Quality Improvement to Cadastral Information in Sweden

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Key words: digital cadastre, quality, cadastral index map, real property register.

SUMMARY

Lantmäteriet is a governmental agency which gives support for creating an efficient and sustainable use of Sweden's real property, land and water. The organisation comprises three main activities, which also form the organisational structure:

- Cadastral Services
- Land and Geographic Information Services
- Division Metria, which provides repayment services.

Land and Geographic Information Services include the analysis and identification of demands and needs for geographic and real property information in society. It also includes the efficient collection, storage and administration of such information.

Cadastral Information in Sweden consists of two main parts; The Real Property Register, which is a description of the cadastral data in a text format and the Cadastral Index Map, which is the geographic representation of the cadastral data.

These two parts are closely connected in an integrated system. During past years and as a consequence of the possibilities created by the rapid development of the IT-systems, the demands on the system have increased dramatically. Demands concerning availability and dissemination from partners and the market and also from society have pushed on the development of dissemination systems.

But technical solutions alone are not enough to meet user requirements; good quality data is also an important element of a well-functioning Land Information System. Data sets must meet user requirements regarding:

- Content
- Actuality
- Completeness
- Correctness
- Structure

A project called ALBIN has been implemented with the aim of improving the quality in the Real Property Register and the Cadastral Index Map. More than 60 persons are involved in this work which will take more than three years with a cost of more than € 10 million.
The project consists of four subprojects:

- Geometric improvement to the Real Property Information in urban areas.
- Real property pattern – Complete and correct representation
- Rights – Complete and correct representation
- Development of methods and test production for improvement to the geometry of the Real Property Information in rural areas.

This paper describes the project, its management, and its activities which are part of the quality improvement process.

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1 THE HISTORY OF THE SWEDISH CADASTRE

The Swedish cadastral system is based on cadastral books from the 16th century that were prepared for taxation purposes. These books list real properties, village by village and every unit in the village is given a number. This numbering system is still used for designation of real properties. During the 17th century the books were complemented by village cadastral maps showing all real parcels in the village. At that time, rural villages were split up into very small parcels. An extensive enclosure movement spread over Sweden in the form of land consolidation during the early 19th century. Much of the basic parcel structure of that time forms the division into property units in the countryside today.

1.1 The Real Property Register

Legislation on property registers was passed in 1908 with regard to rural areas and in 1917 with regard to urban areas. The property registers were, manly, intended to provide a reliable basis for the already existing system of land registration (title and mortgage registration). Property registers were established during the nearest following decades. The registers were paper registers (books), with a very limited content.

In 1968, these two registers were merged and integrated with the land register. Computerisation of the registers, which took almost two decades, was completed for the whole of Sweden in 1995.

Since then, the Real Property Register has gradually been improved. A new law on the Real Property Register was introduced in 2000. The law replaced the old legislative framework for the Land Data Bank System and is a base for a partly new structure for real property information. An important change is that the Cadastral Index Map is now a part of the Real Property Register. The information in the Real Property Register is divided into five different parts with the information listed below:

Real Property Part	**Land Register Part**
property unit joint property unit co-ordinates plans, regulations and rights precincts joint facility cadastral index map	Title leasehold mortgage rights notifications
Building Part	**Address Part**
building unit address coordinate register	address unit property unit
Property Tax Assessment Part	
total assessed value assessed value for land assessed value for buildings basis for valuation owner	

1.2 Cadastral maps

In cities, the register included a cadastral index map from the start. These maps were relatively simple from a geometric point of view and some of them lacked a coordinate system. They were, however, produced in a standardised way and were updated by the registration offices in cities and counties.

In rural areas, although there was a great need for a cadastral index map with good coverage, nothing was produced until the late 1950s since no good quality base map was available.

In 1957 production of the Land Use Map of Sweden (The Economic Map) was begun. Maps in this series were based on aerial photography, photo mosaics and, later, on orthophotos and were at a scale of 1:10 000. Cadastral boundaries were transferred from old village maps to the new maps mainly by photo interpretation of the boundaries and comparison with the old maps. After completing the information on the maps with information about physical plans, regulations, easements and other rights of land, the Economic Map has been used as a base for production of a cadastral index map for the rural areas.

