Cadastral Surveying Methods

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SUMMARY
The presentation covers the technical surveying part of the «Cadastre improvement project» at Røst in Lofoten, Norway. The aim of this project is to develop simplified methods for correcting the Norwegian cadastral map, which is of mixed quality and, in many areas, not fit-for-purpose. The partakers of the project are Røst and Bodø municipalities, the Norwegian Mapping Authority and Western Norway University of Applied Sciences, with financial support from Nordland County. The cadastral fieldwork has been done by students, supervised by teachers and municipal surveyors.

Improvement of the Norwegian cadastral map is a formidable task. Many properties are not shown in the map, and many others have never been surveyed accurately. Our current cadastral system seems to lack mechanisms which improve the situation as time goes by. Therefore, new, efficient, and cost-effective methods are needed. In this presentation, I will give an overview of the surveying and calculation methods that we have tested. These methods include: 1) Making less measurements than what the current standard demands, replacing redundant observations with visual control of the result against aerial images. 2) Using more cost-effective surveying equipment, both standalone and service-based GNSS-receivers have been tried. 3) Using smartphones instead of field computers during surveying. 4) Using opensource software to handle the dataflow from surveyed points to cadastral map-data. 5) Updating larger areas instead of single parcels.

The general impression is that the proposed methods are working, but there are some challenges. Use of low-cost equipment often implies that the surveyor must be more active in solving technical problems, compared to use of more expensive, well-tried, and well-supported equipment. Another issue is time consumption. If less time is spent on surveying, there is a risk that too little time will also be spent on locating the correct boundaries, which may result in a less correct map in the end.

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INTRODUCTION

Cadastral surveying in Norway is currently performed with GNSS, making real-time observations by use of a base-station network service. Sometimes, lack of satellite signal or missing cellular network makes total station the preferred instrument, but these are exceptions.

The cadastral map in Norway is unfinished and of very mixed quality (Nysæter, Leiknes, & Mjøs, 2019). A lot of properties are completely absent from the map, many others are totally or partly misplaced. Because a lot of surveying will be needed to make the cadastral map accurate and complete, there is a need for investigating more efficient methods of cadastral surveying and mapping.

1. THE CURRENT METHOD

Cadastral mapping relies heavily on the landowners identification of the boundaries in the field, which is what the land surveyor will survey if it doesn't contradict the existing documentation in an obvious way.

1.1 Demands

The land surveyor is obliged to

- notify the involved parties in due time
- be impartial
- survey every boundary point several times with sufficient time between observations to ensure independent observations, this with a controlled instrument
- register point, boundary and parcel attributes
- perform a control against blunders
- perform a reliability analysis and document that external reliability doesn't exceed 10 cm
- digitize boundary lines between boundary points

1.2 What is not demanded of the surveyor

The land surveyor does not have to

- find out where the correct boundary is located
- be responsible for the quality of the result, only that the right procedures have been followed

2 CRITIQUE OF THE CURRENT METHOD

What is the purpose of the cadastral map? The cadastral authorities don't seem to have the complete answer. And as long as this question remains unanswered, it is difficult to propose detailed recommendations for mapping procedures. But some simplifications of the current methodology can be proposed.

2.1 Redundant observations

This current demand could be made optional. In many cases it will suffice to make one control measurement in a fixed position before the surveying starts. Then each point is surveyed only once. In many cases, the result can be visually controlled by overlaying the data on an aerial image. An experienced surveyor will know when additional observations are required, for example when there is a great risk for multipath.

2.2 Blunder detection

Blunder detection in surveying projects is often performed by use of sophisticated mathematical and statistical software operations. Earlier, when all observations were connected in a geodetic network, the method was justified, and computers made it possible to precisely locate problems in complex surveys. But in projects containing only GNSS point observations, blunder detection can and should be made simpler. It is all about identifying outliers in sets of three observations. One possible method is to calculate the median value for northing and easting, and then to calculate distance from the median for each point observation. If the distance exceeds 3σ, the observation is discarded (σ is given by the operator of the base station network). This method is simple, and also understandable for everyone.

