Starpath StarPilot Procedure for Lunars.

Given DR (best guess) Lat and Lon, measured Lunar Distance, IC, HE, Limb for each body, Temp, Press, and Approximate time, and correct date, find correct Time and Longitude.

(a) To find both accurate longitude and time, the navigator uses one lunar distance sight (which is best selected from a set of similar measurements) with an approximate GMT and approximate DR position. The second body can be the sun, a planet, or star. The method is best when the second body is in line with the easterly motion of the moon. In the analysis, we compute a number that tells how good the situation was during the process compared with the best it could be, ie maximum rate of change of lunar distance with time. Note it is best that the approximate Longitude used be consistent with the approximate time that is used. This can be achieved by using the same watch to find longitude by LAN to get them correlated. Note the Latitude can be assumed to be accurate as we can find that without accurate time.

(b) The sextant is used in a diagonal orientation to measure the angular distance between one edge of the moon and the edge or center of the second body. It is as if the rim of the moon was being used for the horizon and the diagonal "height" of the body was measured relative to it.

(c) This distance is corrected for IC, but note there is no conventional dip correction in this process. The Height of Eye is used in the computation but not for a dip correction. Both the IC and the HE are asked for duing the Lunar input. Note that the HE in this case is a true elevation above sea level. If the sights are done from an elevation of say 300 ft, then enter HE = 300. This is not a conventional use of HE.

(d) To analyze the sight, StarPilot first computes the apparent positions (Ha and Zn) of the two bodies in question at the given approximate time as viewed from the approximate position. In this process, the refraction and parallax corrections are applied "backwards" to the computed altitudes to obtain what we should see. (Normally these corrections are applied to the measured altitudes, but here we do it on the computed altitudes since we have not actually measured them.) [Notes 1]

(e) Next we compute from these corrected positions the angular distance between the two bodies that we should actually measure if our time had been exact. We call this Dc. This is done by first computing center to center distance, and then increasing or decreasing it for the semi-diameter of each body as needed. The semi-diameter corrections will depend on the limbs used in the sight. [Notes 2]

(f) We then compute Dc again at a time 60 minutes before the approximate time in order to find out how the lunar distance is varying with time during the period near the measurement time. At present this procedure is used in all versions of StarPilot, and it seems to work well in the numerous cases we have tested.

(g) We then compare the measured lunar distance value (corrected for SD) which we call Da to the Dc values to see which time and longitude will make them equal and those are the results we present. [Notes 3]

(h) The input is: DRlat, DRlon, Approximate WT, Date, HE, IC, Temp, Press, Lunar Distance and limbs used.
The output is: Corrected WT, Watch Error, Da, Dc, S, and delta D. S is the slope of the lunar distance vs time curve for the conditions of the sight, where a value of, say, 189 would mean the lunar distance is changing at a rate of 1' per 189 seconds. The value of delta D is another way of evaluating the data — it shows how much change in measured lunar distance would have accounted for the full Watch Error reported. If WE turned out to be 5m 51s and delta D was 1.85 it means that an error in the measured lunar distance of just 1.85' could have wiped out the WE completely or nearly doubled it. In short, this procedure requires very careful sights and IC measurements.

If you wish to use external almanac data for the computations instead of StarPilot's internal almanac, then select the body with NA in front of it on the screen that says ** Body for Lunars **. "Sun" means use internal almanac, "NA Sun" means use external data, and then you will be prompted for it.

___________ [Notes over] _______

[Notes 1]
1-A. The internal StarPilot Almanac is used to compute position of moon and second body at the Approximate Time of the measurement. Computed values are RA (Right Ascension), DEC, SD, and Horizontal Parallax (HP) for both bodies. Note we also have the option of solving for Lunars using user's input of external Nautical Almanac data, which might be of interest when comparing historic results.

1-B. Corrections for Parallax are computed using the following formulation.
b/a=0.99664719
u=arctan((b/a)tan(Lat))
pSin(Lat') = (b/a)sin (u) + sin (Lat)*HE/6378140
pCos(Lat')=cos(u) + cos(Lat)*HE/6378140
[Meeus, pg 78]

1-C. The RA and Dec are corrected as follows:
CorrectedRA = RA + arctan(**-**pCos(Lat')sin(HP)sin(LHA)/(cos(Dec) **-** pCos(Lat')sin(HP)cos(LHA))

CorrectedDec = arctan((sin(DEC) **-** pSin(Lat')sin(HP))cos(DeltaRA)/(cos(DEC) **-** pCos(Lat')sin(HP)cos(LHA))
[Meeus, pg 264]

Note: Dependency of Height of Eye above sea level in the Parallax computation.

[Note 2]
2-A. Next we compute Hc and Zn from the corrected RA and DEC, and then

Correction for Refraction is computed and added to Hc to get Ha
Ha =Hc + 1.02/tan(Hc+10.3/(Hc+5.11))*0.28(Pressure)*0.0167/(Temp+273)
Note: Dependency on Temp and Pressure in Refraction correction.
[Meeus pg 102]

2-B. Next Ha and Zn are converted back to RA and DEC.

The Parallax correction is computed using
CorrectedRA = RA + DeltaRA, CorrectedDec = Dec + DeltaDec

Angle between two bodies (Dc) is computed using:
Dc = Arccos{ sin(DEC1)sin(DEC2)+cos(DEC1)cos(DEC2)cos(RA1-RA2) }
[Meeus pg. 105]

2-C. Computed angles Dc are also computed for the incremented times before and after the Approximate Time

Note: Correction for Parallax and Refraction is dependent on Lon. If DR position is way off due to large time error then a new fix should be computed with corrected time and lunars run again. It may take several iterations of Fix, Lunars to get an accurate time and DR position. Note that Longitude may be off by several degrees before a big impact in the Parallax and Refraction corrections are noted. In the 89 and PC versions of StarPilot, we do these iterations automatically, with the number of interations input at the beginning of the process.

[Notes 3]
3-1. When doing the semidiameter corrections to the measured distance, the semidiameter of moon is corrected for topocentric semidiameter by multiplying SD*(1 + sin(Hc)sin(HP)). Where HP and Hc used are from the internal almanac computation using the Approximate Time.

3-2. A simple linear interpolation is used on data to find the correct time and longitude.