GIS**Matters**

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Using the GCDB

Practical Applications of the Geographic Coordinate Database (GCDB) in GIS

The U.S. Department of Interior Bureau of Land Management manages the Geographic Coordinate Database (GCDB) as a representation of the Public Lands Survey System (PLSS) of the Western states. The purpose for creating the GCDB was to standardize an improved and consistent digital framework for the basis of cadastral data. The Western Governors Association passed a resolution in 2000 declaring the GCDB as the best representation of the PLSS, and urging its adoption by federal, state, local, tribal governments and others for use by the surveying, mapping, and GIS communities. This article explains some of the utility of the GCDB in GIS for cartographic and topologic purposes.

Information about the GCDB is available on the BLM's GCDB Home Page at *www.blm.gov/gcdb/* (**Figure 1**). From there you can search and download GCDB data for those areas where the GCDB is available. It is important to note that the GCDB is not a legal record of survey information, but rather a database inventory of estimated positions of PLSS corners, or coordinated points (see disclaimer in **Figure 2**). From the GCDB Home Page you can access documents describing the database design, history, collection process, standards, information on the GCDB spatial reliability, and the point identification schema.

The areas of GCDB availability are shown on a map interface (**Figure 3**) that also facilitates the download of the GCDB data in ESRI shapefile format or ASCII flat file format. To gain an understanding of the GCDB database design, see the BLM standards document: *www.blm.gov/gcdb/Standards/LSI-DDD-08-02-final.pdf*

The GCDB GIS files are suitable as a cartographic reference to show township, range and section lines, coordinated points (*e.g.,* quarter corners, meanders, etc.) and labels. Additionally, the lines, points, and polygons of the GCDB are used as the basis for geometry of other layers in GIS, surveying and mapping applications.

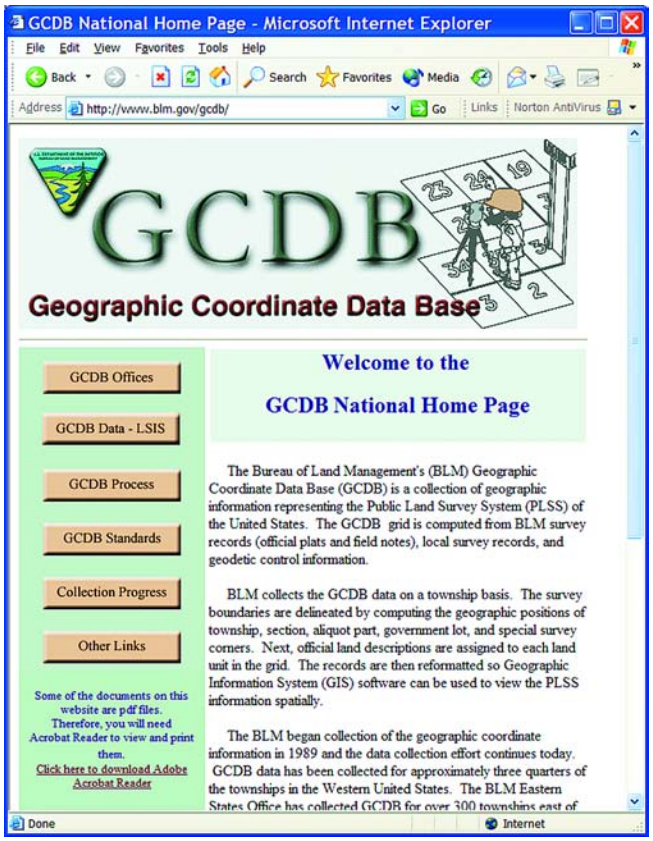


Figure 1 GCDB Home page

Cartographic Uses

The GCDB data set contains sufficient geometry and attribution for a variety of cartographic purposes. The data sets contain polygons for townships, polygons for sections, polygons for label descriptions (*e.g.*, NWNW), points for township, section, section-breakdown corners, and other points (**Figure 4**). The rich attribution of the GCDB data allows for a variety of labeling and cartographic options, although some of the labeling requires a bit of string manipulation to conform to standard output. For instance, to create a typical township label requires concatenating (linking) four different fields along with some additional text, as shown in **Figure 5**. However, the cartographic results are quite workable as can be seen in **Figure 6**. The township and section lines shown in Figure 6 were created from the two polygon files. In this case, only the boundaries of the section and township polygons are shown. The labeling is based on the township attributes of the township polygons, and the section attributes of the section polygons. In this particular instance, the GCDB data are stored in a geodatabase, which provides better speed as well as data integration. More on that later.

