A practical guide to preparing, implementing and ensuring sustainability of reforms to property rights registration systems.

Real Estate Registration and Cadastre

Practical Lessons and Experiences - Chapter 7. Boundaries and the Cadastral Survey.

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Chapter 7 Boundaries and the Cadastral Survey

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Introduction

As mentioned in Chapter 1, boundaries, boundary markers and surveys have been necessary for identifying properties and their ownership for centuries. *The primary purpose of describing or surveying a boundary is so that the location of that boundary can be found when someone is unsure of the extent of the land (such as a new owner) or there is a dispute.* From earliest days, deeds that record transfers of ownership always included a description. This is sometimes in simple terms such as the 'field at Anathoth' referenced in Chapter 1, and sometimes by 'metes and bounds', where the 'metes' specify the distance and direction of a boundary and the 'bounds' describe the boundary itself or the abuttal with someone else (e.g. running along the main road or adjacent to the field owned by Mr X). More recently, reference to a recorded or registered plan is more likely, with reference to markers that exist at corner points and/or coordinates of the corner points.

Boundaries do change with time. Stream or river routes change, and roads or paths get moved. Hedges grow and expand in size, and treelines can move as old trees die and new ones sprout. Sometimes a boundary feature is moved (often unintentionally) when a fence is replaced, or the original markers get displaced or lost, and natural development occurs that effectively moves the boundary as was once known to a new place. Sometimes a fence erected for other purposes, such as keeping animals in an enclosure, becomes a boundary unintentionally. In some instances, this is deliberate. I recall my own law lecturer at college telling me that he had moved his fence several metres into a field next door. He then waited the 12 years required to obtain a prescriptive right (through adverse possession) and then claimed that land as his own. I once set a question for a survey licensing exam that said, "A boundary location is only fixed for 12 years. Discuss." No-one chose to answer that question though.

In Malawi, as in the UK, they had a 12-year prescription period, so the land within any commonly accepted boundary location that had not been challenged and was occupied peacefully in an uninterrupted manner could be acquired through adverse possession. When undertaking a survey, the cadastral surveyor should compare the existing possession and usage with the documentation to see if a prescriptive right might exist and advise the owner accordingly. The laws for claiming prescriptive rights vary considerably by country.

When reviewing this document, Tony Burns (a very well-known and experienced land surveyor), suggested that the purpose of describing or surveying a boundary might be better expressed as *".. to provide clarity over the land that a set of rights, responsibilities and restrictions apply to"*. In the case of disputes, the surveyed land and measurements are just one piece of evidence. It varies by country of course, but priority is usually given to what was publicly accepted. If the previous owner can be found, and he or she clearly describes or points out what was transferred, then this is clear evidence. If neighbours have accepted the position of a boundary for many years then this is also clear evidence. Next in priority come the markers that show the boundary, including the walls, fences, hedges or pathways or the monuments that have always been accepted by the local population. Then follow descriptions in the deeds, and, finally, the details on the plans and the coordinates are taken into account. In fact, it is all just evidence that a judge will consider. However, it seems that the intention of the original parties, common usage and public acceptance as understood by physical features on the ground are the most critical factors. In New South Wales, their standard text, 'Legal Aspects of Boundary Surveying as Apply in New South Wales' by Hallman, states in section 13.13:

> The courts have established precedents granting priorities of weight where two or more of the following boundary features present conflicting evidence in the hearing of the dispute. These in order of priority:

1. Natural boundaries
2. Monumented lines
3. Old occupations, long undisputed
4. Abuttals
5. Statements of length, bearing or direction.

<u>What are you sitting on?</u>
As a novice surveyor, I recall conducting a field survey for a new property that abutted onto a very large piece of land (over a hundred hectares) for which the survey had been done many years before. I used all my technical skills, because the old survey used 'southings and westings' (we were in the Southern Hemisphere) instead of eastings and northings that were later used with a different coordinate system. It was unlikely that corrections for curvature of the earth or reductions to sea level had been taken into account when the original survey was concluded. I took all this into account in my complex calculations and derived the position where the key monument should be. The calculations were made in the field shortly after completing my survey. I calculated the position of the monument and pointed out the spot where my team should dig to see if the monument was still there. They didn't move. So, I got up and pointed to the exact spot to dig and said 'Just here. Dig about half a metre down just in case it got buried', and then went and sat down again. Again, this experienced crew did not move. They just looked at me with confusion, then one said, 'Excuse me sir, what are you sitting on?' and sure enough there was a large brick monument. Monuments were usually concrete and quite small, but this must have been how they made boundary markers in those earlier days. At least my calculations and survey brought me to within about 5 metres of the old mark, so I should have been satisfied! The brick monument took precedence over the very precise coordinates that I had just derived.

