Utilizing 3D Building and 3D Cadastre Geometries for Better Valuation of Existing Real Estate

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Keywords: 3D Cadastre, Valuation, Building, Real Estate, Geometry

SUMMARY

Valuation of the properties is known as real estate appraisal, property valuation or land valuation and is a process which focuses on determining the value of a building or a land lot. The valuation of each real estate is required prior to any transaction as every property is unique in terms of shape, volume, location, orientation, quality and as the transactions on real estate occur less frequent then usual business transactions. The valuation can be accomplished to determine the amount of mortgage loans, for setting the tax value, and also for determining the market value for sales transactions. The earlier analysis of the authors regarding the current valuation practices in Turkey, United Kingdom, USA, Germany, and The Netherlands portrayed that property valuation and valuation for taxation is not currently significantly benefiting from digital 3D Building Models and 3D Cadastres. The overall research investigates the utilization of building/cadastral information models in derivation of valuation-related information. Following a literature review of building and land administration models, the paper elaborates on information requirements for valuation related to 2D and 3D geometries and Rights, Restrictions, Responsibilities (RRRs) associated with land lots and buildings. The papers concludes by indicating the role of "streetview" images and 3D models in enhancing the presentation of valuation information.

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1. INTRODUCTION

Valuation of real estate/ properties is in many countries/ cities the basis for fair taxation. The value depends on many aspects, including the physical real world aspects (geometries, materials, and other aspects of quality or desirability) and legal/virtual aspects (rights, restrictions, responsibilities, zoning/development plans applicable to the objects spaces). Different countries make different trade-offs between efficiency, simplicity, and various aspects of perceived fairness. One aspect of perceived fairness may be that the assessed tax be proportional to fair market value – except for a multitude of popular exceptions, such as farming or homestead exemptions. Another aspect may be for property tax to remain predictable over ownership of many years. One aspect is nearly always at the expense of another, and national systems can change, over time. The earlier analysis of the authors regarding the current valuation practices in various countries (i.e. Turkey, United Kingdom, USA, Germany, and The Netherlands) (Isikdag et al,2014) portrayed that property valuation and valuation for taxation is not currently significantly benefiting from digital 3D Building Models and 3D Cadastres. This is caused by low awareness regarding the possibilities provided by semantically rich 3D models and the availability of 3D models suitable for valuation. Although the 3D building geometries are not used today for valuation, they might well be used in the (near) future. While the highly detailed Building Information Models (BIMs) provide opportunities for model-driven valuation for the new construction projects, the utilization of CityGML 3D geometries give good opportunities for better valuation of existing buildings. 3D building models exist in a range of flavors: ranging from simply extruded footprint with height value to the earlier mentioned BIM/IFC models (including even materials and indoor geometries). Both extremes are not suitable. The extruded footprints are rather 2D geometries (with a height attribute) and do not show the added value of 3D geometries. The highly detailed BIM/IFC models could be used, showing the power of true 3D however, they are only available for a few of the new buildings (and presently not even in all countries). The overall research investigates the utilization of building/cadastral information models in derivation of valuation-related information.

This paper focuses on requirements related to geometries in digital building models and cadastres, for fair and efficient computation of key valuation factors. After this introduction, a review of the building and land administration models is presented in Section 2, focusing on relationships between building and land administration models. Section 3 lists the information requirements for valuation, related to geometries and RRRs (Rights, Responsibilities, and Restrictions) for each of the involved countries. A summary of the geometry information needs for valuation is given in Section 4. Next Section 5 discusses the use of geometry, 3D models and “streetview” images, for the purpose dissemination of valuation data. The final section of the paper presents the main conclusions.

2. BUILDING AND CADASTRAL MODELS

2.1 Building models (physical objects)

The representation of physical buildings with digital building models has been a subject of research since four decades in the fields of Construction Informatics and GeoInformation science. The early digital representations of buildings mainly appeared as 3D drawings constructed by CAD software, and the 3D representation of the buildings was only geometric, while semantics and topology were out of modeling focus. On the other hand less detailed building representations, with often focus on 'outside' representations, were also found in form of 2D /2,5D GeoInformation models These models contain geometry and linked semantic information in compliance with the feature model of the GIS domain (as explained in ISO 19125-1).

