SUPER- VS. REASONABLE-ACCURACY IN MAP MAKING

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As General Hugh S. Johnson might say, "This is to be a talk about accuracy in map making!"

Undoubtedly many able topographers will disagree with the writer, and his ideas will appear rank heresy to conscientious souls who take their cartography or political opinions too seriously, but we are experienced in the fine art of dodging verbal brickbats and empty ink bottles, so here goes!

We will begin by asking a question that has never yet failed to start a good argument, to wit:

Of What Good is an Accurate Map, Anyway?

Before continuing with this diatribe or whatever it might turn out to be, let us define two expressions that we propose to make frequent use of: "super-accurate," in contradistinction to "reasonably-accurate."

By a super-accurate map, we refer to one that holds to a certain maximum tolerance of position at *all* points. By a reasonably-accurate map, on the other hand, we refer to one in which while certain important points *are* accurately spotted, we don't give a hang as to the precise position of the general topography so long as desired features are shown somewhere in the very nearly proper vicinity and in a relatively correct inter-feature relationship.

Now don't jump to hasty conclusions and do us wrong before we get the real argument started. Understand, we are in no manner presuming to advocate deliberately inaccurate, careless or slipshod work. Neither have we any fault to find in a super-accurate production, per se. What we are trying to get over is that for the life of things we cannot see why topographers in general should kid themselves into believing that it is good business to strive toward a very costly creation in the name of accuracy when a reasonably-accurate product would serve any practical purpose and be producible at far less cost.

Some time ago, we played a minor part in a fair-sized mapping conspiracy, and despite a continually growing disgust at conscientious but nevertheless ignorant bungling of what could have been a most interesting project, we were forced to stand by and see thousands of dollars frittered away in the name of "accuracy." With control galore, with very good aerial photographs covering the entire area and with apparatus and paraphernalia sufficient for the job, the project should have been fairly well completed within one year. But at the end of nearly one year and a half, the only apparent result of all labors seemed to be a few jigsaw puzzles in miscellaneous stages of completion. We had numerous sheets on which were very accurately spotted literally hundreds of accurately plotted control points. We had photographs on which we had cute little circles by the dozen in all colors of the rainbow (many of them carefully spotting images on photographs of wrongly identified or unlocatable objects on the ground). We had all kinds of so-called tilt analyses—but we had *no maps!*

We were then projected into another situation; one, however, that was handled in a more intelligent fashion. Some thirty odd topographical maps of prospective reservoir areas were needed and—needed in a hurry. We had little control, practically no equipment, and a miscellaneous collection of flight strips containing the choicest collection of tilted photographs, figure "S" patterns and varied overlaps that ever a topographer was called upon to work with. But with the assistance of a few out-of-date quadrangle sheets, one or two ten-cent store stereoscopes and an elaborate suspended pantograph (which for lack of space we could not utilize), we did produce *maps*—and this in the course of a very few weeks.

At the time of their first "publication," we would have hated to have had these sheets criticized by "experts." There would have been many errors, but despite these academic trivialities the following might be offered in our favor:

1. The streams we desired to show were shown.
2. The contours gave a very good indication of hills, valleys, and ravines.
3. The main roads, bridges, and railroads and other topographical features involved were indicated in at least a very close approximation to their true positions.
4. The cost was ridiculously low in comparison with the super-accurate affairs usually strived for in many instances.

Our original sheets were, of course, constantly under revision. As the work progressed and additional information trickled in from the various parties carrying out field surveys in the areas, errors of omission or commission were eliminated. The surprising feature was the general confirmation by these reports from the field of the cartographic work already completed.

Please do not misconstrue our motives! We have no quarrel with a continued striving toward the ultimate in accuracy which aims at a zero error at any place. We do feel, however, that this aim might better be confined more to the laboratory than to the average project office in the field of operations. New and better methods will continually be developed in such research laboratories and will ultimately find application in the field.

