By Joel Leininger, LS

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Boundaries by the Numbers

From time to time surveyors argue with me over the use of least squares analysis in boundary retracement. Because the arguments tend to trace similar paths with one another, and because software enabling the practice is widely available, it seemed appropriate to discuss the issue here. Although analytical tools to assist in complex problem-solving would seem to be welcome in a process that might need defending one day in court, I have concerns stemming from the ease with which one might violate boundary retracement doctrine with such a tool.

Least squares adjustments necessarily analyze the positions under consideration in light of the geometry specified between them. Geometry is an indispensable component of the equation – in fact, without geometry there is no equation. Geometric checks ensure the integrity of the measurements and provide the fuel on which adjustment depends. Were it not for the mathematics, no misclosure could be detected, and thus no adjustment would be warranted.

The Rule

In boundary retracement, the courts have held that measurements, in most cases, must yield to other factors deemed more reliable. (Some courts have gone so far as to characterize retracement by measurements as a matter of last resort.) The general rule of construction handed down by the courts is that when conflicts arise between elements of a description, monuments, having a greater certainty than other elements, are to be honored above the other elements. Next in the order of priority come courses and distances, followed by area and, finally, coordinates.

There are some qualifications, however. First, the rule applies to conflicts between elements in the *same* grant. Conflicts between grants must be resolved in favor of the elder, because older grants have priority over younger grants. This is the doctrine of senior rights. Uncalled-for monuments introduce a second wrinkle to the problem. Surveys conducted subsequent to the original grant but prior to the current survey inject yet a third complication to the scenario. So, although monuments are afforded the highest priority in a general sense, one cannot automatically assume that every monument out there qualifies for the distinction. The same considerations apply to the lesser elements of a description.

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Weighting the Factors

Most least-squares analysis software allows the user to "weight" the various factors to be considered in the solution, so that factors which are more certain receive less adjustment, and vice versa. Thus, one could, for instance, weight some of the monuments to be "fixed" and force all adjustment into the other elements.

When ranking the evidence for weight, it seems easy to decide how to treat the elements to be honored at all costs: one simply gives them enough weight to ensure that the adjustment will not alter the position. But how does one decide how much weight to assign to the lesser elements – especially with respect to one another? In other words, how much weight does one assign to this course and distance or to that uncalled-for monument? Is there any legal or scientific basis for such a decision, or is the task akin to "picking numbers out of the air"? Suddenly the procedure does not seem as rigorous as the mathematics involved.

But let's suppose that one takes care to rank each element under consideration, precisely as it should be according to the rules of construction, for least squares treatment. Wouldn't the examination then be over? What is there left to do?

The process of ranking the evidence is the *essence* of retracement analysis. Once that evaluation is completed, the only remaining task concerns "filling in the blanks." Since this effort is also covered by boundary doctrine, what awaits adjustment? (Boundary doctrine dictates that, in the absence of monuments called-for in the description, courses and distances called therein must be used to retrace lines. There are a couple of exceptions to this rule – double proportional measurements in the Public Land states

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comes to mind, and apportionment within subdivisions – but essentially the doctrine specifies that a call for 100 feet must be retraced at 100.00 feet or as close as the surveyor can place it.)

A few retracement tasks do lend themselves to least squares analysis. Averaging a line through a series of road centerline locations is best accomplished when each location is given as much consideration as the next, each having been derived from the same survey and (presumably) being subject to the same error sources. Therefore, any evaluation that affords every location equal weight in the solution would be the most defensible. I know of no better tool for this than least squares. One *might* be able to extend that logic to averaging a line through a series of monuments known to have been set by the same surveyor at the same time. (However, because monuments are involved, the rule of construction is triggered and, at least in some states, the intermediate monuments enjoy a dignity equal to that of the terminal monuments – especially if they have been relied upon by those in the area as being on the boundary line. *Any* deviation from the monument itself, then, is incorrect.) In most retracements, though, tasks such as these form only a small part of the overall effort.

Simultaneous Evaluation

There has been some discussion in the national surveying press about the desirability of "simultaneously" evaluating boundary evidence. Somehow the lure of rigorous mathematical analyses is irresistible to surveyors uncomfortable with the historic methods and reasoning of retracement. Do not be fooled. The fundamental problem with the concept is that the emphasis centers on the mathematical data contained in the former surveys, whereas the courts place the *least* emphasis on that data. Beyond that, as we have seen, the actual process of weighting the lesser elements is far from a rigorous exercise. Because weighting elements can introduce large shifts in adjusted position, it follows that incorrect weighting would result in inappropriate results.

The courts do not care about least squares or simultaneous adjustments or fancy-schmancy computer programs. They merely demand retracement of the boundaries *where they have always been.* We would do well to remember that.