2.1.1 Building Information Models

Since the start of 2000s, detailed models containing geometric, topology and semantic information have began to emerge with the advent of Building Information Models. Isikdag & Underwood (2010) defined Building Information Modeling as "the information management process throughout the lifecycle of a building (from conception to demolition) which mainly focuses on enabling and facilitating the integrated way of project flow and delivery, by the collaborative use of semantically rich 3D digital building models in all stages of the project and building lifecycle". From this same perspective a Building Information Model(s), i.e. BIMs can be defined as "the (set of) semantically rich shared 3D digital building model(s) that form(s) the backbone of the Building Information Modeling process". These models are capable of containing geometric/semantic information regarding the building indoors and outdoors, in a very high level of detail (i.e. models can be regarded as LOD ∞, or LOD N models), where a model in some cases contain the geometry/semantics of nut & bolt or a picture frame in the house. The complexity of the BIMs (in terms of object relations) is very high and furthermore as the population of the entity instances (i.e. the data) of the model increases, it becomes costly to store and perform advanced queries on the models.

2.1.2 CityGML Model

Another model that is found valuable in 3D representation of buildings, has its roots in geoinformation modeling. A well-known schema of GML (an OGC standard which is developed mainly for the exchange of geoinformation), namely CityGML (OGC,2012, Gröger and Plümer, 2012), offers digital representation of models in different levels of details, LOD 4 of the model offers possibilities of indoor representation.

- *LOD 0:* LOD0 of the CityGML model is a terrain model that includes city objects. Building footprints or roof outlines are represented as (horizontal) surfaces with a height value (Lowner et al.2013)
- *LOD 1:* As explained by OGC CityGML Encoding Standard (2012), "Buildings may be represented in LOD0 by footprint or roof edge polygons". LOD1 is the well-known blocks model comprising prismatic buildings with flat roof structures.
- *LOD 2:* A building in LOD2 has differentiated roof structures and thematically differentiated boundary surfaces. In LOD 2 of the CityGML model, the outer façade of

the building can be represented in a greater detail, but it mostly very similar to the one in LOD1. The biggest differences between the LOD 1 and LOD 2 (in terms of geometrical representation) is the walls and the roofs of the building can be represented with multiple faces since they are semantically identifiable.

- *LOD 3:* LOD3 denotes architectural models with detailed wall and roof structures. In a LOD 3 of CityGML model, the façade of the building can include openings such as doors and windows.
- *LOD 4:* LOD4 completes a LOD3 model by adding interior structures for buildings. Buildings in LOD4 are composed of rooms, interior doors, stairs, and furniture.

2.2 Land Administration (legal/virtual objects)

Land administrations systems (land registry, cadastre) have different origins in different countries. The information was sometimes collected for taxation purposes and in other cases for legal security. Over the years, in many countries the land administration systems more and more served both applications; e.g. in the area of spatial development or spatial planning. In this context the term multi-purpose cadastre is used. Based on the initiative of the FIG (International Federation of Surveyors), ISO has developed the standard Land Administration Domain Model (LADM), ISO 19152:2012. In the standard, land administration is described as the process of determining, recording and disseminating information about the relationship between people and land (or rather 'space').

The LADM standard defines a basic administrative unit ('basic property unit') as an administrative entity, subject to registration (by law), or recordation, consisting of zero or more spatial units ('parcels') against which (one or more) unique and homogeneous RRRs (rights, e.g. ownership right or land use right, responsibilities or restrictions) are associated to the whole entity, as included in a land administration system. A parcel can be described by 2D or 3D geometry or even by textual descriptions (Lemmen at al, 2010). Homogenous means that the same combination of RRRs equally apply within the whole spatial unit. Unique means that this is the largest spatial unit for which this is true. Making the unit any larger would result in the combination of rights not being homogenous. Making the unit smaller would result in at least 2 neighbor parcels with the same combinations of rights. The objects (parcels) are called legal or virtual objects, because they do not need to be visible in the real world.

However, it should be noted that quite often the boundary of a parcel coincides with a physical real world object; e.g. a fence, wall, edge of road. In case of 3D parcels, this is even more true; e.g. the geometries of physical objects such as tunnels, building (parts) or other constructions correspond also to legal spaces with unique and homogeneous RRRs attached. Perhaps valuation is not directly a 3D cadastre topic, but is it strongly related, because most property tax systems are one way or the other based on an assessed value of the property and relevant in context of multi-purpose cadastre.

