Use of Cadastral Data in Recovery from Disaster - Quality Issues

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SUMMARY

Norway has since 1960 been modernizing the cadastral system. While neighboring countries and other countries in Northern Europe with German style cadastral system established nationwide cadastral maps in the 1800s and even earlier, the first attempt to conduct a cadastral survey starting in 1804-05, was stopped in Norway in 1815. In rural areas in Norway boundary descriptions was based on written descriptions up to 1980, by lay-men, and there were no large-scale maps. In cities and dense-built areas cadastral surveying mapping should develop. After the Second World War there was increased focus on issues of land planning and control, and the lack of proper maps for this became apparent. This triggered the economic survey that should be carried out throughout the 1960's and 1970's and well into the 80s. The economic survey should cover most of the area of the Norwegian mainland below the timberland, i.e. half of the Norwegian mainland territory. The economic mapping was based on photogrammetric methods and with no systematic adjudication process nor approval of registered property boundaries from the landowners. It is estimated that less than 50% of the boundaries were demarcated and registered in the economic mapping. In 1980, nationwide cadastral surveying was introduced, as a response to the needs for updating the new cadastral maps. The responsibility to conduct cadastral surveys were assigned the municipalities, but no surveying profession was established. Documentation of cadastral surveys is today mainly focused on producing coordinates only. The paper discusses what quality issues there are in the Norwegian cadastral system, and what limitations this leads to in respect of the cadastre being a tool for recovery from disaster. The case of a city fire in Bergen in 2008, and the subsequent reconstruction, is presented and discussed.

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1. INTRODUCTION

The mainland of Norway is not a place prone to volcano eruptions and destructive earthquakes. Natural disasters that can cause damage on ground property and boundary demarcation are normally fire, landslides and flooding.

Nationwide economic mapping started in Norway around 1960, in cities and towns precise cadastral surveying and mapping had been in place since 1800s. The Norwegian economic mapping project from 1960 was based on photogrammetric methods, and these maps are the basis for the present Norwegian cadastral map. The issue of this paper is do present and discuss how cadastral information in Norway can be used for recovery of property boundaries after a natural disaster or destruction, with a special focus on the challenges in dense built areas. A city fire in Bergen in 2008 is used as a case study, and the situation was highlighted in the authors trial lecture in his dr.philos. defense (Mjøs, 2016[2]).

Firstly we have to look into the history of cadastre and boundary registration in Norway, to understand the present Norwegian property boundary concept.

2. THE CONCEPT OF THE NORWEGIAN CADASTRE

2.1 Cadastral development 1600 - 1960

The Norwegian cadastral system is a German style cadastral system (Williamson et.al, 2010). Both the land register and the cadastre originates from the 1600s. The land register originates from the court protocols introduced in the early 1600s, and the cadastre from the tax cadastre introduced in the latter 1600s. Similar to other countries in Central and Northern Europe, modernization of the tax cadastre by cadastral mapping was started in 1804-05. After the union with Denmark was dissolved in 1814 and Norway came into a loose union with Sweden, cadastral mapping was abandoned in 1815 due to poor economy and resistance from the farmers. When the land register and the cadastre was coordinated from 1848, this coordination was based purely on the identification numbers of the cadastre, and not on a cadastral map. In rural Norway land subdivisions should up to 1980 be based on metes and bounds descriptions written by laymen and registered in the land register, and not on cadastral surveying, like in neighboring countries. In cities and towns cadastral surveying and mapping was introduced individually mainly from around 1900, in the major cities even earlier, and the organizational issues the responsibility of the municipality. With the building law of 1924 cadastral surveying became compulsory for cities and towns and to be connected to the fixed points of the maps, and coordinates for boundary points should be included in the survey certificates.

The land consolidation courts were was established in 1859, and should conduct massive land consolidation project and produce large amounts of land consolidation maps in the latter 1800s and early 1900s. Efforts to combine the mapping activities of the Mapping Authority and the Land Consolidation Courts in the late 1800s and early 1900s into a nationwide economic map, failed. The system with land subdivisions carried out by laymen and no mapping of their activities should succeed.

