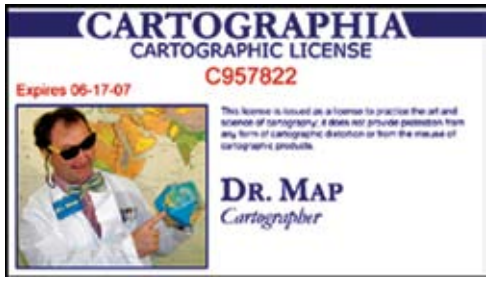
Ask Dr. Map!

Lost in Space



Dear Dr. Map:

Q: In your recent discussion (*ACSM Bulletin* no. 225), I have a significant quibble with the statement that State Plane Coordinates are based on the Clarke 1866 ellipsoid. The Clarke 1866 ellipsoid was certainly the basis for the original SPCS, but the National Geodetic Survey updated the SPCS equations and tables for the NAD 83 readjustment at least two decades ago. All the constants and conversion inputs are different as they are now based on the GRS 80 ellipsoid, and, to ensure no confusion between SPCs based on NAD 27 and NAD 83, the National Geodetic Survey switched coordinate values to meters rather than feet, and also changed the false northings and eastings at the origins to different values.

A: You are indeed correct, and I have referred Dr. Map to a great source of information on SPCS by David Doyle (*Professional Surveyor*, vol. 24, no. 1, online at: http://www.profsurv.com/archive.php?issue=84&article=1180). While the adoption of NAD 83 and the change to a metric SPCS was a massive improvement, it did not however eliminate the enormous number of existing printed NAD 27 maps, especially the 1:24,000 USGS topographic series, all now immortalized as Digital Raster Graphics and used in everything from GPS hiking software to GIS. To quote the U.S. Geological Survey, "A digital raster graphic (DRG) is a scanned image of a USGS standard series topographic map, including all map collar information. The image inside the map neatline is geo-referenced to the surface of the Earth and fit to the Universal Transverse Mercator projection." The DRG program from 1995 to 1998 scanned some 60,000 USGS maps, using copies of the published paper maps. Although many areas have since been updated, it will be decades before all show NAD 83 and the new SPCS. So while geodesists and surveyors can enjoy the merits of the updated SPCS, GPS users and GIS practitioners often have to reconcile the differences. Those differences are most problematic at zone edges. I stand by my statement that they are full of "mind-boggling contradictions and idiosyncrasies."

Q: In the same article (*ACSM Bulletin* no. 225), many of the projection exceptions you cited no longer apply. Doyle (see citation above) says that the only exceptions to the use of Lambert and Transverse Mercator projections based on SPCS 83 are the Alaska panhandle (Oblique Mercator projection), American Samoa (Lambert Conformal Conic with a single standard parallel), and Guam (Azimuthal Equidistant projection). Both the Lambert and TM use secant projection surfaces in SPCS 83.

A: True, again, that the idiosyncrasies mentioned are specific to the NAD 27 version of SPCS, and some were eliminated by the change to NAD 83 SPC. There were several significant changes to SPCS from NAD 27 to NAD 83. For example: California Zone 7 (Los Angeles County) was included in CA Zone 5; Michigan moved from TM to Lambert; Montana eliminated three zones in favor of a single statewide zone; Nebraska, South Carolina, Puerto Rico, and the Virgin Islands eliminated two zones in favor of single zone systems; and American Samoa and Guam are not defined in NAD 83 SPC. David Doyle commented by e-mail: "Considering the size of the country, I find there are really very few such contradictions and idiosyncrasies. The vast majority of the country is provided a system of coordinates that, once learned, can be carried in concept from state-to-state with only minor differences." Dr. Map wonders whether a single, accurate and easily understandable single grid system, such as the U.S. National Grid (see http://www.fgdc.gov/usng/index.html) or some other system, perhaps even global in scope, might not be superior.

Q: Finally, and most egregiously, your article mentions (*ACSM Bulletin* No. 225) that states elongated North-South use the Lambert projection and those aligned East-West use the Transverse Mercator. Dr. Dean's tutorial actually has it correctly stated, and it is just the opposite! I greatly enjoy your column in each issue, but your "cartographic license" needs an occasional edit!

