
3D aspects of property transactions: Comparison of registration of 3D properties in the Netherlands and Denmark

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At the Department of Development and Planning
Center of 3D geo-information
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Jantien Stoter

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Summary:

The real property market is served by cadastral systems, which maintain and provide information on real property. The main objective of my short-term scientific mission at Aalborg University was to make an inventory of the limitations of current cadastral registrations, in which a 2D parcel is the basic entity, in case of 3D situations.

In countries with an increased pressure on land, there is a tendency of building properties on top of each other and to build above and under the ground. Since cadastres are traditionally built for a 2D dimensional registration of real properties (registration of rights and limited rights on 2D parcels), the registration of the legal status of real estate properties on top of each other meets complications. This also has consequences for transferring 3D real property. To improve the transparency of real property markets, the third dimension of cadastral systems needs to be considered.

In November, 2003 I spent four weeks at Aalborg University, Denmark. I worked at the Department of Development and Planning. During my visit I studied the transparency of the real property registrations in Denmark in case of 3D situations: what kind of information is available and how is the information accessible. In collaboration with the Department of Development and Planning and the Danish National Survey and Cadastre (KMS), I investigated two types of real property registration from practice: apartment units and infrastructure objects. I compared the results of this study with the results of a similar study which was carried out in the Netherlands. The aim of the comparative study was:

- to get on overall picture on how real property is registered in Denmark
- to obtain insight in how information on 3D property (property on top of each other and infrastructure objects above and below the surface crossing parcel boundaries) can be obtained from the Danish registrations on real property
- to identify the differences and similarities between the cadastral registration system in Denmark and the Netherlands concerning 3D situations
- to list the complications of registering real property in 3D situations in Denmark

In this report I describe the results of my study.

The follow-up step will be making recommendations for facilitating transferring real property in general any 3D configuration. The provided description of various effects of property registration may serve as inspiration for other countries, also by addressing the issue of transparency of real property transactions in case of 3D real property.

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TU Delft, Research Institute for Housing, Urban and Mobility Studies

Jaffalaan 9, 2600 GA Delft, the Netherlands

Tel: +31 (0)15 278 4548; Fax 015-278 2745; E-mail: gist@tudelft.nl

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1 Introduction

Traditionally, cadastral registration systems are parcel based systems. A whole country is divided into parcels, while rights and limited rights on property are established and registered on 2D land parcels. Although use of a property has always been related to 3D space -i.e. use of land always has been in 3D- the state of the art of techniques and the existing needs for cadastral registration in the past, has led to the development of a two-dimensional cadastral system (2D cadastral map), which has served its purposes for decades.

Although property has been located on top of each other since ages, only since 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 (private) 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 [6]. 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, to see if other countries than The Netherlands meet the same problems and to see if cadastral systems in different countries serve the cadastral tasks similarly, a comparison case study was carried out on 3D situations and cadastral registration in Denmark. This report describes the results of this case study which was carried during a working visit in Aalborg, November 2003. The results of this case study resulted in an overview of the transparency of real property registrations in Denmark. The literature used in this report is [1] [2] [3] [4] [5].

This report starts with an introduction in land administration in Denmark in general (section 2). Section 3 describes the types of property registration with a possible 3D component. In section 4, two case studies are presented to illustrate how 3D property currently is registered in order to show limitations of current registration practise. The differences between cadastral registration in Denmark and The Netherlands are discussed in section 5. Finally, section 6 concludes on the need for 3D registration of property in Denmark.

2 Introduction in registrations of real property in Denmark

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

- cadastral register
- land register (Land Book)

-
- building and dwelling register
 - valuation register

How these registrations interact will be made clear 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 Environment. The Danish cadastre originally started as a system supporting the collection of land taxes. The main objective of Danish cadastre nowadays is to support an efficient land market, as well as providing a basis for appropriate land management. The cadastre still provides information on entities for taxation (*vurderingsejendom*). This information is selected from the valuation register of the municipalities (see further).

