

The Dilemma at the Border

Registering Vector Data Across Datums

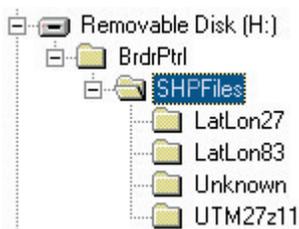
By Mike Price, ESRI

As I work with GIS professionals in earth science, natural resources, public safety, and other fields in the United States and around the world, one of the most common and disconcerting complaints that I hear is “My data is not quite lining up! It is off by just a few meters.”

Data mismatch can stem from many factors including incompatible projections, inconsistent map units, and different plotting scales. Differences in the relative age of data sets may mean differences in data collection methods and accuracy. The improper application of a datum to a data set is an increasingly common and very important cause of data alignment problems.

Datum issues are some of the least understood and most troublesome reasons why data sets may not align properly. Datum differences in geographic or projected space are often not identified until significant problems arise that require considerable money and effort to resolve.

This tutorial will familiarize GIS professionals with the importance of datums and demonstrate methods for identifying and fixing datum differences. An accompanying article “Datums—Who Needs 'Em Anyway?” provides an overview of datum development and use. Coincidentally, while researching this article, I received a request for assistance from the El Centro Sector office of the United States Border Patrol. Two similar sets of street data, one from the El Centro Sector office and another from the San Diego Sector office, were not aligning. Data in different datums proved

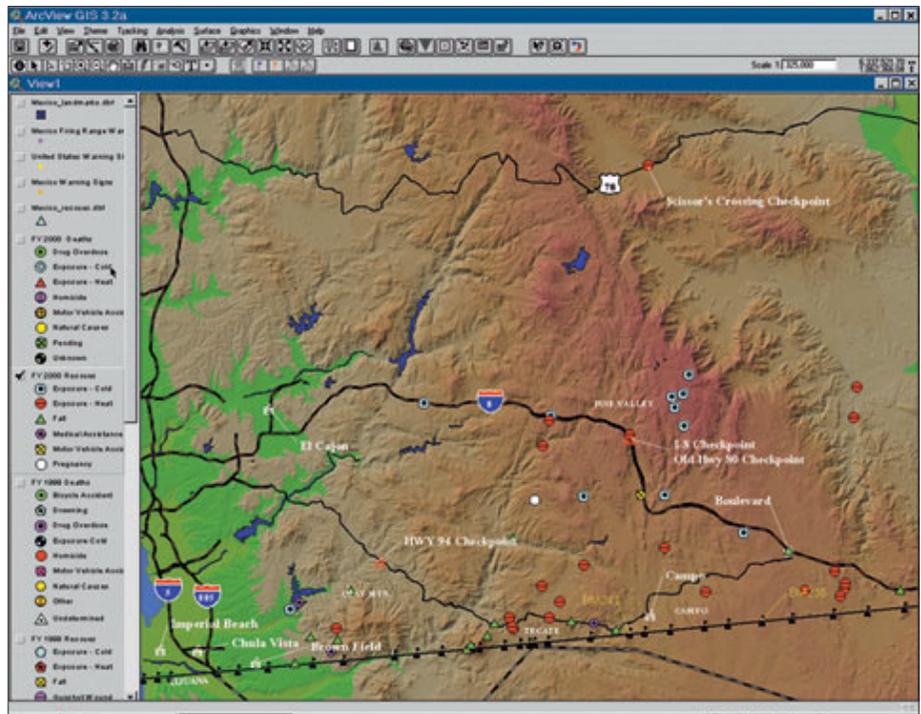


Create a directory structure to organize files.

to be the source of the problem. The El Centro Sector street data was built using the North American Datum of 1927 (NAD27) while the San Diego Sector uses street centerline data created using North American Datum of 1983 (NAD83). These offices have generously allowed me to use their data.

Setting Up the Project Environment

In this exercise, we will manage and use data registered in several projected coordinate sys-



The U.S. Border Patrol uses GIS to assist with rescue efforts.

tems including two data sets in unknown coordinate systems. Creating a data framework to manage different data sets is important. Before downloading, copying, or unzipping any files, set up the following directory structure.

1. Open Windows Explorer and create a directory named BrdrPtrl at or near the root directory on your hard drive.
2. Under this directory, create a subdirectory named SHPFiles. Inside of SHPFiles, create four subdirectories named LatLon27, LatLon83, Unknown, and UTM27z11.
3. Download sample data from the ArcUser Online Web site and place the files in the subdirectories as shown in Figure 1.