2.2 Cadastral development from 1960

After WW2 there was an increased focus on land planning and control. However in Norway, outside the cities and build up areas the necessary tools for this – large scale economic maps – were missing. Around 1960 the economic mapping project started, mapping most of the Norwegian mainland below the timberline, mostly in scale 1:5000. Triggered by new needs; public administration and control, and not by the more traditional needs; taxation and protection of property rights. The economic mapping project should be based on photogrammetric methods and initially only properties larger than 0,5 ha should be mapped. Quality control was poor, and there was no process of public hearing and landowners acceptance of cadastral information.

The economic mapping project should highlight the deficiencies of existing the land subdivision system, with laymen doing the boundary marking and surveying and no map-making knowledge. Committees and groups, highly distributed and organized at local level, were established to prepare the legislation for nationwide cadastral surveying and the future mapping and land information system. The coordinate method – use of map coordinates to collect and organize information about property and natural recourses – came strongly into focus.

These efforts led to cadastral reforms and a new land subdivision and cadastral law, in force from 1980. Nationwide cadastral surveying was introduced, and the municipalities were made responsible to undertake cadastral surveys when land was subdivided and land lease established for more than 10 years. A new cadastre, the GAB system, was introduced, comprising information about ground properties, addresses and buildings, but with no cadastral map. The GAB system was managed by the Government and information should be registered and maintained by the municipalities. The municipal surveyors obligation was to issue a cadastral certificate including property map when land subdivisions were carried out or land leases were established, but no regulations for at contiguous cadastral map came into being. Authorization of cadastral surveyors was not introduced and there was no strengthening of the education systems, the municipalities were in principle free to appoint any person to undertake cadastral surveys.

In the mid-1980s the establishment of digital cadastral maps started by digitization of the economic maps and municipal survey certificates, partly in the 18 governmental county mapping offices and partly in the municipalities.

In the mid-1990s poor quality and lack of coordination was obvious, and a law committee was established to modernize the system. The most important proposals of the law committee was to establish a state cadastral authority, responsible to establish a new nationwide cadastre under governmental authority including at cadastral map, based on digital cadastral maps and the GAB system, and to introduce a system of authorized private surveyors replacing the municipal surveying system. Updating of the new cadastre was to be carried out by the municipalities.

There was resistance from the existing system, especially with respect to the question of authorized private surveyors, and the issue turned into politics. Even if a law was adopted in 2005 introducing authorized surveyors, this was abandoned in 2007 by a new government with a more red color, and the system of municipal surveying was to continue. However the introduction of new cadastre including a nationwide digital cadastral map was to be realized from 2010, under municipal cadastral authority responsible to carry out cadastral surveys and to update the cadastre.

The system of issuing survey certificates was also abandoned. From 2010 the obligation of the municipality is to register the boundary lines in the cadastre purely on the basis of coordinates, and the documentation to the landowners involved in a survey is a report from the cadastre showing all registered information.

The system highly trust the coordinates. There are no legal requirements for more information submitted from the municipal surveyor to the municipal cadastral registrar, than a list of coordinates defining the precise location of the boundary points. There is no requirement for any survey documentation like a map showing distances to adjoining terrain details. The cadastral survey is normally only documented by coordinates of the boundary points.

2.3 Boundary determination system

A boundary survey is in Norway a technical survey of the boundary identified by the parties, if there is a disagreement between the adjoining landowner about the boundary line, the surveyor might try to mediate and shall according to the cadastral law register both parties claims, if the parties do not agree. It is then the choice of the parties to resolve the disagreement either by reaching an agreement, or bring the case to court, either the ordinary court, or the land consolidation court. The land consolidation court have their own surveyors employed who will survey and register the final decision taken by the court, a boundary decision taken by the ordinary courts will not automatically be surveyed. It is the responsibility of one of the parties to acquire a boundary survey from the municipality, to have the ordinary court decision, surveyed and registered.

There are in cadastral law, bylaws elaborated by the Ministry and in standards elaborated by the Mapping Authority, in place very detailed regulations and standards for the cadastral processes, and measurements for determination of coordinates for the boundary points.

