11.6.2. Obtain needed corrections, sextant correction, refraction, etc., and apply these to the Hc by reversing the sign (remember, we are striving to derive a precomputed value to ensure the correct body is shot). Measure the altitude (Ho) of the celestial body with the sextant and record the midtime of the observation.

11.6.3. Find the intercept, which is the difference between Ho and Hc. Intercept is toward the subpoint if Ho is greater than Hc and away from the subpoint if Ho is smaller than Hc.

11.6.4. From the assumed position, measure the intercept toward or away from the subpoint (in the direction of Zn or its reciprocal) and locate a point on the LOP. Through this point, draw the LOP perpendicular to the Zn.

11.7. Additional Plotting Techniques. The preceding techniques involve the basic plotting procedures used on most stars and the bodies of the solar system. However, there are certain techniques of plotting that are peculiar to their own celestial methods; for example, the plotting of LOPs obtained by using Polaris, which is discussed later. Also, certain precomputation techniques lend themselves more readily to other plotting techniques, such as preplotting the true azimuths or plotting the fix on the DR computer.

11.7.1. These last plotting techniques are discussed in Pub. No. 249 in the section on precomputation.

11.7.2. Other special techniques are discussed in the section on curves, in which the celestial observation is plotted on a graph rather than on the chart.

Section 11B—Interpretation of an LOP

11.8. Basics. Navigation has two aspects—the mechanical and the interpretive. The mechanical aspect includes operation and reading of instruments, simple arithmetical calculations, plotting, and log keeping. The interpretive aspect is the analysis of the data that have been gathered mechanically. These data are variable and subject to error. You must convert them into probabilities as to the position, track, and GS of the aircraft and the direction and speed of the wind. The more these data are subject to error, the more careful the interpretations must be and the less mechanical the work can be. LOPs and fixes especially require careful interpretation. It is convenient to think of a fix as the true position of the aircraft and of the LOP as a line passing through this position, but these definitions are optimistic. It is almost impossible to make a perfect observation and plot a perfect LOP. Therefore, an LOP passes some place near this position, but not necessarily through it and a fix determined by the intersection of LOPs is simply the best estimate of this position on the basis of one set of observations. Thus, in reality, a fix is a most probable position (MPP) and a LOP is a line of MPP.

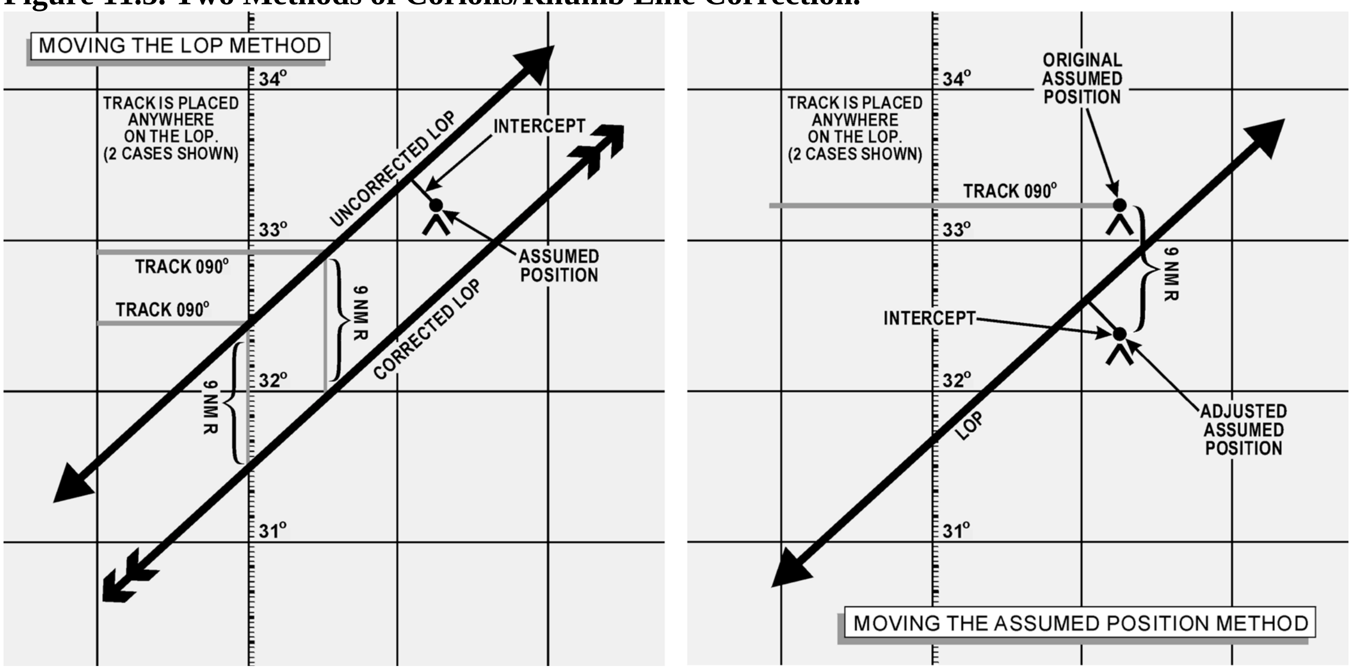
11.8.1. The best interpretation of LOPs and fixes means they are used, to the best advantage, with DR. But good interpretation cannot compensate for poor LOPs, nor can good LOPs compensate for careless DR. To get good results, every precaution must be taken to ensure the accuracy of LOPs and exact DR calculations.