Inherent Sources of Error

In producing maps, let us remember that we are dealing with three inherent sources of error, namely: (1) a succession of processes, (2) a succession of variable mediums, (3) a succession of human beings, not necessarily of research ability or laboratory temperament but most of them interested in their topographical activities largely as the result of a peculiar combination of circumstances that impel them to labor, to eat, pay rent and meet the unavoidable time-payments due on the first of each month.

As a scientific achievement the production of a perfect map is a glorious goal. But we fear that the principal advantage gained would be the personal gratification it gave the artisan who contrived it.

As might be suspected, we are not declaiming against accuracy in general relative to the art of map-making. We are, on the contrary, strong for reasonable-accuracy. It is super-accuracy that we are questioning. Nor are we intentionally sticking our rhetorical neck out in a reckless manner. The term "reasonable-accuracy" is one susceptible of even wider range of interpretation than the elastic clause in the Constitution. We will, therefore, refrain from defining the term too closely, but if driven into a corner, our defense will be based on the assumption that the accuracy assumed to be reasonable has some vague relationship to the money available and the dead-line set for the production of the necessary or desired result.

If we are agreed that a super-accurate map is largely valuable as a work of art, let us ask of what value is a reasonably-accurate one—one not susceptible of accurate scaling measurements over its whole face within the assumed tolerance limits prescribed, but chock full of detailed information as to what is present and approximately where it is. Our answer is that many thousands of people may need and can use such maps with complete satisfaction.

The railroad time-table map is still a classic example of the map that, though glaringly inaccurate from the position standpoint, has brought immeasurable comfort to millions of travellers by assuring them that the road over which they are travelling is the shortest distance between them and their destination. The filling station handout, usually on the Rand and McNally or some similar projection and relatively inaccurate according to accepted geodetic standards, enables many hundreds of thousands to plan satisfactory motor trips and avoid long stretches of dirt, gravel, and macadam roads.

"Good" Maps

In the opinion of the great majority of map users who, incidently, are the ones who authorize the production and eventually pay the bills, a *good* map has the following characteristics:

1. It must show the information desired.
2. It must not be too complicated.
3. It must show familiar landmarks in proper conformation.
4. The edges of adjacent sheets must match.

There are probably some more factors but these are all we can think of at present.

As the result of many interviews with people who came to see us in regard to the topography of various areas or regions in which they were interested, we are firmly convinced that Mr. Average Map-user does not give a hang about the absolute correctness of positions so long as the relative locations are correct and familiar features are included. When Jonathan Marshmeadow comes in to get an idea of what the new dam is going to do to his farm, he has far more confidence in the engineering reputation of the office if the map we show him actually shows the creek in his cow-pasture with three bends and two branches. And, believe you me, you can see the country school teacher's face beam with admiration when she notes the two small square black dots that appear near the rear corners of the school-house lot.

We technical experts are too prone to forget that there is a legitimate difference between the theoretical and the practicable in all technical endeavor. This legitimate difference or tolerance differs with the occasion. In the machining of modern interchangeable automobile or other machine products, Johansen gauge-blocks may be necessary but when we are cutting cloth for a new suit it is hardly necessary to use a Brown and Sharp engine divided yard-stick and attempt to cut accurately to the one-hundredth part of an inch.

Some months ago, we gained considerable prestige from the publication of an article in one of the leading technical journals on "Correlating Ground and Air-Survey Methods," so much so, that among strangers we can sometimes pass as expert. With our immediate associates, however, the prestige of the magazine took a severe slump. At any rate, in this article we arbitrarily divided land areas into three general divisions, to wit:

1. Land of great value, or front-foot value, such as city lots, particularly in congested areas.

2. Land of moderate value, such as farm land at, let us say, from fifty to one hundred dollars an acre.

3. Land of little if any value, such as ordinary mountainous, prairie, desert, etc.

In regard to mapping these three classes of areas we are forced to the following conclusions, to wit:

1. Regardless of the accuracy obtainable and the time and care spent in preparation, no map can be of sufficient accuracy on which to measure such land from the standpoint of accurate land evaluations.

2. The cost of an accurate survey is so much greater as a rule than the value of a few feet or square yards more or less that only a reasonable degree of conformality is sufficient.