Boundary Survey for a Registration System

There are different specific instances in which boundary surveys are required, and they often require different methodologies for the survey:

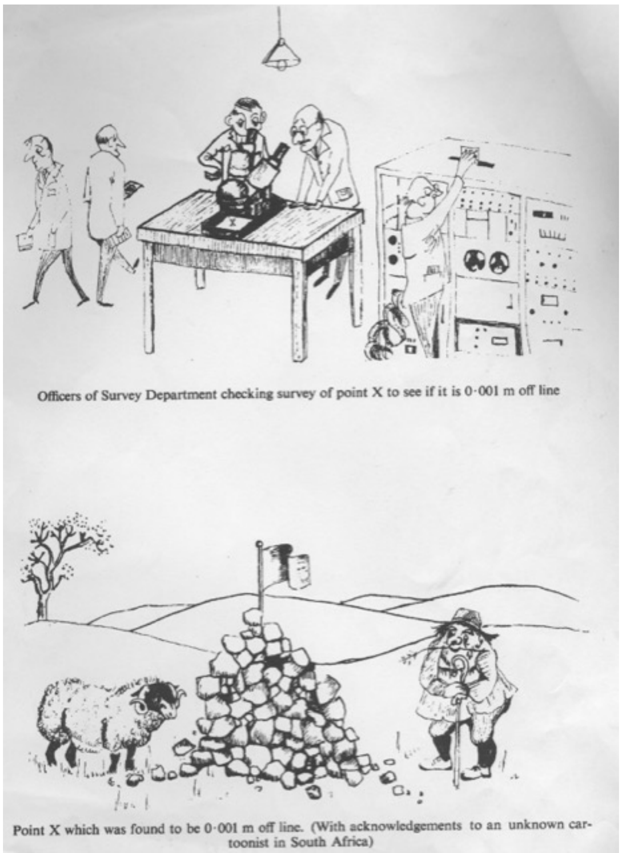
(i) <u>On-going changes in an established system</u>. Most countries already have established systems that function to some extent. Even in the most under-developed country, there is some system operating in urban areas or for major farms because historically, people have obtained legal documents to their rights and some description of the property and its boundaries are included. Whenever a piece of land is sold, divided, consolidated with another plot or assigned by government, a new survey will need to be done. It is likely that other previously surveyed plots will exist nearby and the location of these will need to be checked to make sure that the new plots do not overlap with the pre-existing plots. (If the property involves the sale of the whole piece of land it is usually optional for the buyer to have a survey done and they generally would not if the boundaries are clearly seen when inspecting the property.) In many countries only a government surveyor or a person licensed to carry out surveys are permitted to do so.

(ii) <u>Registration for the first time.</u> If a new system is being put in place, especially if a new Register of Title is being introduced and properties are to be registered for the first time, then it is normal for a (cadastral) index map to be produced. This will provide a clear mapping of every parcel of land to ensure that it is uniquely defined and identified with a unique number[1]. There should be no overlaps or unexplained gaps between

[1] The unique identification number for parcels or property units is required so that different systems in a national spatial data infrastructure have a common standard, but they have always been required to ensure that it is absolutely clear what is being sold, leased, mortgaged, etc. and thus different owners, etc. are not recorded for the

parcels. The parcel of land should also be uniquely linked with one legal record that describes the legal rights to that property. In this instance, there are basically two methodologies:

a. Sporadic registration. Properties are registered for the first time on a request basis or when a transaction occurs. Each survey is done as and when needed and then included within the register. The survey is usually paid for by the client and is completed by a government or a licensed surveyor as noted in (i) above.



Peter Dale (one of the reviewers for this book) provided this cartoon that he included in an article for the Survey Review in about 1974/75. It shows how illogical it can be to try to get very precise and highly accurate surveys for situations that do not require it. It illustrates how the on-going problem of making sure that surveys are 'fit for purpose' has been an issue for a very long time.
{The top cartoon shows the survey specialists checking why there is a discrepancy of a millimetre in measurement for the position of a boundary marker, while the marker itself, shown below, does not require that level of precision.}

Figure 1: Cartoons on Boundary Marker Precisions (Survey Review 1974/75)

b. Systematic registration of all land in a specified area. In this instance, it is most common that a set geographical area is declared to be subject to registration (usually under a law that specifies how this is to be done) and all properties in that location are to be registered. It requires public support and a program to systematically go through every deed, legal record and plan for that location and to survey all properties to be included in a new complete cadastral index map. It is a very different operation from the examination or survey of a single (or a few) properties as described in (i) and (ii)a

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same parcel or property unit. As such they are a fundamental requirement. The format of the number varies substantially and is dealt with in detail on pages 355-358 in book reference 7 in Annex 1. In practice, having long numbers or sequences of numbers and letters or geocodes in the identification number can be confusing and are rarely understood by the public. Complex combinations also increase the chance of mistakes when the number is transcribed by hand. In the old paper-based systems a logical structure for the parcel identifier was very important, but I have increasingly seen computer-generated sequential numbers used in newly developed systems, which could be randomly generated. For accessing the database or for the enquiries, members of the public will rarely refer to the unique parcel identifier or registration certificate number. A simple address, owner's name, postcode, etc. are more user friendly for searching to find a record. Also, I have often seen registration office staff getting very annoyed when they have to use long and complex unique parcel identifiers because of the frequency with which they are mistyped into the system.

