Landbase Accuracy and Land Surveyors

Across the United States, the points, lines, and polygons that delineate rights-of-way and parcels within a GIS-powered landbase are at the heart of decisions that affect everything from planning to public safety—**by Coleen M. Johnson, RPLS, Jan Van Sickle, PLS, and Milton Denny, PLS**

—Images: http://gis.esri.com

Minimizing errors in the representation of these objects in public Geographic Information Systems (GIS) should be a high priority. But which errors are we talking about?

In his recent book *Thinking About GIS*, Roger Tomlinson, director of the Canada Geographic Information System, the first computerized GIS, identified "four types of error—referential, topological, relative, and absolute." The differences between these types of error are critical to any discussion of landbase accuracy.

An example of good referential accuracy, also known as "attribute accuracy," is having the correct address on the correct house in a landbase. An example of good topological accuracy is having the lines that go around a parcel end in the same place they started and forming a closed figure.

Deficient referential and topological accuracies can be enhanced by data cleanup, which involves improving attribute assignment, eliminating gaps and overlaps, and repairing dangling nodes and lines, undershoots, overshoots, and pseudo nodes, among other things. However, this cleanup work by itself does not address the other most important types of accuracy—relative and absolute accuracy.

Quantifying relative and absolute accuracy requires additional information. If a careful field measurement between two property corners matches the length of that line's representation in the landbase, the comparison reveals good relative accuracy within that area. If properly performed measurements are established at deflections along a right-of-way and they match the coordinates of those same deflections as represented in the landbase, their absolute accuracy is probably good

Of course both the field measurement work and the landbase must be on the same datum and in the same coordinate system for the comparisons to be valid. In other words, there is one definitive way to establish the relative and absolute accuracy of a landbase—by a careful comparison of the positions of points, lines, and polygons as they exist on the ground with the representation of those positions in the landbase. Achieving these accuracies requires field measurements and comparison, both of which are part of land surveyor's area of expertise. This expertise should be used in developing GIS-powered landbases.

A perfect example of an effective use of surveyors' expertise comes from Orange County, Florida. The reasons for utilizing field measurement in the County's landbase and how this improved its relative and absolute accuracy are described in Kevin Hardester's paper "Orange County Parcel Base Map Re-engineering Project."

The County experienced the same difficulties that most GIS development projects face. After the existing parcel sheets were digitized, it became clear that the resulting mapping did not tie to the real world; in many places there were inaccuracies of 200 feet and more. The County experts realized that to transform their current GIS into a spatially accurate GIS that could be fully utilized, the parcel layer would need to be re-engineered.

"The accuracy of the geometry and legal descriptions must be referenced to the geodetic control in order to validate the positional accuracy in the real world," wrote Hardester. "If this is not the case you will create a 'floating' map with relative accuracy, and that relative accuracy can vary greatly. If a GIS system is built on the 'floating' map concept, then any layer or theme that is developed, like land use or transportation, will have constant problems overlaying properly on top of each other since they are not based on the same geodetic foundation." In other words, the floating map that results has no definite spatial accuracy.

To remedy the situation, Orange County decided to "secure the services of a survey company to locate all of the section and quarter section control points and obtain state plane coordinates on those points for input into the GIS. The County Surveyor would act as the Property Appraiser's agent in coordinating with the survey firm and the Property Appraiser's GIS Manager. The Property Appraiser would have to hire eight contract-mapping personnel to create the re-engineered parcel data. The contract mappers would consist of two professional licensed surveyors, four cartographers, and two annotation or data entry personnel."

The inclusion of land surveyors on the team of professionals assigned to the re-engineering made sense; we suspect, it also greatly enhanced the project and contributed to its winning an award.

The Florida experience demonstrated that the section corners of the Public Land Survey System (PLSS) can provide a convenient grid on which to build the necessary surveying control for improving the spatial accuracy of landbases in the other 29 states where it exists. To wit, using the PLSS in Iowa's third largest county, Scott County, helped establish a highly accurate GIS-based landbase.

Describing the project in their article "Solid Foundation," Matt Sorensen and Adam Teale, PLS, wrote: "Despite the relatively large population and tax base, [Scott County] had an antiquated parcel mapping system based on hand-drawn tax maps and manual work flows. In 2002, the County started planning the development of a multi-purpose enterprise GIS to support county operations and the delivery of public information and services."

Field measurements tied to a GPS survey control network are now widely used across the U.S. to improve the spatial accuracy of landbases.

