Date	16 May 1995
DR Latitude (1156 ZT)	39° 55.0' N
DR Longitude (1156 ZT)	157° 23.0' W
Central Meridian	150° W
d Longitude (arc)	7° 23' W
d Longitude (time)	+29 min. 32 sec
Meridian Passage (LMT)	1156
ZT (first estimate)	12-25-32
DR Longitude (12-25-32)	157° 25.2'
d Longitude (arc)	7° 25.2'
d Longitude (time)	+29 min. 41 sec
Meridian Passage	1156
ZT (second estimate)	12-25-41
ZT (actual transit)	12-23-30 local
Zone Description	+10
GMT	22-23-30
Date (GMT)	16 May 1995
Tabulated Declination / *d*	N 19° 09.0' / +0.6
d correction	+0.2'
True Declination	N 19° 09.2'
Index Correction	+2.1'
Dip (48 ft)	-6.7'
Sum	-4.6'
h_s (at LAN)	69° 16.0'
h_a	69° 11.4'
Altitude Correction	+15.6'
89° 60'	89° 60.0'
h_o	69° 27.0'
Zenith Distance	N 20° 33.0'
True Declination	N 19° 09.2'
Latitude	39° 42.2'

longitude difference. The correction for 7° of arc is 28' of time, and the correction for 25.2' of arc is 1'41" of time. Finally, apply this time correction to the original tabulated time of meridian passage (1156 ZT). The resulting time, 12-25-41 ZT, is the second estimate of LAN.

Solving for latitude requires that the navigator calculate two quantities: the Sun's declination and the Sun's zenith distance. First, calculate the Sun's true declination at LAN. The problem states that LAN is 12-28-30. (Determining the exact time of LAN is covered in Article 2011.) Enter the time of observed LAN and add the correct zone description to determine GMT. Determine the Sun's declination in the same manner as in the sight reduction problem in Article 2006. In this case, the tabulated declination was N 19° 19.1', and the d correction +0.2'. The true declination, therefore, is N 19° 19.3'.

Next, calculate zenith distance. Recall from Navigational Astronomy that zenith distance is simply 90° - observed altitude. Therefore, correct h_s to obtain h_a; then correct h_a to obtain h_o. Then, subtract h_o from 90° to determine the zenith distance. Name the zenith distance North or South depending on the relative position of the observer and the Sun's declination. If the observer is to the north of the Sun's declination, name the zenith distance north. Conversely, if the observer is to the south of the Sun's declination, name the zenith distance south. In this case, the DR latitude is N 39° 55.0' and the Sun's declination is N 19° 19.3'. The observer is to the north of the Sun's declination; therefore, name the zenith distance north. Next, compare the names of the zenith distance and the declination. If their names are the same (i.e., both are north or both are south), add the two values together to obtain the latitude. This was the case in this problem. Both the Sun's declination and zenith distance were north; therefore, the observer's latitude is the sum of the two.

If the name of the body's zenith distance is contrary to the name of the Sun's declination, then subtract the smaller of the two quantities from the larger, carrying for the name of the difference the name of the larger of the two quantities. The result is the observer's latitude. The following examples illustrate this process.

Zenith Distance	N 25°	Zenith Distance	S 50°
True Declination	S 15°	True Declination	N10°
Latitude	N 10°	Latitude	S 40°

2011. Longitude at Meridian Passage

Determining a vessel's longitude at LAN is straightforward. In the western hemisphere, the Sun's GHA at LAN equals the vessel's longitude. In the eastern hemisphere, subtract the Sun's GHA from 360° to determine longitude. The difficult part lies in determining the precise moment of meridian passage.

Determining the time of meridian passage presents a problem because the Sun appears to hang for a finite time at its local maximum altitude. Therefore, noting the time of maximum sextant altitude is not sufficient for determining the precise time of LAN. Two methods are available to obtain LAN with a precision sufficient for determining longitude: (1) the graphical method and (2) the calculation method. The graphical method is discussed first below.

See Figure 2011. For about 30 minutes before the estimated time of LAN, measure and record several sextant altitudes and their corresponding times. Continue taking sights for about 30 minutes after the Sun has descended from the maximum recorded altitude. Increase the sighting frequency near the meridian passage. One sight every 20-30 seconds should yield good results near meridian passage; less frequent sights are required before and after.

Plot the resulting data on a graph of sextant altitude versus time and draw a fair curve through the plotted data. Next, draw a series of horizontal lines across the curve formed by the data points. These lines will intersect the faired curve at two different points. The x coordinates of the points where these lines intersect the faired curve represent the two different times when the Sun's altitude was equal (one time when the Sun was ascending; the other time when the Sun was descending). Draw three such lines, and ensure the lines have sufficient vertical separation. For each line, average the two times where it intersects the faired curve. Finally, average the three resulting times to obtain a final value