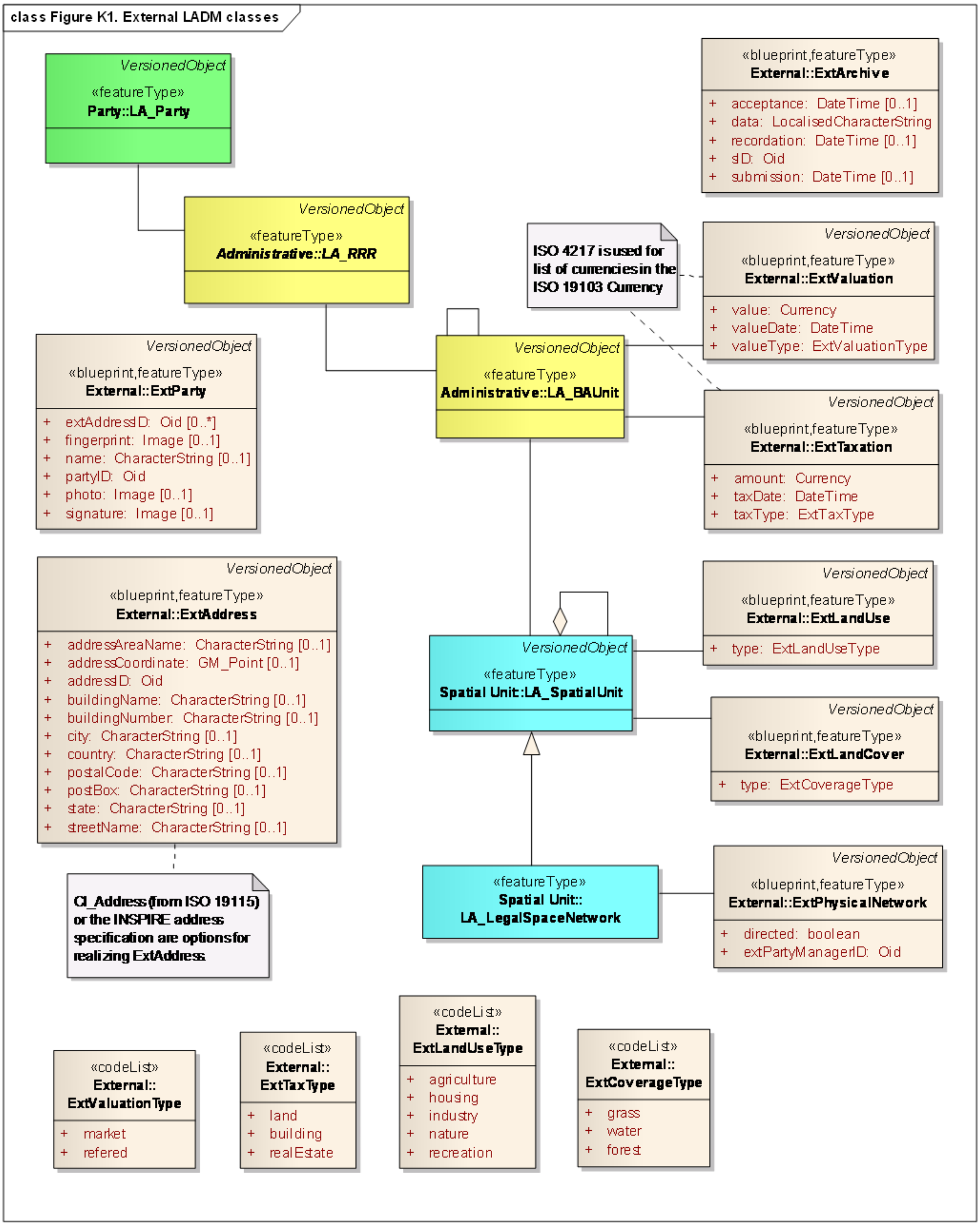

Figure 1. LADM Core classes (in color and 'LA_' prefix) and LADM external classes (with 'Ext' prefix), taken from ISO 19152:2012

