Virtual 3D Models as a Basis for Property Formation

Martin ANDRÈE,Goran MILUTINOVIC and Stefan SEIPEL, Sweden

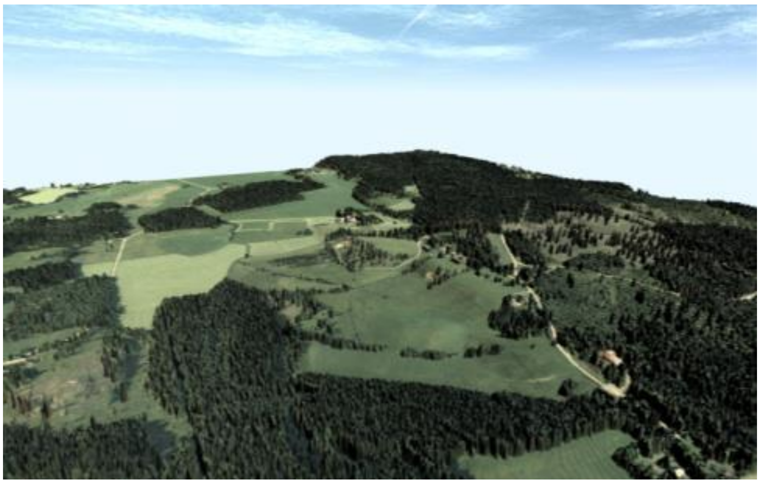
Key words: LIDAR, 3D, Cadastre, Survey, e-government, process development

SUMMARY

Property formation is the process of making changes in the real estate division by forming new or modifying existing properties.

Various customer surveys in Sweden have shown that the cost of property formation is perceived as high, but also that cases take too long to process. If the costs and case handling times are reduced, it will directly benefit the landowners and also society at large by getting the real estate market streamlined. The field survey is estimated to account for at least one tenth of the total cadastral operations.

A field visit is often necessary to sort out the legal boundaries' condition, and to arrive at a decision for location of new boundaries. Additionally, all new or reorganized properties are required to be suitable for its purpose, an assessment which often requires an on-site visit.



This paper is based on a study that investigates how access to 3D information can be used to support an efficient administration of the land survey focused on fieldwork in the cadastral procedure. The study investigates how data quality is managed to create a 3D model from available information and a technical description of the implementation of 3D model in a demo application.

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1. INTRODUCTION

Property formation is the process where the cadastral procedure is based on an application to change in the property division. A regularly accruing type of case is subdivision of residential lots, another is to move a boundary between two properties. The property formation procedure is funded entirely by fees from the customer. Property formation in Sweden has a turnover of approximately SEK 800 million per year, and is conducts within the Swedish Land Survey (the national cadastral agency) and within the 39 municipal cadastral authorities in the larger cities in Sweden.

Various customer surveys over the years have shown that the cost of property formation is perceived as high, but also that cases take too long to process. If costs and lead times can be reduced, it will directly benefit the land owners, but also society at large by making the real estate market more efficient.

During property formation visits in the field are often necessary to sort out the boundary conditions. Placement of new boundaries is also almost always done physically in the terrain. Additionally, all new or reconfigured properties are to be suitable for their purpose, calling for an assessment which often requires a site visit by the land surveyor. The field work is expected to account for one tenth of the total cost for cadastral operations. If the number of site visits can be decreased, this is assumed to result in reducing both delivery times and costs for property formation cases.