The cadastre consists of four elements:

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

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 which a parcel consist of, share in common parcel, registration as protected forest, registration as coastal and 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 noted together and have the same owner. A parcel may consist of several land units. Apartment units are not known in the cadastral system.

Cadastral map The cadastral map is a legal overview map which 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). All land parcels and roads in the cadastral map have a parcel identifier. Public roads have an identifier consisting only of letters. Private roads can also be recognized: the parcel identifier of private roads contains three digits without any letters. Apart from parcels, the cadastral map also contains other information such as other boundaries (centre line in stream wider than 3 meter 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).

2.2 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 as titles, name of landowners, mortgages and easements (servitudes). Since 2000, the land register is fully digitised although titles are still only analogously available. The state guarantees the content 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.

2.3 Building and dwelling register

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) which 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 for every building containing detailed information on construction and renovations. The BDR summarises information from these documents. The key identifier of the buildings in the BDR registration is a combination of the `kom-mune_nr` (commune number), the `ejd_nr` (property number) and the `byg_nr` (building number).

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 generated address coordinates. A standard procedure has been developed by combining BDR, cadastral registration and buildings maintained in the Top10DK [5] 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.

2.4 Valuation register

Apart from the BDR, the municipality also maintains a sales and valuation register, to record valuation on single property 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 inserted in 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.

2.5 Cross reference register

Originally the building and dwelling registration, the valuation registration and the cadastral registration were created as separate registrations. To be able to link these separate registrations, in 1978 the cross reference register was created. 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-content. 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 property-related registers.

2.6 Data model of real property registration in Denmark

From the above can be concluded that in Denmark three organisations maintain a registrations on real properties:

- municipality: valuation registration and building and dwelling registration
- cadastre: parcel registration and real property registration
- land registry: registration 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.

The entity 'property' is maintained in all four registrations. 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) which is defined in the cadastral register as one real property. However, the entity is maintained in every system separately (different instances), while no inter-relationships are maintained between the different databases.

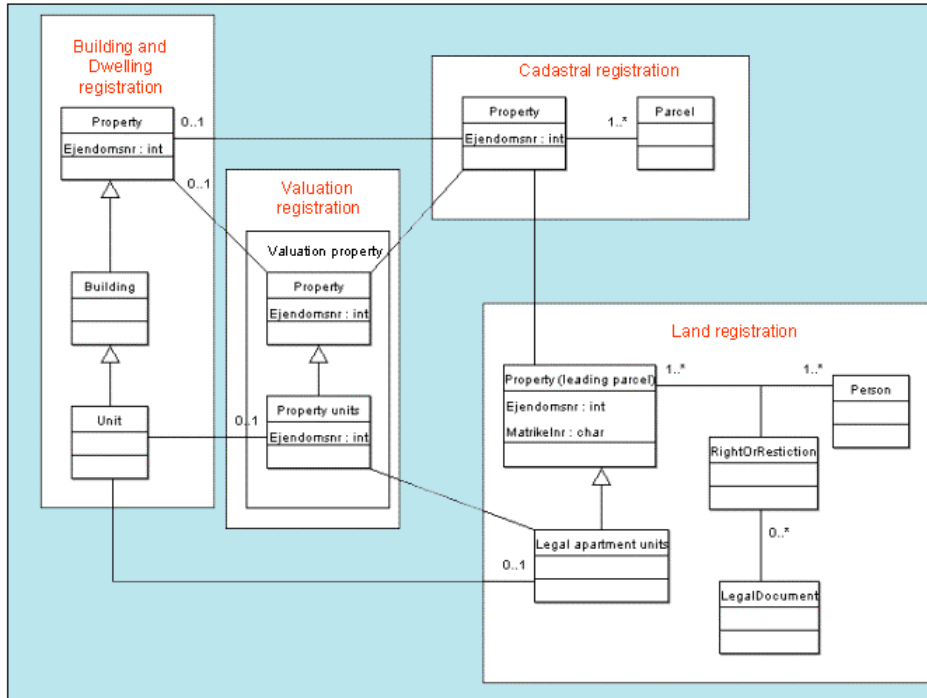


Figure 1: *Data model of registration practise of real property in Denmark.*

Property in the building and dwelling register also refers to the 'property' entities in the other three registers, however this property is only registered when it is related to a building. The valuation register distinguishes further in properties at unit level ('property units') which 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 slightly differ in the different registrations, the organisation of information on real property is complex.

