Visualisation of 3D Property Units - experiences from a case study in Stockholm, Sweden

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

SUMMARY

This paper focuses on experiences concerning a project aiming at visualisation of three-dimensional (3D) property units in Stockholm, Sweden. The Swedish national registration system, the national real property register, includes a textual description as well as a two-dimensional map, normally consisting of a scan of the legal map document produced during the property formation process. Today, a 3D-pdf or a BIM model cannot be part of the formal property formation decision and documentation. It can thus be difficult to illustrate 3D real property on just a two-dimensional map.

The paper describes a project carried out by Stockholm municipality to visualise 3D property unit volumes within the municipality by combining them with existing 3D city models (including building- and terrain models). The aim is to show and analyse the problems and challenges identified in the project by illustrating what has been done and how the use of 3D real property information can be further developed in the future.

The method used in this research is a document study of the project focusing on representation in the digital cadastral index map for 3D real property units as part of the national real property register, as well as associated documentation from other agencies, and by interviewing key persons involved in the project.

The project created a local 3D model which is stored in the municipality´s own internal database. Some information was retrieved from the national real property register, such as information on height (lowest and highest) and the horizontal expansion of the real property. Data was then processed and analysed using Feature Manipulation Engine (FME) to create 3D property volumes. The project used in-house software and data as much as possible. The volumes were stored in the municipal database.

The 3D volumes could be used as a supplement to the information stored in the national real property register and the cadastral dossiers. The results can be used as a component for the development of a national three-dimensional cadastral index map as well as for enabling 3D models as part of the formal cadastral property formation procedure.

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1. INTRODUCTION

It has been possible to form 3D real property and property volumes (hereafter called 3D property units) for almost twenty years in Sweden. The number of 3D property units is increasing, even if they still are a rather small number in relation to other forms of real property. The current number of 3D objects in the national real property register is ca 5000 (LM 2023). Swedish 3D property volumes are described by two-dimensional drawings and a verbal description. These drawings may consist of or include sections of 3D models in the form of a picture or 2D drawings. All Swedish real properties are described in the national real property register. The register has a textual part and a geometrical part, where the maximal extension for 3D volumes only are described horizontally and with the highest, respectively lowest, point for the volume. This makes it difficult to obtain a vision of the volume's exact extension and form. Many actors have the need to determine the exact extension of a real property, for example property owners, building permission staff, city planners, different agencies and the building industry.

1.1 Problem description

3D property units are difficult to present in a two-dimensional map. The Swedish Cadastral Index Map is part of the national real property register and is currently only displaying data in 2D. It provides, in the case of 3D real estate spaces, mainly information about approximately where the 3D property unit is located. The exact extension cannot be determined solely from the property register. The owner of the 2D property unit that is hollowed out by the 3D property unit can therefore recognise that the hollowing is not located outside the boundaries specified in the property register, but it is not possible to identify the exact locations of its boundaries. To know exactly where the property boundaries are located within these 2D boundaries, the documents in the property formation dossier must be consulted; it is only there that the exact location of the property boundaries is recorded.

The property formation dossier consists of 2D drawings (usually pdf files). Currently a 3D pdf or BIM model or similar cannot form part of the property formation decision. A 3D volume therefore needs to be presented in the form of 2D drawings and verbal description.

Stockholm Municipality has implemented a project to visualise 3D property units within the area of the municipality in the form of volumes that are combined with an existing 3D city model. The project has not focused on detailed and accurate volumes, but instead on an overview design and location in relation to the borders of other properties and in relation to the location of buildings, in order to be able to make a rough assessment of the location and design of the respective 3D property units.

There is today no national system for registration or storage of 3D files such as BIM files. Today, this results in that many files are stored locally e.g. by the City of Stockholm.

