

3D Registration of Real Property in Denmark

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Key words

SUMMARY

Real property in the physical world is in three dimensions. Until today registration of properties has always been done in one dimension (text) or two dimensions (cadastral maps). Accessible technologies for describing and measuring registration and communication have been used.

Facing three-dimensional digital technologies, it becomes still more interesting to discuss and investigate methods and needs for three-dimensional description and registration of spatial legal objects.

This paper discusses the result of a case study on the spatial legal objects in Denmark trying to create transparency in the understanding of the three dimensions of real property and spatial legal objects. Finally, the need for 3D registration is discussed.

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1. INTRODUCTION

Traditionally, cadastral registration systems are parcel-based systems, since the individualisation of land started with a subdivision of land using 2D boundaries. A whole country is divided into parcels, while rights and limited rights on property are established and registered on 2D land parcels. This 2D cadastral concept has served its purposes for decades. It should be noted that also in the traditional cadastre use of a property has always been related to 3D space, i.e. use of land has always been in 3D; otherwise it would have been impossible to use the land parcel.

Although property has been located on top of each other for ages, only recently the question has been raised if cadastral systems should be extended into the third dimension. The growing interest for 3D cadastral registration is caused by a considerable increase of value of property, by increasing situations with property on top of each other - the number of tunnels, apartments, cables and pipelines, underground parking places and shopping malls have grown considerably the last 40 years - and by an upcoming 3D approach in other domains (3D GIS, 3D planning) which makes a 3D approach of cadastral registration technologically realisable.

In the Netherlands a research was started to study the needs, possibilities and constraints of a 3D cadastre (Stoter and Ploeger, 2003). As part of this research, current cadastral registration in the Netherlands was studied in order to get a good overview on problems that arise when registering 3D situations in a 2D cadastral registration system. This overview provides insight into the real needs for a 3D cadastre. To place the research in the Netherlands in an international context and to see if other countries than the Netherlands meet the same problems, a comparison case study was carried out on 3D situations and cadastral registration in Denmark.

This paper describes the results of this case study that was carried during a working visit in Aalborg, November 2003 in collaboration with the National Survey and Cadastre (Kort & Matrikelstyrelsen) and the Centre for 3D GeoInformation at Aalborg University.

The case study resulted in an overview of the transparency in real property registrations in Denmark when dealing with 3D property units. A 3D property unit is a sub-division of a real property and describes the amount of space to which a person is entitled by means of real rights.

The literature used in this research is (Enemark, 1998; Enemark, 2002; Hvidegaard, 1998; Lilleholt, 2002; Starup-Hansen, 2001).

This article starts with an introduction to land administration in Denmark in general (section 2). Section 3 describes the types of property registrations with a possible 3D component. In section 4, two case studies are presented to illustrate how 3D property units are currently registered in order to show limitations of current registration practice. Section 6 concludes on the need for 3D registration of property in Denmark.

2. INTRODUCTION TO REGISTERS ON REAL PROPERTY IN DENMARK

In Denmark there are four basic registers of real properties falling under different authorities:

- the Cadastral register
- the Land register (Land Book)
- the Building and Dwelling Register
- the Property Valuation register

How these registrations interact will be described below.

2.1 Cadastral Register

The Danish cadastre is maintained by the National Survey and Cadastre (KMS) which is an agency within the Ministry of the Environment.

The Danish cadastre originally started as a system supporting the collection of land taxes. The main objective of the Danish cadastre nowadays is to support an efficient land market, as well as to provide a basis for appropriate land management. The cadastre still provides information on entities for taxation (*vrderingsejendom*). This information is selected from the valuation register of the municipalities (see further).

The cadastral register consists of four elements:

- a register of real properties (*ejendom*) and land parcels (see below)
- a cadastral map (see below)
- measurement sheets related to boundaries
- register of control points used for cadastral surveys

2.2 The Parcel and Property Register

The cadastral register of parcels and properties is an administrative registration. The registration maintains information on parcels such as parcel identifier, area, area of road, area of protected forest, area of coast protection zone, area of dune protection zone, number of separate land units of which a parcel consists, share in common parcel, registration as protected forest, registration as coastal zones, polluted land parcel, land use.

The cadastral register also maintains a register on real properties. A real property may be one parcel or a collection of parcels that have been registered together and have the same owner. A parcel may consist of several land units. Apartment units are not known in the cadastral system.

2.3 Cadastral Map

The cadastral map is a legal overview map that shows the registered boundaries of land parcels and roads. Roads are not considered as cadastral parcels, although they form a full planar partition with the cadastral parcels (no overlap and no gaps). All land parcels and roads in the cadastral map have a parcel identifier. Apart from parcels, the cadastral map also contains other information such as other boundaries (centre line in stream wider than three metres in case the stream is a boundary, road boundary, railway boundary, edge of lake, coastline, parish boundary) and areas of public restrictions which restrict owners to use the land freely (protected forest, dune protection zone, coast protection zone, polluted land parcel).

2.4 Land Register

The land registry is a register of rights in real properties and falls under the responsibility of the Ministry of Justice. It contains legal data like titles, name of landowners, mortgages and easements (servitudes). Since 2000, the land register is fully digitised although the legal documents are still only analogously available. The state guarantees the contents of the land register. The land registry is decentralised to the (100) local courts. The land register uses the identifications of real property established by the cadastre.

2.5 Building and Dwelling Register

The municipalities (275 in total) are responsible for two real property registrations: the building and dwelling registration (BDR) and the valuation registration (SVUR). The Ministry of Economic and Business Affairs is responsible for these two registrations.