Folder	Files
Unknown	Street10.* and Street2k.*
UTM27z11	Usqs100k.*
LatLon83	clippol1.*

Figure 1: Locating data files in folders

ArcView GIS and ArcInfo 8 ship with a five CD-ROM data set called *ESRI Data & Maps*. For this exercise, make sure you have the 1999, not the 1998, version of this set. The needed files are located on Disc 3, “Western United States (by State).” These files are also available as a separate self-extracting zipped

file on the ArcUser Online Web site accompanying the online version of this article. These files contain 1:100,000-scale data describing roads in the State of California. If you are using the data from the CD-ROM, navigate to the westusa\ca folder and locate seven files with a “cards” prefix that make up this data set. If you are using the downloaded data set, simply extract the files into the UTM27z11 subdirectory previously created.

In addition to the familiar .shp (shape), .shx (shape index), and .dbf (dBASE) files, this data set contains .avl (legend), .sbn (spatial bin), .sbx (spatial bin index), and .prj (projection data) files. Left click cards.prj to select it. This file contains projection information for the California roads data. Projection information is provided for all data sets on the 1999 version of *ESRI Data & Maps* CD-ROMs.

To view the projection information contained in cards.prj, hold down the Shift key and right click on the file name to bring up a context menu. Select Open With from the menu list, scroll down and select WordPad, and click OK. Stretch the WordPad window across the screen. The new one-line projection file format shown below is used by the ArcView Projection Utility and ArcInfo 8 and contains information on projection, datum, spheroid, prime meridian, units of measure, and y-shift.

View	New Name
View 1	1. Unknown Projection, Datum
View 2	2. Lat Long NAD83
View 3	3. Lat Long NAD27
View 4	4. UTM NAD27 Zone 11

Figure 2: Naming Views

View	Shapefile	Data Location or Source
1. Unknown Projection, Datum	Street10	\BrdrPtrl\SHPPfiles\Unknown
1. Unknown Projection, Datum	Street2k	\BrdrPtrl\SHPPfiles\Unknown
2. Lat Long NAD83	Clippol1	\BrdrPtrl\SHPPfiles\LatLon83
2. Lat Long NAD83	Cards	Data CD in \Westusa\ca
4. UTM NAD27 Zone 11	usgs100k	\ BrdrPtrl\SHPPfiles\UTM27z11

Figure 3: Load Themes into View

```
GEOGCS["GCS_North_American_1983",
DATUM["D_North_American_1983",SPHEROID
["GRS_1980",6378137,298.257222101]],
PRIMEM["Greenwich",0],
UNIT["Degree",0.0174532
925199433]]
```

This file confirms that the California roads data is stored in geographic coordinates (latitude/longitude) using NAD83. If you are using the data from the CD-ROM, it is not necessary to copy this file, but if you are using the downloaded version, place this file in the LatLon83 folder.

Setting Up the Project

With the data organized, the next step is to create a new ArcView GIS project with four views. Start ArcView GIS, create four new views, and choose View > Properties to rename them with the names shown in Figure 2. Choose Windows > Tile to tile four empty views in the ArcView GIS window.

Load shapefile data into three of the views as shown in Figure 3. Don't worry about loading data in 3. Lat Long NAD27 yet. In 2. Lat Long NAD83, turn on the Clippol1 theme and zoom in on the El Centro, California, area. Turn on the cards.shp theme. Because a legend (.avl) file called cards.avl was saved in the same location, a prebuilt legend for cards.shp will automatically be applied. Now is a great time to do some project housekeeping. Choose File > Set Working Directory and set the default data path to \BrdrPtrl\SHPPfiles. Name the project Border01 and save it in the BrdrPtrl folder.

Understanding Our Data

Select 1. Unknown Projection, Datum. To keep the screen proportioned for this project, use

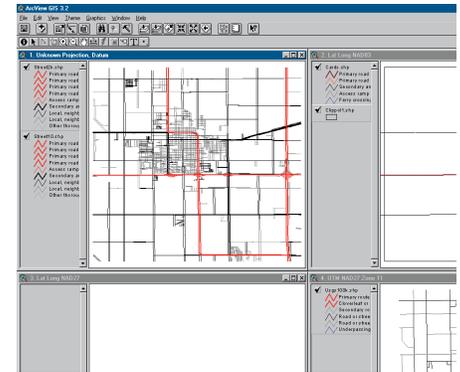
the maximize button to expand the view so that it fills the screen. Choose View > Properties and verify that map units are set to decimal degrees and distance units are in meters. Double click on the Street2k theme in the legend. Use the Legend Editor to change the legend to a unique value color scheme that contrasts with the colors in the prebuilt legend for the Street10 theme.