2. PRE STUDY , QUALITY IMPROVEMENT TO THE CADASTRAL INFORMATION

In 2005, a pre study was carried out. The main objectives for the study were to review user needs for better quality in the Real Property Register and to give priority to activities for the

quality improvement work. In the study, user satisfaction concerning content, actuality, completeness and correctness, which also include structure, was examined.

In the pre- study, the most important areas for quality improvement were listed in order of priority:

- Improved geometric quality in the cadastral index map, particularly boundaries in rural areas.
- Complete and correct information about the property units.
- Complete and correct representation of rights and joint facilities.
- Complete and correct representation of building plans and regulations.
- Complete and correct representation of the properties area figures.
- Complete representation of cadastral surveys.

3. ALBIN, THE QUALITY PROJECT

The work with quality improvement is organised in a project named ALBIN. The project started in 2006 and will continue for at least three years. More than 60 persons from different departments are involved in the project which will cost more than € 10 million.
The aim of the project is to decrease costs for managing the system and to enlarge the applications. During the course of the project it has been shown that the quality improvement work is a prerequisite for the comprehensive on-going work with object-oriented data modeling and new software technology.

The project consists of a main project and four sub-projects:

- Improvements to the geometry of real property information in urban areas.
- Real property pattern – complete and correct representation.
- Rights - complete and correct representation.
- Development of methods and test production for improvement to the geometry of the real property information in rural areas

4. IMPROVEMENT TO THE GEOMETRY OF REAL PROPERTY INFORMATION IN URBAN AREAS.

4.1 General

Data in the Cadastral Index Map in urban areas originates from many sources. Examples of the origin of data are: large scale index maps of small villages at a scale of 1:2000 covering areas where a scale of 1:10 000 was unsuitable; municipal base maps of high quality and field measurements gathered during revision work. Both digitised and measured data are used in the different kinds of Cadastral Index Map– though geometrical quality usually is much better in urban areas.

Lantmäteriet (National Land Survey of Sweden) has agreements with most municipalities in the country which make it possible to use municipal data from their base maps to improve the quality of the Cadastral Index Map. The project also uses large cadastral surveys which were not used when the Cadastral Index Map was produced.

The on-going project has a special activity for incorporating the municipalities' data and large cadastral surveys into the national system.

4.2 Activities and methods

In this project it is necessary to have close co-operation with the municipalities and the local cadastral authorities. The work starts with contacts between the involved parties, so that we can find out which data that is available. To ensure that we use good quality datasets the project carries out a series of checks, such as what geometric quality can we expect and is the base map up to date?

- The municipalities' data can be in local coordinates systems and the data can be of varying geometrical quality.
- Control of the structure of the data.
- Comparison with the information in the Real Property Register.
- Judge if this area is of priority.

When the data quality has been ensured, the work of incorporating it starts. This work comprises modification, complementation and standardization of the data before it can be merged in the Cadastral Index Map.

4.3 Results

The project has incorporated all available municipal data, based on the priorities that were set. The latest work in the project, which has not yet been completed, is to make an inventory of large cadastral surveys that can be used to improve the Cadastral Index Map and to prioritise how to use them.

5. REAL PROPERTY PATTERN – COMPLETE AND CORRECT REPRESENTATION

5.1 General

In this project, clearly identifiable typing errors are corrected to create a complete and correct representation in the Real Property Register and on the Cadastral Index Map. Special attention is given to settled and other valuable areas. Errors in geometry such as undershoots or overshoots will be corrected. Properties that exist in the Real Property Register but not on the Cadastral Index Map and vice versa, will be investigated and corrected where necessary. This check can be done semi-automatically through a comparison of the Real Property Register database and the Cadastral Index Map database.

5.2 Activities

During 2008, priority will be given to the following activities:

- Correction of obvious errors when comparing the Real Property Register and the Cadastral Index Map
- Correction of errors in geometry in the real property pattern
- Investigation and correction of joint property units in the county of Gotland
- Property registration in the mountain areas
- ID groups on joint property units will be deleted and reregistered with unique area numbers
- Investigation and correction of unregistered properties

5.3 Methodology

Automatic or semi-automatic comparisons are made between the databases for the Real Property Register and the Cadastral Index Map. These operations identify areas that exist in the register but not in the map, and vice versa. To be able to correct these faults, an archive research is made for each area, old documents are checked and other materials are examined.