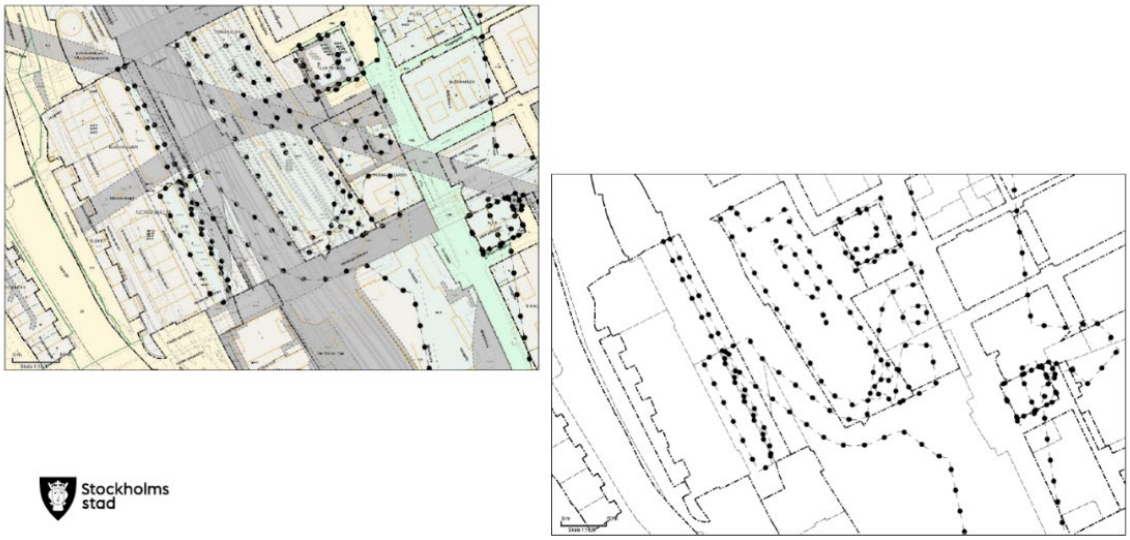

Figure 1. Selection from the cadastral index map used in the City of Stockholm. The left image includes all RRRs as well as buildings and other infrastructure, while the right image only shows real property boundaries (3D property boundaries are displayed by a filled circle on the dashed line). Adapted from Larsson, Nordqvist-Darell (2021)

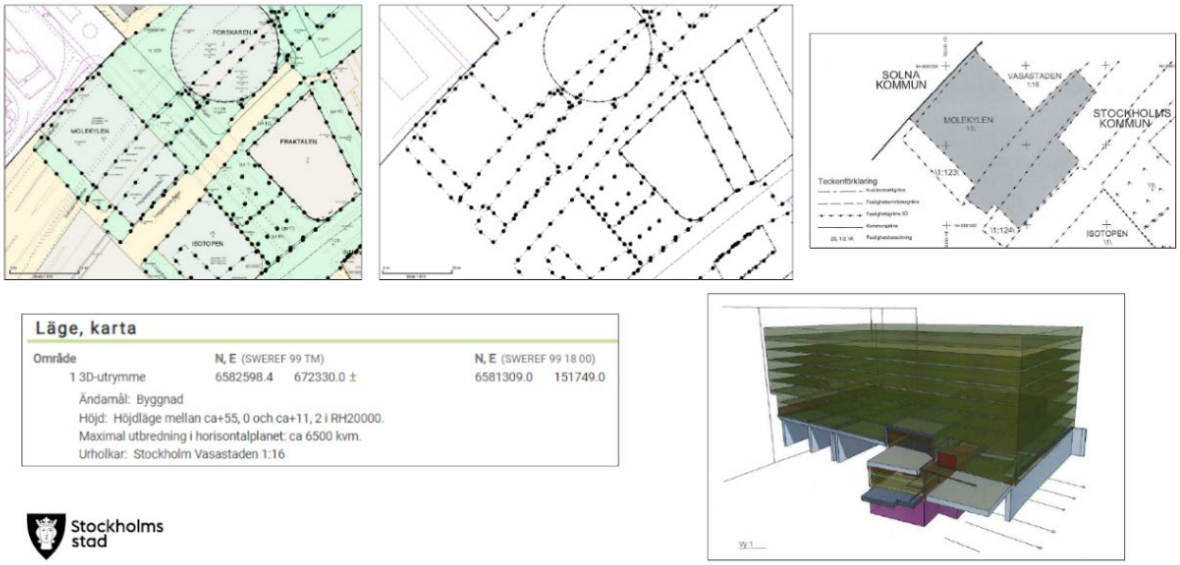

Figure 2. Top right and top middle: Selection from the cadastral index map used in the City of Stockholm. The left image includes all RRRs as well as buildings and other infrastructure, while the right image only shows real property boundaries (3D property boundaries are displayed by a filled circle on the dashed line).Top right: Map from property formation dossier including 3D property units. Lower left: Textual information about a 3D property unit in text as part of the land register, the only information is approximate maximum "footprint" by the 3D property unit, coordinates for the centre of the 3D property unit, as well as approximate maximum and minimum height position for the 3D property unit. Lower right: Screenshot from 3D model of 3D property unit, used as part of the property formation decision. Adapted from Larsson, Nordqvist-Darell (2021)

1.2 Aim and method

The paper addresses problems and challenges concerning visualisation of 3D property boundaries in Sweden based on experiences from a 3D property project in Stockholm. Focus lies on legal issues, although other aspects are mentioned as well.

