Legal Coordinated Cadastres – Theoretical Concepts and the Case of Singapore

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Key words: Cadastre, legal coordinated cadastre, terminology, Singapore

SUMMARY

The field of cadastre holds an inherent complexity much based on its interdisciplinary characteristics and the national uniqueness of each cadastral system. In addition, some cadastral terminology is vague or ambiguous, which is why omission of the explicit sense and context of a particular term may bring obscurity to international comparisons and analyses. The concept *legal coordinated cadastre* (and kindred expressions), occasionally mentioned in connection with visions and plans of cadastral modernisation, is discussed here in order to clarify possible meanings and implications. In an elaborate form, such a cadastre denotes that all property boundaries within a jurisdiction are legally defined by coordinates guaranteed by the State. In less extensive forms, the coordinates in a digital cadastre are one means of evidence but they may not prevail over physical monuments on the ground.

After an account of these theoretical issues, this paper presents the results of a case study of the recent cadastral reform in Singapore. The new Singaporean cadastre, implemented in August 2004, is considered to be the first complete legal coordinated cadastre in the world. This achievement involved great technical efforts as well as adjustments to the laws in force. For example, a new national reference system and a network of reference stations for GPS were established, enabling a systematic conversion of existing boundary data. From a legal perspective, the cadastral map coordinates became conclusive evidence in court. The Chief Surveyor is, however, empowered to correct the cadastral map should it be defective due to e.g. measuring errors. As before, the liability of the boundary data stays with the surveyor who performed the survey.

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1. INTRODUCTION

Countries worldwide are engaged in developing their cadastral systems, trying to make them meet the increasing range of demands within the modern society. Although the users' needs vary from state to state, digitalisation of cadastral records and maps is a common element of the move towards multi-purpose solutions. In several cases this choice coincides with the establishment of new or refined national geodetic reference systems. Another, more subjective, means of improving cadastres and their usefulness is through benchmarking, a tool much focused on during recent years. Comprehensive studies thereof have, for instance, been presented by FIG Commission 7 (Steudler & Kaufmann 2002) and individual researchers (Steudler 2004). Since every cadastral system is coloured by its original purpose and the underlying national land legislation, a holistic approach that includes but goes beyond the technical characteristics is necessary throughout if the comparisons of such systems are to reflect the actual situations in all their complexity.

Despite a general approbation for computerized land administration systems, the question of a digital cadastre's validity in respect of the recorded parcel boundaries has been the subject of debate. Somewhat simplified, two groups represent quite opposite points of views. While some experts argue that boundaries (still) ought to be primarily defined by physical features on the ground, others see a considerable potential for higher cost effectiveness and the implementation of new GIS applications if boundaries are legally determined by coordinates. Those rejecting the idea of a so called *legal coordinate cadastre*[1] emphasise the landowners' need for visible boundary indicators, and usually also express their concern regarding the instability of reference systems over time. Such arguments are often discounted by the proponents of reform, who for their part point to the rapid development of GPS devices and the technological advances in the field. The latter group thus maintain that both professionals and laymen would in the end gain from a system in which coordinates prevail.

A few countries, such as Austria (Zevenbergen 2002), have taken a stand in favour of legal coordinated cadastres and have started implementing nationally unique systems. Similar ideas have been evolving for some years in jurisdictions such as Hong Kong (Tang 2002), Israel (Fradkin & Doytsher 2002) and Sweden (Karlsson 2004). On the other hand, there are also states that have abandoned earlier thoughts of such reforms, e.g. in Canada (ALSA 2002) and in Australia (Jarman 2006). However, until recently no jurisdiction had yet established a complete legal coordinated cadastre, and thus there have been no actual implemented systems to analyse.

[1] Kindred terms used are (legal) coordinate cadastre, digital cadastre, numeric cadastre and coordinate based cadastre.

