Introduction to Maps

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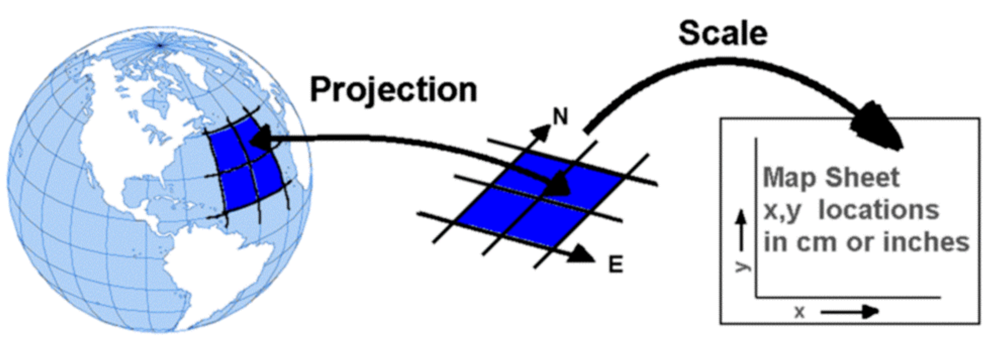
I. A Map is a Map

We all know what a map is, or at least we have a good idea of what we think of as a map. There are, in fact, many kinds of maps. Maps attempt to show the spatial relationship of different items. (There are also maps that show functional relationships, particularly in computer science, but we will not deal with these.) These relationships can be accurate or very symbolic. The issue is what they are trying to communicate.

You may have given a map to friend showing how to get to your house. It might show a rough outline of a large area with a few major highways and streets. As the map approaches the destination it becomes more detailed until you have a couple of streets and the houses on a block. This is a perfectly valid map. If it gets the guest to your house it was a good map, it communicated the needed information. It is a map because it showed the spatial relationships.

II. Round Earth to Flat Maps

Most things we think of as maps appear to be accurate. The **scale** of the map seems to be constant. If you blow up the map a 1000 or a 100,000 times, it might lay on the earth with the roads and houses over the actual items. But of course this is a simplification. The earth is curved and the map is flat. But the earth is big and over a small area it looks flat. So this might be true of a map of a small area. In detail it cannot be true, but the issue is how for off the map would be. We are not talking of map accuracy here, just the problem of representing a curved earth on flat paper. The only way to get around this problem is to use a spherical map, that is a globe.



Mapping Round Earth
On Flat Sheet Leads To Distortion

The process of placing a part of the earth on a flat surface is called **Projection**. All flat maps have distortion. There are many different version of this, that is many map **projections**. There early projections (in the middle ages) were done geometrically. Several today are only defined by a set of equations.

After the section of the earth has been projected, it is **scaled**. That is the huge sheet of paper is reduced to some fraction of its size. Thus if the scale is 1 to a thousand, each kilometer on the earth will be a meter on the map. This is a 1:1000 scale. (The value 1:1000 is read " 1 to 1000" and is called the **representative fraction.**) A scale of 1:1000 is a very large scale for a map. More common are scales between 1:10,000 and 1:10,000,000. <u>The processes of projection and scaling can be done in either order.</u>

III. Types of Maps

Ignoring the hand drawn map, there are two basic categories of maps:

General Maps, and
Thematic Maps.

Some people will include categories of **combination** or **aggregate maps** between these two.

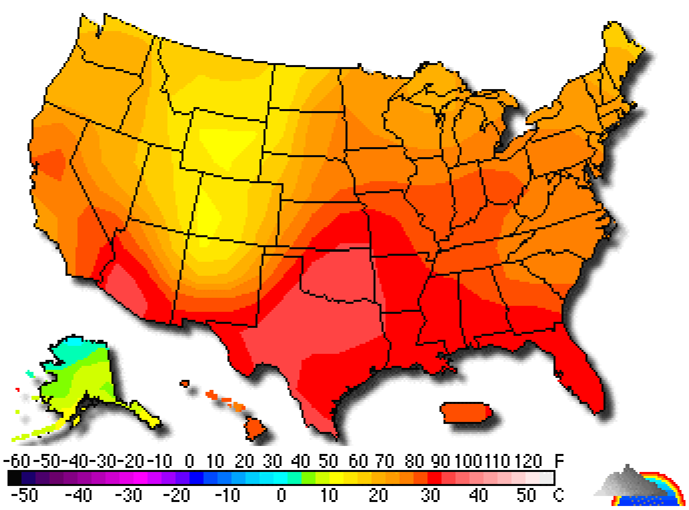
It is more meaningful to call the "general" category a **representational map**. A representational map is intended to show how things (like roads and cities) are related on the earth.

Representational maps often are intended to show not only spatial relationships (San Francisco is north of Monterey) but also <u>quantitative information</u> , the distance between features. Thus <u>you can get location information from some representational maps</u>. Highway maps, navigation charts and topographical maps are all examples of representational maps.

Thematic maps communicate some information that varies with location, but this quantity is not the actual layout of things on the ground. Common examples of thematic maps are subway and bus maps. These originally were colored lines on a real (representational) map. In the 1930's the map of the London Underground (subway) got so confusing in the city center that a diagram was substituted. The map separations between stations distances were not proportional to the real distances and the lines were mainly straight. This proved more useful to the passengers than the older "real maps".