The methods used in this research are the study of the cadastral and other project documents kindly provided by Stockholm municipality, supplemented with interviews of participants (e.g. cadastral surveyors, 3D visualisation experts and geodata strategists) from the municipality participating in the property formation project.

2. SWEDISH 3D PROPERTY RIGHTS

3D property units are real property limited by vertical as well as horizontal boundaries. Examples are ownership apartments and other building constructions such as tunnels, parking garages and other technical installations. It has been possible to form 3D real property units in Sweden for almost two decades. The Swedish national registration system, the national real property register, includes a textual description as well as a traditional, two-dimensional map, normally consisting of a scan of the legal map document produced during the property formation process. A traditional, two-dimensionally delimited, property is an area of land and/or water with attached property fixtures. The two-dimensional property has no upward or downward limitation, making it include in theory all air upwards into the sky and the ground down to the centre of the earth. In practice, the extension above and below ground is limited by how much the property owner can use. When the law came into force in 2004, it became possible to form properties also with horizontal boundaries, forming three-dimensional (3D) property units. For further information on the Swedish real property system, see Larsson et al. (2018).

The extension of a 3D property is thus bounded both horizontally and vertically. Compared with other jurisdictions (see e.g. Paulsson, 2007), Sweden has no specific legal rules for how to draw or visualise the cadastral boundaries in relation to the physical building construction. Since the 3D property shall contain a building or facility (Swedish Real Property Formation Act), the boundaries shall in principle follow the construction. However, according to the recommendations, there is a possibility to also include a small volume of air in the property unit in order to include protruding construction details for e.g. maintenance if deemed appropriate.
The Swedish national registration system, the national real property register, includes a textual description as well as a two-dimensional map, normally consisting of a scan of the legal map document produced during the property formation process. The property formation decisions presented in the cadastral map contain a mixture of properties and rights which are in some cases delimited in height and in some cases have no definite limitation in height. The decisions may also contain rights that are not specifically located within the properties at the time of the decision.

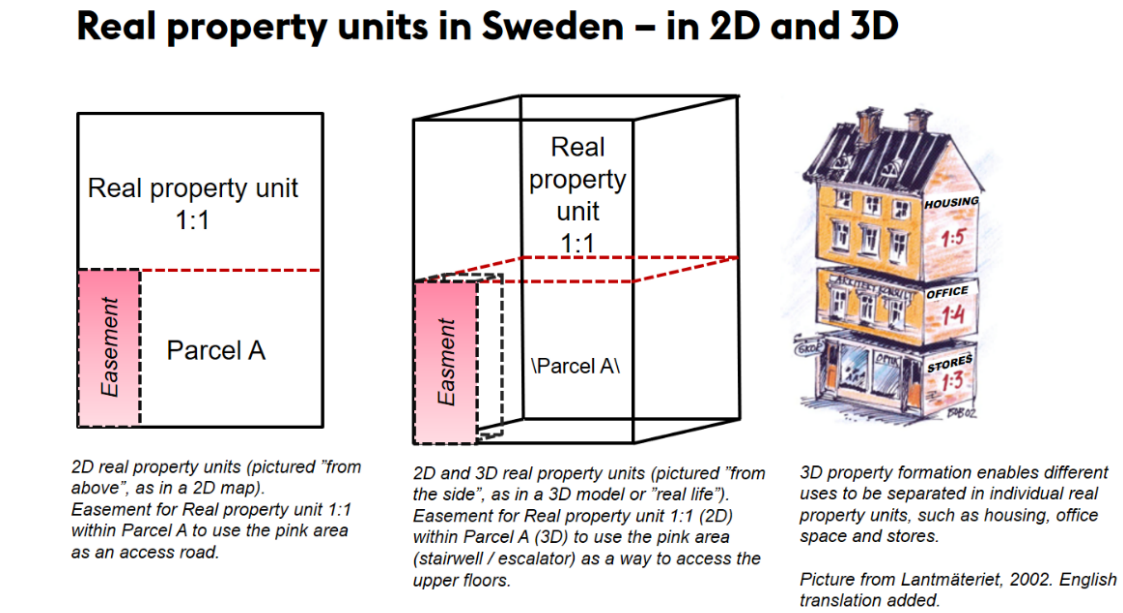

Figure 3. Description of difference between 2D property formation and 3D property formation in Sweden. Adapted from Larsson, Engström Askelin (2015)

3D property units have been possible to create in Sweden for about 15 years and the numbers are constantly growing. The complexity of design increases and several different 3D property units are located within the same 2D area in several locations.