The situation changed in August 2004, when the Singapore Land Authority (SLA) introduced the first nationwide legal coordinated cadastre. The implementation of the new system involved many technical tasks but also changes in the legal framework, eventually enabling a simultaneous transition for the whole country. Besides its interest as the first such course of action in the world, some of the decisions made within this programme of reform could also break new ground in the cadastral discourse.

The Singaporean system thus provides a unique opportunity for gaining insight into the construction and functioning of a legal coordinate cadastre and would serve as an important source of information for benchmarking and other types of analyses. Specific technical issues, e.g. the establishment and subsequent refinements of the new reference system, have been studied in various contexts over the last years (see e.g. SNAP 2000 and Khoo & Tor 2005). Regarding the legal aspects of the reform, however, the references are fewer. Tang (2002) includes in his thesis a brief background and some comments on the new legislation, but otherwise little has been reported internationally on this matter.

Since neither terminology nor interpretation is universal and distinct in this field, this paper initially discusses theoretical aspects and concepts of legal coordinated cadastres. There then follows a presentation of principle features of the new Singaporean system and its legal implications. In the latter respect, the applied methods of data acquisition and coordinate conversion are discussed, as well as the creation of a new reference system. Emphasis is then placed on the amended Boundaries and Survey Maps Act, which gives legal significance to the boundary coordinates in the digital cadastre. In this context, the possibilities for correcting erroneous coordinates and the lack of a State guarantee for the recorded boundary data are objects of discussion.

2. DIFFERENT APPROACHES

2.1. Concepts and Interpretation

Many terms used in the cadastral field are subject to interpretation and are, hence, given different meanings depending on the context. Besides the fact that cadastres world-wide are designed to meet local needs under nation-specific conditions such as legislation, the ambiguous terminology may, to some extent, be explained by the limited amount of research carried out using a systems approach. For some time studies focused mainly on isolated issues, for example comparisons between fixed and general boundaries or registration of title versus deeds, without any deeper concern for the other components of the interlaced system. Alternatively, when a specific national cadastre was considered more thoroughly, there was often more emphasis on facts such as technical characteristics and organisational structure than on functions and applications.

During the last decades, however, the importance of viewing cadastres as whole and often multi-purpose systems has been emphasised by a range of professionals. In addition, alongside the general trend toward globalisation, the possibilities of investing in real estate outside the domestic market have also inspired the development of standardised terms.

Consequently, some efforts have been made to establish generally applicable sets of concepts, such as through special glossaries developed by EULIS (2003) and UN-ECE (2004), thus facilitating a greater interchange of information and a common basis for further discussion. The terms legal coordinated cadastre, legal coordinates etc. are however not included in those lists, possibly due to their vagueness and limited realization.

2.2. Aims and Arguments

One central issue for all cadastres is how property boundaries are represented in the register, especially on the cadastral map(s). Since many countries now modernise their cadastres by digitising the analogue records, thereby making the spatial information more accessible and easily managed, this question has become even more highlighted in recent years. Numerous reports about various countries' digitisation processes – from early visions to actual implementation methods and technical results – have, accordingly, been presented at national and international conferences. One general aspect worth noting is that the digitising itself does not improve the spatial accuracy of the boundary points, rather the reverse. In order to achieve more accurate coordinates, there has to be additional work done such as field surveys.

While many potential advantages of digital boundary data are universally recognized, expert opinion varies widely regarding the relevant level of accuracy as well as the legal significance of the coordinates. Thus, terms such as legal coordinates have different meanings depending on the speaker. Williamson (1996), for example, states that coordinated cadastres are a key to building future GIS, aiming at an accuracy of the coordinates sufficient to represent the "true coordinates" for all practical purposes. In figures, such accuracy is estimated to be about ±0.03 m in urban regions, ±0.2-0.3 m in rural areas and ±0.5-2 m in mountainous districts. Yet, he is reluctant to allow these coordinates constitute the legal definition of boundaries, since such a development would require a complicated change in the traditional "monuments before measurements" principle long since practiced in Australia. Dale (2002) goes even further, using the word "crazy" about the idea of defining boundaries by coordinates. His message is clear: physical demarcation on the ground is of crucial importance, especially to the landowners.

