

WHAT IS YOUR POSITION?

FEATURE **PATRICK VAN HOESERLANDE**



Determining the position in a time when nautical charts were not very accurate. Photo by Royroleg.

In the previous articles published in both the June and September issues, we touched two elements important to a diver: time and depth. However, there is still a third out there that we need on some of our diving trips: position. In fact, without that concept every successful wreck dive would be a lucky shot (though I think this is sometimes the case anyhow). After having read the two other articles, you will understand that there is a lot of history and science hidden behind the coordinates flashing on your GPS screen. Let's discover it.

On land or close to the coast one can easily use landmarks to pinpoint a position. A navigator can determine with a compass the direction of two towers he sees. By drawing corresponding lines on a map, he can locate the whereabouts of his ship. Further at sea or at night, he can use lighthouses in a similar way in determining his location or in finding the right way for entering a harbor. But these methods do not work out at sea, out of view of any landmark or pathways indicated by powerful lighthouses. So, we need something universally applicable, independent from any visible object.

I would like to suggest that we, as in the previous articles, digest the large amount of information ahead of us by analyzing our positional

problem in two parts: latitude and longitude. If we leave the third dimension, i.e. height, out of the equation, we will be able to use these two to geographically indicate any point on earth's surface (sea surface would be more accurate) by its spherical coordinates. And to find that point again, we only need to plot those coordinates on a map. Let us start easy.

LATITUDE

The latitude of a point on the globe is the angle of the line through that point and the center of the earth, with the plane of the equator. The latitude varies from 0° to 90°, with the addition of N (north, north of the equator; in the northern hemisphere) or S (south latitude, south of the equator; in the southern hemisphere). A degree is divided into 60 minutes. A minute on a great circle or orthodrome with a diameter equal to the diameter of the globe, corresponds to a distance of one nautical mile or 1852 meters. All parallels, imaginary horizontal lines of the points with the same latitude, run parallel, hence the name, to each other and are lines in the east-west direction across the globe. With the exception of the equator, these circles of latitude are small circles. This means that the distance of one minute on a parallel decreases with increasing latitude, from a nautical mile on the equator to zero on the poles.

But how do you determine the latitude? This can be done on the basis of the position and the movement of the stars in the sky. The latitude in the northern hemisphere can easily be determined based on the height of the Pole star in relation to the horizon.

We do know, however, that Earth is not a perfect sphere, but rather flattened towards the poles. This makes it harder to exactly define the center of Earth. To complicate things further, the Pole star is not perfectly aligned with the North. So, we will get different coordinate systems (often the longitude stays the same) depending on the reference used. In Belgium, we previously used the 'European Date 1950' (ED 50) but we replaced it by the 'World Geodetic System 1984' (WGS 84). ED50 and WGS 84 differs in Belgium about 100 meters from each other.

The accuracy of the determination of a location plays a double crucial role. For example, suppose that somewhere at sea there is a rock formation which is not visible, but the water above is shallow enough to cause serious damage to your ship. As the ship's navigator, you want to avoid this lurking danger. It is therefore important to know the exact location of your vessel so that you position it precisely on the nautical chart in

relation to the danger zone. Not only do your navigational skills have to be near perfect, but the indication of the danger on the chart must be precise. What is the use if you steer the ship 500m away from the coordinates of the danger zone, if those coordinates are plotted 500m off track?

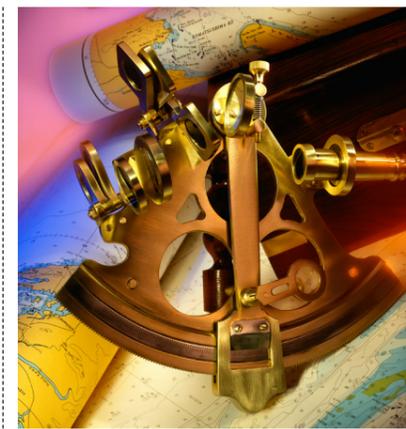
LONGITUDE

The second element of a coordinate is the longitude. This is the angle between the plane containing the meridian through Greenwich, the so-called Prime Meridian and the plane containing the meridian of the position. A plane containing a meridian runs through both poles. The longitude varies from 0° to 180°, with the addition E (eastward longitude, to the east of the prime meridian, in the eastern hemisphere) or W (westward longitude, west of the prime meridian, in the western hemisphere). When a sign is used, eastward longitude is awarded a positive and westward a negative value.

A meridian connects all the points with the same geographical longitude. These lines are equally long and run like half great circles between the poles. The distance between meridians varies greatly with the geographical latitude: on the equator the distance between two meridians with a difference of one degree is approximately 111 km. At the poles the same one degree equals 0 km.