Figure 4. Selection from cadastral index map used in the City of Stockholm, showing around 50 of the close to one thousand 3D property units registered within the Stockholm municipality. City of Stockholm 2023

There has in recent years been published several publications concerning 3D property formation in Sweden focusing primarily on the legal aspects as well as visualisation of three-dimensional RRRs. See e.g. Andrée et al. (2020); Larsson et al. (2018, 2020, 2023), Seipel et al. (2020).

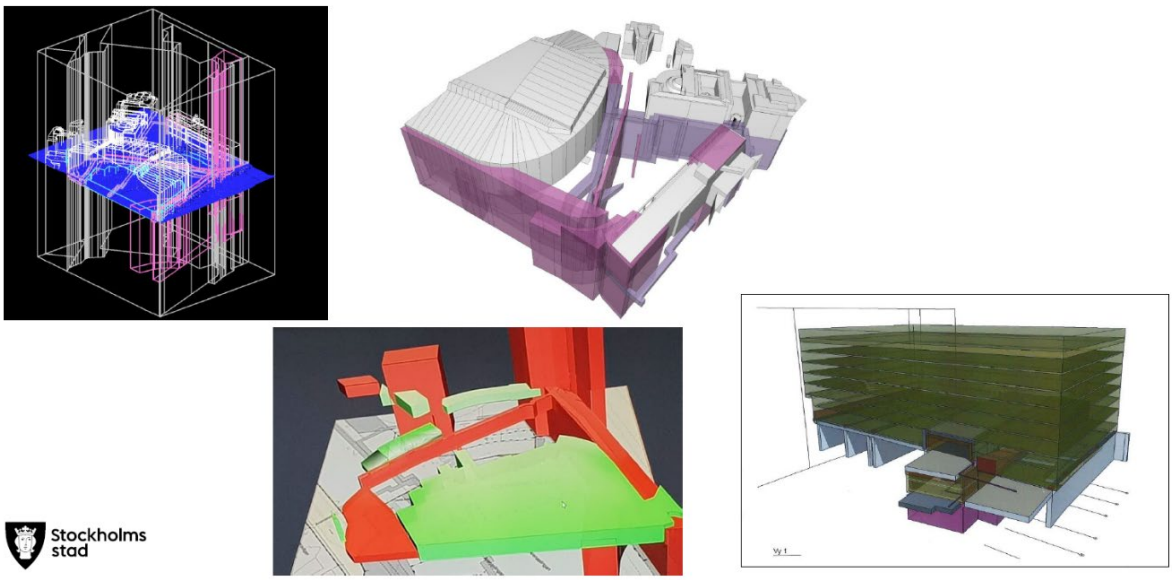

Figure 5. Test with visualisation of 3D real property boundaries and volumes. See e.g. Andrée, et al. (2020), Larsson et al. (2020), Seipel et al. (2020), Larsson et al. (2018, 2023)

Nationally and internationally there has been conducted previous research in this field, but we have not found research focussing on the exact same conditions. Examples where 3D models have been in focus are SmartBuilt (2018; 2021), Sun et al. (2019); Sun et al. (2021), Sun (2022). Analogue real property information that has been digitised into 3D models have been addressed in for example SmartBuilt (2020). Swedish 3D property boundaries have been researched in e.g. Larsson et al. (2020), Seipel et al. (2020), and Sun et al. (2019).

3. CASE STUDY

The case study worked on creating a local 3D model for the city of Stockholm where the information is saved in an internal system. The project was based on the use of existing tools and data. Height information (highest and lowest height) for existing 3D property units has been extracted from the textual part of the real property register, the maximum extent (area) has been retrieved from the cadastral index map. The data has then been processed with Feature Manipulation Engine (FME) to create volumes that correspond to the maximum extent of the respective 3D property units (i.e. the volume within which the entire 3D property unit fits). The volumes are saved in a separate internal database that can be read together with other existing databases, such as a 3D city model (including ground model and building model).