Take a careful look at the Street10 and Street2k themes. Even at a scale of 1:100,000 there are significant differences between these two shapefiles. Zoom both themes so that downtown El Centro is at a 1:5,000 scale. Locate the same feature in both themes and use the Measure tool to determine the east-west offset between the two data sets. This offset should be approximately 77 meters or about one-half of a city block. This is just what the El Centro Border Patrol GIS analysts saw—a data offset caused by the application of two different datums. The Border Patrol needed to merge these data sets and map at parcel level scale so a discrepancy this large was unacceptable.

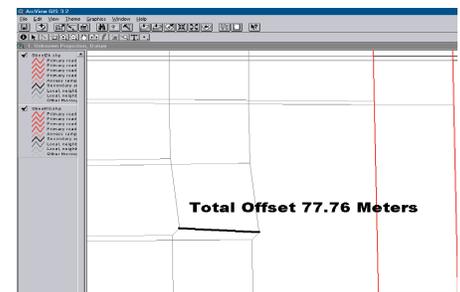
To determine the datum for the Street10 and Street2k data, let's compare these data sets with data in a known projected coordinate system. Copy the Street10 and Street2k theme from 1. Unknown Projection, Datum to 2. Lat Long NAD83. Select both themes and use Edit > Copy Themes, make the 2. Lat Long NAD83 view active, and choose Edit > Paste to add both themes to the 2. Lat Long NAD83 view.

This view already contains the ESRI sample data for this area that is registered in geographic coordinates in NAD83. Turn the Street10 and Street2k themes on and off individually and change the scale by zooming out to 1:100,000 and into 1:24,000. Notice that the Street10

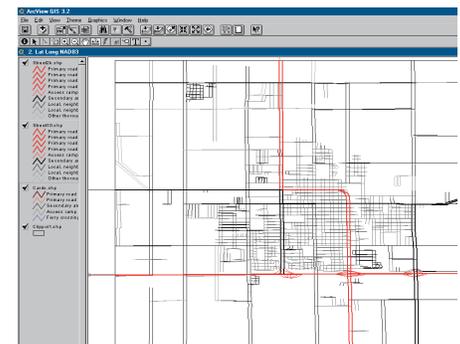
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Choose Windows > Tile to tile four empty views in the ArcView GIS window then add themes to first, second, and fourth view.



Using the measuring tool reveals that the two themes are about 77 meters offset from each other.



While Street10 theme aligns quite well with Card.shp, the Street2k theme shows a half block east-west offset. Do not stare at this for too long—it can be very hard on your eyes!

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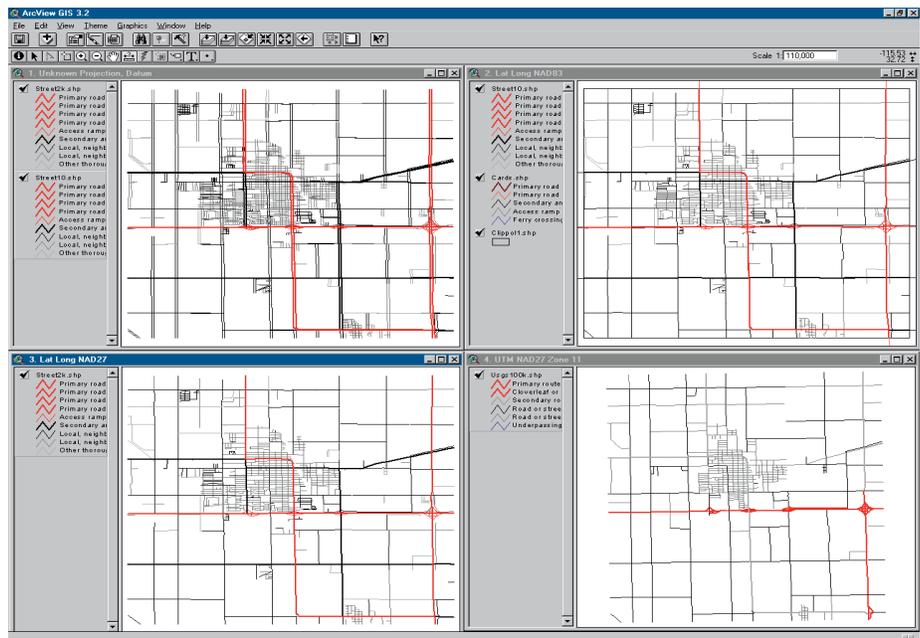
theme aligns quite well with the known set, Card.shp, while the Street2k theme shows a half block east-west offset. Do not stare at this for too long—it can be very hard on your eyes!