2.3 Relationship between physical and virtual objects

A (3D) building registration is something else than a (3D) Cadastre. Cadastre is about the legal spaces. That is, spaces described by geometry (and topology) where certain RRRs are attached to. So, all kinds of building details, such as different rooms/ spaces, may not always be relevant (when same RRRs apply). Only when the RRRs are different, a separate geometry is needed. So, most likely only a part of the indoor building modeling information may be relevant in 3D Cadastre context (and perhaps that geometry is even implicit; e.g. a 3D boundary defined by the 'middle of the wall'). The geometries of the real world (physical) objects and the geometries of the legal objects should be consistent and we should design rules for this. Further, one could argue that when in a certain jurisdiction one has the responsibility to pay certain amount of tax based on the function/ type of a room/ space in a building, then this would fall under the definition of a legal space. This will further reinforce the link between 3D cadastre and building models. The Annex K from ISO 19152 (Figure 1), is a UML diagram showing in color core classes of the LADM standard: green, LA_Party (person), yellow, LA_RRR (right, etc. such as ownership)/LA_BAUnit in blue, LA_SpatialObject (parcel) and showing not in color the LADM external classes (with stereotype <<blueprint>>, e.g. ExtTaxation, ExtValuation). LA_BAUnit stands for basic administrative unit, a group of LA_SpatialObjects with same RRRs attached. LA_SpatialObject has several specializations, such as LA_LegalSpaceNetwork (shown in diagram, including link to ExtNetwork, the physical network registration) and LA_LegalSpaceBuildingUnit (not shown in diagram, but could be linked to physical building registration). LADM is more a conceptual framework defining concepts and terminology, than prescriptive standard. A country should first develop an LADM country profile supporting the legislation of the country (and described in concepts of the international standard), before transforming this into a land administration implementation.

3. INFORMATION REQUIREMENTS FOR VALUATION IN VARIOUS COUNTRIES

Various valuation approaches and the role of 2D/3D geometries in countries such as: Turkey, United Kingdom, USA, Germany, and The Netherlands were examined in our previous study (Isikdag et al, 2014). There are mainly 3 approaches to valuation in most of these countries:

1. *Statistical Approach* relies on determining the value of the property using sampling and approximation (for example by comparison with reference sales prices in that region, or by multiplying a pre-determined value by an inflation factor)
2. *Revenue Approach* focuses on determining the value based on total yearly income and revenue generated by the property.
3. *Direct Costing Approach*, is where the value of the land lot needs to be added to the value of the building (which is calculated using the building's geometric and semantic information), in order to find overall value of the property.

In this section we will summarize the information requirements related to geometrical information and RRRs. The information requirements on RRRs is very important as, based

on the information related to RRRs 3D legal objects can be generated. 3D legal objects illustrate the legal boundaries of the property, or what is the allowed building volume/size on that land lot/parcel. If a legal space of allowed for construction is larger than the actual size of the building, this may have a (positive) effect on the market value. Furthermore other types of legal information related to RRRs (right = positive value, restriction = negative value, or responsibility) can provide key information on, ownership status in 3D, and restrictions in 3D such as restriction due to protected monument status, or due to a subsurface pipeline.
The following tables *only provide information requirements* for property valuation *related to geometrical information and RRRs*. The tables present information requirements for a subset of valuation methods (mentioned above) where geometrical information is a requirement. The other methods that are currently in use but which do not require geometrical information (for instance most methods in *Revenue Approach* are not included in the tables).

Table 1. Information Requirements for Property Valuation (Turkey)

Purpose	Information Required	Calculated Entities	2D Geometry Requirement	3D Geometry Requirement	RRR Information Requirement
Turkey					
Property Type : Land Lot Valuation Approach: Direct Costing					
Market Value Calculation	Building Coverage Ratio (BCR) Floor Area Ratio (FAR) HMax (maximum allowable building height).	Maximum floor area that can be constructed over the lot Maximum building volume that can be constructed	2D coordinates of land lot boundaries	-	Building Coverage Ratio (BCR) Floor Area Ratio (FAR) HMax (maximum allowable building height).
Valuation for Taxation	N/A	N/A	N/A	N/A	N/A
Property Type: Building Valuation Approach: Direct Costing					
Market Value Calculation	3D LOD N digital building model	Direct Cost Calculated by Building Cost Study	-	Detailed 3D volumetric information on all building elements walls, slabs, columns, beams, HVAC, MEP elements	Ownership of Property / Flat
Valuation for Taxation	Total Gross Floor Area of Building	Value= (Total Gross Floor Area) x (Unit Cost)	Floor Plans for all floors	-	Ownership of Property / Flat

Table 1 shows the information requirements in *Direct Costing Approach* for property valuation in Turkey. In calculation of the market value for land lots zoning information on RRRs such as Building Coverage Ratio (BCR), Floor Area Ratio (FAR) and HMax (maximum allowable building height) play a key role in valuation. By using these ratios and restrictions maximum floor area that can be constructed over a lot and maximum building volume that can be constructed over a lot is calculated. These values are then used as an input to determine the value of a land lot. The valuation for taxation of the land lots are completed by taxation commissions of municipalities in Turkey with own internal practices, thus in this phase of the research the authors could not yet identify how value for taxation is calculated for land lots in Turkey. For buildings in Turkey the use of detailed 3D geometrical and semantic information (i.e. LOD N / BIM Level) is required when direct costing method is used in calculating the cost of the building, this is then added up with the cost of the land lot, to determine the overall market value of the building. For taxation studies of buildings in Turkey the government agencies requires the total gross floor area of building, which is a sum of all gross floor areas including wall thicknesses etc. To calculate this value 2D floor plans which are up-to-date is required. Ownership information related to each individual legal space (i.e. flat) is the required RRR related information in Turkey.