The ideas and arguments mentioned above do not, however, stand unchallenged. Proponents for legal coordinated cadastres and supporters of the introduction of such systems are found around the world. Some parties mean that the cadastral field should keep pace with and benefit from the new technologies and their great development potential (see e.g. West & Sarib 2001 and Kaufmann *et al* 2002). Others point to the risks to traditional systems should cadastral proficiency decline due to reduced number of students specialising in surveying (Blanchfield & Elfick 2006). However, full-scale implementation is so far rarely seen. In Europe, for example, Austria has been the leading country, starting in 1969 to create their "Grenzkataster". Since the Austrians apply a sporadic method by which this new cadastre is built up in connection with subdivisions etc., the pace of completion is consequently relatively slow. Hence, not more than about 12 % of the parcels were legally defined by coordinates thirty-five years after the start. (Karlsson 2004) Singapore, on the other hand, completed its legal coordinated cadastre within a decade, much owing to a forced programme

(see section 4 below). The small geographical size of Singapore and the comparably modest number of properties did obviously contribute to the accomplishment of the reform, though an equally important contributor to the quick progress was the systematic method of data acquisition.

3. POSSIBLE INTERPRETATIONS OF "LEGAL COORDINATED CADASTRE"

3.1. Similar Words, Different Meanings

As stated above, the term legal coordinated cadastre needs to be clarified and established as the first step in any discussion of its possible implications and effects. While the word *cadastre* itself has been rather thoroughly elaborated over the years, there are some important aspects of the two attributes *coordinated* and *legal* that require clarification.

Firstly, and most apparent, one must distinguish between *coordinated* as in "under organisational coordination" and as in "based on coordinates". The first interpretation refers to the fact that different parts of the register are operated and maintained by separate authorities but joined together in some way (FIG 1995), or that the cadastral processes are coordinated or integrated in one system (Williamson & Hunter 1996). Although the organisational structure of a cadastre is often highly relevant for the system's efficiency and capacity, this is not the meaning of the term in this context.

In this paper the term *coordinated* refers exclusively to the cadastre being based on boundary coordinates. The crucial issue here is that the geographical extent of every registered parcel is described or defined numerically by national coordinates stored in a data base and visualised on a digital cadastral map.

The primary interest in investigating this aspect of coordination is the great potential for the direct use as well as the adaptation of digital spatial data, both within the cadastral community and among other parties in the public and private sector. From the surveyors' point of view, a complete and survey-accurate digital cadastral map is an important tool for reducing the time spent on field work and mapping. Further, the demand has increased significantly during the last decades for digital property data to be used for efficient infrastructure planning, construction, register management and various GIS applications. The rationalisation effects within these individual contexts also favour the property owners, who cover the expenses for survey services etc. through fees. Irrespective of the fact that there are many alternate ways for data acquisition and achieving the required levels of accuracy of the boundary coordinates, a coordinated cadastre with a digital cadastral map is generally accepted as a justified development for many countries.

The meaning and importance of the second aspect in question, the attribute *legal*, are less obvious. One way of interpreting a legal coordinated cadastre is to regard the digitally registered property information about e.g. ownership and rights as legally valid primary data, while the recorded boundary coordinates only describe (mirror) the true boundaries on the ground. The motive usually referred to for excluding the digital boundary data from the legal

significance of the rest of the cadastre is that demarcation on the ground should prevail over survey measurements (see e.g. McEwen 1994). According to this meaning of a legal coordinated cadastre, the attribute *legal* focuses on *cadastre* and most of its contents but not, however, on the boundary coordinates.

Another way of viewing the concept in question, as is the case in this paper, is to link the attributes *legal* and *coordinated*, thereby indicating that the boundary coordinates do have legal significance. In this respect, the degree of legal significance could still vary from a moderate extent, where coordinates are one means of evidence to assist in defining boundaries (see Williamson & Hunter 1996), to a high level, where they are primary, statutory evidence in determining boundary location (see Todd *et al* 1999). Depending on user demands and the overall aim of the specific cadastre, various solutions may thus be implemented.

