Cadastral Registration of Cross-Boundary Infrastructure Objects

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Key words: 3D cadastre, cross-boundary objects, cables and pipelines, tunnels, cadastral data model, subsurface cadastre

SUMMARY

In this paper the complications of current cadastral registration is outlined in case of cross-boundary infrastructure objects. Traditionally, cadastral registration concentrates on parcels defined by their surface boundaries. Consequently the legal status of the subsurface and rights regarding constructions in the subsurface is established and registered by means of the surface configuration. Especially in the case of infrastructures that cross parcel boundaries this leads to problems in understanding the legal situation when querying the cadastral database. In this paper first the principles of land ownership and of cadastral registration are explained. Although we focus on the Dutch situation, we address general issues as well. In the second part we describe the way the legal status of cross-boundary infrastructure is currently secured in the cadastral registration, which meets complications. In the third part we propose and evaluate a solution to improve current cadastral registration in case of cross-boundary infrastructure without changing the basic entity of cadastral registration which is the 2D parcel. We end with conclusions in which we argue that cadastral registration can considerably benefit when the land oriented approach as only approach for cadastral registration would be abandoned.

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1. INTRODUCTION

Underground infrastructure like cables, pipes and tunnels, are as a rule not located within one parcel. The existence of this cross-boundary infrastructure, raise the question about the property rights involved and how to register these rights.

Registration of (subsurface) infrastructure can fulfil several aims, like risk management (e.g. the registration of pipes for transport of hazardous goods), to facilitate the management of the subsurface, or to make transfer of infrastructure possible and to use it as a security for loans. In this paper we limit us to the typical and traditional cadastral aspect of registration: the registration of real rights and restrictions.

The starting point of our research is Dutch law and the Dutch land and cadastral registration. However the suggestion for a system for registration of cross-boundary infrastructure is not limited to Dutch cadastral registration since it addresses general issues.

This paper consists out of three parts. In the first part (section 2) we discuss the main principles of (Dutch) law on land ownership and the main characteristics of (Dutch) cadastral registration. Section 2 concludes on questions and complications around the cross-boundary infrastructure that rise because of those juridical and cadastral principles. Section 3 deals with the actual cadastral registration of real rights on parcels because of cross-boundary infrastructure and with the cadastral registration of cross-boundary infrastructure objects themselves. Section 3 ends with an overview of complications of current cadastral registration in case of cross-boundary infrastructure. In section 4 we propose a solution for the raised questions and complications in order to better reflect the real situation in case of cross-boundary infrastructure objects. We end with conclusions.

2. OWNERSHIP OF LAND AND SUBSURFACE INFRASTRUCTURE

2.1 Main Principles

The main principles of land ownership in the Netherlands (and also in most countries with either European continental civil law or Anglo-American common law systems) can be described by two Latin legal maxims: "*superficies solo cedit*" (whatever is attached to the land is part of it) and "*cuius est solum, est usque ad sidera, usque ad inferos*" (the ownership of land encloses the right up to the stars and into the underworld). (Ploeger 1997)

The first principle, also known as the rule of (vertical) accession, originates from classical Roman Law (see Gaius, Institutes II, 73-74). Buildings and other constructions that are permanently fixed to the land are considered part of that land, and therefore owned by the owner of the land. See Article 20 of Book 5 of the Dutch Civil Code (Civil Code, 1992):

To the extent the law does not otherwise provide ownership of land comprises:

a. the surface;
b. the layers of soil under the surface;
(…)
e. buildings and works forming a permanent part of the land, either directly or through incorporation with other buildings or works, to the extent that they are not part of an immoveable thing of another person;
(…) ‘

So fixtures like houses, stone sheds, but also – as may be assumed after the important judgment of the Dutch Supreme Court of 6 June 2003 we will discuss below – cables are part of the property by vertical accession. That is unless the construction is a part of another property. This means that parts of a construction encroaching another parcel are part of the main part by horizontal accession (see figure 1). Therefore the owner of a construction is also the owner of the components which the construction consists of.

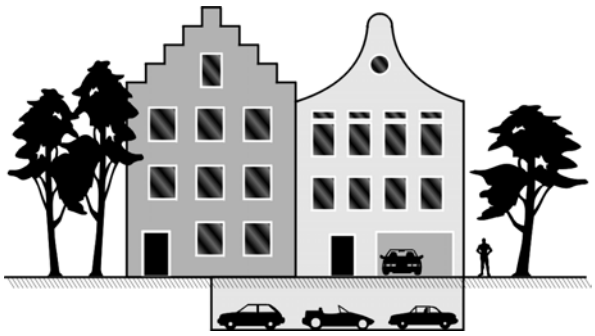

Figure 1: Illustration of 'horizontal accession to real estate'. The part of the grey house that is situated under the white house (cellar) belongs to the owner of the parcel under the grey house since this part is a component of the grey house.