5.4 Results

The activities in this project will result in a higher level of quality in the Real Property Register and the Cadastral Index Map. The aim is to have complete and correct representation of the real property pattern in both databases and for the whole of Sweden.

6. RIGHTS - COMPLETE AND CORRECT REPRESENTATION

6.1 General

The work in the project concerning legal rights is carried out at ten different places in Sweden. The participants in the project are specialists in cadastral registration and are very skilled in archive research.

Once a year, all participants in the project meet, otherwise the work is mostly carried out through telephone meetings once a month.

Competence development within cadastral registration and archive research has also been carried out since the beginning of the project.

6.2 Activities

The activities concerning the legal rights project are:

- Completing the cadastral index map with easements shown in the Real Property Register but not on the map.
- Completing the map with joint facilities and utility easements shown in the Real Property Register but not on the map.
- Completing the map and register with information from cadastral procedures carried out within the old Act on private roads.
- Completing the Real Property Register with easements that are missing, or where there is an incomplete list of involved properties.
- Correcting the notes related to participants in joint facilities in the Real Property Register.

6.3 Methodology

Automatic or semi-automatic comparisons are made between the databases for the Real Property Register and the Cadastral Index Map. These comparisons result in a list of errors, which is sent to the participants in the project for correction. To be able to correct the errors archive research has to be done, old documents checked and other materials examined.

6.4 Results

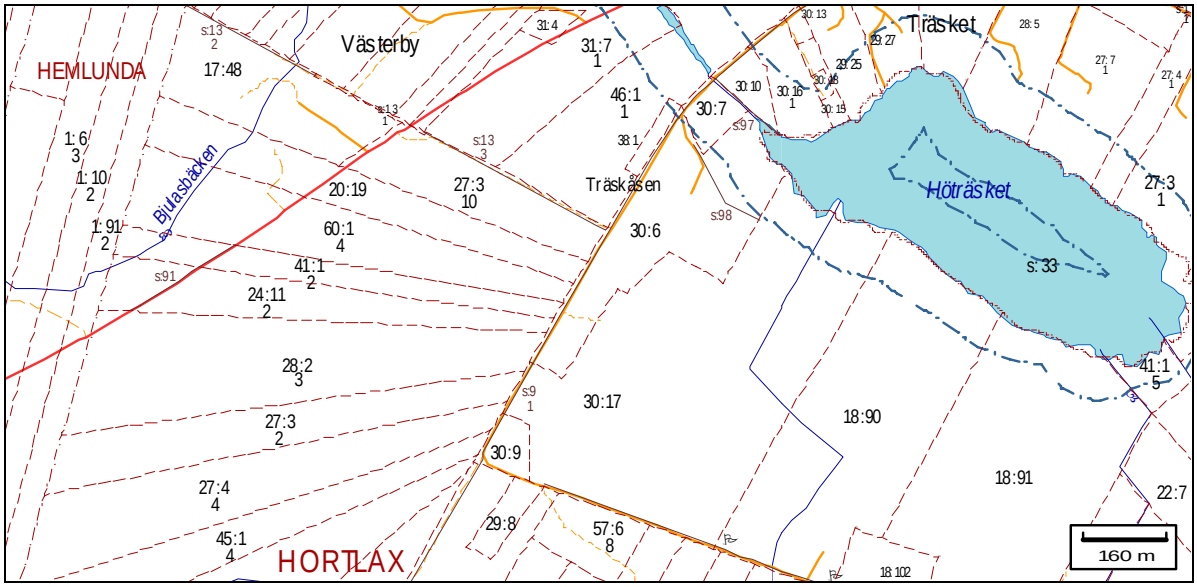
All of the above mentioned corrections and completions contribute to a higher level of quality in the Cadastral Index Map and Real Property Register. The aim is to make the property formation process easier and more efficient and also to adapt property-related information to a new technique for storing data.