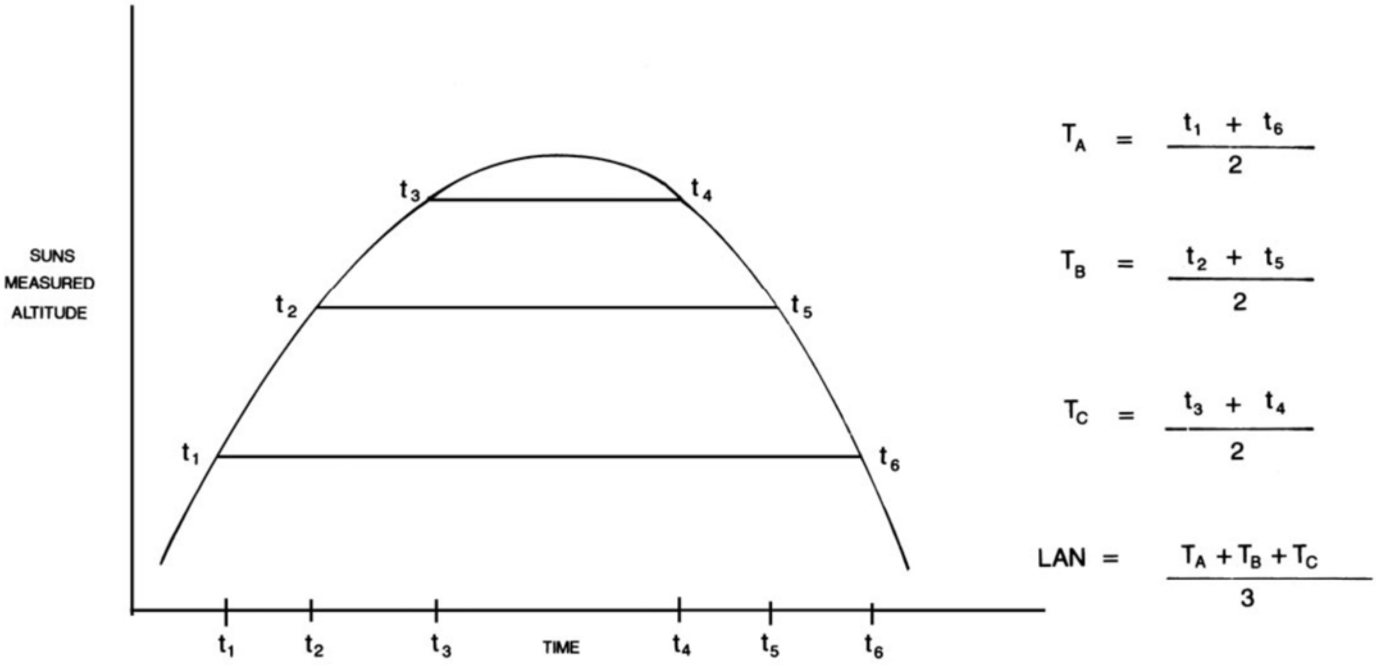

Figure 2011. Time of LAN.

for the time of LAN. From the *Nautical Almanac*, determine the Sun's GHA at that time; this is your longitude in the western hemisphere. In the eastern hemisphere, subtract the Sun's GHA from 360° to determine longitude. For a quicker but less exact time, simply drop a perpendicular from the apex of the curve and read the time along the time scale.

The second method of determining LAN is similar to the first. Estimate the time of LAN as discussed above, Measure and record the Sun's altitude as the Sun approaches its maximum altitude. As the Sun begins to descend, set the sextant to correspond to the altitude recorded just before the Sun's reaching its maximum altitude. Note the time when the Sun is again at that altitude. Average the two times. Repeat this procedure with two other altitudes recorded before LAN, each time presetting the sextant to those altitudes and recording the corresponding times that the Sun, now on its descent, passes through those altitudes. Average these corresponding times. Take a final average among the three averaged times; the result will be the time of meridian passage. Determine the vessel's longitude by determining the Sun's GHA at the exact time of LAN.

LATITUDE BY POLARIS

2012. Latitude by Polaris

Since Polaris is always within about 1° of the North Pole, the altitude of Polaris, with a few minor corrections, equals the latitude of the observer. This relationship makes Polaris an extremely important navigational star in the northern hemisphere.

The corrections are necessary because Polaris orbits in a small circle around the pole. When Polaris is at the exact same altitude as the pole, the correction is zero. At two points in its orbit it is in a direct line with the observer and the pole, either nearer than or beyond the pole. At these points the corrections are maximum. The following example illustrates converting a Polaris sight to latitude.

At 23-18-56 GMT, on April 21, 1994, at DR Lat. 50° 23.8' N, λ=37° 14.0' W, the observed altitude of Polaris (h_o) is 49° 31.6'. Find the vessel's latitude.

To solve this problem, use the equation:

$$\text{Latitude} = h_o - 1° + A_0 + A_1 + A_2$$

where h_o is the sextant altitude (h_s) corrected as in any other star sight; 1° is a constant; and A_0, A_1, and A_2 are correction factors from the Polaris tables found in the *Nautical Almanac*. These three correction factors are always positive. One needs the following information to enter the tables: LHA of Aries, DR latitude, and the month of the year. Therefore:

Enter the Polaris table with the calculated LHA of Aries