Integration of 3D Cadastre, 3D Property Formation and BIM in Sweden

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Key words: 3D Cadastre, Property Formation, Building Information Model (BIM), Property Right

SUMMARY

This paper describes problems and solutions concerning interaction between BIM (Building Information Modelling) and the registration and visualisation of 3D real property information. Although BIM and 3D property are two seemingly different domains that have not been combined much in previous studies, the authors argue that they can interact and get benefits from other. Looking at procedures for 3D property formation, the use of BIM is not always considered or even discussed. The paper addresses the current 3D cadastre situation and possible future developments in Sweden. The research presented focuses on how BIM can add to and improve the 3D cadastre. The aim is not to create a combined 3D property and BIM model, but to discuss how these domains can interact to serve the needs for effective information handling by e.g. importing BIM/CAD drawings as a basis for 3D cadastral boundaries as input in the 3D cadastral formation process.

A case study is made of the Nya Karolinska project, in which a new hospital in Stockholm, Sweden, is being constructed. By having data on each element, component and property of a building, BIM can provide input to 3D cadastre information for each element or the whole building in relation to surrounding properties. Although BIM is considered today as the most detailed and comprehensive object-oriented method of modelling buildings, it still does not fulfil the needs for modelling complete 3D cadastre. Therefore, in this paper, four different virtual surfaces are proposed to model the hospital buildings and create a complete 3D cadastre information system, namely “Building Elements Surfaces” that represent boundaries on the building elements, “Digging Surfaces” that exist for underground buildings (e.g. tunnels and car parking) or objects (e.g. foundations), “Protecting Area Surfaces” that are usually important to define restrictions on land use or other activities close to a property, and “Real Estate Boundary Surfaces” which are border lines extended in the vertical direction, or combining surfaces from the other three surface types.

The study has resulted in a discussion of the use of BIM and 3D property information in the case of a large construction project, and a proposal of how these two domains could be combined in general and in particular in registration of 3D property objects. The study has shown possibilities for potential use of 3D cadastre for presenting its legal parts in several stages of the construction process.

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1. INTRODUCTION

A little more than a decade ago, Stoter and Ploeger (2002) stated that there is competition for space, especially in the cities, with increasing population and more advanced space-demanding activities that have to share space within the same traditional two-dimensional (2D) property unit. Many complex situations where there is a need to separate the ownership within an existing parcel and its space can be found (Stoter and Ploeger, 2002, p. I.2).

The use of three-dimensional (3D) property rights has for many years been a tool for providing secure and lasting rights for the use of space and has become a common feature internationally (see e.g. Paulsson, 2007). In order to efficiently manage these complex situations of ownership - and other rights, restrictions and responsibilities associated with land, water and air - the procedures for 3D property formation and registration also have to be addressed.

This paper provides an introduction to Swedish 3D property formation and registration processes, which is used as basis for a discussion of challenges concerning the interaction between BIM (Building Information Modelling) and the registration and visualisation of 3D real property information. Implementing the concepts of BIM into and to develop a nation's 3D cadastre by adding information on buildings and building surfaces is a method of improving the use and visualisation possibilities of a cadastre, e.g. by making database queries on legal boundaries associated with building details, such as that a 3D legal boundary surface follows the outer surface of a building in which the legal basic property unit is located.

BIM has evolved in the construction domain, whereas 3D property has evolved in the legal cadastral domain. Although they are two seemingly different domains that have not been focused upon in previous studies[1], the authors argue that they can interact. BIM is considered as an object-oriented process which describes buildings in respect to their geometric and semantic properties. It therefore involves the generation as well as management of spatial digital representations of physical and functional characteristics of building spaces and their surrounding environment (Isikdag & Zlatanova, 2009a). Through this definition, it can be understood that BIM is characterised by a clear and logical structure of spatial objects of a building enabling to have spatial analyses rather than only visualisation of a building and its spatial elements.

For constructing an information model for a building, a great amount of manual work is usually involved. This work covers all phases and data from initial drawings and their architectural design, structure design, utility networks and plans of the surrounding

[1] Our impression based on the papers presented at the 1st - 3rd International Workshops on 3D Cadastres.

environment. The manual work beside the need for different data sources and stakeholders are considered as the main reasons for why BIM is not widely used for existing buildings (Isikdag & Zlatanova, 2009b).

This paper addresses the current 3D cadastre situation in Sweden and possible future developments. The aim of this paper is not to create or present a combined 3D property and BIM model, but to discuss how these domains can interact to serve the needs for effective information handling by e.g. importing BIM drawings as a basis for 3D cadastral boundaries as input in the 3D cadastral formation process. Thereafter, the challenges of incorporating BIM in the Swedish 3D cadastre is exemplified by how the 3D property formation has been performed and registered in the cadastre by using a major Swedish building project, the New Karolinska hospital in Stockholm (called Nya Karolinska in Swedish), as an example. The hospital is an ongoing huge construction project carried out during eight years, which will result in facilities consisting of approximately 330 000 square meters total gross area. How BIM has been used in the 3D property formation within this project has been studied. By having data on each element, component and property of a building, BIM can provide input to 3D cadastre information for each element or the whole building in relation to surrounding properties. The study results in a discussion of the use of BIM and 3D property information, and a proposal of how these two domains could be combined in general and in particular in registration of 3D property objects.