One cartographic product of interest to surveyors is the reliability diagram. One can generate a diagram of the reliability of the coordinates for each PLSS corner in the GCDB from the accuracy values in the COORD point file (coordinated points). The COORD point file has

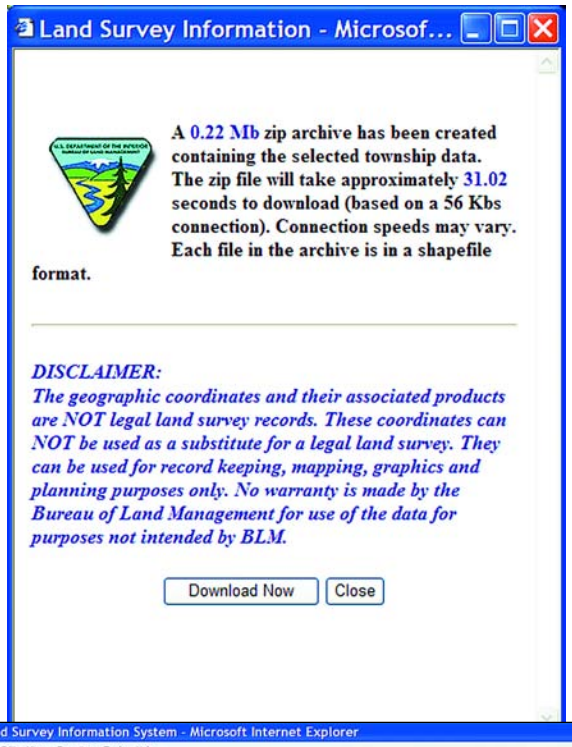


Figure 2 GCDB Disclaimer

survey data that went into creating the GCDB for any particular area. Some areas had ample survey control and good supporting survey data, while other areas had poor surveys and/or little survey control. Therefore, the results vary considerably. Anyone who is not satisfied with the accuracy of the GCDB in their area of interest can work with the BLM to reduce the magnitude of the errors. The BLM is drafting a process for improving the spatial accuracy of the GCDB using a combination of inputting existing survey data and acquiring new survey control. This process will be more fully described in a later issue. The overall horizontal reliability of the coordinate can be calculated from X and Y error estimate vales, and then symbolized, such as shown in Figure 7. In Figure 7, the size of the dot is related to the magnitude of the estimated error–the larger the dot, the greater the error. The numbers next to the dot represent the magnitude of the estimated error in feet. Figure 7 is a quick and straightforward characterization of the distribution of error across this particular township. Perhaps more useful is to calculate the reliability of entire sections of lines between points in order to help understand the spatial distribution of the errors. Such calculation and conflation of values from the point geometry to the polygon geometry requires some GIS analysis work and a little computer programming. Nevertheless, it is useful when viewing the reliability from the perspective of polygon geometry, such as the reliability of parcel boundaries based on GCDB.

