

**COORDINATES IN CONTEXT:
TECHNICAL, SOCIAL & LEGAL IMPLICATIONS OF
USING COORDINATES-ONLY TO DEFINE BOUNDARIES**

Final Report to the Canadian Council on Geomatics

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Dr Brian Ballantyne

and

Khaleel Khan & Tom Conyers

Table of contents

Recommendations	2
Executive Summary	3
Part I - Introduction	
1. Purpose	5
2. Context	5
3. Definitions	7
4. Related concepts	7
Part II - Non-Monumented Boundaries: Past & Present	
1. Features as boundaries	10
2. Limited monumentation	10
3. Deferred monumentation	11
4. The New Brunswick experience	12
Part III - Technical Issues	
1. Datum adjustments	13
2. Density of control monuments	14
3. Technical capacity of industry, profession & users	15
4. Stability of the earth's crust	16
5. Accuracy	16
Part IV - Social & Institutional Issues	
1. Territoriality	18
2. Experience from the developing world	19
3. Landowners' preferences	20
4. Institutional capacity of the profession	21
Part V - Legal Issues	
1. Doctrine of original monumentation	23
2. Hierarchy of evidence	24
3. Adverse possession - Prescriptive rights	25
4. Conventional boundaries & estoppel	26
5. Guaranteed boundaries & risk management	27
Part VI - Harmonizing Monuments with Coordinates	
1. New coordinates-only subdivisions	29
2. Temporary marks	30
3. Re-establishing existing boundaries	31
4. Tolerances	31
Part VII - Conclusion	33
References	35
Appendices	39

‘While you’re refreshing yourself’, said the Queen, ‘I’ll just take the measurements.’ And she took a ribbon out of her pocket, marked in inches, and began measuring the ground, and sticking little pegs in here and there.

Lewis Carroll on the use of monuments - *Through the Looking-Glass* (1872).

Those to whom the King had entrusted me, observing how ill I was clad, ordered a Tailor to come next Morning, and take my Measure for a Suit of Clothes. This Operator did his Office after a different Manner from those of his Trade in Europe. He first took my Altitude by a Quadrant, and then with Rule and Compasses, described the Dimensions and Out-Lines of my whole Body; all which he entered upon Paper, and in six Days brought my Clothes very ill made, and quite out of Shape, by happening to mistake a Figure in the Calculation.

Jonathan Swift on the use of coordinates - *Gulliver’s Travels* (1735).

Recommendations:

1. That the Canadian Council on Geomatics support a trial project using coordinates-only to define parcel boundaries; to include two residential subdivisions in a suburban setting. The purposes of the project are to evaluate measurement and adjustment methodologies; to perform a cost-benefit analysis; to gauge social acceptance and develop awareness campaigns; to determine the risk associated with transfers of land; and to apply any principles gleaned from the Canada Lands and New Brunswick experiences. The two subdivisions should be monitored over a five-year period, and should be located in either British Columbia, Alberta or New Brunswick, because legislation in those three jurisdictions now allows subdivision using either coordinates-only or deferred monumentation.

2. That the Canadian Council on Geomatics encourage the integration of all new parcel boundary monuments to the Canadian Spatial Reference System, as is now done in many integrated survey areas and within specified distances of control survey monuments in many jurisdictions. Such encouragement should take the form of debating the merits of integration to parcel-based mapping, of demonstrating how integration will enhance the skills of the land surveying community, and of discussing the adoption of a uniform set of national standards for integration.

3. That the Canadian Council on Geomatics acknowledge that parcel boundaries will continue to be demarcated with monuments and that such monuments should not be disturbed in the servicing, house-building and landscaping phases of subdivision development. Such acknowledgment means supporting a requirement that the monuments be visibly, physically marked (as is now done in British Columbia), and encouraging the use of deferred monumentation (as is now permitted in Alberta and British Columbia).

Executive Summary

The purpose of this study was two-fold. The first purpose was to report on the implications of adopting a coordinates-only approach to defining real property corners, by examining the technical, social, and legal implications. The second purpose was to report on the legal concepts which would have to be enshrined in legislation in order to implement such an approach.

The study found three themes in the debate over using coordinates-only to define boundaries. There is a lack of consensus within the legal and geodetic surveying communities on what is meant by using the terms “coordinates-only” or the “coordinate-based cadastre.” There is as much ideology as there is analysis in the debate; various assertions have been advanced for three decades at the expense of evidence. A hybrid system of some coordinates and some monuments can, and to some extent does, coexist in various jurisdictions, including Canada Lands and New Brunswick. Owing to significant differences in the cadastral infrastructures in the eleven jurisdictions, though, the use of coordinates-only should not and cannot be implemented on a national scale.

The analysis suggests that the technical, social and legal barriers to using coordinates to define boundaries (and not merely to represent boundaries in a database) are neither insignificant nor insurmountable. The prerequisites for using coordinates fall into four categories:

- access to cadastral coordinates which are linked to an accurate, distortion-free reference frame such as NAD83(CSRS). Maintaining and using the CSRS, and ensuring access to reliable archived data, are necessary, but not sufficient conditions.
- the ability of land surveyors to employ correct adjustment and measuring methodology. The surveying profession is, in fact, embracing the use of GPS, and has many options for adopting the technology, such as sharing and pooling equipment, expertise, and data.
- legislation (statute and regulation) which permit boundaries to be defined by coordinates-only. Any new legislation must be predicated on the use of coordinates-only being more reliable and less expensive than any system it replaces.
- social and institutional acceptance of using coordinates-only. This would require a pragmatic and cautious campaign of persuasion, directed at land surveyors, land developers, house builders, lending institutions, landowners, First Nations, and municipalities.

The use of coordinates-only becomes a matter of policy for the Surveyors-General or Directors of Surveys in each jurisdiction. The primary agency for evaluating the merits of implementing a system of defining boundaries using coordinates-only are the ten provincial governments (those agencies responsible for cadastral surveying, registration of rights in land, and mapping and geodetic surveying within the provinces), and the Legal Surveys Division of Geomatics Canada (responsible for surveying on Canada Lands). Each of the 11 respective jurisdictions would have to demonstrate the will to use coordinates-only, and to reflect that will in policy, procedures and regulations.

If the view of Canadian landowners (who are the primary stakeholders in the cadastre) are discounted or qualified, then two dangers loom. First, it would demonstrate a singular lack of consistency, given that all parties agree that the view of First Nations’ peoples should be respected as to how their boundaries are defined. Second, it would risk alienating an ally if public opinion is needed in lobbying for changes to provincial legislation to allow the use of coordinates-only.

It would be prudent to run a trial project in at least two new residential subdivisions, in two different suburban communities, over a five-year period. This would allow standards, methodologies and techniques to be evaluated, would gauge stakeholders' opinions, would determine the acceptable levels of risk, and could provide some cost-benefit analyses. If, after the successful completion of the trial, the policy decision is made to use coordinates-only on provincial or regional scales, then legislation must be explicit in setting out the conditions to be met so as to ensure that the use of coordinates is reliable; must prohibit the concurrent use of monuments at the same boundary; must give no legal sanction to temporary monuments; and must set relative accuracy tolerances within which no boundary dispute would be entertained.

Concurrent with such a trial project, a national debate should begin regarding the integration of the positions of all new boundary monuments to the Canadian Spatial Reference System. As a stand-alone initiative there is much to be gained by explicitly linking integration with efficient, reliable parcel-based mapping and land information systems. As an intermediate step in any possible transition to the use of coordinates-only, systematic integration will increase the skills of the land surveying community in the use of technology and techniques, will stimulate the discussion of a national set of integration standards, and will enhance the value of cadastral data.

Finally, it would be prudent to pursue two related initiatives. First, investigate the enhanced use of deferred monumentation. Second, implement better safeguarding of monuments. Both measures should serve to enhance the survival of the monumented cadastre.

Part I - Introduction

1. Purpose:

The Canadian Council on Geomatics endorsed the following resolution at its 1997 Annual Meeting:

- Whereas there is increasing pressure to move to coordinates-only as the legal definition of the corners of real property boundaries; and
- Whereas positioning technology has advanced to the point where this concept may be technically and economically feasible; and
- Whereas the concept has significant legal, technical and social implications that are national in scope; therefore,
- Be it resolved that a working group of interested CCOG member agencies be formed ... to investigate and report on the implications of adopting a coordinates-only approach to defining real property corners and on the legal concepts that would have to be enshrined in the legislation of each jurisdiction to implement such an approach.

Therefore, the purpose of this study is to “report on the implications of adopting a coordinates-only approach to defining real property corners.” The study is set out in seven parts. Part I describes the context within which the debate is taking place and defines the terms. Part II focuses on past and present examples of the use of non-monumented boundaries in Canada. Part III examines the technical implications of using coordinates-only, and asks if it is technically feasible: Can it be done? Part IV examines the social and institutional implications of using coordinates-only, and asks if it is socially acceptable: Should it be done? Part V examines the legal implications of using coordinates-only, and asks if it is legally permissible: May it be done, and if so, how? Part VI discusses the concepts which would have to be enshrined in legislation if coordinates-only were to be implemented. Finally, the study concludes in Part VII with a summary of the issues which inform the debate, which issues directly inform the three recommendations.

2. Context:

Most parcels of real property which are now created in Canada upon grant, transfer, subdivision or severance use physical monuments placed by land surveyors to define their boundaries and corners. Such monuments are colloquially known as posts, pins, bars, and so on. The time at which the monuments are placed in the ground (immediately or deferred), their type, the frequency of their use (density of placement), and their integration with control systems, vary across the eleven jurisdictions - Canada Lands and the ten provinces. See Appendix 1 for the governing legislation on boundary monumentation in the respective jurisdictions.

Given the use of monuments to define boundaries in Canada (and there is no evidence that any other common law jurisdiction in the world has dispensed with the use of monuments to define boundaries), why is there now a debate about the use of coordinates-only? The impetus appears to come from at least three sources. First, various commentators have over the past three decades broached the subject. See Appendix 2 for an annotated bibliography of much of the literature

within the Canadian setting and of some literature from elsewhere. In examining the arguments which have been presented, there appears to be no consensus of opinion about using coordinates-only, much less unanimity of opinion on such use. A 1975 conference on the concepts of a modern cadastre concluded that : "There does not appear to be any consensus of opinion as to whether coordinate values alone should be relied upon for the definition of property boundaries, without reliance on boundary monuments." (Conference, 1975). Indeed, the arguments shed more heat than light on the use of coordinates-only to define boundaries, many of the assertions about the need for monuments remain unsubstantiated, and there is seldom a clear distinction made between defining by coordinates and merely representing by coordinates.

The second source for the debate is the increasing capability of technology in surveying parcel boundaries. Indeed, the origins of the various pronouncements in Appendix 2 seem to coincide with the introduction of electronic distance measuring (EDM) technology. Perhaps EDMs first made possible surveys which were accurate enough to suggest that monuments might be dispensed with. More recently, the combination of a common, homogeneous geo-spatial reference system (CSRS); the presence of reliable, accessible control (either local HPN or more distant active control); and the more common use of global positioning systems (GPS), has led some to question the merit of monuments and to extol the virtues of coordinates.

In a study of the mandate of the Legal Surveys Division of Geomatics Canada, two of the major issues identified in the delimitation of parcel boundaries were the use of coordinates as evidence and the need for physical monumentation: "Advances in GPS technology now make it feasible to consider delineation of boundaries using coordinate values" (Nichols et al, 1998). A study group on the coordinate-based cadastre which reported to the Alberta Land Surveyors Association found that "the momentum of technological change will make serious consideration of a coordinate-based cadastre inevitable" (ALSA, 1999). The cadastral surveying profession has been touted as having the opportunity to use coordinates-only, so as to allow it to continue to control the set of data concerning cadastral boundaries (de Rijcke, 1998).

A third source for the debate about using coordinates in place of monuments to define boundaries is unease about whether the public is now being well-served, if boundary monuments are destroyed in the subdivision development process. If the primary reason for placing physical monuments is to provide long-term evidence of the location of the boundary, then it is critical that they remain in their original locations. Appendix 3 sets out the methodology used to determine the survival rate of monuments, after servicing by utilities and municipalities, house construction, and landscaping. Of 642 monuments investigated in 19 plans of subdivision across five municipalities, 67% of them survived. Of those monuments still present, 85% were found to be in good condition. Thus, one-third of monuments are removed in the development and building process. Of those that remain, most are undisturbed. Overall, 57% of monuments which have been used in recent subdivisions are undisturbed, and thus of use in re-establishing boundaries. If this survival rate (taking into account that it might include monuments which have been replaced after the development process) is unacceptable, then it lends impetus to any debate about using coordinates-only (or at least to ensuring a better survival rate).

3. Definitions:

Some commentators on the use of coordinates-only explicitly advocate that monuments continue to be placed, but that they be subordinate to coordinates in defining the boundary. This argument misses a few legal and social truths. First, the purpose of defining a boundary is to give some certainty to the landowner about the spatial extent of his/her rights in the parcel. Certainty is not well served by using both a coordinate and a monument to define the boundary. Indeed, the use of both would introduce unnecessary ambiguity into the transfer, possession and use of land. One of the purposes of the cadastre and of cadastral surveying is to minimize and resolve such ambiguities. So, let us take it as a given that real property boundaries can only be uniquely defined; that is, by only one legally-sanctioned method and not by a multitude of legally-sanctioned methods. Finally, the CCOG resolution which guides this study was explicit in requiring that “coordinates-only” be investigated.

