3D property formation in complex infrastructure- and building projects - Exemplified by the Slussen project in Stockholm

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Key words: 3D real property, property formation, 3D models, registration, Sweden.

SUMMARY

This paper describes the use of 3D real property formation at a major construction site in Stockholm, Sweden, project Slussen.

Real property formation with complex 3D volumes and numerous real properties and associated rights, restrictions and responsibilities (RRRs) has to be shown with the real properties and RRRs in relation to each other. The present legal solutions and documentation thereof are based on analogue documentation (digitalised to pdf) and cannot be attached as e.g. dwg files. Architects and other professionals do not normally have access to the 3D real property boundaries in their 3D building models from the beginning of a project and the exact locations of boundaries are agreed upon during the formation process to achieve as usable solutions as possible.

The aim of this paper is to describe the 3D property formation process when involving complex solutions securing RRRs to solve legal and planning challenges on different levels of detail. The paper focuses on the cadastral real property formation procedures using 3D property formation for constructions above and underground, as well as how they are registered in the national real property register. The paper illustrates a complex 3D property solution and adds to the understanding of the challenges of registration and visualisation of Swedish 3D real property in Stockholm, focusing on legal as well as technical experiences.

This research is a document study based on an analysis of the property formation and planning documentation and processes of a cadastral procedure conducted in the Slussen project, as well as associated documentation from other agencies, and by interviewing key persons involved in the project. The paper illustrates the need for a national cadastral index map in three dimensions to be used in the formal real property formation procedures, to achieve a comprehensible and correct representation and visualisation of 3D real properties and RRRs in Sweden.

The results can be used as input in coming property formations of a similar kind, as well as a component for the development of a national three-dimensional cadastral index map. Furthermore, the results can be an input to capacity building for the future use of 3D models as part of the formal cadastral property formation procedure.

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1. INTRODUCTION

Three-dimensional (3D) property rights have been successfully used for a long time in a number of countries, see e.g. Oosterom et al. (2018), but in Sweden, the formation of 3D real property is a rather new possibility. It was introduced in the legislation in 2004, followed by legislation allowing apartment ownership in 2009 (SFS 1970:944).

1.1 Background

A demand for the formation of 3D properties had existed before its introduction in Sweden for quite some time, to create the possibility of dividing the ownership of space or buildings above or below ground. Among the needs for 3D property that were expressed in the investigations preceding the legislation (Proposition 2002/03:116) were mentioned separating the ownership in large complex projects with a need for extensive funding, e.g. for infrastructure purposes.

The formation of 3D property has so far not been as high as was expected when introducing the legislation, but the use of it seems to be increasing. This also creates a larger need for finding sustainable solutions for three-dimensional registration and visualisation of 3D property units and connected rights, restrictions and responsibilities (RRRs). This can in particular be the case for more complex projects. This paper describes the use of 3D real property formation at a major construction site in Stockholm, Sweden. Project Slussen is an initiative to demolish the old existing lock in the historic waterway through the city, which is connected today to an ineffective traffic solution in central Stockholm, and replace it with a modern boat lock and a new traffic solution. The Slussen lock has since centuries formed an important waterway through the Swedish capital regulating the boat traffic and water level between the Baltic Sea and Lake Mälaren. This construction project also includes the formation of 3D real property as well as RRRs. Stockholm municipality is responsible for real property formation within their boundaries, a municipal responsibility that is allowed in currently 40 Swedish municipalities, whereas property formation is the responsibility of Lantmäteriet, the Swedish Mapping, Cadastral and Land Registration Authority, in the remaining parts of Sweden.

Real property formation with complex 3D volumes and numerous real properties and associated RRRs are shown with the real properties and RRRs in relation to each other. The present legal solutions and documentation thereof are based on analogue documentation

(digitalised to pdf) and cannot be attached as e.g. dwg files. Architects and other professionals do not normally have access to the 3D real property boundaries in their 3D building models from the beginning of a project and the exact location of boundaries are agreed upon during the formation process to achieve as usable solutions as possible.

1.2 Problem description

According to Swedish legislation and recommendations, cadastral boundaries for 3D property units shall be described in relation to the physical construction surrounding the property unit and the 3D volume shall enclose a building or other construction. The legislation is based on the procedure that in normal cases, first a legal 2D-property is created, thereafter building permission is obtained and finally the 3D property is created. This procedure is however not possible to use when a detailed plan vertically separates public space and development district. In such cases, it is required to separate the procedures for public space and development districts before being able to obtain a building permit.

The result is that the separation between public space and development districts has to be made before acquiring the building permit and constructing the building. In order to secure that it is possible to obtain a building permit on the property and thereby ensure its suitability, normally a parallel process with building permit and property formation is created in such cases. The parallel process is needed for both the cadastral surveyor and the building permit official to be able to co-operate in understanding and interpreting the situation, since the decisions are co-dependent.

The cadastral surveyor in these property formation processes needs to interpret the applicable regulations in the detailed plan to make sure, for example, that the border between public space and development districts complies with the regulations. This applies both horizontally and vertically when 3D property units are created. The detailed plan regulations include a scope of interpretation, but should to a high degree show a clear picture of boundaries between different permitted uses.

A challenge for the cadastral surveyor is to assure that it is clearly described where the boundaries of the 3D property unit is located as well as the extent of other RRRs, though without using a 3D model as part of the cadastral decision, since this at the moment only can consist of 2D documents. This creates challenges to visualise without being able to use for example a 3D model of the 3D property unit. Also, when recording the result of the property formation into the real property register, it can, as of today, only be displayed in a 2D map and with limited information about height spread, since there is not a 3D cadastral index map available.

1.3 Aim

The aim of this paper is to describe the 3D property formation process when involving complex solutions securing RRRs to solve legal and planning challenges on different levels of detail. The paper focuses on the cadastral real property formation procedures using 3D property formation for constructions above and underground, as well as how they are registered in the national real property register. The paper illustrates a complex 3D property

solution and adds to the understanding of the challenges of registration and visualisation of Swedish 3D real property, focussing on legal as well as technical experiences.

1.4 Method

This paper is based on the study of project documents from the cadastral dossier from creation of the property unit subject for the case study (cadastral map, descriptive texts of the cadastral decision as well as describing pictures from 3D models etc.), including material from construction companies submitted to Stockholm municipality as part of the Slussen project. In addition to this, interviews were made with experts and others involved in the property formation and creation of associated RRRs, as well as the visualisation thereof. The project was conducted with the responsible cadastral surveyor in charge of the property formation and the GIS expert responsible for the digital models and drawings used in the formation process. The research investigated how different legal documents and technical documentation for the property formation were created, how new cadastral boundaries were formed and how this was illustrated in an optimal way in 3D drawings/models.

The process for 3D real property formation described in this paper is general for Sweden, but the presented project is of a particularly complex nature and thus involves parts and aspects that are not always relevant in all cases of 3D property formation.

1.5 Previous research

National and international research has focused on more theoretical issues and (manual) digitization of geographic information, but has not addressed to a large extent how increased automation and use of 3D models etc. in decision-making can contribute to streamlining the community building process. In international research over the past two decades, there has been a focus on the implementation of conceptual technical solutions as part of the development of registration and visualisation of 3D properties. Technical solutions investigated in the international research primarily consist of conceptual models for the visualisation of 3D properties developed specifically for implementation in an intended legal domain. A lack of practical examples of implementation was already described several years ago in connection with a lack of focus on the legal aspects within the research area e.g. (Ho et al. (2013). This is consistent with bibliographic analyses of publications in the research area, published in 2013 and 2021 (Paulsson and Paasch, 2013; Paasch and Paulsson, 2021).

2. SWEDISH 3D PROPERTY RIGHTS

The Swedish traditional 2D property unit is delimited horizontally with x and y coordinates. In theory, it contains a volume extending upwards into the sky and down to the centre of the earth, but in practice limited by how much the property owner can use upwards and downwards from the ground level. In densely built areas where there are different activities competing for the same space within the volume, different actors can gain access through different kinds of rights, or through 3D property formation where the ownership of these different activities can be separated. A three–dimensional property is formed in the same way as a traditional 2D property and is regulated by the same rules, although additional rules for

this type of property have been included in the existing real property legislation. See Larsson et al. (2018; 2020) and Seipel et al. (2020) for an introduction to the Swedish 3D real property formation process.

The 3D property is delimited both horizontally and vertically. The property is intended to accommodate a building or other facility, or part thereof. Unlike many other jurisdictions (see e.g. Paulsson, 2007), Swedish legislation has not included regulation on the location or visualisation of the cadastral boundaries in relation to the physical building construction that has to surround the 3D property unit and make its boundaries visual. It is stipulated that the boundaries shall follow the construction, but according to the cadastral recommendations, a small volume of air can be included in the property unit in order to include e.g. protruding construction details, although no additional space is allowed for future building rights. Despite the requirement for the property boundary following a construction, it is possible to form a 3D property for a future construction with the condition that it will be developed within a fixed amount of time set in the property formation decision.

Necessary rights needed for the proper use of the 3D property unit must be legally secured in the property formation. Ownership apartments (condominium) is a special form of 3D property intended for a single dwelling and has additional regulations for its formation, such as that it can only be formed in new buildings or in existing buildings which have contained no residential housing for the past eight years.