The BDR contains information on three levels of registration:

- Property (related to buildings) that is the same property as registered in the cadastral system. The attributes maintained at property level are type of ownership, water supply system, sewage disposal system, etc.
- Building. The main attributes maintained at building level are the purpose for which the building is used, accessibility from the street, number of dwellings, year of construction (rebuilding, extension), basement area, top story area, number of floors, etc.
- Units. The main attributes maintained at unit level are the purpose of dwelling/unit, type of dwelling, area of dwelling (demarcated by outside boundary of walls), area used for living, area used for business, number of rooms, etc.

A property (consisting of one or more land parcel(s)) may consist of one or several buildings; a building may be subdivided into units.

When a building is built it has to be announced to the municipality. This announcement should contain construction drawings. Every renovation of the building has to be made known to the municipality as well, accompanied by drawings. Consequently, the municipality maintains an archive containing detailed information on construction and renovations of every building. The BDR summarises information from this archive.

The BDR does not contain any spatial information. The Danish cadastre (which sets the guidelines for maintenance of the BDR) started a pilot in order to link buildings to address coordinates. A standard procedure has been developed by combining the BDR, the cadastral registration and buildings maintained in the TOP10DK (Starup-Hansen, 2001) to generate address coordinates. This procedure results in 50% of the cases in correct locations of address coordinates of the buildings. For the other 50% the geo-coded address coordinates have to be edited and controlled manually. This is due to several problems such as more than one building may be positioned on one parcel, more addresses may exist for one building (e.g. flats) and points may fall outside buildings.

2.6 Valuation Register

Apart from the BDR, the municipality also maintains a sales and valuation register, to record valuation on single properties to assist authorities in calculating and collecting property taxes. The tax authorities use the sales and valuation register for calculation and collection of taxes. The valuation registration contains information concerning identification of the property (cadastral number and property number), land area of each parcel and all results of taxation. The valuation contains two parts: valuation of land and valuation of buildings. When a property is transferred, the value used for buying the property is entered into the valuation registration.

The property number is the property number from the cadastral registration. However, in case of apartment units, the properties are not known as individual properties in the cadastral registration. Therefore self-owned apartment units get identifiers for property in the valuation register although they are not known as individual properties in the cadastral registration. These properties cannot be subdivided into buildings and units. The Ministry of Taxation sets the guidelines for the maintenance of the valuation register. The assembly of valuation properties (which parcels belong to a *vurderingsejendom*) is provided to the cadastre, as well as the value of the properties.

2.7 Cross-Reference Register (KKR)

Originally the building and dwelling registration, the valuation registration and the cadastral registration (and the land registration) were created as separate registrations. To be able to link these separate registrations, the cross-reference register was created in 1978. The cross-reference register contains all key identifications and the unique cross-reference data between the building and dwelling register, the valuation register and the cadastral register by which it is possible to exchange data between the different registers.

The register has no data contents. It only contains common keys as well as the relations between these keys. Beyond functioning as a property map the digital cadastral map can also be used as a key of access to the other property-related registers.

2. 8 Data Model of Real Property Registration in Denmark

From the above it can be concluded that three organisations maintain a register on real properties:

- the municipality: valuation registration and building and dwelling registration
- the cadastre: parcel (and real property) registration
- the land registry: register of real rights, restrictions and subjects on property

How the entity 'property' is related throughout the different registrations is shown in the UML model in figure 1.

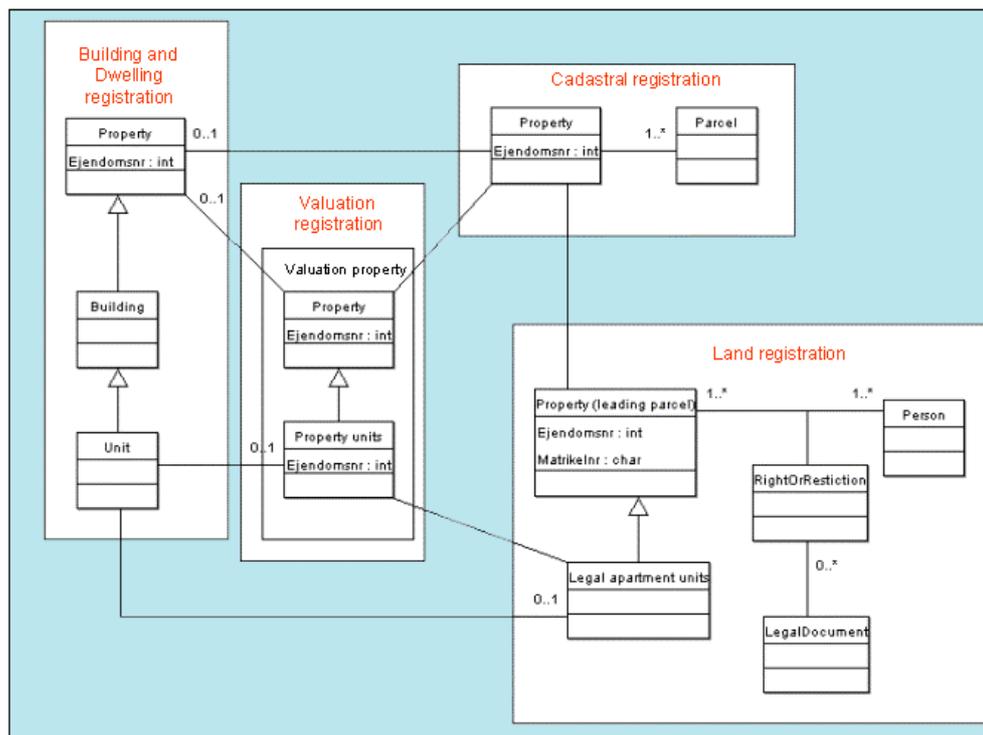


Figure 1: Data model of registers of real property in Denmark.

