**SURVEYING IN SOUTH AFRICA**

Coordinate vs monument cadastre

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The following article is an extract from correspondence with an Otago Surveying graduate who worked in Christchurch, New Zealand (NZ), and then in South Africa (SA). The Otago programme proved to be excellent preparation even for a different legal system (Roman-Dutch civil law in SA, as opposed to English common law in NZ), but nothing could have prepared the graduate for work in game reserves, where he is usually accompanied by an armed game scout in case of elephants and lions. He has good things to say about the NZ system, but has also enjoyed some features of the SA system.

David Goodwin (DG): Hi, I’m glad you have finished your law exams. How are you finding the South African system relative to New Zealand?

Otago Graduate (OG): Sorry for my delayed reply! I received some good news this week. I passed my Professional Land Surveyor exams!

In response to your query, it’s frustrating not having an online database like Landonline (e.g. surrounding data/packet description text), but otherwise I have found the SA system a lot more simple than in NZ. I like the fact that the corner beacons hold an accuracy weight as working points/survey points. We don’t record or look at directions and distances in the field anymore. You upload coordinates to a GPS controller, find a mark, find a control mark, then Survey Mark or trip, perform a site calibration, check onto another few marks and place your control where necessary. Then if you need to use a total station, the same controller is used with the coordinates you have just determined by GPS measurement. Enabling you to setup on that point, back sight and look at residuals in coordinate format, check on another mark then complete the job and export points in a CSV file, download into software, fiddle around, prepare your final coordinate list and submit. Your surveyed coordinates then become the new published digital coordinates.

I was initially frustrated at the limitations of the software used here for computing traverse and vector information as I was accustomed to using the 12d traverse tool. However I rarely use it now because I don’t have to recreate the traverse around a site. Occasionally I use this function for old diagrams with only angles and distances. Obviously Landonline does allow the extract of digital coordinates in smi format but this is still unnecessarily cluttered by the vector data.

The diagrams and working plans are a lot less cluttered here as the vectors are not shown. But SA regulations still require you to submit a vector comparison sketch showing the original vectors of the boundaries being re-established, and your surveyed and final adopted direction and directions. DG: these vectors are calculated by calculating joins from original coordinates and from surveyed coordinates. I guess coordinates and vectors both have their place; sometimes it is easier to analyse data by looking at a coordinate shift, and other times distance and directions tell the story from a different angle.

We should be submitting digital coordinates, but at the moment SA is still submitting hard copies or PDFs, and the Surveyor General then captures the coordinates and checks closures. The survey data is then input into a GIS database, but there is no direct integration or sharing of the coordinate information for survey purposes, which is frustrating. The old survey records are slowly getting scanned to an online database. What I miss about NZ is the generally higher standard of work ethic, professionalism and obviously the more technologically advanced cadastral system. I think the development of the system here is restricted by financing and government recognition and the scale and spectrum of land tenure issues is much bigger here.

DG: Heartiest congratulations on passing your exams! You have given some good insights. I was interested to read about the vector comparison sketch. Yes, a coordinate transformation usually shows what is happening, but occasionally a comparison between joins from the previous and present survey can better show what movement there has been, and then a comparison sketch is helpful.

I like what you say about SA not requiring vectors to be shown on a working plan/survey plan, although sometimes, even where one is not obliged by law to show measurements, surveyors find it helpful to do a printout of a layout and to hand in measurements in red pen to prove to themselves just as much as the Surveyor General, and also for the benefit of future surveyors that every surveyed point has been checked.

DG: I do wonder where things will be in a few years time, as I hear the accuracy of phone GPS may get much better. I imagine with the integration of augmented reality, and a secure digital cadastre there could be a time when we do away with the placing of physical corner beacons. Home owners may be able to put on a head set and walk to the corner of their properties. The stakeout application could be via a phone app available to anyone, e.g. both adjacent property owners (allowing transparency, less conflict if both can get the same answer at any time). Surveyors will then become more like managers of the digital cadastre, ensuring its correctness, security and maintaining and updating the coordinates. I know it’s a lot more complex than this because of the history of land ownership, records and mathematics involved etc., but the physical monument will always be vulnerable to disrespectful land owners and obviously to certain forces of nature.