The process to form a 3D property unit starts with an application to the cadastral authority who will check the application if it meets the requirements in the legislation, planning regulations, building permission, etc. As mentioned, the legislation does not define the location of the property boundaries for the 3D property units, which means that this will be discussed between the cadastral surveyor and the applicant and decided which is the most suitable solution for the location. The location of the boundaries and their relation to adjacent property units will be described in writing, in addition to shown on maps and drawings. Also other boundaries for RRRs, e.g. easements and joint facilities, are described in the same way. The cadastral documents that are submitted to the authority or created in the property formation process are mostly in paper format or frozen digital images. Examples of such documents are previous property formation decisions, planning regulations and building permissions. CAD drawings containing the 3D real property boundaries may also be used in the process, created and provided by the developer/entrepreneur. Such drawings will however not be archived in the national real property register, although they may be archived for future use by the cadastral authority where no standardised solutions exist but are done differently depending on authority.

Real property formation with complex 3D volumes and numerous real properties and associated RRRs has to be shown with the real properties and RRRs in relation to each other. The present legal solutions and documentation thereof are based on analogue documentation (digitalised to pdf) and cannot be attached as e.g. dwg files. Architects and other professionals do not normally have access to the 3D real property boundaries in their 3D building models from the beginning of a project and the exact locations of boundaries are agreed upon during

the formation process to achieve as usable solutions as possible. The same type of documents and cadastral procedures are used for all types of 3D property formation, although the case presented in this paper is more complex than most other cases of 3D property formation and thus includes more complications and aspects to consider.

The study presented in this paper is a continuation of and an addition to previous research in this field that has been carried out by, among others, the authors of this paper. Research in Sweden within 3D properties has been going on for more than two decades, but many research results have not yet been implemented in legislation or included in development projects by authorities and other actors. However, research has been conducted in several sub-areas relating to 3D real estate objects, such as comparative studies of ownership of 3D real property in selected national legislations, e.g. Paulsson (2007) and Çağdaş et al. (2020) and the use of 3D property formation in the construction of bridges and other infrastructure facilities (Karabin et al., 2020), as well as analyses of trends in the 3D property research field (Paulsson and Paasch, 2013; Paasch and Paulsson, 2021). In recent years, 3D models have been the focus of some research, e.g. regarding the use of BIM in connection with 3D property formation and management of property information as well as the use of 3D city models for digital register maps (Sun et al., 2021; Sun et al., 2023). An ongoing project in the City of Stockholm works with visualisation of existing 3D spaces in the municipality.

In addition, several research projects have been conducted within the Smart Built Environment, e.g. around BIM as information support for 3D real property formation (Andreé et al., 2018),. Examples of this are which information is only available in analog form today and which information must be digitised, possibly retrieved from other sources to be used in administrative proceedings, and that guidelines must be drawn up for archiving geodata and property information produced in connection with the handling of the proceedings; BIM data for accounting of 3D real estate formation, as well as issues linked to infrastructure data/projects; overview information such as small-scale geodata and overview plans, as well as perceived legal barriers to a digital community building process have also been investigated. See e.g. (Andreé, et al (2019; 2020). Other relevant projects deal with Swedish 3D property boundaries (Larsson et al., 2020), visualisation of 3D property boundaries (Seipel et al., 2020).

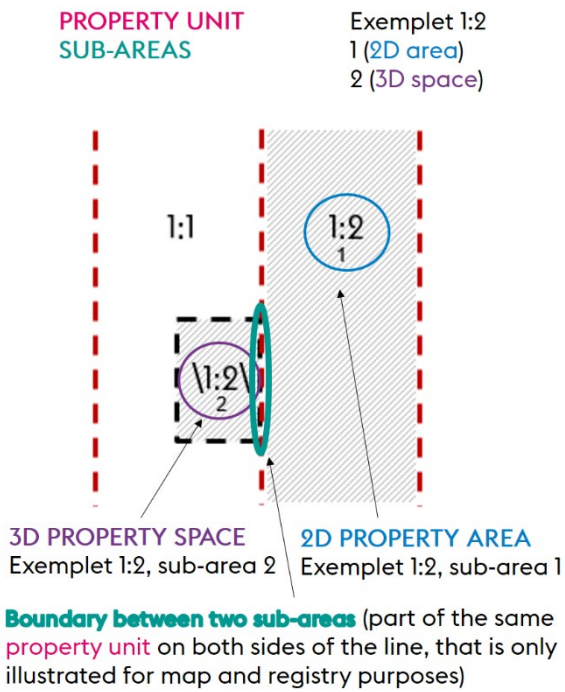


Figure 1. Illustration of representation of 2D in relation to 3D property in the real property register and cadastral dossiers

3. CASE STUDY

For all 3D property formation there is a need for reliable and correct presentation of the property boundaries and property rights in the property formation decisions as well as in the cadastral index map and the real property registry. The Slussen area in Stockholm, that is used for this case study, is more complex in many ways than the average 3D property formation in Sweden, however the findings and experiences can be used for all cases of 3D property formation.

3.1 Background of the area

The Slussen area in Stockholm is named after its historically main function, a water lock ("sluss" in Swedish) between lake Mälaren and the Baltic Sea, and Slussen translates thus to "the Water Lock". The infrastructure surrounding the water lock has been rebuilt and modernised several times since the first known water lock was completed in 1642. From older maps we can determine that the strait between the islands of Gamla Stan (Old Town) and Södermalm, two parts of Stockholm city, has been used as a passage for longer than that. The water lock has since 1642 been rebuilt once every century (years 1755, 1850 and 1935), due to wear and tear as well as changes in water levels and other natural changes. This has also impacted the area around the water lock.

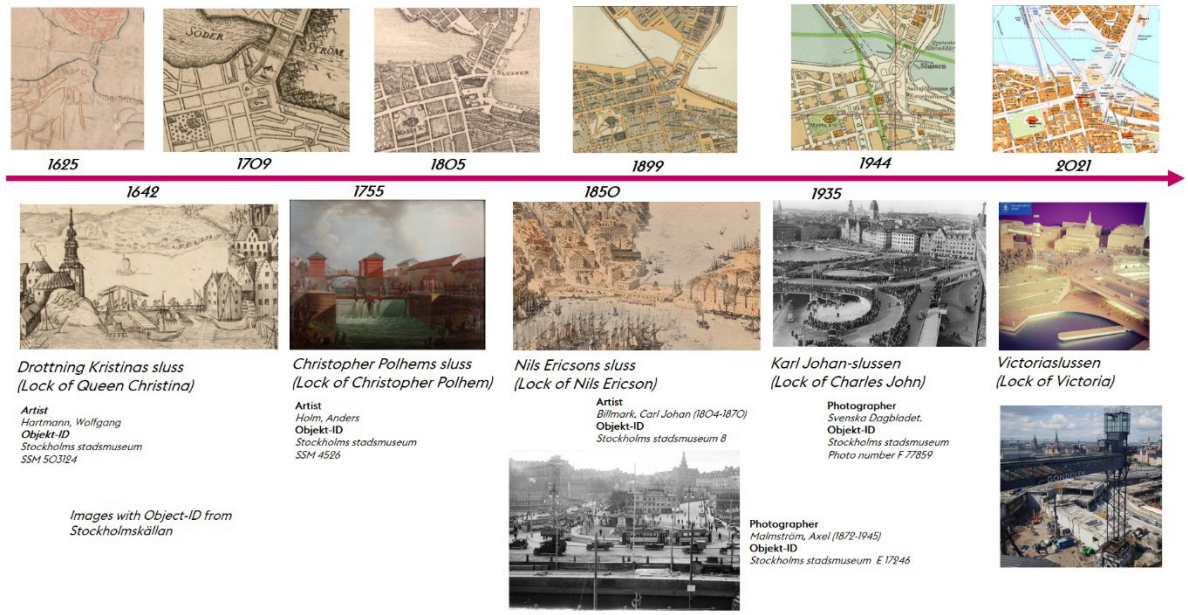


Figure 2. History of water locks in the Slussen area https://stockholmskallan.stockholm.se/

The Slussen water lock was last rebuilt in the 1930s, almost a hundred years ago. The construction was mainly made out of concrete, and after several decades the constructions started to deteriorate, and another reconstruction was thus needed. The new water lock, currently under construction, is called Victoriaslussen (Water Lock of Victoria), named after the current Crown Princess Victoria of Sweden.

3.2 Current development in the Slussen area

A new detailed development plan was produced for the Slussen area prior to the ongoing reconstruction and became legally binding in December 2011. However, the planning process for a new water lock facility began decades earlier with an idea competition arranged in the early 1990s. Around the turn of the millennium, the work resumed and in 2004, an architectural competition was announced where a winner was also named.

The detailed development plan makes possible for a full reconstruction and new locations and stretches of infrastructure, as well as new structures for development districts and connected building rights. There are many different types of infrastructure located in the area; two subway lines intersect, as well as a third line about to be built, there is a large bus station and a local train line end station, ferry lines and also cars, bikes and pedestrians, both locals and tourists. The area consists of a variety of branches of activity, such as housing, offices, hotels, restaurants and commercial areas.

