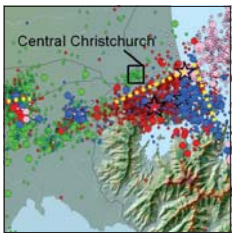
Geomatics World

MAY | JUNE 2012

Issue No 4 : Volume 20

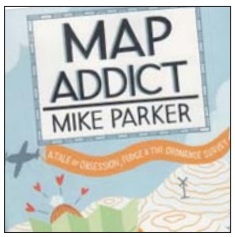
Surveying for geographical and spatial information in the 21st century

Repairing New Zealand's shaken cadastra



Can 19th c. mapping help in retracing boundaries?

GeoForum hears Map Addict author



Marine technology and Oceanology

Marking the retirement of Leica's 360° man

Retracing a 6" Townland boundary using the original survey field books

by Kieran O'Shea

Can reference to the original mapping made more than a century ago improve boundary accuracies and perhaps help resolve a boundary dispute? **Kieran O'Shea** presents a novel method of tracing boundaries using the original survey records behind the 19th century Irish 6" mapping.

Any surveyor who has been involved in a boundary dispute quickly realises the limitations of the maps attached to property folios when trying to establish the 'legal line' on the ground. Either they do not scale uniformly or they just don't match what is on the ground. This is particularly so when dealing with the 25" (1:2,500) and 6" (1:10,560) mapping but is sometimes experienced with maps of more recent creation and at larger scales.

It must be stressed that the accuracy of the maps is not in question here as such, but rather their suitability for purpose. The accuracy of drawn maps (or drawn maps that have been digitised) is limited by their plot scale. A 0.2mm wide line on a 6" map is equivalent to 2.1m on the ground. However, it is normal practice for the survey observations behind the mapping to be made to a higher accuracy. It was therefore decided to investigate if it is possible to 'drill down' further into these maps to extract the maximum accuracy from the surveyed detail.

The original Irish Ordnance Survey (OS) maps were surveyed by chain survey on a parish triangulation framework. The purpose of this article is to investigate the accuracy and precision of these original surveys and whether or not this 'lost' precision could be retrieved.

Working with old maps

Most surveyors today have had some experience of scanning, rotating and stretching old maps to fit modern grids in the hope that light will be shed on their inquires. But more often than not the light dims or a thick fog descends.

Ordinarily a boundary dispute arises where there is uncertainty about the exact location of the boundary, e.g. on which side of a ditch does the boundary lie etc. Although different features are represented on OS maps as a single line, some of these features are two or three metres wide.

The issue of whether or not Ordnance Survey maps show private boundaries is a topic for another discussion. The fact (or legacy) is that the old 6" and 25" maps reside in the conveyance instruments and are usually the first item to be scrutinized when there is a boundary issue.

The best estimate of the accuracy of these maps is some combination of the accuracy to which they were plotted, the accuracy to which one can scale off and the distortion of the paper. In practice this is probably about 4-5m for 6" maps and 1-2m for 25" maps.

OS 6" Survey: a technical triumph

The original 6" Survey was a technical, logistical and scientific triumph. The foundations for this survey had been laid down over a number of years in England, Wales and Scotland but in 1825 Thomas Colby was given a blank canvas that was Ireland. It took twenty years to map the entire country parish by parish and plot the maps on a county basis (See Fig1).

Fig 1 Fair Drawing of Ferrybank, Arklow, Co Wicklow.

This 6" Townland Survey, as it was called, and the subsequent 25" survey, conducted around the turn of the century, became the de-facto maps attached to most land transfers in Ireland. Although more folio maps are based on the 25" mapping rather than the older 6" mapping, it was decided to investigate the original 6" field surveys for two reasons. Firstly, the 6" survey was the basis for the later 25" survey and secondly it can be argued that of the two, the 6" Survey was the only proper cadastral survey.

6" Townland boundaries

The first element of the 6" Townland Survey was for the valuation office boundary surveyor to take to the field with existing maps of the day and to contact all relevant land owners. A local man was assigned as meresman and both he and the boundary surveyor liaised with all owners and met with

them to mark out the agreed private boundaries that lay along the Townland boundary. The boundary surveyor mapped in these pegged boundaries noting the mereings (the exact line of the boundary on the field feature) and forwarded this signed map to the ordnance surveyor in charge of that district. The ordnance surveyor perambulated and recorded the boundaries with the meresman to ensure the correct boundary was identified.