The second maxim (that is not of origin of Roman classical law, but has been developed by medieval legal scientists) makes clear that ownership of land contains a 3D component. Actually, the right of ownership of land (as all other interests in land) always relates to a certain space, otherwise the use of the parcel would be impossible. See Article 21 of Book 5 of the Dutch Civil Code.

– The right of the owner of land to use it includes the right to use what is above and below the surface.
– Other persons may use what is above and below the surface if this takes place so high above or so deep below the surface that the owner has no interest in objecting thereto. (…)’

This quotation from the Civil Code indicates the ambiguity of the way ownership is defined in the vertical dimension: the vertical dimension of ownership is not explicitly bounded. But -

and contrary to what the medieval legal maxim suggests - the rights are not unlimited. The use of space above and under the surface is permitted to others, as long as this is done as high or as low, that the owner cannot reasonably object to this use or in case this use is regulated by other laws. A good example of the latter is the Mining Act 2003 (*Mijnbouwwet*) which provides the extraction of minerals from the ground of private owners by a permit holder. Moreover, even the land owner himself cannot extract minerals from his own land without such a mining permit.

This "separation of rights on surface and subsurface" is a main principle of mining law in the Netherlands, and many other countries. The reason for this separation is simple. Reserving the right to extract the minerals to the surface owner is not very efficient. In far most cases this owner is not able to start a profitable mining. Furthermore, in the case the ownership is scattered over a very large amount of subsurface parcels within a (relatively) small area it is clear that the cost of mining for each owner will always be bigger than the profits that may be expected. The result will be that mining will never take place. So from an economic point of view it is very inefficient to keep all rights on the space under the surface parcel to the land owner.

2.2 Surface and Subsurface: Two Spheres

Mining is a very specific use of the subsurface, and we will not further deal with this in this paper. But it helps to illustrate a major point when dealing with subsurface use in general. At surface level, the land has been divided in separate properties. But the use of the subsurface is not necessarily limited to the boundaries of the surface parcels, nor is it necessary or logical that the space under the surface will only be used by the owner of the land itself. More in general we can discriminate between the surface world (including some depth needed for foundations, piles and for the building of cellars), and the subsurface world, where we find a lot of infrastructure: sewer systems, networks for power, natural gas and telephone, and metro tunnels. This last world has no direct relation with the surface use, except where they physically meet (e.g. the entrance of a metro station).

2.3 The Dutch Land and Cadastral Registration

The Netherlands has a deed registration, which is organised together with the cadastral registration in one organisation: the Netherlands' Kadaster.
The Netherlands' Kadaster maintains both the land registration and cadastral registration. The first, the so called Public Registers (*Openbare registers*) is a collection of notarial deeds creating or transferring real rights to land, archived in chronological order.

The cadastral registration consists of (Lemmen et al., 1998):

- a 2D geo-DBMS for maintaining the geometry and topology of parcels (and buildings for reference purposes) called LKI (*Landmeetkundig Kartografisch Informatiesysteem*, 'Information system for Surveying and Mapping')
- an administrative DBMS for legal and other administrative data related to parcels called AKR (*Automatisering Kadastrale Registratie*, 'Automated Cadastral Registration')

The cadastral registration makes information (rights and restrictions) in deeds referring to individual parcels accessible. See for a more detailed description (Stoter and Ploeger 2003).

2.3.1 Cadastral Model

The current administrative cadastral data model in the Netherlands, like most other countries, is based on three key types: real estate object, person (subject) and right or restriction (for the UML class diagram of the data model, see figure 2) (see also (Lemmen et al., 2003)). Real estate objects are parcels and apartment rights (linked to a 'mother' parcel, not shown in figure 2). Persons are natural or non-natural persons with rights on parcels. Beside rights, there can also be a 'restriction' relationship between a real estate object and a person, since a person can be the subject of a restriction.

In case of a restriction a so-called legal notification (*Object belemmering*: object restrictions) is registered in the cadastral registration. Legal notifications are an administrative category which indicate that a restriction is imposed on the ownership of the parcel but are not rights themselves. In most cases these are Public Law restrictions, e.g. the building on the parcel is a protected monument, or the obligation to tolerate a construction needed for a public work (e.g. a high voltage power line) imposed by special acts, like the *Belemmeringenwet Privaatrecht*. Strangely enough, and from a legal point of view confusing, in the specific case of superficies for pipelines (see section 3.2) this limited real right established by parties under civil law is also registered as a legal notification and so in fact treated as a restriction.

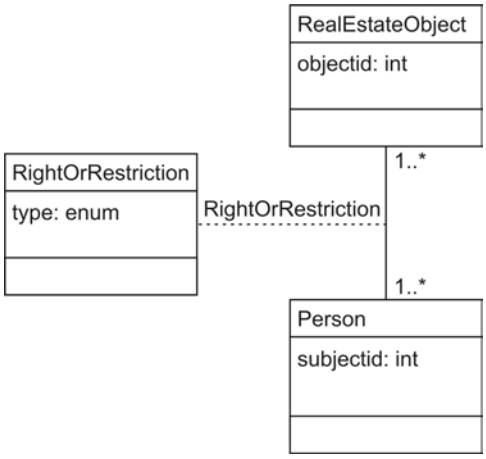

Figure 2: The current administrative cadastral data model in UML.