3.2. Theoretical Legal Aspects

Focusing on coordinates that actually define boundaries by representing best evidence, two particular legal questions can be considered. Firstly, are the registered coordinates indefeasible or is it possible to correct them should they prove to be wrong? If the purpose of the cadastre is a register of information that constitutes certain legal facts – providing fully reliable data at all times (comp. registration of titles) – the idea of amendment is in itself contradictory, irrespective of the error. In this case, the only changes to be made are updates based on proper boundary adjustments due to reallotment etc. The argument for such a model (though probably implemented nowhere) is the crucial importance of trustworthiness of the registered data. Consequently, it much favours third parties. If, on the other hand, the cadastral data is above all else to serve the property owners, the approach needs to be more practical. Thus, corrections of errors made by the surveyor or registrar, or adjustments due to certain land movements, must be allowed. The issue of adverse possession could possibly also play a role in this case, but there is a common move to abolish such instruments.

Secondly, are the coordinates guaranteed in any way? Although such a guarantee could take many different forms, it is generally a State liability that is considered in this context. Depending on the choice of model discussed above, the State could guarantee the correctness of the registered coordinates either by keeping the data fixed and compensating the person facing loss due to this strictness, or by correcting the data and compensating the person facing loss due to the change of coordinates in the register itself. The types of errors and possible corrections that entitle parties to such indemnity may vary from solely technical faults in the data base to a more generous approach where all disclosed errors and mistakes result in liability. In the contrary case, the State has no liability at all for the registered coordinates, which instead are the responsibility of the individual surveyor or the cadastral authority delivering the data.

So far, very few jurisdictions have implemented a cadastral system in which boundary coordinates prevail as conclusive evidence. As a consequence, information and experiences are scarce for evaluating their usefulness and applicability. However, by the declaration of a

complete and legally valid coordinated cadastre in 2004, Singapore is regarded as having reached the highest stage of development of such systems.

4. THE COORDINATED CADASTRE OF SINGAPORE

4.1. Background

The cadastral history of Singapore dates back to the late 19th century, mainly as a result of the 1884 legislation on Boundaries and Survey Maps and the consequent resurvey of the colony that started in 1902. After examining registered deeds and survey records, all occupational boundaries were at that time identified and, if agreed upon, fixed and then represented on the so called Published Maps. For a certain period of time, these maps were open for objection before they became conclusive evidence of the parcel boundaries. Later, all subdivisions and amalgamations were shown on survey plans which, when approved by the Chief Surveyor, became the basis of the certified plans and also the cadastral maps (replacing the Published Maps). As regards land registration, Singapore originally introduced a deeds registration system in 1887, which since the mid 1950s is gradually evolving into a title system. This development and above all the demand for better and uniform survey techniques brought about concrete ideas about a modern cadastral reform in the 1990s. (See Goh 1994 and Song 1992)

One decade later, in August 2004, Singapore's Coordinated Cadastre was accomplished. The Singapore Land Authority (SLA) has described the overall aim of the reform to be an increase in efficiency. More specifically, the anticipated benefits are to result from faster cadastral survey processes, greater integration and sharing of data amongst organizations, and lower survey costs. The achievement of these goals were, and still are, dependent on the creation of a whole new system including the development of technical prerequisites for GPS surveys, a cadastre based on GPS coordinates, better administrative device for cadastral procedures and adapted cadastral rules and regulations. (SLA 2005a)

