“Why the County Series”
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**Why the County Series?**

Rob Wheeler

The six-inch survey of Northern England and Scotland was authorised on 1st October 1840.¹ There seems to be nothing in the discussions that led to this about its projection(s) or sheet lines. Three options were open to the Survey:

1. Each county to have its own Cassini projection, based on an origin within the county, and (as a consequence) a system of sheet lines unrelated to that of any other county.

2. A smaller number of projections to be used, each serving a region (or perhaps one for the whole country) with a system of sheet lines running unbroken across the region. A particular form of this could involve

2a. The counties of northern England to be on the Cassini projection on the Delamere origin.

3/3a. As 2/2a, with a sheet lines grid running across each region but a separate numbering system for each county.

1 had been in use in Ireland,² but the arguments that might have led to its adoption there were not necessarily applicable to Great Britain. 2 was adopted in Germany, where the 1:25,000 series in Bavaria (for example) used the same projection as the earlier smaller-scale maps. Indeed the projection used for Prussia prior to 1871 was in due course extended to the whole Reich. 3 was increasingly used for the County Series in Great Britain from the 1870s.

The first of the English Six-inch sheets to be signed off was Lancashire 23, in 1842.³ Since its sheet lines are based on the Lancashire meridian, that tells us that by 1842, a decision had been made to go for option 1. Why?

**Why not?**

It is logical to start by explaining the problems with 1:

*Extra work.* In contrast to the position in Ireland, there was already a higher-order triangulation, with coordinates calculated (for northern England) on the Delamere meridian. Using a county meridian necessitated taking a set of astronomical observations to determine that meridian, and then converting the higher-level trigs to these local coordinates. Assuming the One-inch was to be continued northwards (which was clearly Colby’s intention) it would be necessary to convert the coordinates of the corners of the Six-inch sheets to the Delamere projection as a preliminary to transferring the reductions of the Six-inch to the new One-inch. Furthermore, unless Lancashire and Yorkshire were to be published as incomplete counties, it would be necessary to resurvey the southern parts that had already been done at the two-inch scale. Doubtless the new survey would be far superior to the old but, given the pressure from Scotland, it seems a curious decision to delay their survey so that southern Lancashire might be re-done.

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¹ R Oliver, *The Ordnance Survey in the Nineteenth Century*, 2014, 149.
² See *Sheetlines* 30, 16-17 for the county origins.
³ Survey was particularly easy, in that there was no land on the sheet.
Inconvenience at county boundaries. It seems to happen all too often that the place in which one is interested lies at the junction of four sheets. The solution in such cases was to buy all four sheets and have the map agent mount them together; it added to the cost but produced a perfect solution. In contrast, if the place lies close to a county boundary that solution was only available if the map agent trimmed one sheet along the boundary, a fiddly job that was almost never done. This remained a problem (albeit eased by the move to combined meridians) until the end of the County Series.

Interdigitation of Counties. Certain townships, like Donisthorpe (figure 1) were a complete patchwork of parts of different counties, in this case Leicestershire and Derbyshire. The northern counties of England seem to have been reasonably free of such problems, but that was not the case in Scotland. And was there no aspiration to extend the six-inch survey in due time to the rest of England?

![Figure 1 Old Series Sheet 63NW showing Donisthorpe divided between Leics and Derbs.](image)

Detached Parts of Counties. Even where detached parts of counties had saner boundaries than in Donisthorpe, there were still problems. Leaving an empty hole in one map, to be filled with a detached part on a different map drawn to a different projection seems an unsatisfactory solution. Perhaps the intention was to ‘tidy up’ the counties for survey purposes, transferring enclaves wholly surrounded by another county to the surrounding county; but unless the surveyors moved smoothly across from one county to the other the exclaves might remain unsurveyed for some years after their parent county had been completed. This was liable to lead to protests from those exclaves, backed up by representatives of the counties (notably their MPs) that the the Survey was...
engaged in an unauthorised diminution of ‘their’ county. Northern England was about to be rationalised by the Counties (Detached parts) Act of 1844 but Scotland would retain its oddities until 1889.