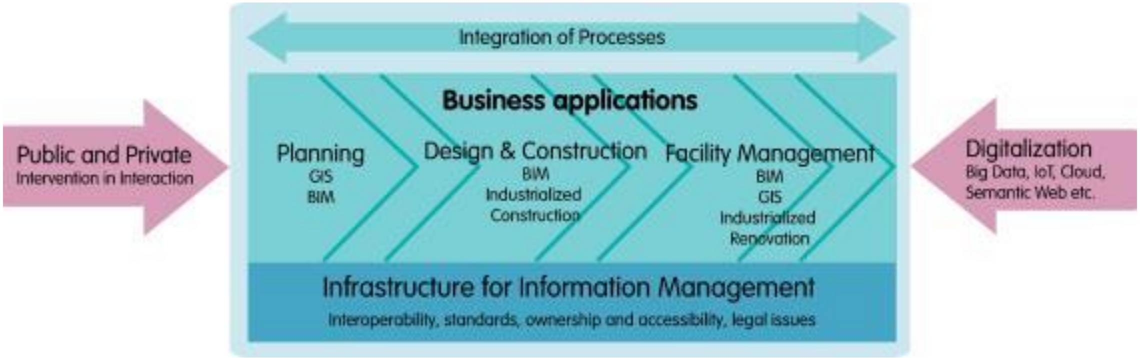
A government commissioned mission to the Swedish Land Survey regarding the provision of mapping and image data in three dimensions (3D) in 2014 (Ref LMV 505-2013 / 3895) points to the possibility of having access to geodata in 3D can lead to reduced costs of property formation procedures.

1.1 National strategies for 3D

Geodata in 3D has begun to be used as an aid in governmental process, especially for planning and design tasks. The largest developments have happened in construction and project planning, where BIM now is coming to frequent use. The overall use of geodata has also increased, but is limited within 3D by factors such as lack of standards for data and data exchange.

The rapid development of digitization processes is a current driving force for change in construction and planning. The vision for the Swedish national strategy for 3D is to facilitate

"Sustainable construction and maximum user benefit through effective information management and industrial processes".



Many municipalities are far ahead in the use of geodata in 3D, including visualization and tools in the civil dialogue in the context of community development, outside the urban areas, it relies on the Swedish Land Surveys basic geodata. Larger municipalities are currently the biggest users in the field of 3D city models and accounting of buildings in 3D. However, there is a lack common policies and standards, and also at different stages of their 3D maturity. One can perhaps assume that the lack of national standards and guidelines contributed to chosen different paths.

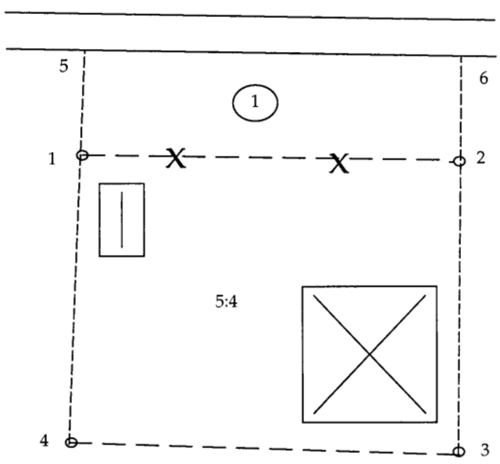
1.2 Properties and cadastral procedure in Sweden

The property formation consists of all the elements of a cadastral procedure from the landowner's application until the result is registered in the Land Registry. In this process, the cadastral surveyor gathers adequate information for making judgments about the legal situation, examine the application submitted and then decide on changes in the property division and /or rights.

The decisions are documented in the cadastral archives and supplemented by physically marking boundaries and rights situation on the ground during the field survey. The process involves contacts with authorities, institutions, rights holders, interested parties, etc. In most cases field survey is done to select and measure the boundary points and sometimes field visits are made to get the full picture of the property formation results.

The result of the cadastral procedure must be unambiguous, understandable, and suitable to reconstruct and measure boundary points to keep a minimum level of quality. If the cadastral surveyor finds that the results can be documented in a way where the minimum level of accuracy can be achieved without field visits / field work, this may be dispensed with.

Cases without the need of field work occur often where no new borders are created when the entire parcel is regulated to another property. In these cases there is often a simple suitability assessment by studying the cadastral map, this can also be considered for cases where new boundaries are created and the minimum quality can be achieved by the use of projected boundary points (see picture below).