4.2. Technical Tasks Associated with the Reform

When starting the reform work, one fundamental technical task was to establish a homogeneous national reference system for supporting GPS surveys. To do this, Singapore introduced a new system called SVY21, based on the WGS84 ellipsoid. As a standard the coordinates are given using the Transverse Mercator Projection. Furthermore, they established a network of reference stations for GPS. The active part of this network, the Singapore Integrated Multiple Reference Station Network (SIMRSN), was set up in 2000 as part of a joint research project. Consisting of five permanent and continuously operating GPS base stations, linked to a central processing facility at Nanyang Technological University (NTU), it supports both post-process static surveys and real time surveys. (Khoo & Tor 2005, Khoo 2002) The passive part of the SVY21 network, the Integrated Survey Network (ISN) comprises approximately 4,000 control points located along all major roads (SLA 2004). These points are uniquely numbered and marked on the ground with labelled markers. The SLA keeps a database with information of all control points describing the particular location

through the pair of coordinates, ellipsoidal height value and containing a site photo or sketch (SLA 2005b). This data, which may be obtained via Internet through the Integrated Land Information Service (INLIS, see www.inlis.gov.sg), is used for all kinds of survey work.

Another technical effort dealt with by the SLA was the conversion to SVY21 coordinates of the existing boundary data of all registered land parcels. Because the previously used plane coordinate system had been non-homogeneous, and the basis of most cadastral surveys had utilized a bearing and distance method, some recorded measurements were ambiguous (SLA 2005c). Consequently, the data conversion could not be made only and directly through simple mathematical means. Much of the initial work, therefore, consisted of systematic, block by block GPS surveys of some strategic control marks and of about 10 % of the intact boundary marks. The obtained SVY21 coordinates were then used both as survey data for the points in question and for estimating transformation parameters for the respective blocks. With these parameters established, it was possible to convert all existing boundary points and store them in the new cadastral spatial data base, the Survey Mapping Sub-system (SMS). Most conversions resulted in high accuracy coordinates, i.e. ±0.03 m, entailing an approved ("class 1") survey quality for these points. Where, in some cases, the original boundary measurements were too poor to bring about coordinates of this accuracy, the survey quality was specified as provisional ("class 2"), calling for a quality-raising update on any following survey in the area of the boundary point in question. (SLA 2005d) The conversion work, which affected approximately 136,000 land parcels, was initiated in 1995 and finished in July 2004 at an estimated cost of 8.67 million Singapore dollars (SLA 2004) or approximately 4.2 million Euros.

Besides the comprehensive technical tasks described above, the SLA also started to improve the administrative solutions for the cadastral process. A system was recently set up whereby registered surveyors are required to submit their cadastral survey jobs to the SLA via the Internet, through an e-submission system known as CORENET. The SLA will handle such jobs in another web-based system, the Job Data Storage System, which supports e.g. validating of submitted jobs, approval of jobs, payment and reporting. (SLA 2005a)

4.3. Legal Tasks Associated with the Reform

The core legal issue confronting the SLA was to bring forward rules and regulations for establishing the coordinated cadastre and for giving it legal effect. This was accomplished mainly through amendments of the Boundaries and Survey Maps Act (Chapter 25) of 1998, in short BSMA.

Initially, according to BSMA Section 7, the responsibility for establishing the coordinated cadastre rested with the Chief Surveyor, who was, for that purpose, empowered to convert boundary coordinates and to declare specific areas to be within the coordinated cadastre. Finally, when all land in Singapore had been likewise declared, the Chief Surveyor was to give public notice of the coordinated cadastre coming into force and superseding all maps published under the repealed act. By that final declaration in the Singapore Government

Gazette, made on 2 August 2004, the registered SVY21 coordinates of all parcel boundaries were thereby given legal significance, in accordance with BSMA Section 13(2):

> *"…every map generated from the co-ordinated cadastre shall be conclusive evidence in all courts of the boundaries of the land comprised in every land shown therein, subject only to any order made under section 12 for their modification, correction or alternation"*.

As for all registers and A.D.P. systems, human mistakes and technical faults may occasionally cause incorrect data. Among other things, Section 12 of the BSMA empowers the Chief Surveyor to correct the cadastral map (i.e. the underlying data base, the SMS) should it be defective due to e.g. errors in measuring or data conversion. Consequently, the coordinate cadastre forms conclusive evidence of boundaries, but it is not definite and indefeasible should faults or errors be established. The liability of errors deriving from cadastral surveys is, as before, tied to the registered surveyor who performed the survey in question, according to BSMA Section 11D(5). Boundary data in the coordinated cadastre is not, therefore, – contrary to registered titles – guaranteed by the Singapore State (SLA 2005d).