2. 3D PROPERTY FORMATION

It can be argued that all property units are in fact three-dimensional, since a (2D) property unit may not consist solely of the land surface, but extends downwards into the earth and upwards into the sky. Thus, the three-dimensional aspect of the property does not concern the actual extent of the property unit, but rather the delimitation of it. It is therefore difficult to define the term 3D property, as noted in Paasch and Paulsson (2011). 3D property is often used as a general comprising term and the content of it differs between countries in their legislation. One description of it is real property that is legally delimited both vertically and horizontally (Paulsson, 2007, p. 31). In Sweden, all land and in principle all water areas are divided into property units or joint property units, all of which are recorded in the Swedish real property register, the cadastre. The property unit is registered in the real property register with a unique registration designation. Changes to property units are made through cadastral procedures, which result in an official decision by the cadastral authorities. The register is managed by Lantmäteriet, the Swedish mapping, cadastral and land registration authority.

The concept of 3D property has only existed in Sweden for a decade, being introduced in 2004 and expanded in 2009 by the addition of condominium (apartment) ownership. 3D property is therefore still a rather new form of land management, but there has been an increased interest in 3D property and ownership apartments, although the demand has not been as high as initially expected. The use of 3D property formation in land management is still to be seen as a supplement to the traditional 2D property formation. During 2013, 202 3D property units and ownership apartments were formed, which is 1.1 % of the total number of new property units (including joint property units and joint facilities) registered in the real property register that year (Lantmäteriet, 2013a and 2013b). The low percentage indicates that the concept of 3D property has not yet been established as a common way to secure rights of ownership and associated rights in land. This can also be seen by the low numbers of 3D property in relation to traditional 2D property in the three largest Swedish municipalities in Table 1.

Table 1. Number of 2D and 3D real properties in Sweden's largest municipalities

Municipality	No. of 2D real properties[2]	No. of 3D real properties[3]	Population[4]
Stockholm municipality	59 333	154	897 700
Gothenburg municipality	69 567	55	533 271
Malmö municipality	31 467	91	312 994

The Swedish 3D property is defined as a property unit, which in its entirety is delimited both horizontally and vertically (Swedish Land Code, chap. 1, section 1a). 3D property may refer to a volume of space that is subdivided and separated from the rest of the property. Often it is a larger unit, including several apartments or offices, or used for facilities and infrastructure objects, such as tunnels. The 3D property units must relate to a built construction or other physical facility. The property unit does not have to consist of a whole building or facility, but can comprise only a part of it. 3D property formation can be used to delimit and separate different facilities or floors within a building or below ground in depth and height. A Swedish 3D property may also extend over or under several ground parcels and thus not bound to be located within a 2D property. The concept of 3D property space is space belonging to a property unit other than a 3D property. It contains space within a 2D property. It is not a separate 3D unit, but included in another 2D property unit. See Figure 1 below.

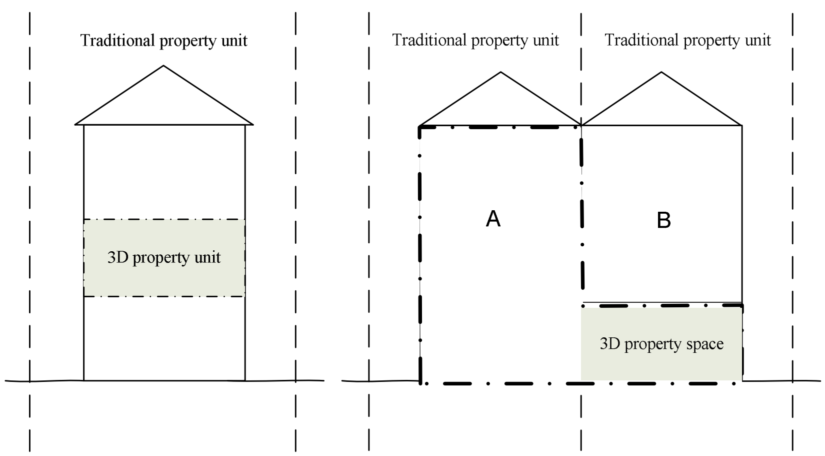


Figure 1. 3D property unit (left) and 3D property space attached to property "A" and carving out property "B" (right)

The Swedish 3D property units all have unique registration numbers and are independent from the land parcel. The 3D property is formed through one of the regular property formation measures and will be recorded in the real property register, defined by x, y and z

[2] Retrieved from the real property register, June 30th 2014.
[3] Retrieved from the real property register, September 17th 2014.
[4] Population per December 31st 2013. Retrieved from Statistics Sweden,www.scb.se.

co-ordinates or other types of indication of its extent in the vertical dimension (Eriksson, 2005, p. 7). The boundaries are usually defined by the surrounding constructions, or by x, y and z coordinates if no natural boundaries exist. Information on what 2D property unit or units that are affected by the procedure is also entered in the register and boundaries, rights and obligations are determined in the property formation order.