The townland boundaries were surveyed in separate field books and mapped to a higher accuracy than all other detail, such as roads and buildings (See Fig 2).

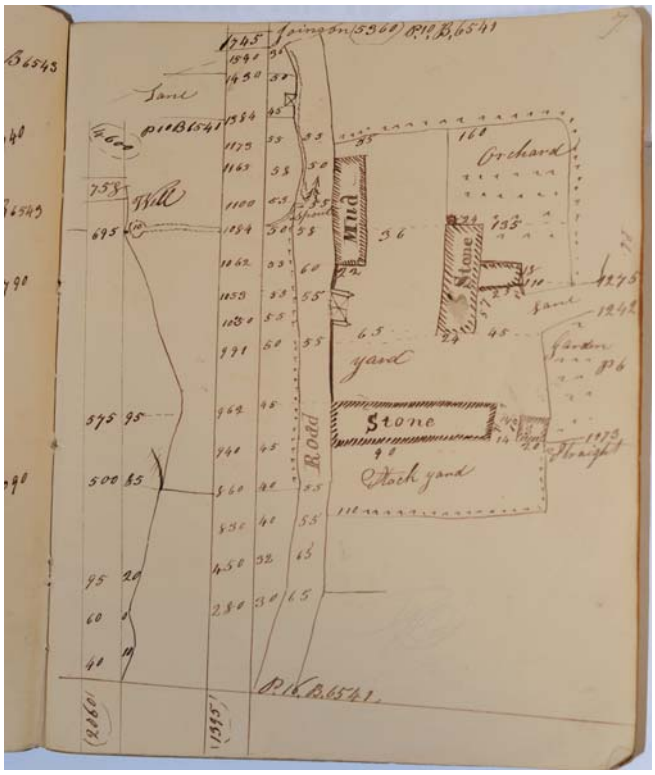


Fig 2: Chain Survey Field Book.

Where to begin?

Boundary retracement is a term more associated with countries that have a cadastral registration system, which is mathematically defined, rather than our map-based system. It must be said that the Property Registration Authority (PRA) in Ireland emphasises that its mapping is an index to registered titles rather than a cadastral map that defines boundaries. But the same map is used to 'describe' a parcel of land in a sale and is understood by parties to a land transfer as fully describing the extents of that land. Thus in the event of a dispute between neighbours, the map often becomes the primary focus.

A retracement of the original survey involves examining the nuts and bolts of that survey down to its fundamental parts. This basically involves re-plotting the original survey from the parish triangulation as this will more fully identify the positions of the original surveyed features. The legal position of such an exercise will not be explored here.