OG: Yes, the question of whether to go to the ultimate abstraction of coordinates only, and dispense with corner marks, is an old one. For countries with appreciable tectonic movement, a coordinate-based cadastre would have special difficulties, and you will have more experience of these than most, having surveyed in Christchurch. Let’s say an entire land parcel, walled and with a house on it, moves relative to the country’s active control reference stations. What is the land owner going to take as the extent of her/his property? Obviously the new position of the house and walls after the quake. However, if coordinates rather than physical boundary evidence ever become legal, then the occupation will be at variance with the legal coordinates. It will take some fairly heavy-duty mathematics to transform the legal coordinates to be in sympathy with the new occupation, and that mathematical transformation will need survey input of the post-quake positions of walls, houses etc. Transformations would also benefit from before-and-after positions of better-defined survey marks, but ironically, in a legal-coordinate cadastre these marks may be few and far between.

If monuments continue to be the basis of the cadastre, a number of difficulties are avoided. If a corner mark is
missing and needs replacing, the usual way to do this is to find the closest survey marks that still occupy the same relationship with one another (checked by a coordinate transformation, or else by comparing joins from the previous and new survey), then to infer a relative position from the closest accepted mark to the missing mark (in order to minimise bearing swing and scale errors), and so replace it. This requires no high-level mathematics, and it ticks the ethical box because it re-establishes the relative positions of occupation to which right holders have agreed.

If countries do go with this kind of “monument based cadastre” there are two obvious corollaries: first, that the more ground marks you have, the easier and more accurately it will be to replace missing or moved marks in future. This underlines the need to place boundary marks with well-defined centres that are as robust as possible, and to require these to be fixed by an independent determination. There is no reason why such marks should not have the same status as the survey control, thereby densifying the control network. The denser the control the better, for a whole lot of reasons, and well-defined boundary marks should be included in this control. Second, to record surveys in the form of coordinates rather than vectors because, while being exactly the same data, observation coordinates are much easier to upload into data controllers and CAD software e.g. for use in coordinate transformations. Coordinate files should be stipulated as a routine part of survey records. [LOG: the excel file is a direct output from the survey software in the form of ASCII, CSV; it takes one click of the button. In other words you build up your survey database on the screen as you would see it in plan view (with the option of opening a dataset that lists your point details).]

Even where a country does not experience major tectonic movement, monument based cadastres are probably a good idea, because “what you see is what you get” again ticks the ethical box. The necessity to possess suitable technology to stakeout corners (as you say, headsets to “see” coordinates on the ground) arguably discriminates against lower income right holders and less-developed countries. Phone chips will also probably continue to need better antennas to achieve really good accuracies. Perhaps a workable and ethical solution that is also in line with technology advances could be for monuments still to be the legal bottom-line, but for real estate agents and right holders for many practical purposes able to visualise approximate boundaries with phone apps (with a legal disclaimer that those results are indicative only). The surveyor’s role here would be managing the data, re-adjusting coordinates in line with tectonic movement and datum shifts, setting out boundary marks for new developments, and also arbitrating in cases where the phone app solution proved inadequate. The latter might include high-value land, contentious right holders, and high disturbance environments. For these cases, a suitably qualified quasi-legal practitioner (i.e. a land surveyor) would still need to confirm the closest unmoved control marks (hopefully these will be quite dense if well-defined and checked boundary marks have comparable status) and to re-establish missing or disputed points where necessary.

Postscript: The correspondence ranged more widely, from the idea of electronic chips being planted in boundary and survey marks, right through to “western’ notions of land rights being at variance with deeply rooted ideas about communal tenure in African and Pacific cultures. From a cadastral perspective, perhaps the biggest paradigm shift for a New Zealand surveyor working in Southern Africa was accepting that observation coordinates are just another way of representing vector information, and not to be confused with “legal coordinates.” Ultimately monument-based cadastres the world over are about surveyors doing whatever it takes to establish and re-establish the relative positions of marks, and although the new generation of digital tools available today has changed the most convenient way of expressing survey data, it has in no way changed the underlying issues.