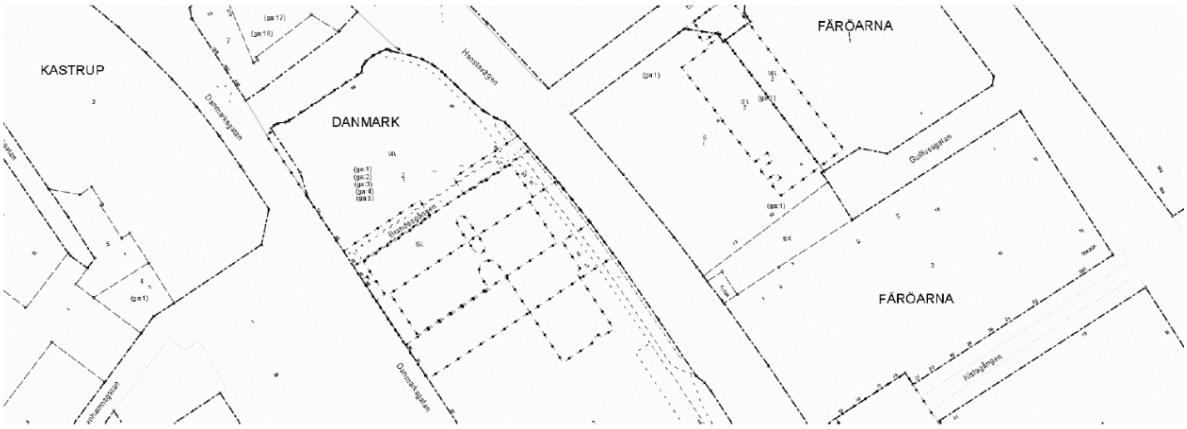

Figure 6. Representation of 2D and 3D property units in the existing cadastral index map. 2D property lines are illustrated with a dashed line, maximum spread of 3D property units are illustrated with a dashed line with filled circles on each section. Adapted from Larsson, Nordqvist-Darell (2021)

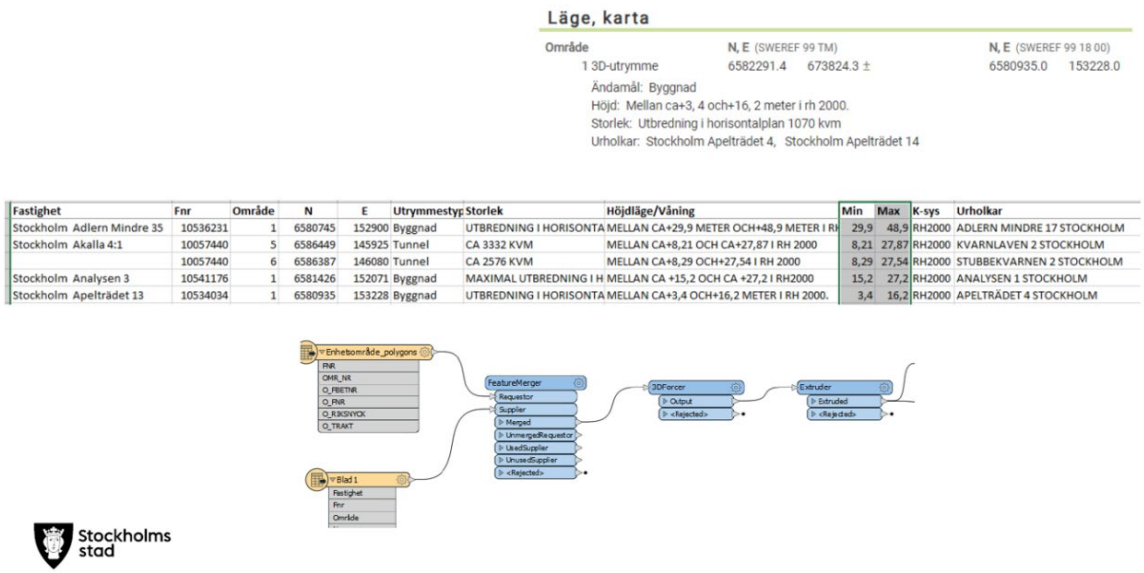

Figure 7. Existing 2D data being used for the project to create 3D volumes. Height information retrieved from the real property registry (top right) and surface spread from the Cadastral Index Map, the data is then processed using FME. Adapted from Larsson, Nordqvist-Darell (2021)

