# FORUM

## Navigating on the Spheroid

*from* A. J. R. Tyrrell
(*Extra Master*)

It seems unfortunate that with the great advances made in modern navigation, the elementary and basic problems have been left unstandardized, incomplete and to a certain extent misleading, causing needless confusion to the student.

The charts used every day are constructed assuming the Earth to be a spheroid and yet there is no method taught whereby one can calculate the distance along a parallel of latitude on the spheroid. The simple spherical formula—distance = *d.* long cos latitude—is taught, explained and practised and automatically it is assumed that distance is never numerically greater than the corresponding *d.* long; and yet by taking a suitable chart on or in the vicinity of the equator it can be shown by simple measurement that the distance can be greater than the *d.* long. This naturally mystifies the young and curious navigator who delves a little off the beaten track.

Mercator, middle latitude, plane and traverse sailings are generally treated as separate problems, leaving the reasons for their limits and their application to the sphere or spheroid a little vague. Basically all the sailings are one and the same problem and could be taught as such. Once the spheroidal properties of the Earth have been explained satisfactorily and convincingly interpreted into a flat mercator chart, the problem becomes one of solving a plane right-angled triangle—the chart triangle which is the one enclosed by the course line, the meridian of the point of departure and the parallel of latitude of the destination —which can be measured in two different units: (*a*) variable units of latitude or (*b*) constant units of longitude. Thereafter the various sailings resolve themselves into particular methods of solving this triangle, using units of latitude or longitude (meridional parts), course angle and simple proportion. The ratio between departure and *d.* long could well be tabulated for all latitudes in preference to the unconvincing cosine middle latitude ratio, which is impossible where it becomes greater than unity.

There is little need for the sphere to be considered when studying the sailings. Let the whole train of thought be concentrated on the spheroid, evolving from the basic problem the minimum number of sailings required for an efficient, accurate and easily understood solution.

It would be wrong to infer that the standard way of teaching navigation is in any way wrong; but standardization could simplify not only the learning but also the tuition of navigation. The gain in accuracy through being 'correct' is not noticeable, but that is hardly a sufficient reason for ignoring the position.

*Captain R. Tosswill, R.N., (Commanding Officer, H.M. School of Navigation and Direction, H.M.S. Dryad) comments:*

The academically minded, to whom this problem forcibly appeals, would undoubtedly agree with Mr. Tyrrell's proposal. From the practical point of view, however, the problem scarcely arises in the Royal Navy, since specialist

officers qualifying in navigation are instructed in meridional parts and the reduction of latitude. In the training of other junior executive officers, the introduction of the spheroid would seem unnecessary. These officers are instructed that the sphere is a convenient assumption and if they wish to delve more deeply into the subject the specialist navigating officer or the instructor officer, to either of whom they would undoubtedly refer for guidance, should be able to satisfy their curiosity.

*Captain H. Topley, Principal Examiner of Masters and Mates, comments:*

Treating Mr. Tyrrell's letter from the purely teaching aspect I think he has overlooked the fact that the sailings are taught either at a pre-sea establishment or at a grammar school to students of about the age of fourteen or fifteen. At this age it is quite sufficient to say the Earth is a spheroid but for all practical purposes of navigation, within the limits of accuracy required, it can be treated as a sphere. It is not until much later in life that the student's mathematical knowledge is sufficient for him to understand and appreciate the more accurate method of treating the Earth as a spheroid or the fact that the value or values assigned to the compression are only empirical ratios and not universally accepted. It is also probable that the shape of the Earth is not a true spheroid, and though to treat it as such gives greater accuracy it can still not be considered 'correct'.

Dealing with the sailings individually we start with plane sailing and this as its name implies treats the small part of the Earth's surface concerned as a plane and this is sufficiently accurate where the run is up to about 600 miles. If we are dealing with geographical positions it is necessary to convert the departure into difference of longitude and the practical method of mean latitude is usually taught. Considering the mathematical background of the students it is sufficient to suggest that this gives a sufficiently correct answer, without trying to prove that it would only be a first approximation even if the Earth were a true sphere.

The next step is usually to teach mercator sailing and only at that stage is it necessary to point out that due to the long distances covered it is necessary to take into account the spheroidal shape of the Earth and to point out that the tables of meridional parts generally take this into account. At this stage it is possible to introduce the correction to mean latitude and it is quite sufficient to state that it is a correction to apply so that the results of middle-latitude sailing shall agree with the results obtained by mercator sailing using the meridional parts for an assumed spheroidal shape of the Earth. In my own view, the use of this correction is of no practical value for a day's run of a ship (or between fixes in an aircraft) and it is quite sufficient to teach mean latitude sailing for use up to distances of about 600 miles and mercator sailing for longer distances.

If Mr. Tyrrell's suggestion that all sailings should be taught on a spheroidal basis was adopted, I dread to think of the teacher's difficulty when he starts on great-circle sailing, which is only used for very long distances, and he tells the student to treat the Earth as a sphere.

*Mr. J. E. D. Williams comments:*

I particularly sympathize with Mr. Tyrrell's first two paragraphs. In navigation practice the spherical form is ignored; yet the syllabuses mention it briefly without requiring application, some navigation tables give meridional parts for

the spheroid and the textbooks devote a few sentences (not invariably accurate) to the subject. Small wonder that the curiosity of any intelligent student is further aroused.

On Mr. Tyrrell's main point, mathematical tables enabling navigators to work accurate spheroidal sailings by either mercator or mean latitude methods (slightly modified) are perfectly practical and have been discussed technically elsewhere. The mean latitude method would probably differ in minor detail from Mr. Tyrrell's proposal for technical reasons and the mercator method is given in the latest edition of Burton's 5-figure navigation tables. When a sufficient number of navigators consider facilities for spheroidal sailings to be a requirement, they will have them.

Air navigators prefer plotting to calculation. Here the solution is simplicity itself. On the mercator (or any conformal projection of the spheroid) it is merely necessary that some meridians be graduated in nautical miles instead of minutes of geographical latitude—these scales being used for distance measurement by the standard method for orthomorphic charts. This is not a radical departure even for our conservative profession.

Returning to the question of training. I think students should appreciate more clearly that the function of mer. parts for the spheroid is merely to keep the *right proportion* between chart length of 1′ long. 1′ lat., so that conformality is retained and angles are correct. The fact that 1′ *d.* lat. is not precisely 1 nautical mile, a more or less arbitrary unit of length, remains. If the spheroid is mentioned at all the student should comprehend that, in consequence of the above, the formulae dist. $=d.$ lat. sec course or *d.* lat. $=$ dist. cos course are as inaccurate as ever, and that in some cases a sailing calculated by mer. parts for the spheroid is in fact in greater error than a simple spherical treatment. I have never understood why some tables designed for the use of navigators give spheroidal mer. parts with no other concession to the form of the Earth.

# The Accuracy of Dead Reckoning in the Air

## *from* W. Hudson

I WAS unable to attend the lecture by Mr. C. S. Durst on 'The Accuracy of Dead Reckoning in the Air', and I was, therefore, very interested to read the paper in the April *Journal*.[1] There are many implications, and Mr. J. B. Parker has endeavoured to suggest some in his article.[2]

It is good to see his definition of dead reckoning; I have often wondered what it means in the subconscious minds of some navigators—perhaps a method of avoiding the necessity of acquiring more accurate information. To me it is a technique not without its uses and certainly not without its fun, but to be kept to the minimum by regular and definite findings. I believe that is the way of most professional navigators.

Mr. Parker concludes with a summary of problems to be reviewed. Various military drills have laid down from time to time requirements for navigators