11.8.2. Intelligent interpretation requires fine judgment, which can only be acquired from experience. You can be guided, however, by certain well-established, though flexible, rules.

11.8.3. The following discussion pertains especially to celestial LOPs and fixes. It also applies to LOPs and fixes established by radio and, to some extent, to those obtained by map reading.

11.9. Single LOP. Previous discussions dealt with the basic plotting of an LOP and errors in LOPs, but they did not show the actual mechanics of the plotted corrections which must be applied. The LOP must be corrected for Coriolis or rhumb line correction and also for precession and/or nutation correction if it is based on a Volume 1 star shot. Coriolis or rhumb line correction becomes a very significant correction at higher speeds and latitudes. For example, suppose the correction determined from the Coriolis or rhumb line correction table is 9 NM right (of the track). The LOP must be moved a distance of 9 NM to the right of track. This can be done either by moving the assumed position prior to plotting, or by moving the LOP itself after it is plotted. (Remember the assumed position is not used in the plotting of the LOP obtained from a Polaris observation.) Consider Figure 11.5, which shows a track of 90°.

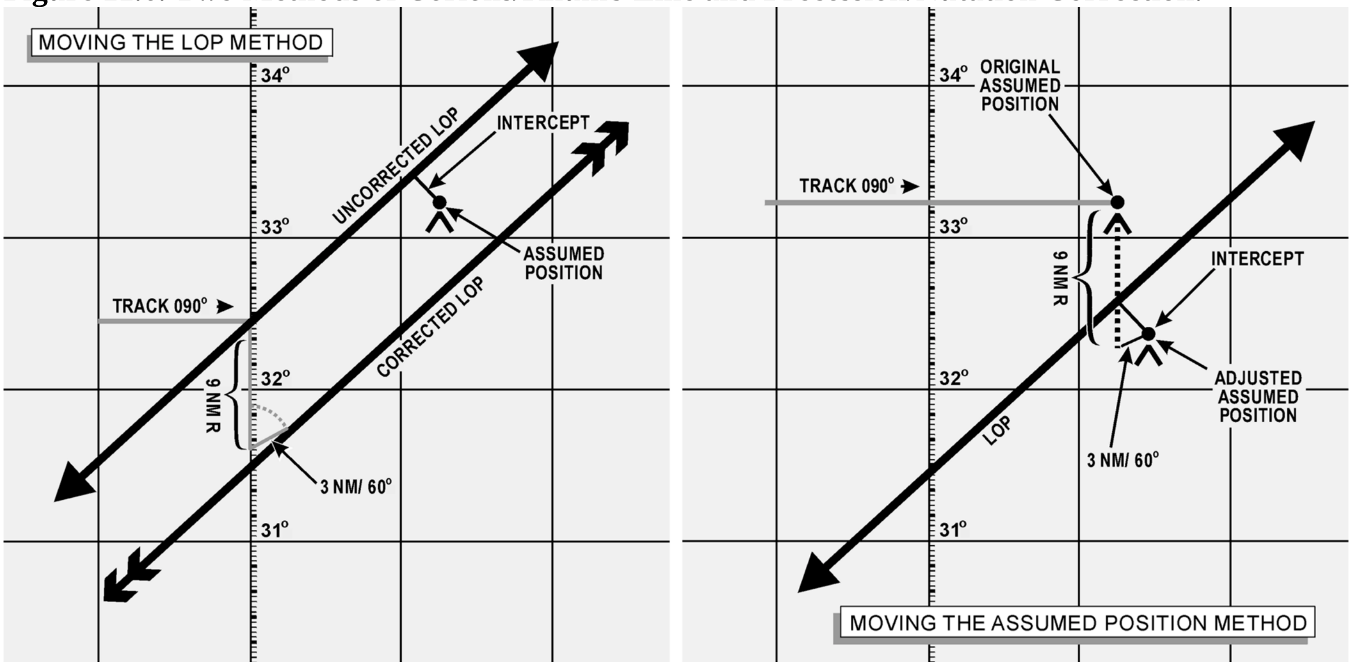
Figure 11.5. Two Methods of Coriolis/Rhumb Line Correction.