Thus, the primary focus of this study is the use of coordinates-only to define boundaries. However, integrated surveys, deferred monumentation, and the use of coordinates to redefine a monumented boundary will be examined, to the extent that they inform the main debate. Defining boundaries using coordinates-only means that monuments are NOT placed in the ground to mark the boundaries.

There is much confusion over defining coordinates and coordinates-only, and over the current and future uses of each. The working definition for this study is that a coordinate is a mathematical definition of a property corner in relation to some form of spatial reference system. There is, however, much difference between a coordinate expressed as a position within the Canadian Spatial Reference System (CSRS) and a coordinate expressed relative to the monumented cadastral fabric (such as block corners, subdivision boundaries or road allowances). In examining the technical, social and legal implications of using coordinates-only, it is assumed that the coordinates have an accuracy relative to the CSRS, as represented by the Active Control Stations, the Canadian Base Network, local High Precision Networks (such as in the Yukon, Calgary, and Victoria), or provincial control markers which have been determined to have high precision (such as in New Brunswick, Alberta, and British Columbia). Conversely, it is assumed in this study that coordinates will NOT be defined relative to local control, which is not integrated within the CSRS, will degrade if not vigorously maintained, and will be very difficult to re-establish.

4. Related concepts:

There is also some confusion over the symbiotic relationship between coordinates-only to define boundaries, deferred monumentation of boundaries (see Part II-3), and integrated surveys. Although this study is not **directly** concerned with the latter two, integrated surveys do represent an intermediate conceptual step between the use of monuments and the use of coordinates-only, insofar as monumented boundaries are integrated to close tolerances within a spatial reference system. The coordinates which are derived for the locations of the monuments can then be used as evidence in re-establishing the monuments. Integrated surveys are already the norm in many parts of many provinces, and serve to provide properly geo-referenced data for use in cadastral mapping and in land information systems.

Their common use and the existence of other studies extolling their virtues (Hamilton & Doig, 1993) make it necessary to consider them a bit further. What follows are merely some examples of the practice in some jurisdictions (not an exhaustive list of all jurisdictions which insist on integrated surveys), so as to examine the value which integration might add.

On Canada Lands, integration is replaced in terminology with coordination. The Minister of Natural Resources is authorized to establish a Coordinated Survey Area, within which the position of all new monuments: “shall be determined by surveyed connection to reference points specified for that purpose and shall be expressed in terms of the system of coordinates specified for the area.” Section 28 of the *Canada Lands Surveys Act* goes on to say that the reference points and the system of coordinates are to be in accordance with the instructions of the Surveyor General, and anticipates that the coordinates of an integrated survey monument, whose position has been lost, can be used of evidence of its position. The Manual of Instructions (as of 1996) lists 11 Coordinated Survey Areas; four in National Parks, two in the Yukon, three in the Northwest Territories, and two in what is now Nunavut.

In British Columbia, various parts of the province are designated as Integrated Survey Areas (ISA). According to s41 of the Surveyor General’s *General Survey Instructions*, all legal surveys within an ISA must be integrated with control surveys in the vicinity of the area under survey. For instance, the municipalities within Greater Victoria are within such an area, meaning that all surveys are currently tied to control. The Geo-Spatial Reference Unit of the Ministry of Environment, Lands and Parks is now establishing real-time centimetre-level GPS service within Greater Victoria, which will include enhancement to the control system to ensure compatibility. Thus integration within that area will mean either tying to sparser control monuments using real time DGPS, or traversing to older, denser control monuments.

In addition, the Surveyor General is proposing changes to the *General Survey Instructions* so as include a section on geo-referencing, presumably as a starting point for GPS baseline processing and as a geo-reference for future cadastral compilation. If surveys outside of an ISA have bearings derived by GPS or from geodetic control monuments, or are completed using GPS, then it is proposed that one point within the survey must be tied to the British Columbia Geo-Spatial reference.

In Alberta, all regulations under the *Surveys Act* were repealed in March 1999, and the standards were shifted to the *Manual of Standard Practice* of the Alberta Land Surveyors’ Association. Section C-5 of the Manual sets out the requirements for integrated surveys. Integration with survey control means “obtaining sufficient measurements from survey control markers into the survey to permit the derivation of grid bearings and the computation of a closure starting at a survey control marker and proceeding along the shortest path through the survey to another survey control marker.” All plans of survey which are to be registered under the *Land Titles Act* are to be integrated with survey control if at least two monuments within the survey (either found or placed) are each within 1km of any two survey control markers.

Some anecdotal evidence from Calgary suggests three things. First, of the subdivision plans submitted to the city for approval, some 25% of tentative plans are integrated; whereas over 75% of the registered plans (which establish new property boundaries) are integrated. Second, the city finds it easier to update its cadastral database, and finds that the results are more reliable, when integrated surveys are used. Third, it acknowledges that the increasing use of GPS will make integration less onerous, and should go some way to reducing the attitude of some surveyors that integration is a necessary (or perhaps unnecessary) evil.

In Ontario, the 1990 Report of the Task Force on Integration strongly recommended that all legal surveys be referenced to the control network: “integration of surveys is the most cost-effective way of keeping a planimetric data base and a property map data base up-to-date ... and up to the accuracy standard that will meet the requirements of all users.” It recognized that responsibility for establishing and maintaining an integrated survey system rested with both the municipalities and with the province.

A rigorous cost-benefit analysis of survey integration is difficult, owing to limited quantitative information, as acknowledged by the Ontario Task Force. Two general conclusions can be drawn, however. First, integration is difficult to justify if its sole purpose is to allow coordinates to represent the primary evidence of lost or disturbed boundary monuments. The experience in British Columbia is that the true benefits of survey integration are as a base for municipal infrastructure, mapping and geographic information systems. Similarly, Alberta recognized that users of many types of geographical data require an accurate base - in particular for thematic features connected to the base graphics.

Second, integration complements well the digital submission of survey plans. In Alberta, such digital submissions became mandatory in June 1999, and the digital plan becomes the official document of record as of December 1999. One of the reasons for insisting on digital submissions is to allow for easier maintenance of provincial cadastral mapping. AltaLIS, a consortium of private sector companies and of Spatial Data Warehouse (which is itself a consortium of utility companies) now has responsibility for maintaining, adding value to, and selling cadastral maps, and it lobbied successfully for introducing the digital submission requirement.

Part II - Non-Monumented Boundaries: Past & present

What are the limited exceptions to the use of physical, artificial monuments placed by land surveyors to define parcel boundaries? This Part serves as factual background to the analysis which follows in Parts III to V, and includes the use of natural and artificial features, the contemporary and historical practice (real or potential) of using only limited monumentation, the current use of deferred monumentation, and the New Brunswick experience of using coordinates in place of monuments.

1. Features as boundaries:

Sometimes the extent of a parcel coincides with a feature - natural or artificial, in which case the boundary is the feature. There is no need for additional monuments to mark the feature, nor for coordinates to define the boundary. The boundary is already defined and marked on the ground. Natural features are an excellent example of this distinction. They often (as in the case of land claims in the north) are the boundaries of parcels. However, care must be taken, especially with the very large parcels of land claims land, to ensure that the features which are chosen to define the boundaries do in fact exist on the ground, and that the maps used to choose the features are accurate and current.

The most common natural feature dealt with by the courts have been water boundaries. Lambden (1989) observed that “natural boundaries ... are monuments in their own right ...” Thus, *in A-G for Ontario v Walker* (1971), the trial court held that the southerly boundary of Walker's parcel was the water's edge at Lake Erie. The extent of the rights in land ended at the water, which was the boundary without the need for monumentation: “Any Crown patent which indicates that one of the boundaries of the lands granted is to be a boundary of water ... establishes that boundary as at the water's edge.” Coordinates could only be used to define the location of the natural feature at a given point in time; if the feature is ambulatory (as in a watercourse) then the coordinate value must be dynamic. This is not a case of the coordinate being subservient to the monument, but it is the case of the coordinate being subservient to the boundary. In addition, the changes in coordinate values in delineating a watercourse over time can prove useful in determining if accretion or erosion has occurred.

A common artificial feature dealt with by the courts has been a wall. Again, the wall can serve as both the boundary and as demarcating that boundary. In *Home Bank v Might Directories* (1914), the court held that the boundary between Lots 1 and 2 on Plan D87, was the south face of a wall. That is, Might's rights extended as far north as the face of the wall only; whereas Home Bank's rights included the entire wall - some 22 inches wide at the base. In such a situation both survey monuments (as in iron bars) and coordinates are unnecessary in defining the boundary (although they are useful for mapping purposes and as evidence if the wall is destroyed).

2. Limited monumentation:

In British Columbia, in Alberta and on Canada Lands, parcels can be created through the use of explanatory plans, descriptive plans or registration plans, respectively, which require no monumentation. The *Canada Lands Surveys Act*, s27, allows the Minister to “direct that Canada

Lands be surveyed, laid out and defined in any manner, by any method of surveying ...” As McEwen (1994) has noted, such latitude would allow boundaries on Canada Lands to be defined by coordinates-only. As it stands at the moment, the Manual of Instructions for the Survey of Canada Lands, in cC1, deals with survey monuments, and cD1, ss5-47 set out the type and frequency of monumentation. However, it could be recommended to the Minister that these guidelines be varied depending upon the existence of reliable control and provided all parties to the transfer of land agree.

In Ontario, township systems such as the single-front and double-front were, in times past, predicated on minimal monumentation. In both systems, only the two front lot corners were monumented by land surveyors. The next era of large-scale township surveys occurred after 1871 in western Canada with the Dominion Lands Surveys systems. There was no requirement in the legislation nor in the Manual of Instructions to monument all corners of sections within each township, nor all corners of quarter-sections. Typically, monuments were only used on the south side of east-west road allowances, and on the west side of north-south road allowances. Perhaps these examples can be discounted insofar as the monumentation was placed in order to provide an easy guide for road clearing or for fencing, respectively.

However, a more recent and relevant example of not monumenting parcel boundaries occurred in Alberta between 1912 and 1988. The *Surveys Act* of that period set out no requirement to monument lot corners in plans of subdivision. Only block corners were monumented; lot boundaries were referenced to them. In the City of Calgary alone, some 109,000 lots were created without being monumented, some 44% of the total number of lots now existing in the city. However, this lack of legally-sanctioned monumentation was overcome somewhat by the custom of placing lot bars at parcel corners, in response to a demand from land owners.

Similarly, the Manitoba *Surveys Act* does not now require that all lot corners be monumented. Only block corners are monumented, and lot corners are referenced to them. Manitoba Natural Resources estimates that 200,000 lots (1000 plans of subdivision per year, each averaging 10 lots) have been created in the last 20 years under the provision. Those lots have their boundaries defined by coordinates-only, unless the landowner specifically requests otherwise. This provision will likely change, according to the Examiner of Surveys, so as to require at least the front corners of lots to be monumented (at least in small subdivisions) in order to maintain the monumented fabric and to appease some municipalities.

3. Deferred monumentation:

Deferred monumentation is intended to enhance the survival rates of monuments which are placed after a subdivision has been serviced. Interviews with public and private sector land surveyors in Atlantic Canada reveal that deferred monumentation, although not explicitly allowed by legislation, nevertheless takes place on an informal basis. However, only legislation in Alberta and British Columbia now permits deferred monumentation, in which the boundaries are defined by coordinates when the plan of subdivision is registered, but only until such time as physical monuments are placed in the ground. If the monuments are placed in accordance with the control markers and the plan coordinates, then they define the boundary.

Section 69 of the British Columbia *Land Title Act* allows for a block outline survey for the purposes of subdivision, highway, or forest service road. Only "key monuments at specified

locations" or "at proper intervals" need be placed. When the plan is registered in the land titles system, most lot corners have been defined by coordinates-only "until a complete and final posting of the boundaries is made ... within a specified period." Such deferrals are typically used on large subdivisions (of the 50-100 lot size), at a rate of about 25 per year. Thus, about 2,000 lots are created each year using deferred monumentation.

As of 1975, s43 the Alberta *Surveys Act* has allowed monumentation to be deferred on plans of subdivision, if sufficient control monuments exist nearby to allow lot boundaries to be defined temporarily by coordinates-only. However, the Director of Surveys suggests that deferred monumentation is rarely used. Since 1976, only 2% of 28,968 plans of subdivision have used s43. On the assumption that deferred monumentation is more attractive to large subdivisions, some 6,200 lots have been created in the City of Calgary alone in that time period, meaning that some 300 lots are created each year in Calgary using s43. This assumption is borne out with evidence from the City of Lethbridge, which shows that subdivisions using deferred monumentation were nine times larger than monumented subdivisions.