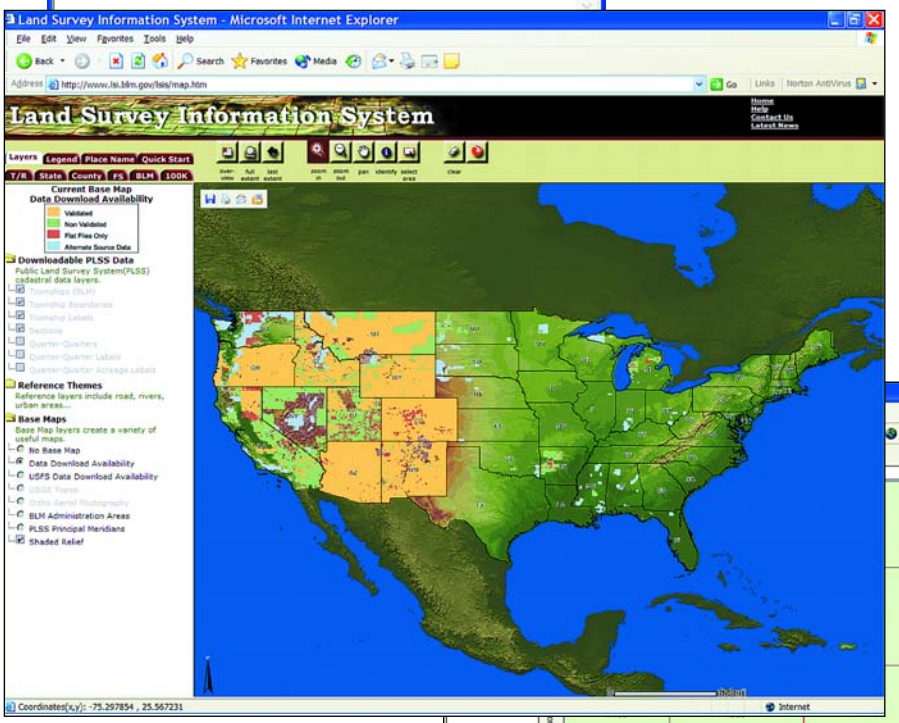


Figure 3 GCDB coverage for downloadable PLSS data

Topologic Uses

The greatest value of the GCDB is as a basis for other GIS layers, such as land ownership boundaries, government unit boundaries, fire, conservation, or school districts or others. Again, the reasons for using the GCDB are to standardize on a common PLSS and to improve the spatial accuracy of the PLSS representation. New accuracy fields for the X component and the Y component of the horizontal accuracy of the coordinates for each point. The values given are in feet. Typical errors are around 40 feet, but as shown in the **Figure 7**, larger errors are also possible. The magnitude of the errors is a function of the amount and quality of control and