The choice for the Prime Meridian through Greenwich as the reference for the longitude is (geographically) completely random. As explained in the previous article, this choice is the result of the English ambition for a large navy and without a reference for the determination of the longitude, it would be impossible for pinpointing a location at high sea and thus becoming a truly global power. History knew different reference meridians, but in 1884, during the International Meridian Conference, 41 spokesmen of 25 nations invited by the President of the United States officially declared that the meridian through Greenwich would, from then on, serve as the sole prime meridian. The international date line runs around on the other side of the planet but for practical and political reasons it is not exactly the 180° meridian.

Although we have a reference, the question of how to determine the longitude is still unanswered. Navigation remained far in the eighteenth century as a mere matter of a best guess. Once at sea, out of sight of any reference points, navigators knew neither where they were, nor in what direction they had to sail for a port. Deciding on the heading meant gambling with the life of the crew and the ship at stake. Where is the nearest island with fresh water and food in relation to our current position? Do we need to steer starboard or backboard to prevent collision with those dangerous rocks on the chart?



The vertical angle between a celestial body and the horizon can be measured with a sextant. If the vertical angle, the date and the moment of the day are known, the position at sea can be calculated. Photo by Jupiterimages.

Navigation was, because of its complexity and the risk involved, a privilege of officers. Questioning the exactitude of a position was equal to questioning the competence of officers. Such an act was an act of mutiny. Sailors were hung because they dared to determine a position themselves! The task of the watch in the crow's nest was not limited to announcing "Land ho" – that moment was always a surprise due to the large uncertainty about the exact position of the ship – but more importantly to quickly recognize that piece of land. In fact, a wrong turn could lead to shipwrecking on dangerous cliffs. And we all know from experience how difficult it is to recognize a coast line, certainly when you expect something else. It is therefore not surprising that the saying, "Land ho!" made everyone aboard nervous. It meant good and bad news.

On February 22, 1707 a large British fleet was wrecked as a result of navigational error: 2000 sailors were left dead at sea. This incident was more than the admiralty could bear. Following this disaster, the British parliament promised the sum of 20,000 pounds – converted to nowadays' rate, a sum worth many millions of euros – to the person solving the longitude problem. The quest was officially open.

Depending on the longitude, the sun, stars and other celestial bodies reach their highest point in the sky on a different moment. A difference of one degree in longitude corresponds to 4 minutes in this so-called solar or star time. Many proposals were submitted as the solution to navigating at high seas and returning safely to the home port. There were proposals like the one for a fleet of signal ships spread over the oceans. Every day at fixed and known times, these ships would detonate a bomb at high altitude. A navigator could calculate his local time, as measured by the sun's position, and compare it with the time of the signal ships. This time difference indicated the distance from the navigator's position to the nearest signal ship. Based on practical problems, this proposal was rejected.

The race for the 'Longitude prize' finally went between two men, the astronomer Sir Nevil Maskelyne and a simple carpenter and clockmaker, John Harrison. The fight was between a 'celestial clock' and a 'mechanical clock'.

The celestial clock is a method that uses a predictable celestial phenomenon visible for everyone for the determination of time on another location on earth. The navigator measures with a sextant the vertical angle between a celestial body and the horizon. If the vertical angle, the date and the moment of the day are known, the altitude line of the location can be calculated. Solar or lunar eclipses lend themselves very well for this, but they are too rare to be really useful. Sir Maskelyne proposed to use the method of lunar distances, which is based on the relatively rapid movement of the moon through the sky. The lunar distance (the angle between the moon and a known bright star) is observable by everyone – although with a parallax error – at the same moment. After the observation, the navigator consults a nautical almanac with the predicted lunar distances and the times at which they will occur. Through the comparison of the adjusted, observed lunar distance with the predicted value, the navigator can calculate his longitude. However, this method is not user friendly – an expression not well-known at that time – because of the complexity of the astronomical calculations in a time without computers.

Harrison's mechanical clock or chronometer (also called sea watch or ship clock) ultimately won the prize giving navigators a trustworthy time reference on board. The miracle of the mechanical clock was that after several months at sea, it still indicated the time in Greenwich. A navigator could calculate the difference in solar times between the local time determined with a sextant by observing the sun and with the time in Greenwich on his watch. For example, when the sun is one hour later at its highest point than the Greenwich time, the navigator can be sure that he is 60 minutes divided by 4 minutes per degree, i.e. 15 degrees longitude West of Greenwich. A derogation of a mere four seconds on the equator means an error of a few nautical miles! So the ships watch had to be very precise.

MODERN METHODS

Fortunately, in the 20th Century other tools, such as radio beacons, radar, automatic positioning systems (e.g. DECCA, LORAN) were introduced and finally in 1985 GPS based on satellites became available. Thanks to this new system, which may be supplemented with a reference station, it is now possible to accurately determine a position with a margin of a few centimeters.

Despite modern resources, it is useful to occasionally reflect on the history and the content of the concepts which we as divers take for granted. I hope that this series of articles has contributed to your personal reflection.