The only other jurisdiction which appears to be considering the formal use of deferred monumentation is Ontario. As a result of lobbying by the Urban Development Institute to the Red Tape Review Commission in 1996, the provisions for monumenting boundaries were shifted in December 1998 from the *Surveys Act* to the *Surveyors Act*, so as to be administered under regulation by the AOLS. The Ministry of Natural Resources has partnered with the AOLS to consult with the land development sector and to determine how deferred monumentation might be implemented. Draft regulations, to be debated by the AOLS membership, contemplate that the perimeter of the subdivision is to be monumented, the survey is to be integrated, bars are to be put in soon after development, and a bond is to be posted with the municipality.

4. The New Brunswick experience

In New Brunswick, s16 of the *Surveys Act* allows for regulations, s4 of which permits a land surveyor to "not plant legal monuments to mark corners of lots in a subdivision" if enough reliable control points are near to the subdivision and if coordinates are computed for each lot corner. This freedom has existed since March 1973. Within the City of Saint John Integrated Survey Area (ISA), 8,266 lots have been created in 2,200 plans of subdivision, 15% of which plans contained lots which were not monumented. Fewer than 1,000 lots exist whose boundaries are defined by coordinates-only, although some lot boundaries might be monumented.

Elsewhere in New Brunswick, it is not a common practice to dispense with monuments on plans of subdivision. Typically, the development officer under the Community Planning Act requires that the lots be monumented. However, the Department of Highways has for a long time been using coordinates-only to define the boundaries of parcels of land which it is acquiring or expropriating. One estimate is that 3,000 such parcels are created each year, 60% of which have no monuments defining their boundaries.

Part III - Technical Issues

This part of the study addresses the technical issues of using coordinates-only. It asks whether it is technically feasible; that is, can a system of coordinates-only technically be implemented? The issues are grouped as datum adjustments, control monuments, technical capacity, stability of the earth's crust, and accuracy standards.

1. Datum adjustments:

The quality of a coordinate-based cadastre hinges on the control framework to which it is tied. Control networks based on the national NAD27 datum and NAD83 datum suffer from the accumulation of measurement errors made in the construction of regional and national networks. The move from NAD27 to NAD83 produced shifts of over 100 metres; in Alberta the shifts were in the order of 240 m. The advent of GPS technologies showed that NAD83 also suffered from minor distortions. Hence, the development of NAD83(CSRS). Shifts resulting from NAD83(Adopted) to NAD83(CSRS) were much smaller across Canada, ranging from 0 to 1.3 m with an average shift of 0.3 m. In re-adjusting the Alberta control monuments, the average difference between NAD83(Adopted) and NAD83(CSRS) ranges from 2 to 70 cm, with most differences lying within the 10 to 20cm range (Michaud, 1998).

It is possible that NAD83(CSRS) will be replaced by a better geodetic model in the future. Shifts resulting from any improvement in the datum from NAD 83 (CSRS) to ITRF in Alberta, for example, are in the order of 1 m. Unlike the conversion from NAD27 to NAD83(Adopted), transformations from NAD83(CSRS) to a new reference frame should be relatively easy to model mathematically, although it will be less easy to correct problems in the densification networks. Coordinates of boundaries may be recalculated to fit the new datum, if necessary. The existence of a new, better datum does not mean an automatic transformation of any coordinate-based cadastre. If the impact on coordinates is minimal, why disturb the established coordinate cadastre and incur the associated computational costs? Any conversion of cadastral coordinates as a result of a datum change would have to be subject to a cost/benefit analysis, to allow an assessment of the risk associated with defining "minimal."

Most provinces are working toward the adoption of NAD83(CSRS) coordinates so they can integrate their provincial networks with the Canadian Spatial Reference System (CSRS). The evolution from NAD83 (Adopted) to NAD83(CSRS) requires resources that some provinces lack. Hence, the rate of change is not uniform across the country. New Brunswick, Nova Scotia, Prince Edward Island, Saskatchewan, Alberta and British Columbia are making concerted efforts to integrate their control systems with the CSRS. Ontario is moving in the same direction but at a slower rate because of budgetary constraints and the uncertainty of the value of re-adjusting existing networks based on conventional observations.

A coordinate-based cadastre would function best where all control monuments are integrated into NAD83(CSRS), thereby eliminating the need to transform coordinates from one datum to another. Unfortunately, this isn't the case. Although most provinces have some control monuments based in NAD83(CSRS), much of the underlying control framework is still referenced to NAD83 (Adopted), ATS77 (in Atlantic Canada), or NAD27. Indeed, it is not uncommon for coordinates of control points to be expressed in several different datum or reference systems (NAD27, NAD83, ITRF), with the transformations between them known.

To reduce the problems associated with the implementation of a coordinate-based cadastre, all maintained control networks should be coordinated in NAD83(CSRS). Also, provinces and surveying associations need to adopt regulations to ensure that all surveys are tied to NAD83(CSRS) control in order to avoid the confusion associated with the use of coordinates based on other datums. The development of a homogeneous system of control will take time and money, both of which are dependent on government/regulatory policy and support by the surveying profession. These are not small considerations. For example, there are more than 16,000 horizontal control monuments in Toronto which have not yet been coordinated with respect to NAD83. If a rigorous re-adjustment is not possible, and if the urban canyons make the use of GPS unfeasible, then the enormity of the task becomes apparent.

2. Density of Control Monuments:

Traditional survey practices required dense monumentation. Technical limitations (sight lines, EDM limits) and the need to reduce the chances for error, resulted in monuments being established every 200 to 800 m in urban areas with a wider dispersal in rural areas. This practice resulted in vast provincial networks encompassing tens of thousands of points of varying degrees of accuracy. Today, the trend is toward fewer monuments of a higher quality. GPS technology has made this all possible. For example, New Brunswick is no longer maintaining some 25,000 second order control monuments; rather, it has developed a HPN of 130 GPS-controlled monuments.

Using single-frequency GPS receivers, it is possible to accurately survey baselines up to 20-30 km long. Beyond that distance, observation times increase, satellite geometry must be ideal, and solutions tend to be unstable. Hence monument spacing of 40-60 km would fulfill most survey needs. Of course, denser monumentation may be desired in the urban areas because of greater survey activity. Such control monuments would allow the use of traditional survey techniques which will still be required in the central business districts due to signal blockage and multipath effects. In New Brunswick, there are 130 HPN stations tied to NAD83(CSRS) at about 15 to 20 km apart. In southern Ontario, the distance is about 50 km. This compares, for example, to the 300-500m spacing of the Alberta Survey Control Monuments (ASCM), and to the 1.6 km spacing of the City of Calgary's High Precision Network (HPN).

A coordinate-based cadastre, referenced to NAD83(CSRS), could be initiated under the present configuration. Unfortunately, if there is no further densification of control monuments based in NAD83(CSRS), the distance between monuments may preclude or limit the use of traditional survey methods. A coordinate-based cadastre without further monument densification may force the survey profession to adopt GPS technology at a faster rate than the profession desires - more so, if regulations are changed to force surveyors to tie their surveys to sanctioned NAD83(CSRS) control monuments. As a consequence, the cost of GPS technology may result in greater industry concentration in the short term with the small survey firm being squeezed out of the market.

3. Technical Capacity of the Industry, Profession and Users:

Manufacturers are already producing GPS equipment that will meet or exceed provincial requirements for legal surveys. Single-frequency receivers, together with software and peripherals can be purchased for \$13-15,000, and dual-frequency receivers for \$26-30,000. Thus single-frequency GPS is similar in cost to that of a total station. However, the equipment is beyond the financial reach of many survey firms, and is often perceived to be expensive. A study undertaken by the Corporation of Land Surveyors of the Province of British Columbia showed that 51% of all firms had used GPS for production surveys. Moreover, land surveyors were somewhat reluctant to embrace GPS technology, owing to “what they perceive to be a high capital investment” and to what they regard as “major training or education” (BCLS, 1997). On the other hand, only 23% of the respondents had used GPS when canvassed in 1992, so the technology has a much larger presence now. Moreover, of those who use GPS, 77% use it for legal or engineering surveys.

The findings on GPS use, and the concerns about the costs and complexity, are echoed somewhat in other provinces. In two telephone surveys in 1996 and 1997, the Director of Surveys in Alberta found that the proportion of firms which used GPS in cadastral surveying had increased from 35% to 50%. On the other hand, no firm performed more than 14% of its cadastral surveying with GPS (Michaud, 1998).

In a discussion paper prepared by the Association of New Brunswick Land Surveyors on the control survey system, GPS was identified as an accurate positioning tool whose use is becoming more common, but “the cost of legal quality receivers is still relatively high.” Given the proposed spacing of the control monuments in New Brunswick, the paper noted that surveyors with single frequency receivers will have a limited range of operations. Thus, their concerns focused on the control system, and on the need for and cost of GPS technology (ANBLS, 1996).

Most of the experts to whom we spoke believed that substantial education and training will be required to ensure that surveys conducted using GPS technology are done to the required accuracy (see also part IV-4). It may be necessary for the provincial professional associations to develop and to continually update standards and procedures for GPS surveys so that they meet the requirements of a coordinate-based cadastre.

In addition, some experts suggested that technical specifications should be developed to ensure there is no misapplication of the technologies (i.e. the use of single-frequency receivers on baselines longer than 30 km). As an alternative to strict specifications, the GPS Validation Networks used by many provinces and by the federal government since 1990 can be used to test equipment and procedures.

Furthermore, the proliferation of cheap, low-accuracy GPS technology cannot be ignored. Homeowners may try to determine their boundaries using these devices. With accuracies in the neighbourhood of +/- 100 metres, it does not take much effort to imagine the consequences of such exercises by homeowners.

4. Stability of the earth's crust:

Horizontal displacement of the earth's crust occurs throughout Canada. Of course, the rate of crustal movement varies across the country. Because NAD83(CSRS) is fixed to the North American plate, tectonic movement becomes less of an issue than intraplate movement. Parts of the west coast have a much higher rate of intraplate movement than does central Canada. On the one hand, crustal movement, either secular or episodic, will affect the values of any boundaries which are defined using coordinates only.

On the other hand, boundaries marked with monuments will suffer from consistent deformation over time - i.e. the movement in the monuments will coincide with the plate movement and boundaries will remain unchanged relative to each other. If coordinates are fixed and legally binding, then there is the potential for large disagreements between the physical evidence and the coordinates. Studies on a dynamic datum in New Zealand, a country which sits astride two plates, have determined that coordinates cannot be definitive without modeling the dynamics of both the cadastre and the coordinate system.

Vancouver Island has horizontal movements of about 10cm per decade relative to the mainland of British Columbia, and also relative to the coordinate system or datum. The movement is not entirely uniform in time or in space. Boundaries defined by coordinates will have to take these movements into account. Therefore, coordinates have to be four-dimensional, not unlike how a natural boundary is ambulatory over time. Every coordinate must have the epoch at which it was recorded. Otherwise, it would be impossible to adjust for crustal changes. As well, crustal dynamics will have to be monitored so these changes can be modeled and adjustment software can be developed.

Presently, crustal movements along the west coast are monitored by the Western Canada Deformation Array - a GPS tracking system. But it will be necessary to monitor movement in other regions as well. Boundaries may last for centuries and the accumulated crustal displacement will have to be accounted for to maintain the integrity of the coordinate-based cadastre. Resurveys of the control monuments will have to be done periodically in order to account for accumulated secular crustal motions.

It will also be necessary to develop procedures for data publication, coordinate notation and survey adjustments in order to alleviate any confusion in the field. Also, educational programmes should be instituted to help train the surveying profession about crustal motion and its effect on a coordinate-based cadastre. Problems with crustal motion and its effect on a coordinate-based cadastre can be overcome. Any solution will have its costs, however, and the magnitude of the costs for monitoring, adjustment and education may offset any gains derived from the use of coordinates-only.

5. Accuracy:

For a coordinate-based cadastre to function effectively, the control framework must be able to support the accuracy requirements of a cadastre. Accuracy standards, however, should reflect the users' needs rather than the capabilities of the technology. Hence, accuracy standards should vary between the urban downtown, the suburbs, rural areas, and remote (northerly) areas. Surveyors have suggested that the relative accuracies of boundaries defined by coordinates-only

should range from 1-2cm in urban areas (downtown), to 5-10 cm in suburban areas and up to 15 cm in rural areas, at the 95% confidence level (Fediow, 1995; ALSA, 1999).

To achieve these levels of relative accuracy, surveyors should tie their surveys, regardless of the techniques used, to provincial or municipal High Precision Networks, to the Canadian Base Network, to the Canadian Active Control System, or to provincial survey control markers which have positional accuracies in the 2-10 cm range. Tying surveys to control monuments outside of this system, will lead to the importation of any error inherent in the monument's coordinates. For example, the NAD83 horizontal networks are known to contain errors of about 0.3 m on average, and over 1 m in some areas. Incorporation of these networks will adversely affect the accuracy of the coordinates within the cadastre.

GPS technology can now only meet the relative accuracy requirements for suburban areas and in rural areas, so long as it is applied correctly and accurate control is used. These requirements are not beyond the capabilities of total station technology so long as surveys are done with the required care. However, the accuracy of the best control - either the Canadian ACS or Calgary's HPN - is only about 1cm, and the accuracy of GPS ties to such control is about 2-5cm. Thus, the resulting accuracy of 3-6 cm does not meet the urban accuracy requirement of 2cm. Moreover, traditional techniques will have to be employed where GPS technologies cannot be used (e.g. urban canyons and heavily forested areas).