**Scale distortion**

Given the strength of the case against county meridians, it is worth trying to find the reasons they might have been adopted. I have outlined some below, along with the counter-arguments that seem to render so many of them of little weight.

The argument most usually cited is scale distortion. The Cassini projection exaggerates north-south distances by a factor which increases in proportion to the square of the displacement in longitude from the prime meridian. The factor is actually the secant of the angle on the great circle perpendicular to the meridian. It reaches 1 per cent some 500 miles away from that meridian. Thus at 200 miles it is about 0.15 per cent; and the whole of Great Britain lies within 200 miles of the meridian at 3°W. This would be the maximum distortion on a Cassini projection on this meridian. Northern England is about 165 miles across, so one could choose a meridian that gave a maximum distortion of 0.025 per cent: 1 part in 4000.

This distortion is independent of the scale chosen for the map, and it is worth noting that it was thought perfectly acceptable in 1840 to have the one-inch map of northern England on a single Cassini projection and (later in the century) to have the one-inch of England and Wales on a single Cassini projection. Because the one-inch was the scale likely to be used for military purposes, a map from which simple soldiers might need to take measurements in a hurry, without time to worry about scale corrections, one might regard scale distortion on this scale as more critical. However, it is doubtful whether any military use of maps at these dates required measurements more accurate than 0.5 per cent. Determination of range by artillery seems the most demanding application; but the uncertainty of corrections for wind and for the particular batch of powder introduce a greater uncertainty. Fortress artillery might be an exception; but was mostly concerned with moving targets (ships) and obtained distances from range-finders, not from maps.

This brings us back to the Six-inch map. There were plenty of users capable of measuring the side of a field who might have had difficulty understanding scale distortion resulting from the Cassini projection. For example, they might be subdividing a field and might find it convenient to take measurements from the map as well as directly on the ground. How accurate do we suppose their measurements might be? At the western extremity of Scotland (taking the hypothetical case of a single projection for Great Britain) the terrain is so rough that I would question whether one can chain a distance to an accuracy of even 1 per cent. East Anglia offers easier terrain, but here the start and end-points would normally be a hedge. Can one really determine the ‘root of hedge’ to an accuracy much greater than a foot? So, potentially one is looking at an error in chaining comparable to the scale distortion.
But the greatest difficulty faced by anyone planning to compare a distance on the ground with a distance on the map is paper shrinkage. Shrinkage in the east-west direction is surprisingly variable: measuring three flat sheets of the engraved one-inch chosen more or less at random (albeit, all printings of the 1890s) I found shrinkage from 1.5 per cent to -0.3 per cent. This was done by measuring distance between neatlines with a metal rule (and checking the result against the scale bar). In all three cases, the north-south shrinkage was an order of magnitude less - a consequence of the fibre structure of the paper. Thus the error a surveyor will make if he measures an east-west distance using a graduated rule is of the order of 1 per cent; likewise if he measures a north-south distance using the scale bar on the map. The only reliable way to measure a distance off an engraved map is to use the dimensions between neatlines to calculate the shrinkage separately for the two directions, and to apply each factored by the sine or cosine of the bearing of the line one is measuring.\(^4\) Any surveyor who is sufficiently knowledgeable and careful to take that much trouble is perfectly capable of including the extra north-south factor for the Cassini projection.

In short, even if the whole of Great Britain were mapped on a Cassini projection, the scale error resulting from the projection would be less than that from other sources.

In the calculation of areas, it would be necessary to apply an additional factor beyond a certain distance from the prime meridian, and this factor would vary with longitude. However, for the maps envisaged in 1840, there would be very little calculation of areas. If private surveyors tried to use the six-inch maps to calculate areas of fields, they would be unable to achieve any great accuracy because of the small scale of the maps and because of paper shrinkage. If they could cope with these, they could certainly cope also with scale distortion.