3. Costly effort to obtain aught but the most readily obtainable conformality is seldom justified.

Having no doubt succeeded by this time in stirring up a fairly good controversy or in meriting a well developed indignation on the part of the faithful, let us now revert to additional consideration of the term "accuracy."

Control Accuracy and Field Accuracy

In referring to cartographic matters, let us keep two other kinds of accuracy in mind. First, the accuracy involved in spotting important or *control* points in their proper grid relationship. Second, referring to the accuracy of location of all points within a given area taken as a whole. Let us for the want of better terms, refer to these respectively as "control accuracy" and "field accuracy."

We may perhaps gain a few converts at this point by admitting that so far as the former or *control accuracy* is concerned, we firmly subscribe to the best tenets of the profession. The basic grids should be drawn as carefully as possible and the principal control should be spotted with no less care. From this point on, a reasonable degree of *field accuracy* is all that should concern us.

We do not believe that an excessive amount of control is necessary. Three or four accurately spotted points at most for each square mile should be ample. Two or three for each ten square miles may be sufficient and two or three for each hundred square miles may be all that is necessary if the cost of locating more be excessive.

Let us term the area included within each triangle of control a differential field area. Naturally the smaller each differential area, the more nearly accurate will be measurements from bounding control points to any point within the area.

Stereoscopic plotting is an automatic approach to zero-error in this field accuracy. Stereoscopic plotting of large areas requires elaborate and costly apparatus and a highly trained personnel for its operation. Consequently, it is our contention that in all but exceptionally few cases, mapping from monoprojected photographs, without undue elaborate correction for image displacement due to moderate differences in elevation or photographic tilt (when a first-class outfit takes the pictures), is amply good for ninety-nine and a large fraction percent of the uses to which the resulting map will be put.

By mapping, we might also differentiate between "first maps" and "subsequent editions." By first maps, we refer to the initial compilation of an area to a large scale or to the mapping of an area for which no modern or reliable maps in the sense to which we refer exist. First maps are frequently of an emergency or preliminary value. Speed in production at comparatively low cost is usually the important criterion. Such maps are more often of value as inventories rather than as accurate scaling media, and for such, even the ordinary controlled photo mosaic or line maps traced directly from such mosaics are not to be despised. Often they prove of far greater value if available sooner than an accurate topographical map completed in the distant future.

In the matter of general map-making, we are also beginning to suspect that too much control is not only unnecessary but confusing.

We can regard a topographical map somewhat as we regard a portrait.

The principal quality of a good portrait is that it be a satisfactory likeness. The principal control points are the eyes, nose, mouth, and ears. These must be exactly located or the portrait becomes a caricature. After that, the exact position of each mole, wart, wrinkle, or dimple is not necessary as long as these secondary features are delineated in an approximately or relatively accurate location. So with topographic or large scale planimetric maps. The principal control points should be properly located but the inter-areas need only be "fudged" in and too much control makes it all the more difficult to "fudge" successfully. We must bear in mind that in this so-called "fudging process" the general error is compensating rather than cumulative in its nature.

As to the edges of the sheet. If one sheet is to match with another *it should match!*

We are, of course, speaking of maps of limited areas in more than one sheet, not regional or world maps drawn to comparatively small scale.

To ninety-nine percent of the persons using the completed maps, such technical niceties as converging meridians mean exactly nothing, but a map-sheet that does not match its neighbor is an exasperation. Consequently, as to the edge detail of adjacent sheets, "fudge," brother, "fudge," and Johnny Q. Map-user will think you a good fellow and be more liberal with his appropriations.

Machine Drawings and Maps

The familiar mechanical drawing of industry is, in many respects, a map.

We have seen beautiful design drawings of revolving doors, in-a-doors, humidors, and cuspidors, all carefully drawn to scale with elaborate drafting equipment, all carefully lettered. The original drawings were most carefully made on detail paper. These were then traced. The tracings were then blue-printed or otherwise carefully reproduced, and these carefully made and beautifully lettered reproductions were sent to the shops.