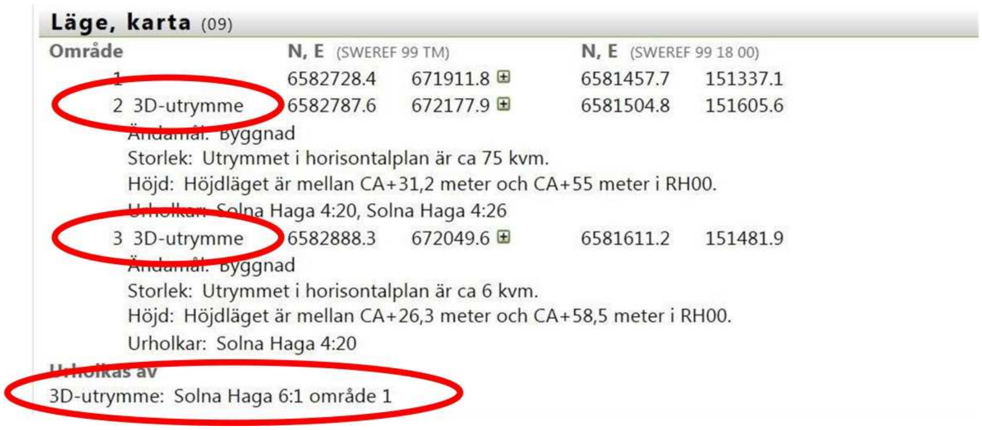
3. 3D CADASTRE

Information on real properties in Sweden is stored in the Swedish real property register (cadastre). The cadastre consists of a textual part (the land register, containing information on title holder, easements, mortgages, unique parcel id, etc.) and a geographical part (the digital index map, containing spatial extension of property units, and associated rights, responsibilities and restrictions). The land register contains the same information as for 2D properties. The cadastre plays a central role in Swedish land management and is accessible on-line. The register is used by a large number of registered users (e.g. financial institutions and other companies) and about 900 000 queries are done each month. In addition to that, the register is accessible to the general public through various Internet services.

All land and in principle all water areas are divided into property units or joint property units, all of which are recorded in the Swedish real property register. Each property unit is registered in the real property register with a unique registration designation. Changes to property units are normally made through a cadastral procedure, which results in an official decision by the cadastral authorities. The property formation procedures are in Sweden executed by Lantmäteriet, the Swedish mapping, cadastral and land registration authority, and a limited number of municipalities. The municipalities are in charge of real property formation within their jurisdictions. They also update the Swedish real property register at Lantmäteriet. The register is updated on a daily basis. The real property units all have unique registration numbers and are independent from the land parcel.

Information on what traditional property unit or units that are affected by the property formation procedure is also entered in the register together with boundaries, rights and obligations that are determined in the property formation order. CAD plans (in DWG-format) supplied by the entrepreneurs are often used during the cadastral formation process. The CAD files are not stored by Lantmäteriet when the 3D property is registered. Cadastral surveys are sometimes done, but not frequently. The unique reference number is a reference to the legal cadastral formation document case file, containing all legal documents, including construction drawings with details on the physical extension of boundaries, e.g. that a boundary follows the outside of a specific wall. The documents are often scanned construction blue-prints, being used as background for legal documentation.

3D property is not registered in a separate cadastre, but additional 3D information is registered on 3D properties in the land register and cadastral index map. The text in the land register specifies whether it is a 3D property or 3D property space, x and y coordinates and gives a brief description of the location in height, e.g. between level “CA” +31.2 meters and level “CA” +55 meters on the construction drawing, which is part of the legal documents, as shown in the example in Figure 2.



Läge, karta (09)

Område	N, E (SWEREF 99 TM)		N, E (SWEREF 99 18 00)	
1	6582728.4	671911.8 ⊞	6581457.7	151337.1
2 3D-utrymme	6582787.6	672177.9 ⊞	6581504.8	151605.6

Ändamål: Byggnad
Storlek: Utrymmet i horisontalplan är ca 75 kvm.
Höjd: Höjdläget är mellan CA+31,2 meter och CA+55 meter i RH00.
Urholkar: Solna Haga 4:20, Solna Haga 4:26

3 3D-utrymme	6582888.3	672049.6 ⊞	6581611.2	151481.9

Ändamål: Byggnad
Storlek: Utrymmet i horisontalplan är ca 6 kvm.
Höjd: Höjdläget är mellan CA+26,3 meter och CA+58,5 meter i RH00.
Urholkar: Solna Haga 4:20

Urholkas av
3D-utrymme: Solna Haga 6:1 område 1

Figure 2. Example of textual 3D information (in Swedish) in the land register (3D-utrymme = 3D space, i.e. 3D property unit or 3D property space)

The visualization of 3D property in the digital index map is quite rudimentary. The boundaries are marked with dotted lines. The area covered by the 3D property is marked with a special surface texture and the property identification, e.g. “\Sörby 1:5\”, is added as cartographic text. Other cartographic representations may only be used if special conditions apply (Lantmäteriet, 2009), see examples in Figure 3 and Figure 4 (3D property and 3D property space), and Figure 5 (apartment ownership).