7. DEVELOPMENT OF METHODS AND TEST PRODUCTION FOR IMPROVEMENT TO THE GEOMETRY OF REAL PROPERTY INFORMATION IN RURAL AREAS

7.1 General

The Cadastral Index Map in rural areas contains graphic information on properties, parcels, plans, regulations and easements. It is produced using data from the old Land Use Map at the original scale 1:10 000. Today, the digital Cadastral Index Map covers most rural areas in Sweden except for the mountain region in the north. The digital medium facilitates easier access and use of the geographical and property-related information for different purposes, such as planning for new infrastructure including roads, railways and electric power transmission lines and also for navigational purposes in the forestry industry. The cadastral authorities use the map for cadastral measurements and are also responsible for keeping it up-to-date. As a result of the production methods and of earlier methods used for maintaining, the

accuracy of boundaries on the cadastral map varies. Whilst some boundaries correspond well to the cadastral survey plans and boundary marks in the field, others only give a very rough picture. The accuracy of current digital cadastral maps varies between a few centimetres, where new surveys have been carried out, to well over 30 metres in some cases. A normal discrepancy in rural areas is around 4-5 metres. Consequently, the cadastral map is not valid evidence of the legal location of boundaries and cannot be used for the purposes mentioned above.



Extract of the digital cadastral map in rural areas.

7.2 Activities

In the project initiating document it was decided that the quality improvement should be made inside the existing technical and legal framework. This means that the material rules determining the legal location of a boundary in the Land Code and the existing system for, for example, quality marking in the Cadastral Index Map should be used in the quality improvement work.

For the test production it was decided that different kinds of cooperation should be tested such as with property owners and local- and central government authorities.

7.2.1 Legal conditions, the Swedish boundary system

The principal rule in the Land Code is that boundary marks emplaced in the ground in accordance with accepted procedures are the primary evidence of the legal boundary's location. Therefore, if there is a difference between a boundary mark and a cadastral survey plan, the location of the boundary mark should be given precedence. If a boundary mark is moved or lost, the survey plan and other documents from the cadastral survey should be interpreted. In this case, possession and other circumstances, such as fences and ditches,

should be considered when the legal boundary is to be reconstructed. If boundary marks have never been emplaced, the cadastral diagram should be used when reconstructing the boundary. The Swedish Land Code has a strict hierarchy of boundary evidence.

- Boundary marks
- Cadastral diagram and other documents
- Possession and other circumstances

These rules must be considered when the boundaries in the Cadastral Index Map are to be improved.

7.2.2 Technical conditions, present quality and quality marking in the Cadastral Index Map.

As mentioned above, the Cadastral Index Map is based on the Land Use Map. Different techniques have been used for inserting the boundaries on the cadastral map. Originally, the boundaries were derived from different kinds of paper maps and small-scale aerial photography. Various adjustment techniques, aimed at improving the geometry have been used but have, in fact, reduced the accuracy even more.

The quality marking of single features on the cadastral index map is based on:

- Source of data
- Geometrical accuracy

Source of data comprises basic information about how the coordinates were determined, such as method e.g. geodetic, photogrammetric or digitising and information on the field methods, such as classical survey measurements or GPS techniques.

The geometrical accuracy is stored as relative precision. The relative precision refers to the precision in relation to the higher order geodetic system.

7.3 Methodology

A number of methods that increase the geometric quality of the cadastral map have been tested.

In most cases, existing data was used for the quality improvement process and, initially, we attempted to limit the need for new surveys to a minimum.

The following methods for quality improvement have been tested:

- Transformation of existing data in the cadastral database.
- Transformation of existing cadastral measurements in the digital archive.
- Geo-referencing of old maps stored in the digital archive.

- GPS surveys
- Photgrammetry
- Satellite images

In one of the test areas, co-operation with the property owners has been tested with very successful results. Property owners located their boundary marks which made it easy for the survey technicians to survey them with GPS.

In the other test area, cooperation with the municipality was tested with good results. In this case the municipality contributed with new orthophotos and help with the survey work and with their experience of the local coordinate systems that were used in different parts of the test area.

7.4 Results

The figure below shows methods used for quality improvement of boundaries with their origin in different kinds of cadastral documents and the accuracy obtained.

