SCALE *VS.* RESOLUTION

"Map scale" is a basic descriptor of the character of a map; it is commonly used as something of a short-hand for the nature of maps by cartographers, historians, and librarians. Map scale is basically the ratio between a length on the ground and the same length as represented on the map. There are, however, some significant historical and terminological problems associated with the use of map scale, so that it is better to use the related concept of "map resolution."

REPRESENTATIONS OF MAP SCALE

Modern cartography texts specify three ways in which map scale can be represented; to these three, we should add a fourth (#2, below). These four methods actually indicate historically distinct ways of conceptualizing map scale for different purposes.

1. Scale Bar

The graphic "scale bar" was developed so map readers could measure distances off a map. Scale bars are a common feature on sea charts, beginning with medieval charts of the Mediterranean, regional maps from the sixteenth century on, and also on property and topographical plans. They represent linear measures (units of length) customarily associated with each cartographic mode, further distinguished by regional variation.

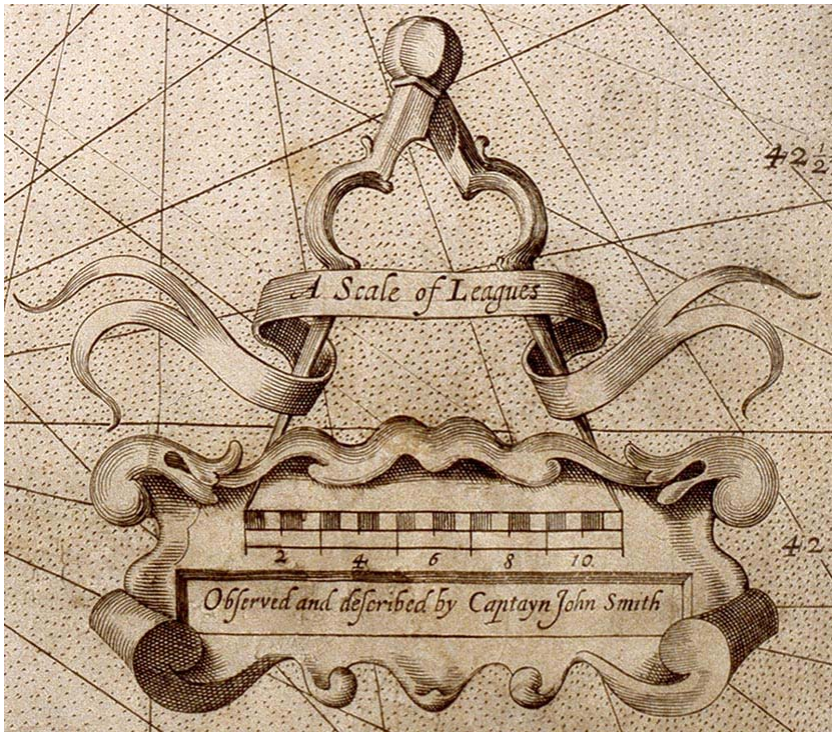

Figure 1. Detail of Simon de Passe, *John Smith* / *New England* (London, 1616/7).

A scale bar comprises a line that is drawn on a map to represent a certain length; various graduations and ticks are generally used to show divisions of that length. (At times, the line connecting the ticks was not drawn.) On Simon de Passe's *John Smith* | *New England* (London, [1617]), for example, the scale bar is graduated to show ten leagues in intervals variously of half,

one, and two leagues (Figure 1). A reader could then set the points of a pair of dividers (also called "compasses") on two features of a map; by then placing the points on the scale bar, the reader could directly read off the distance between those features. (The early modern convention of surmounting a scale bar with a pair of dividers perhaps originated as a guide to the map reader: look what you can do with this map, you can determine distances!)