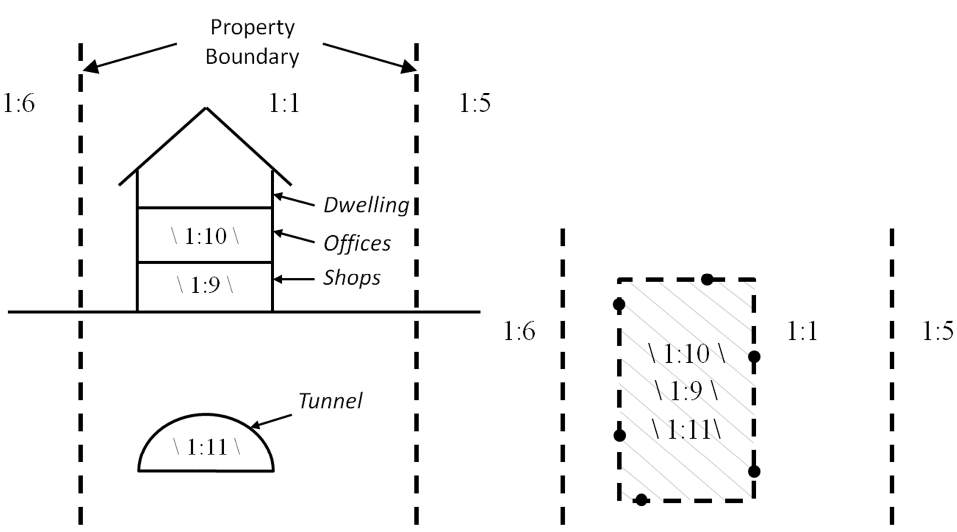


Figure 3. Examples of Swedish 3D property shown in cross section (left) and the visualization on the cadastral index map (right). Based on Lantmäteriet (2004)

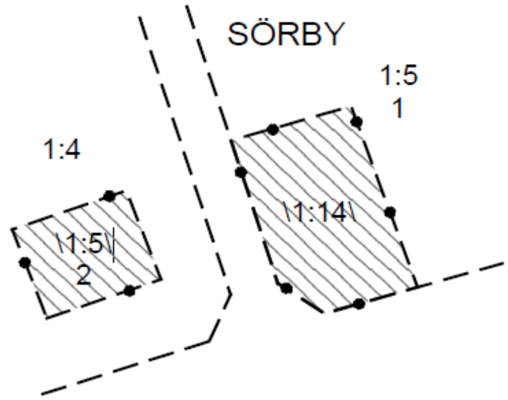


Figure 4. Cartographic representation of 3D property in the cadastral index map. The real property "Sörby 1:4" is a 2D property being caved out by the 3D property space "Sörby 1:5 area 2". "Sörby 1:5" is a traditional property where area 2 is carving out "Sörby 1:5". "Sörby 1:14" is a 3D property carving out "Sörby 1:5" (Lantmäteriet, 2004)

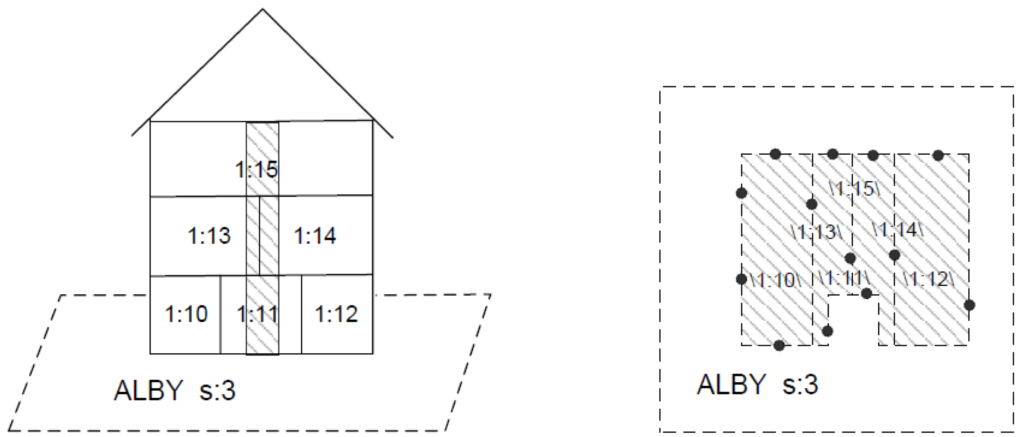


Figure 5. Cross section (right) of ownership apartments and their cartographic representation in the cadastral index map (left) (Lantmäteriet, 2004)

Despite the use of 3D information during the property formation process, the information is "lost" in the cadastral registration process due to the registration of 2D information in the cadastre, meaning that the real property registration authority has access to 3D information of good geometrical quality in construction plans, but the information is only used as input to create 2D based geometrical descriptions on the cadastral index map and 3D textual description in the real property register.

With the increasing international awareness and research efforts on 3D cadastre, building information modelling (BIM) has become an important player in this field because of its rich object-oriented and semantic 3D approach (Amirebrahimi, 2012). In Sweden, the use of BIM has been discussed at Lantmäteriet in regard to e.g. 3D property registration, but no decision has been taken yet regarding if to expand the property register with (three-dimensional) building objects. The real property formation process can, in regard to the use of 3D CAD construction plans, be summarized as shown in Figure 6.

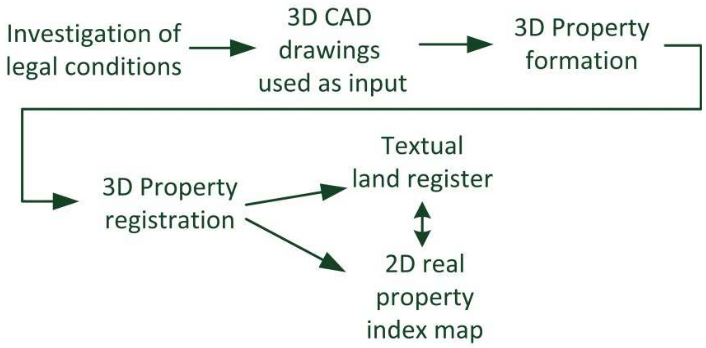


Figure 6. Current 3D property formation and registration process using 3D CAD data (simplified)