2.7 Subdivision of parcels

When land is subdivided, an owner must apply a licensed surveyor for the necessary legal surveys and for the preparation of documents needed for submission of an application to the National Survey and Cadastre for updating the cadastre (Denmark does not have a notary-system). The application must contain a copy of the cadastral map showing the alteration of boundaries, measurement sheets showing the new boundaries, documentation for legal rights, as well as documentation showing the approval of the future land use according to planning regulations and land use laws. The National Survey and Cadastre updates the cadastral system after approval of all documents. The cadastral update is also sent to the municipality for updating the valuation registration and the local land registry office for updating the Land Book. Titles and mortgage can then be entered into

the Land Book using the updated cadastral identification. The title cannot be registered in the Land Book unless it is proved that the sales declaration has passed the municipal authority. Part parcels as known in the Dutch system, are therefore not possible.

In order to avoid that a whole parcel is encumbered with a limited right, while the right is only valid for a part of a parcel, e.g. a servitude is established for a pipeline, new parcel boundaries can be created. However, since recently the Danish cadastre decided that boundaries which are not visible in the field should not be maintained on a cadastral map (all boundaries are demarcated in the field with iron pins). Therefore, new parcel boundaries to indicate a servitude area on the cadastral map can no longer be created. Instead of this, an analogue drawing can be added in the title establishing the servitude. Consequently the spatial extent of cross-boundary objects is no longer visible in cadastral registration but need to be obtained by querying the land registry via analogue documents.

2.8 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)
- Central Population Register 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 cadastral 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 other international laws on property: right of property is established on parcels and is not limited in the vertical dimension. A (juridical or factual) horizontal division in property can be established by *rådighedsindskrenkninger* (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 also has a juridical construction called *bygning på lejet grund*, which means buildings on leased ground which is more or less similar to the right of superficies.

The cadastral registration of the spatial extent of restrictions according to Private Law is the same as in the Netherlands. The spatial limitations of these rights are not registered directly in the cadastre. However, 2D and 3D spatial information on the limited rights (what is the space where a right applies for) can be added in the title establishing the limited right which is registered in the land registry. Information in case of *bygning på lejet grund* is also available in the building and dwelling registration.

Apartment units in Denmark Denmark distinguishes three types of apartment units:

- The whole apartment complex is owned by one person and individually 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*). Indirect ownership is in legal perspective similar to Dutch condominium right, although in the Netherlands it is possible to mortgage an apartment unit which is indirectly owned.
- 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 case studies (see section 4).

3.2 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 or available 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 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. In contrast to the Dutch 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 of 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 practise 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 which are specific for Denmark. The registration of infrastructure objects were selected since these objects especially require a 3D approach of 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):

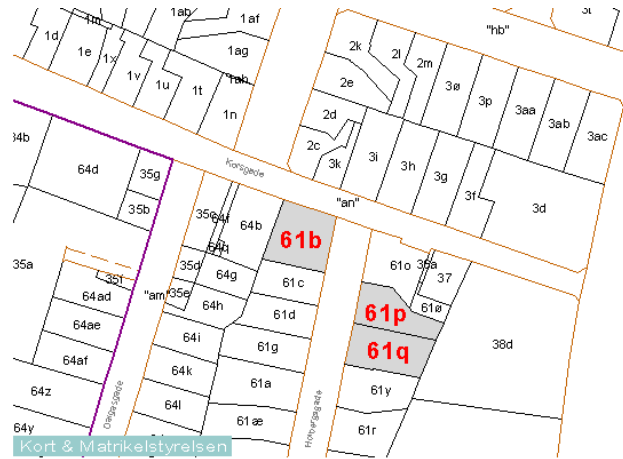
- Holbergsgade 2: self-owned apartment units (direct ownership)
- Holbergsgade 3: one private person is the owner of the whole apartment complex