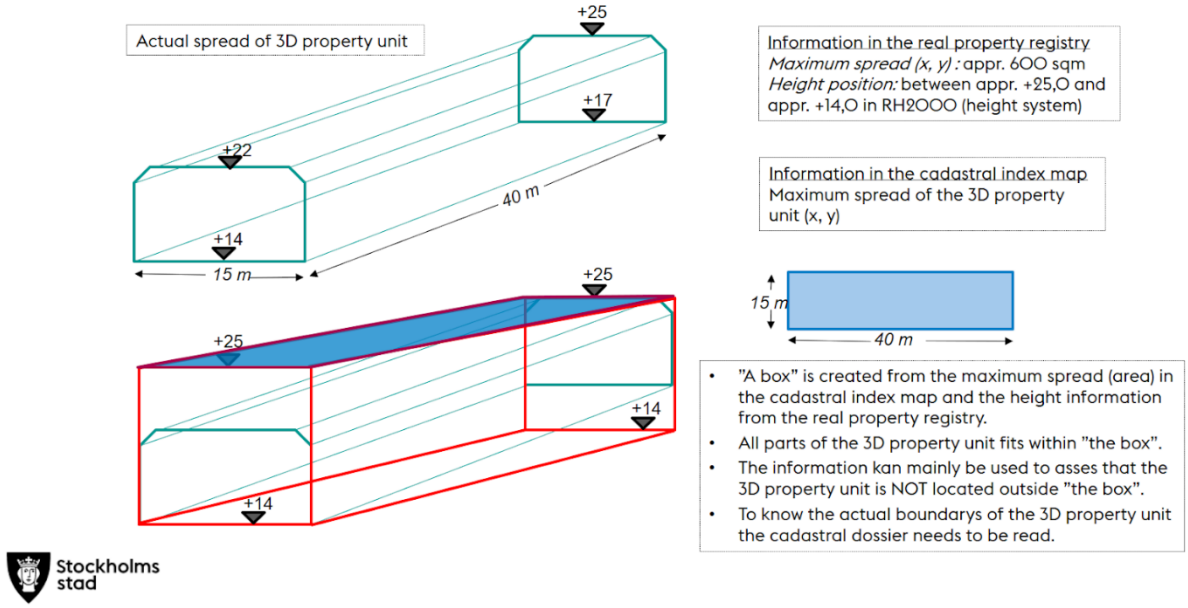

Figure 8. Illustration of specification of 3D real property units in the Swedish real property registry and cadastral index map. The red square illustrates the general 3D volume created in the case study. Adapted and translated from Larsson, Nordqvist-Darell (2021)

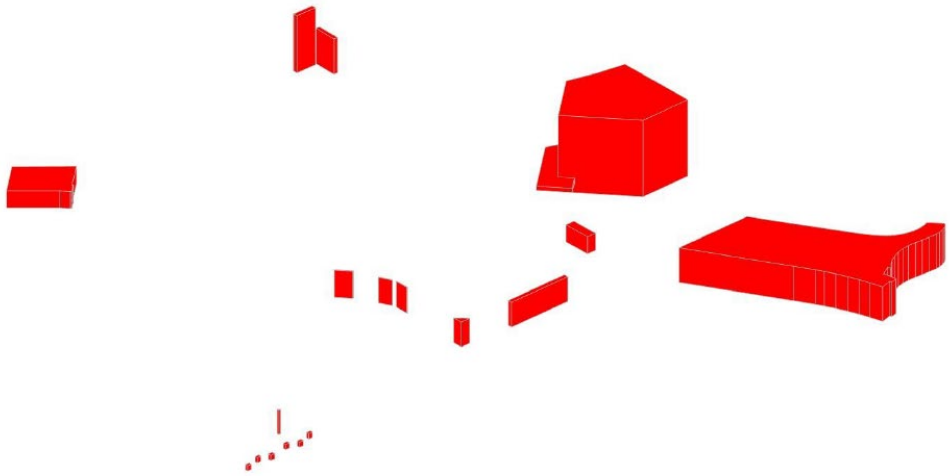

Figure 9. Picture from the database containing 3D property units. Adapted from Larsson, Nordqvist-Darell (2021)

Manual processing of the volumes was done when needed, including for very extended 3D property units (e.g. railway tunnels), where the highest and lowest heights resulted in the 3D volume for the tunnel ended up above ground in some parts, as well as where a smaller part of the 3D property unit (e.g. stairwells on a lower level than the rest of the property unit) means that the total spread is perceived to be greater than it actually is if not adjusted. In these cases, the 3D volume has been reduced to more accurately account for the actual spread, however none of the 3D volumes have a complete accuracy.