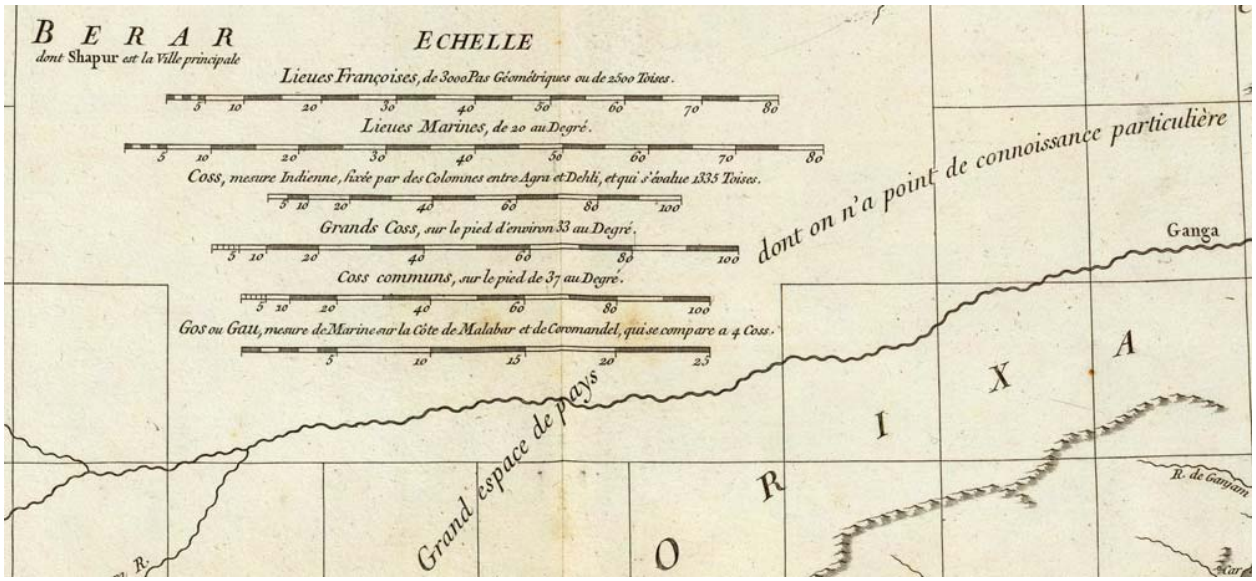

Figure 2. J. B. B. d'Anville, *Carte de l'Inde* (Paris, 1751)

By the eighteenth century, regional maps could bear a collection of scale bars, each representing a different linear measure. J. B. B. d'Anville provided six scale bars on his *Carte de l'Inde* (Paris, 1751) (Figure 2). Two of the six defined French leagues (both land and marine); their provision indicates the intended audience of the map (French readers) and also that d'Anville took much of his information from sources expressed in those same French measures. The other four scale bars represent various incarnations of the South Asian coss; given that the map was not made for Indians, it is most likely that these also indicate d'Anville's sources. Such collections of scale bars displayed to the reader the array of source materials on which the map maker had drawn, and thus made a statement about the quality and reliability of the map.

In the same example, d'Anville qualified the six linear measures in order to permit comparisons between the different measures. For several of the measures, he gave a formula equating "so many" of the units to "one degree" on the earth's surface; the nature of this degree was rarely specified and could variously refer to the length of one degree of longitude at the equator, or to the length of a degree of latitude along a meridian (presuming a spherical earth). This length of a degree, despite its inherent ambiguities, was the closest thing to a universal standard of length in the eighteenth century. For example, d'Anville noted that one degree was equivalent to either 37 "common" coss or about 33 "grand" coss. In effect, this information was an initial attempt to standardize linear measures and so impose philosophical order on the chaotic practices of the world.

2. Length/Distance Statements

On some property plans, surveyors wrote the lengths of each portion of a boundary around a piece of property directly on the plan; this practice reinforces the manner in which early property plans were created by plotting out a verbal metes-and-bounds description of the property. On some regional maps, map makers wrote the lengths of segments of road directly on the map, taken from a written itinerary. (In this case, the specific length is the length of the road, not necessarily the direct distance.) Both practices effectively gave the reader a sense of map scale, albeit it in an idiosyncratic manner.

3. Verbal Scale

The standardization of surveying practices — whether informally (as in property mapping, when communities of surveyors and property owners settled on common practices) or formally (when the efforts of many military surveyors needed to be coordinated) — led to standardized scales for plotting maps of property, topography, and territory. While these scales could be shown graphically with a scale bar, it was also important for the surveyor to highlight the fact that a standard scale had been consistently applied in making a map. To this end, early modern surveyors began to express scale as a verbal statement: such a length on the map equates to such a length on the ground. The two lengths were expressed in different units: the units used to subdivide a ruler (inches, *lignes*, etc.) for the map; for the ground, whatever the customary units of measurement were for the survey (rods or chains for property mapping, miles for territorial maps, etc.). For example:

One inch to a hundred feet	one inch [map] == hundred feet [ground]
One inch to a mile	one inch [map] == one mile [ground]
Ten miles to an inch	one inch [map] == ten miles [ground]

4. Representative Fraction ("RF")

Over the course of the nineteenth century, it became increasingly common to express scale as a unitless numeric ratio, or "representative fraction." Use of a numeric ratio is a central element in the modern cartographic ideology, which holds that all maps are properly based on detailed surveys; the RF was developed in large part as a means to indicate the degree to which survey data had been generalized to make a map.

The key to defining RF is to express the lengths on map and ground in the same units. For example, a scale commonly used for British territorial maps—one inch to a mile—can be expressed as one inch on the map to 63,360 inches on the ground (one British statute mile being comprised of 63,360 inches); the specific units "cancel out" so that one might also say that one of any linear unit (centimeter, cubit, whatever) on the map represents a ground distance of 63,360 of the same linear unit. Numerically, this RF is written either as a ratio (1:63,360) or as a fraction ($^{1}/_{63,360}$). The unitless character of the RF means that it can be used as a universal means of comparing maps regardless of nature or origin.

It is very common for historians and map librarians to convert scale bars and verbal statements on old maps into RFs. Measure the length of the scale bar, convert the represented length into

the same units, and express the two as a ratio. For example, Augustin Herrman's *Virginia and Maryland* (London: John Seller, 1673), bears a scale bar, 8.1cm in length,[1] representing "24 English miles." So:

8.1cm = 24 English miles

8.1cm = 24 * 63,360 * 2.54 cm (to convert miles to inches, then to centimeters)

8.1cm = 3862425.6cm

1cm = 476842.67cm

Dropping the units and rounding gives an RF of ca.1:475,000. Of course, to make this kind of calculation, one first needs to know the length of old linear units in modern units!

