

Part 1: The Basics

Practical geodesy

In the series on satellite navigation the importance of the geodetic parameters was briefly discussed. They play a crucial role not only in positioning, but in cartography (and therefore GIS) as well. The geodetic knowledge within most organizations seems to be at two distinct levels. First there is a highly abstract level, with geodesy and geodetic calculations being practiced by the 'true' geodesist. On the other hand there is the GIS specialist or surveyor who is responsible for production and is led by the information given by the supplier.

By Huibert-Jan Lekkerkerk



Mercator was the first to invent a projection that provided a mathematical means to project the globe onto a flat surface. (Source: www.georgetown.edu).

can use simple, high school mathematics for calculating direction and distance.

It has been known for a long time that the representation of reality by a level and rectangular surface is only an approximation of reality. Every land surveyor takes this into account when performing a level survey. The surveyor reduces the maximum measurement distance to 200 meters in order to minimize the effect of the curvature of the earth.

Reality

Until deep into the Middle Ages, reality according to the Catholic Church was that the earth was flat. How simple the life of surveyor and cartographer must have been. This ideal was however ruined by two men, a certain Copernicus and Galileo, who were adamant that the earth was not flat but, instead, a globe. Nothing new under the sun however: the ancient Greeks already knew this.

And even the globe is nothing more than a representation of reality. Maybe a potato is a better approximation, an oval with dents and bulges over its entire surface. It is obvious that performing calculations on this potato, or geoid as it is called, is not so easy. Therefore the geoid was soon simplified into a more mathematical model, the ellipsoid.

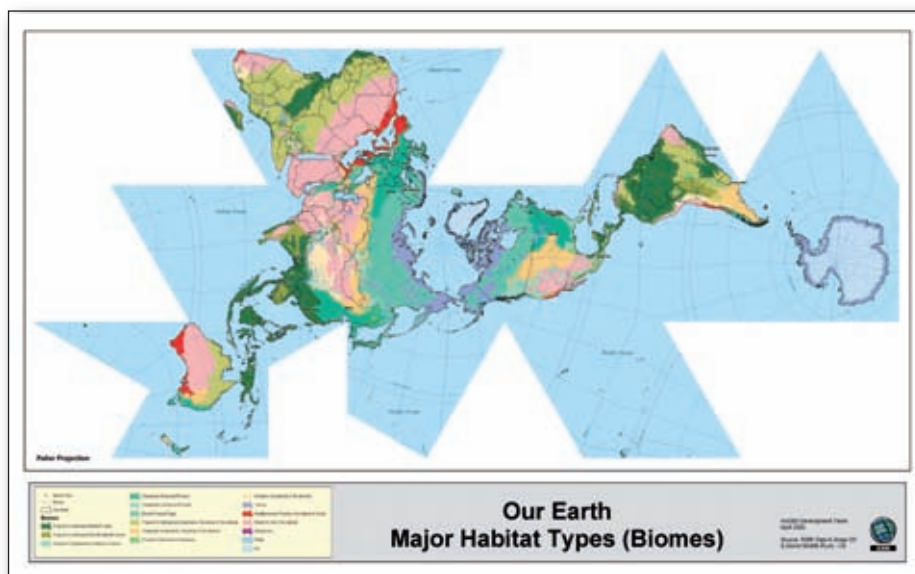
Reality Approximated

The ellipsoid, an ellipse rotated around its short axis, came into full development in the