2.3 Reliability analysis

This analysis can be omitted completely. It does not provide any significant insight concerning the quality of the result. The reason for this is that point observations made by using a base station network, will always have an accuracy far better than the demanded reliability within 10 cm. If we know that the instrument and the system is working, we also know that the result will have an accuracy of $\sigma \approx$ 1-2 cm. And the way to ensure that the instrument and system is working, is by measuring a known position, not by making any mathematical analysis on the observations.

2.4 Organizing of the survey

It is mainly the landowners themselves that initiates and pays for a cadastral survey. They pay for the parcels they want to be surveyed, and those parcels will be surveyed. Other parcels in the same area are not surveyed, even if they aren't properly located in the map. In this way, it takes a lot of time before the general quality of the cadastral map is improved.

2.5 Expensive instruments

In the recent years, more cost-effective GNSS receivers have entered the market. It has been said that these receivers fail to meet the demands that are required for cadastral surveying. More specifically it has been pointed to lack of covariance values between the individual

coordinates that constitute a point observation. But test measurements and calculations have shown that the effect on the adjusted result by covariance values are negligible in cadastral surveying (Nysæter, 2017).

3 ALTERNATIVE METHODS

As part of the cadastral improvement project, some alternative surveying methods have been tested.

3.1 Simplified surveying procedure

In 2020, cadastral mapping in a specific neighborhood in the municipality of Røst was undertaken. The survey was funded by the participants of the beforementioned cadastral improvement project, the landowners did not have to pay for the survey.

The whole survey was made within a couple of hours, one afternoon. Groups of students were assisted by supervisors and walked form property to property measuring the boundaries that the landowners showed them. Every point was observed only once. The observations were entered into a map, and boundary lines were drawn. The result was compared to the visual boundary lines in an aerial image (for illustrations, see the accompanying presentation). As no adjustment computation could be made, no computed accuracy of the result could be documented. It was therefore decided to register these boundaries with slightly less accuracy than boundaries surveyed by the conventional method.

The same procedure was also tried the same year at another location in Røst municipality, on a small island with approximately 15 parcels. Both places, the initiative was well-received. Most of the landowners were present during the survey, and they seemed happy with having an improved map as result.

The year after, in 2021, the same concept was tried out in new areas in Røst municipality. This time we experienced disagreement on where some of the boundaries were, and also lack of knowledge among the landowners about boundaries and boundary marks. When focusing on a relatively large area, instead of just a single parcel, less time was available to resolve individual disputes and uncertainties. Without agreement between the landowners, we were not able to improve the cadastral map.

3.2 Low-cost GNSS receivers

In 2022, the use of low-cost GNSS-receivers combined with smartphones was tested. In short, it was found that the instruments can safely be used. These instruments use the same base station network as the high-end receivers. They are reliable and provide results that are accurate enough (Nysæter & Leiknes, 2023). The challenge was the dataflow, and some python-programming was needed to get the data from the smartphones into the standard Norwegian surveying applications. Several parcels were surveyed using both high-end and

low-cost GNSS receivers. When we compared the results, we found only insignificant differences regarding quality.

During fieldwork in the autumn of 2023, we have tried to do the cadastral surveying using both low-cost GNSS receivers and open-source software. A new plugin for QGIS has been made to prepare a QGIS-project for cadastral surveying, and to perform blunder detection and adjustment of eventual redundant observations. The development of the plugin and the processing of the data from the 2023-survey is still in progress.

With the development of open-source software solutions, it will be possible to perform cadastral surveying without having to buy expensive software applications to perform complex analyses. To this, one can justly oppose that the software expenses are small compared to the surveyor's salary. Therefore, the most important reason for making alternative software is to provide the possibility to perform all necessary calculations in an understandable way, by using procedures that are fit-for-purpose.

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