Real estate objects and persons have a n:m relationships via rights (and restrictions): a person can have rights related to more than one real estate object (e.g. a person owns three parcels) and one real estate object can be related to more than one person (e.g. one person is bare owner of a parcel and another person has the right of superficies on the parcel) (Oosterom, 2000).

Every person should at least be associated with one real estate object and vice versa every real estate object should be associated with at least one person (indicated with the multiplicity of '1..*').

2.4 Registration of Cross-Boundary Infrastructure Objects: the Need and the Questions

A very important type of subsurface infrastructures are utilities for water, gas, power, telecommunication. In the Netherlands (a country of ca 41,000 square kilometres) those networks have a total length of nearly two million kilometres, The value of those networks is estimated to be 100,000,000 Euro. (RAVI 1988, COB 2003, De Haan 2004).

So it is important to register property rights of infrastructure objects. Not merely to secure the value of the real estate for the persons involved by providing correct and clear information about the infrastructure, but moreover to indicate who has interests in the object, for example in case of damage. Also the information on the exact location of tunnels and pipelines is indispensable in risk management with regard to the increased attention on calamities in the past ten years. The need for a well functioning and up-to-date registration of cables and pipelines in the Netherlands has recently been emphasized by the Dutch research institute Centrum Ondergronds Bouwen (*COB* 2003). But more in general in case of such an intensive use of the subsurface, knowledge of the location of underground constructions is needed to control and plan both surface and subsurface use avoid conflicts between users. The main problem is we cannot see those constructions and – as we have seen – the subsurface use has not necessarily any connection with the divisions of the land by parcel boundaries on ground level.

It can be questioned if all those goals of registration mentioned are specific cadastral tasks. In any case we will discuss the question of the registration merely from the traditional cadastral point of view: the registration of rights.

2.5 Mapping Real World Objects

Parcels defined by their boundaries in 2D are the basis for cadastral registration (see e.g. Dutch Cadastre Act articles 1 and 48).

The Dutch cadastral geographical data set contains not only boundaries of parcels and parcel numbers, but also outlines of buildings for reference purposes, street names and house numbers.

The outlines of real world objects can also be incorporated in the cadastral geographical data set for reference purposes, such as railways and since recently also transport systems and telecom-networks.

Apart from the classification code, these lines are encoded with a visibility code. The visibility code indicates the visibility of the topographic line. A visibility code '2' means 'not visible from above'.

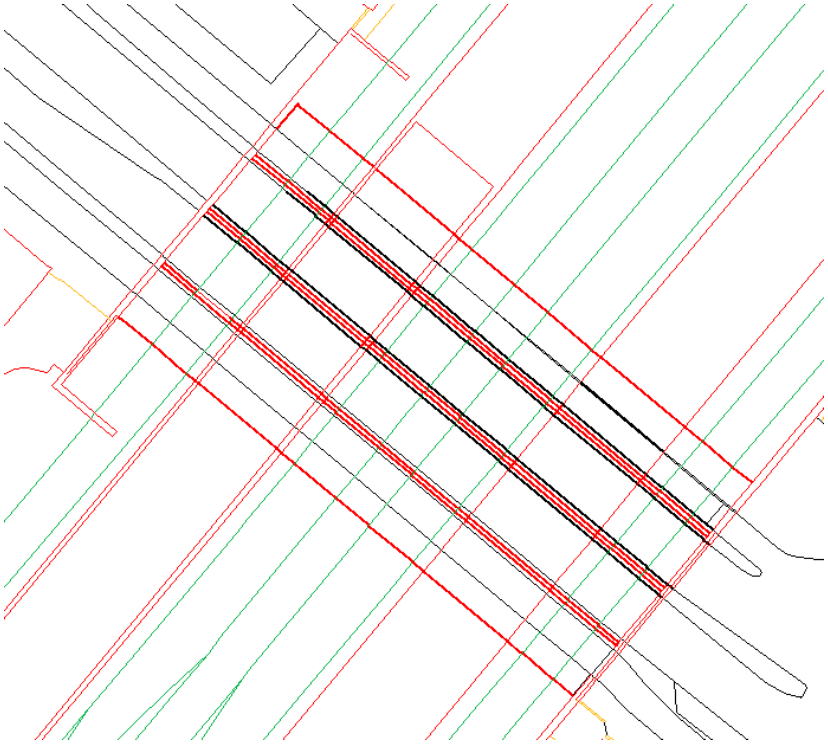

Figure 3: Lines encoded as 'invisible' in the cadastral geographical data set.