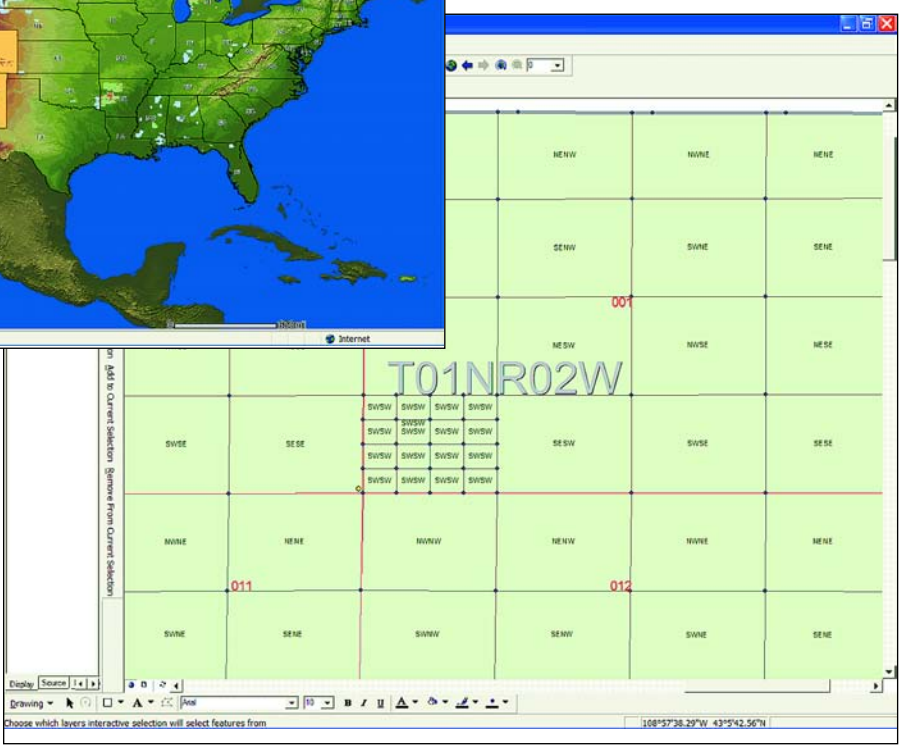
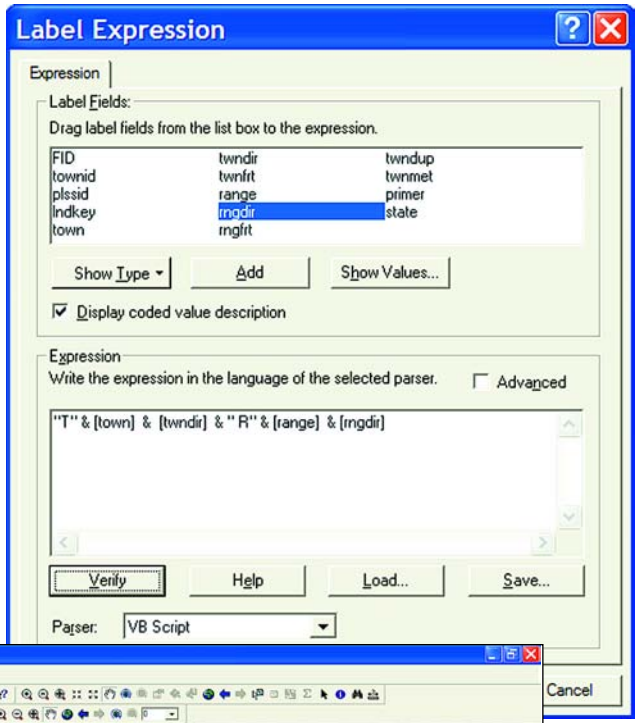


Figure 4 GCDB elements and attributes

GIS data that is based on the GCDB framework should better align with other GIS layers from other sources. In addition, existing GIS data can be adjusted to fit the GCDB.

Topology, which defines the relationships between GIS layers, is generated by storing GIS layers in a geodatabase, then establishing the relationships between layers. The GCDB data design supports topology. In the PLSS states, legal descriptions for properties–public or private, as well as government and non-government agency boundaries–are based on the PLSS. In addition to federal lands (*e.g.*, U.S. Forest Service), fire districts, school districts, county boundaries, and a variety of administrative boundaries such as census tracts and voting precincts, all have some elements of the Public Lands Survey System in their legal descriptions. Thus, these legal descriptions have a topological relationship with the GCDB. That is, the lines of legal descriptions should coincide with the lines of the townships and the lines of the sections or parts of sections. One can build a GIS layer from such legal descriptions by snapping the lines to the coordinated points of the GCDB.

Figure 5 Formatting the township string for labels



Generating the topological relationships between the GCDB and *existing* GIS layers is a bit more problematic and can be a tedious undertaking. In order to make an existing boundary (such as a fire district boundary) conform to the GCDB, the existing geometry must be edited to make the vertices of the existing boundary snap to the GCDB (coordinated points or vertices of the section or township polygons). Alternatively, some of the snapping may be automated through the construction of a topological relationship between the layers of the GCDB and the boundary layer. However, the results from an automated topological process, where a search radius is generalized for the entire dataset, can yield unpredictable results, so this must be done with care.

The GCDB is a work in progress, and surveyors are helping to make the GCDB a reality, whether by developing the GCDB or improving it. The GCDB development and maintenance is a cooperative effort that benefits the entire surveying, mapping, and GIS community. Adopting the GCDB as your PLSS standard, is a step toward data integration and enhanced data sharing.