Table 2. Information Requirements for Property Valuation (UK)

Purpose	Information Required	Calculated Entities	2D Geometry Requirement	3D Geometry Requirement	RRR Information Requirement
United Kingdom					
Property Type: Building Valuation Approach :Direct Costing					
Market Value Calculation	3D LOD N digital building model	Direct Cost Calculated by Building Cost Study	-	Detailed 3D volumetric information on all building elements walls, slabs, columns, beams, HVAC, MEP elements	Ownership of the property
Property Type: Building Valuation Approach Statistical (Banding- UK Taxation Scheme)					
Valuation for Taxation	Total Gross Floor Area of Building (including wall thickness) Total Net Floor Area of Building (excluding wall thickness) Boundaries of each individual flat	No explicit information on literature	Floor Plans for all floors	-	Ownership of the property Ownership of the flat

In UK, *Statistical Approach (comparative method)* is used -based on banding- for valuation of residential properties and *Revenue Approach (investment method and profit method)* is used for valuation of commercial properties; see Table 2. *Direct Costing Approach (residual method and cost method)* is used for valuation of bare land/redevelopment areas or valuation of buildings of which profit figures cannot be obtained. For the market valuation, similar to Turkey the use of detailed 3D geometrical and semantic information (i.e. LOD N / BIM Level) is required, this is then added up with the cost of the land lot, to determine the overall market value of the building. Residential properties are valued according to the banding scheme for taxation purposes. In the UK banding scheme Total Gross Floor Area of Building(including wall thickness), Total Net Floor Area of the Building (excluding wall thickness), Boundaries of each individual flat are required to be known which in turn identifies the requirement for 2D floor plans for all floors. Ownership information related to each individual legal space (i.e. flat) is the required RRR related information in UK.

Table 3. Information Requirements for Property Valuation (USA)

Purpose	Information Required	Calculated Entities	2D Geometry Requirement	3D Geometry Requirement	RRR Information Requirement
USA					
Property Type: Land Lot Valuation Approach: Statistical Approach					
Valuation for taxation	2D land parcel	Square footage	2D coordinates of land lot boundaries 2D coordinates of allowable (permitted) area (e.g for farming)		Ownership and zoning restrictions
	3D land parcel	Measure of land quality		3D coordinates of land parcel 3D coordinates of building permit bounding volume	Ownership and zoning restrictions
Property Type: Building Valuation Approach: Statistical Approach					
Valuation for taxation	2D Floor Plans 3D LOD 4 digital building model	Square footage Number of floors	Floor plans for all floors		
		Measure of quality		CityGML LOD 4	
		Measure of value			RRR tied to current building/ use (not applicable to replacement or different use)

The valuation approach in the USA can be loosely categorized as the *Statistical Approach;* see Table 3. To model the current manual valuation, systematically, we would require 2D and 3D land parcels, as well as 2D polygons for areas with building permit, farming permit, and other geographically defined RRRs. Since the entire land parcel is also available in 3D, the sub regions of building permit, etc. are frequently sufficient in 2D. Specific for the building permit, there might also be a 3D solid maximum building volume. It does not only restrict square footage, and number of floors, but also maximum shape, possibly even the direction of the roof. In some areas, such a bounding solid does not apply, and the permit might simply be in 2D plus number of floors. Regarding the building, we require a 2D representation of floor plans, and, depending on region, a 3D representation of approximately the CityGML LOD 4 detail. Also, part of the RRRs might relate to the current building, and may not be applicable to a replacement or alternative use.