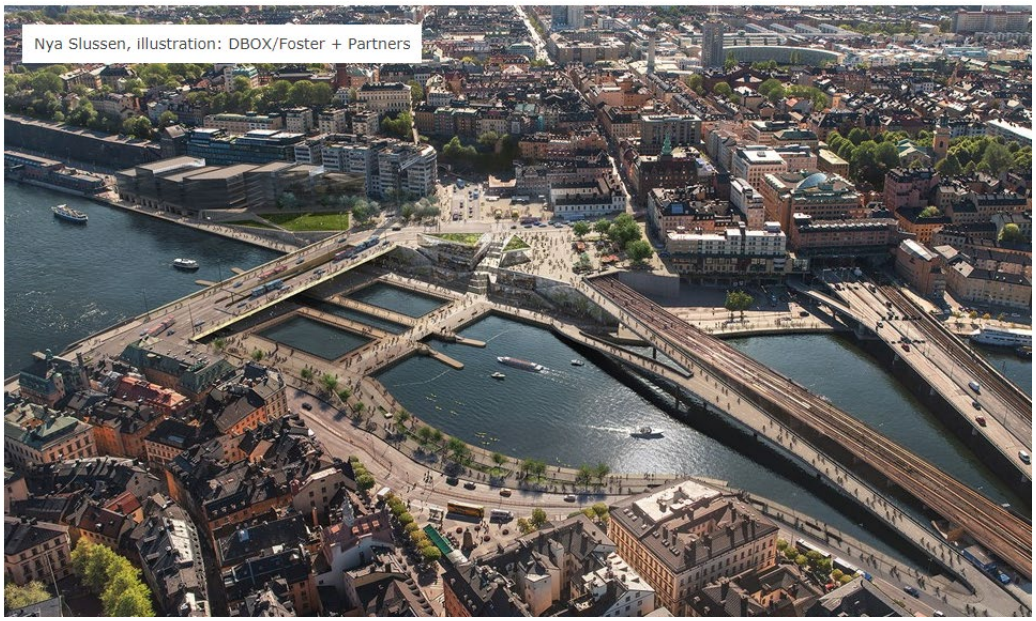


Figure 3. Vision picture of the Slussen area when completed https://vaxer.stockholm/projekt/slussen/

The detailed development plan is a 2D plan describing a lot of regulations in 3D, i.e. public spaces on top of building rights for stores underground. Within the property formation and building permit processes there is a need to interpret where the boundary between public and private areas is located within the detailed development plan, both horizontally and vertically. The full reconstruction of the water lock Slussen as well as connecting infrastructure and a lot of the new buildings are estimated to be finished in 2027.

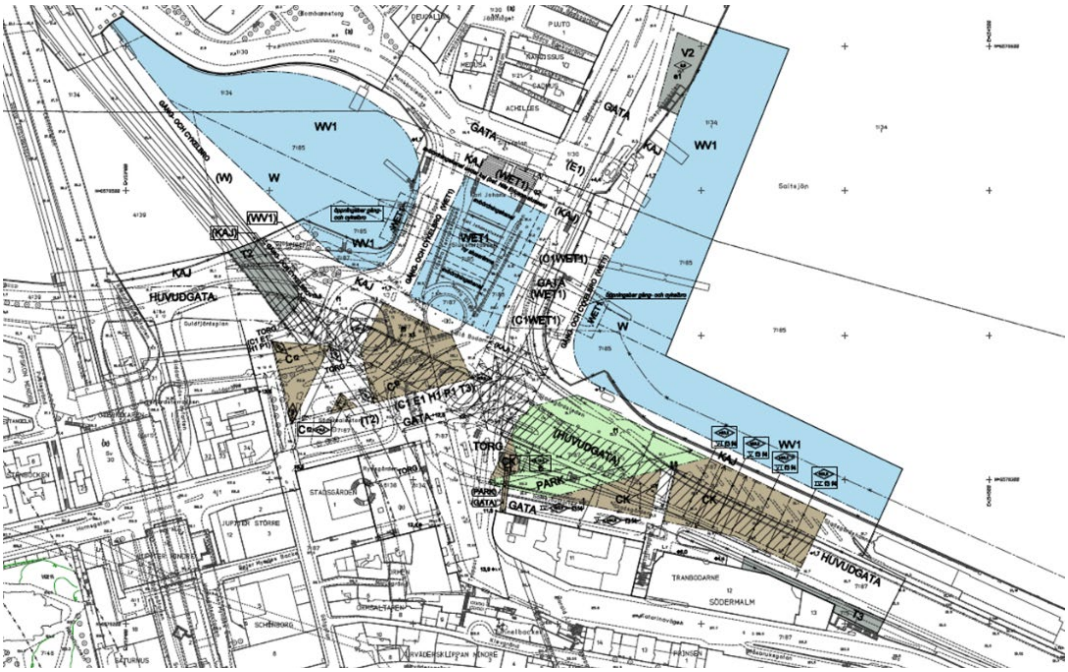


Figure 4. Extract from the current detailed development plan of Slussen area (P2005-08976). Source: Bygg- och plantjänsten, City of Stockholm https://etjanst.stockholm.se/Byggochplantjansten/gallande-planer/sok-via-karta

The changes in the buildings and facilities in the Slussen area also have influenced the necessary and suitable division of the real properties and associated RRRs, both in 2D and 3D. The first larger cadastral procedure in the project was carried out during 2021-2022 and constituted a very complex 3D property formation combining a number of different interests. The main property unit subject for re-formation, called "Södre Torn 1", is located next to as well as under and above public spaces (street, plaza, quay, etc.), subway facilities and thoroughfare car tunnel (another 3D property unit that was created at the same time). The property unit "Södre Torn 1" will at a later stage be connected to another 3D property unit for shopping facilities that will be created. A multitude of RRRs are needed to ensure the suitability of these 3D properties.

3.3 Property formation in the Slussen area

The property formation is, as described above, part of the implementation of the reconstruction of this part of central Stockholm. Involved parties in the process, such as developers and the municipality (who owns the current property units), have produced 3D models for the facilities as part of their work that in detail show planned buildings, infrastructure, positions of pipes etc. However, these 3D models do not include planned or desired 3D boundary lines. In Sweden, as of current conditions, 3D models cannot be used as part of the real property decision. The property formation dossier consists either of paper documents or of pdf-files (not 3D pdf). That is why the content of the cadastral plans produced as a basis for the cadastral work has been extracted from the 3D digital models and used in 2D drawings, in addition to creating 3D cadastral volumes showing the approximate location and extent of 3D real property volumes, which are later used in 2D form (pictures of 3D-volumes from different directions). Architects and construction companies do not have boundary lines in their 3D-models from the beginning, and the actual location of the boundaries are decided upon during the cadastral formation process to create suitable real properties and associated RRRs.

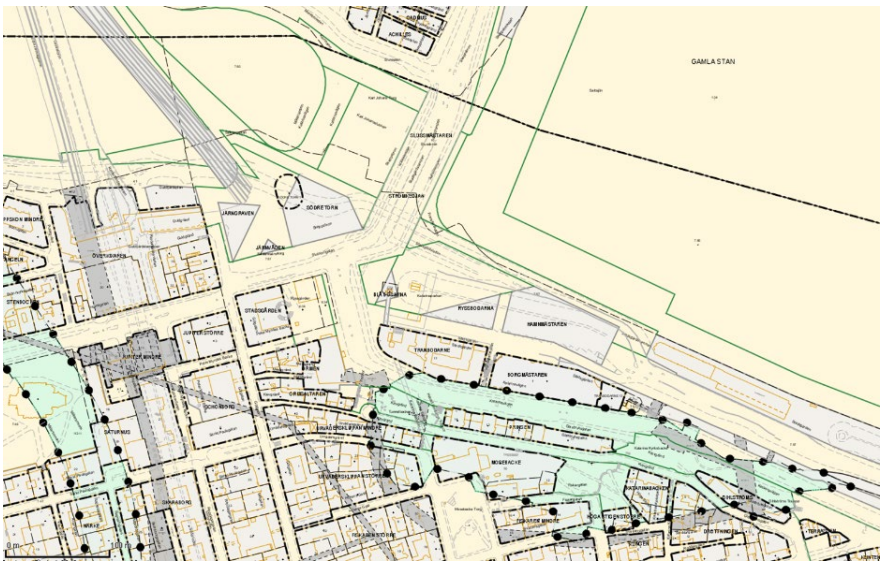


Figure 5. Cadastral index map of the Slussen area before the transformation of property unit Södre Torn 1. Adapted from Larsson (2021)

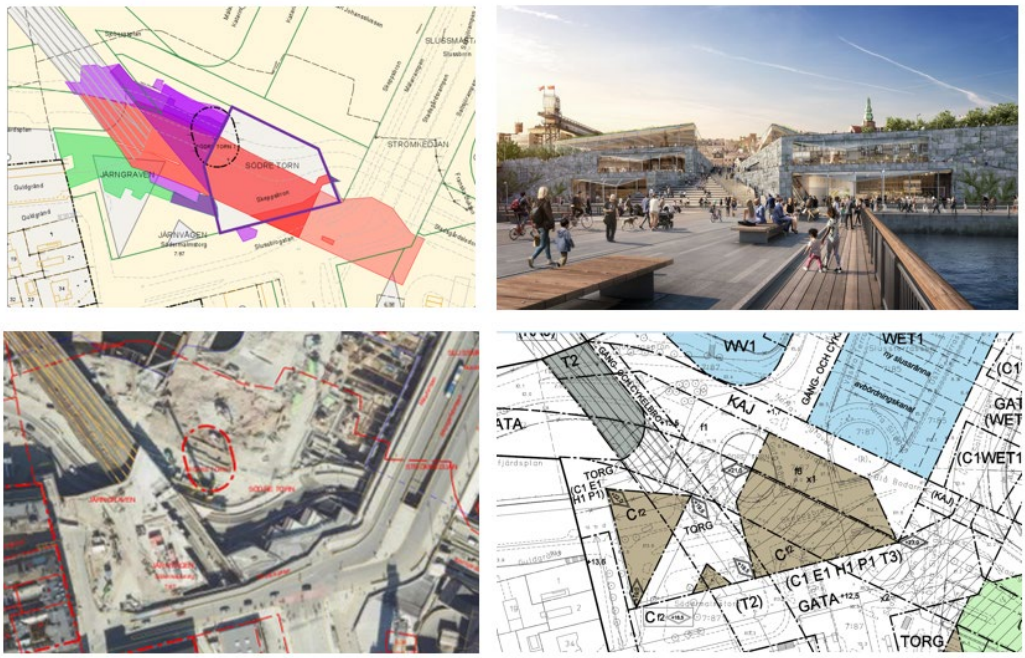


Figure 6. Top left: Requested new RRRs for Södra Torn 1 merged to the cadastral index map for reference, as part of the property formation process. Top right: vision picture of the area around Södra Torn 1. Bottom left: Orthophoto of the Slussen area before the transformation of property unit Södra Torn 1. Bottom right: Regulations in the detailed plan of the area. Adapted from Larsson (2021)