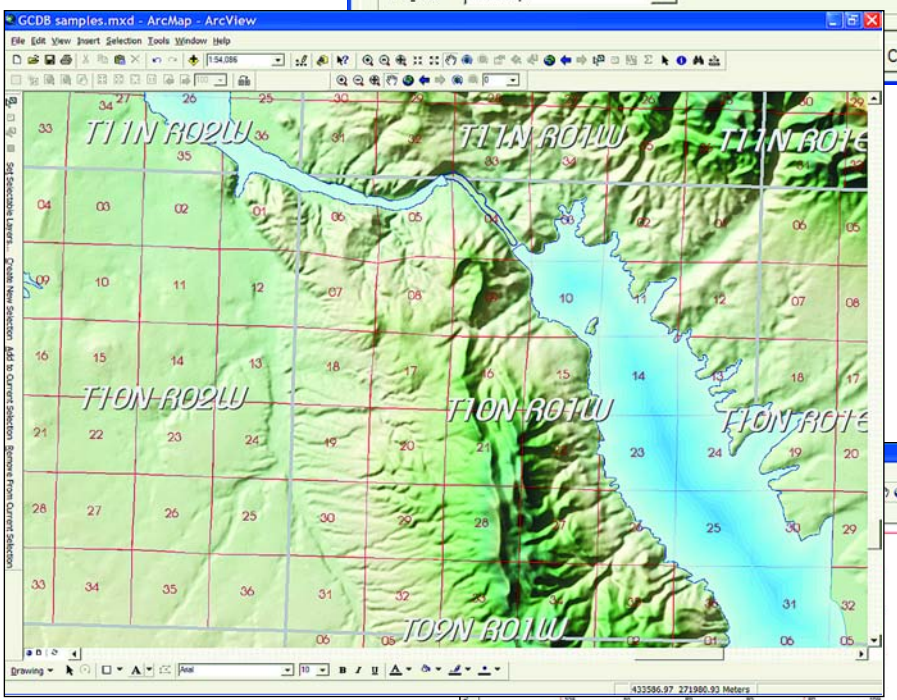


Figure 6 Cartography example

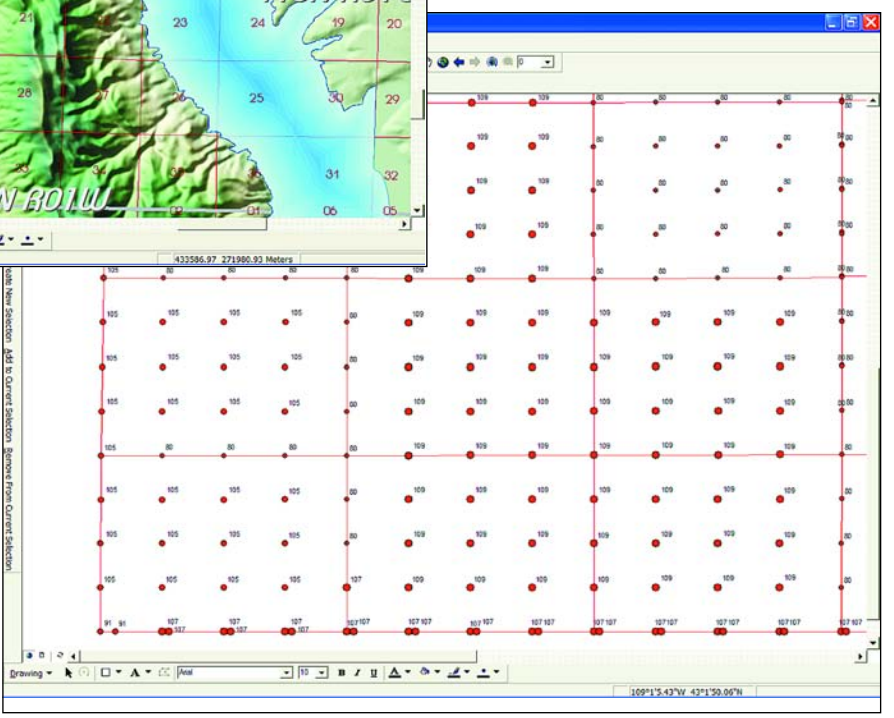


Figure 7 Reliability of coordinates