above because thousands of properties may need to be included in the process *every day.* For this reason, different methods must be used to undertake the survey using the 'fit-for-purpose' methods outlined in book reference 16 and 17 in Annex 1. In fact, it is quite impossible to survey or examine the legal documents for the properties in the same way as used for (i) and (ii)a because of the scale of the work and the costs that might be involved. The only place that I know of where the survey for systematic registration was done using the same methods that might be used for individual surveys is in the Seychelles, where the survey of the 12 000 properties involved took five years in the early 1980's. However, they had to register every property with a 'provisional' title because of the time and difficulty that would have been involved in accessing and checking all the legal documents.[2] The registrar would change each provisional title to full title once a transaction was approved for registration after the parties had brought in their legal documents for checking. The book reference 16 of Annex 1 (Fit-For-Purpose Land Administration) describes how systematic registration was done for Rwanda, Ethiopia and Kyrgyzstan, primarily using aerial photography methods and simple ground checking. In fact, the same (or very similar) methodology has been utilised for most mass registration programs that were a success since the 1960's. This included almost the entire post-socialist block of Eastern Europe and Central Asia (including the former Soviet Union) covering some 300 to 400 million properties in a period of about 20 years using 'fit for purpose' methodologies.

When undertaking any of the work above, it is usually done or overseen by a government or licensed surveyor. As the 'systematic registration' approach referred to above requires hundreds, or even thousands, of field workers doing this work, the people actually working in the field would be trained for the purpose in a few weeks and then sent out to do the work. The government or licensed surveyor would then just oversee its completion.

It is often thought that the survey side of a systematic registration project is the most difficult, time consuming and expensive part. In fact, this is not usually true. Time is taken to publicise, check the legal documents and the 'root of title' together with any encumbrances (such as mortgages and rights of way). Time is also required to visit every property to make sure that the person being registered is the true legal owner and agrees that the rights and the locations of the boundaries (often demarcating them with a marker or paint when unclear) are correct. The survey is the easy part, unless the methods for doing the survey are badly chosen – and not 'fit for purpose'.

It should also be noted that the accuracies and methods required in more rural areas or in high density informal areas may be different from those required in locations with more expensive real estate. In my experiences in Malawi in the 1970's to 1980's, rural surveys for systematic registration were based on survey traverses that needed an accuracy of 1:1000 and positional accuracy of one metre. In high density informal areas, we used new orthophotography and took offsets from the buildings themselves to graphically mark the parcel boundaries on the orthophotomap. In Thailand, the largest scale cadastral map in rural areas is typically 1:4000 scale line-maps and most boundaries have traditionally been charted under regulations to plus and minus one millimetre at map-scale (plus and minus four metres on the ground). The Thais do have provision for the use of total stations and the preparation of survey plans – first order surveys – but most boundaries are charted graphically – second order surveys. The Thais place corner marks and the locations of corner marks are decided by agreement of the landowners, provided they do not encroach on public land. Where a mark needs to be replaced, the prime process is through the agreement of the landowners on the position for the relocation of the mark – not the survey records, which are only a reference.[3]

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[2] When reviewing this book Stig Enemark referred to another case in Bhutan, where the whole country was surveyed between 2009 and 2012 using GPS control points and total stations. About 160 000 households were registered.

[3] Information on Thailand provided by Tony Burns when reviewing this book.

Licensed Cadastral Surveyors – Why do You Need Them?

In the 21st century surveying is so simple that you often wonder why countries require special qualifications and issue licences before a person is allowed to practise as a surveyor. With the right equipment you can measure a corner point of a property in a few seconds to within a few centimetres of accuracy – and you can train a moderately intelligent person to do that in a day.

A Brief History of Survey Measurement

Of course, it has not always been like that. There have been various 'revolutions' in survey work that have gradually made the work faster and easier. The very early work would have just used ropes of a certain length, wooden poles and rough angle measurements. However, if we move rapidly forward to the 18th century, we see the beginning of more sophisticated equipment and the use of coordinate systems when countries were building national cadastres and more accurate survey measurements were being made. This required the use of theodolites to accurately measure angles, special tapes to measure distances for 'controlling' surveys and various other pieces of equipment like plane tables, compasses, chains, optical measurements using vertical staves and the like. A lot was not standard, for example a 'rod' (straight piece of wood used to measure field boundaries) might be a certain length in one municipality, but a different length in another. The survey methods and equipment used were really designed to give a rough measurement so that the physical feature marking a boundary (line of trees, fence, stream, rock, brick pillar, etc.) could be found. If you got to within a few metres of the monument (or 100 metres in more rural very large properties) from your survey, then that would be good enough. It was the monument at the corner of the property that was key. As time went by measurements became more accurate and surveyors began to use the position of the stars or sun to calculate the latitude and longitude of a point and took greater care to survey more accurately. It was all quite complex and needed well-educated professionals to do this work.

Figure 2: Surveying team in France, 1908, using theodolites for fixing a control point and plane tables for recording topography and parcel boundaries.