**Meridian error**

When counties were moved to common meridians from the late 19th century, there was a tendency to group counties in north-south strips. The most extreme case is the use of the Dunnose meridian for a group of counties stretching from the south coast to the Midlands (see figure 2). This suggests that at this date it really was concern about scale distortion that was driving the policy. In contrast, for the early surveys each county generally employed its own meridian, even if it lay within the range of longitudes of a county to north or south that had already been surveyed. (I exclude here a couple of Scottish ‘joint counties’ like Perth and Clackmannanshire, where the smallness of one of the counties seems to have been the driving factor.) This seems to suggest a concern that the origin used ought not to be too far in any direction from the area where it was being used. Such a concern cannot have been driven by scale distortion.

One possible explanation for this might have been that small errors in determining the direction of north at the origin would lead to misplacement of the grid lines, the sheetlines themselves being the only public manifestation of

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\(^4\) This is still not perfect, as paper shrinkage is not uniform across the map, but non-uniformity is smaller by an order of magnitude.
this grid. Such an error might cause an object which ought really to have been on
one sheet to be on an adjoining one; it is difficult to see how this could be
rectified without completely redrawing all the sheets. Might that have been the
concern?

Figure 2 The tidied-up meridians (from Winterbotham, The National Plans, 1934).

Any consideration of this needs to start with the likely error in the
astronomical observations to determine the direction of true north at the chosen
origin. David L Walker has kindly reviewed the accounts of these observations
and agreed that an error of of 0.05 mRad or 10 secs of arc is a reasonable order
of magnitude to assume. At a distance of 30 miles from the origin, such an error
will cause the sheet corners to be displaced by about 8 ft on the ground or 0.01
inch on the map. I note that Brian Adams in his articles tended to regard one-
hundredth of an inch as the smallest change on the map that was measurable. Such a change would only be noticeable in extreme instances, such as when the dot at the centre of a trig might be coincident with the neatline of a map or might be to one side or the other.

If an origin is chosen that is reasonably central to a county, then we can conclude that the likelihood of an error in measuring the meridian causing an observable error in the maps is small. In contrast, using the same origin for a whole group of counties might be thought to involve an unacceptable risk.

That prompts the question of why, if this explanation is correct, the Survey was willing subsequently to move groups of counties to a common meridian. I suggest the answer may lie in the rather casual attitude within the Survey to the exact positions of the county origins, as indicated by what Brian Adams called “the Ordnance Survey’s most inaccurate map(?)”. If one finds that the true longitude of a county origin is actually 10 seconds of arc east of where it has always been supposed to be, the easiest way out is to declare the origin to be 10 seconds of longitude east of where it had previously been stated to be. That will be about 60 feet on the ground, which may be slightly inconvenient if the origin has a name like ‘Danbury Church Tower’, but is quite all right if it has a vaguer name like ‘Delamere’. Indeed, such a shift has actually been applied to Greenwich, which is a good deal more famous than any of the county origins. Assuming that all the coordinates used in calculations are referred to a False Origin to avoid negative values, one can move the origin without moving the False Origin. The error is rectified, but nothing needs to be changed.

Politics
There is another argument for a County series which is not technical at all. Given a national set of sheet lines for the Six-inch, it would be difficult to avoid a national sheet lines diagram. In this context national may mean Scotland, or Scotland with northern England. Either way it would consist initially of a small number of published sheets and a large number of projected sheets. Annual progress reports, assuming that Parliament or the Treasury demanded such things, would all look much the same: a few more sheets coloured in as complete but a massive number still to be done. There would be pressure for a quicker outcome, and that pressure would inevitably lead to an argument for reverting to the one-inch scale.

There would also be continual tension between tidiness - a steady progression from south to north - and giving priority to those areas where the need or benefits might be greatest. This was apparent already in the pressure from Ross-shire to be surveyed out of turn - presumably because of the utter absence of any half-decent county map rather than because of any prospect of industrial development. As long as the jockeying for position was between counties, it could be accommodated by the existing political process: each county had its representatives in Parliament and if necessary Parliament could decide the order.

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6 Projections and Origins, 2006, 41.
of priorities for counties. But a national series of sheetlines allows much greater subtility of choice and raises the prospect of a scatter of isolated sheets being surveyed because they corresponded to a Burgh constituency (many of which consisted of multiple small towns, deeply jealous of their status as burghs and utterly insignificant economically). Indeed if influence was to determine priorities, one might envisage pressure to survey the estates of certain great landowners who were government supporters in preference to those of their neighbours who were so perverse as to be in opposition.