- Holbergsgade 5: a private housing association owns the whole apartment complex and the members of the association have right of use of individual apartments (indirect ownership)



Figure 2: *Overview of three apartments of case study.*

Apartment units and cadastral registration The cadastral registration 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.



Matrikeloplysninger:**Aalborg Bygrunde**

Ejerlav 2005051
 Matr.nr. 61b
 Beregning
 Lodantal 1
 Areal 394 m²
 Vejareal
 Jordforureningsforhold efter
 jordforureningsloven ikke oplyst
 Journalnr. M1898/03297
 Ændringsdato 01-jan-1900

(a) Parcel 61b

Matrikeloplysninger:**Aalborg Bygrunde**

Ejerlav 2005051
 Matr.nr. 61p
 Beregning
 Lodantal 1
 Areal 309 m²
 Vejareal
 Jordforureningsforhold efter
 jordforureningsloven ikke oplyst
 Journalnr. M1910/01404
 Ændringsdato 01-jan-1900

(b) Parcel 61p

Matrikeloplysninger:**Aalborg Bygrunde**

Ejerlav 2005051
 Matr.nr. 61q
 Beregning
 Lodantal 1
 Areal 371 m²
 Vejareal
 Jordforureningsforhold efter
 jordforureningsloven ikke oplyst
 Journalnr. M1924/04065
 Ændringsdato 20-feb-1902

(c) Parcel 61q

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

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).

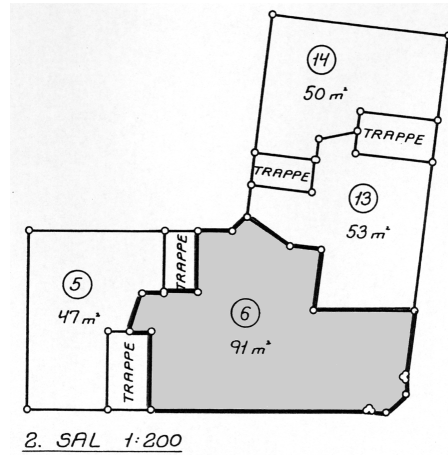


Figure 5: Overview of apartment number 6 (third floor, on the right), Holbergsgade 2.

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 case of Holbergsgade 3, the concerning titles are established on the whole ground parcel. However, the existence of apartments is not explicitly, neither implicitly mentioned in the titles.

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 Cadastal 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, the properties known in the cadastral registration are maintained which means in all three cases one property for the whole apartment complex. At property 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 (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:

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

Holbergsgade 2 contains 19 properties, since the house is a house at a corner 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 reference 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 spatial information (what floor and what side of the building). The information that is maintained per unit was described earlier.

Apartment units in the valuation registration The valuation registration maintains and provides information on the '*ejendomsnummer*' (property number), the '*ejendomsværdi*' (property value) and the '*grundværdi*' (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.

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	Apartment complex owned by private housing association	Apartment complex owned by one person
Cadastral Registration	Only ground parcel(s)	Only ground parcel(s)	Only ground parcel(s)
Land Registry	Individual apartment units	Ground parcel(s) and 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 registration 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 not maintains information on the owner or renter of the unit.

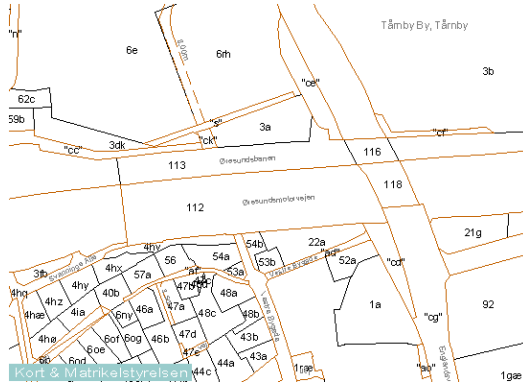
4.2 Case study 2: Infrastructure objects

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.