Another important scientific contribution in the land and urban administration domain is the international standard for land administration, ISO 19152, Land Administration Domain Model (LADM). Even though its main focus is not the 3D cadastre, it can be used to describe 3D property. The standard features are the representation of 3D components by using the topological concepts of "faces", "boundary faces" and "boundary face strings". A face is a two-dimensional topological primitive (ISO, 2003, 4.38). The geometric realization of a face is a surface. Boundary face is used in the three-dimensional representation of a boundary of a spatial unit. The volumes represent legal space, not the physical space in e.g. a building (ISO, 2012, 4.1.4). Boundary face strings are used to represent the boundaries of spatial units by means of line strings in 2D. In a 3D land administration system it represents a series of vertical boundary faces where an unbounded volume is assumed, surrounded by boundary faces which intersect the Earth's surface, e.g. such as traditionally depicted in the cadastral map (ISO, 2012, 4.1.5). See Figures 7-9, illustrating the concepts of boundary face and boundary face strings.

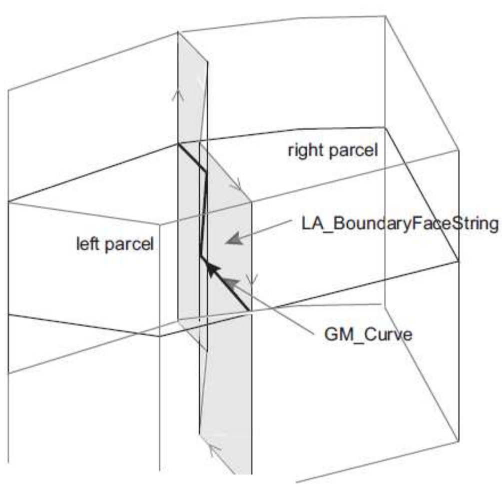


Figure 7. The concept of spatial units defined by boundary face strings (ISO, 2012, annex B)

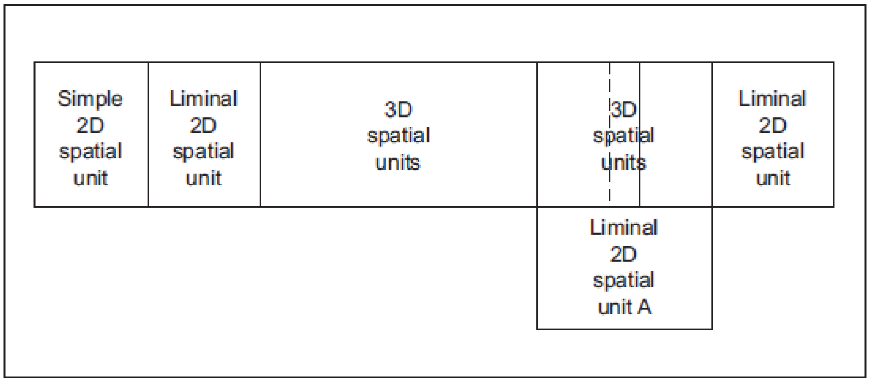


Figure 8. Top view of mixed 2D and 3D representations (ISO, 2012, annex B)

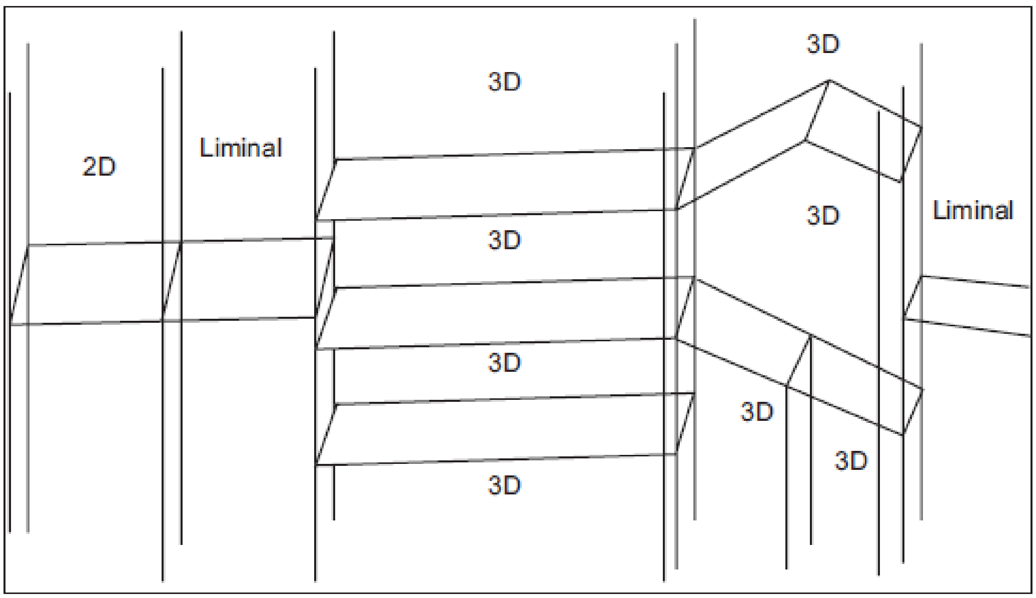


Figure 9. Side view showing mixed use of boundary face string and boundary faces (ISO 19152, annex B)

Reviewing the above mentioned research efforts and scientific contributions, it can be concluded that 3D cadastre is still a problematic area with a number of challenges. We agree with the conclusion of the Second International Workshop on 3D Cadastre (November 2011, Delft, The Netherlands) that there is no one single best solution for 3D cadastre as well as no single complete 3D cadastre. Therefore, we focus in the following sections on the challenges of the current standards, BIM and LADM, and how to overcome them.

