The nonsensical running fix

BY JOHN KARL

Have you been taught to avoid narrow LOP crossing angles in plotting running fixes? Have you had difficulties in getting satisfactory agreement with your GPS? Shouldn't any new LOP, even with a narrow crossing angle to a previous one, improve your position estimate? Well yes it should — and it does. We need to rethink running fixes, just as I did in my book *Celestial Navigation in the GPS Age*, where I had to rethink several navigation traditions. Traditions run strong at sea — but we shouldn't let them run us aground.

Estimations

Tradition has it that Columbus was a very poor celestial navigator, but one whale of a navigator nonetheless. By estimating and plotting speed, heading, leeway, and currents he was able to return safely to Portugal from the New World. Today navigators call using estimated speed and heading dead reckoning (DR). Upgrading the DR position by using leeway, currents, or any other relevant information, such as a newly acquired LOP, results in an estimated position (EP). Both the DR position and the EP are estimates. And the rules for making the best estimate are simply common sense: use all available information without invoking unnecessary assumptions or contradictions.

This self-evident logic of estimation theory is easily applied to the running fix. We consider the case where the LOP accuracy is substantially greater than the dead reckoning accuracy, as is usually the case after a run of some length. Many kinds of LOPs will satisfy this, such as range, bearing, and celestial. (Short-run fixes, such as in a round of star shots taken over a relatively short time from a slow vessel may well have better DR accuracy than LOP accuracy — that's a different topic.)

To start our line of reasoning, consider dead reckoning from a known departure point, followed by establishing an LOP at a substantially later time. Figure 1 shows this situation with our position at DR1 when LOP1 was acquired. We now wish to upgrade our DR position to an estimated position using the new and more accurate LOP1 information. We know

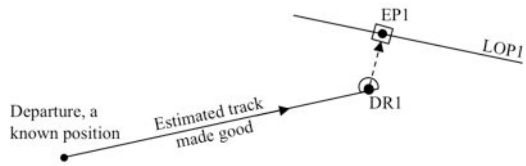

Figure 1

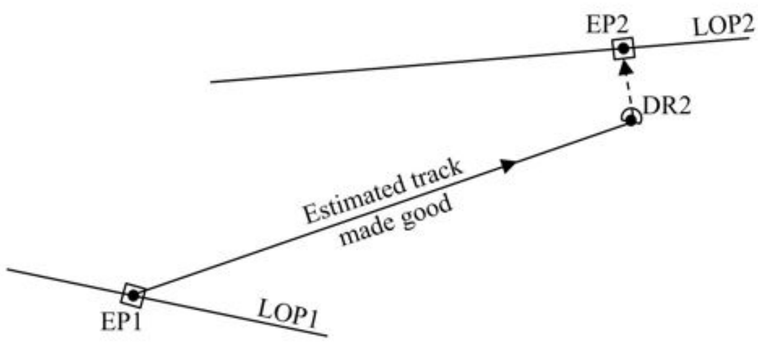

Figure 2

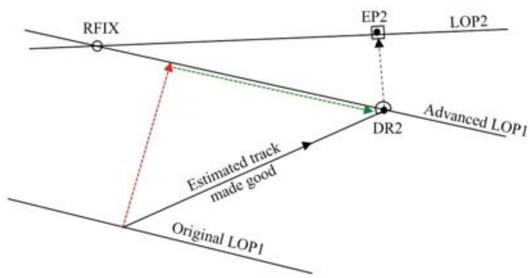

Figure 3

that this new LOP1 only constrains our position perpendicular to itself, with no constraint whatsoever along it. So if we drop a perpendicular to LOP1, from DR1 to EP1, we make full use of the LOP's perpendicular constraint, while retaining all of the DR information parallel

Figure 1 shows how an estimated position (EP) is established on a new LOP. Figure 2 shows that with LOP2 we can create a new EP. Figure 3 shows errors possible with a running fix.

to LOP1. So that is the best estimate, meeting all the above criteria — it uses all available information without invoking unnecessary assumptions or contradictions.

Next, let's say at some later time a second observation provides LOP2 when the ship's position is placed at DR2, as shown in Figure 2. Over time the run from EP1 has degraded our position estimate into a DR position by using estimates of heading and distance. So we again have a DR position with a newly acquired LOP, just as in Figure 1. Therefore we again drop a perpendicular line to the new LOP to get our estimated position at EP2. This is an *EP running fix*. We use this method for each newly acquired LOP, continually adding newly acquired LOPs, while intentionally retaining DR information which has not been overruled by the latest LOP.

A tradition of the sea

Now our old man hollers, "hold on there mate, punch the MOB button, do a quick-turn recovery — we've just lost a tradition of the sea overboard! Every old salt knows that we're supposed to advance the first LOP to the time of DR2 and plot a running fix where that advanced LOP intersects the new LOP.

Our captain has the tradition right, but he has jettisoned logic to leeward. His traditional running fix, diagrammed in Figure 3, fails all of our estimation criteria; even worse, it contains nonsensical assumptions. First note that this traditional running fix completely ignores any information about the location of the ship along LOP1. This means that *any* estimated track with the same component perpendicular to LOP1 yields the same running fix, regardless of our knowledge of the ship's location along LOP1. But in actual reality, we always have *some* idea of where our ship is. Why not use this information?

Even more significant, as can be seen from the figure, this traditional running fix assumes that the component of estimated track perpendicular to LOP1 is exact, while in contrast, it assumes that the component of the estimated track along LOP1 is capable of unlimited error. As shown in the figure, this means that RFIX can even be forced in the opposite direction of the track component along LOP1. It's trapped into allowing arbitrary error along the advanced LOP1, otherwise LOP2 would necessarily pass through DR2. Thus it nonsensically allows the orientation of LOP1 to decree the directions of exact information and of arbitrarily large error. And neither even exist in our dead reckoning. Furthermore, it's obvious that whatever the direction and magnitude of dead-reckoning errors, they're independent of LOP1's orientation. So that's a contradiction piled upon unjustified assumptions, all while disregarding available information. Is there a worse approach to estimation logic?

Additionally, we see that for all crossing angles and dead reckoning uncertainty, the estimated position EP2 is always closer (or equal) to our best previous estimate at DR2 than is RFIX. Indeed, you can see from Figure 3 that for sufficiently small crossing angles, RFIX could be off by many miles, magnifying the DR error, rather than reducing it as the estimated position does. Thus the EP increases the value of LOPs having narrow crossing angles. After all, *any* new LOP must *improve* the dead-reckoned estimate by constraining it to a line. And this is exactly what the EP does — it always improves the DR estimate, while the traditional running fix can easily make it worse. Also note, as can be visualized from Figure 3, that as the angle between two successive LOPs approaches 90°, the results of the EP running fix and the traditional running fix approach one another.

The ultimate example of narrow LOP crossing angles is successive meridian shots in celestial navigation (such as the famous noon-sun shots). Since every sight gives a new latitude, these successive east-west LOPs never cross. Without even thinking about running fixes, navigators of old corrected their DR position by the newly observed latitude, but retained their dead reckoned longitude: in plotting terms, they're dropping a perpendicular from the DR position to the LOP — a perfect example of using the estimated position between successive LOPs.

The EP is always superior. We have seen that it's the best estimate after a substantial run between successive LOPs; it's useful at all LOP crossing angles; and it's even easier to plot. The next time you're working the chart table, why not compare several successive traditional and EP running fixes with your GPS — you'll be glad you did when that GPS fails. ■

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