Table 4. Information Requirements for Property Valuation (Germany)

Purpose	Information Required	Calculated Entities	2D Geometry Requirement	3D Geometry Requirement	RRR Information Requirement
Germany					
Property Type: Land Lot Valuation Approach: Statistical Approach					
Valuation for taxation	2D land parcel	Square footage	2D coordinates of land lot boundaries 2D coordinates of allowable (permitted) area (e.g for farming)		
	3D land parcel	Measure of land quality		3D coordinates of land parcel (potential impact) 3D coordinates of building permit bounding volume	Ownership and zoning restrictions
Property Type: Building Valuation Approach: Statistical Approach					
Valuation for taxation	2D Floor Plans 3D LOD 4 digital building model	Square footage Number of floors	Floor plans for all floors		
		Measure of quality		CityGML LOD 4 (potential impact)	
		Measure of value			RRR tied to current building/use (not applicable to replacement or different use)

As shown in Table 4, in Germany the market value for land lots and buildings can also be loosely categorized as the *Statistical Approach,* where part of the value can be calculated, statistically, based on sales transactions, population density, current or potential use, etc. The geometrical and RRR requirements for systematic valuation for taxation in Germany are almost identical with the US system, even if the evaluation algorithm differs, substantially. One difference is that 3D land parcel and CityGML LOD 4 model tend to have less impact, in the German model, than in the US. The 2D parcel and floor plan alone could likely yield a better approximation, than they would in the US.

In the Netherlands the market value of property (land and building as a whole) is also used for taxation; see Table 5. The methods used for valuation for market purposes and for taxation purposes are therefore comparable. Only for taxations the systems used for mass appraisal must be able to value all (about 8 million properties) each year. For residential property the direct comparison with sales prices is important. For this comparison not only type, size and age of the building are important, but also quality of building, quality of facilities and maintenance condition. To check and update these object characteristics with as less work in the field as possible a 3D model enriched with photographic images can be very helpful. The

RRR requirements for valuation for taxation in the Netherlands are especially important for multifamily dwelling and multi tenants' offices and shops. The taxable object in the Netherlands (WOZ-object) is also based on the user (tenant) of the units. Sometimes it is hard to make clear with part of a building belongs to or is used by with person or firm.

Table 5. Information Requirements for Property Valuation (the Netherlands)

<table>
<tr><th>Purpose</th><th>Information Required</th><th>Calculated Entities</th><th>2D Geometry Requirement</th><th>3D Geometry Requirement</th><th>RRR Information Requirement</th></tr>
<tr><td colspan="6">the Netherlands</td></tr>
<tr><td colspan="6">Property Type: Land and Building Valuation Approach: Statistical Approach (residential) and Revenue Approach (commercial)</td></tr>
<tr><td rowspan="3">Valuation for taxation = market value</td><td>2D land parcel</td><td>Land area</td><td>2D coordinates of land lot boundaries</td><td></td><td>Ownership and zoning restrictions</td></tr>
<tr><td>3D

single family dwelling

Single tenant offices and shops</td><td>Usable floor area

Type of building

Quality of building

Quality of surroundings</td><td></td><td>LOD2
To see type of building and roof structure

Outbuildings

Photographic images of building and surroundings</td><td></td></tr>
<tr><td>3D

multi family dwellings

multi tenant offices units with shopping mall</td><td>Usable floor area

Type of building

Quality of building

Quality of surroundings</td><td></td><td>LOD3
To see location in the building

Parking space, storage unit

LOD3/LOD 4 Facilities (elevator etc.)

Photographic images of building and surroundings</td><td>Ownership</td></tr>
<tr><td colspan="6">Property Type: Land and Building Valuation Approach: Direct Costing Approach</td></tr>
<tr><td rowspan="2">Valuation for taxation</td><td>2D land parcel</td><td>Land area</td><td>2D coordinates of land lot boundaries</td><td></td><td>Ownership and zoning restrictions</td></tr>
<tr><td>3D

Special building (schools, hospitals)

Industrial plants</td><td>Gross floor area

Type of building

Type of construction/ building costs</td><td></td><td>LOD2
To see type of building and structure

Photographic images of building and surroundings</td><td></td></tr>
</table>

4. SUMMARY OF INFORMATION NEEDS FOR VALUATION

In light of the information needs for valuation for the various countries as presented in section 3 and as result of the findings in (Isikdag et al, 2014) the required geometrical information and 3D information related to legal entities can be grouped into the following. Different aspects have varying impact, depending on country and region.