4. BIM IN SWEDEN

With the development in information and communication technology (ICT), it has become apparent that information modelling has formed an important and accepted approach in this development. Since its original development in the mid-1980s, information modelling has been used in many industrial sectors in engineering domains including architecture, engineering and construction (AEC) and facilities management (FM) (Barrett & Grobler, 2000). However, lack of communication and fast consensus decisions on spatial events (e.g. natural or man-made crisis) has had a negative impact on the effectiveness of applications in this industry (Gallaher et al, 2004). As a result of heavy R&D activities in this area, BIM was developed as an important concept for organising all type of activities in and surrounding buildings with their objectives. In addition to that, BIM has today become an active research area for dealing with problems related to information integration and interoperability.

The use of BIM has gained an increased interest in Sweden in recent years and is used on a number of building projects, creating detailed 3D building models with associated information on building details, such as dimensions, types of material and producers of used material. All involved parties, from architects and plumbers to building managers, can create a common model and thus avoid problems (Lantmäteriet, 2014b). However, despite the increased interest in BIM as a cost-effective tool in construction and building management there are some issues of concern to be addressed. One issue is the access to 3D digital information (Digital Elevation Models, Ortoimagery, etc.). Another issue to be addressed is the lack of or use of co-operating standards, resulting in variants of BIM created for each building project, as mentioned in a recent report to the Swedish government (Lantmäteriet, 2014b, p. 15). The interest organization Swedish OpenBIM –now renamed BIM Alliance Sweden – consisting of organizations from the construction industry, has made suggestions for how to improve the interchange between BIM and GIS (Lantmäteriet, 2014b). The Swedish Standards Institute, SIS, is currently discussing how to join ongoing standardization activities within construction and geographical information areas. The interoperability between CAD and GIS standards has also been observed by the BIM interest organizations, stating that common national and international guidelines and a consequent strategy are a condition for a development of standards for concepts, information exchange or formats for data storage (Ekholm et al, 2013).

5. CHALLENGES OF AND SOLUTIONS FOR INCORPORATING BIM IN THE 3D CADASTRE

The status today is that there is no interaction between BIM and the 3D property formation process in Sweden. The digital building information is supplied by the building contractors and used in the property formation process, resulting in detailed information on the extension of legal boundaries in relation to building surfaces and other constructions details. The construction plans are made part of the (paper based) legal documents, often as appendices, being registered by the property formation agency. The documents are available in the digital archive as pdf files. The textual part of the land register contains a reference to the property formation documents. The digital information used in the property formation process is "abandoned" after the property formation is completed, as mentioned above.

BIM can add to improve the real property formation, registration and visualization processes in Sweden. There are, however, some questions to be addressed. First is the increased use of geographical information standards and use in connection with other standards, such as CityGML and IFC. Second, the real property formation process used today only use the available digital information, e.g. BIM/CAD DWG files supplied by the construction companies to a certain extent by using the information in the real property formation process.

In the construction phase different rights could be identified in 3D in order to check how to construct and manage a project. Finally, after the construction is finished, the 3D cadastral systems could be useful in showing 3D perspectives of spaces and spatial relationships between them. A change in these spaces or activities might then result in changing the cadastral maps, land use rights, etc., all related to legal and organizational aspects of 3D property.

One example from the New Karolinska project is illustrated in Figure 10 showing a part of these challenges. In the figure, the extension of the hospital building is shown approaching over the street making an "easement" relationship (i.e. the right to use other property) on the public property (road), creating a boundary face through the building. Regardless of the purpose of this extension, it is needed to be represented, registered, and calculated in volumes and spaces. However, these functions can neither be fulfilled in the 2D-based cadastre systems nor with the current BIM applications. In 2D-based cadastre systems, the spatial relationships are only described in text documents which have no representation in 3D. In BIM applications, the spatial relationships are visualised in 3D and the related analyses are fulfilled, but the mentioned cadastre functions with the type of rights, restrictions and responsibilities (RRRs) are not represented.

There are different challenges with BIM for representing information required for a complete 3D cadastre. It can be concluded that different aspects with different classifications are attached with a complete 3D property representation. Paulsson and Paasch (2013) classify 3D aspects into four groups; legal, technical, registration and organizational aspects. This classification is also used below.

Legal aspects define the boundaries of a property, the rights of its activities, how the area is calculated and the content of a property.

Technical aspects deal with how 3D properties can be visualized, geometrically represented, managed and extracted from different data source formats on technical applications.

Registration aspects concern how the registration of 3D property in land administration systems (refers to any system that stores 3D property information such as land registers and purpose cadastres) is done. It includes aspects such as the content, storage, structure and maintenance of 3D property information.

Organizational aspects include aspect for institutional, management and capacity-building issues. They even deal with operational issues on the property and its financial structure.