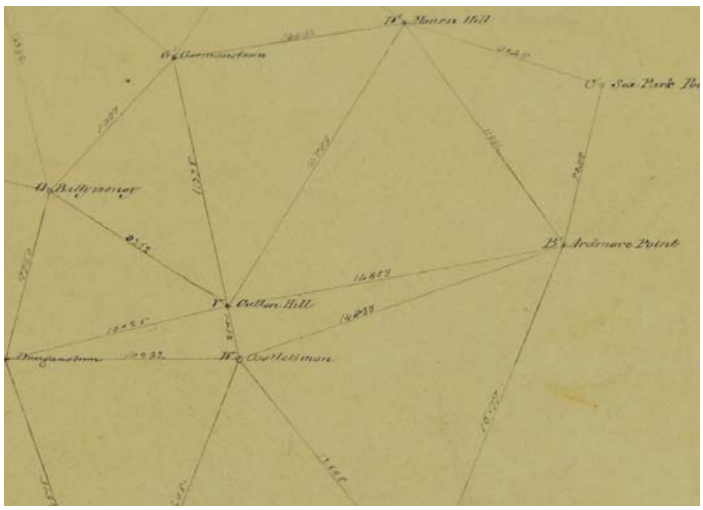
6" Parish triangulation

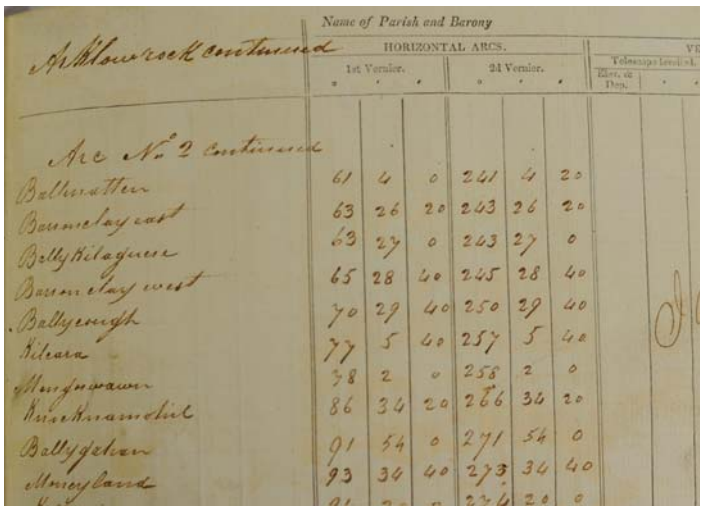
Before we can re-trace a survey we must have an understanding of how that survey was performed. The detail of the 6" survey was surveyed and plotted on a parish triangulation framework, which was established using a 7" or 8" theodolite from a number of main stations established from the secondary triangulation. Typically two main triangulation stations were established in each parish and these provided the 'distance' needed to scale or compute the local parish triangulation (See Fig 3). This parish triangulation provided the 'Trig'l distance' needed by each division to commence their chain survey, as without this they could not close (check) their main chain lines.

Parish triangle sides typically measured circa 2-3km depending on local terrain. The theodolite was set up over each station and three rounds were observed to surrounding stations (which were marked by piles and poles) and also to reference objects such as lighthouses, chimneys or spires (See Fig 4).

The parish triangulation plan shows the reduced / adjusted distances for each triangle in feet or links. The spread of the angular observations was usually large, probably owing to circle eccentricities but the precision and accuracy of the parish networks appears to be high and possibly at the 0.1m level where all

*Below: far left, **Fig 3**, Parish triangulation plan with 'distances'.*
*Below: **Fig 4**, Parish Observation Book.*





three angles of a triangle were measured. At the periphery of the Parish Triangulation Networks there were weaknesses.

The 2011 Survey (Resections)

The field retracement started with these parish observations, but rather than climbing up some rough terrain with a theodolite, it was decided that it was easier to coordinate (on the new ITM Grid) the reference objects booked during the parish theodolite observations. This way we would not have to worry about obstructions on the lines. Two lighthouses, a church belfry, a church tower and an old castle tower later and there were enough reference points to locate the three stations (R-Q-K in Fig 5) forming the main triangle, using a weighted resection. StarNet was used for this and each station was computed independently except for the last station, which included rays to the two stations computed previously.

The advantage of using rounds of angles is that they are independent of scale and grid. The actual scale conversion was not critical as it was the original station positions computed from these original angles that were of interest, i.e. we wanted to establish where the 8" theodolite was centred in 1838. The main chain lines were set out from these stations.

When the parish triangulation distances were compared to the resected distances we found that there was typically a 1:2000 scale difference, circa 1m per side. A combined scale factor to convert between the ITM Grid and the local 6" Triangulation (Ft.) was calculated in order to plot the 6" Survey detail over the 2011 GPS survey.

To get some idea of the precision of the three resected stations, an independent point (Water Guards Signal Pole), which was recorded in the original parish observation book was plotted in CAD. The error triangle formed by these three original angle observations (intersection) as plotted from the new resected positions measured less than 0.1m. This indicated a high degree of precision both in the original observations and in our resected positions.