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 7 shows the results of a query in the cadastral database for parcel 112 and 118. On the location of parcel 118 the state road is crossed by the provincial road, while in the cadastral registration the parcel is indicated as state road (see figure. 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.

The cadastre also contains information on the whole property (*hele ejendom*) of which these parcels are a part and on the valuation property (*vurderingsejendom*). However, the collection of parcels which form the whole real property of the state road real property



(a) Cadastral map



(b) Ortophoto

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

as registered by the cadastre is different than the valuation property as registered by the municipality: both systems give a different collection of parcels when querying the concerning property.

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 going on, 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.

Matrikeloplysninger:

Tårnby By, Tårnby

Ejerlav	11658
Matr.nr.	112
Beregning	0
Lodantal	1
Areal	13519 m ²
Vejareal	13519 m ²
Hovednotering	S
Jordforureningsforhold efter jordforureningsloven ikke oplyst	
Øresundsmotorvejen	
Journalnr.	U2001/08503
Ændringsdato	20-nov-2001

(a) Parcel 112

Matrikeloplysninger:

Tårnby By, Tårnby

Ejerlav	11658
Matr.nr.	118
Beregning	0
Lodantal	1
Areal	1571 m ²
Vejareal	1571 m ²
Hovednotering	S
Jordforureningsforhold efter jordforureningsloven ikke oplyst	
Øresundsmotorvejen	
Journalnr.	U2001/08503
Ændringsdato	20-nov-2001

(b) Parcel 118

Figure 7: *Result of query in the cadastral system.*

Metro tunnel, Copenhagen Copenhagen's first Metro system opened in October 2002. The metro has a driverless train. During the initial stage, trains run 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. At the moment a new phase of the metro system is being built connecting Nørreport to Frederiksberg to the west and Vanløse, further west. The final part of the system will be up and running in 2007 and will stretch to Copenhagen Airport to the south east. When 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 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 establishing 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 property 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 property
- 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, stations-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.

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

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 a servitude, new parcel boundaries were generated. Although this solution makes it possible to indicate the location of water-pipeline on the cadastral map, the subdivision process leads to very small parcels (figure 9 (a)). Also real property formerly containing only one parcel is divided into a collection of parcels as can be seen from the cadastral register (see figure 9 (b)).



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

Matr.nr.	B	Areal m ²	Vejareal m ²	Lodantal	F	Journalnr.	Ændringsdato
LI. Skensved By, Højelse (50655)							
12a		158211	730	1		U1999/06023	01-sep-1999
Jordforureningsforhold efter jordforureningsloven ikke oplyst							
12l		905	60	1		U1999/06023	01-sep-1999
Jordforureningsforhold efter jordforureningsloven ikke oplyst							
12o		4801	593	1		U2003/06666	09-sep-2003
Jordforureningsforhold efter jordforureningsloven ikke oplyst							
12p		905	0	1		U1999/06023	01-sep-1999
Jordforureningsforhold efter jordforureningsloven ikke oplyst							
12r		495	0	1		U1999/06023	01-sep-1999
Jordforureningsforhold efter jordforureningsloven ikke oplyst							

I alt: **5** matr.nr(e) med et samlet areal på: **165317** m²

(b) Information on the whole property which intersects with the water-pipeline

Figure 9: Information maintained in the cadastral system on location of pipeline.

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.

Summary of cross boundary objects in real property registrations in Denmark

From the above it can be concluded that a cross boundary 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 property. The whole property of a road or tunnel is also only available in the cadastral system when a right of property was used. The alternative for a right of property to establish the legal status of a cross boundary object, when the owner of the intersecting parcel is not the same as the holder of the cross boundary object, is a servitude. What information is available in the different real property registrations in case of cross boundary objects using a right of property or a right of servitude is summarised in the next table.