The entity 'property' is maintained in all four registers. The entity 'property' in the land registry, the cadastral register and the valuation register refers to the same object: one or a collection of parcel(s) that is defined in the cadastral register as one real property. However, the entity is maintained separately in every system (different authorities), while no inter-relationships are maintained between the different databases.

Property in the building and dwelling register also refers to the 'property' entities in the other three registers. This property is, however, only registered when it is related to a building.

The valuation register distinguishes further in properties at unit level ('property units') that can be self-owned apartment units also registered as legal apartment units in the land registry, but also rented apartment units or apartment units in apartment complexes owned by a housing association (see further).

This data model shows that much information on real property is registered in Denmark. However, since registration of real property in Denmark is divided among different governmental bodies and since the definition of real property may differ slightly in the different registrations, the organisation of information on real property is complex.

2. 9 Other Public Digital Registers (Databases) in Denmark

Since the late 60s, Denmark has established a wide range of digital public registers, at the state level as well as at the county and municipal level:

- The Planning Register is a nationwide register for municipal plans, local plans, town plan regulations as well as urban renewal plans and land value areas (registered and used by municipalities, counties and state authorities)
- The Central Population Register (CPR) system. The register numbers all persons residing in Denmark and includes the address of each individual person.
- The CPR Road Register contains a complete list of all Danish roads with house number intervals and divisions into administrative districts.
- The Central Enterprise Register (CVR) is a central administrative register of all private and public legal entities (enterprises).
- All Danish farmers are registered in the General Agricultural Register (GLR)/Central Domestic Animal Register (CHR). The register contains information about the farm. Digital maps in the form of "field block maps" are linked to the GLR/CHR register.
- The Land Information System (AIS) is the first attempt to collect and integrate geoinformation from different regional and national authorities within the nature and environment field in Denmark. The system contains information about the countryside such as habitat types, land use, hydrology, natural resources, polluted areas, etc. A central element in AIS is the nationwide land information map (AIS-map) describing the land use in urban and rural areas.

As examples of other registers can be mentioned the Central Forest Register, the Building Preservation Register, the History of Civilisation Register, State and Local Registers of Statistics, the National Health Register and the Information System of the Road Sector (VIS).

3. REGISTRATIONS OF REAL PROPERTY WITH A 3D COMPONENT

When looking at the 3D cadastral issue in Denmark, it is relevant to look at real property registrations with a possible 3D component. This section describes the main cadastral registrations with a possible 3D component.

The Danish Law is based on the same principles as laws on property in other countries: right of ownership is established on parcels and is not limited in the vertical dimension. A (juridical or factual) horizontal division in property can be established by *raadighedsindskrenkninger* (restrictions in property). These restrictions can be defined both according to Private Law and Public Law.

3.1 Registrations according to Private Law

Rights according to Private Law, which can be used to establish a (juridical or factual) horizontal division of property, are mainly condominium rights or servitudes. Denmark has also a juridical construction called *bygning på lejet grund*, which means buildings on leased ground that is more or less similar to the right of superficies.

Rights are not registered directly in the cadastre. However, 2D and 3D spatial information on the limited rights (what is the space for which a right applies) can be added in the title establishing the limited right that is registered in the land registry. Information in case of *bygning på lejet grund* is also available in the building and dwelling registration.

3.2 Apartment Units in Denmark

Denmark distinguishes three types of apartment units:

- One person owns the whole apartment complex and individual apartments are rented from this person (*Udlejningsejendom*).
- The whole apartment complex is owned by a cooperative housing association while each of the members of the association has a right of use of a dwelling (indirect ownership). It is not possible to mortgage individual units (*Privat Andelsboligforening*).
- All units are owned by individual persons (direct ownership) (*Ejerlejlighedsejendom*) and common parts are held in co-ownership.

How these different types of apartment units are registered in the real property registrations, will be illustrated by the case studies (see section 4).

3.3 Registrations According to Public Law

Public servitudes (restrictions according to Public Law) are registered in the land registry, in which a public authority is the owner of a servitude. The locations of these restrictions are (in most cases) not visible on the cadastral map nor are they available elsewhere in the cadastral system.

Restrictions according to Public Law can also be laid down in local plans (municipal or provincial level). These restrictions are not always available in the cadastral registration or in the land registry. Information on these restrictions is maintained and provided by local and county authorities.

Nowadays the Danish cadastre supports management of environmental acts. Information on protected forests, dune protection zones, coast protection zones and polluted land parcels is therefore maintained in the cadastral registration. Restrictions because of these protection zones are defined in the titles in the land registry. All this information is also spatially maintained on the cadastral map.

Detailed information on protected forests, dune protection zones, and coast protection zones is therefore directly available from the cadastral map. These zones do not need to coincide with parcel boundaries, which means that limitations concerning protected forests, dune protection zones and coast protection zones can be laid down on just a part of a parcel,

without needing to create new parcel boundaries. The spatial extent of these limitations is shown (in 2D) on the cadastral map.