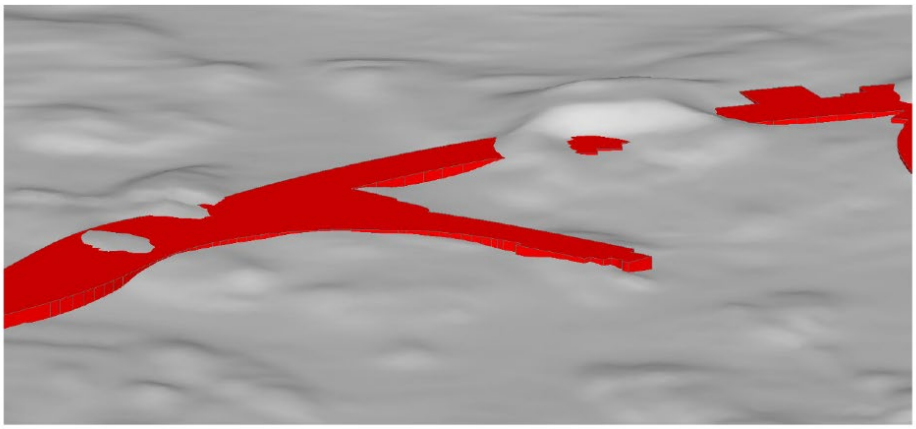

Figure 10. Illustration of specification widespread 3D property unit (tunnel) that appeared to be located above ground before manual adjustments. Red volumes represent the created 3D volume, grey spread is a representation of the ground model. Adapted from Larsson, Nordqvist-Darell (2021)

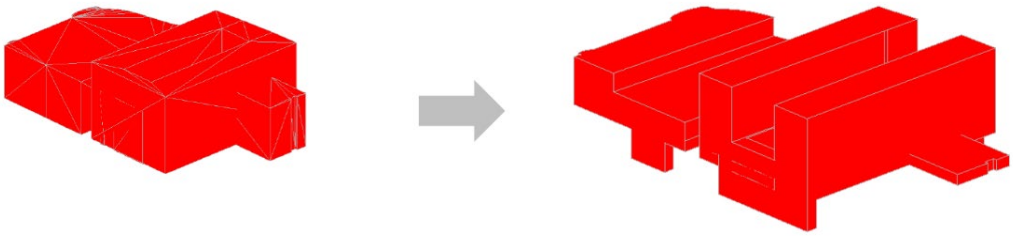

Figure 11. Illustration of 3D volume before and after manual adjustment. Adapted from Larsson, Nordqvist-Darell (2021)

Once the volumes had been produced, they were visualised together with the 3D city model (and/or ground model). Manual processing produced images with the highest possible readability. Images from suitable angles have been saved as pdf files that become available to case managers.

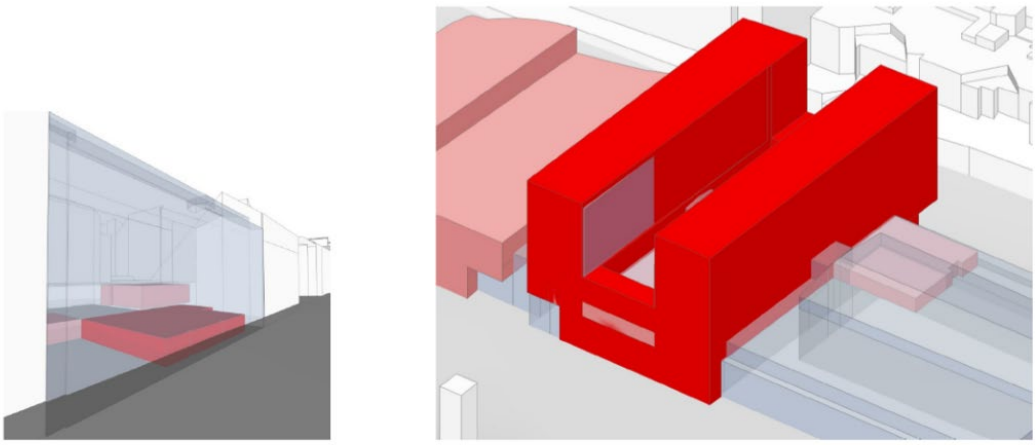

Figure 12. Illustration of 3D volumes (red) presented and visualised in combination with the 3D city model. Adapted from Larsson, Nordqvist-Darell (2021)

The project of visualising existing 3D property units started with the goal of providing a clearer picture of the design of 3D property units within the municipality of Stockholm and thus being able to streamline and save time in issuing building permits, town planning, administration, permit review and other legal tasks in municipal operations. A better and more accurate representation of property boundaries leads to greater legal certainty and minimises incorrect decisions and is a prerequisite for a fully digitised civil engineering process. The aim of the project was to be able to present 3D property units in the form of 3D volumes to make them easier to understand, especially for users who lack specialist competence in the field but need the information for their handling. The 3D volumes are intended to be used as a supplement to the property register and the documents in the executive acts.