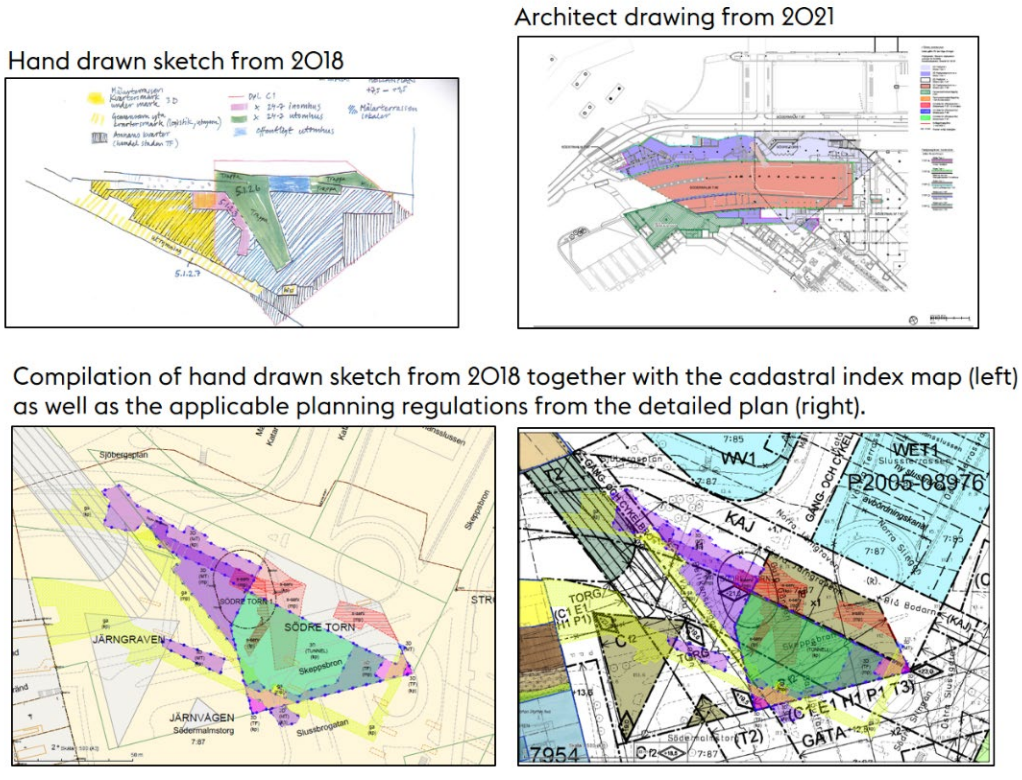


Figure 7. Material used during the property formation process. Adapted from Larsson (2021)

To be able to visualise the overview distribution of and relationships between different 3D property units, a simplified 3D model was created. The detailed CAD plan drawings of different levels were used as reference, then each floor/layer was elevated up to the next available level of plan drawing. From this, volumes of each 3D property unit was created, and the separate property units were given different colours. These volumes simply gave a rough estimate of the spread of each floor, without showing any details. The volumes created were combined with a BIM model of the planned building that was provided by the property owner and property developer. In the 3D model created it was possible to show or hide any property unit in order to view the desired spread or relationship. The viewing point could be shifted to the desired position to be able to distinguish details. Screenshots of the 3D model were used as part of the property formation decisions of Södre Torn 1. In addition a 3D pdf was provided by the property developer. The 3D pdf had more detail than the 3D model created from CAD plan drawings, but still only shows an estimate of the spread, not the exact boundaries.

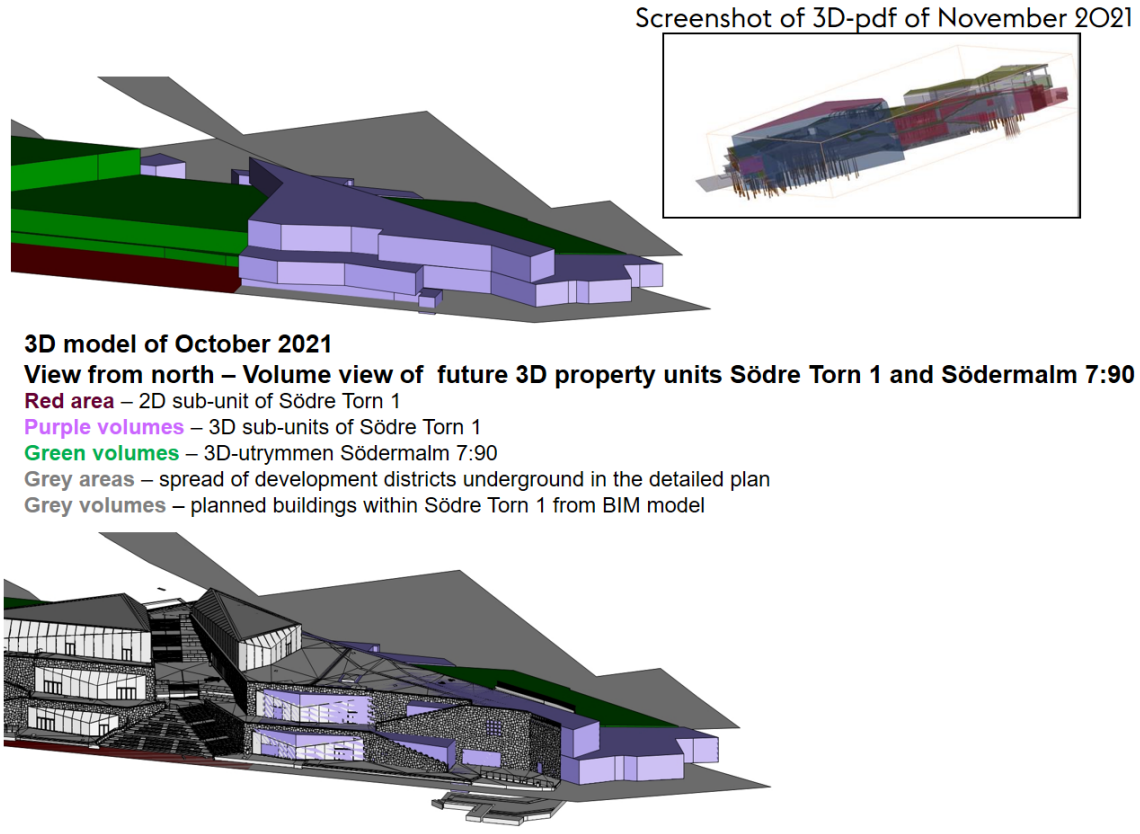


Figure 8. Left: Early versions of 3D volumes created within the property formation process and combined with BIM model of planned buildings acquired from the property owner and developer, to use for understanding and interpretation of suggested property boundaries etc. Right: Screenshot of 3D pdf, later used as part of the property formation decisions. Adapted from Larsson (2021)