After viewing these themes at both 1:100,000 to 1:24,000 scales, you can reasonably conclude that the Street10 data is registered in geographic NAD83 space, while Street2k is not. Since the Street10 data has been identified as being in geographic NAD83, use Windows Explorer to save the Street10 files in the \LatLon83 directory as Street10. Determining the datum of Street2k will require a little detective work. Some ways for finding out projection and datum information might include reading a metadata file or calling the data provider. After learning that Street2k is an older data set registered in geographic NAD27 space, there are two choices—order a replacement data set in NAD83 or use the ArcView Projection Utility to reregister the data in NAD83. Before reprojecting this data set, use Edit > Cut Themes to remove the Street2k theme from 2. Lat Long NAD83 and use Edit > Paste to add it to 3. Lat Long NAD27.

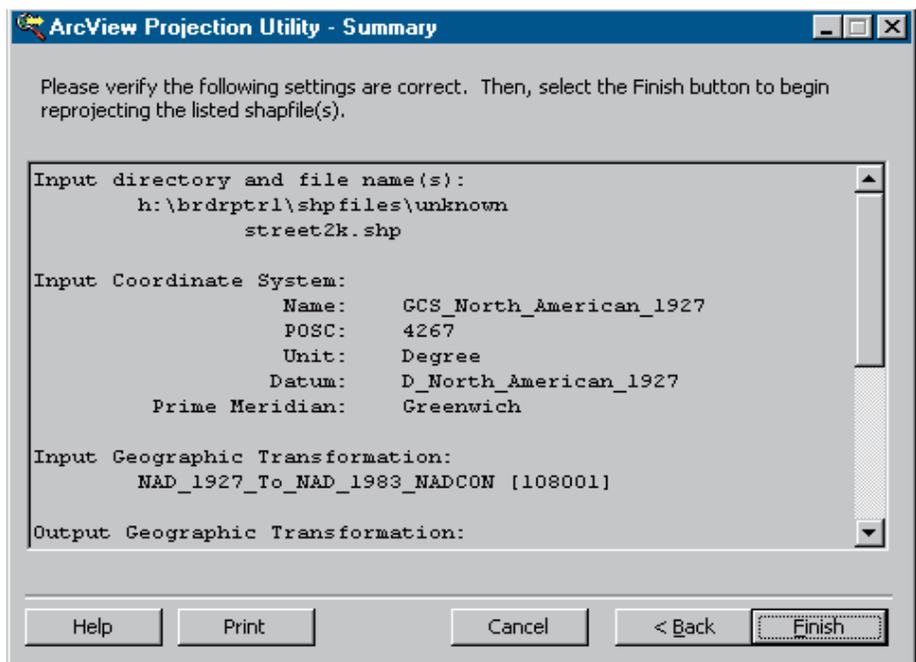
Reregistering with the ArcView Projection Utility

The ArcView Projection Utility will be used to associate the Street2k theme with the NAD83 datum.

1. Choose File > Extensions to load the Projection Utility Wizard extension. Start the Projection Utility by choosing File > ArcView Projection Utility and wait as it loads.
2. In the Projection Wizard, select Street2k as the shapefile to reregister. Notice that the coordinate system shown for this data is unknown because there is no projection (.prj) file for this data set. One will be created soon.
3. Click the Next button to go to Step 2. In the Step 2 panel, check the Show Advanced Options box to display four tabs—Name, Parameters, Datum, and Ellipsoid. Click on the Name tab and verify that the ArcView Projection Utility has recognized Street2k as being in GCS-NORTH_AMERICAN_1927 [4267] and that units are set to degrees. To specify a new datum for Street2k, click on the Datum tab and choose select NAD27_to_NAD83_NADCON as the Geographic Transformation type. Click Next to continue. A dialog asks if you want to save this new coordinate system information. Click Yes to create a projection file and store it in the Unknown directory.



Street2k is an older data set registered in geographic NAD27. Before reprojecting this data set, cut it from 2. Lat Long NAD83 and paste to 3. Lat Long NAD27.