Summary:

The combination of the Canadian Spatial Reference System, active and high precision control systems, the increasing use of GPS technology for positioning purposes, the advent of digital plan submission (which, for instance, became mandatory in Alberta in June 1999), enhanced internet, cellular and radio communications, and cadastral mapping and the integration of cadastral data into geographic information systems, suggest that the use of coordinates-only to define boundaries is technically feasible. Such feasibility should be enhanced as real-time GPS use becomes more common and reduces the need for post-processing, owing to enhanced digital cellular telephone technology, to the launch of other positioning satellite systems (for instance, from Japan or Europe), and to the advent of three-frequency receivers.

However, any coordinates to be used to define boundaries must have their date specified, the reference system that was used must be noted, and the adjustment method and measuring methodology must be supplied. This information must remain accessible to subsequent remote users. Moreover, there will remain some settings in which the use of coordinates-only relative to the CSRS will be either technically very difficult or financially prohibitive.

Part IV - Social & Institutional Issues

Simply because something can be done, does not necessarily mean that it should be done. In any debate about the use of coordinates-only, it is foolish to ignore the views of those for whom the cadastre exists: the occupiers and managers of land. Certainly, this premise underlies successful land claims negotiations, in which the views of the First Nations must be respected. For example, the Yukon Indians, the Sahtu Dene, and the Metis generally want monumented and cleared boundaries, and would not accept using coordinates-only to define boundaries of land. Early indications suggest that the Treaty Land Entitlement process in Manitoba will also include monumented, cleared boundaries. There are also many examples of Specific Land Claims which are founded on grievances owing to ambiguous demarcation of boundaries. It is entirely consistent, therefore, to also seek and respect the views of non-indigenous peoples living in urban and rural areas of southern Canada.

Therefore, the premise underlying this part of the study is that most peoples are astute about the nature of the boundaries of their parcels. Certainly, there is much evidence to support the premise from the social ecology literature on territoriality, and from the experiences of informal settlements (and from First Nations) in the cadastral reform process. This part canvasses the views of landowners in southern (primarily urban) Canada with regard to preferred style and accuracy of boundary definition. Finally, a summary of the reaction of the land surveying profession is offered.

1. Territoriality:

Two themes respecting human territoriality are evident when reviewing the social ecology literature: defensible space and social behavior. In looking at human territorial behavior, Taylor (1988) incorporated both concepts of territoriality in defining human territorial functioning. He stated it is a system of attitudes, sentiments, and behaviors that are specific to a particular site, which in the context of individuals in a group, reflect and reinforce some degree of excluding from use, responsibility for, and control over activities for that specific site. Whether discussing territoriality or territorial functioning, the focus remains centered on a specific space or site.

Humans use territorial markers in defining the boundaries of these spaces (Taylor, 1988). These can be either permanent or symbolic and consist of physical elements that encompass such behaviors as maintenance and decoration. Permanent markers such as walls or fences tend to be discussed from the defensible space perspective. Symbolic markers such as plantings or decorations are considered more as methods for residents to establish identity or exert control over their territories (Edney, 1976). Despite the type of marking used to define a space, some boundary must exist. Sebba and Churchman (1983) found that a place could only be considered a territorial area when it had “clear, identifiable physical boundaries.”

However, even if a territorial area is defined, it may not necessarily have territorial displays present. Appleyard (1979) suggested that the need for territorial display is a function of identity. If a person is amongst an established or stable group, then they have already achieved a sense of identity and have no need for display. Conversely, members of permeable groups have a greater need or dependence on display to exert or establish a sense of identity. This distinction suggests

that there is an inverse relationship between environmental or territorial display and the extent of power or stability possessed by an occupant.

Territorial marking has received considerable attention in the literature. The presence of a fence or upright barrier was considered a form of territorial display in a study that confirmed territoriality as a function of length of residency (Edney, 1972). Households were approached in neighbouring pairs (target and control) where the target household had some visible display of territoriality in the yard (such as keep out signs). Fences or other barriers at the front portion of the property were considered secondary protective displays. Edney found that 21 households with some form of protective display had been in residence for an average of 21.0 years. This was a significantly longer residence period than the 10 occupants without territorial display who averaged 9.9 years in residence. Edney also recorded home ownership in this study but could not significantly distinguish territorial defense as a function of this variable.

Edney's study exemplified the defensive space concept. A second study that looked at similar parameters set out to explore the social behavior aspect of territorial markers (Greenbaum and Greenbaum 1981). This was a more extensive study encompassing 459 households. Length of residence could not be shown to have a significant correlation with territoriality through personalization of property. However, it found home owners exhibited notably greater levels of personalization than did renters. Reference was made to Edney's study (1972), suggesting that due to its smaller sample size the results regarding length of residence and ownership were ambiguous. Further, despite basic differences between preventive markers and personalizing markers, Greenbaum and Greenbaum suggested markers in general are representative of ownership rather than a function of length of residence.

2. Experience from the developing world:

There has been some significant research done on the boundaries of informal and traditional settlements in many parts of Africa. In both Zimbabwe and South Africa efforts are being made to grant formal property rights and infrastructure to informal settlements, which are the home to some eight million people in South Africa alone (about 20% of the population). In summary, anecdotal evidence from the Urban Sector Network in Natal suggests that families want visible boundary monuments, whether put in by surveyors or not.

A study of 102 families living in informal settlements in Cape Town assumed that attitudes to statutory boundaries is an easily measured indicator in newer settlements. It found that those who knew of the presence and location of boundary monuments were "fiercely protective" of their space and of their boundaries (Barry & Mason, 1997). In a newer settlement in which all boundaries were demarcated with stone monuments, 98% of the respondents would tolerate no encroachments. On the other hand, respondents in areas in which there were no monuments were amenable to "reorganising" their boundaries, in light of minor encroachments over the boundaries. Thus the Cape Town study concluded that the exact locations of structures in informal settlements is of little real concern to residents, provided that they do not diminish the spatial extent of other rights. However, in the formal site, boundary monuments were "sacrosanct" insofar as they were visible to the residents.

The desire for visible monuments even in informal settlements was supported with evidence from Natal. Labour tenants who had been evicted from commercial farms near Pietermaritzburg

established a settlement through land invasion. In so doing, the community staked out plots on the vacant ground, and the boundary beacons remained visible, above the ground (Jackson, 1997). A final bit of evidence comes from research into the boundaries of an older, established settlement in Zimbabwe (Goodwin & Regedzai, 1997). In a High Density Developed Township (HDDT), the views of 47 land owners were sought as to how their boundaries were marked. It found that physical boundaries markers were placed by the residents in a very short time - two-thirds of the boundaries were marked within seven years of settlement and 90% of the boundaries were marked within 17 years. More significantly, residents preferred fences - 63% of the boundaries were so marked, with hedges (16%) being next most favoured.

Elsewhere in Africa, there is much evidence that people in the rural sector prefer that boundaries of field and village plots be marked with physical features. In the Kikuyu area of Kenya, trees were commonly used to demarcate the boundaries of sub-clan (mbari) lands, and the gitoka lily was used to mark out the boundaries of smaller land units (githaka). Indeed, "it was really the process of demarcation which eventually confirmed the use of trees in clarifying rights of land tenure" (Deweese, 1995). Anecdotal evidence from Chad suggests that rural parcels of land were bounded by neither survey monuments nor coordinates. Although such physical features as the edge of a peanut field were imprecise, they were mutually agreed-upon. The location of the boundary might vary with time; however, agreement as to its location and character did not vary.

3. Landowners' preferences:

As the annotated bibliography shows (see Appendix 2), there is much debate within cadastral surveying about what the public wants and/or needs, without actually asking the people so affected. The American Society of Civil Engineers has assumed that "higher-value lands require more accurate surveys" (ASCE, 1993). In the Australian context, questions have been asked as to whether accuracy should vary according to different land uses, and according to the value of the land, or whether one standard should be applied to all lands (Williamson, 1986). However, seldom has research been done to answer these questions or to support the assertions with evidence. Neither the 1977 New Brunswick study, the 1992 New Zealand study, nor the 1998 Australian study focused on how land owners want their boundaries marked, only on the accuracies that they sought.

If the primary purpose of real property boundaries is to define the extent of a landowners' rights, then their preferences as to type of monumentation and degree of accuracy must be sought. As set out in Appendix 4, a questionnaire was used on 379 landowners in door-to-door interviews in eight communities across Canada (actually, 9% of the respondents were found to be tenants, whose preferences were included). The communities represent an excellent spatial distribution, as well as a range between inner-city - as in Calgary, and rural - as for the Bancroft environs.

Question #5 asked the landowners: "Have you actually seen any survey monuments at the corners of your lot?" If the answer was yes, the respondent was asked to describe said monument. Only if the description sounded reasonably like that of a survey monument was a "yes" recorded. Thus, 140 (37%) landowners do know of the existence of monuments at their boundaries. Furthermore, for 59% of the landowners the existence of the monuments is "important."

Question #7 asked: "How would you prefer to have your boundaries marked?" The four options were visible, natural features (such as a hedge), visible artificial features (such as a fence), a

buried monument (such as an iron bar), or a coordinate (such as latitude or longitude). The examples were provided so as to assist the landowner; geographic coordinates were chosen on the assumption that they were most familiar to people. Very few landowners expressed difficulties in understanding the distinctions between the options. The preference for something physical to demarcate a boundary clearly overwhelmed anything as abstract as a coordinate.

Although there was no significant difference among the preferences for natural feature, artificial feature or monuments, the latter was sought by 121 (32%) landowners. There was a significant correlation, however, between having seen a monument (and correctly describing such a monument), and subsequently preferring a monument. Perhaps having seen a monument makes people value them more highly, or perhaps knowledge of monuments (having been prompted a mere two questions earlier) guides a respondent's choice (in the absence of any other strong preference).

The final question which captured landowners' preferences was #8: "In marking your boundaries, how much error would you tolerate?" Five options were available, in both metric and imperial terms. Preferences for accuracy (or tolerance) were highest for perfect accuracy (at 35%), and dropped off consistently to a low of 7% who would tolerate their boundaries being marked more than 31cm from the true boundary. Ottawa and Bancroft both expressed much greater tolerance; only 15% of the landowners in each community sought perfect accuracy. Indeed, 37% of the rural community would accept a tolerance of 30cm.

4. Institutional capacity of the profession - readiness

The views of land surveyors varied widely. There was much confusion between using coordinates-only, using partial monumentation, deferring monumentation, and integrating the positions of monuments; confusion which is understandable given the ambiguous nature of the terms and concepts. In general they were cautious about the merits of using coordinates-only to define boundaries, and raised many valid (and some straw man) concerns. For instance, at the CCLS meeting in Winnipeg (September 1998), the *raison d'etre* of land surveying was expressed as "putting sticks in the ground;" another respondent noted that monumenting boundaries ensures the long-term survival of the cadastre, because some original evidence is bound to survive a very long time.

Based on the premise that speaking with many experts in many jurisdictions would yield a few, very powerful insights, over 65 experts were contacted, half in person and the other half by telephone. All provinces and both territories were covered, as were five different sectors: private land surveyors and professional associations, federal survey regulators, provincial survey regulators, municipal survey regulators, and others - such as developers and utilities. Their views are summarized here, and are elaborated upon in Appendix 5.

Suffice to say that the reservations of the surveying community about defining boundaries using coordinates-only can be grouped thus: It reduces the role of the land surveyor from that of evaluating evidence: "To curtail this ... exercise for the expediency of boundary retracement by coordinate definition may have its appeal, but does violence to the fundamental concept of 'parcel'" (de Rijcke, 1988). It forces all to use GPS and thereby endangers the small, unsophisticated practitioner, without commensurate benefits to the consumer (as also noted in ANBLS, 1996). It ignores the danger of multi-coordinated points owing to unreliable control

systems. It ignores problems with using GPS in urban canyons, under tree canopies, and in conjunction with multi-path. It marginalizes the desire of landowners for cut-out boundary lines in rural areas, for corner monuments in forestry blocks, and for boundary markers in urban areas. It forgets that various shifts and adjustments in control networks and datums are problematic. It fails to recognize that many house builders stake out their own excavation using their lot monuments. Finally, it does not admit that many municipalities will not approve subdivisions which have not been first monumented.

On the other hand, unequivocal support for the use of coordinates-only to define boundaries fell into five themes: It meets the needs of the seismic/petroleum industry in locating well-sites. It eliminates excessive damage to monuments during the development process. It encourages the land surveying profession to embrace the science of adjustment theory and error propagation. It will reduce the time required to survey, which cost savings will be passed on to the consumer. Finally, it fits within the paradigm of digital cadastral data management, which will allow the profession to combat the inroads made by title insurance.

In general, land surveyors supported the use of coordinates-only where appropriate and feasible. They indicated a willingness to adapt, and adapt to, the most current technology, provided that cautious strategies are employed to implement the use of coordinates-only.