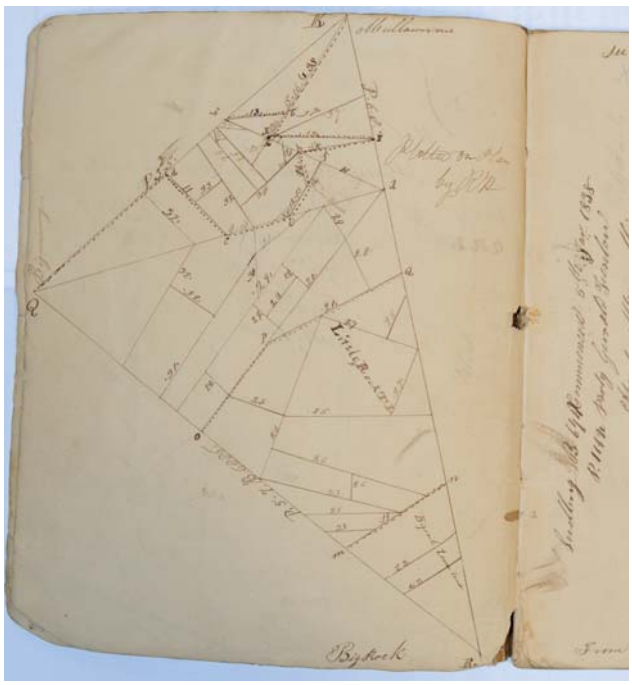


Fig 5: Chain triangulation diagram.

The 1837 chain triangulation

A 66' chain with 100 links and surveyor's arrows was used to carry out the chain survey. The first job was to peg out the main triangle lines with a theodolite and record the vertical angles at changes of slope for the reduction of the chained lengths to the horizontal. Next, the line was chained on the slope and closed at the end 'trig l stn'. The chained distances were reduced to the horizontal and adjusted in the horizontal levelling books. These distances were usually written into the field books before plotting. The misclosure of these lines was often in the 5-7m range but where the main chain line had a small vertical difference they would sometimes close to as little as 0.5m.

The main triangle was then sub-divided into a series of smaller (minor) chain triangles that were fitted around the townland boundaries (See Fig 5). The boundary detail was surveyed from these chain lines using offsets and recorded in the content field books. It is not exactly clear how these minor lines were set out, but it must be assumed that the 5" Theodolite was used for this purpose.

Plotting the original 6" field books

The main chain (triangle) lines (R-K & R-Q) were plotted in CAD onto the resected station network and all intermediate stations along these lines forming the minor chain triangulation were also plotted. This case study was focused on one townland boundary along an old stone wall. The chain line running parallel to this feature was a minor chain line (q-p-o) running between two main chain lines for approximately 700m. Before we could plot the original 6" field book detail, it was necessary to determine the accuracy of the adjusted chainage positions of 'q' and 'p' and 'o'. The distributed chaining error along the main chain line was 7m or 1:350.

Limitations of the accuracy of chaining

To check the effectiveness of chaining over such long distances, a number of well defined intermediate points were surveyed using GPS. These were features, still present today, that were bisected by the main chain line (R-K), i.e. on zero offset as recorded in the field books. At the lower end of one of our main chain lines there were a number of farm outhouses that we surveyed as checks. The GPS distance to this feature as compared to the adjusted 6" chainage agreed to 1m, which was fairly good. But moving closer to the middle of the main chain line, a check on a wall showed a miss of circa 3m with a similar miss on the main line (R-Q) of circa 2.3m. These checks indicated a random or non-linear aspect to the chaining errors.

So the proportional distribution of substantial errors in the chaining, particularly along long lines of uneven terrain, would appear to have been of questionable effectiveness and limits the usefulness of establishing the parish triangulation stations

and main triangle using resections.

It was also likely that this weakness in the chaining over lines up to two miles long was known and contributed to the view that the 6" field books could not be accurately plotted at the 25" scale, although they were used in two counties. The accuracy of the minor chain lines of the internal survey would be even more compromised. It is not known if or how these chaining difficulties were dealt with in the 25" Survey.

Localised fit of the 6" chain line

Because of the weaknesses identified in chaining over long distances it was decided to locally fit the 6" chain line survey to the hard detail on our GPS survey. This involved accurately surveying features such as walls, well defined banks etc, which crossed the chain line concerned. The CAD plot of the chain line (q-p-o) was re-positioned onto these well defined GPS surveyed features using two points 600m apart.

In order to verify the validity and accuracy of this 'fixing' procedure it was necessary to check a number of intermediate points / features which were also close to or bisected by the same chain line. The results of three check positions along the line were favourable with agreement typically of less than 0.3m.