	Using right of property	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 cross boundary object
Building and Dwelling Registration	No information	No information
Valuation Registration	No information	No information

5 Comparison between the Netherlands and Denmark

There are some basic differences between cadastral registration in the Netherlands and Denmark, which influence the actual need for 3D registration of real property:

- In the Netherlands expropriation can be carried out only for a whole parcel column, while in Denmark it is possible to expropriate a parcel only partially by, for example, establishing a servitude (which serves a public authority) in which limitations are described. This makes the need to establish 3D properties on top of each other different than in the Netherlands. In the Netherlands you always have to expropriate a whole parcel column, if the public authority and the former owner cannot agree on other methods. Expropriation of a whole parcel column is a heavy method when only a limited amount of space is needed (e.g. for a tunnel) and not the whole parcel column. In the Netherlands, expropriation or the process to come to an agreement is therefore much more expensive. When property can be established on top of each other, total expropriation will no longer be necessary.
- The organisation of registration of real property in the Netherlands makes information on 3D (but also on 2D) situations in current registration more accessible. In the Netherlands, all registrations on real property are the responsibility of one

organisation, while in Denmark you have to query several registrations to find out the legal and factual status of property, although more information on real property is maintained in Denmark.

- The Dutch cadastral system provides information on who has a right on a certain parcel, while the Danish cadastral system does not maintain information on rights and subjects of rights on parcels. This means that from the Dutch cadastral system you already can see that something is going on in the third dimension (more than one right is established on a parcel), while the Danish cadastral system does not warn the querier at all.
- The fact that a ground parcel contains different apartment units is not known in the Danish cadastral system, while the Dutch cadastral system maintains (administrative) information on individual apartment units.
- the Netherlands only uses indirect ownership rights for condominium rights. The individual apartment units are recognised as single real properties which can be mortgaged. The Danish system distinguishes in direct and indirect ownership of apartment units. Only directly owned apartment units are recognised as single real property (only in the land registry) which can be mortgaged.
- The Danish cadastral map contains more information than the Dutch cadastral map which contains only parcel boundaries, outlines of buildings for reference purposes and outlines of underground constructions. In the Danish cadastral map one can see that public restrictions have been established on just a part of a parcel. However, also the Danish cadastral map is a 2D map, which means that it does not contain information on constructions and phenomena on top or below the surface.
- The Netherlands cadastre defines a real property as a parcel, while in the Danish cadastral system real property can be one parcel but also a collection of parcels. In the Netherlands physical objects such as roads are divided into smaller pieces to register the legal status, while afterwards you cannot find out that these parcels refer to the same road. This is possible in the Danish cadastral system, since a collection of parcels can be defined as one property.
- Since June 2003, cables and pipelines in the underground (with different legal status) are considered real property in the Netherlands since they are considered as permanently fixed to the surface (immovable goods), which means that they must be registered in the cadastral system. In Denmark cables and pipelines are not considered real property.

6 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.

The actual needs for a 3D cadastre and 3D property registration consist of general, fundamental needs for a 3D cadastre, but also of country specific needs. General needs are addressing the issue how to maintain and provide 3D information on real properties in cadastral systems which are traditionally based on a 2D cadastral map. This leads

to the same basic conceptual (3D) cadastral data models. Country specific needs for 3D property registration of one country, i.e. Denmark, were revealed by the study described in this report.

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 providing 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 due to 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 and subjects of rights on parcels
- information on 2D or 3D spatial extent of rights, with the exception of public restrictions (protected forest, dune protection zone, coast protection zone, polluted land parcel)

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
- transferring the object means changing titles of all intersecting parcels
- location of physical object 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 sketched 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 side, 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 what 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 which 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 that the different registrations can communicate and that representations of the same real property can be interrelated with each other.

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