In "Standard for boundary surveys" (no: *Stedfesting av matrikkelenhets-. og råderettsgrenser, 2011*), the land area of Norway is subdivided into different area categories. According to this standard the needs and requirement for quality in cadastral surveys are varying in many different situations according to building activities and ground exploitation in the area. Table 1 shows the different area categories:

Area category	**Type of area**	**Map category**
Area category 1	Cities and towns	(FKB-A)
Area category 2	Built-up areas	(FKB-B)
Area category 3a	Scattered settlement/cultivated land	(FKB-C)
Area category 3b	Forests/outfields	(FKB-C)
Area category 4	Mountains	(FKB-D)

Table 1. Area categories

The specified quality requirements for boundaries follows from Table 2 below:

Area categories	Maximum deformation of boundary points "external reliability"
Area categories 1, 2 and 3a	0,10 m
Area category 3b and 4	0,50 m

Table 2. Area categories and external reliability

It is my understanding of the "Standard for boundary surveys" and the "external reliability" value is that this should have the consequence that when a boundary point is reconstructed by use of the coordinates, the reconstructed position of the boundary point should not deviate more than what is shown in the above table, from the "true" position.

Figure 1 and 2 shows examples of documentation of a cadastral survey based on GPS/accurate surveying that is normally delivered from the municipal land surveyor to the municipal cadastral registrar. The next Figure 1 shows a protocol that contains the names and signatures of parties met in field with the purpose to point out their boundaries, and a hand drawn sketch (not precise) showing the location of boundaries, and in this actual survey, a signed boundary agreement.

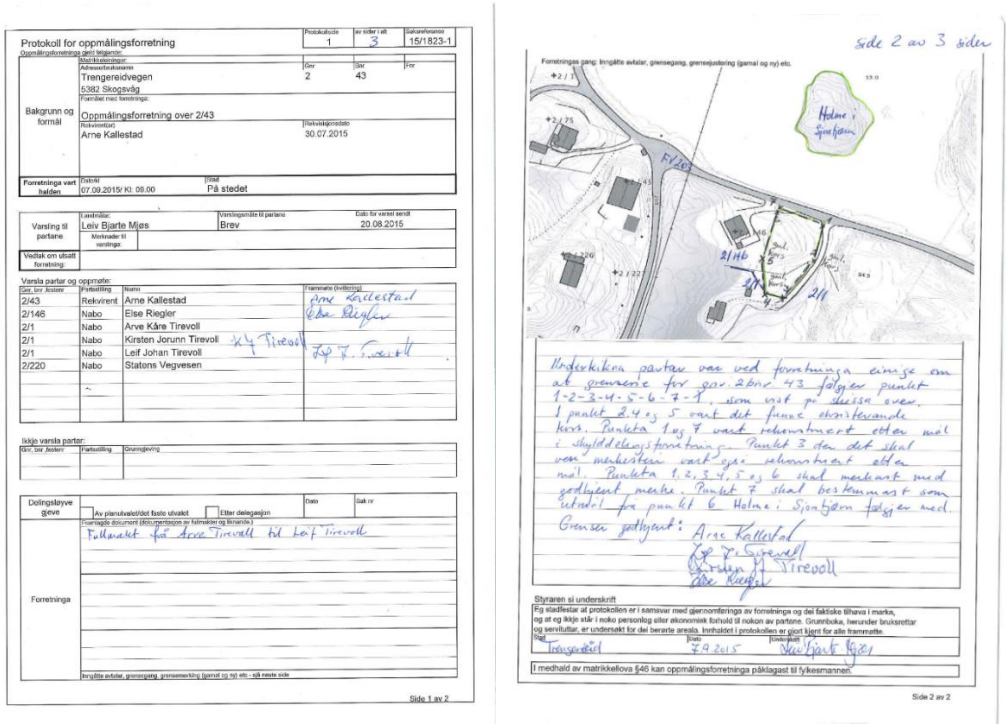

Figure 1. Protocol page 1 and 2.

Figure 2 also visualizes of the process of registration. The coordinates calculated by the municipal land surveyor are registered in the cadastre. The coordinates delivered from the land surveyor are normally given an accuracy of 0,10 meters (external reliability). In the cadastral map the coordinates are registered with the attribute *standard deviation error*, normally 0,08 – 0,13 meters (Nysæter, 2015). The final result is graphically accessible at www.seeiendom.no, a public site.