11.9.1. Notice that, in both methods, the corrected LOP is in the same place with respect to the original assumed position and that the intercept value is the same. The resultant LOP is the same regardless of the method used.

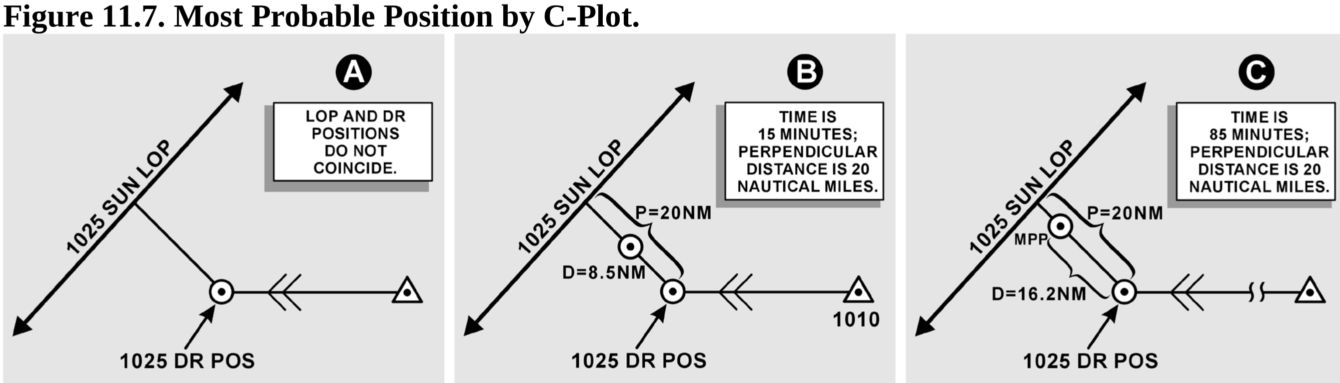
11.9.2. If, in addition to the Coriolis or rhumb line correction, a precession and/or nutation correction of 3 NM in the direction of 60° is required, it would have been further applied as shown in Figure 11.6. Again, the corrected LOP is the same, using either method, because the intercept and resultant position of the corrected LOP to the original assumed position are the same. The corrected LOP alone gives very little information; hence, a position must be arrived at only after considering the LOP and the DR position for the same time.

Figure 11.6. Two Methods of Coriolis/Rhumb Line and Precession/Nutation Correction.



11.10. Most Probable Position (MPP) by C-Plot. The MPP is just what the name implies. It is not a fix; however, since it is the best information available, it is treated as such. Notice in A of Figure 11.7 that the DR position and celestial LOP (for the same time) do not coincide.

Figure 11.7. Most Probable Position by C-Plot.



11.10.1. Obviously, the DR information or celestial information, or both is in error. Notice that the prior fix has no time on it. Suppose this prior fix had been for the time of 1010. It would then be very likely that most of the error is in the celestial information and the probable position is closer to the DR position than to the celestial LOP. On the other hand, suppose the prior fix had been for the time of 0900. Since the accuracy of the celestial information is unaffected by the time from the last fix, it would, in this case, be most likely that the actual position is closer to the LOP than to the DR position.

11.10.2. A formula has been devised to position the observer along the perpendicular to the LOP according to the time factor. The formula is:

$$\frac{d}{t} = \frac{p}{t+p}$$

where t is time in minutes, p is the perpendicular distance between the DR position and the LOP and d is the distance from the DR position for the time of the MPP measured along the perpendicular to the LOP. Look at B and C of Figure 11.7 and see how the formula works for the two problems cited above if the perpendicular is 20 NM in length. In B of Figure 11.7, t is 15 minutes and p is 20 NM, so the MPP would be located along the perpendicular about 8½ NM from the DR position.

$$\frac{d}{15} = \frac{20}{15+20} \qquad d = \frac{300}{35} = 8.57\text{NM}$$

11.10.3. Now, consider C in Figure 11.7 where t is 1 hour 25 minutes or 85 minutes, p is 20 NM and in this case, the MPP would be over 16 NM away from the DR position along the perpendicular to the LOP.