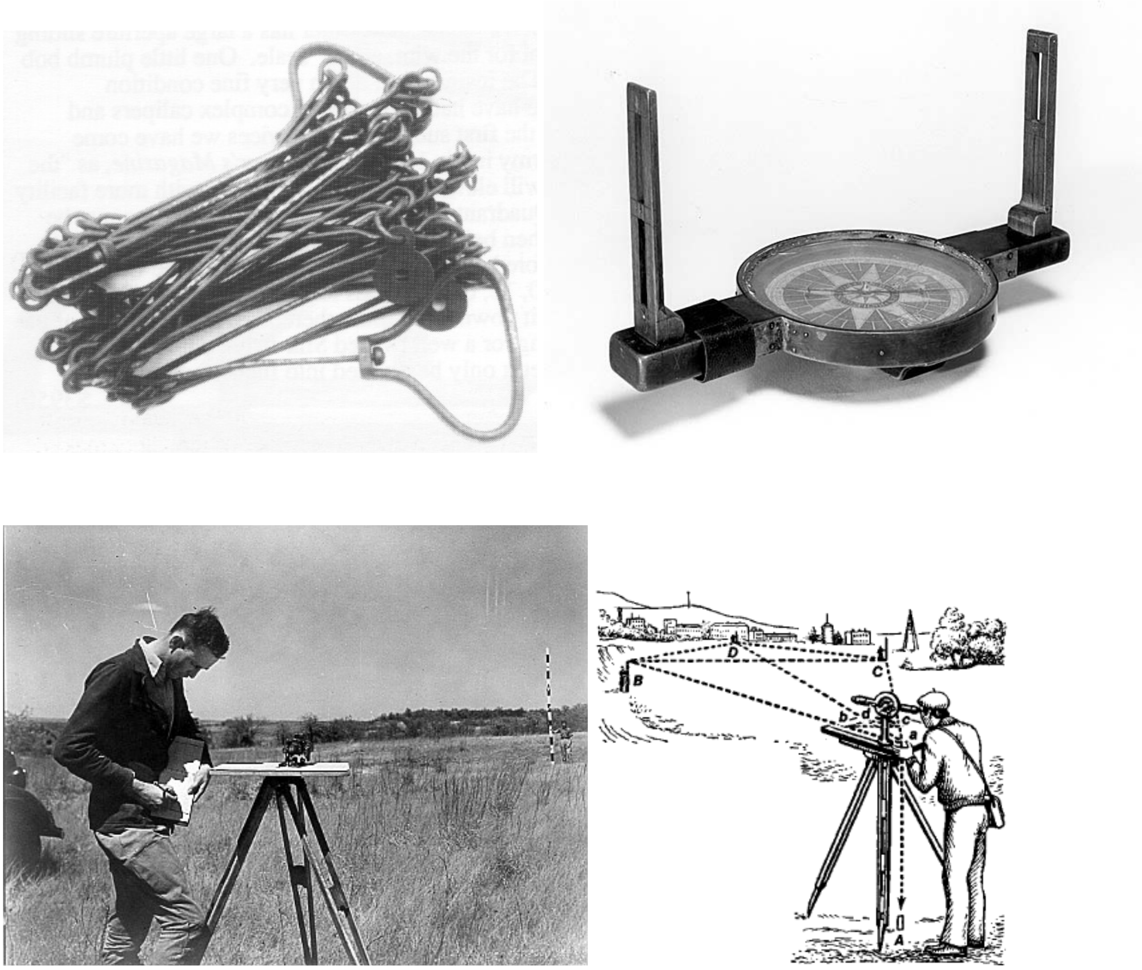


Figure 3: Chain and compass for surveying (above) and plane tables (below) – very common through until late 1960's

Sajen A frame. Commonly used in rural areas. The base is 2 metres wide and the handle at the top allows rapid measurements of 2 metres at a time. It folds down into a long stick that can easily be carried.

Figure 4: Sajen A Frame

It is really when you get into the middle of the 20th century that you see equipment being used that is accurate enough to relocate a boundary with any degree of accuracy. National coordinate systems became more common and equipment was more accurate. Many surveyors will remember the times when there was a need to locate a boundary and the owners regarded you as a magician because you went out to the field and located an old concrete or stone marker or just an iron rod buried in the ground, in a place where neighbours had been arguing about where a new fence must go. Very often it was the case that you would say, 'Just clear that undergrowth over there and there should be a concrete marker with CP2 (or something) written on it.' And sure enough, there it would be. Then you would go and find CP1, CP3 and CP4 in the same way.

Revolutions in Surveying Methodologies

Aerial Photography

The first big revolution came when it was apparent that aerial photography could be used to directly locate and measure boundaries quite accurately. In the UK, property boundaries had been marked on topographic maps since 1897, but it was not until after 1950 that the Ordnance Survey GB began using aerial photography and the science of photogrammetry to produce the topographic maps as a standard procedure and for updates. As far as I know, the first instance of using aerial photography to undertake systematic registration of title was in Kenya in the 1960's. Owners were required to plant hedges (and the government even had a hedge inspection team to make sure that the hedges were planted and watered) so that aerial photography could be flown and the boundaries plotted from the imagery. Malawi in the 1970's and other countries, including Thailand in the 1980s, used similar photogrammetric methods for their programs. For systematic registration, it became normal because it was far cheaper and faster than measuring every property on the ground. Aerial imagery has a very important and useful function in quality control – it is immediately clear and apparent by overlaying a cadastral plan on a photomap if the plan is incorrect. If the boundary lines drawn on the plan do not match the physical location of the property on the ground as visible on the photomap, then they are probably wrong!