Figure 3 shows part of the LKI database (spatial part of cadastral registration).
In this figure a road (running from north-west to south-east) crosses a railway (running from south-west to north-east) by an underpass. The road at the location of the underpass is invisible from above. All lines encoded as 'invisible from above' are drawn using a thicker line style in figure 3. The mapping of underground features using a special classification and 'invisible' code is not obliged.

3. CROSS-BOUNDARY OBJECTS: RIGHTS AND REGISTRATION

In the Dutch cadastral registration, as in most countries, the legal status of constructions above, on and under the surface is not registered on the construction itself. The legal status of the construction can only be known from the rights that are registered on the surface parcel(s). in the cadastral database of September 2003 more than two million cadastral recordings were found that could indicate such a 3D situation.
In case of infrastructure objects the following registered rights and restrictions are relevant:

- ownership
- superficies
- emphyteusis (right of long lease)
- easement and restrictive covenant
- obligation to tolerate imposed by public law (like *Belemmeringenwet Privaatrecht* and Telecommunication Act)

In this section, these rights are described, together with the cadastral registration of these rights. Also the codes that are used in AKR (administrative database) are given.

3.1 Ownership of Land (Vertical and Horizontal Accession)

Above we discussed the two principles of ownership of land. According to the rule *superficies solo cedit* (vertical accession) as described in the Civil Code the right of ownership contains all constructions that are permanently fixed to the land. So, the owner of the parcel becomes the owner of the constructions in the underground, since those are permanently fixed to his parcel (*verticale natrekking*). But in case of cross-boundary infrastructure the horizontal accession can play a role. If horizontal accession gets priority to vertical accession, the owner of the parcel where the cable or pipeline is permanently fixed to the surface (comes to the surface) becomes the owner of the cable or pipeline. This parcel can be called “mother parcel” or “anchor parcel”.

So case of a tunnel it can be uphold that the ownership of a tunnel must not be divided over the intersecting parcels, but that the owner the tunnel itself is the owner of the point, and thus the parcel, where the main part of the tunnel is fixed to the surface. This is presumably where the entrances are (Ploeger 1997). The same can be maintained for utility network. However if this holds true is still a point of debate in legal literature (see De Haan 2004).

However what the answer on this legal question will be it is relevant to note that in case of horizontal accession the ownership of the construction is a result of the factual situation. Consequently, the legal status will change if the factual situation changes. Therefore it is not so surprising that in case of horizontal accession to real estate the legal status of the situation is not registered in the cadastral registration.

It should also be noted that the horizontal accession of real estate does not justify the factual situation. It is for example not allowed to build a construction encroaching another parcel without permission of the owner of the encroached parcel.

3.2 Superficies

The right of superficies (*opstalrecht*) is "a real right to own or to acquire buildings, works or vegetation in, on or above an immovable thing owned by another" (Article 101 of Book 5 Dutch Civil Code). The holder of this limited right is the owner of the construction. As a result a horizontal division in ownership takes place (Ploeger 1997).

In case of a right of superficies, AKR uses the code 'OS' for the right of superficies and the code 'EVOS' for the right of ownership to the land encumbered with the limited real right.
When a right of superficies is established for a cable or pipeline, AKR uses the special code 'OL' (*Opstalrecht ten behoeve van leiding*). From a legal point of view it is confusing that this special use of a right of superficies is in the cadastral registration not treated as a limited right but as a legal notification.

In all cases of superficies a drawing to the deed recorded in the Public Registers can be added, although no geometry is maintained in the cadastral registration to reflect the spatial extent of the ownership of the buildings nor of the right itself.

See for a more elaborated discussion of the right of superficies our paper for the Paris FIG working week 2003 (Stoter and Ploeger 2003b).

3.3 Emphyteusis (Right of Long Lease)

The right of emphyteusis gives the long leaseholder the power to hold and use the parcel of the bare owner, as if he were the legal owner. This right is indicated by the code 'EP' in AKR (*erfpachtsrecht*). Code 'EVEP' is used to indicate the ownership of the land encumbered with the right of long lease.

It is not possible to establish a right of long lease for just a part of a parcel or part of a 'parcel column': i.e. no (juridical) horizontal division in ownership takes place by a right of long lease.

However in some cases of subsurface use a right of long lease has been used. For instance for a part of the Amsterdam metro network the bare owner of the parcel (municipality of Amsterdam) is the 'user' of the metro tunnel. The leaseholder (private party) has the right to use all of the parcel above the construction, but must tolerate the tunnel under the surface of his land. By means of conditions imposed to the leaseholder (described in the deed), the use and protection of the construction can be arranged and also the dimensions to which the right of long lease applies and which causes a factual stratification of land ownership.

Again the geometry of the space where the right applies for is not maintained in the cadastral registration and can only be specified in a drawing in the belonging deed.