Concerning 3D, the most important Public Law restriction for which the third dimension is relevant is a restriction because of soil pollution since soil pollution is a 3D phenomenon. However, current registrations of property do not contain 3D information on soil pollution.

4. Case Studies

To illustrate current registration practice of 3D situations in Denmark, two types of registrations have been selected for detailed case studies:

- apartment units
- registrations for physical infrastructure objects crossing other properties (tunnels and pipelines)

The apartment units were selected since the registration of apartment units is a typical Danish registration. The case studies will therefore reveal complexities of current registration in 3D situations that are specific for Denmark.

The registrations of infrastructure objects were selected since these objects especially require a 3D approach to a cadastre and are similar to the selected case studies in the Netherlands.

4.1 Case study 1: Apartment Units

To illustrate the way apartment units are registered, three apartment complexes from a street in Aalborg (Holbergsgade) are examined (see figure 2):

- Holbergsgade 2: self-owned apartment units (direct ownership)
- Holbergsgade 3: one private person is the owner of the whole apartment complex
- Holbergsgade 5: a private housing association owns the whole apartment complex and the members of the association have the right of use of individual apartments (indirect ownership)



Figure 2a: Overview of the three apartments of the case study.



Figure 2b: Similarly looking buildings in the same street contain the same physical objects but very different spatial property objects. From the left Holbergsgade 2 (condominium), 3 (one-person-owned property – apartment complex) and 5 (private housing association with common ownership). They need different property models in the different registers.

4.2 Apartment Units and Cadastral Registration

The cadastral register can be queried via the Web-Matrikel (Web-Cadastre). Using the system requires subscription. Figure 3 contains the cadastral map of Holbergsgade obtained from the Web-Matrikel.

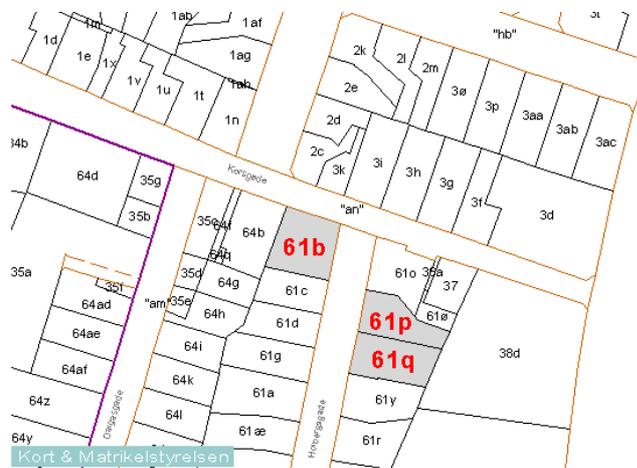


Figure 3: Cadastral map of Holbergsgade. Parcel number 61b contains Holbergsgade 2, parcel 61p contains Holbergsgade 3 and parcel 61q contains Holbergsgade 5.

The cadastral register does not contain information on the existence of apartments as can be seen from figure 4, which is the result of querying the administrative part of the cadastral

register. The information shown is: the road-code, the parcel number, type of calculation of area, number of land units, area, road area, number of document, mutation date.

Matrikeloplysninger:		Matrikeloplysninger:		Matrikeloplysninger:	
Aalborg Bygrunde		Aalborg Bygrunde		Aalborg Bygrunde	
Ejerlav	2005051	Ejerlav	2005051	Ejerlav	2005051
Matr.nr.	61b	Matr.nr.	61p	Matr.nr.	61q
Beregning		Beregning		Beregning	
Lodantal	1	Lodantal	1	Lodantal	1
Areal	394 m ²	Areal	309 m ²	Areal	371 m ²
Vejareal		Vejareal		Vejareal	
Jordforureningsforhold efter jordforureningsloven ikke oplyst		Jordforureningsforhold efter jordforureningsloven ikke oplyst		Jordforureningsforhold efter jordforureningsloven ikke oplyst	
Journalnr.	M1898/03297	Journalnr.	M1910/01404	Journalnr.	M1924/04065
Ændringsdato	01-jan-1900	Ændringsdato	01-jan-1900	Ændringsdato	20-feb-1902

Figure 4: Information queried from the cadastral registration for parcels 61b, 61p and 61q.

4.3 Apartment Units and Land Registry

The Land Registry Office in Aalborg was visited to obtain information on the apartment complexes in Holbergsgade. This research revealed that only in the case of self-owned apartment units (Holbergsgade 2), titles on the individual apartment units are maintained. For the ground parcel at Holbergsgade 2, one title is maintained which describes the division of the original property in apartment units. This title does not contain spatial information. An overview of every apartment (including common area) is added in titles of the individual apartment units (see figure 5).

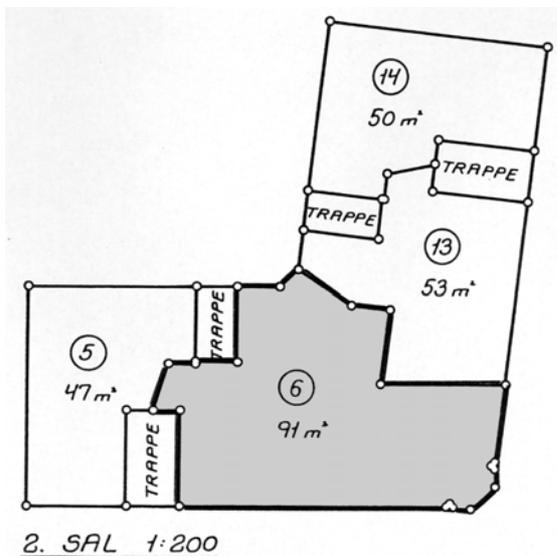


Figure 5: Overview of apartment number 6 (third floor, on the right), Holbergsgade 2.