Until very recently, it was too expensive and slow to use photogrammetric methods for recording property boundaries unless many thousands of properties were being surveyed at the same time. You still needed very experienced and professional surveyors to oversee this work. It should be noted that photogrammetric methods are not always the best answer. In the Caribbean in the late 1960's through to the mid-1980's, major programs for systematic registration primarily used compasses and tape measures to measure properties. (As in Turks and Caicos, British Virgin Isles, Anguilla, Antigua, St. Lucia, Cayman Isles.) The vegetation is so thick in these tropical countries that images from the air do not help. When I visited St. Lucia in 1991, they described how they had prepared their index maps from compass and tape measurements without destroying the banana groves that covered the countryside. They had differentiated on their index maps between boundaries that they were sure about because owners had been present and the 'provisional' boundaries produced when the owners could not be present and they had to estimate where they thought the boundary was located. The provisional boundaries were drawn using a dashed line. Once a new survey was completed, they would just erase the dashed line and replace it with a solid line. They had no problems with the boundaries produced in this way.

Electromagnetic Distance Measurement and the Total Station

The second revolution came with Electronic Distance Measurement (EDM) that enabled long distances to be measured using infrared or microwave technology. The first equipment came out in the late 1950's, but it was still very expensive, specialised equipment well into the 1970's, and it required a separate theodolite to measure angles. It made survey work much quicker and much more accurate. It also coincided with a time in which national coordinate systems were now common and there would be a requirement for all surveys to be linked to that system. More powerful computing systems (really just high-performance calculators) came out around the same time and this drastically reduced the time it took to do all the calculations necessary to complete surveys. The *total station,* which combined in one machine the angle measurements, distance measurements and more computing power, came into common usage in the 1980s. This made survey work even quicker. However, it was still very complex and required people with very good technical skills to utilise the equipment.

The Wild T2 Universal Theodolite was the most common theodolite for angle measurement from 1921 through to 1996. It would be accompanied by a steel tape for measuring distances or, from the 1960's onwards, electronic distance measurement equipment.

Figure 5: Wild T2 Universal Theodolite (Pictures from the Archive of the Wild Heerbrugg AG, apart from the tape which was found from general Internet search)

Figure 6:Variety of EDM Equipment

Figure 7: Leica Total Station GEFOS and Leica Viva GS 14 GNSS receiver (pictures from Internet search)

GPS and Satellite Based Positioning Systems

The third revolution came with Global Navigation Satellite Systems (GNSS), which most people know as GPS (Global Positioning System) - although that is the name of the system put in place by the USA. The Russians have an equivalent known as GLONASS, China has BeiDou and the European Union has Galileo. Most equipment uses more than one of these systems to get the coordinates of a point. The equipment was initially very expensive and required two sets; one to be established on a known base station and the other to be used as a rover, linking to the base station. GPS really only came into full use after President Clinton opened the system fully for public use (without degrading the signals) in 2000. Prior to this, the signals were deliberately degraded for public use and the accurate signals could only be utilised by the military. Since then the cost of GNSS systems have been gradually reducing and they are being more frequently used. Continuously Operating Reference Networks have been established so that a central provider (often the government) provides the known base station information country-wide and companies or individual surveyors only need to utilise rovers to get real time survey coordinates. The big advantage is that you no longer have to have triangulation pillars on hill tops, correct measurements for slopes or reduction to sea level, or to make lots of complex calculations to ensure that resultant coordinates are correct. It is a black box technology that basically just gives you an answer quickly. The actual equipment needed for survey grade measurements (accuracy of a few centimetres) is very different to what you will get from mobile phones and hand-held GPS (accuracy of maybe 3-20 metres depending on which part of the world you might be in), but this is changing rapidly as this equipment improves. Measurements do not really need highly specialised people anymore.

21st Century Technology

The fourth revolution uses drones to undertake aerial surveys of small areas quickly and with great accuracy and new LiDAR systems that generate accurate three-dimensional images from equipment that can be mounted on a helicopter, car or drone. High resolution satellite imagery provides aerial images that are precise enough for locating boundaries with sufficient accuracy for even high value urban areas, and often this can be purchased cheaply from a library of records or (more expensively) ordered on-line. The software prints the map, including all boundary features that were visible, without much user interface and employs automated recognition software that can recognise boundaries, buildings and many other features.

Watch this space! Mobile phones are becoming more sophisticated and accurate so that anyone will be able to walk to a point and get an accurate coordinate (not quite there yet). More new technology (that we have not yet even dreamt about) is likely to come soon.

So, Why do We Still Need Licensed Surveyors?