Furthermore, changes were needed in the regulations governing the conduct of cadastral surveys. This was partly effectuated by amendments to the Land Surveyors (Conduct of Cadastral Surveys) Rules authorised under the Land Surveyors Act. In addition, the CS Directive on Cadastral Survey Practices, as well as guidelines for various types of GPS surveys, were issued by the SLA. Among other things, this directive includes the administrative steps and technical specifications of survey procedures, e.g. requirements concerning traverse circuits, area computation and plan design (see SLA 2005e).

4.4. Landowner Participation and Acceptance

Another notable aspect of the Singaporean reform method was the low level of landowner participation during the years of preparatory work. For example, the field surveys were performed without the proprietors being present, and the measured or calculated SVY21 coordinates were registered without any kind of approval by the respective parties. The communication between the authorities (generally the SLA) and the public was also mainly one-way, often announced through official notes of information in the Singapore Government Gazette or on the SLA website. (SLA 2005d)

This fairly simple course of action seems to have been well accepted, presumably due to the fact that the systems change was considered mostly technical and thereby of little concern to the general landowner. In this respect, one important factor was that the area (in square metres) of each individual property – tied to the registered title and constituting an important basis for taxation etc. – stayed unaltered without any risk of adjustment due to the new coordinates. This solution was a precautionary measure, deliberately taken in order to avoid problematic conflicts of interests. (SLA 2005d) Furthermore, since the coordinated cadastre may be corrected if discrepancies are observed between the coordinates and e.g. reliable boundary marks on the ground, the amendments of the Boundaries and Survey Maps Act

giving legal significance to the new cadastre are of limited actual effect to the property owners.

5. FINAL REMARKS

The new cadastral system in Singapore is technically advanced, providing good conditions for efficient use, interchange and update. Exactly how the coordinated cadastre will perform in practice, and what the economic savings will be, will be revealed in the years to come.

From a legal perspective, every Singaporean property created or altered after the implementation of the coordinated cadastre is recorded with an unambiguous specification of its physical extent. As to properties existing at the time of the reform, however, the registered area may not correlate to a calculation made from the legal boundary coordinates. Whether or not such an ambiguity will cause any real problems is hard to predict, but it brings an element of uncertainty into what is otherwise a uniform cadastre.

The Singaporean concept that the registered boundary coordinates may be corrected where found to be faulty, and also that they are not guaranteed by the State, mirrors a fairly practical view of the cadastre. With respect to the extremely high land prices, it is somewhat remarkable that the parties within the property market accept such a moderate "security" of boundary location. On the other hand, the very high development density and great number of multi-dwelling blocks (often 3D properties) makes boundary issues perhaps less controversial than would be the case in sparsely populated areas. Somewhat simplified: Once the buildings are raised, few people bother about the exact position of the legal boundaries.

Besides the direct effects to the Singaporean society, the completion of the legal coordinated cadastre also brought a new dimension to the cadastral field in general. What used to be a theoretical and hypothetical question is now a reality which can be discussed, evaluated and subjected to benchmarking. Time will show whether the Singaporean cadastre will be regarded as a prototype of other systems or an isolated case of experimentation.

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BIOGRAPHICAL NOTES

Kristin Andreasson (formerly Karlsson) holds a M.Sc. in Surveying from Lund University, 1999. After working as a cadastral surveyor at the Regional Cadastral Authority in Malmö, she was employed by the National Land Survey of Sweden, Department of Strategic Planning and Information, in 2001. Besides involvement in various development and production projects, her main assignment is a Ph.D. study, linked to the Department of Real Estate Science at Lund University, on issues of a future legal coordinated cadastre in Sweden. She obtained the post graduate degree Licentiate in Engineering in 2004 and will submit her doctoral thesis in spring 2007.

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