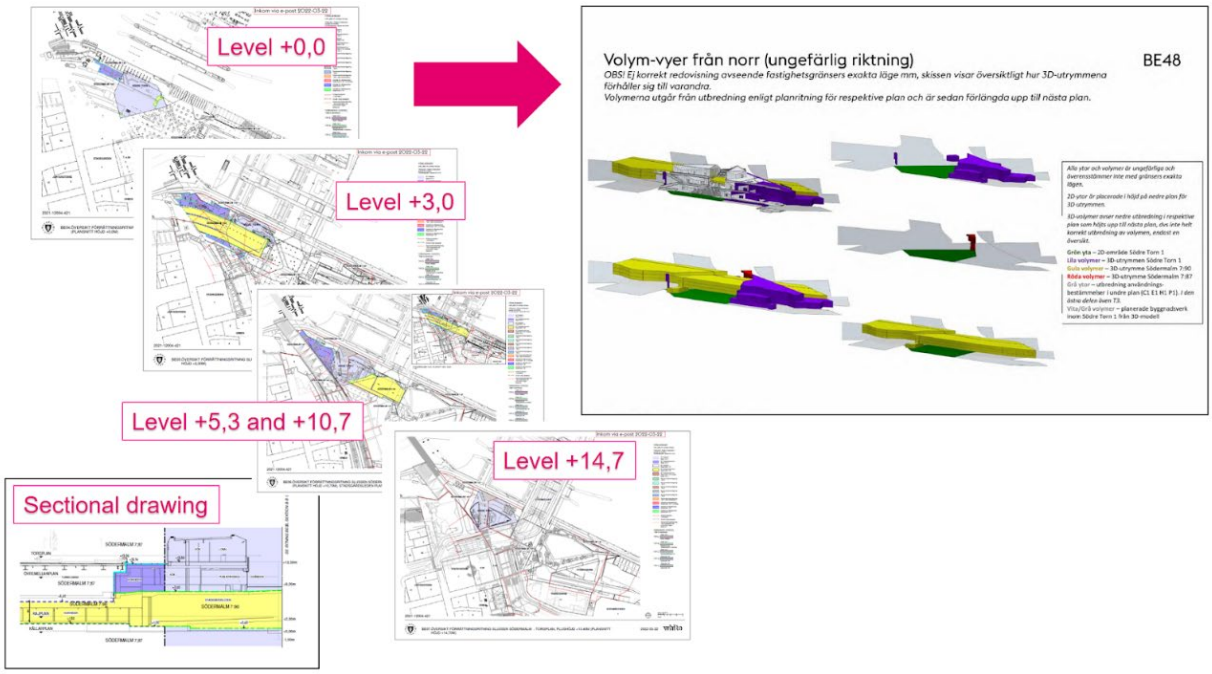


Figure 9. Extract from property formation dossier. Example of visualisation of 3D models of 3D property unit Södre Torn 1. From the property formation dossier of Södre Torn 1, 0180K-2021-12004. City of Stockholm

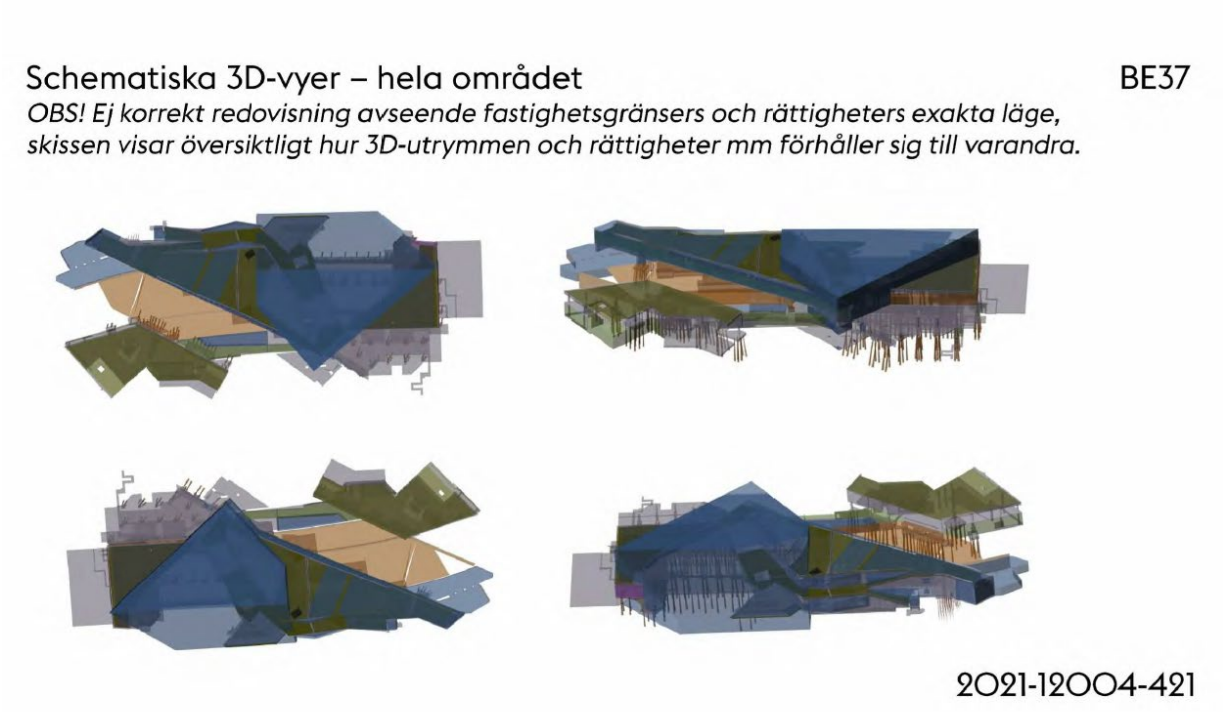


Figure 10. Extract from property formation dossier. Example of screenshots from a 3D pdf showing 3D property unit Södre Torn 1 as well as surrounding property units in a schematic manner. From the property formation dossier of Södre Torn 1, 0180K-2021-12004. City of Stockholm

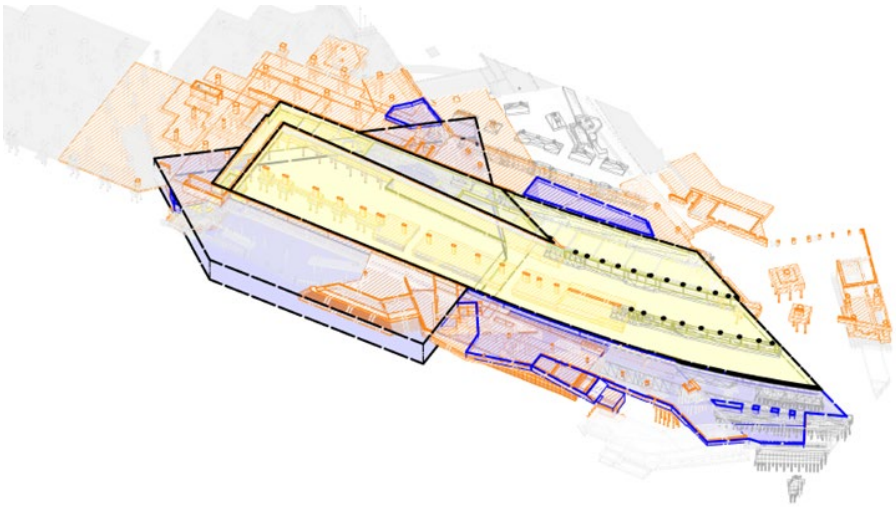


Figure 11. Extract from property formation dossier. Example of screenshots from a 3D model delivered by the property owner and property developer, showing 3D property unit Södre Torn 1 as well as surrounding property units and RRRs in a schematic manner. From the property formation dossier of Södre Torn 1, 0180K-2021-12004. City of Stockholm.

The property formation dossier of 3D property unit Södre Torn 1 consists of, among other documents, four cadastral maps, 26 pages of verbal description of the property formation, 100 pages of drawings, over 30 pages of compilation of planning provisions and nine pages of protocol including a summary of the property formation as well as the property formation decisions. These documents need to be read and interpreted together to be able to determine the exact location of a certain boundary line or other detail regarding the concerned RRRs.

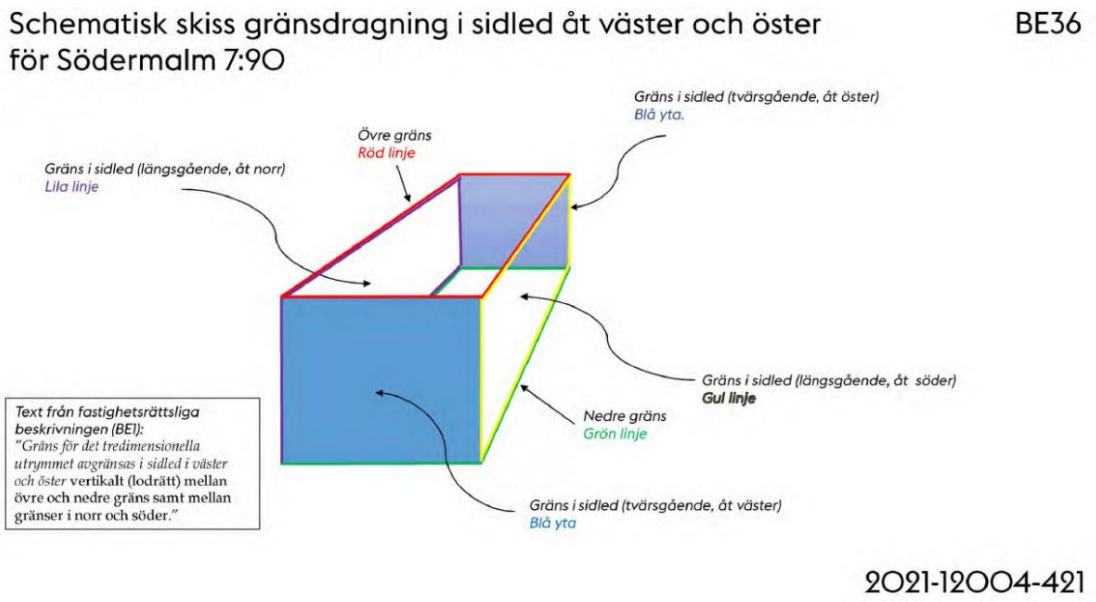


Figure 12. Extract from property formation dossier. Schematic drawing describing boundaries of 3D property unit Södermalm 7:90 at the entrances of a road tunnel. From the property formation dossier of Södre Torn 1, 0180K-2021-12004. City of Stockholm