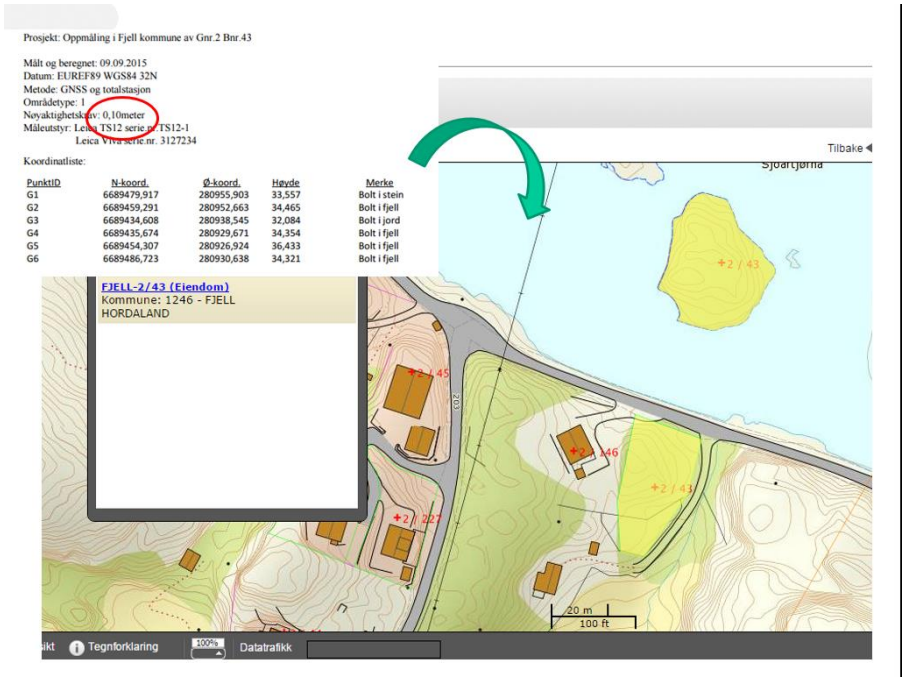

Figure 2. Coordinate list registered and shown at www.seeiendom.no

The question is then how these coordinates can be used for reconstruction of the boundaries. I will try to find an answer by a case study.

3. CASE STUDY – RECONSTRUCTION AFTER A CITY FIRE IN BERGEN IN 2008

In September 2008 four properties in Skuteviken area in Bergen, the second largest city in Norway, were hit by fire. Skuteviken is an area near by the city center, with high property values.

Figure 3. Map with fire place marked with red spot. Source: Statens kartverk

The four properties involved were Skuteviksbodene no. 11 (167/879), Skuteviksbodene no. 12 (167/880), Skuteviksbodene no. 13 (167/881) and Skuteviksbodene no. 14 (167/882). The buildings no. 11 and no.14 were only partly damaged and were repaired, while no. 12 and 13 were totally damaged.

Figure 4. Before the fire. Source: unknown

Figure 5. After the fire. Source: www.wikipedia.no

The owner of no. 13 should soon start to plan the reconstruction of his property, and in 2010 he entered into agreements with the owners of the adjacent properties no. 12 and 14, that the reconstruction should be based on survey certificates of 1914 (no. 12 and 13) and 1920 (no. 14), shown in Figure 7.