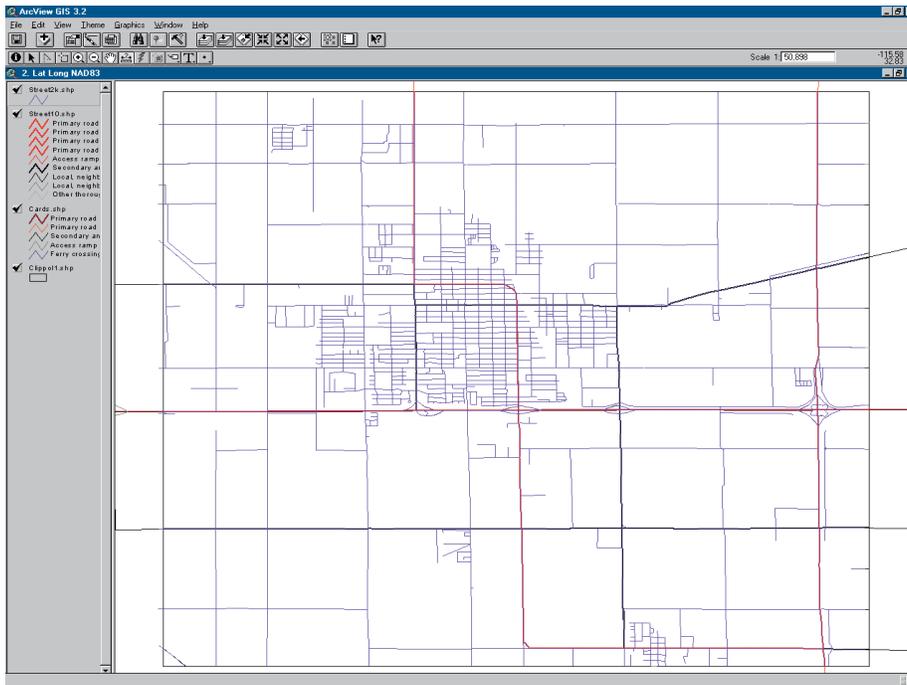


After reprojecting Street2K, inspect the summary page and verify that the parameters are correct.

4. In Step 3, choose Geographic as coordinate system type and select GCS_NORTH_American_1983 [4269] as the Name and Degrees [9102] as the units. The datum transformation rules are set, so click Next to continue.
5. Step 4 asks for a location for the reregistered data. Save the new shapefile to the \SHPFiles\LatLon83 directory and name

it Street2k. The same name can be used because the new shapefile will be stored in a different directory. Click Save, then Next to continue.

6. Review the Projection Utility Summary. Verify that the input geographic transformation and the new file name and location are correct. If not, use the Back button to move back through the process



If correctly registered, the newly reprojected Street2k theme should sit right on top of Street10 in 2. Lat Long NAD83.

and fix any errors. Print this page and save it for future reference.

7. When everything is correct, click Finish to complete the process. When finished, ArcView GIS will ask if you want to add the new data to a view. Click Yes and navigate to SHPFiles\LatLon83 subdirectory, select the Street2k theme and add it to 2. Lat Long NAD83 view.
8. Maximize 2. Lat Long NAD83 and notice that the new Street2k shapefile is turned off, on top of the Table of Contents, and its legend is a Single Symbol type. Double click on the Street2k theme and use the Legend Editor to choose a color that contrasts with the Street10 theme streets. Turn the Street2k theme on.

If correctly registered, Street2k should sit right on top of Street10 in 2. Lat Long NAD83. Zoom in and see how these themes align now. Your boss at the Border Patrol is sure to be pleased with your results—the Street10 and Street2k data sets are now registered in the same datum.

A Bigger Challenge

Now for the data loaded in the 4. UTM NAD27, Zone 11 view. This data is from the United States Geological Survey (USGS) EROS Web site and includes 1:100,000-scale digital line graph (DLG) roads data registered in a Universal Transverse Mercator (UTM), a nongeographic space, using NAD27. Your mission is to get this data to line up with themes in the 2. Lat Long NAD83 view. Try this one when you have plenty of time to con-

centrate.

Here is a hint: Reproject the usgs100k theme to geographic coordinates in NAD27 and add it to the 3. Lat Long NAD27 view. Reregister the geographic NAD27 data to geographic NAD 83 in the 2. Lat Long NAD83 view. If you do this correctly, you should see a close, though not exact, alignment of both Street themes and the USGS DLG roads theme. If you do this, you are a true Projection and Datum Wizard. **AW**

Summary

Once the Border Patrol El Centro Sector office realized the two Street data sets were built using two different datums, they obtained a NAD83 data set to replace the one in NAD27. As GIS users become more sophisticated and use data from a variety of sources, differences in data set datums will become more of an issue. With a better understanding of datum and projection issues, you can identify and correct issues caused by something as small as “just a few meters.”