The answer is that we do, but maybe not so many, because the actual measurements can now be done by people with minimal training. The licensed surveyor can oversee a larger number of assistants that actually do the measuring. However, the licensed surveyor still has some very important roles:

i. The property descriptions in deeds and cadastral maps could have been done by any of the methods referred to above at various times in history, and it is important to appreciate the origin of the surveys so that decisions about where the boundaries are, or should be, can be made by understanding the context. (See my example above about 'What are you sitting on?' and the one below 'He's dropped a chain'.)

ii. New surveys will often abut, and maybe overlap, with old surveys. It is very common that the original deed or title was issued many years ago and subdivisions have been done since then. Tracing the history of title and the subdivisions and whether current usage fits with older documentation may create issues that need to be solved through agreement and following legislation. Principles of mediation may be required and there are set ways of creating new agreements about boundary locations between parties. The licensed surveyor would normally have to pass examinations showing their understanding of land laws and to have been apprenticed to a licensed surveyor for a couple of years. So, they should have learned how to deal with disputing neighbours, at least to some extent. Land is a very valuable asset and mistakes can be very costly to correct.

> <u>He's dropped a chain!</u>
> I recall a case when a dispute between parties concerning a triangular piece of land had to be adjudicated. Both sides had deeds, one much newer than the other, and both were based on surveys carried out by licensed surveyors. There was no apparent problem with the surveys. The problem was on the ground where neighbours disagreed. One side of the disputed triangle was about 20 metres in length and another side had a long row of mature trees running along its length. I immediately thought the line of trees was probably the boundary, which meant that the older survey was probably wrong because it did not match the current location of the tree line and that the newer survey just assumed the old one was correct and adopted the incorrect line. Then, I remembered that a 'chain' used in many old survey methods was 66 feet long, which is about 20.1 metres. The original surveyor must have made a simple mistake. Instead of recording a distance of (say) 6 chains and 37 links, he recorded 5 chains and 37 links probably, because he miscounted the number of times that he had laid the chain out. The new surveyor just adopted the boundary as shown on the neighbour's earlier plan. There were no old survey records to check, but enquiries from the person who originally sold the land (who was now in his eighties) confirmed that indeed the row of trees was the correct boundary when he sold the land, and the new surveyors who were now representing both parties to the dispute agreed that the original surveyor from long ago must have "dropped a chain".

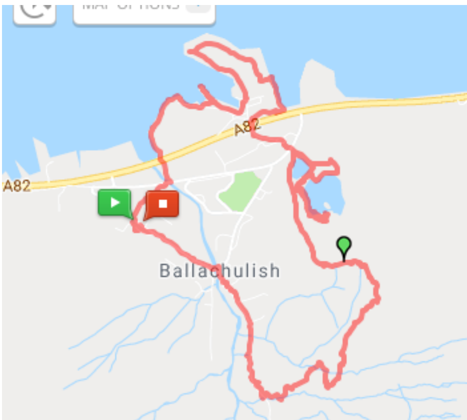
iii. The modern licensed surveyor is often also required to ensure that properties conform to town planning legislation and planning layouts, and to deal with other professionals, such as engineers, putting in roads (that have to meet road reserve criteria) or pipelines, understand the wayleaves[4] for utilities, easements (such as servitudes) and licenses that are relevant, and then to ensure that the boundaries and records reflect all these things.

iv. The licensed land surveyor understands 'errors' and where they come from. There are always errors in survey work. There can be gross errors (mistakes), random errors (small errors from normal survey work and equipment used that may be positive or negative and effectively cancel each other out over the survey work period) and systematic errors (errors, usually in the equipment, that are always in the same 'direction'.) A very simple example of a systematic error is if a tape measure has been distorted through long usage and has stretched. Then every measurement would be recorded as too short. Surveys can never be perfect and systematic errors always exist because of something in the equipment or surroundings. One surveyor I was responsible for had completed his survey work, but the work turned out to be "too" accurate, with over 1:1 000 000 accuracy (i.e. one centimetre error over a distance of 10 kilometres, when 1:10 000 was more likely and to be expected because systematic errors always exist). I checked and found an error in a measurement (a mistake) that had compensated for the accumulated systematic errors that were normal.

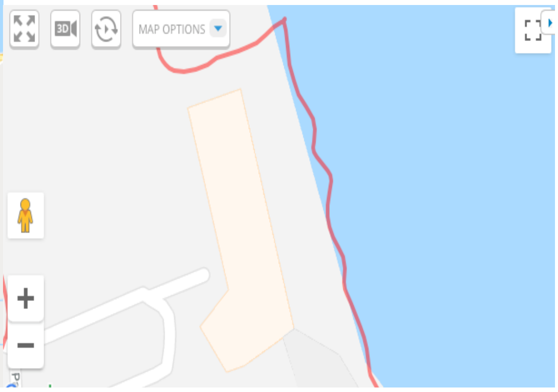
<u>Can I walk on water?</u>

Another example of a systematic error is when I use my mobile phone to track the distance I walk. Every time a signal comes in on my GPS it may be 3-7 metres 'out'. This gives the impression in the App that you are drunk, as if you can't walk in a straight line. (You only see this if you expand the image to a bigger scale.) It can be amusing when walking beside a river as the number of times you apparently 'walk on water' is amazing. I find that the App always shows that I walked almost 10 per cent further than I really did walk. This has implications if using simple mobile phones or handheld GPS for measuring boundaries. It is fine to do so, especially for large parcels in lower value areas, but it is important to know what you get in terms of accuracy. Such methods are suitable for a record that can be used to relocate a boundary on the ground (like a path, tree line or stream) but less useful for locating an exact position in time of dispute. Having said this, the speed at which such simple and inexpensive equipment is improving in terms of accuracy is likely to make such methods as just 'walking around' a boundary with a mobile phone much more accurate and more common over the next few years.