3.4 Easement/ Restrictive Covenant

An easement (servitude) is a (negative) charge imposed upon a parcel (the serving parcel), in favour of another parcel, the dominant parcel (*erfdienstbaarheid*), e.g. an obligation to tolerate a pipeline starting from the dominant parcel.

It is also possible to establish a right similar to a right of easement without linking it to a dominant parcel. It is a contract which imposes an obligation to the owner of land to tolerate, and that will be also binding for future owners of this land after registration of the deed (restrictive covenant). This option will be used for constructions (like pipelines) were a clear dominant parcel lacks. The restrictive covenant *Kwalitatieve verplichting*, (literally: qualitative obligation) is established by a notarial deed archived in the Public Registers, while AKR registers a 'KV' code as a restriction on the parcel (as a legal notification). The restriction is linked to the subject who causes the restriction. Although no geometry is maintained in the cadastral registration to reflect the spatial extent of the ownership of the buildings nor of the right itself)

Unlike the restrictive covenants, easements are not registered in AKR nor are they spatially be defined in the cadastral geographical data set, although a drawing can be added to the deed specifying the spatial extent of the easement. They can only be known from the deeds in the deed registration.

3.5 Obligation to Tolerate Objects in the Subsurface by Public Law

Many restrictions can be imposed by Public Law on the owners of land. Some of those regulations can impose the landowner to tolerate constructions on or in his property.

3.5.1 Restrictions for Public Good in General

According to a special law (*Belemmeringenwet Privaatrecht*) the owner of land can be obliged to tolerate constructions for public good hold by others such as lampposts, power lines, water pipes, telecom pipes, etc.. This restriction can only be imposed only when no other agreement could be arranged with the owner (e.g. right of superficies or a personal right from contract).
AKR registers the restriction as a legal notification and uses the codes 'BP' and 'BG', or 'BPD' and 'BGD' for an obligation established for part of a parcel.

Since the objects themselves (cables, pipelines, tunnels) are not registered, only the parcels are known under (or above) which a construction is situated and not the exact (horizontal and vertical) location of the construction, although it is technical possible to incorporate the outlines of an underground construction in the cadastral map. However, in the cadastral geographical data set of September 2003, no occurrences were found of such objects.

3.6 Cadastral Registration of Cross-Boundary Infrastructure in the Subsurface

Constructions and infrastructure under or above the surface are not registering objects themselves. A building registration does also not exists in the Netherlands, although research has been carried out to set up such a registration in the future (Kap and Zevenbergen, 2000).
Nevertheless in the Netherlands there are two types of cadastral recordings that resemble a registration of infrastructure itself.

3.6.1 Legal Notification in the Administrative Database

A few years ago a registration of the mere existence of an underground object has been introduced. This registration is irrespective of the nature of the right on the land, or the construction. For this special case of legal notifications the registration code 'OB' or 'OBD' (*ondergronds bouwwerk*: underground construction) is used in the AKR. This is just an indication in the administrative database of the existence of an underground object in the subsurface of a parcel. An 'OB' code is linked to parcel and to a subject, which is the person responsible for the object. The 'OB' code indicates a factual situation but it is not a right or restriction itself. Although it is registered as an object restriction, it has no juridical consequences and also it does not give any indication of the legal status of the construction.

To know this the user has to query what rights, restrictions and legal notifications are established on the surface parcels.

Until September 2003 an 'OB' code has been registered 1532 times on a total number of 6,595,393 parcels. To see if there was any structure in those registrations we selected the registered OB codes, grouped by the different (cadastral) municipalities. See figure 4, where the municipalities are ordered on the number of OB-occurrences.

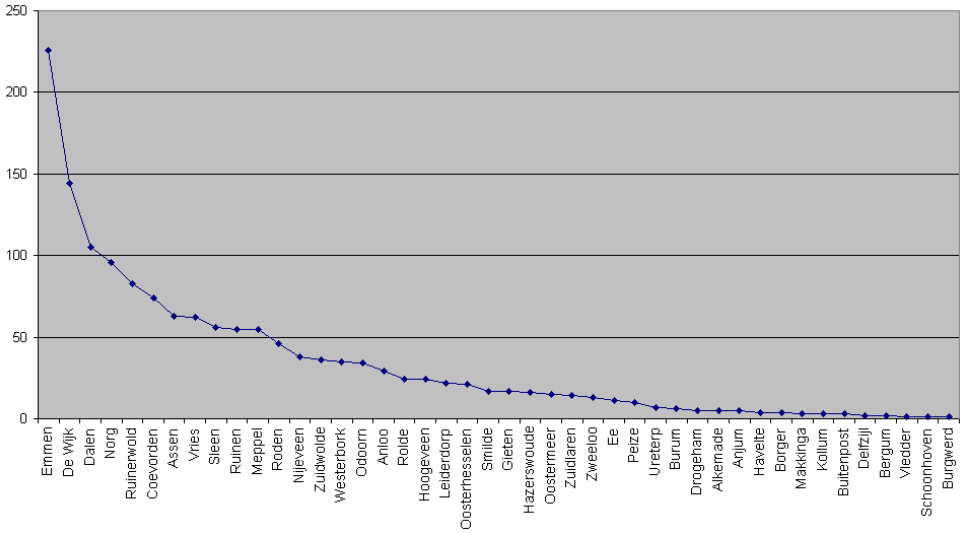

Figure 4: The number of occurrence of an 'OB' code per cadastral municipality. Municipalities with no OB-codes are not mentioned