In the case of Holbergsgade 5, the concerning titles (mortgage, transfers) are established on the whole ground parcel. Information on the private housing association is also maintained e.g. statutes of the housing association. However, the individual apartment units or the

members of the association are not identified in the land registry and are only known within the housing association itself.

In the case of Holbergsgade 3, the concerning titles are established on the whole ground parcel. However, the existence of apartments is not mentioned in the titles.

4.4 Apartment Units in the Building and Dwelling Registration

The building and dwelling registration and the valuation registration is accessible for the public by means of an Internet application (www.ois.dk). From this Web-site information from the Cadastral Register, the Communal Property Data System, the Planning Register and the Sales and Valuation Register can be obtained.

The building and dwelling registration maintains information on three levels: property, building and unit.

At property level (highest level of the building and dwelling registration), the properties known in the cadastral registration are maintained which in all three cases means one property for the whole apartment complex.

At building level (linked to addresses Holbergsgade 2, 3 and 5), the type of property (*ejerforhold*) is maintained which is respectively:

- '*Andet, herunder moderejd. samt ejd. med flere kategorier af ejere*': miscellaneous including mother-properties as well as properties with several categories of owners. It is owner-occupied flats (British) or condominiums (American) (Holbergsgade 2).
- '*Privatpersoner, incl. I/S*': private individuals including partnership with personal liability of partners (Holbergsgade 3).
- '*Privat andelsboligforening*': private cooperative housing association (Holbergsgade 5).

Other information that is maintained for Holbergsgade 2, 3 and 5 at property level is:

Holbergsgade	2	3	5
Bygninger (number of buildings)	1	1	2
Småbygninger (number of small buildings)	0	0	1
Ejerlejligheder (number of properties)	19	0	0
Enheder (number of units)	19	9	10
Beboelseslejligheder (number of units for living)	19	9	10
Erhvervsenheder (number of business units)	0	0	0

Holbergsgade 2 contains 19 properties, since the house is a corner house and is combined with a house containing 9 apartment units in the side street. In the cadastral registration one property (consisting of one parcel) is used for both the apartment complex at Holbergsgade 2 and the apartment complex at Korsgade 25 (the apartment complex in the side-street) as can be seen on the cadastral map in figure 3.

At unit level, information on the individual units (apartment units) is maintained for all three cases. The following units (addresses) are known in the building and dwelling registration at Holbergsgade 2, 3 and 5:

Holbergsgade 2, 1 TH
Holbergsgade 2, 1 TV
Holbergsgade 2, 2 TH
Holbergsgade 2, 2 TV
Holbergsgade 2, 3 TH
Holbergsgade 2, 3 TV
Holbergsgade 2, 4 TH
Holbergsgade 2, 4 TV
Holbergsgade 2, ST TH
Holbergsgade 2, ST TV
Holbergsgade 3, 1 TH
Holbergsgade 3, 1 TV
Holbergsgade 3, 2 TH
Holbergsgade 3, 2 TV
Holbergsgade 3, 3 TH
Holbergsgade 3, 3 TV
Holbergsgade 3, KL
Holbergsgade 3, ST TH
Holbergsgade 3, ST TV
Holbergsgade 5, 1 TH
Holbergsgade 5, 1 TV
Holbergsgade 5, 2 TH
Holbergsgade 5, 2 TV
Holbergsgade 5, 3
Holbergsgade 5, 4 TH
Holbergsgade 5, 4 TV
Holbergsgade 5, KL
Holbergsgade 5, ST TH
Holbergsgade 5, ST TV

The references to the units contain the house number, the level of the unit (ST is ground level, 1 is first level, etc., KL refers to a cellar) and the side of the unit (TH ('til højre') means 'right', TV ('til venstre') means 'left' and MF ('mellem') means 'in the middle'). These references contain some spatial information (what floor and what side of the building). The information that is maintained per unit was described earlier.

4.5 Apartment Units in the Valuation Registration

The valuation registration maintains and provides information on the '*ejendomsnummer*' (property number), the '*ejendomsvaerdi*' (property value) and the '*grundvaerdi*' (value of the ground).

An examination of the valuation registration (at www.ois.dk) revealed that only in the case of Holbergsgade 2, the individual properties are distinguished. This is no surprise, since only in case of self-owned apartment units, taxes are collected for the individual units. In the case of Holbergsgade 3 and 5, taxes are collected for the whole property.

4.6 Summary of Apartment Units in Real Property Registrations in Denmark

Information on apartment units can be obtained from the several registrations on real property in Denmark. What information is maintained in the different real property registrations for the three types of apartment units is summarised in the next table:

	Self-owned apartment units (<i>Ejerlejlighedsejendom</i>)	Owned by private housing association (<i>Privat Andelsboligforening</i>)	Apartment complex owned by one person (<i>Udlejningsejendom</i>)
Cadastral parcel registration	Only ground parcel	Only ground parcel	Only ground parcel
Cadastral property registration	Only ground parcel(s)	Only ground parcel(s)	Only ground parcel(s)
Land registry	Individual apartment units	- Ground parcel(s) - Information on association	Ground parcel(s)
Building and dwelling registration	Individual apartment units	Individual apartment units	Individual apartment units
Valuation registration	Individual apartment units	Whole apartment complex	Whole apartment complex

In all cases the cadastral register does not provide any information on the existence of apartment units. The cadastral register only maintains the ground parcel(s), while no information is maintained on the existence of more properties on the parcel(s). Consequently, the real property registered in the cadastral property registration is one real property consisting of the ground parcel(s).