A conclusion that differs from cadastral renovation projects in other countries is that we found that GPS measurement of boundary marks is a cost-effective method for getting a correct picture of reality on the ground.

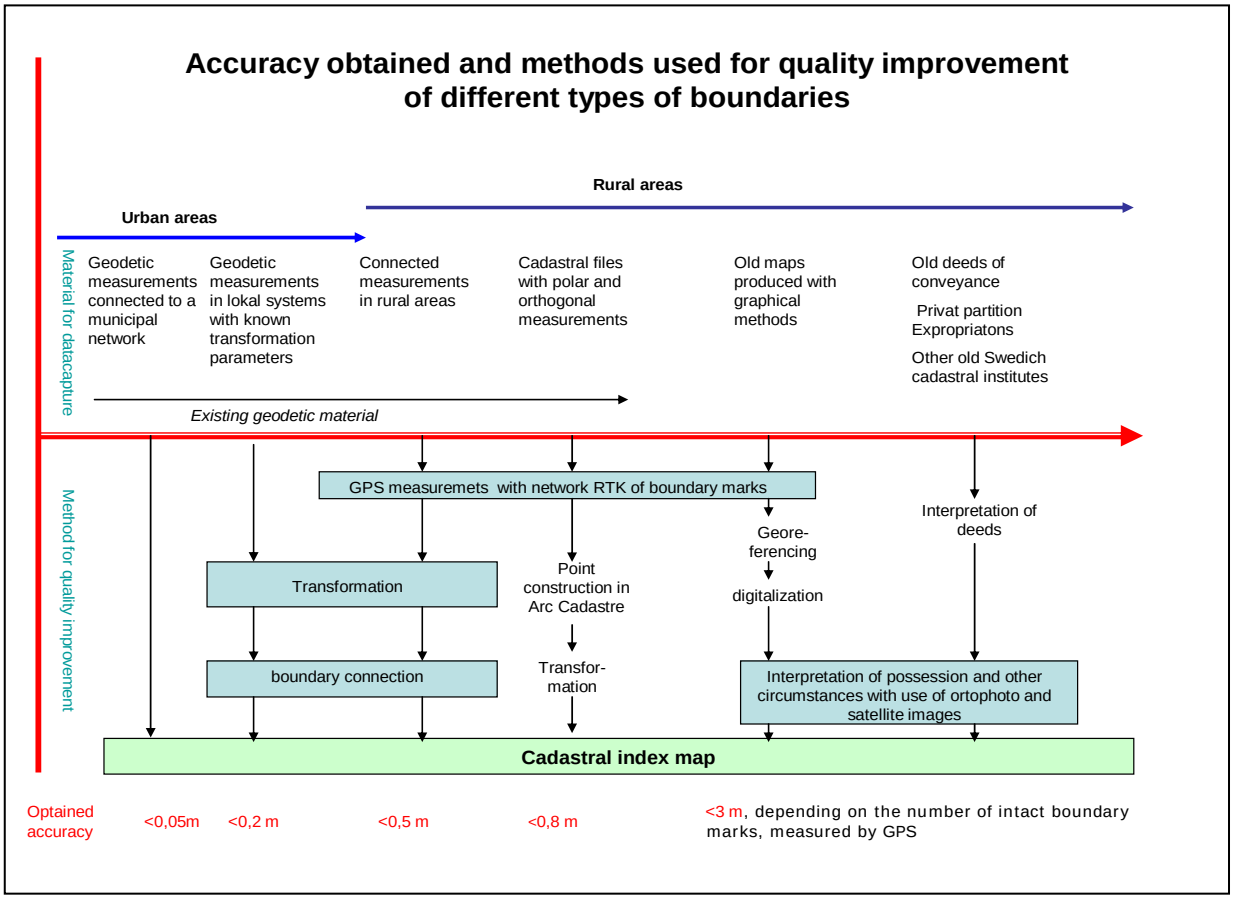


Figure showing the results of the project

8. PROJECT MANAGEMENT

8.1 Project organization and management

Governance and control of the ALBIN project is managed in a main project that consists of four different sub-projects. The main project is led by a main project manager who reports to a steering group. The chairman of the steering group is the project sponsor and has ordered the project. Each sub-project is headed by a project manager who reports to the main project manager.