These results show that four municipalities are responsible for 40 percent of the OB-occurrences: Emmen, De Wijk, Dalen, Norg (in total there are 1218 cadastral municipalities in the Netherlands of which 44 with one or more occurrence(s) of an 'OB' code). In addition the first 19 municipalities of this list are all situated within the cadastral district of the regional office of Assen. It is noteworthy that this is one of the least dense populated parts of the Netherlands. From the fact that a spatial correlation is present in the registration of OB-codes, while the high number of 'OB' codes does not correspond with a more frequent occurrence of underground constructions, it seems that the registration of an OB-code is strongly influenced by subjective preferences and thus that this is not uniform. So for the person who queries the cadastral system, it is not unambiguously clear when an OB-code is used, and what he can or cannot expect.

3.6.2 Telecommunication

A special case, and also the only legal regulation on the subject of cross-boundary infrastructure in the Netherlands, is the Telecommunication Act. According to this act the holder of the permit to exploit a public telecommunication network is and will be the owner of the cables. After a period of legal uncertainty if those cables had to be considered as fixtures or chattel, the Dutch Supreme Court decided in 2003 that telecom-networks in the

ground are immovable (Hoge Raad 6 June 2003). Because the cables are owned by the holder of the permit to exploit the cable, the rule *superficies solo cedit* doesn't apply on them.

Because telecom-networks are immovable a registered notarial deed is needed for the transfer of ownership and for the establishment of limited real rights (like usufruct or mortgage).
The cadastral registration of telecom-networks is a bit complicated because nor the Telecommunication Act nor the Cadastre Act gives any rules how to deal with it. A procedure has been developed by the Netherlands' Kadaster last summer. In case of a transfer of a telecom-network, the holder of a telecom-network offers the spatial description in 2D (centre line) of the network to the cadastre for making a (analogue) "network map". This as far as possible with information on a zone indicating the accuracy or the width of the network. Deed and network map are registered in the Public Registers. The deed of transfer only refers to one parcel, the so called "anchor parcel" (see figure 5).

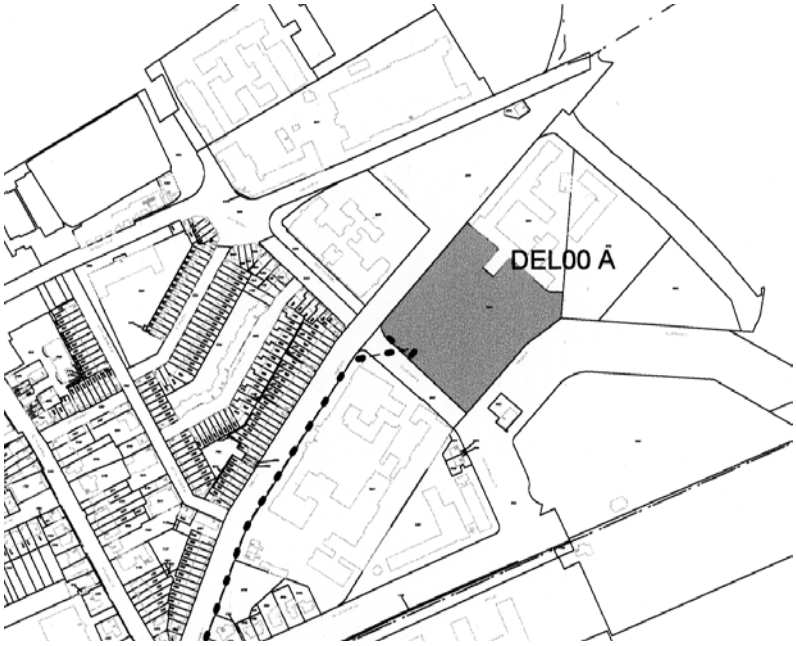

Figure 5: Example of drawing added to deed in case of cadastral recording of a telecom-network.

On the intersecting parcels an object restriction (legal notification) is registered, AKR code 'TC' or 'TCD'. Because these intersecting parcels are not mentioned in the belonging deed, they can only be found by a spatial query. The spatial description of the network can be incorporated in the cadastral geographical data set (as telecom-networks).

In September 2003 we examined the cadastral database. On the total amount of 6,595,393 parcels we found that with respect to the TC codes (parcels used for registering a telecom-network), 1,569 parcels. At that time only five networks had been registered with three holders in total. But this number has increased in the last months.