Summary:

The literature indicates a decided preference by land owners for visible features to mark boundaries. Landowners in informal settlements also want something which is visible to them. There is a distinction between newer, surveyed settlements where visible pegs are desired and respected, and older informal, unsurveyed settlements where fences and hedges were chosen. In terms of the Canadian cadastre, although only 37% of landowners have seen a boundary monument, 86% of landowners want their boundaries to be physically marked, and 54% of landowners want their boundaries to be marked with a hedge or fence. Some 65% of landowners would accept their proprietary rights being marked on the ground with a tolerance of +/- 10cm.

There is a rather ironic conclusion to be drawn from this. On the one hand, most landowners have not seen a monument and only one-third of landowners want their boundaries defined by monuments. On the other hand, landowners expressed no strong preference for the use of coordinates-only. The users or consumers of survey services will have to be convinced that there is some benefit to be gained from using coordinates-only. Most landowners want something tangible; such sentiments are ignored at one's peril. The sentiments would account, in part, for the desire for lot bars in Alberta after the 1950s.

Finally, the concerns of the surveying profession - many of which are legitimate, some of which are based on ideology, and a few of which are unfounded but, nevertheless, strongly-held - should not be discounted. If coordinates-only are to be used to define boundaries, then those two stakeholders - public and profession - must be convinced that the merits outweigh the demerits.

Part V - Legal Issues

Any discussion of the legal implications of using coordinates-only is moot, until the judgment is made that it is both technically feasible and socially acceptable. Thus, the premise underlying

this part of the study is that the questions in Parts III and IV can both be answered in the affirmative. The discussion of legal principles assumes that defining boundaries by coordinates-only can and should be done, and asks: May the use of coordinates-only legally be done? The legal issues that are examined include the doctrine of original monumentation; the hierarchy of evidence; the effects of prescriptive rights, estoppel and conventional boundaries; and guaranteed boundaries and the assumption of risk.

1. Doctrine of original monumentation:

Land surveying is primarily concerned with establishing and re-establishing the spatial extent of rights in land. The rights attach to the legal parcel, and the transition from one parcel to the other (from the rights of one to the rights of another) is known as the boundary. It is the character and location of this boundary which concern land surveyors. However, neither monuments nor surveys create boundaries; boundaries are created by the legal action of a parcel owner by operation of law (see, for instance, *Richmond Hill Furriers v Clarissa Developments*, 1996). Monuments or coordinates are merely the physical or the mathematical way of giving meaning to the boundary. They have little significance in themselves; as stated in *Kingston v Highland* (1919), landowners, the courts and the state are concerned with "proprietary rights". Boundaries are merely a means to an end, and the method of marking or locating the boundaries are then a means to a means to that end.

If the extent of the parcel does not coincide with a natural or artificial feature (as discussed in Part II-1), then the "doctrine of original monumentation" (Dobbin, 1998) suggests that physical monuments (sometimes visible and sometimes buried) must be put in the ground at the time that the boundaries are first surveyed. Various biblical injunctions are regularly trotted out to support the doctrine, such as Deuteronomy 19:14: "Do not move your neighbour's boundary stone set up by your predecessors in the inheritance you receive in the land ...". The doctrine is also supported by the assertion that landowners desire such monuments. For instance, McEwen (1994) suggested that it is not "reasonable to expect an owner to be satisfied with a boundary that is not marked physically," and that coordinates should only govern "until such time as the corner is marked by a monument." This temporary use of coordinates was advocated in the context of deferred monumentation.

Of course, as McEwen also acknowledged, the practical boundary of a parcel, as opposed to the legal boundary, is the visible fence, wall, or hedge. This distinction between monumented boundaries and general boundaries was described by the Ontario Law Reform Commission, which noted that landowners expect their parcel boundaries to be visibly marked. However, this expectation "does not dictate the continuation of comprehensive monumentation of boundaries. The interest is ... satisfied not by iron bars, but by ... fences and hedges." (Ontario LRC, 1971)

As the Commission implied, therefore, the doctrine of original monumentation must not become a self-fulfilling prophecy. Simply because many boundaries have in the past been monumented, should not suggest a trend where all future boundaries must be monumented. Indeed, the key is that many boundaries in the past have not been monumented, but have simply been referenced by measurements (usually bearing and distance) to a controlling feature or monument, or by implication of plan geometry. Thus boundaries defined by coordinates-only (albeit relative to the local cadastral fabric, and not to the CSRS) have long been a part of the Canadian cadastre (refer to Part II).

2. Hierarchy of evidence:

The hierarchy of evidence was first explained in Canada in *McPherson v Cameron* (1868), as the general rule, that is used where there is ambiguity in the parcel description, to give most effect to those things about which men are least liable to mistake. In re-establishing a boundary, first natural features are to be used (but only if referred to in the description); second, original monuments are to be used (but only if placed in the ground to mark the boundaries); third, evidence of occupation is to be used (but only if built in accordance with the original monuments); finally, documentary evidence can be used.

More recently, the criteria under which the hierarchy is to be applied have been examined by the courts. *Okanagan Radio Ltd v Dunlop* (1996) noted that “there is a hierarchy of evidence recognized by land surveyors in determining the location of boundaries.” Justice Hamilton referred to the six elements of the hierarchy (as described in *Hawkes Estate v Silver Campsites*, 1989) as natural boundaries; monuments in place; occupation by owners; fieldnotes, distances and angles; plans and tentative plans, and finally, areas. He found that there were no natural boundaries, nor any reliable monuments to aid in determining the southerly boundary of parcel A, which was the reestablishment of the southerly boundary of the district lot. Thus, occupation by the owners since a time when the location of the boundary was presumed to have been known was taken as the best evidence of the boundary.

However, if there is no uncertainty about what is transferred, then the hierarchy is not to be referred to. In determining the boundaries of the Cobham lot in *Herbst v Seaboyer* (1994), the Nova Scotia Court of Appeal held that the description was not ambiguous. Thus, the intention of the grantor “must be taken from the words of the description as there is no ambiguity in the description as was the situation in *McPherson v Cameron*.” The court then went on to stress that: “The well-known rules that are applied to find the intent of a grantor where there is an ambiguity ... have no application whatsoever with respect to determining the [boundaries] as there is no ambiguity when the description is applied to what is on the ground.”

A similar decision resulted in *Richmond Hill Furriers v Clarissa Developments* (1996), in which the court explicitly defined the hierarchy as only an evidentiary principle, and as not a hard and fast substantive rule. The appellants had argued that “a rigid and strict application of the general rule that the best evidence of the location of the boundary between lots are the original posts is improper in certain circumstances.” The Ontario Divisional Court agreed: “In our view, the ‘evidentiary’ rule that posts govern does not apply where the intention of the parties is clear and manifest as to the boundaries.” Given the obvious error in not relocating the posts to reflect the change before registration in the subdivision plan, the posts were held to not define the boundaries. Thus monuments in the ground since the 1920s, but which were placed in error and reflected neither the plan nor the intent of the parties, were held to be inferior evidence to that of the plan distance.

So, if there is no ambiguity in the legal description of a parcel, then the hierarchy of evidence is irrelevant. If there is ambiguity, and monuments were placed to reflect the intentions of the grantor, then the object is to re-establish the boundary according to the position of the original monuments. If, however, no monuments were placed, as if coordinates-only are used, then the

coordinates can become the best evidence of the location of the boundary. This hierarchy therefore is not an impediment to using coordinates-only, for two reasons.

First, it is not all that rigid a hierarchy, as McEwen (1994) ably pointed out: "The rule expressed in *McPherson v Cameron*, taken from an American jurist [Greenleaf 1848] ... is often erroneously assumed to be a rigid evidentiary pyramid that consigns ... coordinates to the lowest and least cogent level. Even in Greenleaf's day that notion could not have always been successfully defended." In essence, each level in the so-called hierarchy complements another. In *Horn Surveys v McCombs* (1980), the court held that a proportioned distance from a block corner was better evidence of a boundary than was a lot bar placed at the time of the original survey and which had been lived up to for some time. If we were to consider the lot bar as evidence of occupation, placed at a time when the location of the original boundaries was known, then the hierarchy would seem to suggest that it is the best evidence (in the absence of natural features or legally-sanctioned monuments) of the boundary. And yet, the court allowed the legislative invocation to use proportioning to overrule the hierarchy. Any use of coordinates-only could likewise be bolstered by a legislative provision.

Second, the hierarchy has evolved from a time when measurement science was less developed, owing to social conditions, terrain, training and equipment. Justice Cooley's speech extolling the virtues of that stuff which people are least likely to mistake (physical monuments) dates to that era. However, measurement science has advanced somewhat since that time, meaning that the hierarchy itself is suspect. Moreover, in the absence of the old hierarchy, and in the face of using coordinates-only, perhaps the courts will develop new principles to allow extrinsic evidence to assist in resolving ambiguities in descriptions.

3. Adverse possession - Prescriptive rights

Prescription tends to refer to rights acquired to use a part of a parcel of land, title to which vests in another. It is a creature of the common law, and is often defined as an easement. Adverse possession, on the other hand, tends to refer to exclusive possession of the land of another, and has its basis in statute law. However, the courts sometimes use the term interchangeably; *Adrian v McVannel* (1992) held that the plaintiff could acquire a prescriptive easement by adverse possession. However defined, prescriptive rights are a creature of the system of registering deeds to land, as in Atlantic Canada and parts of Ontario. With the single exception of Alberta, prescriptive rights have been abolished in land title legislation, as in Ontario and western Canada.

However, most land titles legislation does provide for remedies when encroachments over boundaries are made in good faith. The Ontario *Conveyancing and Law of Property Act* allows the person encroaching to retain the land if compensation is paid, or to acquire a lien upon it, if various conditions are met (see *Noel v Page*, 1995). This provision is echoed in the western provinces, as in Saskatchewan's *Improvements Under Mistake of Title Act*, Alberta's *Law of Property Act*, and British Columbia's *Property Law Act*.

Prescriptive rights - whether possession or mere use - require the existence of a parcel boundary, over which the use of land must be open, continuous, notorious, adverse to the rights of the true owner, and for a period of time specified in legislation. Without such activity over a boundary, a claim for prescriptive rights fails. How the boundary is defined is another matter altogether.

That is, if a boundary is defined by coordinates-only, then it changes the doctrine of prescriptive rights not a whit. Thus adverse possession across a parcel boundary must not be confused with possession of land which serves as evidence of the location of a boundary.

Nor does using coordinates-only obviate the responsibility that a purchaser of land has for ascertaining the location of the parcel boundaries. Any change in the method of defining a boundary does not preclude the need to get a survey. In *Adrian v McVannel* (1992), the respondent was castigated for taking “none of the steps which a reasonable owner would take to ascertain the extent of his property boundary, such as having a survey prepared.” In *Holmes v Walker* (1997), the applicant had bought a cottage lot, only to discover a few years later that some 95% of the cottage was located not on her parcel but on a road allowance. The court held that “she caused the problem by failing to get a survey before closing when it was such an obvious, easy and prudent thing to do.”

The use of coordinates-only should not preclude the need to get a survey before purchasing land, nor should it necessarily increase the need for such a survey. To the extent that the survival rate of monuments is now low, and given that many people do not know of the existence or location of boundary monuments, it will continue to be a prudent purchaser of land who first gets it surveyed. However, the looming spectre of adverse possession as a reason to reject the use of coordinates-only appears to be unfounded. Despite the many lots created without monumented boundaries after 1912 in Alberta (some 109,000 in Calgary alone), and despite s74 of the Alberta *Land Titles Act* allowing adverse possession, it has seldom been proven. There is little to suggest that the situation would change if monuments were prohibited and the use of coordinates-only allowed by legislation in certain circumstances.

4. Conventional lines and estoppel:

Would the use of coordinates-only (such that monuments are not placed) lead to a much higher incidence of land owners agreeing on a visible location for a boundary? If the location differed from the true (although non-monumented) boundary, and if the location of the true boundary was known to be different, then a conventional line has not been established. Neighbouring owners must “have genuine doubt or uncertainty” about the location of the true boundary, “coupled with an honest intention to re-establish the boundary in its correct location” (McEwen, 1997). To the extent that at present many parcels have not been monumented, that many monuments have subsequently been disturbed or removed, and that most land owners have never seen a monument, it is difficult to see how people could be any more uncertain about their boundary using coordinates-only than they are now. If the true boundary location can be determined (enter the land surveyor), then it is not an uncertain boundary that can be varied by agreement, as *Bea v Robinson* (1977) held. Furthermore, it is not at all clear if the doctrine of a conventional boundary can ever apply in a land titles (Torrens) system, according to *Hawkes Estate v Silver Campsites* (1989).

Estoppel is the legal doctrine by which A is prevented from complaining of the violation of his rights by B if: A knew of his legal rights, and B was mistaken as to legal rights, and B spent money in accordance with his mistaken beliefs, and A kept silent upon knowing of B’s mistaken belief. In relation to real property, A could be estopped from asserting his title to land against B, if B has used and occupied a portion of the property and the four conditions have been met. Certainly those were the circumstances which prevented Rollings from evicting Smith from a

part of a parcel of land owned by Rollings (*Rollings v Smith*, 1977). The doctrine appears untroubled by how boundaries are demarcated, and its rare use in real property disputes should be little affected by the use of coordinates-only.