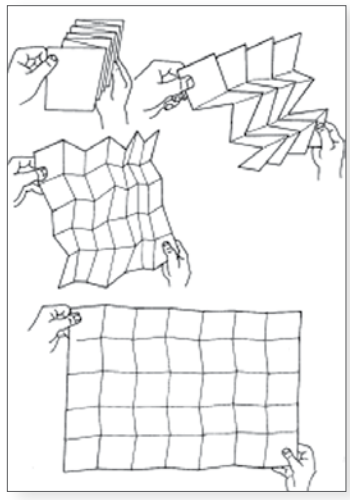
A: Dr. Map is very fond of on-line maps, especially when they are clickable. See http://www.vterrain.org/Projections/spcs.html for a first rate map of the USA, with SPC zones within states clickable. Another is at http://home.comcast.net/~rickking04/gis/spc.htm. Quoting Dr. Dean (again, see above), "State plane zones whose long axis run north-to-south are mapped using a Transverse Mercator projection, but unlike the Transverse Mercator projection used in the UTM system, the State Plane system uses a Transverse Mercator projection that is tangent, not secant. State plane zones whose long axis runs east-to-west are mapped using a Lambert Conformal pro-

jection" (my emphasis). Doing as Dr. Dean advises and clicking on a couple of states, I got the following two state maps (Ohio-wider than high, and Arizona-higher than wide). As can be seen, Ohio has two zones (North and South) extending east-west across the state, while Arizona has three zones (West, Central and East), extending north-south across the state. The Ohio zones have a long axis running east-west, so Ohio should be a Lambert state, while Arizona's zones run north-south, so we would expect transverse Mercator.

Dr. Map quotes from Arizona Revised Statures, Title 33, Chapter 1, Article 3. B. "For the purpose of more precisely defining the Arizona coordinate system, the following definitions of the National Geodetic Survey are adopted: 1. The Arizona coordinate system, 1983, west zone, is a transverse Mercator projection of the North American datum, 1983, having a central meridian 113 º 45' 00" west of Greenwich, on which meridian the scale is set one part in fifteen thousand too small. The origin of the coordinates is at the intersection of the meridian 113 º 45' 00" west of Greenwich and the parallel of 31 º 00' 00" north latitude. This origin is given the coordinates of "X" equals seven hundred thousand feet and "Y" equals zero feet." And sure to follow, Ohio does indeed use the Lambert Conformal Conic. Just to confirm this, Snyder's classic *Map Projections—A Working Manual*, on page 52, lists Arizona as "transverse Mercator" and Ohio as "Lambert." In my answer to the previous question about SPCS, I stated: "States elongated from East to West, such as New York, have zones running North-South, so use a transverse Mercator projection, which minimizes error along a N-S meridian. States that are elongated from North to South, such as California, use a Lambert conformal conic projection." Using Snyder p. 52 as the source, California is a Lambert state, and New York is a transverse Mercator state (OK, except for Long Island). This is because California is elongated North-South (and so has East-West elongated zones, better mapped on a Lambert Conformal Conic), while New York is wider East-West, so divides into zones elongated North-South, better shown on a transverse Mercator. So I believe that makes both Dr. Dean and Dr. Map egregiously correct. I will indeed be editing that Cartographic License, but merely to update it (observant readers will note that it expired on 6-17-07).

Now back to those contradictions and idiosyncrasies. Why is Long Island an exception? Why does the Arizona State Statute give an origin point in feet, not meters? Why 1 part in 15,000? And why is Gila County in the Eastern Zone, when clearly most of the county falls in the central zone? And did Michigan actually change its shape in 1983?

Q: Why are paper maps so hard to re-fold correctly?



A: Maps are hard to re-fold because the folds are made along printed gridlines of the State Plane Coordinate system, which has many contradictions and idiosyncrasies. These combine with fractal geometry and paper-fold mechanics to stretch the paper, making it too large to get back into the original form. An alternative theory is that maps actually "cook" while in glove compartments due to auto engine heat, drying and shrinking them, and so making them too small for their folds. There is also the theory, popular in Michigan, that maps change shape every century or so when their grid system updates, distorting and wrinkling the paper. [Image source: http://roger.kaywa.ch. Note the grid lines and folds.]

Got a question for Dr. Map? Send it to ask-drmap@cox.net