The Metrication of Navigation

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THE following notes stem from Ronald Turner's somewhat controversial paper on the metrication of navigation.[1]

The unique feature of the nautical or sea mile as a unit of distance is that it is directly related to a commonly-used unit of angular measure. To be more precise, the nautical mile may be defined as the length of a meridianal arc of the terrestrial sea-level surface, the geographical latitudes of the end points of which differ by one-sixtieth of a degree. In other words, the sea mile is a minute-mile, and the resulting convenience to mariners is one that is not too lightly to be sacrificed on the altar of the metric system.

The association of the seaman's unit of distance with the unit of angular measure and with the size of the spherical Earth, became a serious consideration soon after the initiation of the Age of Discovery by the Portuguese navigators sponsored by Prince Henry. Before this epoch, and indeed for some time after, seamen used landsmen's units of measure: units derived from homely, but certainly non-scientific, standards such as the length of a thumbjoint, forearm, foot and pace, and in no way related to the size of the Earth.

The inconveniences in trade and commerce caused by a wide variety of units of length and weight must always have prompted men to suggest standardizing these units. But even in these enlightened times the difficulties of so doing are almost insurmountable; and, indeed, most of us are content to carry on as we have always done, resisting change with all the power at our command.

It is interesting to note that as far back as 1670 proposals were made in France for a comprehensive decimal system of weights and measures based on a minute of arc of a great circle of the Earth. The most fruitful attempt at standardizing the units of measures, however, was made immediately following the French Revolution, when the Metric System, as we now know it, was devised. The underlying principle of this system is that one-hundred-thousandth part of the quadrant of the globe between the equator and the pole through Paris should be the standard unit of length. The metre was adopted on this basis. With the passage of time, improved knowledge of the dimensions of the Earth made it evident that the now widely adopted international metre is not precisely the length it was intended to be.

Were the Earth a perfect sphere the length of a minute of arc of a great circle of the sphere would be constant. But treating the Earth as an oblate spheroid of rotation having a compression of $1/293{\cdot}5$ (that of the Clarke 1880 spheroid which is widely used for navigational purposes), the length of a minute of arc of a meridian varies with latitude. In latitude 0°, where the meridianal curvature is greatest, the radius of curvature is least and the length of a minute arc is also least. In latitude 90°, where the meridianal curvature is least, the radius of curvature is greatest and the length of a minute arc is also greatest.

The formula generally used for finding the length l in feet of a minute arc of a meridian in geographical latitude ϕ, is:

$$l = 6077 - 31 \cos 2\phi$$

From this formula it may readily be verified that l is 6046 ft. in latitude 0° and 6108 ft. in latitude 90°.

The U.K. nautical mile, which is the standard unit of distance used by British navigators, is 6080 ft. (1853·18 m.). This is about 0·06 per cent greater than the international nautical mile which is 1852 m. exactly. The United States nautical mile, the length of which is 6080·22 ft., is defined as the length of a minute arc of a great circle of a sphere having an area equivalent to that of the Clarke 1866 spheroid, the compression of which is 1/295. An illuminating account of these and related matters is to be found in a paper by Moody.[2]

Whatever disadvantages the standard nautical mile may have as a navigational unit of distance, it does not come into that category of units mentioned in the second paragraph of Ronald Turner's paper.[1] On the contrary, it is a unique unit of distance systematically related to, which blends harmoniously with, the units of the sexagesimal system of angular measurement.

There is no doubt that advantages are to be gained by adopting an international unit for heights and depths shown on charts, and by replacing the foot and fathom by the international metre. But whether or not the mariner's unit and scale of distance, which correspond respectively to the unit of d. lat. and the scale of latitude on a Mercator chart, and whether or not the standard nautical mile is obsolescent, are matters which demand close attention.

If the kilometre is to be adopted as the standard unit of distance for navigational purposes, then it would not be unreasonable for navigators to demand a new system of angular measure in which the desirable harmony between the respective units of distance and angle is preserved. Such a system of angular measure could well be based on the decimal system, proposed by French philosophers of the last century, in which a right angle is divided into 100 equal parts or *grades*, each grade being sub-divided into 100 *centigrades*. The important factor is that the new unit should bear the same ratio to the minute of the sexagesimal system as the kilometre bears to the standard nautical mile. In this event, the kilometre would be the logical unit for use in navigation, and the present relationships between rhumb-line course, rhumb-line distance, d. lat., departure, and d. long., would be preserved. But the problems involved in changing to such a system of angular measure would be so considerable that the result would not be worth the effort.

REFERENCES

1 Ronald Turner (1968). The metrication of navigation. This *Journal* **21**, 81.

2 Moody, A. B. (1952). Early units of measurement and the nautical mile. This *Journal* **5**, 262.

Line of Position from a Horizontal Angle

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A horizontal angle between two charted objects provides a line of position and two angles between three or four objects will provide a fix or running fix except in the unique case of a 'swinger' or 'revolver'. The method is faster than the conventional three-arm protractor.