5. Guaranteed boundaries & risk management:

One of the characteristics of a land titles system which distinguishes it from a deeds registry system, is that title to land is guaranteed by the province. With certain exceptions and implied conditions, the certificate is evidence of title, “except so far as regards any portion of land by wrong description of boundaries ...” (Alberta *Land Titles Act*, s66). All land titles legislation in Canada is remarkably consistent in not guaranteeing actual areas of parcels. As an example, the Alberta legislation warns in s91, that: “Every parcel of land described in a certificate of title consists only of the actual area within its legal boundaries ...” That is, in no jurisdiction of Canada - registry or land titles - are the locations of parcel boundaries guaranteed by the state.

If newly-created parcels of land continue to be transferred by reference to a plan of survey (subdivision or otherwise), then the purchaser will continue to acquire (for example) lot 2, block 3, plan 456. The boundaries of the parcel will be defined by monuments, or by coordinates tied to a reference system. It is unclear how boundaries would be any more fixed under the latter system than under the former. The location of the original monument is just as much fixed, if by fixed what is meant is the location of the original boundary (see Dale & McLaughlin, 1988, for three concepts of a fixed boundary). There are certainly many examples of parcels having been created and parcels are still being created which were not monumented, but were referenced, integrated or coordinated. No such guarantee of their location was contemplated.

If, however, the state wishes to guarantee boundaries defined using coordinates-only, then Nichols (1996) suggests that the implementation costs would be significant and would occur in the immediate future. She identifies financial costs in plan examination, in legislative changes, in improving the reference system, in government liability, and so on.

The question remains, however, as to the respective roles of land surveyors (the profession), of the subdivision authority (typically, a municipality), and of the registration and regulatory system (the province) in administering the liability associated with the veracity of coordinates used to define boundaries. Allocating responsibility for assigning official coordinate values is a task of each of the ten provinces, or the Surveyor-General for Canada Lands, respectively. At the moment, land surveyors are given the exclusive rights through legislation to demarcate parcel boundaries in the course of cadastral surveying. The provincial land surveying associations are assuming greater roles in the plan examination process, concurrent with the rolling back of the state. The Directors of Surveys or Surveyors-General have responsibility for preserving the legal cadastre. Provincial agencies in conjunction with the Geodetic Survey Division of Geomatics Canada establish and maintain the spatial reference system. Other provincial agencies are responsible for receiving and registering plans and documents related to the transfer of land. Finally, many municipalities perform their own cadastral mapping, in conjunction with their mandate to regulate the subdivision process.

Given these many overlapping roles, it is critical to ask whether the use of coordinates-only would require a new organizational model. That is, are the existing professional and regulatory bodies sufficient to administer a cadastre in which coordinates-only were used? The ALSA

Study Group suggested that the use of coordinates-only should be predicated on **not** requiring a new organizational model. Two possible scenarios were suggested (ALSA, 1999):

- That coordinates shown on the registered plan of survey by the land surveyor define the boundary. The surveyor therefore assumes full liability for the correctness of the coordinates.
- That coordinates contained in the cadastral mapping base (as administered by municipalities, the provinces, or the Legal Surveys Division) define the boundary. The mapping agency therefore assumes full liability for the correctness of the coordinates.

The second scenario would require more regulation and quality control by various levels of government, which might be unpalatable in this era of government downsizing and out-sourcing.

Finally, significant checks and redundancy must be built into any system of using coordinates-only, so as to minimize the effects of errors in coordinates. Also, a mechanism must be put in place within each jurisdiction to allow such errors to be resolved. Some examples are the Ontario Boundaries Act process, the survey error investigation process (Alberta Surveys Act, s9), or the registered plan variance/correction process (Alberta Land Titles Act, ss92-94).

Summary

There are a few legal, institutional and risk management issues to be addressed before implementing the use of coordinates-only to define boundaries. However, there are many examples, diverse in time and space across Canada, where many boundaries were never monumented in the original survey. If coordinates-only are to be used to define boundaries, then it might mean sacrificing intent to expedience. Certainly this would be the case, if the intent of the buyer and seller (as represented by temporary marks in the ground - see Part VI-2) has less significance than the boundary defined by coordinates. Perhaps sacrificing such intent to expedience is the legal price to be paid if coordinates-only are to be used.

However, any move to a cadastre based on the use of coordinates-only must be sympathetic to the management structure of the cadastre within that jurisdiction. In that context, decisions can be made as to who bears responsibility for the risk associated with the use of coordinate values.

Part VI - Harmonizing Monuments with Coordinates

This section discusses some of the legal concepts which would have to be enshrined in legislation in order to implement a coordinates-only approach. It has a four-part structure: establishing new boundaries, the status of temporary marks, reestablishing existing boundaries, and tolerances.

1. New coordinates-only subdivisions

In order for monuments to be eliminated in favour of coordinates for new subdivisions, changes are required to legislation, to regulations, and, to a lesser extent, to the policies and guidelines of each provincial association. Using Alberta merely as a model for the other jurisdictions (with the possible exception of Quebec), the most significant change is to the *Surveys Act*. Section 41 of the Act now requires that, pursuant to a plan of subdivision, all lot corners and bends be demarcated with a physical monument. This section would have to be amended by deleting any reference to monuments if the entire province was to embrace the sole use of coordinates. If, however, coordinates were to be used only within an integrated survey area (such as within the City of Calgary, given its High Precision Network of control monuments), then the *Surveys Act* would still allow the use of monuments in other circumstances.

Such a hybrid system is now contemplated in the legislation. Section 41(5) recognizes that lot corners were not monumented between 1912 and 1988, and prescribes that the technique of proportioning between block corners shall be used in redefining such boundaries. It is but a short conceptual leap in the legislation from proportioning (bearing and distance from a reference monument) to using coordinates. Both are predicated on the existence of reliable reference monuments (be they nearby or not), and both assume the absence of boundary monuments.

And so, the legislation (or regulations) should explicitly define the form of control framework to which boundaries must be referenced, and should set out the acceptable method of measurements, in order for coordinates-only to be used. Such referencing and measuring would fall into one of two paradigms. The first paradigm would anticipate using traditional traversing by EDM or GPS-style surveying, both referenced to nearby, dense control monuments, such as the High Precision Network in Calgary. This would be the preferred paradigm for real-time surveying. The second paradigm to be provided for in legislation would contemplate using GPS to reference Active Control Points which are located at great distances from the parcel being surveyed. This should only be permitted when temporary, local control points are established by the surveyor.

There are legislative precedents for the first paradigm. Part C, s5.7 of the *ALSA Manual of Standard Practice* prescribes the number and density of control markers which must exist before non-monumented surveys are allowed, and thus anticipates the use of deferred monumentation, under s43 of the Act. Perhaps it would be clearest if deferred monumentation was no longer permitted, so as to eliminate any uncertainty between the temporary use of coordinates and coordinates-only.

Thus, only two scenarios need be considered. If the reliable, accessible control so permits, then no monuments would be allowed. There would be no need to defer monumentation (unless deferral is taken to mean an unlimited time period). However, if the measurements and control

monuments were insufficient, then no coordinates would be allowed. As at present, these if-then scenarios are best dealt with in regulation, to allow for easy changes once the status of a reference framework changes in any given area.

2. Temporary marks:

In areas in which coordinates-only are to be used, legislation should also explicitly prohibit temporary boundary marks from assuming any legal significance. Such marks might be put in by a land surveyor to assist developers, builders and house owners in erecting improvements, but would have no legal sanction. This prohibition is needed so as to not muddy the pool of boundary evidence. The judgment of *Horn Surveys v McCombs* (1980) supports such a prohibition. In fact, the Surveys Act of the time only implied that monuments at lot corners should be disregarded. The court agreed that lot bars (whose use was merely customary, and not required) should be disregarded. If the lack of legal status for temporary marks was made explicit in the legislation, rather than implied, then the courts would have little difficulty in interpreting the legislation.

Certainly, the court held, in *Richmond Hill Furriers v Clarissa Developments* (1996), that monuments placed not in accordance with the plan of subdivision, and contrary to the intention of the landowner, had no legal status. Moreover, that was in a setting where monuments were required by legislation. If monuments were prohibited by legislation, and they were nevertheless placed, then the courts should have no difficulty in rejecting them as evidence of the boundary. Thus, the legislation should make explicit the distinction between dense control monuments, Active Control Points, boundary monuments, and temporary monuments. Use of either of the first two should be an explicit condition of using coordinates-only. The latter two should be explicitly rejected if coordinates-only are used to define boundaries.

This is not to stop the land owner from requesting that a land surveyor put in a monument to allow the former to erect improvements, for instance. Experience tells us that such requests will continue to be common, and they are certainly supported by much evidence as to peoples' preferences for physical, visible marks on boundaries. However, **if** a coordinates-only system is indeed to be implemented, then, by definition, the monument can be no more than the surveyors' opinion as to where the coordinated position applies to the ground.

Recall that in a very significant case involving a discrepancy between the boundary description and monuments in the ground (*South Australia v Victoria*, 1914; see also *Equitable Building v Ross*, 1886), it was not simply the placing of the monuments by the surveyors which defined the boundary. It was, in fact, the placing of the monuments combined with the sanctioning of the location, through acceptance by the neighbouring states, which allowed the monuments to define the boundary. The distinction with the use of unofficial (perhaps temporary) marks, is that such marks cannot be allowed to be sanctioned as defining the boundary. That is, the boundary can be defined by both the coordinate and the monument, **if and only if** the monument is at the coordinated position. Of course, if the monument is sanctioned as defining the boundary, regardless of where it is placed, then a system of using coordinates-only has either ceased to be, or never existed in the first place!!

3. Re-establishing existing boundaries:

The discussion so far has assumed the use of coordinates only for new subdivisions. What of the monuments that now exist to demarcate the boundaries of lots already created. In the case of the re-establishment of such boundaries, then the land surveyor has the duty to find the monument and should then integrate it with the reference system. In the absence of the monument, the land surveyor must use the best available evidence to find the original location of the monument. Legislation (probably the Surveys Act) should be amended to require the land surveyor, after finding the location, to establish the coordinates of the location, if control in the area meets the minimum required by regulation. If that condition was met, a coordinate would replace the monument for that boundary. If control was not sufficient in the area or could not be reliably used, then the legislation should require the land surveyor to re-monument the boundary to assist in maintaining the cadastral framework.

These if-then scenarios should significantly reduce the potential for the location of monuments to conflict with coordinate locations, because there would be no such overlap for the purposes of re-establishing boundaries:

Is the boundary defined by a monument (either artificial or natural, as in a watercourse)? If yes, then there is no need to use coordinates-only. However, the monument should be integrated with the CSRS. If no, then:

- Is there sufficient control in the area or accessible elsewhere? If yes, then the boundary should be defined by coordinates-only. If no, then a monument is placed.
- The retracement exercise assumes, of course, that the coordinate value supplied by the surveyor is nothing more than his/her opinion about the location of the boundary. The coordinate, after all, is only evidence of the boundary.

4. Tolerances:

The courts are only concerned as to whether a boundary dispute results in a parcel being materially different than that which was bargained for. In *MacBean v Aboumourad* (1989), the court held that a swimming pool which encroached onto a utility easement did not make the property materially different. In *Koo v Redhill* (1993), the court held that an encroachment of a building across a boundary by one to three inches was of no consequence. On the other hand, both disputes were set in Ontario. In other jurisdictions, such as Alberta, the current purchase and sales agreement provides a very strong warranty for the buyer. The agreement states, in part, that "the buildings and other improvements on the Land ... are entirely on the land and do not encroach on neighbouring lands." This warranty has been the deciding factor in resolving some boundary disputes, such as the fence encroachment in *Bright v Tanguay* (1995). Such encroachments, by definition, must be across a boundary. The resolution of encroachments and of other boundary disputes, require that the courts be able to define the boundary in a unique location, as represented, for instance by a monument.

In the absence of such monuments, boundaries defined by coordinates-only will have a relative accuracy greater than 0. That is, there will be a very thin, finite zone, within which the boundary will lie. Given this zone, and given the transfer warranty, perhaps any legislation allowing the use of coordinates-only to define boundaries should explicitly permit small discrepancies between two or more retracements of the same boundary. By so doing, surveyors who use coordinates to define boundaries need only concern themselves with the relative accuracy of a

boundary defined by coordinates. If land surveyor-1 re-establishes a boundary within the relative accuracy tolerance of the coordinates of land surveyor-2, then there should be no dispute entertained by land surveyors, by the courts, nor by legislation. Most significantly, if landowners should be made aware that their coordinated boundary is only relatively accurate, and that there is a distinction between an encroachment in law and an encroachment in fact.

As a model, the standards manual for New Brunswick land surveyors allows tolerances of 7.5 cm for subsequent re-establishments of the same lot corner. In practice, in the Saint John Integrated Survey Area, tolerances no greater than 6 cm are expected as a matter of policy, although most tolerances are below 3 cm relative to the nearest control monument. Thus, the legislation must be explicit in setting out the conditions that must be met so as to ensure that the use of coordinates is reliable; must prohibit the concurrent use of monuments at the same boundary; must give no legal sanction to temporary monuments; and must set relative accuracy tolerances within which no boundary dispute would be entertained.

