

# PROJECTION? PROJECTION? PROJECTION? WHAT'S A PROJECTION?

by Cynthia Levinson

Cartographers would certainly find their job much easier if the earth were like a paper towel roll or an ice cream cone and not like a sphere. Why? Because you can wrap a sheet of paper snugly around a cylinder or a cone until the ends meet without any difficulty. If you then unroll that same sheet of paper and lay it flat on a smooth surface, it will have no creases and no wrinkles. To make sure of this, you would have used a square- or rectangular-shaped sheet of paper to circle the roll and a fan-shaped piece of paper to circle the cone.

Now, try wrapping a piece of paper—try all sizes and shapes—around a sphere.

**Ptolemy Map:** This map, taken from the 1472 book that was the first to include maps, was originally drawn by the Alexandrian geographer Ptolemy around A.D. 150.



Can you do it without wrinkling or folding the paper. Impossible!

Let's try a different approach. Can you peel a thin layer, similar to a piece of paper, from the earth's surface without stretching or tearing it? This, too, is impossible.

Yet, spheres, also known as globes, are the truest representation of the earth because they accurately include the four essential elements of mapmaking:

- 👉 **shapes** of landmasses and oceans
- 👉 **areas** of landmasses and oceans
- 👉 **distance** from one place to another
- 👉 **direction** from one place to another

## It's the Touch That Counts

Globes, however, are not easily positioned in ships, cars, or space capsules. So, how then can anyone create an accurate map to be used in these vehicles? The answer is simple: with projections.

The most common types of projections are cylindrical, conic, and planar. Each touches the sphere in different ways.

Cylindrical and conic projections intersect the globe around a circle, while

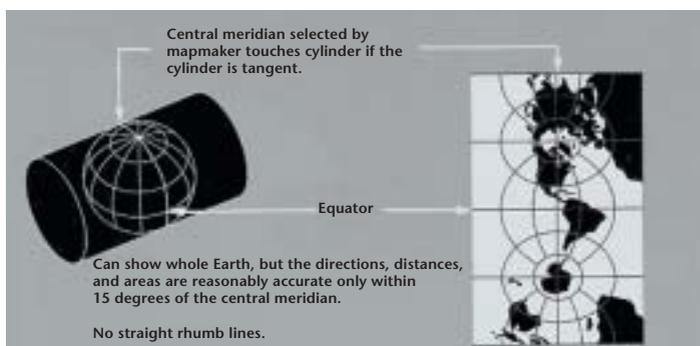
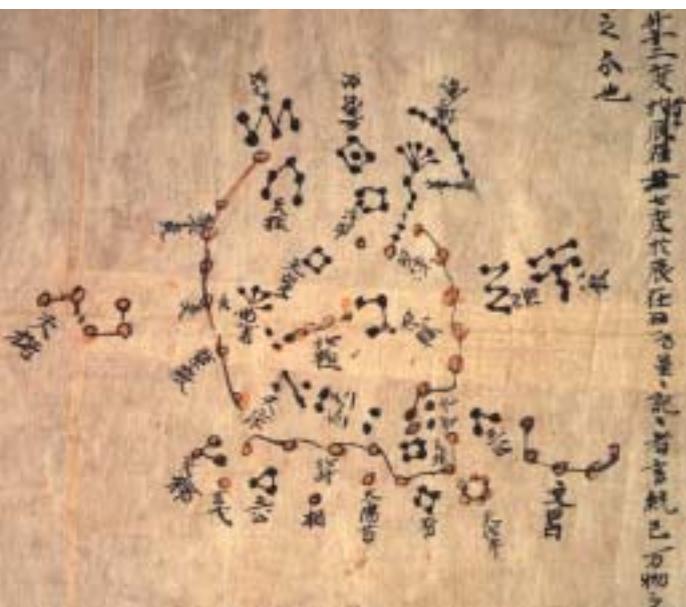
planar projections touch the globe at a single point. Without a doubt, the most accurate area of a map is the point at which the projection makes contact. As the mapped section grows larger, the surrounding areas become distorted.

If a cylinder were placed around the globe and if that globe is not tilted, the cylinder would touch the earth at its widest part—the equator. Cylinders can also “slice” through the earth. Such maps, known as polycylindrical, intersect in two places. As a result, they are more accurate.

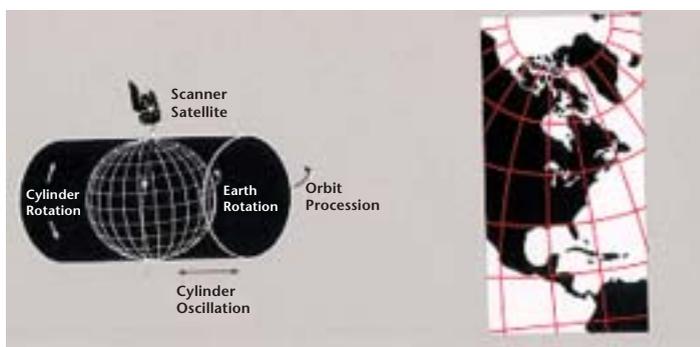
Let’s continue this line of thinking. If the northern hemisphere wore a cone-shaped hat, the sweatband would touch the earth on a parallel north of the equator. If the earth were dropped, southern hemisphere down, into a cone, it would nestle along a parallel south of the equator. Like cylinders, cones can also “slice” through the earth. Exactly where polyconic maps touch depends on the cone’s angle.

A sheet of paper propped against a globe touches it at only one point. So, these planar projections are exact at that spot only. While the point can be anywhere on the globe, if it is directly at a pole, then the map is called a polar projection.