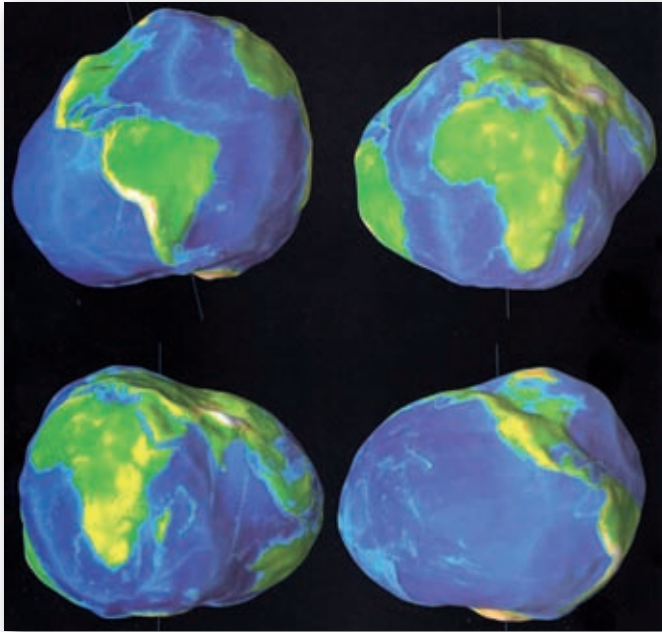
In day-to-day practice it is desirable for the second category of users to have at least a basic, working knowledge of the background behind the hardware and software settings. In this series I will try to explain the basic aspects of geodesy as far as their practical application in surveying and GIS is concerned. This article provides a general introduction to the subject.

Rectangular Coordinate Systems

Before the advent of systems and software such as GPS, GIS and Google Earth, the world according to a surveyor was relatively flat. Of course heights were measured, but always relative to a local, rectangular coordinate system. As long as one is working within a relatively small area (a few kilometers in diameter), there is no objection to this practice which makes life a lot easier. When working in a rectangular coordinate system one



The Fuller projection is the only projection that can be folded back into a globe without distortion (Source: www.esri.com).



The earth as a geoid, with the deviations from the ellipsoid greatly exaggerated.
(Source: www-geol.unine.ch).

19th century and today is still the basis for all survey and cartographic work. Although the ellipsoid (or spheroid, as some say) is a mathematical figure, performing calculations on this figure is no simple matter.

What happens, though, is that a globe in turn approximates the ellipsoid -- an approximation of an approximation. That this does not ultimately help precision should be obvious. For a transatlantic crossing, for instance, the error would easily be in tens of kilometers if one steered blindly by one's calculations. Since in navigation additional systems are used, however, there are usually no great problems.

In survey work errors of this size are generally not allowed: positioning should be done within meters if not centimeters. When working in a larger area, say the North Sea, the true shape of the earth cannot be ignored. But even when working with a global positioning system in a relatively small area, as is the case with land surveys, we need to take the true shape of the earth into account.

And Flat again

The ellipsoid could be used as a basis for survey work, albeit one on which calculations are rather difficult. When making maps and charts this shape is not really practical. Instead one could use a globe since the differences are generally small enough. The disadvantage of a globe, however, is that it needs to be very big in order to display correctly a small piece of land such as a Caribbean island. So the globe, too, is impractical for mapping.

The ancient Greeks already knew this and portrayed the earth on a flat surface, the map. The disadvantage of almost any map, however, is that it cannot truly portray reality. An

example: try to flatten half an orange (only the peel...) on a tabletop. This cannot be done without the peel splitting and deforming.

When trying to portray the earth on a flat surface such as a piece of paper a similar problem exists: the portrait of the earth will be deformed. A general rule is that the smaller the surface to be portrayed, the smaller the deformation. Now we are back to square one: when we want to portray a small area, we can use a rectangular coordinate system without any major problems, but when mapping a whole country we have a dilemma.

The first person to find a working solution to this problem was Gerhard Kremer, better known as Mercator. He developed a method to portray a particular area of the earth in a controlled manner on a flat surface.

This method, called a chart or map projection, is actually a mathematical approximation of the ellipsoid or globe for a defined area. In the resulting rectangular coordinate system we can, with due caution, use all our simple mathematics.

Finally

It should be clear by now that geodesy is nothing more or less than a set of mathematical formulae used to map and calculate the true shape of the earth. Without geodesy, mapping or surveying larger areas is impossible. In the following articles the geoid, ellipsoid and map projection will be discussed.

Huibert-Jan Lekkerkerk

(hlekkerkerk@geoinformatics.com) is a freelance writer and trainer in the fields of positioning and hydrography.