Part VII - Conclusion

A hybrid system of some coordinates and some monuments can, and to some extent does, coexist in various jurisdictions across Canada. Certainly, examples exist in New Brunswick and in the land claims processes on Crown land (Canada Lands and provincial lands) of hybrid systems of natural features, artificial survey monuments, and coordinates being used to define boundaries, with the locations coordinated to spatial references systems. There are other examples from Alberta and Manitoba of many parcels being created over many years which were not monumented. Finally, deferred monumentation is a very real concept in Alberta and British Columbia, in which the boundaries of parcels are defined by coordinates-only during the development process. None of the three models appears to have been unduly hindered by technical, social or legal barriers.

Although significant differences in the cadastral infrastructures in the eleven jurisdictions precludes the use of coordinates-only on a national scale, the prerequisites for using coordinates fall into four categories:

- access to cadastral coordinates which are linked to an accurate, distortion-free reference frame such as NAD83(CSRS). Maintaining and using the CSRS, and allowing access to reliable archival data are necessary, but not sufficient conditions of using coordinates.
- the ability of land surveyors to employ correct adjustment and measuring methodology. The surveying profession is, in fact, embracing the use of GPS, and has many options for adopting the technology, such as sharing and pooling equipment, expertise, and data.
- legislation (statute and regulation) which permit boundaries to be defined by coordinates-only. Any new legislation must be predicated on the use of coordinates-only being more reliable and less expensive than any system it replaces.
- social and institutional acceptance of using coordinates-only. This will require a pragmatic and cautious campaign of persuasion, directed at land surveyors, land developers, house builders, realtors, lending institutions, landowners, First Nations, municipalities, and the resource extraction industries.

It cannot be overly stressed that although the “implications” have been investigated here, and the “legal concepts” assessed, the use of coordinates-only remains a matter of policy for the Surveyors-General or Directors of Surveys in each jurisdiction. The primary agency for evaluating the merits of implementing a system of defining boundaries using coordinates-only are the ten provincial governments (those agencies responsible for cadastral surveying, registration of rights in land, and mapping and geodetic surveying within the provinces), and the Legal Surveys Division of Geomatics Canada (which is responsible for Canada Lands). Each of the 11 respective jurisdictions would have to demonstrate the will to use coordinates-only, and to reflect that will in policy, procedures and regulations.

If the view of Canadian land owners (who are the primary stakeholders in the cadastre) are discounted or qualified, then two dangers loom. First, it demonstrates a singular lack of consistency, given that all parties agree that the view of First Nations’ peoples should be respected as to how their boundaries are defined. Second, it risks alienating an ally if public opinion is needed in lobbying for changes to provincial legislation to allow the use of coordinates-only. It is disingenuous to argue, on the one hand, that landowners are not astute enough about the nature of their boundaries to be able to enter the debate on coordinates-only, and that by the time a landowner settles on a parcel, it is of little consequence if original monuments are disturbed. On the other hand, the argument goes, landowners will be clamouring

to have the state guarantee their boundaries, and will regard their boundaries as fixed if monuments are not used.

An attempt to do a cost comparison simulation (between a conventional monumented subdivision and a subdivision which used coordinates-only) in this study tentatively found little difference in cost. However, the simulation foundered on much criticism based on the size of the subdivision, the charge-out rates, the need to place temporary marks, and the involvement of builders in staking-out house foundations. It is clear that an analysis based on Calgary conditions, for example, has little relevance to other jurisdictions. Thus, cost-benefit studies of the use of coordinates-only in at least two suburban residential subdivisions over a five-year period should be done, to test the assertion that their use will result in reduced costs of initial boundary definition and subsequent boundary retracements (Nichols et al, 1998). Such a time series analysis would also test the various assertions being made by both advocates and opponents of coordinates-only in the name of technical, social and legal issues.

This study of the use of coordinates-only found that any discussion of parcel boundaries invariably touches on the integration of legal surveys and on the preservation of monuments. Consider then that the final two conclusions are peripheral to coordinates-only, but directly related to cadastral surveying.

First, the integration of surveys are not ends in themselves, but are the means to ends. Those ends include:

- an independent check on the work of a surveyor in laying out a subdivision
- a technique for re-establishing or searching for monuments
- a necessary condition for reliable and efficient parcel-based mapping, to be used for many purposes, including planning, engineering and assessment.

If cadastral mapping and GIS applications are seen to be of such value that the private sector is keen to assume responsibility, and that digital plan submissions can be justified as a requirement, then the benefits of integrating surveys are easy to accept. So, outside the debate about using coordinates-only, integrated surveys have merit. Within the debate, integrated surveys on a national scale would be a sensible intermediate step. Such systematic integration would allow the surveying profession to adapt to GPS technology and to become familiar with network adjustments and analysis of measurements. Little change to the regulatory infrastructure need occur for integration to be embraced, and agreement on its merit could lead to a consensus on national standards.

Second, monuments will continue to be a part of much boundary definition in Canada, at least in the short-term. It would be prudent to investigate the enhanced use of deferred monumentation and better safeguarding of monuments. Both measures should serve to enhance the survival of the monumented cadastre.

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Appendix 1 - Legislation dealing with boundary monumentation

British Columbia	Land Title Act, s67
Alberta	Surveys Act, s41
Saskatchewan	Land Surveys Act, s39
Manitoba	Real Property Act, s117
Ontario	Surveys Act, s62
Quebec	An Act Respecting Land Survey, s20
New Brunswick	Surveys Act, s4
Nova Scotia	Land Surveyors Act, s37
Newfoundland	Land Surveyors Act, s13
Canada Lands Instructions	Canada Lands Surveys Act, ss3&27; cD1 - Manual of

Appendix 2 - Annotated bibliography

To provide the background to the debate on using coordinates-only to define boundaries, the following arguments were examined. They are grouped into two categories: Canadian and Other.

Canadian

Hadfield (1966) acknowledged that a frustrated surveyor might think it "a dandy idea to get rid of stakes". However, he argued that getting rid of the stakes would have a disastrous effect on legal surveys and coordinate systems." In a choice between monuments and dimensions, monuments have the greater legal significance. Thus his analysis is slightly off topic in discussing the use of coordinates-only in defining boundaries, because he assumed that monuments and coordinates would co-exist. For instance, although "the division of land pre-supposes monumentation" ... coordinate systems will "no longer be at the bottom of the list of priority of evidence." He concluded with a wee bit of hyperbole about the effect of defining property boundaries mathematically: it was "not in the public interest", and would result in "organized chaos" and in surveyors aborting their responsibilities. He did, however, observe that using coordinates in re-establishing monuments required reliable control networks, acceptance by surveyors and the technical competence of surveyors.

In his next installment Hadfield (1970) had mellowed somewhat. He advocated a system of deferred monumentation, because the "placing of monuments at all lot corners ... is a difficult technical decision to defend against criticism", given that the "timing of monumentation is incorrect." This "middle position" was that only streets in new subdivisions would be surveyed before registration. The lots would have "approximate widths and depths", with the true and unalterable boundaries created after construction. In avoiding any "remedial surgery" on the survey fabric, he suggested that the house initially be the monument which witnessed the lot corner, which could then be marked to a positional accuracy of +/- six inches.

McLaughlin (1970) weighed in with some heresy/clairvoyance. He argued that the traditional reliance on monuments was a direct result of primitive surveying techniques and instrumentation. Given advances in both, and given the high costs of retracement surveys, he advocated using the existing original monuments only until they are lost or disturbed, and then relying on coordinates-only at those boundaries. Although his position is akin to one of our recommendations, he justifies it with some assertions, some of which he fails to substantiate. These include "enhanced" security of title, lower costs for both subdivisions and retracements, and the "ability to insure boundaries." In concluding that it was time to "upset tradition and to give serious consideration to the use of coordinates", he noted four preconditions: acceptance by surveyors, dense control, an updating process, and tolerable deviations. Three of the four continue to be preconditions three decades later, although access to accurate, yet distant control has reduced the need for dense control.

Sensible recommendations all, but not according to Flatman (1970). He argued that McLaughlin's article was based on a "popular misconception", presumably because boundary definition required monuments. Although better coordinate fabric (control points and ties to boundary monuments) was needed, "legally substituting variable for fixed points would be retrograde and of no furtherance to the object of boundary definition." The reference to variable

points seemed to anticipate that the values of the coordinated boundary could change, whereas the physical location of the boundary remained the same.

The conclusions and resolutions of the Conference on the Concepts of a Modern Cadastre (1975) would have provided an apt epigraph for this section. Their sentiments echo throughout the review of expert's opinions both in the literature and in interviews: "There does not appear to be any consensus of opinion as to whether coordinate values alone should be relied upon for the definition of property boundaries, without reliance on boundary monuments." Given this conclusion, the Conference recommended that land surveyors "examine the consequences of boundary determination through the use of monuments contrasted with recourse to coordinate reference."

Volohatuke (1975) took up the challenge. He argued for much reduced physical demarcation, which in some cases need not take place before subdivision plan registration, and in other cases need not take place at all. Unfortunately, he failed to support the assertions that fewer monuments would lead to savings in time and cost. On the other hand, as we have also noted, he observed that the DLS system in western Canada used only "partial monumentation." His conclusion, that monuments should "not define points, but only be evidence of them," seems not to support using coordinates-only.

This roused Dale's ire (1976). He argued that "people live by monuments," and that there is a distinction between defining boundaries and merely describing their positions. His second point also happens to be the premise underlying this study. If monuments are dispensed with, he feared that only surveyors would know where the boundaries are and then only approximately.

Lambden (1976) followed (perhaps unknowingly) the same line of reasoning. He argued that monuments are needed to visually demonstrate on the ground the parcel limits, and that coordinates cannot override the physical evidence. However, in anticipation of this study, he suggested that the issue of using coordinates-only be re-visited in "several decades" (1998?) and that there might be some merit to giving boundaries some sort of guarantee, affirmation, or warranty, so as to avoid a "rash of litigation" for petty disputes.

Chrzanowski et al (1977) argued that integrated surveying and mapping is a "must," but did not address using coordinates-only to define boundaries. They advocated that third-order control monuments in an urban area have a spacing of 200m.

The Maritime Cadastral Accuracy Study by McLaughlin et al (1977) is the only large-scale analysis of how accurately landowners want their boundaries defined. The study did not concern itself with the matter of how boundaries should be defined: "the question of physical monuments versus coordinates as primary evidence has not been resolved." Nevertheless, the insight still applies that the "surveyor is the person on the front-line ... he must have the resources to cope with the new policies and regulatory procedures ... he must have sufficient knowledge of and faith in the new system if public support is to be engendered." In canvassing 254 landowners, it found that 42% wanted their boundaries marked exactly, and that preferred tolerances increased along the urban-suburban-rural vector. It thus recommended tolerances of 5cm, 10cm, and 50cm, respectively.

In summarizing the study for a wider audience, Thomson et al (1977) argued that the quality of the cadastre is a function of both equipment and "historically accepted professional practices."

They noted, but did not explain the "judicious mating" by LRIS of physical monumentation (demarcation) and the used of two-dimensional coordinates (delineation).

McEwen (1981) made the distinction between the admissability of evidence and the weight to be given to it. He argued that although measurements might be given a higher order of importance owing to advances in surveying technology, it was "facile" to conclude that coordinates should supplant monuments. That is, the governing factor in boundary determination is still the existing physical monument, a point we have elaborated upon in this study.

The Report of the Task Force on Integration of Surveys in Ontario (1990) strongly recommended that all legal surveys be referenced to the control network. However, the focus of the Task Force was on Ontario Base Mapping, land information systems, and the densification and maintenance of the survey control network, and not on defining the boundaries of rights in land. Thus, there is no mention of using coordinates-only to define boundaries.

Nichols (1996) canvassed well the issues of guaranteeing boundaries in New Brunswick. She appeared to find no jurisdiction (including Canada, Australia, Malaysia, and Switzerland) in which legislation or case law has explicitly guaranteed the location of a boundary. To be clear - the character of a boundary can be assured, as in a physical monument or natural feature, but assurances as to the location of that monument or feature are problematic. She did suggest, however, some mechanisms which would have to be put in place by the profession and the province in order to allow for the provision of guaranteed boundaries. These include explicit legislation, acceptable tolerance, rigorous plan examination, an assurance fund, and so on. However, given the paucity of successful claims made to the assurance funds in western Canada and in New Zealand (funds set up to bolster the guarantee of titles in the land titles system), it seems unlikely that guarantee of boundaries would mean much.

It is appropriate that the final words go to Fediow. As Dobbin (1998) graciously acknowledged, it has been the work of Fediow (1995, 1996a, 1996b) in Alberta on a coordinated cadastre which has "re-sparked interest in the topic." In his MEng thesis (1995), Fediow made the case that using steel posts to mark boundaries is "inefficient, expensive and incompatible" with mapping technology. The latter criticism seems to overlook the distinction which must be made between defining boundaries and delineating (or representing) boundaries. He strongly advocated a "cadastre based on mathematical coordinates derived from measurements from survey control monuments", and he did so with much passion. This thesis led directly to two related articles, in which he argued for empirical data on landowners' preferences, and that deferred monumentation could serve as a transition to using coordinates-only.