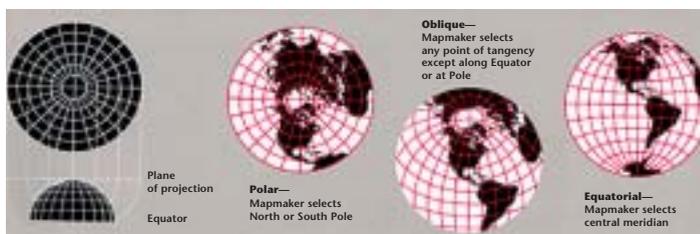
**Chinese Star Chart:** This scroll map, dating to the Tang dynasty (A.D. 618–906), depicts the night sky as seen from the northern hemisphere. It is divided according to the stations of the planet Jupiter into 12 sections.



**This transverse Mercator projection is mathematically the same as a standard Mercator, but oriented around a different axis.**



**The space-oblique Mercator projection is used in Landsat images.**



**An azimuthal projection shows distances and directions accurately from the center point, but distorts shapes and sizes elsewhere.**

## Which Is Best?

When drawing a map, the first step is to decide whether the map will be cylindrical, conic, or planar. The answer governs which of the four basic elements will be emphasized and which ignored. The map’s purpose governs the decision.

Centuries ago, cartographers wanted to map the stars, help sailors navigate the seas, and help soldiers plan battles. So, in the second century A.D., the Chinese developed a grid system similar to latitude and longitude. However, they probably did not know that the earth is a sphere. In the seventh century, they produced the oldest known star map, using the cylinder shape.



**Mercator's son Rumoldus drew this world map in 1587. Its configuration was based on the map his father had drawn almost 20 years earlier. Rumoldus first published it in 1595 in the book titled *Atlas*.**

sailors had difficulty recognizing the shapes of coastlines and measuring exact distances as they followed a course on the high seas. A Flemish cartographer named Gerardus Mercator (see sidebar page 19)

Also in the second century A.D. but thousands of the miles to the east, Ptolemy, a Greek astronomer and geographer living in Egypt, believed that the earth was round. To illustrate his theory, he drew a cone map with longitude lines converging at the North and South poles. He also established the tradition of orienting maps with north at the top and east to the right.

But Ptolemy knew of only three continents, and, because he could not measure the earth accurately, his longitude lines were too close together.

### **Follow the "Rhumb Line"**

All these maps were inaccurate. As a result,

### **Did you know?**

To seek a Northwest Passage in 1576, Martin Frobisher paid one pound, six shillings, and eight pence for a Mercator map.

wanted to make maps that would show true direction. His creations, known as conformal maps, allowed sailors to plot a straight route, called a "rhumb line," without having to adjust their compass bearings. To accomplish this, he plotted the known world onto a grid with parallel latitude lines



and parallel longitude lines that crossed at 90° angles. By using cylindrical projection and spreading latitude lines farther apart as they neared the poles, he made a map that made it possible for sailors to measure their compass bearings directly from the map. For example, if a line between ports on opposite shores of an ocean ran exactly northeast–southwest, then a sailor going between those ports could steer that course and be confident of reaching his destination.

The continents on Mercator’s conformal cylinder maps appear larger than they actually are. In fact, Greenland seems to be the same size as Africa, even though it is actually 14 times smaller. To show which continent is the largest, maps need to illustrate true area, or “equal area.” But, no map can be both conformal and equal area.

### More Shapes

To measure the length of a round-the-world trip, you need equidistant maps. These show correct distances, but are neither



## Cartographer Par Excellence

Born in Flanders 20 years after Christopher Columbus’ first voyage, Gerardus Mercator (1512–1594) grew up during the Age of Exploration. He studied Latin, the art of copying manuscripts, and penmanship in school. At the University of Louvain, he pursued his goal of becoming a mapmaker and studied with the distinguished cartographer Gemma Frisius, who specialized in terrestrial and celestial globes.

Mercator won renown for the accuracy of his geographical maps, as well as for his work as a copper engraver and instrument maker. His ambition was to help navigators by projecting the surface of the globe out flat so that places were in the correct positions. To construct his globes, Mercator used tapered gores of paper that, glued together, would fit around a sphere. His 1569 world map—the one that won him world fame—is actually a series of 18 sheets, with the sites all drawn utilizing his new projection (see page 17).

Mercator continued producing maps until his death in 1594. At the time, he was in the middle of making a comprehensive atlas of the world, all done with maps, but died before completing the task. His son Rumoldus—and other family members and grandsons—followed through on his plans. In 1595, Rumoldus published the first complete edition of his father’s maps under the title *Atlas*, a word now synonymous with cartography.

—Cynthia Levinson



**Mercator first printed this projection in 1569. It remains today the essential projection for sea, air, and space navigation.**

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conformal nor equal area. Finally, to plot the route of a trip, it is essential to have maps that indicate true direction.

Using trigonometry and calculus, cartographers have devised thousands of ways to project a three-dimensional sphere onto a two-dimensional plane. The results come in dozens of different shapes—square, circular, flat on top and rounded at the

sides, diamond, triangular, in gores (wedges), even heart-shaped. Latitude and longitude lines can be straight, curving, wavy, elliptical, or bent. 🏛️

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**Mercator projection:** This world map, with precise coastlines, was created in May 2006. Inset (top right): This poster shows a flattened Mercator projection of the view from the Huygens Probe as it descended toward Titan, a moon of the planet Saturn. The images were taken on January 14, 2005.



**Jiangxi Map:** A 19th-century cartographer used brilliant blues and greens to create this visually stunning image of Jiangxi Province in southeastern China.