Examples of property formation of area 1 where the base level under certain conditions can be achieved by paragraphs 5 and 6 is calculated as the extension of the line through the point and 4-1 respectively . point 3-2

2. DATA QUALITY

The Swedish Land Survey has since 2009 been commissioned to produce a national elevation model with high accuracy. In this process the Swedish Land Survey has chosen to use the technology LIDAR (light detection and ranging). Point Cloud describes not only what can be interpreted as a firm ground, but also in part the vegetation above ground. The classification of LIDAR data points can be chosen based on the laser reflection intensity but also by integrating information from other sources of information (mapping and object databases).

Elevation data from the national elevation model is supplied in areas of 2,500 times 2,500 meters in LAS format and the attained point density (unintended point class) is at least 0.5 points / m2 for 98% of the scanned surface (except the bare mountain areas and water surfaces). LIDAR data forms the basis for all 3D modeling in this study.

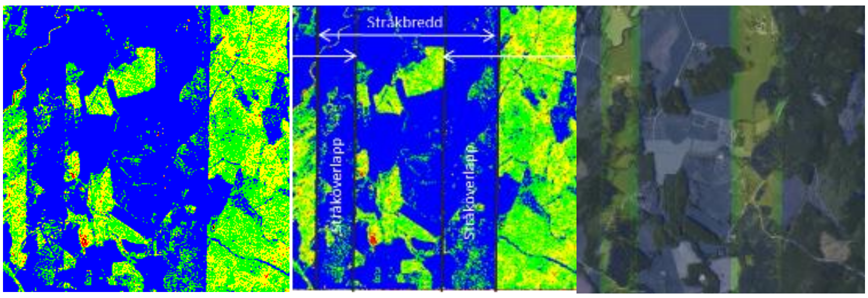
The area for this pilot study is called Hodalen and it is located a few kilometers south of DalsEd municipality in Sweden. The area measures 2.5 x 2.5 kmand includes both open land and forest of varied kinds. The following is an analysis and description of the basic data in this area.

The LAS file from the national elevation model covering the study area contains a total of 8,725,127 points that are classified according to the table below, taking into account all points regardless of their classification, the point density of 1.4 points / m^2 is higher than the minimum guaranteed point density of the solid model. As seen in the aerial photo large part of the area is open fields, a large proportion of the measuring points (53.7 %) are classified as ground points. Related to the entire surface (including forest areas where usually no ground points are observed) there are 0.75 measuring points per square meter.

LAS Class	Object	number	%	number/m^2
1	Trees/etc.	4035706	46,3	0,65
2	Land	4688614	53,7	0,75
9	Water	561	0,0	0,00
11	Bridges	246	0,0	0,00
Total		8725127		1,40

In order to assess the potential of LIDAR a density map is included with the delivery of LAS files. The figure below shows such a density map of the area, where the colors represent the point densities as follows:

- Blue: > 0.5 points / m^2
- Green: 0.25 to 0.5 points / m^2, at least one point per 4 m^2
- Yellow: 0.0625 to 0.25 points / m^2, at least one point per 16 m^2
- Red: > 0 and < 0.0625 dots / m^2, less than one point per m^2



As the forest areas is overlapping zones the density of ground points increases considerably, which means that the density in open terrain should increase beyond what is seen in the blue color.

3. TECHNICAL CONCEPT

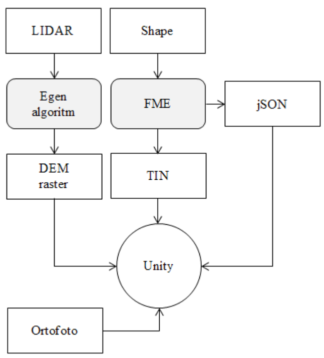
For 3D data to really bring something new, simplifying to facilitating property registration, a virtual 3D environments need to be created from spatial data that is both realistic and interactive.

As the first step in the development of an interactive system for display and analysis of spatial data in 3D, the study examined existing development environments and selected one that was suitable for the purpose, to define and develop techniques for importing different types of geodata.