Information needs for valuation of Land Lots:

- 2D information
  - 2D land lot boundaries
  - 2D permit boundaries (building, farming, other geographic RRRs, potentially implicit or explicit)
  - Accessibility (roads), utilities
  - Vegetation, particularly if protected (might represent restriction)
  - Typical flow-off of rain water (might represent risk)
- 3D information
  - 3D land parcel (may yield additional information about quality, usability, value)
  - 3D building permit boundary solid
    - Volume of the admissible bounding solid (In Germany, for instance, the relevant government institution allows a property owner to build a house within an admissible bounding solid. It might not merely be an extruded rectangle, but a more complex solid, even with roof shape and orientation.) Property tax can be significantly impacted by building permit, including that bounding shape, as opposed to merely the actual physical building, which may be much smaller or lower, or less deep into the ground.
    - In Turkey zoning information on RRRs such as Building Coverage Ratio (BCR), Floor Area Ratio (FAR) and HMax (maximum allowable building height) play a key role in valuation
  - Some other geographic RRRs may also be 3D in nature, such as 3D boundaries of admissible trees, bushes, fences, etc.

Information needs for valuation of Buildings:

- 2D information
  - 2D Floor Plans
    - (Derived) Ground area
    - (Derived) Floor area
    - (Derived) Floor area with certain increases for high ceilings
  - Building orientation
    - e.g. broad side toward lake (can be more expensive)
- 3D information
  - 3D LOD 4/N model for cost study or statistical value estimate
    - (Derived) Volume with certain reductions for diagonal walls, roofs, etc, or with increases for higher floors (for more inhibiting other peoples' views)
      (Derived) Roof area consisting solar panels

    - (Derived) Wall/window area to compute energy labels.
    - (Derived) Check for total gross floor area, usable floor area based on estimate of number of floors
    - (Derived) 3D model for neighboring houses can yield influence of sun, noise, visibility of landmarks, mountains, lakes, etc., level of privacy, etc. (more advanced analysis)
- Separate building parts by year built, likely longevity
- 3D model of building and surroundings with pictures to have faithful model of quality of building and quality of surroundings (virtual reality).

5. THE USE OF GEOMETRY FOR DISSEMINATION

For dissemination of valuation data the geometries are also used. In the Netherlands, the 2D information is today used by most municipalities and this will also be used to present the assessed value to the public (starting 2016) as can be seen in Figure 2. The use of 3D information for dissemination is now in an exploratory phase. This means that the 3D models will not only be used for valuation, but also for disseminating the valuation information. Note that in many countries a lot of properties are apartments and it is not easy to show their value on a 2D map (and adding a table to a complex building is not giving clear insights). So, it could be an option to use a 3D building and/or cadastral models for this. One of the challenges is that the boundaries of the 3D property, WOZ object in the Netherlands, should be aligned with the geometries in the 3D building and/or cadastral model; e.g. as collection internal volumes in case of an apartment. In addition to 3D building and/or cadastral models also georeferenced “streetview” images could be integrated for visualization of property values in 3D which are enhanced by the use of photo imaginary; see Figure 3 and 4. In order to show a detailed representation of the values of the 3D physical and 3D legal spaces, 3D models and building representations in lower LODs are foundational information.