The Land Book needs to be consulted for further information. The Land Book gives additional information only in the case of self-owned apartment units and a little bit information in the case of private housing associations. The fact that there is a private housing association can be known from the land registry implying the existence of indirectly owned apartment units.

The building and dwelling registration is the only registration that contains information on the individual units in all cases, although it does not maintain information on the owner or renter of the unit.

4.7 Case Study 2: Infrastructure Objects

Tunnels and pipelines crossing properties of third parties are good examples of 3D situations. To see how tunnels and pipelines are currently registered in the cadastral system two tunnels and a water-pipeline have been selected.

4.7.1 Tårnby Torv, Kastrup (near Copenhagen)

A state-owned road (with a railway track next to it) crosses a province-owned road via a tunnel in Kastrup. The cadastral map and an ortophoto from the location are shown in figure 6. The state road is going from east to west, and the provincial road is going from north to south.

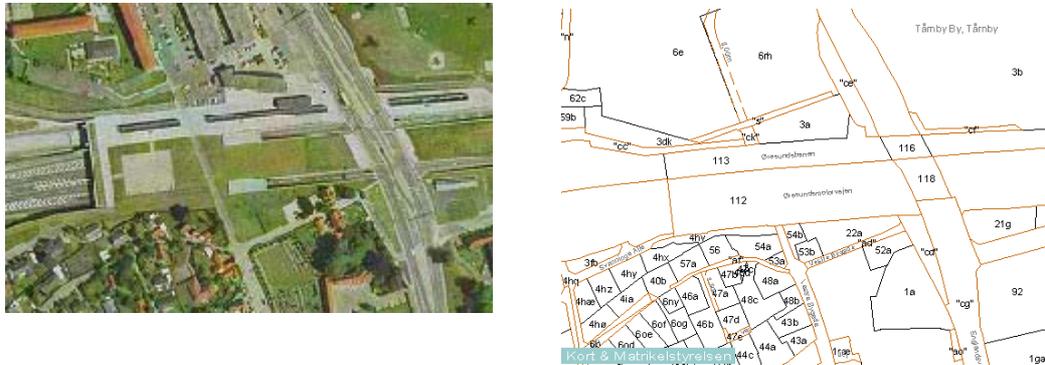


Figure 6: Ortophoto and cadastral map at the location of the Tårnby Torv tunnel.

Figure 7 shows the results of a query in the cadastral database for parcel 112 and 118. On the location of parcel 118 the provincial road crosses the state road, while in the cadastral registration the parcel is indicated as state road. The reason for this is that in the current cadastral system only one type of land use per parcel can be registered. On parcel 112, also two types of land use are located on top of each other (the tunnel and the grass on top of the tunnel). The cadastral registration only indicates the tunnel (as state road) on parcel 112.

Matrikeloplysninger:		Matrikeloplysninger:	
Tårnby By, Tårnby		Tårnby By, Tårnby	
Ejerlav	11658	Ejerlav	11658
Matr.nr.	112	Matr.nr.	118
Beregning	0	Beregning	0
Lodantal	1	Lodantal	1
Areal	13519 m²	Areal	1571 m²
Vejareal	13519 m²	Vejareal	1571 m²
Hovednotering	S	Hovednotering	S
Jordforureningsforhold efter jordforureningsloven ikke oplyst		Jordforureningsforhold efter jordforureningsloven ikke oplyst	
Øresundsvejmotorvejen		Øresundsmotorvejen	
Journalnr.	U2001/08503	Journalnr.	U2001/08503
Ændringsdato	20-nov-2001	Ændringsdato	20-nov-2001

Figure 7: Result of query in the cadastral system for parcel 112 and 118.

The cadastre also contains information on the whole property (*hele ejendom*) of which these parcels are a part and on the valuation property (*vurderingsejendom*).

The titles belonging to a property consisting of more than one parcel are registered in the land registry on one 'leading' parcel, parcel 86 in this case (this is not visible in the cadastral map).

An examination of the land registry revealed that only the state is registered as owner of this property (including parcel 112 and 118). No other rights (e.g. servitudes) are registered for these parcels that could indicate that something is located above or below these parcels (e.g. the existence of the provincial road). Although this does not reflect the real situation, it can be expected that this situation may not cause problems since both the province and the state are governmental bodies. More problems can be expected when a tunnel crosses privately owned properties as will be shown in the next case.

4.7.2 Metro tunnel, Copenhagen

Copenhagen's first metro system opened in October 2002. The metro has a driverless train. During the initial stage, trains ran from Nørreport, in the city centre, to Lergravsparken, in eastern Amager (the island to the south east of the city centre), and from Nørreport to Ørestad, the new development area on central Amager. In October 2003 a new phase of the metro system was opened connecting Nørreport to Frederiksberg to the west and Vanløse, further west. The next part of the system will be up and running in 2007 and will stretch to Copenhagen Airport to the southeast. When this step is completed, the metro will have 22 stations in total, linked by 21 km of track, of which 11 km will be in tunnels beneath the ground.

