FORUM

Use of a Doppler Navigation System and Fixes to Monitor Aircraft Heading

from Wing Commander D. F. H. Grocott, A.F.C.
(R.A.F. Air Warfare College)

When trials of civil aircraft doppler navigation systems are carried out over land the pattern of results generally show a small along-track error component and a large across-track error component, whereas when the basic doppler radar is assessed, the errors over land are about $\pm 0{\cdot}2$ per cent of distance gone and $\pm 0^\circ.2$in drift (standard deviation). It is not possible to quote system errors for all permutations of doppler equipments and compass systems but it is suggested that a good working figure for the across-track system error component would be about ± 3 per cent (standard deviation), i.e. a compass error of $\pm 1^\circ.7$. Advantage can be taken of the inherent accuracy of the doppler radar equipment to determine the heading error from a knowledge of track made good and the mean doppler drift along that track.

The standard twin-channel civil doppler navigation computer combines aircraft heading with doppler drift and doppler distance gone to form a 'computer track' in coordinates of distance along and across a preset track and distance. The computer is, in effect, meaning the doppler drift between selected points and adding this value to an arbitrary datum (aircraft compass) to form the computer track. If we can determine the true track over the ground we can assume that the error between computer track and actual track is caused entirely by error in the arbitrary datum, i.e. heading error. In general this is true; compass errors tend to have a large constant or D.C. component and a small variable or A.C. component, provided the aircraft continues to fly in the same general direction.

Let us assume that a civil airliner leaves London Airport and heads via Daventry and Prestwick to a D.R. position at 58°00′N. 10°00′W. and 60°00′N. 20°00′W. Using the standard twin-channel civil doppler computer the navigator will be aware of an increasing across-track component error, caused by compass error, as he checks the computer position with ground fixes. For the sake of argument we can assume that the aircraft was flown on a constant track from London Airport to 58°00′N. 10°00′W. although the principle holds good if the aircraft 'dog-legs' across this mean track. On approaching 58°00′N. 10°00′W. the navigator obtains Tacan distances (accuracy $\pm 0{\cdot}3$ n.m. standard deviation) from the Tacan stations at Stornaway and Prestwick, ideally situated to give a perfect 90° cut at this point. At the same time as the Tacan distances are obtained, the navigator notes the along and across track coordinates on the doppler computer (Fig. 1).

For the example shown in Fig. 1 the computer coordinates show 3 n.m. to left of the intended track and 461 n.m. from London Airport whereas the Tacan fix is 10 n.m. to starboard of the intended track and 460 n.m. from London Airport. The computer error is therefore 13 n.m. and this has accumulated on a run of