The ownership to telecom-networks as defined in the Telecommunication Act refers only to the physical extent of the network: if the holder of a network also wants to own a safety

buffer around the network, this has to be explicitly established. Since the spatial extent of networks is available in the cadastral registration, the networks can be indicated on the cadastral map.

3.7 Complications of Current Cadastral Registration of Cross-Boundary Infrastructure

The ownership of cross-boundary objects is only clear in three instances:

- the construction is fully in " own land" . A lot of underground situations relate to infrastructure where the owner of the parcel is also the owner of the subsurface object (e.g. a subway-tunnel in land owned by the municipality).
- right of superficies is established
- if the special rules of Telecommunication Act apply.

However, in none of these cases it is possible to query the infrastructure itself, because the object has no own cadastral identity. Only per parcel the rights can be queried, while these rights are not related to the object or even the function of the object, but to the holder of the object. In case of a TC network, the intersecting parcels can be found via the "anchor parcel" mentioned in the registered notarial deed and the spatial information supplied d by the manager of the network.

4. IMPROVEMENT OF CADASTRAL REGISTRATION

In our 3D cadastre research (Stoter and Ploeger, 2003) we proposed several solutions to improve cadastral registration in case of 3D situations, ranging from a full 3D cadastre, in which the cadastral registration is no longer related to a 2D cadastral map but which is related to a division of space into 3D volumes, to a cadastre in which just a link is made to a 3D situation (as in the current cadastral registration).

In case of cross-boundary infrastructure objects we proposed and evaluated a registration of physical objects themselves, within the current Dutch cadastral and juridical framework. This means that the legal status of physical objects is still established and registered on the surface parcels, however the physical objects is maintained in the cadastral registration as well to be able to better reflect the real situation.

4.1 Registration of Physical Objects

Knowledge of the actual location of physical objects without drastic changes in the current cadastral and juridical framework is possible by the registration of the complete construction (tunnel, pipeline) itself with a spatial description of the object. The physical objects are added for the same purpose in the cadastral map as buildings: to link cadastral registration with representations of reality (i.e. topography). A physical object is a construction above or below the surface which (mostly) crosses parcel boundaries.

Note that in the case of physical objects, the objects themselves are registered and not what we call the "legal space", i.e. the space to which the holder of a physical object has a right to ensure the property of the object, which is usually larger than the physical extent of the object itself (for example including a safety zone).

The proposed registration of physical objects can be compared with the actual registration of telecom-networks in the Netherlands (since June 2003). However, the Telecommunications Act makes the registration of rights for telecom-networks considerably simple by stating that the owner of a telecom-network is the holder of the permit to exploit the cable and the landowner has to tolerate the existence of the part of the network in their land. So no rights have to be established for all intersecting parcels and the ownership rights on the network are clear and undisputed.

The existence of a 3D physical object forms the base for registration. A registration of 3D physical objects needs to be organised and maintained and this registration will become a cadastral task. For the implementation of this registration either a finite list of objects that must be registered has to be made or the registration could be voluntary. The last is based on the idea that such a registration offers benefits for the holders of 3D physical objects.

In the cadastral registration spatial as well as non-spatial information on the whole 3D physical object is maintained (directly or via a Geo Information Infrastructure). A 3D physical object can be queried as a whole. For example, which parcels are intersecting with (the projection of) a 3D physical object (this is a spatial query)?; which rights are established on these parcels; who are the associated subjects?

The relationship between the 3D physical object and the intersecting parcels is stored implicitly, because the holder of a 3D physical object is maintained. This person is (should be) the same (non-natural) person who has a right on the intersecting parcels. In general the holder of a 3D physical object is the person or organisation who is responsible for the 3D physical object.

He has an economic ownership to the construction (right of exploitation) and benefits from the construction but also pays the costs for maintenance and replacements. The relationship between a parcel and a 3D physical object can also be obtained by means of a spatial query.

The solution of registering the 3D physical objects (including geometry in 3D) meets the need of a 3D cadastre to register constructions themselves, or at least to have the 3D location of physical objects available in the cadastral registration (and included in the cadastral map). The intersecting parcels still need a kind of legal notification or limited right referring to the physical object, but the parcels do not need to be divided into smaller parcels, since the exact location is known in the registration. In addition the information on the physical object needs only to be maintained once, instead of with every intersecting parcel.
The spatial relationships between parcels and the 3D object can be maintained with spatial functions in the DBMS.
Finally, since the physical objects are integrated in the cadastral geographical data set, the real situation is much better reflected than in current cadastral registration.

The UML class diagram of the cadastral registration of physical objects is shown in figure 6.

