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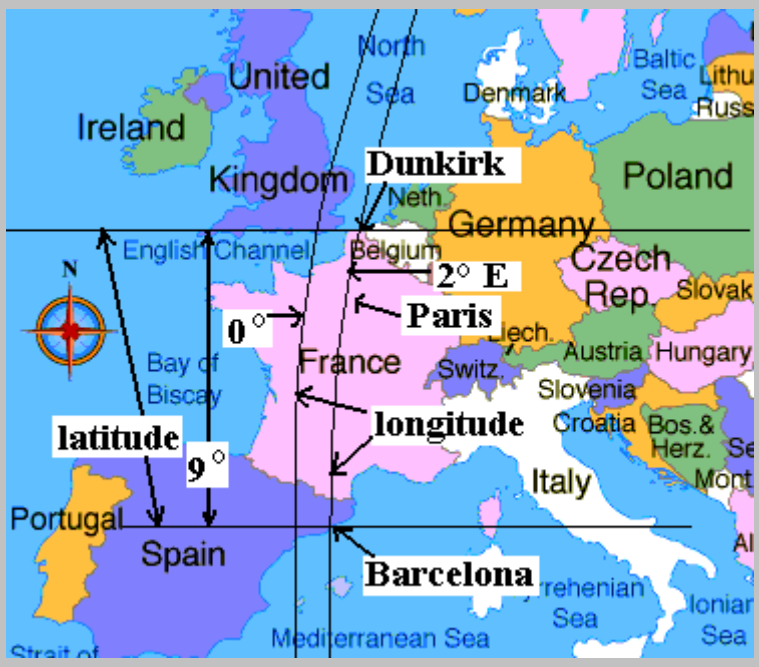
Making a better measuring tape

The standard metre, which was first defined as one ten millionth of the distance from the equator to the north pole, is now linked to the cesium clock and the speed of light, says S.Ananathanarayanan.

It is difficult to list out the different units and systems of measurement that had burgeoned in Europe by the beginning of the nineteenth century. But with the French revolution, that country decided that ‘equality’ was not only a political ideal but also needed to be manifest in the manner of measurement.

The Paris meridian

The longitudinal arc that passes through Paris had long been celebrated as point of reference for astronomical observations but its length itself now became important for defining the metre. The distance actually measured was the distance from Dunkirk to Barcelona, which, based on latitudes, was known to be one tenth of the distance from the equator to the Pole.



This distance was measured by a number of celebrated persons, sighting landmarks along the way, with chains and telescopes and using the method of ‘triangulation’. The distance from the equator to the pole that followed from these measurements soon fixed the ‘standard metre’ length, which was formally adopted in 1795, and documented by two marks on a rod of platinum, which is now preserved just outside Paris. Subsequent and more accurate measurements proved the ‘standard’ to be 0.2 millimetres shorter than intended, but the standard was allowed to remain.

For actual use all over the world, ‘facsimiles’ of the Paris standard were produced and certified and these were used to make sure that everybody was talking about the same length when they referred to a ‘metre’.

A better standard

For most commercial purposes, this standard was quite adequate and so remained undisturbed till 1960. By 1960, demands of measurement for scientific uses became very exacting indeed, down to a great many decimal places below millimeters or even micrometers. And the distance between two marks on a rod of platinum was just not good enough. So a new standard was developed, based on the wavelength of an orange-red spectral line emitted by the krypton atom. This was a major advance, because now the metre could be experimentally reproduced anywhere in the world, without reference to the platinum metre bar in Paris.

Yet a better standard

The trouble with the krypton standard was that the krypton lamp, with an instrument called the 'interferometer', could calibrate other measuring tools, but was not easy to use directly as a day-to-day standard. A new standard, adopted in 1983, is based on the fact that the speed of light, in a vacuum, is absolutely constant and the availability of very accurate instruments to measure intervals of time.

'Atomic clocks', which use the 'ticking' of the cesium atom as the most accurate balance wheel known yet, now enable us to measure time with an accuracy of one part in a hundred billion! Using this ability, and light generated by the fairly common red helium-neon laser, we are able to measure lengths with uncertainty less than one part in a billion.