From these carefully prepared reproductions on which soon appear corrections in black, blue, or red pencil or blemishes in the form of sweat marks, oil, and tobacco juice, the craftsmen evolve the particular variety of door that the drawing calls for.

On the other hand, we recollect a master mechanic who evolved an intricate comparator to be used in accurately measuring the positions of star images at one of the country's leading observatories. For weeks we occasionally watched the progress of its construction. For sheer accuracy in its parts, particularly with regard to micrometer readings, it was an instrument to marvel at and its finish was a gem of the old-time instrument maker's art. Yet the only drawings for an instrument that would probably have cost between five and ten thousand dollars if produced commercially, were comparatively crude pencil sketches on several sheets of ordinary paper, some made with benefit of compasses and a couple of triangles but mostly drawn free-hand.

These two examples are, of course, extremes. They are intended to point no moral. The moral that we do wish to point, however, is that the important information on both the intricate drawings and the pencilled sketches was not scaled from the lines but taken from certain numbers usually found at the middle of a lightly drawn line with arrowheads at each end.

Why not take a leaf from the book of the machine draftsman and apply it to mapping? Owing to personal errors in original compilation and subsequent errors due to processing and instability in reproduction media, we do not believe that the map of any considerable area has yet been made on which we could assume that all distances shown could be scaled off to within the high degree of tolerance usually specified. Therefore, why waste time in kidding ourselves that our maps should be made to conform to such integral accuracy? Furthermore, the United States is not Switzerland, Italy, Afghanistan, or Baluchistan. Ours is a region of enormous extent and the money now available for mapping or likely to be made available in the near future can, we believe, be better and more wisely spent on doing a practical job that covers considerable territory, rather than on the beginning of an enormous laboratory experiment. If we are too particular in the matter of striving for needless accuracy, mapping costs will not only be excessive but existing maps will be hopelessly out-of-date in this ever developing nation before any general program will have been fairly started.

In the writer's opinion, the place for real absolute accuracy is not so much in the cartographic processes as in the realm of the surveyor. Relieved of the ornery details formerly connected with surveying, the ground crews can devote their main attention to the precise establishment of important control, leaving to the photogrammetrist the task of caring for the topographic details. Furthermore, we believe that the more extensive use of modern state-wide plane rectangular co-ordinates will eliminate undue fussiness in map compilations. If we can be content with producing reasonably accurate maps we can make more maps with less expenditure of effort, time, and money per square mile.

Plane Rectangular Co-ordinates and Mapping

In the very near future, we believe ordinary surveying will be universally carried on in an entirely different manner from the ordinary or independent local survey of the past. The advantages offered by the U. S. Coast and Geodetic Survey's Systems of plane co-ordinate plotting are too obvious to those who have taken the trouble to understand them. If the present crop of surveyors will not take the trouble to understand them, it will soon be displaced by the forthcoming generation who will! The importance to cartography of this transition is that all points on or tied into any traverse will in the near future augment or check existing control and tie in thousands of points within areas so surveyed with existing primary triangulation stations whose geographic positions are well established.

In other words, although the accurate positions of inter-control areas might not be accurately spotted, we will have their correct "addresses." These can be listed by the thousands, and distances between any two such points can easily and quickly be determined by simple right angle triangle relationships to within a few one-hundredths of a foot if desirable. Points on the map of sufficient importance may be accurately defined by a simple fraction at the far end of an arrow pointing to the spot, thus:

$$\cdot\!\leftarrow\frac{356.75}{427.52}$$

The terms refer to the "x" and "y" co-ordinates, the preceding figures being omitted but noted at the lower and left margins of the sheet. Thus the "427.52" would be the hundreds and lesser units of the whole co-ordinate which might be "y = 1,403,427.52," if expressed in its entirety.

By combining a *reasonably-accurate* map with such plane co-ordinate addresses for the points of special importance, we would obtain the advantages of a machine drawing with important dimensions shown accurately in plain figures.

Having no doubt laid the foundation for a first-class discussion, we will now retire to a safe distance and avoid the brick-bats.