure 6 as mentioned above.

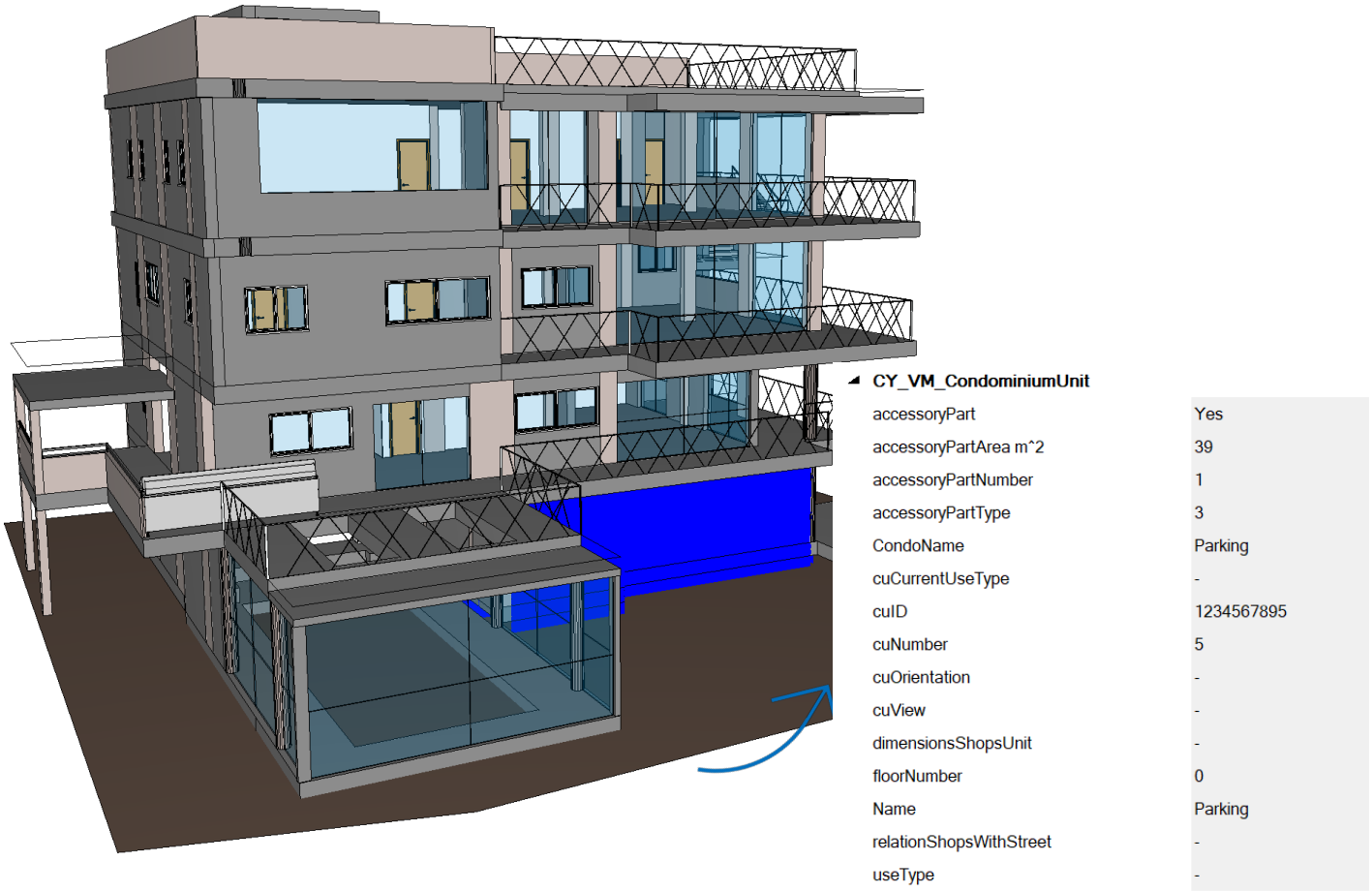

Figure 17 – Visualization of the characteristics of the CY_VM_CondominiumUnit in IFC format – DDScad viewer

Figure 17 depicts the attributes of the class CY_VM_CondominiumUnit. These attributes were stored in the Revit Space entity using Schedules. The reason they were stored in the Space entity in this specific case (Name=Parking) was that this condominium unit consists of a single space. The entity IfcSpace is highlighted in blue underline color.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The results, as demonstrated by both the findings and the proposed model, underscore the under-development standard's capability to meet the requirements of an existing general valuation model tailored to the data specific to the studied country. This application also highlights the flexible semantic structure of the standard, showcasing its adaptability to the unique of individual countries or regions. Consequently, it offers a pathway for countries to

align their land management system and land value estimation methodologies with this standard, while considering the relevant legislation and regulatory frameworks.

In Section 3, certain challenges were encountered during the modelling process. Initially, the mapping of entities between the existing valuation model of Cyprus and ISO 19152-Part4 was not a one-to-one (1→1) correspondence, necessitating appropriate adjustments. Additionally, several attributes present in the existing valuation model of Cyprus were absent in ISO 19152-4, requiring them to be modelled using the specific "language" followed by ISO 19152-4. However, due to the flexible semantic structure of ISO 19152-4, all the difficulties were mitigated. The model allows to model new entities that were deemed necessary for the optimal representation of the valuation model, thus covering all its needs. This flexibility was particularly evident during the modelling of code lists. Moving on to the technical application presented in Section 4, the modelling of an existing building in BIM/IFC format was carried out, followed by the incorporation of valuation attributes into the BIM model. This integration enables the automatic retrieval of this information for valuation purposes, streamlining the process.

5.2 Recommendations for future work

In the context of creating the valuation model for Cyprus according to ISO 19152-Part 4, this paper operates at the conceptual level, without implementation of the database itself. Therefore, the next step involves establishing a database for the proposed conceptual valuation model in aligning with ISO 19152-Part 4 for Cyprus and enriching it with real-world data that can be sourced from the General Valuation Department - Valuation Division, in collaboration with relevant departments. The expected outcome of this effort is the facilitation of bidirectional data exchange, allowing the IFC model to both receive and contribute data to the database. The next stage of the technical application may involve the three-dimensional visualization of the model. This entails the collection of spatial and semantic data from the General Valuation Department - Valuation Division and other relevant authorities. Utilizing this date three-dimensional buildings' representations (at Level of Detail 2 - LoD2) for adjacent properties can be generated for a specific area, alongside the integrated BIM model. In this context, by integrating land value information for adjacent properties, queries regarding land values can be supported, with results presented visually.

Implementing such an application within a three-dimensional environment serves to comprehensively represent all the characteristics considered in land value estimation. Specifically, by modelling elements of the surrounding environment, such as utility poles, etc., which can be optimally incorporated into the valuation model (like obstacles). The same applies to features such as views, proximity to the sea, and so on. As of the current status, ISO 19152-Part 4 has not yet received official ratification as an ISO standard by the global standardization organization ISO, as the first edition of the ISO 19152:2012 LADM standard is presently undergoing a revision process. Consequently, since minor modifications to the standard can emerge through the standardization process, the proposed model will be adjusted accordingly if necessary. Within this context, upon its adoption as an international standard, a validation process will be initiated to evaluate the compliance level of the proposed model, as established through the conceptual mapping and according to the compliance matrix included in the standard.

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