The participation of land surveyors is also a vital component of another practice that has been shown to tighten landbase accuracy even more specifically—the recording of digital plats. These instruments bring valuable field measurement to landbase reconciliation processes. Sorensen and Teale describe their effect on their work in Iowa

—An example of error when overlays, such as the orthophoto in this image, do not match the polygons of the parcel database

Just as Orange County had done, Scott County called on land surveyors to perform the survey-grade network of control as the basis of their landbase improvement. They prepared "A highly useful county-wide GPS survey control network of approximately 100 points tied to the Iowa High Accuracy Reference Network (HARN) established in 2005...", Sorensen and Teale reported. This was done because ". . . no matter how precisely you construct your parcel lines, if they aren't anchored using good control, you won't get the most out of your conversion efforts." Again, the involvement of land surveyors was critical.

this way: "With survey grade state plane coordinates on nearly 500 government section corners throughout the county, parcel conversion technicians can reference plats and surveys to the actual corners shown on the plats . . . and accurately map the original survey instruments into the GIS. . . [they] serve as highly accurate 'islands' within the larger parcel database and can be used to anchor or adjust adjacent properties. This creates a ripple effect, which improves positions well beyond the surveyed corner locations."

Michael Binge and Patrick Breshnahan describe this concept in their paper "What Should I Record My Survey." They are convinced that "even if a local government has maintained a relatively accurate base layer of parcels, importing digital surveys provides spatial accuracy that helps improve GIS with time. Some have called this concept the 'self-healing parcel map.' It accepts initial inaccuracies within the data layer and anticipates improved accuracy over time as survey references are added."

The products developed by a GIS professional are derived from record information obtained from a variety of sources, which represents the general location of man-made objects and natural features and record real property boundaries and their approximate relationships.

The GIS product does not represent the authoritative property boundaries and should not therefore be used for determining property rights and interests. Conversely, the products developed by a Professional Land Surveyor are the combined result of records research, field measurement, examination of junior–senior rights, boundary law, legal principals and the evaluation of each of these.

By education, experience, and examination, land surveyors are the experts when it comes to the interpretation and location of real property boundaries. Their work products can be leveraged to add substantial value to improving the relative as well as absolute spatial accuracies of land databases.

Guidance by land surveyors is sure to be most effective as the process of developing these databases gains momentum. Incorporating islands of highly accurate surveys into the framework of less accurate points, line, and polygons of the landbase is seldom a simple matter. As described by Hardester, "One of the most technically challenging aspects of the project is placing the subdivisions and parcel boundaries using state plane coordinates on geodetic reference points. It is one thing to write a separate legal description or to survey one lot or subdivision, with bearings, angles, and distances without regard as to the real world fit of that boundary into the larger map picture, and quite another challenge to accurately place that boundary into the larger map puzzle. Often there are overlaps and gaps that need to be reconciled. Decisions need to be made based on original intent, errors in legal descriptions, and insufficient or erroneous survey information. These decisions require good judgment and common sense together with the expertise in mapping real world parcel data."

Hardester's account of the work involved in building land databases, and its possible pitfalls, is an excellent summation of the reasons land surveyors spend their entire career building a knowledge base. It is these types of problems to which they are prepared to offer solutions. It makes sense to tap into that resource.

Let us now briefly turn to the other dataset that is widely used in improving the spatial accuracy of landbases—orthorectified imagery. Such imagery provides a background that is useful in acquisition of planimetric data. These data can support the placement of the points, lines, and polygons that comprise rights-of-way, parcels and other data in the landbase. However, their utility is dependent on the spatial accuracy of the orthorectification.

Accurate orthorectified imagery can be achieved by collecting photo-identifiable ground control points established by surveyors on the ground or by using GPS to establish the horizontal and vertical control points to be occupied and utilized in conjunction with airborne GPS techniques.

As we have seen, two out of the four components of landbase accuracy are decidedly spatial. It is prudent to improve those accuracies for the benefit of the local government as well as the public. Yet, while improving efficiency through the accurate registration of additional layers, it is important to address the misuse of data by various parties, including the general public.

The professionals involved in a GIS may be aware that the points in the landbase are not property corners, that the lines are not property boundaries, and that polygons are not the correct parcel areas, but the public often presumes that they are. A disclaimer statement should accompany the GIS product to define the developer's responsibility for the accuracy and content and to inform the general public of the product's intended use as well as its limitations.

Due diligence would seem reason enough to encourage the establishment of the maximum reasonable spatial accuracy in land databases. To minimize the consequences of misuse and other reasons, it would seem that the inclusion of land surveyors and the application of their unique expertise in the improvement of the spatial accuracy of landbases is not only a matter of cost effectiveness—it is in the public's best interest.

—Trimble R8 GNSS

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