Doing the survey a county at a time prevented the worst of these abuses. It also allowed annual reports to describe progress: ‘This year saw the completion of Blankshire’. Yet a further advantage was that it became possible to avoid a national sheetlines diagram.

None of this required county origins: option 3 or 3a would suffice. Nevertheless, having a different projection for each county would reinforce the message that counties must be treated as a whole and no demand for a national diagram could be entertained.

**Conservatism**

Continuing with the procedures that had been adopted in Ireland certainly made sense. Colby had transformed the Survey into what has been termed a ‘map factory’ manned by men trained only for very specific roles. This made the use of the six-inch scale in England necessary if a great deal of retraining was to be avoided. However, the choice of meridian affected only a very small proportion of the Survey’s staff, most of whom were at a level where they might reasonably be expected to have all the necessary skills and knowledge.

The complete adoption of Irish practices, to the extent of employing individual county origins looks more like thoughtless drift than a considered desire for continuity.

**The town scales**

The early surveys of towns at the 10-foot scale also had their own meridians. When questions were asked about the authority for undertaking these surveys, Colby’s answer in 1843 was that urban areas were surveyed at this scale as part of the process of producing the Six-inch map. Manchester appears to have been in the lead; and the 10-foot and the Six-inch maps clearly share a common source, although, because they were not published simultaneously, pre-publication revision has resulted in differences between the two. So why do the two maps use different meridians? It must have occasioned extra work: the coordinates of trigs established for the six-inch work would need to be converted to the local meridian; and, when the six-inch was reduced from the 10-foot work, the sheet corners of the 10-foot would need to be converted back to the county meridian.

One difference with maps of urban areas is that it really is possible to take accurate measurements on the ground. The corner of an important building, faced
in ashlar with good sharp arrises, can be determined to 0.1 inch. Another is that these were originally intended to be manuscript surveys rather than a printed product; thus paper distortion would be less. Even so, if one has an urban area, 2 miles square, lying 40 miles west of the county origin and one measures a distance that is 10 sheets north-south, counting each sheet as being exactly 24 inches high, the effect of scale distortion will amount to 0.004 inches. That is less than the accuracy with which one can plot a point on the paper. So there really was no need for separate town meridians - and they were abandoned quite early on.

Nevertheless, considering the town scales forces us to concentrate on the manuscript record, which was in effect the Survey’s topographical database. I implied early on that a scale error of 1 part in 4000 was acceptable. This would amount to a maximum of 0.006 inches within a single 3 feet x 2 feet sheet. It is less than the accuracy with which a point could be plotted, but it is on the edge of what is discernable. Colby was somewhat obsessive in his pursuit of scientific accuracy. Perhaps his thinking was that, in the course of time, plotting might be made more accurate but map construction would still be dependent on graphical construction: therefore a projection which built in a scale error that could reach 1 part in 4000 was unacceptable.

**Conclusion**

The practice of using individual origins for each county would be the cause of trouble and vexation for the next hundred years. The use of local origins for the town scales suggests that scale distortion away from the prime meridian was the underlying cause, but no attempt appears to have been made to quantify the effects and balance them against the inconveniences of multiple projections. Continuing with the procedures established in Ireland seems to have been a default option, and Colby’s autocratic style of command must have prevented any of his subordinates from proposing any changes.

**Postscript**

I have since found that Winterbotham expressed similar views to this.

*It was not until the battle of the scales that the Ordnance Survey seems to have realised the inconvenience implied by so many divisions [ie meridians]. [Sir Henry] James spent what was evidently an unpleasant quarter of an hour in trying to explain to the lay mind that surveys would join up even if sheet lines would not. Major Larcom stated at a later date that, had the public convenience of more continuous areas been realised earlier, Great Britain would have been plotted on three parallel° meridians. ... The original survey left us burdened with 42 meridians in Great Britain, not from scrupulosity, but from accepting, without due forethought, the habit of mind of contemporary surveying.*

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8 Of course, two meridians can never be parallel. What is meant is three meridians applicable in north-south bands lying alongside one another.