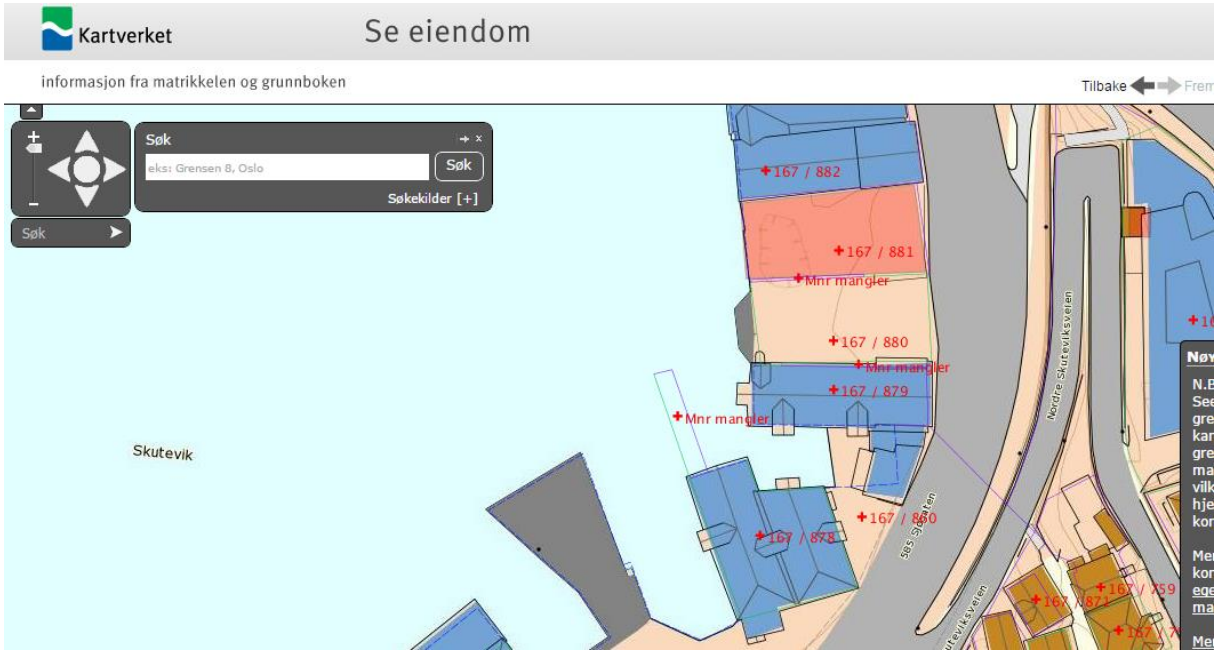

Figure 6. The cadastral map. Source: www.seeiendom.no

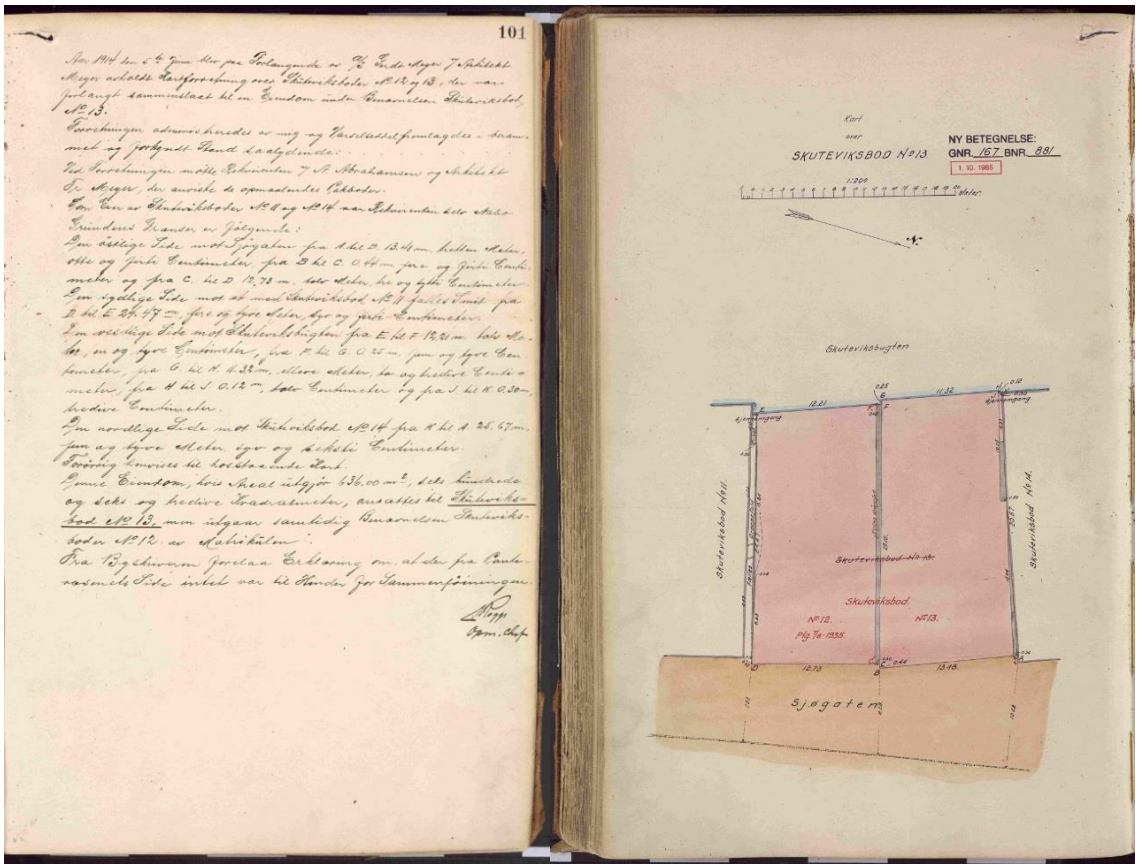

Figure 7. Survey certificate from 1914 over Skuteviken nr. 12 and 13, where the buildings were totally destroyed in the fire in 2008. Source: Bergen City Archives