Below is a map of the Washington DC subway system. The location of the stations appear on real maps, but for those inside the subway, this map is more useful. Travel is linear along lines until you change lines. There is some two dimensional spatial information, but you would not want to make distance measurements from this map.

A common example is the weather maps we often see. (Some would call the weather map below a combination or aggregate map. This map has fairly accurate locations of state boundaries. But those lines are just to assist the user in determining the temperature near his location of interest. When used this way, the underlying map is called the **base map.** Notice that Alaska and Hawaii are in the wrong places, but the user still finds this useful. Also those two states are not to the same scale.



Other thematic maps may be more symbolic. For example the US National Weather Service might have a map that shows the administrative regions it uses.

There are tourist maps with California (or New York) very large and detailed with the rest of the US shown much smaller than it should be. These are also thematic maps.

IV. Maps And Accuracy

The location information on maps will always be inaccurate at some level. It is just a question of how inaccurate and is it accurate enough to serve the purpose. There are many sources of map inaccuracies and most are not related to errors in the data used to generate the map. The measurements that go into the map do have some error, however this is usually not the main source of map error.

Even a map intended to show accurate locations always has errors. There are error that just can not be avoided in making a map. The process of making a flat map from the curved earth, performing a introduces errors. This is the projection process. Each projection has its' own error characteristics, and there are dozens of common projections.

In general the projection process cannot represent the curved earth accurately all over a map. The coordinates will be correct only at a point or along one or two lines. The distortion will grow as you get further from these "**standard lines**". There are many projections and each has its own particular distortions.

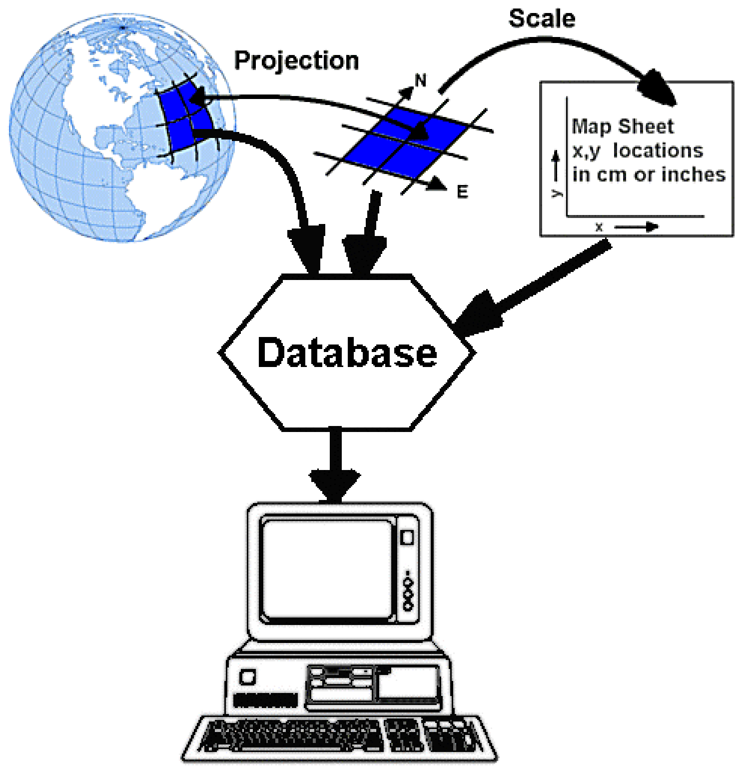
The projection distortion will effectively cause the map scale to be incorrect at most places on the map. And the true scale is not only a function of where you look on the map, but may also change with direction. Some maps preserve shapes in the small and the scale distortion is not direction dependent, some do not. The latter will distort shapes. Projections that preserve shapes and angles are called **conformal projections**. Maps for airplane navigation are usually on conformal projections.

Another source of error comes from the size of the symbols on a map. It may not be possible for the map maker to place all the important symbols on a map in the correct place. Roads are clearly not to scale for example.

On a state or national highway map they would be unreadable if they were the true width. They must cover up other things on the map. Usually this is not an issue. The road location in relation to other things on the map is correct though. Occasionally there are things that are close, such as a railroad next to a highway, that both need to be placed on the map. The map maker will move one or both. This is called **cartographic license**.

V. Electronic Maps

The computer might be the solution. But it is not the total solution yet. The issue is how to get the data into the computer and how it is stored. <u>The key item to electronic maps, in their many forms, is the database.</u>



In many cases paper maps are just scanned and placed in a database. Or more likely, the database just includes information about what is stored in each map image and where the images are store on the computer. This gives convenience, but no improvement over paper maps. In fact, the case sometimes is made worse because key information on the legend and edges of the map is lost.

A true **Geographic Information System (GIS)** type of **spatial database** includes information about a object. The object in the GIS data base could be point, a line, or an area. These are primitives that are used to build the map. The location of the objects is stored in terms of latitude and longitude (or equivalent). The information is not projected until requested by the user. Thus maps on different projections can be generated (rendered) from the same GIS database.

The position information in the database be augmented with other information or **attributes**. For example an airport runway might have the length, orientation, width and surface material included as attributes. The first three items are needed to display the runway, the surface material is just extra useful information.

Electronic maps can be very powerful, or just a convenient storage of images. If they are to be used for navigation they must also have some other qualities. They must be as accurate and up to date as possible. They must be safe from corruption, by accident or otherwise. So electronic maps used for navigation must be accurate, current and have **integrity**. There is a lot of work that goes into electronic navigation charts in order to ensure the integrity.