An alternative approach to determining the RF of an old map, whether to check the accuracy of a scale bar or if no scale bar is provided, is to measure the distance on the map between two known points, whose intervening distance on the ground is known, and calculate the RF accordingly.

CLASSIFYING MAPS BY SCALE

1. Large-Scale and Small-Scale

Maps are often grouped together according to broad categories of scale: "large scale"; "medium scale"; and "small scale."This classification was developed by professional cartographers and is based on the representative fraction. For example, just as ½ (0.5) is a larger number than ¼ (0.25), so $^1/_{63,360}$ is a larger number than $^1/_{1,000,000}$. Thus, a map at 1:63,360 is said to be at a larger scale than a map at 1:1,000,000. Generally, it is easier to remember a rote device:

maps of the whole world and extensive regions	::	small scale
very focused maps, of a town or plot of land	::	large scale

2. Pragmatic Problems with this Classification

There are, however, two significant problems with such classification. In the first place, there is no clear and unambiguous definition of large versus medium versus small scale. Mary Larsgaard reviewed the professional literature from the twentieth century and found no agreement of the limits of "large scale": for some government surveyors, "large scale" is larger than 1:10,000 and "very large scale" is larger than 1:1,000; for others, "large scale" is larger than 1:100,000. Thus, depending which practice is followed, the 1:63,360 topographical maps of Britain are either large-scale or medium-scale.[2] My own rule of thumb is as follows:

greater than 1:10,000	very large scale	detailed property plans
1:10,000 to 1:100,000	large scale	modern territorial mapping
1:100,000 to 1:1,000,000	medium scale	early territorial mapping
1:1,000,000 to 1:10,000,000	small scale	regional maps
less than 1:10,000,000	very small scale	small world maps

But, ultimately, it must be appreciated that the differences between these categories of scale are impressionistic.

The second problem is that the terms "large scale" and "small scale" are counterintuitive for the many people untrained in professional niceties. Colloquially, "large scale" means extensive and widespread, "small scale" tight and constrained, the exact opposite of their technical meaning. Official topographical map series are made at scales that are technically large and do indeed cover extensive areas, but then many technically large-scale maps cover only small and precise pieces of land and so are, in colloquial terms, small-scale. And vice-versa. The USGS thus began a "fact sheet" on scales with the heading "Large Is Small."[3] Confused? Most people are.

3. Conceptual Problems with this Classification

In addition to these two pragmatic problems, there are also some significant conceptual problems with the application of representational fractions and scale categories to old maps.

As professional cartographers will readily admit, scale actually varies across all maps, because the mathematical transformation from the curved surface of the earth to the plane of the map warps the spatial geometry. For very small areas, such as a small plot of property, the scale variation is so small as to be utterly subsumed within the precision of the lines and is so quite negligible. But for maps of large areas, from large countries to the whole world, the variation in scale across a map can be truly significant. In this respect, the application of an RF to a map is only ever an approximation.

Furthermore, maps (new and old) are not necessarily made to scale. Topologically structured maps, such as the famous map of the routes of the London Underground, consciously manipulate geometrical relationships so that it makes absolutely no sense to determine a scale for them. Many maps have been made of imaginary or mythical places, places for which scale is irrelevant. What about the center-enhanced space of cosmographical maps that combine the real world with the divine?

Most important, it is an ahistorical imposition to apply RFs and the associated concepts of a universal cartography to all maps in the past. Application of an RF to an early modern map serves to reduce it to the modern cartographic ideal that holds that there is one practice of map making, one type of thing called a "map," and that it is meaningful to describe and define a map by means of its scale. But, as has been indicated, the different representations (and so conceptions) of scale are integral to the particular practices of each cartographic mode in a given era and place.

MAP RESOLUTION

Given the pragmatic and conceptual problems associated with map scale, and especially with the blanket imposition of representative fractions, it makes sense to use an alternative means to describe the character of maps. After all, if we are impressionistic in classifying a map, we should eliminate the fake precision of RFs.

The solution is to consider the **resolution** with which maps represent the world. Broadly speaking, resolution is akin to scale: high-resolution maps, which show a great deal of

information for the surface area of the map, are also technically large-scale maps; low-resolution maps, which show a small amount of information for the surface area of the map, are akin to technically small-scale maps; etc. But resolution does not carry with it any presumptions of a necessary mathematical relationship that will obscure and pervert our historical understanding of maps.

Notes

[1] It is standard practice to use metric units when measuring maps for bibliographic purposes.

[2] Mary Lynette Larsgaard, *Topographic Mapping of the Americas, Australia, and New Zealand* (Littleton, Col.: Libraries Unlimited, 1984).

[3] "Map Scales," USGS Fact Sheet 015-02 (February 2002), http://egsc.usgs.gov/isb/pubs/factsheets/fs01502.html (accessed 8 November 2008).