Building permit was issued by the building authorities with precise positioning of the new building based on the distances to neighboring boundaries. However, the boundaries reconstructed on basis of the cadastral map were not agreed on, and when the owner of the Skuteviksbodene no. 13 engaged a surveying company to measure out the position of his new building on the plot,it became clear that there were different opinions of how to interpret the distances shown in the survey certificates, and thus the actual sizes of the two plots. Consequently, it was a challenge to agree on the position of the new building. The surveying company involved the author of this paper, and I was given the objective to try to unravel the tangle.

The first question to answer is shown in a section of the survey certificate, see Figure 8. There were different opinions of what actual detail is defined by A.

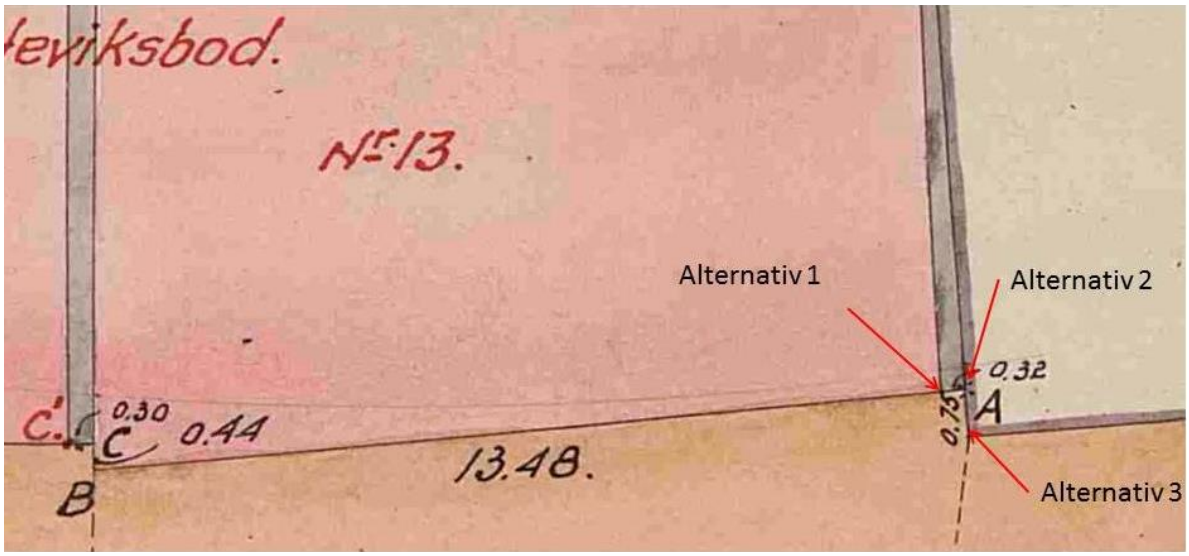

Figure 8. What is the location of point A? Three alternatives indicated on the survey certificate from 1914 (Figure 6)

To find the answer on this question, I had to go to the city archive to look into the original survey documentation, see Figure 8. This clarified the situation and finalized this part of the discussion, and the owner of no. 13 accepted to reduce the width of the planned house towards the road, with 32 cm.