$$\frac{d}{85} = \frac{20}{85+20} \qquad d = \frac{1700}{105} = 16.2\text{NM}$$

11.10.4. If you prefer not to use the formula, a simple table can be easily constructed to solve for d with entering arguments of t and p as shown in Figure 11.8. The table could easily be enlarged to handle larger values of t and p. In most fixes, the DR position is so close to the LOP that the midpoint between these two can be considered the MPP. A good rule to use is to take the midpoint of the perpendicular if the total distance between the DR position and the LOP is 10 NM or less. If the value of p is greater than 10 NM, use a table or the formula to determine the MPP. Up to this point, determination of the MPP has been rather mechanical. Experienced navigators will frequently further adjust the position of the MPP for other factors not yet considered. For example, if the LOP is carefully obtained under good conditions or if it is the average of several LOPs, you may further weight the MPP in the direction of the LOP by an amount that judgment dictates. However, the reverse may be true if the LOP is obtained under adverse conditions of rough air. In the latter case, you might move the MPP closer to the DR position by some amount determined by sound judgment.

Figure 11.8. To Solve for Distance.

P ▼	"t"—TIME IN MINUTES			
	10 m	15 m	30 m	60 m
12	5	7	9	10
14	6	7	10	11
16	6	8	10	13
18	6	8	11	14
20	7	9	12	15
25	7	9	14	18
30	8	10	15	20
35	8	10	16	22
40	8	11	17	24
45	8	11	18	26
50	8	12	19	27
55	9	12	19	29
60	9	12	20	30
To the closest NM values of "d" in the formula.				

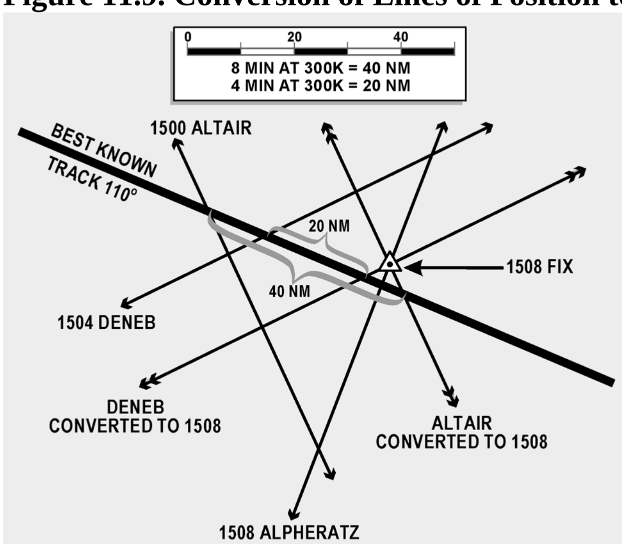
11.10.5. Further, consider the validity of the DR position in relation to factors other than time. A DR position at the end of 40 minutes would be more reliable with Doppler drift and GS versus one based on metro information. These factors may also adjust the original MPP closer to or farther away from the DR position, along the perpendicular. However, these last mentioned factors are judgment values that come only with experience. In fact, with experience you may mentally calculate all the factors involved and arrive at the final position of the MPP without recourse to a formula or table.

11.11. Finding a Celestial Fix Point. Up to this point, only the single celestial LOP and what to do with it have been considered. Now, the celestial fix should be considered. To establish a fix, two or more LOPs must be obtained. Since, in most cases, two or more LOPs cannot be obtained simultaneously, they must be converted to a common time. For example, a LOP obtained at 1010 must be converted to the LOP obtained at the fix time of 1014. There are several methods for making this conversion, which are discussed in this chapter. Consideration is also given to the planning of the fix and the final interpretation of the fix itself.

Section 11C—Conversion of LOPs To A Common Time

11.12. Moving the LOP. One method of converting LOPs to a common time is to move the LOP along the best-known track for the number of minutes of GS necessary for the time conversions. This method is similar to that used for correcting for Coriolis or rhumb line and precession or nutation. For example, suppose the track is 110^{o} and the GS 300 knots. LOPs are for 1500, 1504, and 1508 and a fix is desired at 1508. This means the 1500 LOP must be moved to the time of the fix, using the track and 8 minutes of the best known GS. The 1504 LOP must be moved to the time of the fix, using the track and 4 minutes of GS. The 1508 LOP is already at the fix time, so it requires no movement. Figure 11.9 shows the method of conversion as it is completed on the chart.

Figure 11.9. Conversion of Lines of Position to a Common Time.



11.12.1. If, at any time, the LOP has to be retarded (moved back) to the time of the fix, use the following procedures. Using the reciprocal track and GS, obtain the correction in the regular manner for the number of minutes of difference. For example, suppose the fix is at 1800 and the last shot is at 1802.