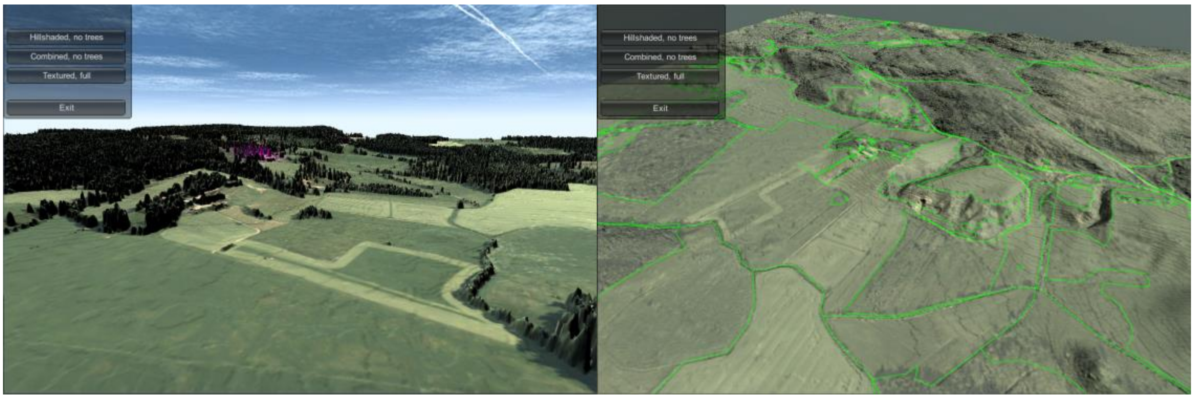
There is currently a number of advanced off-the-shelf gaming and rendering engines that meet the needs of this study, and developing a system from scratch was found unnecessary. The tool chosen for implementation of the demo systems was Unity3D.

Unity is an integrated tool that, among other things, contains a game engine, a simple modeling tool and a development environment with support for scripting in C #, Unity Script (JavaScript) and Boo (scripting language with Python-like syntax). Unity's perhaps greatest strength is its portability. Unity supports development of all types of devices (mobile devices, PCs, Macs, game consoles), and virtually any operating system (Windows, OS X, iOS, Linux, Android, PlayStation, Xbox, Wii, etc.). The assessment is that Unity meets the requirements, with support for automatic generation of terrain based on DEM files (raster) and support for importing from all major types of TIN objects (.fbx, .obj, .mb).

All relevant data, such as boundary points, property boundaries, etc. was supplied as shape files and not supported by Unity. To retrieve information from the SHAPE files into a format that can be used in Unity it was transformed using FME. The flowchart below shows the approach to generating realistic interactive 3D environments based on existing data.



The game environment shown in the demo application is entirely based on available data (LIDAR , shape, aerial photo) for the pilot area and gives a realistic virtual representation of the area. The level of detail and hence gaming's accuracy is of course dependent on the quality of available data.



The 3D terrain model is designed using all available LIDAR data and textured with aerial photos. Hill shading and aerial photos have been combined to get a better view of the area. The green lines mark the property boundaries for the area.

The demo application has been created for the purpose of showing possibilities to use interactive gaming environments of geodata and it is therefore limited in its functionality and built around geodata files for a specific pilot area.

4. CADASTREAL PROCIDURE WITH VIRTUAL MODELLS

When initiating a property formation procedure there is often a dialogue with stakeholders to find what action is requested, the scope, relevance and an initial preliminary cost is estimated. The land surveyor can at this stage, together with the applicant, use the 3D model to discuss the upcoming case and the problems it can face, the current design, the need for driveway, water and sewage issues, etc. This allows one to increase the accuracy of the application. More accurate application means that more ordinances can be implemented without additional changes during the cadastral procedure.