The picture of the whole 'parcel'



The picture of one boundary expanded. It should be a straight line along the lakeside wall.



[4] Wayleave – a right of way granted by a landowner, generally in exchange for payment and typically for purposes such as the erection of telegraph wires or laying of pipes.

v. As a follow on to the above, there have been many new innovations in surveying methods over the years – but they often have limitations. Licensed surveyors should know what these limitations are. For example, when GPS equipment began to be used some twenty years ago, I came across people using hand-held GPS to record boundaries, when this equipment could only record a point to 20 meters (they are better now, and 3 metres is usually possible). However, they were using it for boundaries that were only ten metres wide and did not know that this was not appropriate. Google Maps and other satellite based imagery is very useful for recording boundaries, but it must be recognised that some do not rectify for errors from slope or sea level, unless specific additional corrections (or rectification) is done. If the satellite image has large value spatial resolution[5] then accuracy may not be sufficient, but the expert needs to know this. There are now global digital elevation models that can be used to rectify images, but you need to know their limitations and what you get in terms of precision and accuracy. There is nothing wrong with using any form of technology or the use of approximate boundaries, but it is important to know what you get as a result and what reliance you can place upon the end result.

vi. Licensed surveyors have to have integrity and they can often identify when something irregular has occurred. Often you just know that something is wrong because it looks wrong. In one case, I checked a simple survey that caused me concern and I discovered that the surveyor made up all the measurements in his car because it was raining; he did not want to get wet. In another case, a surveyor had to undertake a survey of a large site in rough terrain that would have required hacking through a great deal of underbrush to do the necessary measurements. He completed his survey, had the survey approved by the Surveyor General and all was in order. Some weeks later another surveyor had to go to a nearby site and thought he would use the same survey lines that were recorded in this previous survey – so that he did not also have to hack through the undergrowth as well. When he got there, he found no evidence of any cut lines or that any survey work had been done. The previous surveyor had fabricated all his observations, measurements and calculations in order to avoid an unpleasant time in the bush. His license was rescinded.

Licensed surveyors are effectively now managers rather than measurers. Apart from ensuring that cadastral survey work meets the legal and functional requirements, they are increasingly involved in wider discussions. This is especially true as countries develop their spatial data infrastructure and integrate the information and services provided by other agencies. For example, if aerial photography is being flown for a systematic registration of title program, then the ministry of agriculture or water department or disaster risk management unit should be included in discussions as the specifications are developed, so that the funds expended can be shared and provide a greater benefit. Town planners and local government authorities would be other key users. Also, there can be implications for methods used during systematic registration. For example, in Kenya the idea of planting hedges and taking aerial photographs of the landscape was good from a surveying perspective, but there was a lot of criticism about how it changed the landscape and reduced the farmland available and also the flexibility of land use that had previously been possible. In the central region of Malawi we used *dambo* edges as boundaries (a dambo is a wide valley comprised of wetlands that often flooded during the rainy season), but the location of the edge of a dambo could be indistinct on the ground by tens of metres. In more recent times this land has become very valuable for market gardening and grazing and that has created tensions between the community and the owners of the adjoining land. The surveyor needs to take these issues into account too – looking to the future as well as the social and practical implications of the work they do.

[5] Spatial resolution refers to the size of the smallest feature that can be detected by a satellite sensor or displayed on a satellite image. It is usually presented as a single value representing the length of one side of a square. The 0.3 metre resolution of Worldview 4 images may be usable in locations where the 5 metre resolution in the older SPOT or RAPIDEYE satellite images are not.

Fixed and General Boundaries

In much of the literature about boundaries, the terms 'fixed' and 'general' boundaries are often used. There are many definitions about the terms, but the 'general' boundary term came about in 1875 in England and Wales (as mentioned in Chapter 1), because trying to 'fix' boundaries created disputes where none previously existed. Neighbours were asked to specify exactly where their boundary was and then it was discovered, for example, that one neighbour thought that the centre of the hedge was the boundary, while the other thought all of the hedge was his or hers. For centuries people had been happy with their hedge, wall or fence, and now it seemed that a great deal of money was being spent to 'fix' boundaries, only to make matters worse and clog the courts with disputes. Some Commonwealth countries have adopted the term in their laws in order to distinguish between physical boundaries that were adopted in the plans prepared (usually in order to cut the costs and time for recording) and boundaries that had been measured more precisely by ground survey and agreed with neighbours. In many countries the difference between being able to register a property and not being able to register a property is the ability to be able to use the 'general boundary' concept. Book reference 16 on Fit-for-Purpose Land Administration in Annex 1 deals with this issue in much more detail.