Steering group meetings are held monthly and at these meetings production progress and budgetary issues are discussed. The budget for 2008 is approximately € 2 820 000.

Project manager meetings involving the main project manager and the sub-project managers are held every third week.

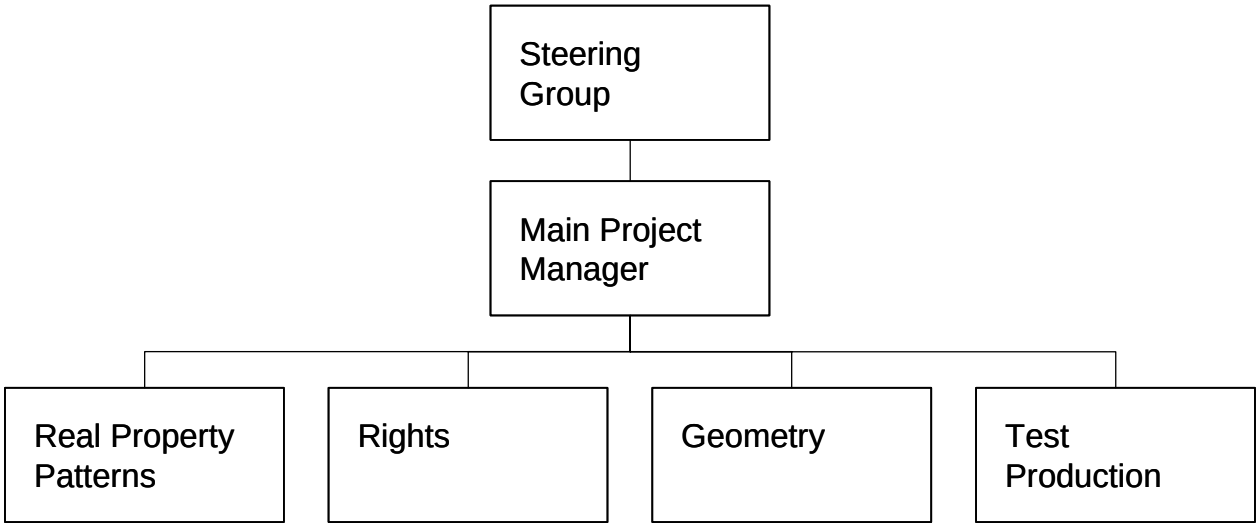


Figure showing the project organisation

8.2 Project follow-up

8.2.1 Production progress

A production progress report system, PROFS, http://www.metainfo.se/website/albin/viewer.htm has been developed for reporting the production progress in three of the four sub-projects. PROFS facilitates production progress reporting on the municipal level for the projects

- Real property pattern
- Rights

For the Geometry Project, a production progress report at population centre level is possible. The system facilitates follow-up on an activity level with a starting and finishing date for the activity. Connections exist to a map. The system is a GIS web-based system and can be accessed outside Lantmäteriet's firewalls. Each operator/supplier can update data on-line through a web-template.

8.2.2 Project costs

Costs for each sub-project and for the main project are compared with the budget on a monthly basis.

8.3 Quality assurance

Two persons are responsible for Quality Assurance (QA). One is responsible for the QA of the sub-projects

- Geometry
- Real Property Pattern
- Rights

The second is responsible for QA of the sub-project Test Production.
The ALBIN project also has access to a reference group of specialists at the Real Property Registry for advice and support.

CONCLUSION

Today the Swedish cadastral system is a well-functioning system, but in spite of all efforts to improve quality and efficiency, there are still a large number of demands that remain to be fulfilled. The project has now been running for two years and the results have been very encouraging. But the task of improving the quality of the Real property Register, including the cadastral index map, is huge. If this task shall be successful completed we need permanent improvement in quality and efficiency (data / information and processes).

Fore most activities in the quality improvement process specialists and experience personal from different parts of Lantmäteriet where engaged. Our experience is that the project organisation fulfils these requirements in the best possible way.

BIOGRAPHICAL NOTES

Gunnar Blixt is Master of Law (LL.M) from the University of Lund, Sweden.
He has been working within the County Cadastral Authority since 1967 and has long experience of property formation and property registration.

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