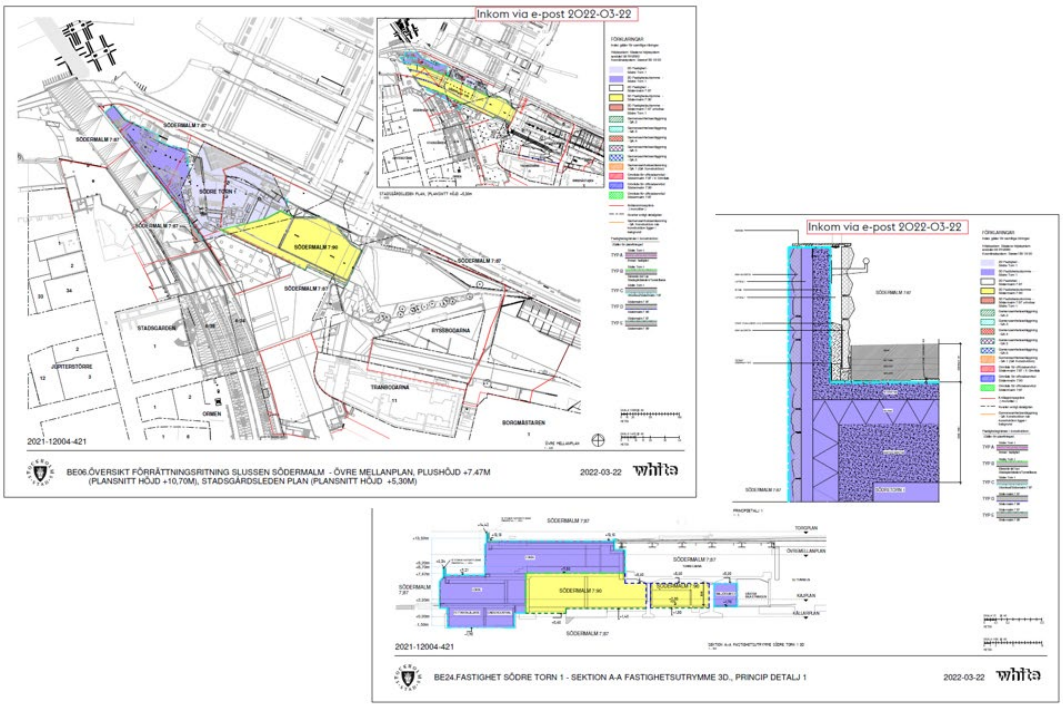
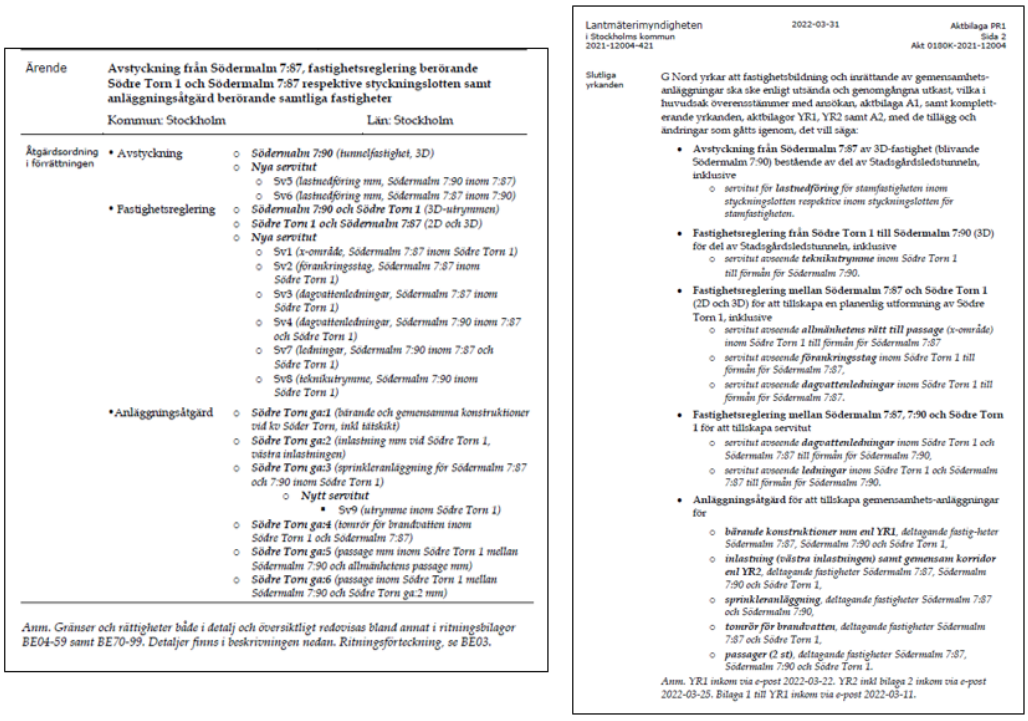


Figure 13. Extract from property formation dossier. Drawings describing boundaries of 2D and 3D property units. From the property formation dossier of Södre Torn 1, 0180K-2021-12004. City of Stockholm



Ärende

Avstyckning från Södermalm 7:87, fastighetsreglering berörande Södre Torn 1 och Södermalm 7:87 respektive styckningslotten samt anläggningsåtgärd berörande samtliga fastigheter

Kommun: Stockholm Län: Stockholm

Åtgärdsordning i förrättningen

- Avstyckning
  - *Södermalm 7:90 (tunnelfastighet, 3D)*
  - *Nya servitut*
    - Sv5 (lastnedföring mm, Södermalm 7:90 inom 7:87)
    - Sv6 (lastnedföring mm, Södermalm 7:87 inom 7:90)
- Fastighetsreglering
  - *Södermalm 7:90 och Södre Torn 1 (3D-utrymmen)*
  - *Södre Torn 1 och Södermalm 7:87 (2D och 3D)*
  - *Nya servitut*
    - Sv1 (x-område, Södermalm 7:87 inom Södre Torn 1)
    - Sv2 (förankringsstag, Södermalm 7:87 inom Södre Torn 1)
    - Sv3 (dagvattenledningar, Södermalm 7:87 inom Södre Torn 1)
    - Sv4 (dagvattenledningar, Södermalm 7:90 inom 7:87 och Södre Torn 1)
    - Sv7 (ledningar, Södermalm 7:90 inom 7:87 och Södre Torn 1)
    - Sv8 (teknikutrymme, Södermalm 7:90 inom Södre Torn 1)
- Anläggningsåtgärd
  - *Södre Torn ga:1 (bärande och gemensamma konstruktioner vid kv Söder Torn, inkl tätskikt)*
  - *Södre Torn ga:2 (inlastning mm vid Södre Torn 1, västra inlastningen)*
  - *Södre Torn ga:3 (sprinkleranläggning för Södermalm 7:87 och 7:90 inom Södre Torn 1)*
    - *Nytt servitut*
      - Sv9 (utrymme inom Södre Torn 1)
  - *Södre Torn ga:4 (tomrör för brandvatten inom Södre Torn 1 och Södermalm 7:87)*
  - *Södre Torn ga:5 (passage mm inom Södre Torn 1 mellan Södermalm 7:90 och allmänhetens passage mm)*
  - *Södre Torn ga:6 (passage inom Södre Torn 1 mellan Södermalm 7:90 och Södre Torn ga:2 mm)*

Anm. Gränser och rättigheter både i detalj och översiktligt redovisas bland annat i ritningsbilagor BE04-59 samt BE70-99. Detaljer finns i beskrivningen nedan. Ritningsförteckning, se BE03.

Lantmäterimyndigheten i Stockholms kommun 2021-12004-421 — 2022-03-31 — Aktbilaga PR1, Sida 2, Akt 0180K-2021-12004

Slutliga yrkanden

G Nord yrkar att fastighetsbildning och inrättande av gemensamhetsanläggningar ska ske enligt utsända och genomgångna utkast, vilka i huvudsak överensstämmer med ansökan, aktbilaga A1, samt kompletterande yrkanden, aktbilagor YR1, YR2 samt A2, med de tillägg och ändringar som gätts igenom, det vill säga:

- **Avstyckning från Södermalm 7:87** av 3D-fastighet (blivande Södermalm 7:90) bestående av del av Stadsgårdsledstunneln, inklusive
  - *servitut för* ***lastnedföring*** *för stamfastigheten inom stycknings-lotten respektive inom styckningslotten för stamfastigheten.*
- **Fastighetsreglering från Södre Torn 1 till Södermalm 7:90** (3D) för del av Stadsgårdsledstunneln, inklusive
  - *servitut avseende* ***teknikutrymme*** *inom Södre Torn 1 till förmån för Södermalm 7:90.*
- **Fastighetsreglering mellan Södermalm 7:87 och Södre Torn 1** (2D och 3D) för att tillskapa en planenlig utformning av Södre Torn 1, inklusive
  - *servitut avseende* ***allmänhetens rätt till passage*** *(x-område) inom Södre Torn 1 till förmån för Södermalm 7:87*
  - *servitut avseende* ***förankringsstag*** *inom Södre Torn 1 till förmån för Södermalm 7:87,*
  - *servitut avseende* ***dagvattenledningar*** *inom Södre Torn 1 till förmån för Södermalm 7:87.*
- **Fastighetsreglering mellan Södermalm 7:87, 7:90 och Södre Torn 1** för att tillskapa servitut
  - *servitut avseende* ***dagvattenledningar*** *inom Södre Torn 1 och Södermalm 7:87 till förmån för Södermalm 7:90,*
  - *servitut avseende* ***ledningar*** *inom Södre Torn 1 och Södermalm 7:87 till förmån för Södermalm 7:90.*
- **Anläggningsåtgärd** för att tillskapa gemensamhets-anläggningar för
  - ***bärande konstruktioner mm enl YR1****, deltagande fastig-heter Södermalm 7:87, Södermalm 7:90 och Södre Torn 1,*
  - ***inlastning (västra inlastningen) samt gemensam korridor enl YR2****, deltagande fastigheter Södermalm 7:87, Södermalm 7:90 och Södre Torn 1,*
  - ***sprinkleranläggning****, deltagande fastigheter Södermalm 7:87 och Södermalm 7:90,*
  - ***tomrör för brandvatten****, deltagande fastigheter Södermalm 7:87 och Södre Torn 1,*
  - ***passager (2 st)****, deltagande fastigheter Södermalm 7:87, Södermalm 7:90 och Södre Torn 1.*

Anm. YR1 inkom via e-post 2022-03-22. YR2 inkl bilaga 2 inkom via e-post 2022-03-25. Bilaga 1 till YR1 inkom via e-post 2022-03-11.