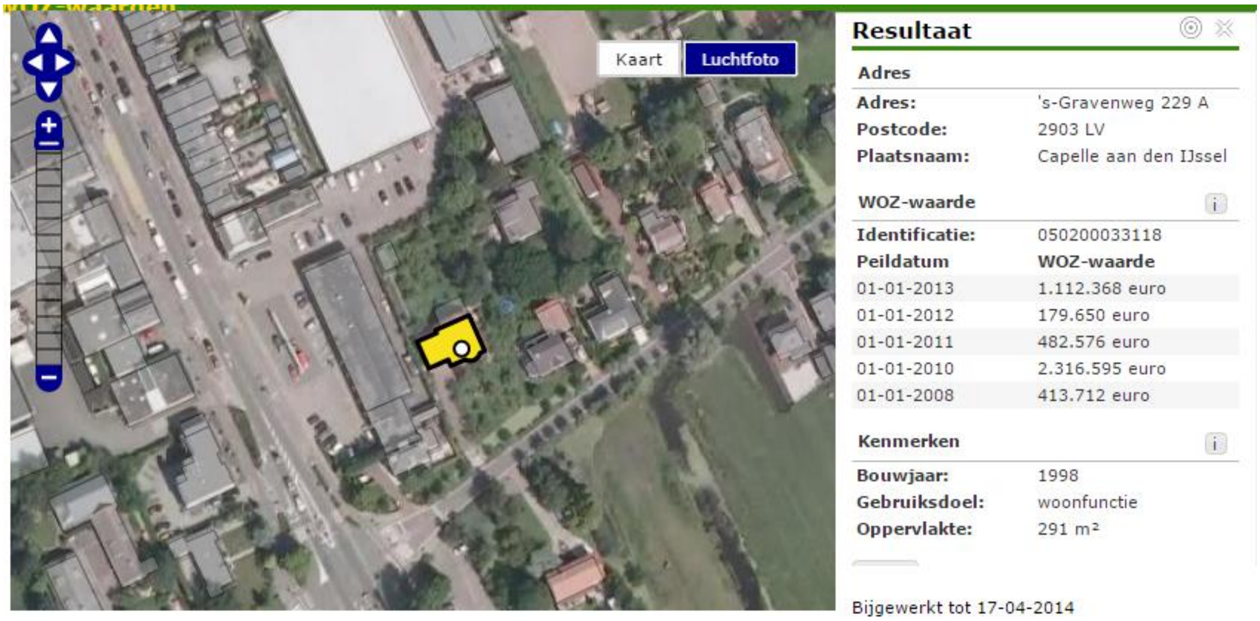

Figure 2: Presentation of valuation information to public

Figure 3: Cycloramas enhanced with parcel information (www.cyclomedia.nl)

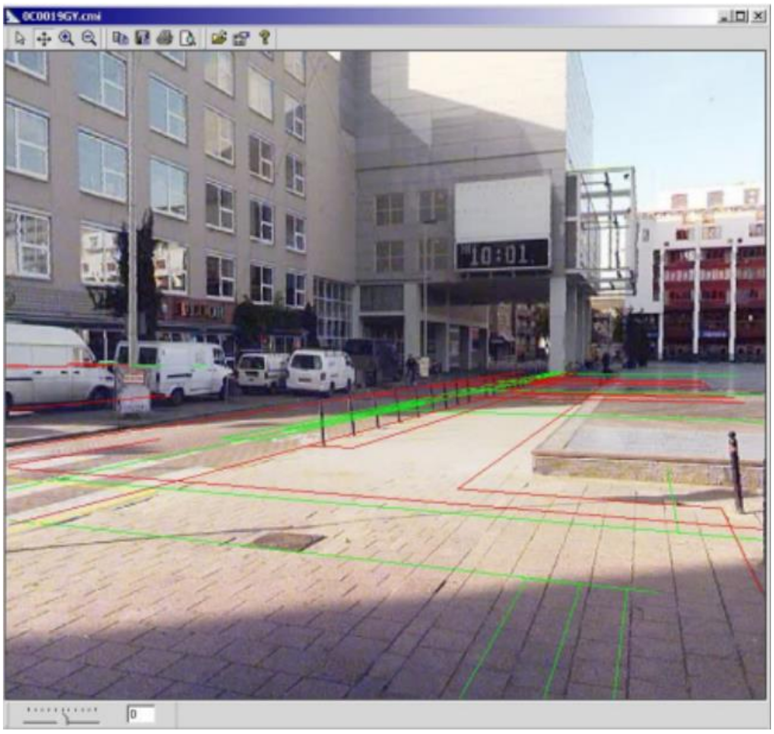

Figure 4: Streetsview (cycloramas) enhanced with parcels and underground pipes (Vebree et al 2004)

6. CONCLUSIONS

In many countries the valuation is based on parameters such as the total square meters or the total cubic meters. These parameters are often considered as simple alphanumeric attributes, which are somehow obtained or estimated. However, it would be more efficient to use actual square and cubic meters as these can be derived or at least checked automatically from the 3D building model geometries (i.e. from the building representation containing outer walls based on building footprint). By adding "streetview" images to the 3D building models, these models will also give information about quality of the building and quality of the environment of the property, which is also of great importance for the valuation.

Large quantities of building models are already available in the world, and it is expected that their number will continue to grow and they would become available as base information for cities and rural areas. This information is also maintained well and can therefore serve a range of applications including the periodic mass appraisal for tax purposes.

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BIOGRAPHICAL NOTES

Umit Isikdag has his MSc in Civil Engineering and PhD (from the University of Salford) in Construction Information Technology with his work on integration of BIM with 3D GIS. His research interests include BIM / IFC, 3D GIS, Internet of Things, RESTful Architectures, BIM 2.0, and Spatial Web Services. He is lecturing in Beykent University Dept. of .Civil Engineering and actively involved in the organization of 3D GeoInfo and GeoAdvances Conferences, editorship of International Journal of 3D Information Modeling, and also serving as the Secretary of ISPRS WG II/2.

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