Real rights had to be established to secure the legal status of stations, emergency exits and the metro track itself. The Ørestad Development Cooperation, in which the municipality of Copenhagen, the municipality of Frederiksberg and the Ministry of Transport participate, is responsible for constructing the line. The state gave out the Ørestad site (on which a new building area has been planned) covering 310 hectares to the Ørestad Development Cooperation. The aim is to finance the metro with the money which will be collected when selling land of the Ørestad site. Consequently, the company wants to own as less land as possible. The aim of establishing real rights for the metro is in the first place to secure passengers' safety and to protect the metro against damage. Securing the legal status of the metro has got less attention in the registration process.

This policy has led to establishment of the following rights:

- when the metro-track is running above the surface by means of a dyke or running on the surface, a right of ownership has been established on parcels intersecting the metro (by means of complete expropriation) and servitudes have been established on neighbouring parcels
- when the metro and stations are below the surface or when the metro is above the surface using a bridge construction, servitudes have been established on the intersecting parcels and on neighbouring parcels
- the legal status of the surroundings of emergency exits has been established with a right of ownership
- when the metro-track intersects public roads, a technical agreement has been set up with the municipality containing restrictions in using the land.

The rights of property and the servitudes were established by expropriation. According to the Law on Expropriation, the expropriation should fulfil the following conditions:

- the object for expropriation should be beneficial for the society as a whole

- the owners which are expropriated should be financially compensated for the loss they are suffering

For the project special tunnel servitudes, station servitudes and emergency-exits servitudes were developed. These servitudes lay down limitations to the owners of parcels above the constructions and to owners of neighbouring parcels. To meet the conditions defined by the Law on Expropriation costs for compensation because of the servitudes needed to be as low as possible. Therefore as few limitations as possible have been defined which are necessary to protect the constructions against damage ("need to have and not nice to have").

The metro is crossing about 1000 private properties. Tunnel servitudes were established on 150 intersecting parcels.

The tunnel servitude forbids the owners of crossing and neighbouring parcels, as indicated in a map (see figure 8), to use the space below a certain distance from the surface depending on how deep the tunnel is below this parcel. Neither is it allowed to put much more pressure on the surface above the tunnel, e.g. to have a building with more than 6 stores above the tunnel. The compensation for the decrease in value due to the tunnel servitude (eternally) is in the order of 1000 Danish Kroner (DKK) (€140) per property. Heavier restrictions are defined for parcels located above stations and emergency exits.

The type of restrictions depends on the distance to the constructions. In this context, four different zones of influence have been distinguished: 1) surcharge loads (pressure), 2) excavations, 3) pipelines and stores of flammable and combustible liquids and 4) equipotential bounding. These zones are indicated on maps (see figure 8 for an indication of different servitudes zones).



Figure 8: Drawing which indicates the zones on which a station servitude has been established.

The tunnel is not considered as real property since no right of ownership has been established for the tunnel. Therefore information on the tunnel (on intersecting parcels or on the whole property of the tunnel) cannot at all be found in the cadastral system (compare to Tårnby Torv tunnel).

Information on the legal status of the tunnel can be obtained by examining the titles maintained in the land registry. However, the tunnel is only mentioned in titles belonging to parcels that are privately owned. The technical agreements are not registered in the land

registry. Consequently, no information on parcels owned by the municipality can be found in the land registry.

As was mentioned before, the legal status of the metro is not secured by the servitudes. A relevant question is what will happen when the metro is sold. The new owner will not take over the ownership, because the company does not legally own the metro. All the rights established for the metro need to be transferred to the new owner. This might not be a problem when the new owner is a governmental body, but it can be expected that a privately owned company will have more problems not having the right of ownership secured in the cadastral system and the land registry.

4.7.3 Water-pipeline

In Køge, a city southwest of Copenhagen, a water-pipeline is crossing several private parcels. The legal status of this infrastructure object has been registered by means of servitudes established on the intersecting parcels.

Although current practice does not allow subdivision of parcels when parcel boundaries are not visible in the field, this used to be possible.

In order to avoid that a part of the parcels, which are not crossing with the pipeline, are encumbered with servitudes, new parcel boundaries were generated. Although this solution makes it possible to indicate the location of water-pipelines on the cadastral map, the subdivision process leads to very small parcels (figure 9). A disadvantage is that the pattern of parcels is dictated by infrastructure below the surface.

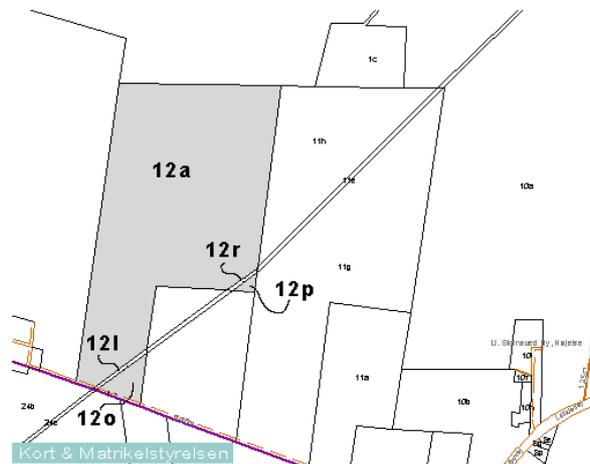


Figure 9: Servitude established for a pipeline. Parcel 11e, 11e and 11g is one real property, as well as 12a, 12l, 12o, 12p and 12r.

The land use of parcels is maintained in the cadastral registration system. In this case the small parcels are indicated as '*vandledningsareal*', which means water-pipeline area.

However, since only one type of land use per parcel can be maintained, mentioning the other land uses (e.g. rural land) on the small parcels is not possible.