The terms 'fixed' and 'general' boundaries are usually misunderstood, with the assumption that a fixed boundary is more accurate than a general boundary. It is not necessarily so. It is more *precisely* specified, but not necessarily more accurate. So, for example, the north side of a wall is agreed by both neighbours to be the actual thin line that is their boundary; they agree, sign the necessary document and register the fact. They now know precisely where the boundary is, but it is no more accurately measured than the original 'general' boundary – the wall. There is also a misconception that in some way a fixed boundary is better than a general boundary. Again, not true. I recently came across a situation where the boundaries of every parcel in a large development were 'fixed' with accurate coordinates and long steel rods placed to mark the corner points, and the rods were banged into the ground and flush with the ground. The survey was examined and approved by the Surveyor General. Unfortunately, no one other than the surveyor that placed them knew where these rods were, and the developments went ahead without taking any notice of the fixed boundaries. The de facto boundaries now bear little relationship to the survey plans, town plans or deeds.

A general boundary is usually a feature like a wall or hedge or fence or stream. It may not be known which side of the feature that the boundary lies (i.e. to the left side of the wall, the centre of the wall or the right side of the wall), but it doesn't really matter, and no one can miss where the wall is or build a house across it without someone stopping them. For most cases, the general boundary is perfectly adequate. The Land Registry of England and Wales estimated that as of June 2, 2014 there were 23 872 035 registered titles; only 1176 include an entry in respect of determined or fixed boundaries. (Data from an enquiry I made to the Land Registry at that time.) This implies that only five in every 100 000 properties have needed to 'fix' *one* of their boundaries since the year 1875 and therefore brings into question the economics of requiring every boundary to be 'fixed'.

In most of the world there is no such concept as a fixed boundary or a general boundary. They are just 'boundaries' that are described in different ways. An Austrian colleague advised me that they retain four levels of accuracy in their cadastre so that they know how reliable the survey work is. Level 1 covers the graphical record produced long ago either from the original surveys or updates when they first conducted the surveys over a hundred years ago. Level 2 refers to the records where the older surveys and graphical works have been transformed to fit the current national coordinates and cadastre system. Level 3 includes properties that have actual measurements based on coordinates. Level 4 includes properties that are considered legally and technically accurate with the owners' agreement. Levels 3 and 4 are often in high value or urban areas, but still almost 50 per cent of properties in Austria are recorded as Level 1 or 2. In this example only level 4 is really 'fixed', because it has been accurately surveyed and the owners have agreed to the boundary and this has then been documented. However, when discussing with a German colleague once, we agreed that in fact it would not be *really* fixed until a second surveyor came along later to locate the boundary markers that had been previously placed and the new survey agreed with the old one. This is because humans make mistakes. So, if you really want (almost) certainty you will need to take this second confirmatory step. Maybe, then, the 'guaranteed area' referred to in Chapter 6 can become a reality.

Summary

This chapter focuses on the purpose of surveying a boundary, which is primarily to relocate a property boundary when there is doubt about its location or there is a dispute. If the boundary is physical, such as a wall, fence, stream, tree line or hedge, it is usually only necessary to be able to relocate that feature. If the neighbours are satisfied about the location of the boundary then it is counterproductive to start telling them that the boundary is elsewhere or that they must specify precisely where that boundary lies – to the centimetre. In fact, most courts around the world consider the commonly accepted locations and evidence from the community as more important than coordinates or lines found on drawings and plans.

It needs to be noted that the surveying methods that can be used for 'one off' surveys for registering one land parcel, which is often paid for by the customer, is a very different proposition to having to measure millions of properties in a mass systematic registration program that is funded (usually) by the government. You cannot use the same methodology because of time and cost constraints, so different methodologies have to be used.

There have been four revolutions in the way to measure property boundaries. The original simple methods were replaced with more accurate and precise methods using equipment that was invented in the early nineteenth century and gradually improved over the next 100 years. These were replaced for mass systematic survey by aerial photography for registration purposes after the Second World War, and then by EDM and angle measurement devices for individual surveys in the late 20th century. The use of GNSS systems has been prevalent in the 21st century for both systematic and sporadic registration programs and the latest technology using drones and LiDAR is coming into much greater use as we write. High resolution satellite imagery is now readily available and provides adequate information on boundaries for most purposes. The next phase is likely to be simply 'walking the boundary' with mobile phones that have accurate GNSS systems and high resolution imagery built within them.

Now that surveying work is so simple, the question arises, *why do we need licensed surveyors at all?* It is more because of history and the fact that old surveys used old technology, and it is necessary to have someone who can understand this and how errors occur. The licensed surveyor should also understand the law, appreciate how to adhere to town plans and other legal requirements when preparing plans showing property boundaries and any relevant easements. Their role to measure can be delegated to lower grade technicians, but their overall tasks dealing with disputes and ensuring that legal requirements are met cannot. We may need far fewer of them, but as yet surveyors are still required.