The target group for the project results was administrators at the city planning office in the city of Stockholm who come into contact with 3D property units in their cases, mainly building permit administrators, administrative surveyors and plan administrators, with an initial focus on building permit administrators.

The officers can access the information by clicking on the affected 3D property unit area in the existing map system, then a picture will appear where you can see the relevant documents from the property formation dossier where the 3D property unit area was formed, and the selected images of the 3D visualisation. The files in the system are attached with a shorter text about where the 3D property unit is located and what it consists of, for example "garage in two floors underground". This text alone may be, for example, sufficient for a building permit officer to be able to ascertain that a building permit does NOT affect the 3D real estate space in the event that the application concerns changes within the building above ground. The 3D volumes can also give indications of whether the requested action is located within or outside the current 3D real estate space.

A minor evaluation by building permit officers has been made as part of the project and the results indicate that the individuals who have tested the new features to visualise 3D property units believe that the information can help in the daily work of building permits when these are located within or close to 3D property units. The project is intended to be continued by investigating more accurate 3D volumes to be created alongside new property formation decisions, i.e. with the use of BIM models or other 3D models displaying 3D property units and RRRs.

4. ANALYSIS AND DISCUSSION

The Swedish example is a description of a problem often encountered in the real property formation process of 3D properties. This approach to the problem shown in the paper has not to the authors' knowledge been noted in earlier research and is thus of interest for the scientific community in Sweden and abroad.

The results of this project is in line with the previously mentioned research on 3D real property, showing that there is a need for better registration of 3D RRR. It is in the current situation not possible to see volumes in relation to the real-world scenario. The experience of

the project is that it is beneficial for the cadastral procedure that volumes are visualised with more detail than their maximal extension. A development concerning improving the current registration of 3D volumes could focus of different challenges, such as what data quality is needed on object level as well as thematic level, the use of different colours, symbols and textures for visualisation for specific stakeholders and groups of users, which data is legally binding and what data is informative, just to mention some examples. The registration of 3D cadastral information can be seen as a paradigm shift, going from a 2D focus to a 3D focus in the cadastral index map. This shift, however, needs to include research regarding legal issues, such as what information is legally binding and how data is to be displayed in a correct and informative way.

Currently, a research project planned for 2023-2025 within the Swedish Smart Built Environment programme (SmartBuilt, 2023) will analyse possibilities and challenges concerning extended registration and visualisation of 3D real property in the national real property register. The project is a cooperation between academia, Lantmäteriet (the Swedish mapping, cadastral and land registration authority), municipalities as well as private companies. The Smart Built Environment programme is a strategic innovation programme for outlining how the built environment sector can make use of new opportunities of digitalisation.

5. CONCLUSIONS

The purpose of the visualisation was to make 3D real property information more accessible to users of cadastral information, especially if they lack specialist knowledge but need to use 3D information as part of their employment at Stockholm Municipality, such as cadastral surveyors and planners. The 3D volumes could be used as a supplement to the information stored in the national real property register and the cadastral dossiers.

The results can be used as a component for the development of a national three-dimensional cadastral index map as well as for enabling 3D models as part of the formal cadastral property formation procedure.

The procedure used in the project, where simple representations of the 3D property units were created, could with quite small effort possibly be used to visualise all 3D property units in the Swedish real property register by using FME. However, there is today no national system for registration or storage of 3D files such as BIM files. This results in that many files are stored locally, e.g., by the City of Stockholm. To create a national system for registration and storage of 3D files would be beneficial on a national level, especially if a national approach of creating 3D volumes would be attempted.

The project has also shown that it would be beneficial to investigate further the possibilities of creating more accurate and detailed 3D volumes.

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BIOGRAPHICAL NOTES

Karolina Larsson is a cadastral surveyor working at the Cadastral Authority of the City of Stockholm (Lantmäterimyndigheten i Stockholms kommun), concentrating on 3D real property units and property formation. She holds a MSc degree in Land Surveying, concentration on Spatial Planning, from the KTH Royal Institute of Technology. She has been, and is currently, participating in several projects looking at possibilities to transform to a 3D cadastre as well as use of 3D models in cadastral procedures in the Swedish context

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