Figure 14. Extract from property formation dossier. Left: Verbal description of actions in the property formation decision. Right: One page of the protocol summarising the applicants claims for desired design of the property formation. From the property formation dossier of Södre Torn 1, 0180K-2021-12004. City of Stockholm

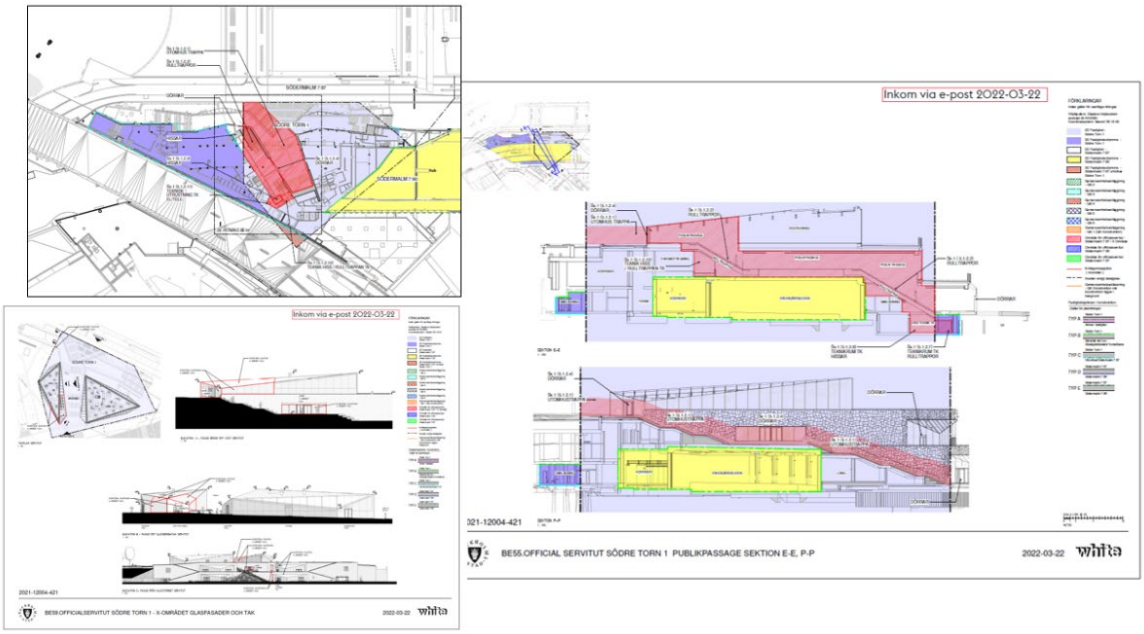


Figure 15. Extract from property formation dossier. Drawings describing boundaries of 2D and 3D property units as well as other RRRs. From the property formation dossier of Södre Torn 1, 0180K-2021-12004. City of Stockholm

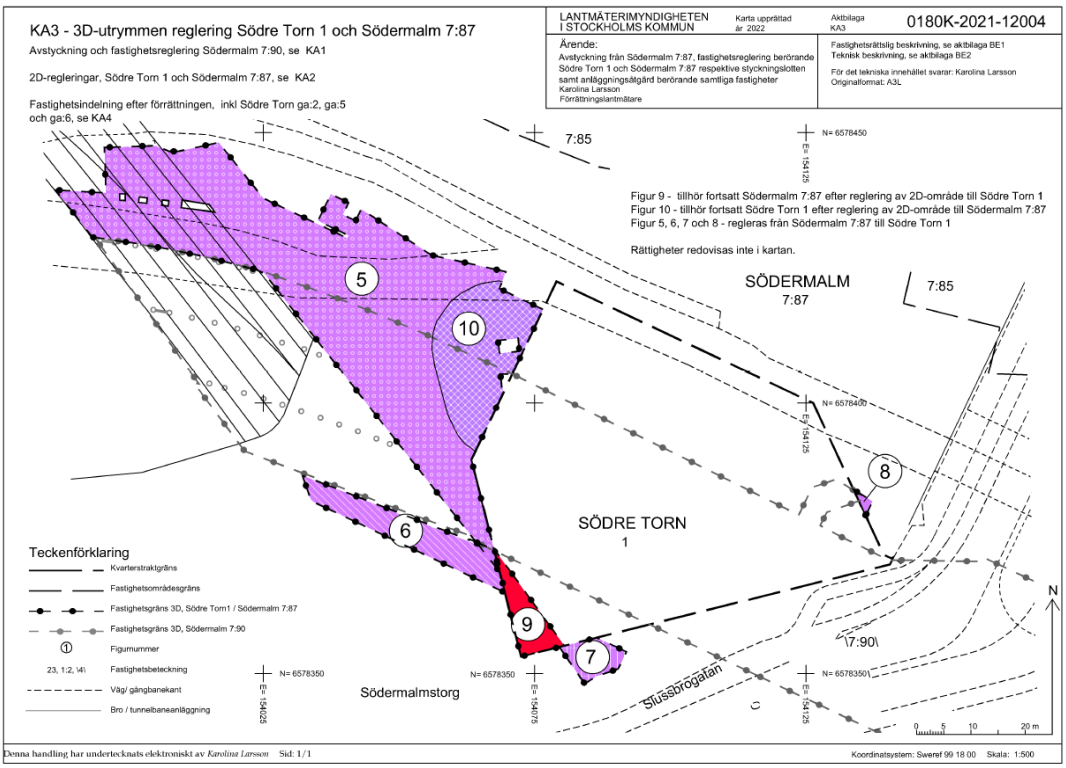


Figure 16. Extract from property formation dossier. Cadastral map no 3 (KA3), showing, among other things, the four 3D property sub-areas of Södre Torn 1. Dossier 0180K-2021-12004. City of Stockholm

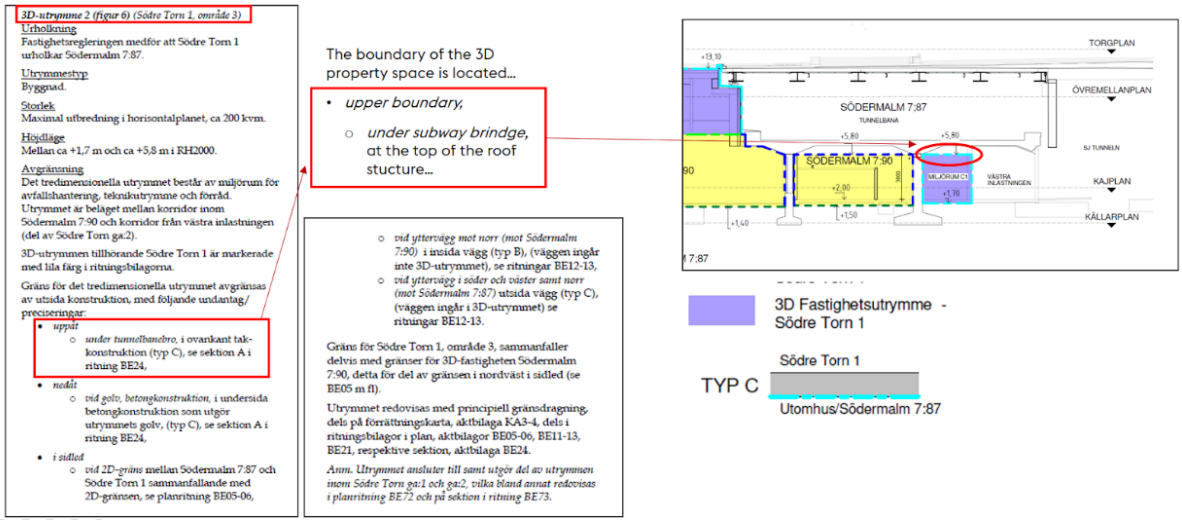


Figure 17. Extract from property formation dossier. Text describing boundaries and the same boundary represented in drawings. Both text and drawings are part of the property formation decision. From the property formation dossier of Södre Torn 1, 0180K-2021-12004. City of Stockholm

Since the area where Södre Torn 1 is located is still a construction site, it is not possible to visit and make sure that the boundaries are located in such a manner that it creates suitable property units, for example regarding their placement in reference to actual building parts such as walls and floors. Therefore, the cadastral surveyor has to rely on drawings and pictures from 3D models and other relevant data when determining that the 3D property unit created is deemed suitable for its purpose.