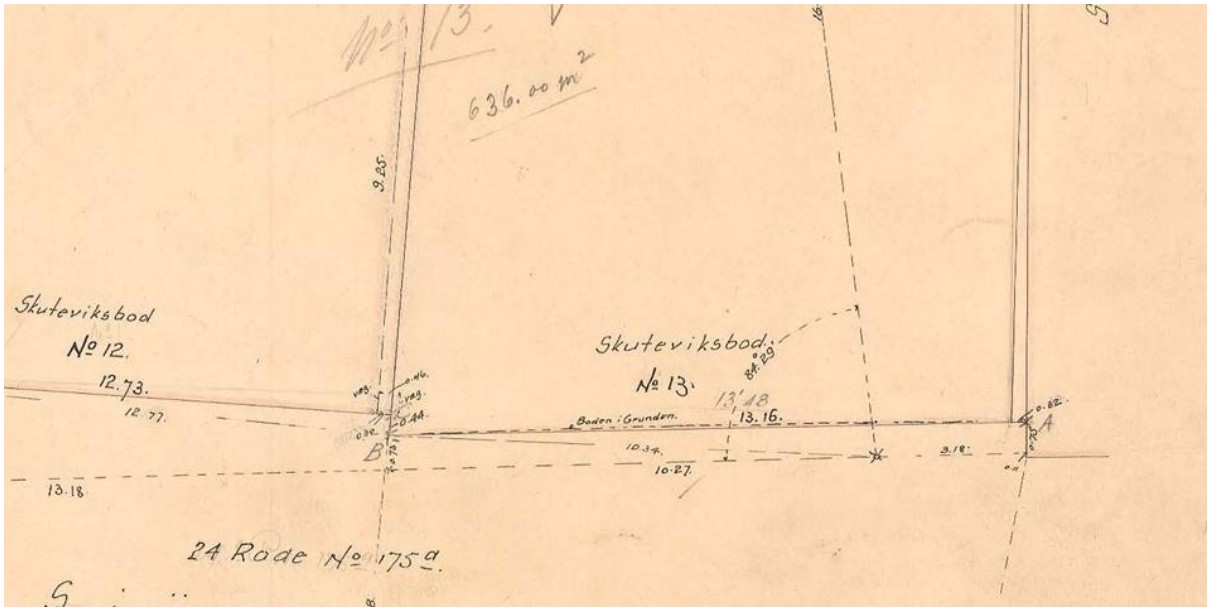

Figure 9. The original construction map. Source: Bergen City Archives

The next question is shown in Figure 10. The survey certificate showed a distance between no. 11 and no. 14 of 24.33 meters, the corresponding original survey documentation showed

24.26 meters, and tape measure showed that the actual distance between the houses were 24.04. There were discussions and many arguments about what had caused this, on centimeter level.

Figure 10. How can the deviations be explained, and how handle it? Photo: Leiv Bjarte Mjøs

My view on the most relevant theory was that when the houses at no. 11 and no. 14 were repaired, they were expanded each with 15 cm because of isolation of the house outer wall. My proposal was to compare photographs from before the fire in 2008, with photographs after the houses had been rebuilt, to find an answer to the question.

Figure 11. Skuteviksboder no. 13 after reconstruction in 2014. No. Photo: Leiv Bjarte Mjøs

Anyhow, the owner of no. 13 reduced the width of his house towards the sea, with 7 cm, and the owners of no. 12, 13 and 14 agreed about the exact position of the new house on no. 13. The problem was then resolved, and the reconstruction of Skuteviksboder no. 13 could start. Within one year the property was reconstructed, see Figure 11. An alternative to the agreement between the parties, was the court system.

4. FINAL DISCUSSIONS AND CONCLUSIONS

Finally the essential issue of the paper will be discussed: what role does the Norwegian cadastral map and the coordinates play, when boundaries are to be reconstructed?

The Norwegian municipalities offer as a service to landowners, to reconstruct previous boundary surveys if the boundary marks are destroyed or the boundaries of other reasons are uncertain. Boundary reconstructions are normally based on use of the coordinates, which means that the position of the coordinates is marked with a boundary mark. And if the only survey documentation is coordinates, which will be the normal situation for surveys conducted after 2010, a coordinate-based reconstruction can be the only possibility for the land surveyor to reconstruct the boundary.

What the case of Skuteviksboder shows, is that the freedom to enter into contracts which has a very strong standing in Norway, overrules the cadastral map. If the parties agree that the coordinates defines their boundary, then the situation is ok. If the parties does not agree that the coordinates of the cadastral defines the correct boundary, then there is a problem.

Even with the coordinates are correct, it is difficult to reconstruct boundaries in narrow streets and in between buildings by use of coordinates. The landowners do not understand coordinates, and they cannot handle them, contrary to the old way of documentation of cadastral surveys (Figures 7, 8 and 9).

The present cadastral mapping system in Norway has major shortcomings when it comes to reconstruction of property boundaries, especially in dense built areas.

The recommendation of the author is to reconsider the strong focus on coordinates in the Norwegian cadastral system, and to consider reintroducing the old ways of cadastral survey documentation.

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BIOGRAPHICAL NOTES

Leiv Bjarte Mjøs is an Associate Professor at Bergen University College, Department of Civil Engineering. He has made a dr. philos thesis with the title *Cadastral development in Norway*. Research interests are within land administration.

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