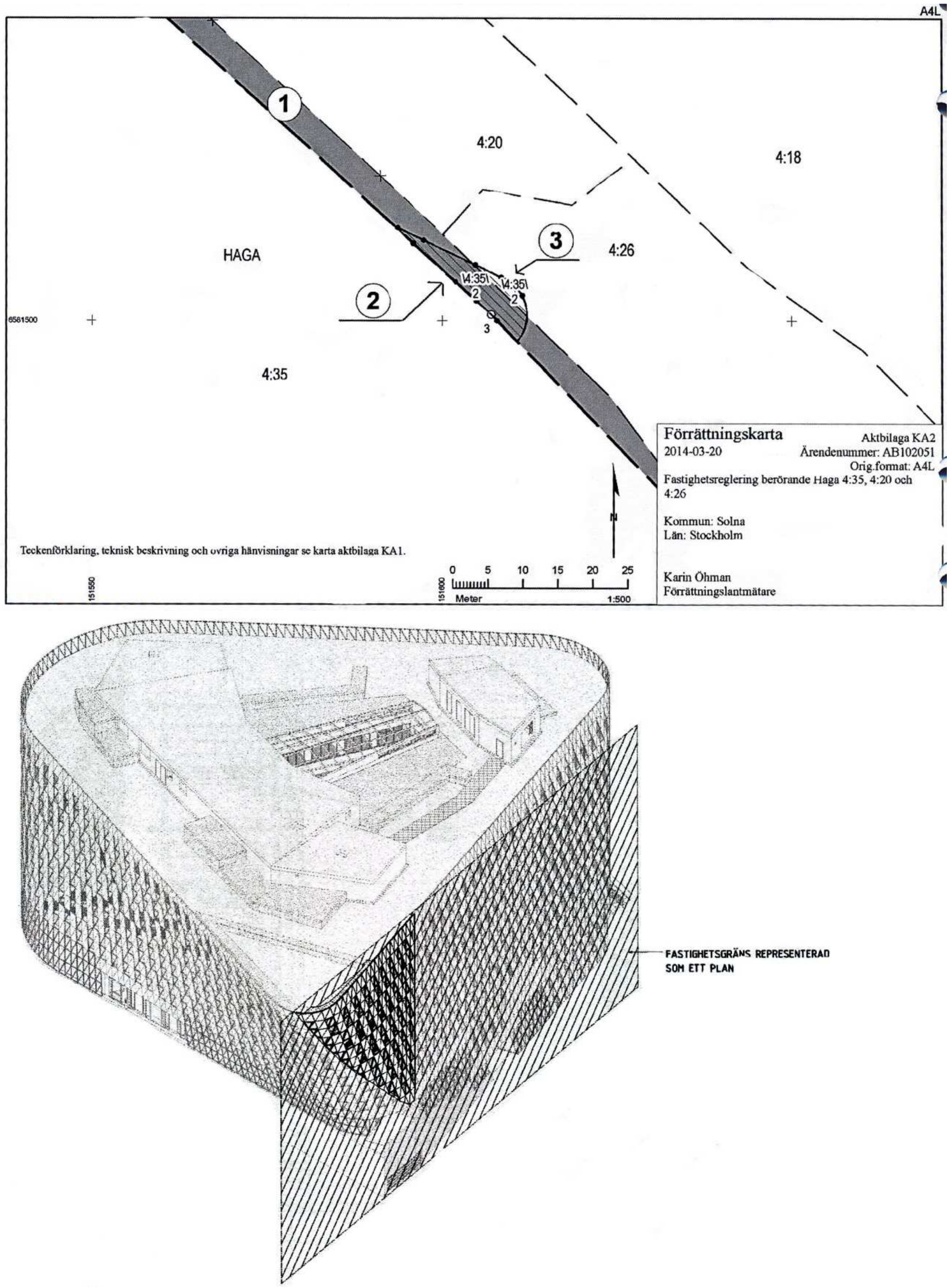


Figure 10. 3D boundary shown as a vertical plane cutting through hospital building in a 2D cadastral survey map (above) and its representation on a 3D construction drawing (below), as appendices in the legal survey documents (Lantmäteriet, 2014a)

By analysing how these four aspects should be represented towards a completed 3D property representation, one can conclude that they cannot be extracted only from physical elements that have clear x, y and z coordinates from which they can be spatially represented and constructed. In addition to that, registration and organizational aspects are not directly related to the representation of the 3D property. Instead, they focus more on how a property is stored and archived in the system, and to schedule activities such as queries, retrieval, maintenance, etc. In that sense, one might expect that if the legal and technical aspects fully support the representation of 3D properties, then the registration and organizational aspects will be easily fulfilled. However, in this paper, the focus is more on legal and technical aspects for how to present them and construct them in real 3D. They include large parts of virtual surfaces that define, for example, underground rights, easements, and aboveground area and content which require clear definition and structure of these surfaces. This consequently brings our proposal for four types of boundary surfaces (El-Mekawy and Östman, 2012) that can facilitate the representation of the legal and technical 3D property aspects. These surfaces are proposed to be constructed as spatial volumes or spaces and to be saved in the 3D cadastre system whether it is based on CAD or geospatial information systems. Figure 11 shows these four surfaces and the relationships between them over a building and its property.