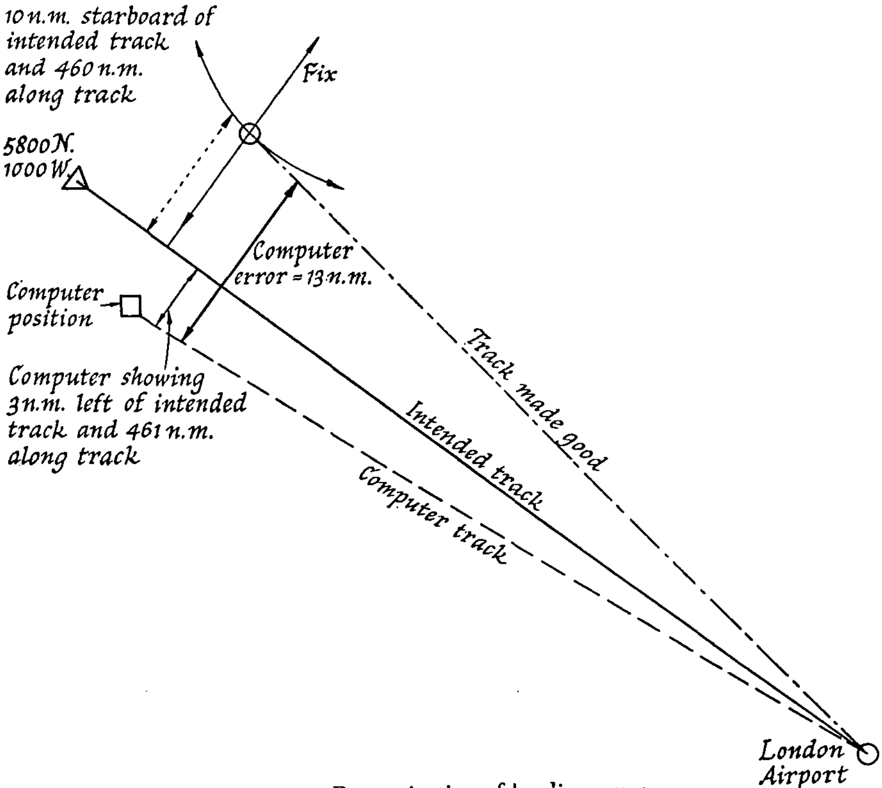

FIG. 1. Determination of heading error

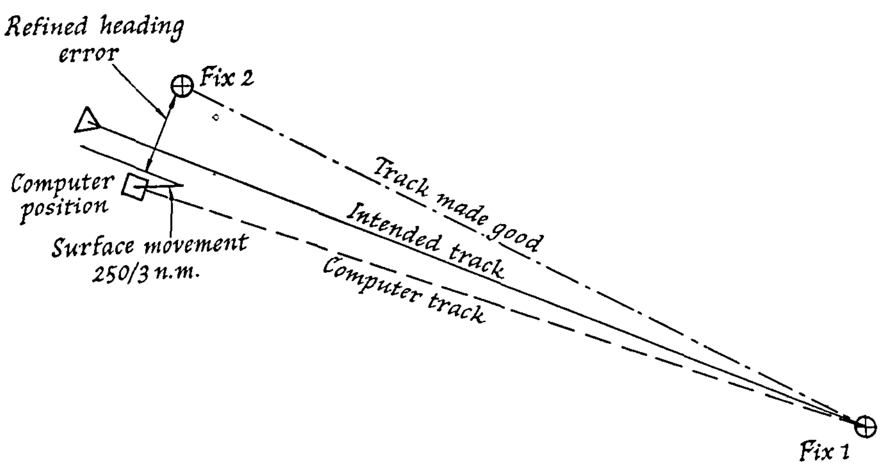

FIG. 2. Determination of heading error when sea movement is present

https://doi.org/10.1017/S0373463300020348 Published online by Cambridge University Press

460 n.m., giving an heading error of − 1°.62. This value may be set on the variation setting control or the navigator can apply a correction of + 1°.62 to all future track directions.

The track for the example quoted in Fig. 1 was mainly over land and therefore not subject to sea movement error (*Journal*, April 1960, p. 220). Should the navigator desire to make a small correction for this error when flying over the sea it will be necessary to apply a vector distance downwind from the computer position as shown in Fig. 2. In this example the met. forecast surface w/v is 250/18 kt. and the sea movement vector error for this wind is 250/4 kt. The time taken between the two fixes is 45 minutes and actual surface movement is therefore (45/60)4 = 3 n.m. This value is plotted downwind from the computer position as shown in Fig. 2.

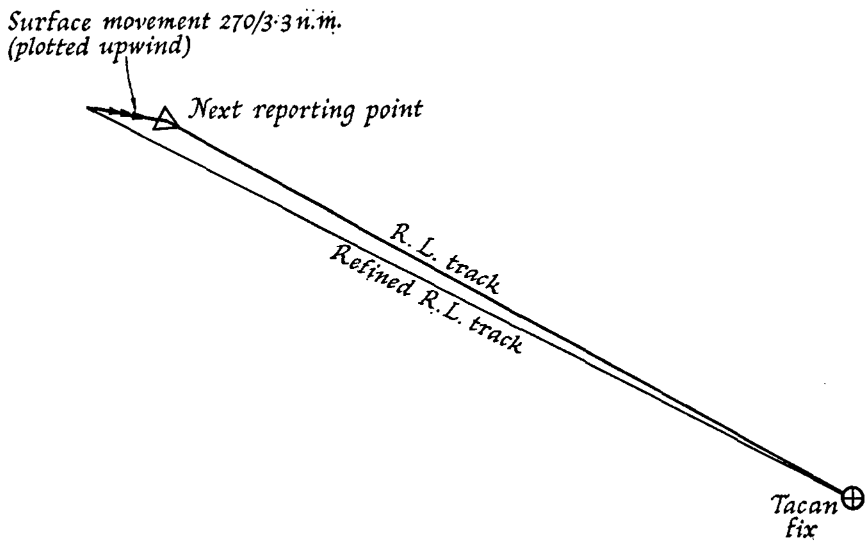

FIG. 3. Determination of refined R.L. track

A refinement may also be applied to the intended track to compensate for sea movement as shown in Fig. 3. In this example the met. forecast surface w/v is 270/30 kt. and the sea movement vector error for this wind is 270/5 kt. The D.R. time from current position to the next reporting point is 40 minutes and the actual surface movement is therefore (40/60)5 = 3·3 n.m. This value is plotted *upwind* from the next reporting point as shown in Fig. 3.

Readers will note that the critical measurement is the across-track component and in the example quoted in Fig. 1 a navigator with a single Tacan equipment (or Vortac) would have concentrated on the Stornaway beacon to obtain the track error. It is perhaps most fortunate that the main civil ground based systems on the North Atlantic, Loran and Decca, yield high accuracy across-track position lines when flying in a general east/west direction.

https://doi.org/10.1017/S0373463300020348 Published online by Cambridge University Press