4.8 Summary of Infrastructure Objects in Real Property Registrations in Denmark

From the above it can be concluded that an infrastructure object is registered as real property in the cadastral system, only when the legal status of the object has been established with a right of ownership.

The alternative for a right of ownership to establish the legal status of a infrastructure object, when the owner of the intersecting parcel is not the same as the holder of the infrastructure object, is a servitude. What information is available in the different real property registers in case of infrastructure objects using a right of ownership or a right of servitude is summarised in the next table.

	Using right of ownership	Using servitudes
Cadastral parcel registration	Land use is known on ground parcel (other land use is not known)	No information
Cadastral property registration	<i>Hele ejendom</i> (whole property) is registered	No information
Land registry	Information on 3D situation available only when limited rights have been established for other land use	Information only on intersecting parcels with different owner than holder of infrastructure object
Building and dwelling registration	No information	No information
Valuation registration	No information	No information

5. CONCLUSION

The land market is served by a transparent and easy-to-access registration of real properties. Current cadastral systems, which traditionally defined real property as one parcel or a set of land parcels, meet complications when maintaining and providing information on the legal status of real property in 3D situations (more than one user per parcel).

The actual needs for a 3D cadastre and 3D property registration consist of general, fundamental requirements for a 3D cadastre, but also of country specific requirements.

General requirements are addressing the issue how to maintain and provide 3D information on real properties in cadastral systems that are traditionally based on a 2D cadastral map. This leads to the same basic conceptual (3D) cadastral data models.

Country specific requirements for 3D property registration of one country, i.e. Denmark, were revealed by the study described in this paper.

From a juridical point of view, we can conclude that the legal instruments in Denmark are sufficient to establish rights needed in 3D. Condominium rights can be used to establish rights in 3D in building complexes, while servitudes can be used and imposed in case of physical objects crossing parcel boundaries. 3D geometric aspects are not addressed in these rights.

However, the main objective of (Danish) cadastral registration is to support an efficient land market, as well as to provide a basis for appropriate land management. Consequently, the cadastre and the land registry should not only secure rights on real properties but also provide insight in the legal status of real properties. Concerning 3D, the current Danish cadastre does not provide insight into the third dimension for a number of reasons.

Since information on real estate is maintained in four different registrations, information on real properties in general is not straightforward accessible. Different registrations need to be queried to get insight in the factual situation.

The Danish cadastre does not contain any information on 3D situations. The cadastre does not maintain:

- information on different types of land use on one parcel (only the main use of a parcel is maintained)
- information on rights, restrictions and subjects of rights and restrictions (with the exception of public restrictions)

Information on condominium rights is not maintained in the cadastral system. The land registry only provides additional information in case of self-owned apartments. A visual overview of every floor of an apartment complex is available in the land registry, although the overviews are only analogously maintained in 2D and not geo-referenced. These drawings are maintained in titles and can therefore not be queried.

Information on self-owned apartment units as well as information on other types of apartment units (indirect ownership and rented apartment units) can be found in the building and dwelling registration, although this information does not include the person who uses (owns or rents) the apartment unit.

The use of servitudes in case of infrastructure objects meets some complications:

- the physical object is subdivided into as many pieces as there are surface parcels
- servitudes need to be established and spatially determined for all intersecting parcels
- the object is not considered as real property and consequently transferring the object meets complications: at this moment transferring the object means changing titles of all intersecting parcels
- location of physical objects is not known in the cadastral system
- the object itself cannot be queried

When a 3D approach of registration of real property is considered in Denmark to meet the complications outlined above, issues on four levels have to be taken into account, which are interrelated to each other.

At the *juridical* level, the question should be addressed how real property on top of each other can be established. At this moment condominium rights is the only juridical instrument to establish a horizontal division of real property.

The registration of rights is only a matter of the land registry. On the other hand, the registration of real property is only a matter of the cadastre. Therefore, a first step is to bring the real right registration of the land registry and the cadastral real property registration together which will make it easier to find out which rights are established on a parcel and which persons have a right on a parcel.

Reorganising registration of real property requires decisions at the *political* level.

Extending the cadastral map into 3D to be able to incorporate 3D information on rights and physical objects requires further study and decisions at the *cadastral* level, i.e. how to organise and implement a system that supports 3D information. 3D information on physical objects could be obtained from companies outside the cadastre.

Finally, issues at the *technical level* covering different aspects (DBMS to maintain 3D data, 3D CAD to model 3D data, 3D GIS to analyse 3D data, Virtual Reality to visualise 3D data) need to be studied to be able to effectuate a 3D cadastre (or a 3D real property registration) in Denmark. A Danish Geo-Information Infrastructure will support to set up an integrated data model of property registration at the conceptual level, which makes it possible for the different registrations to communicate and that representations of the same real property can be interrelated with each other.

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BIOGRAPHICAL NOTES

Jantien Stoter (MSc) graduated in Physical Geography in 1994. She started her career as a GIS specialist/consultant with the District Water Board of Amsterdam and Surroundings (1995-1997). From 1997 till 1999 she worked as a GIS specialist/consultant at the Engineering Office Holland Rail Consult. Since 1999 she is an assistant professor in GIS applications, section GIS technology, Department of Geodesy, Delft University of Technology. Also doing a PhD on 3D cadastral registrations. In this research the needs, possibilities, and constraints for 3D cadastral registrations are studied. The emphasis of the research is the implementation of the facility to incorporate 3D real estate objects (geo-objects) in the current 2D geo-DBMS of the Netherlands' Kadaster.

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