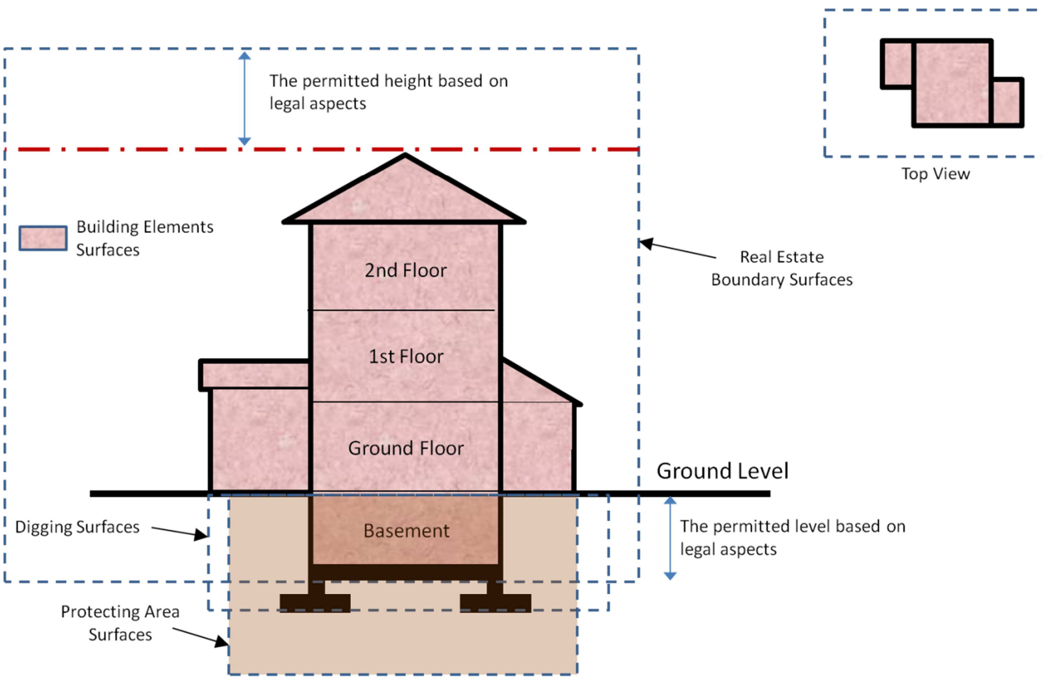


Figure 11. The four proposed boundary surfaces for 3D property representation

"Building Elements Surfaces". This type of surface represents the outer lines of all surfaces and building elements. While the building elements (e.g. walls, slabs, stairs) themselves have different internal and external surfaces, the building element surfaces can be formed by the union of all external surfaces of the external building elements.

“*Digging Surfaces”*. These surfaces are used for modelling the underground 3D usage (i.e. rights, restrictions and boundaries) of a property. It is important not only for constructions like tunnels and multi-storey car parking, but for underground objects like foundations and representation of different easements for utility networks. Although these virtual surfaces cannot be seen or recognized by most of the users, they can define the contents, area and even the legal boundaries of underground parts of a property.

“*Protecting Area Surfaces”*. This type of surface has relationships to the “*digging surfaces*” but it has another purpose. These surfaces define the area around a 3D property in which some legal aspects are applied. For example, restriction distance is always applied around underground buildings such as tunnels, to come closer to a water area (e.g. sea, river or channel), or around an underground utility network. Restrictions and legal rights may be related to dangers or risks on constructions themselves or on people using the property.

“*Real Estate Boundary Surfaces”*. These surfaces define the real legal boundaries of a 3D property after applying the previous three types of surfaces. It is introduced for two main reasons. Firstly, in cadastre systems in 2D maps, a cadastre unit is defined by points on its borders with lines connecting these points to construct the final polygon of legal boundaries. However, in 3D, these boundaries are extended downwards into the earth and upwards into the sky. Defining the highest and lowest levels should be stored somehow to serve different applications such as the skyline development of a city, designing an airport or calculating densities of urban areas, etc. Secondly, these surfaces have different relationships to other surfaces. They can be identical to any one of the surfaces as follows; identical to the “*Protecting Area Surfaces”* in cases where constructions such as tunnels need restrictions in land use, identical to the “*Building Elements Surfaces”* in cases where the external building elements also constitute the legal boundary such as in row-houses or compact cities. In other examples, the legal boundaries of the 3D real estate property should be created separately, combined or extracted from one or more of the other surfaces. A clear example of this case is the joint ownership in apartments when two apartments share the same building element such as a wall, a slab, a stair, an elevator, etc. It should then be extracted from different surfaces of the building elements or defined virtually in the centre of their walls.

6. CONCLUSION

This paper has described some problems and solutions in the interaction between BIM and the registration and visualisation of 3D real property information and how these domains can interact to serve the needs for effective information handling by e.g. importing BIM/CAD drawings as a basis for 3D cadastral boundaries as input in the 3D cadastral formation process.

Although BIM is considered today as the most detailed and comprehensive object-oriented method of modelling buildings, it still does not fulfil the needs for modelling complete 3D cadastre. However, this paper has shown that in the Nya Karolinska project, as an example of a large construction project where BIM is used for other purposes than related to 3D cadastre and 3D property formation, BIM could be a useful tool for effective information handling. By having data on each element, component and property of a building, BIM could provide input to 3D cadastre information for each element or the whole building in relation to surrounding properties.

The proposed four different virtual surfaces could be a useful way of achieving this purpose and creating possibilities for the potential use of 3D cadastre for presenting its legal parts in several stages of the construction process. Further studies are needed in order to investigate how this could be done and to present a model for it. Using Nya Karolinska as a case study object would be of benefit for such a study and solutions could be developed that in the future could be used also in construction projects of less extent.

The spatial unit concept of 3D property in the LADM would in our opinion be a valuable input to the future development of the Swedish cadastral index map and allow a more advanced presentation of 3D property than the current rather rudimentary 2D presentation described above. However, when and to what extent the LADM will be implemented in Sweden has yet to be decided.

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