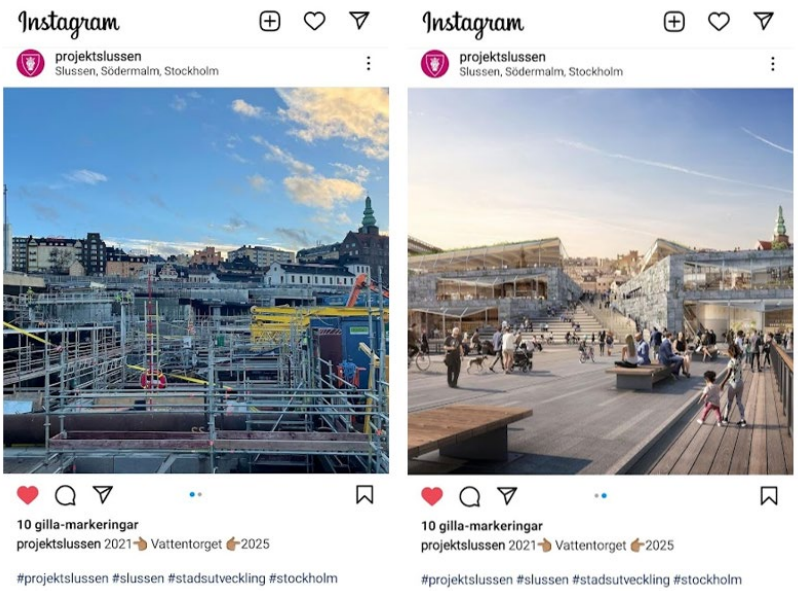


Figure 18. Picture on the right shows what the buildings within the property unit Södre Torn 1 are planned to look like when completed in 2025. Picture on the left shows the actual view of the same area in 2021 when the property unit Södre Torn 1 was about to be created. Adapted from Larsson (2021)

The 3D volumes of existing 3D property units cannot be distinguished in the digital index map, since it only displays objects in 2D. What can be deducted from the map is the maximal spread of each 3D volume. There can be several sub-areas, in 2D and/or 3D, belonging to the same real property unit.

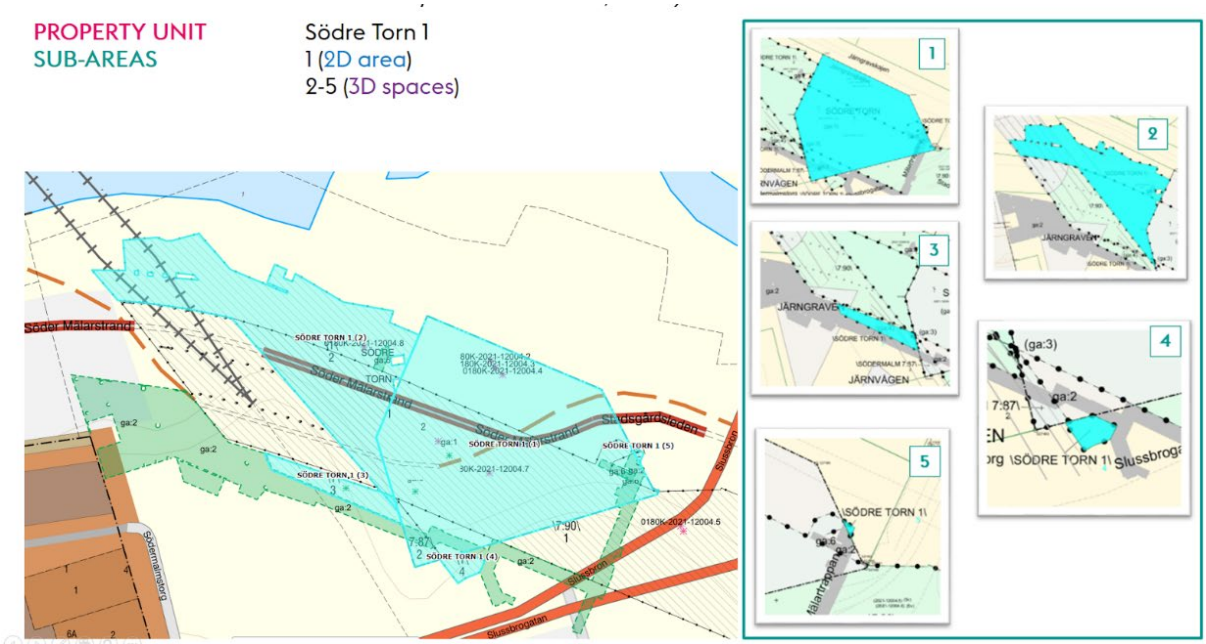


Figure 19. The property unit Södre Torn 1 consists of five sub-units (marked with turquoise), one in 2D and four in 3D. The sub-unit in 2D is partly hollowed by two other 3D property units. 3D property lines are marked by black dashed lines with filled dots on. Some of the existing joint facilities are marked in green in the left picture and grey in the ones on right. Picture on left extracted from the cadastral index map of Lantmäteriet, GeoVy. Pictures on right extracted from cadastral index map of City of Stockholm.

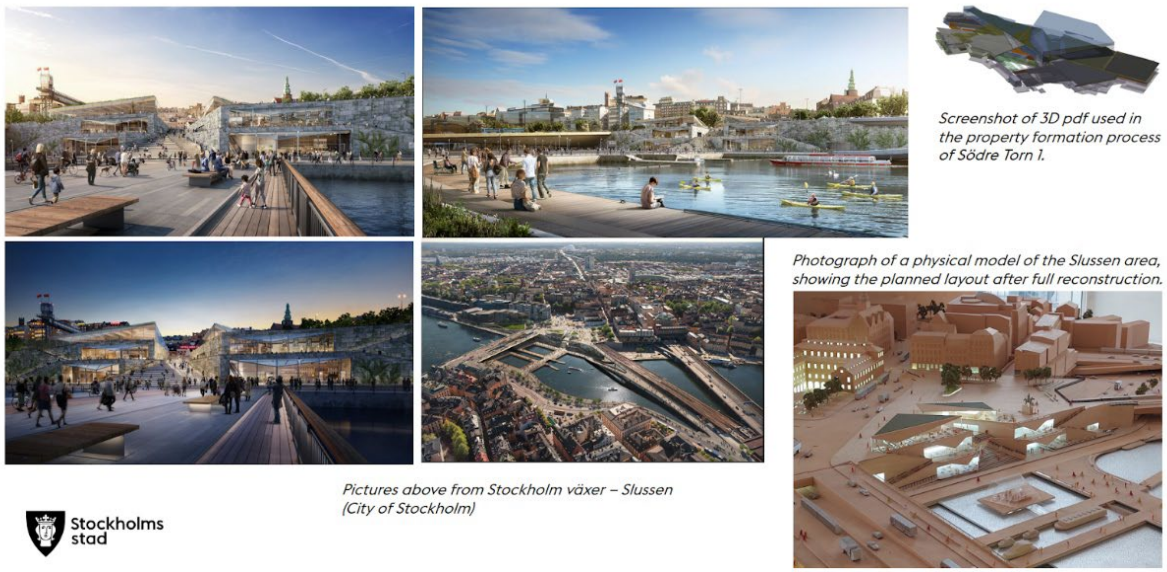


Figure 20. Illustrations of the planned layout of the Slussen area once completed. Adapted from Larsson (2021)

4. ANALYSIS AND DISCUSSION

Sweden has a secure legal process for forming 3D real property boundaries. However, the Slussen project has shown that current methods to register and describe 3D real property in the national real property register is not sufficient in complex building- and infrastructure constructions containing a multitude of RRRs on different levels and extensions, which hinders an effective property formation process. One experience is that it is not possible to be as detailed in the planning phase as in the property formation phase, but the data must be detailed enough so that property formation can be made according to plan. Especially the boundaries between public spaces and the building sites should be clearly visible.

3D digital models of the constructions, such as BIM models, are often used as input in the property formation process. These models are however not stored digitally in the national real property register but reduced to 2D pdf-files making the interpretation of details difficult, especially when a property has to be altered or a new adjacent 3D property has to be formed. It is possible to store models locally at municipality level, but this may give rise to difficulties when e.g. a property has to be formed on the other side of a municipal boundary.
Another issue to be solved is the copyright of the digital building models being used in the property formation process, e.g. by having contractual agreements for further use of the digital information therein, often being owned by the construction companies.

It can be noted that if a 3D model could legally have been a part of the property formation decision for the property unit Södre Torn 1, the boundaries and other RRRs would probably have been easier to describe and visualise.

5. CONCLUSIONS

This paper illustrates the need for a national cadastral index map in three dimensions to be used in the formal real property formation procedures, to achieve a comprehensible and correct representation and visualisation of 3D real properties and RRRs in Sweden.

The results can be used as input in coming property formations of a similar kind, as well as a component for the development of a national three-dimensional cadastral index map. Furthermore, the results can be an input to capacity building for the future use of 3D models as part of the formal cadastral property formation procedure.

It is recommended to investigate the possibilities to change the legislation so that a 3D model can be part of a 3D property formation decision in order to make it easier to describe and visualise 3D property boundaries. Such future solutions would have to include the legal aspects of strategies for archiving property formation dossiers in this form. It is also recommended to investigate whether a national 3D digital cadastral index map is economically and practically feasible to create on a national basis in the future.

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