These checks suggested that the 1838 minor chain line (q-p-o) location was re-established to an accuracy of circa 0.2m, but when the offsets to the boundary feature were plotted, there was poor agreement with the actual positions surveyed by GPS in the order of 1-2m too short (See Fig 6). Something was not adding up.

A second project area 200m to the south was investigated. In this area the same chain line ran on the opposite side of the boundary feature. If the chain line was mis-positioned, the content field book offsets would plot too long. But once again the offsets to the feature plotted short.

Clearly there was some breakdown between the chain line and the boundary feature being measured, but it must be remembered that they were surveying for a scale of 1:10560.

In this particular retracement the objective was to investigate the feasibility of improving upon the accuracy limitations of scaling from the 6" and in particular the 25" maps. One important observation made during this study was that where the chain line passes over or very close to a feature, it was surveyed more accurately.

Reviewing the 6" field books showed a minor chain line (28) perpendicular to the chain line (q-p) and bisecting the feature that was the focus of our investigation. It was decided to plot this line which crossed the boundary wall of interest, 31 links from an intersection with our minor chain line (q-p). The results were good with the 6" recorded position of the wall in question plotting right on the centre of to our GPS surveyed position.

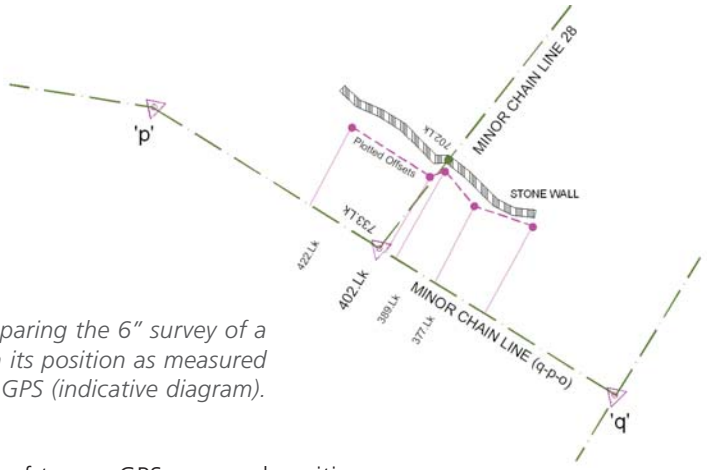


Fig 6: *Comparing the 6" survey of a wall with its position as measured using GPS (indicative diagram).*

These findings highlight the main potential of the old 6" survey field books in that the plotting of a chain line will more accurately indicate the distance between features over which it crosses than distances scaled off the 6" maps. Whereas any detail plotted from the field book with offset greater than 10 links was found to be of poor accuracy in this case study area.

Conclusion

Although the retracement has identified some pitfalls there is much to be gained by re-plotting the original 6" field books in order to open up a level of accuracy that is not obtainable by reviewing the maps alone.

This case study has shown that there is another dimension available to surveyors to help in solving issues caused by unclear mapping. It is up to surveyors to grasp the thorny issue of poor legal maps and develop accepted solutions that it is hoped will be part of a mediation remedy in such cases.

When completed, the OS 6" maps provided Ireland with the most comprehensive mapping coverage of any country. It is a testament to the skill, ingenuity and perseverance of the ordnance surveyors of this era that their surveys more than hold their own against some current day mapping.

All the remaining Irish 6" OS survey records are lodged at the National Archives, Bishop Street, Dublin. There is also a wealth of books, registers and plans pertaining to the 19th Century OS maps and surveys in the British and Irish libraries and Archives and every surveyor should visit them at least once.

When the parish field books are held up and shaken, you will find that the sheets are tightly glued together.

Acknowledgements

Images of OS Material reproduced courtesy of the National Archives of Ireland (NAI) and The Director of the NAI
OS/105A/191(Fair drawing)
OS/104A/191(Parish Triangulation Plan
OS/58A/191(Content Field Book)
OS/43/162 (Parish Obs Book)
OL/3.5471(Boundary Survey)

"This case study has shown that there is another dimension available to surveyors to help in solving issues caused by unclear mapping."

About the author

Kieran O'Shea graduated from Bolton Street , Dublin in Geo Surveying and is also a licensed surveyor in the state of New Jersey. He runs a small land surveying business in Co Wicklow and can be reached at **kieran@lasersurveys.ie**