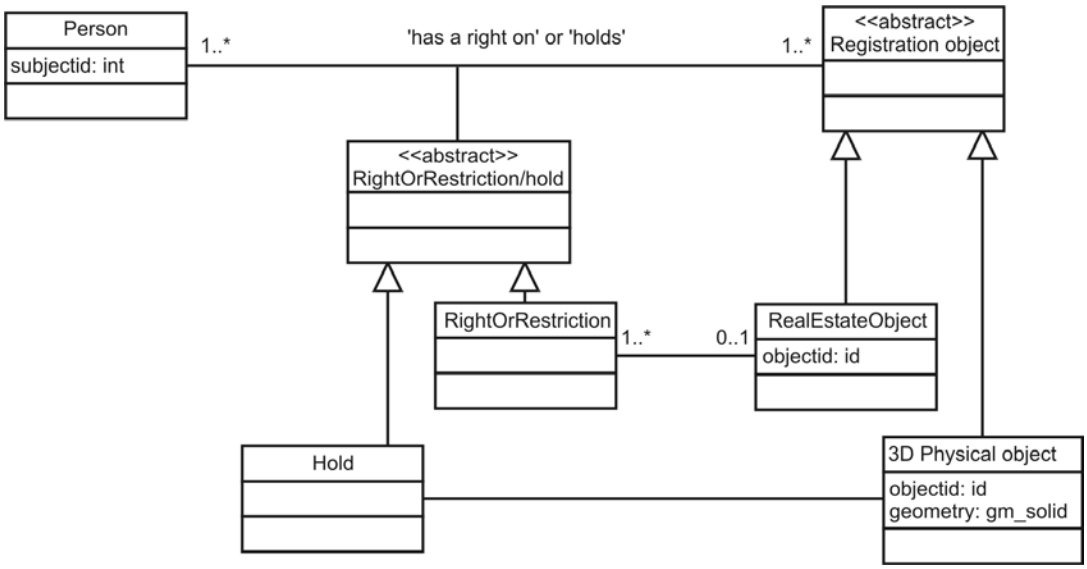

Figure 6: UML class diagram of 3D physical objects.

6. CONCLUSIONS

In this paper we sketched the complications of the availability of information of cross-boundary infrastructure (mostly subsurface constructions) in the cadastral registration, which is originally a registration of the surface.

The surface parcel is always the entrance to a cadastral recording. The 2D parcel as basic (and only) real estate object in the cadastral registration meets several drawbacks. The legal status of space above and below the surface can only be obtained by collecting information on the legal status of intersecting surface parcels. More than two million cadastral recordings were found in the cadastral database of September 2003 that could indicate a 3D situation (limited real rights and restrictions). The third dimension of rights and restrictions of these recordings cannot be reflected in the cadastral registration, even if this information is available in deeds, drawings and/or survey plans. Consequently the current cadastral registration provides information on which persons have a right on a parcel but not on the spatial extent of these rights or on the function of the object to which the right relates.

We propose to improve current cadastral registration by the introduction of a registration of physical objects. In case of 3D physical object registration, the 3D physical object is the starting point of registration, independent of the rights that have been established. The 3D description of the physical objects (extent of the object) can be used for reference purposes (to improve the reflection of the real situation) and to support cadastral tasks. All parcels intersecting with the physical object can be found by a spatial query (by an overlay with the projection of the 3D object). Preferably 3D information on physical objects is maintained by

organisations responsible for the objects and accessible in the cadastral database via the Geo-Information Infrastructure.

However, our proposal is a solution within the current cadastral and juridical framework. In the 3D cadastre research we also looked to a more fundamental solutions in which the cadastral registration is no longer (only) related to the surface, i.e. surface parcels, but to volumes. In this proposal the registration of the surface and subsurface is integrated.

The FIG Bathurst Declaration (FIG, 1999) concluded already that "most land administration systems today are not adequate to cope with the increasingly complex range of rights, restrictions and responsibilities in relation to land". As in the Netherlands, many other existing cadastres are still based on the paradigm of a land parcel and the land oriented concept of rights on real estate that has its origin decades ago. This paradigm needs to be reconsidered and adjusted to today's world. Although parcels are traditionally represented in 2D, someone with a right to a parcel always has been entitled to a space in 3D. This led to no disputes as long as only one person was entitled to a land parcel. However, in recent times stratified property is common practise while also the way humankind relates to land has changed drastically (value of private property has increased considerably). Today's cadastral registration should therefore reflect the true principle of property rights that entitle persons to volumes and not to just areas.

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BIOGRAPHY

Dr. Hendrik Ploeger studied law at Leiden University. In 1997 he finished his PhD-thesis on the subject of the right of superficies and the horizontal division of ownership rights (Horizontale splitsing van eigendom, Leiden). The same year he did research at the E.M. Meijers-Institute of Legal Studies on the subject of bored tunnels and the rights of landowners. After an assistant-professorship in civil and notary law at Leiden University, he is since 2001 assistant-professor at Delft University of Technology , OTB, section Geo-information and Land management. He is also chairman of the FIG working group on 3D-Cadastres.

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