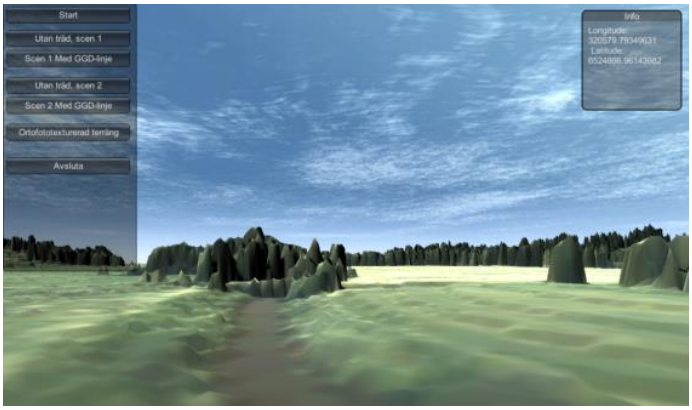
3D models can support the need to ensure the feasibility and scope of the proposed property formation through a virtual inspection and to form an opinion in an early phase of the case handling, which raises the quality of the decision making process. Another application within inspection would be to assess the extent of the alleged plot location within the area covered by the provisions on the shoreline.

During land valuation within property formation a 3D model can serve as a tool to estimate the value based on terrain, the parcel layout and to compare different value objects in the area. When the surveyor have a good idea of the values in the area a field visit may not needed to end up in the right range of value.

In the case when field survey is needed, the cadastral surveyor can use the 3D model in preparation and reconnaissance for the field work to get a better picture of the environment and how the survey should take place and estimate time needed for the survey.

During the cadastral procedure, a dialogue with the concerned parties is generally needed. The 3D model can be used as a tool in this communication. Today, this dialogue is often held on the phone and the surveyor has the map in front of them to describe what he/she means for the party on the other end of the phone. Through a web shared 3D model it would be possible to jointly walk in 3D model and describes the problems and questions more clear together with the concerned parties.

Today some property formation cases are conducted without field work, for example when existing parceled transferred to another property unit, or new boundaries placed, for example, in a ditch or the center or middle of the road. The 3D model serves as a tool to get information about the size and location of such ditches or the road surface etc. to reduce the need of field surveys. The screenshot below shows a trench in the 3D model that can serve as natural boundary in the cadastre.



5.CONCLUSION

The recommendation of this study is to proceed with an in-depth pilot and to select 30-50 property formation cases, preparing a 3D model of the specific case areas. The purpose of the in-depth pilot study is to measure the real benefits that arise during actual cases handling and draw experience from the practical application. The recommendation is also to select a corresponding number of control cases to measure against in order to identify any differences in processing time and quality. A 3D data project is to be initiated within the Swedish Land Survey during 2016 to manage this in-depth study.

BIOGRAPHICAL NOTES

Martin Andrée is the head of development and support for cadastral procedures at the Swedish Land Survey and has 13 years of experience in business development within the

Swedish Land Survey. He holds a MSc in GIS and has experience from both local and national government and international development work.

Goran Milutinovic is a computer science teacher at the University of Gävle, Sweden. He has been teaching different subjects such as programming, web development, 3D game design and multimedia production. He has recently started PhD studies in geo-spatial information science.

Stefan Seipel is a professor of computer graphics and visualization at Uppsala University and University of Gävle, where he is heading the research group in geospatial information science. His present research is in developing and evaluating interactive and visual technologies for efficient presentation of geo-spatial data.

CONTACTS

Mr. Martin Andrée
Lantmäteriet
Cadastral Services Division
801 82 Gävle
Sweden
Tel. +46 (0) 26 63 36 65
Email: martin.andree@lm.se
Web site: www.lantmateriet.se

Mr. Goran Milutinovic
University of Gävle
Department of Industrial Development, IT and Land Management
801 76 Gävle
Sweden
Tel. +46 (0) 70 78 39 296
Email: goran.milutinovic@hig.se
Web site: www.hig.se

Prof. Stefan Seipel
University of Gävle
Department of Industrial Development, IT and Land Management
801 76 Gävle
Sweden
Tel. +46 (0) 26 64 85 63
Email: stefan.seipel@hig.se
Web site: www.hig.se