Other

Fisher et al (1982) extolled the virtues of the survey system of South Africa, especially the integration of all legal surveys to the control network. However, given that "the land parcel is defined by its monuments (beacons) as placed during the survey that created it", they dismissed using coordinates-only. They did suggest, however, that using both monuments and coordinate values has led to a beacon common to several properties having multiple coordinate values!

McRae (1985) touched on the concept of tolerance in measurements, and by extension in coordinate values, primarily from a New Zealand and Australian perspective. He acknowledged,

somewhat ruefully, that the land titles and survey legislation provides no assurances about boundaries (the spatial extent of title): "there is virtually no reference to a guarantee in the Act." He was thus forced to review case law which defined the "little more or less" clause in many parcel descriptions. In *Belfrage v McNaughton* (1924), the court held that a discrepancy in the area of 1.8% was acceptable. In *Moore v Dentice*, 20 NZLR 128, the court held that a linear discrepancy of 1.1% was acceptable. In *Russell v Mueller* 25 NZLR 256, the court held that two linear discrepancies of 0.7% and of 1.4% were acceptable. Of course, all of these tolerances are relative, and not absolute as a coordinates-only system would require.

A study in New Zealand tried to determine what the public needed or expected from cadastral surveying (Hoogsteden et al, 1992). It asserted that information on public attitudes and needs towards property boundaries is vitally important. A sample of 260 included 172 urban residential and 88 rural land owners. As in the New Brunswick study, it found that the accuracies sought in the urban setting were higher than in the rural setting. For instance, 55% of urban respondents would tolerate no error in marking their boundary, whereas only 30% of rural respondents sought no error. However, no definitions were provided of urban and rural. More distressing is that it came to the startling conclusion that experienced respondents - 37% of the sample, defined as those who worked with the land (14%), who had consulted a surveyor, who had had a boundary located, or who had experienced a boundary dispute - differed in their tolerance for errors from amateur respondents. This conclusion is simply not true, at least at the 95% confidence level. In fact, the lack of statistical analysis in the New Zealand study means that little significance can be attached to its results.

At least three studies on a cadastral coordinate system or legal coordinated cadastre were done in South Australia and the Australian Capital Territory. Nisbet (1992) acknowledged that monuments would continue to be used, but "the peg is only a symbolic representation of the coordinates." The Angus-Leppans (1990) noted that "in a coordinated cadastre, surveys for subdivision will continue to be carried out, with corner pegs being placed. A corner peg will be an indicator of the position defined by the coordinates."

In an American context, Leininger observed that "boundaries are not a hot topic down at the local pub." In an argument against the use of coordinates-only to define boundaries, he asserted that retracement surveys are the centrepiece of the surveyors' contribution to society, and observed curiously that the only group who saw the use of coordinates as inevitable was the GIS/geodetic surveying/GPS community: "You see, technicians who are adept at manipulating instruments and who are familiar with geodetic computations would be able to locate positions with high accuracy using no judgment." Buckner concurred by making a neat distinction between boundaries and the monuments used as evidence of the boundaries; "a boundary retracement surveyor is primarily looking for corners, not monuments. Monuments are just part of the evidence."

Finally, in a study of 57 rural land owners in Queensland, Stock (1998) asked for similar information about boundary accuracy requirements in a number of ways, so as to examine the consistency of responses. She found that land owners' preferred a boundary accuracy of 20cm. Interviews with local authorities and with utilities showed that they preferred boundary information accuracy of 50cm

Appendix 3 - Survival rates of monuments

How many original, legal monuments survive the slings and arrows of the development and construction process and remain undisturbed? The process includes servicing by utilities and municipalities, house construction, and landscaping. In other words, what is the survival rate of monuments?

In order to answer this question, we looked at 19 plans of subdivision in British Columbia, Alberta, Manitoba and Ontario in five different municipalities. All the plans used immediate monumentation. Plans using deferred monumentation were rejected, because the purpose of the exercise was to determine the effects of the subdivision development process on boundary evidence. The locations were spatially distributed across Canada. The 19 subdivisions were developed by 15 different developers over 14 years, and were surveyed by 18 different land surveyors. Thus there was significant variety among the subdivisions - in location, size, date, developer, and surveyor.

The constant was that all used metal posts to monument all lot boundaries, with the exception of the Winnipeg subdivisions, in which only the block corners were monumented. The second constant was that all the subdivisions had completed the development process - utilities, roads, houses, landscaping. In all jurisdictions the existence of the monuments was sought, generally at the front (road-side) of the lots, for a couple of reasons. First, concrete channels at the rear impeded the search. Second, access at the front was easier and less disruptive to the landowner. If buried, a metal detector was used in the search.

From the total sample of 642 monuments which were sought, only 432 (67%) were found. The two anomalies were Abbotsford and Winnipeg. We speculate that the white, 4x4 (triangular) wooden post used to guard all monuments in British Columbia helps in their preservation. For the Manitoba sample, we speculate that the legislative requirement upon municipalities to maintain block corners ensures a slightly higher rate of preservation.

The second half of the investigation involved uncovering with a shovel (provided they were not already visible) a smaller sample of the monuments which had been found. The depth below grade varied from flush to 40cm. Once the first few centimetres of each monument was uncovered, then we visually assessed the nature of any physical disturbance. From the sample of 181 monuments which were closely assessed, 154 (85%) were found to be undisturbed. Clearly, the Calgary sample is an outlier, because we tended to dig up monuments which were more deeply buried and which therefore had a greater chance of being disturbed by backfill.

The requirement that municipalities in Manitoba maintain lot corners, as set out in s6 of the Surveys Act, seems to help in monument preservation. The practice in British Columbia of marking all monuments with a solid white stake must help in preserving a significantly higher number of monuments than in other jurisdictions.

City	# of plans	# of lots	Dates
Abbotsford	2	33 - 53	1987 - 1997
Calgary	8	2 - 164	1989 - 1995
Kanata	3	52 - 243	1985 - 1993
Scarborough	3	33 - 362	1983 - 1993
Winnipeg	3	161 - 383	1988 - 1993

City	Monuments sought	Monuments found	%
Abbotsford	136	122	90
Calgary	217	143	66
Kanata	124	76	61
Scarborough	97	43	44
Winnipeg	68	48	71
Overall	642	432	67

City	Monuments dug	Monuments good	%
Abbotsford	95	93	98
Calgary	31	15	48
Kanata	19	16	84
Scarborough	17	15	88
Winnipeg	19	15	79
Overall	181	154	85

Appendix 4 - Landowners' preferences

Ten minutes were spent interviewing each landowner, which began with the canvasser explaining the purpose of the study. To assist with the explanation and to assure the landowners of the merits of the research and that their responses would be both confidential and aggregated, a participation consent form was left with each. For the most part, landowners were keen to participate.

Community	Responses	Seen monument?	%
Bancroft	27	24	89
Calgary	225	56	25
Edmonton	32	14	44
Ottawa	45	16	36
Saint John	11	9	82
Scarborough	10	2	20
Winnipeg	24	15	63
Others	5	4	80
Totals	379	140	37%

Preferred method of defining boundary?

Community	natural	artificial	monument	coordinate
Bancroft	6	2	19	0
Calgary	72	58	50	45
Edmonton	3	13	13	3
Ottawa	12	10	20	3
Saint John	2	0	8	1
Scarborough	5	5	0	0
Winnipeg	5	9	8	2
Other	1	1	3	0
Totals	106	98	121	54
%	28%	26%	32%	14%

Preferred accuracy to which boundary should be defined?

Community	0cm	1-10cm	11-20cm	21-30cm	31+cm
Bancroft	4	6	3	10	4
Calgary	74	43	36	50	22
Edmonton	19	7	6	0	0
Ottawa	8	21	10	4	2
Saint John	7	1	2	1	0
Scarborough	6	4	0	0	0
Winnipeg	13	10	0	1	0
Others	3	0	1	1	0
Totals	134	92	58	67	28
%	35%	24%	15%	18%	7%

Appendix 5 - Synthesis of comments from surveyors

Question: ‘What are your views on the use of coordinates only to define parcel boundaries?’

Bracketed responses have been paraphrased; otherwise, comments are reported verbatim.

PRO:

Defining parcel boundaries by coordinates sounds good, however, from practical and social perspectives the corners will have to be monumented. To have monumented corners that don't govern would be a problem. Using coordinates as evidence for re-establishment would be more practical.

[Our firm uses coordinates extensively.] Drafting, calculations, layouts, etc. are all based on coordinates that are derived from preliminary survey tying in survey monuments...the transition would be easily attained.

[Coordinates have their place especially in the urban setting.]

In areas of intensive land use, coordinates will provide a cost-effective means of defining parcel boundaries...intensity of use would be the criteria with a mechanism in place where citizens can request their local government to implement a switch from a legal monument-based cadastre to a legal coordinate-based cadastre.

[A fuller reliance on coordinates] would reduce the man hours involved in land surveying activities.]

[Coordinates provide] a more practical interface with emerging technologies.

The coordinate-based cadastre needs to be defined. At present each land surveyor has his own concept and a general format is required.

[If the coordinate-based cadastre is legally binding and incontrovertible, the liability for improper positioning of boundaries may be shifted from surveyors to the government or whomever the custodians of the cadastre are.]

Globally, it is very tough to operate on [coordinates only at this point]. This option could be achieved with sufficient local infrastructure. Infrastructure requirements will change over time - maybe very quickly.

[The coordinate-based cadastre] is workable but good maintenance of the system is crucial!

To go along with coordinate definition, we need a good property database and a good topographic database (lines, buildings), as well as national standards. Central (provincial) coordination of rules and policies is critical.

Political support and public education are needed [to foster acceptance of coordinates].

The difficulties encountered so far are not crucial enough to stop coordinates.

Benefits accrue to a large user community - municipal cadastral mapping is used by engineering departments.

The enhanced accuracy of GPS facilitates development of provincial mapping program, GIS.

Coordinates are doable but there is the question of who will absorb the cost. Surveyors may resist since they feel that, if they provide good coordinates, they will be cut out of the loop.

With proper survey control, coordinates would provide very good evidence of boundaries, particularly in built-up areas, e.g. downtown areas [where points are routinely destroyed].

The coordinate or referencing system must demonstrate accuracy and repeatability.

We favour coordinates, and corners should only be monumented at the request of clients.

Coordinates are not suited to all areas but are ideally suited to [describing tracts] e.g., in northern areas.

CON

I now have a lot of real time GPS experience It can give the wrong answer!! Checks are necessary. For me, checks on RTK often involve conventional measurements. It is a great tool in prime locations, but you will pull your hair out in a lot of cases. T16 and EDM to the rescue.

Would adjustments to the coordinate base require that all existing plans be amended as new values are computed?

By using 'coordinates-only' are you starting to slowly eliminate the profession of surveying and creating a bunch of gps technicians?

[In cases where a physical monument is needed, what if the physical monument is established in error? Do the regulations provide for resolving this discrepancy?]

If you didn't mark a corner with some kind of monument I could foresee all kinds of problems especially the questioning of the reliability of the surveyor.

Landowners want monuments or at least something physical to mark their boundaries.

[It is costly for the surveyor who initially integrates a new survey with control. If a survey is not initially integrated, who pays for this extra work?]

[Coordinates-only are unacceptable, unless the error ellipse is within, say, 0.1 feet or 2cm.]

Physical evidence is the basis for boundary definition and retracement.

'...Measurements disagreeing with physical evidence' is the rule rather than the exception.

Coordinates do not help landowners - only developers wishing to save money. Coordinates are still only measurements subject to transposition errors and misinterpretation of datum.

[Coordinates do not provide landowners with anything tangible to live by.]

[The official sanctioning of coordinates by the government as the final record of a boundary reduces the laying out of boundaries to a mathematical problem. Any 'art' that a surveyor would use in the determination of the boundary has been removed. This is the beginning of the end for land surveying.]

[Adoption of the coordinate model is driven by advances in GPS but, in practice, the technology is not foolproof. GPS is still susceptible to difficulties caused by multipath, tree cover and urban obstructions.]

Having no monuments does a disservice to the landowner - it keeps them indebted to the black box / GPS experts.

Total conversion from monuments to coordinates is not possible - technically, socially and economically.

Private surveyors will probably continue to use conventional control. There are very few survey-grade GPS receivers [among private firms] in the province.

In our tests, transforming from ATS77 to NAD83, we are finding huge discrepancies - this makes me nervous about relying on coordinates.

[There is perhaps a danger if real estate developers and landowners see coordinates and lines shown on index maps and land use maps as being conclusive of boundaries.]

[What is the value of a marker placed after a coordinate is registered? Definite rules re: what governs and provisions for 'grandfathering' existing monuments are required.]

[Coordinates-only presents no problems but it would be very difficult to go out in the field and explain to homeowners where the boundary is.]