

# Three-body Sextant Piloting

Many of the old techniques of piloting have long been left out of many modern textbooks, but there is at least one that deserves reconsideration, even in modern times of GPS. That one is the onetime famous "3-body fix" made from sextant sights of landmarks.

The three-body fix is probably the most accurate piloting technique, and it is also one that is very easy to do and to resolve on the chart. There are several solutions. The technique is often considered "marine surveying" rather than just piloting because of its potential accuracy.

A new interest in this method might come about once it is recognized that we do not need an expensive sextant to do the measurements. The simple Davis Mark 3 plastic sextant (list price under \$50) will do the job very nicely, and indeed the inexpensive model is almost preferred in many applications to sextants that cost \$2,000 or more because of its ease of use in this application. We do not need the precision of a high-quality metal sextant in order to obtain high precision in this sextant piloting procedure. A few tenths of a degree is plenty of accuracy and this is easily achieved with the Davis Mk 3 unit.

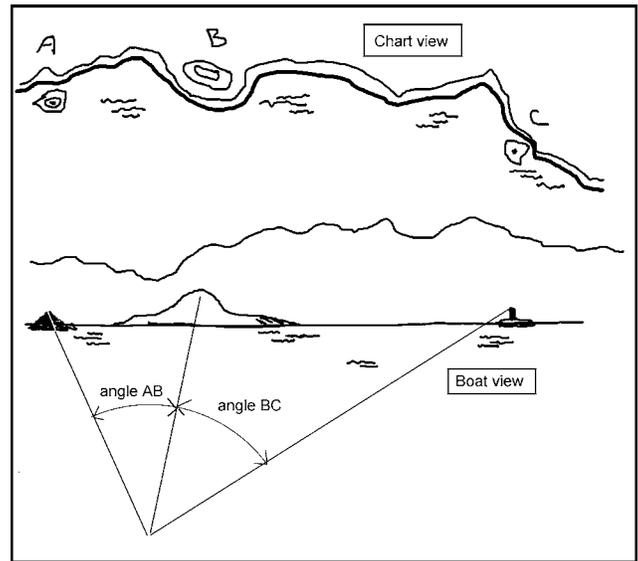
The procedure is to identify 3 well localized charted landmarks on the horizon that are less than some  $90^\circ$  apart in bearing. The use the sextant, held horizontally, to precisely measure the actual angles between the center one and left one, and then the center one and the right one. Calling the points A, B, and C as shown in figure 6-25, we end up with two angles AB, and BC.

Note that you could indeed take compass bearings to A, B, and C, and then subtract them to get the angles AB and BC, but this will not be nearly as accurate, although it might be a way to practice the plotting technique on a chart without a sextant.

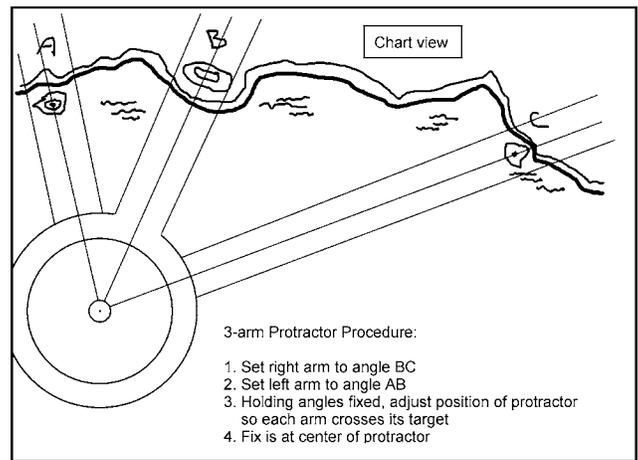
Figures 6-26 and 6-27 show how to get a fix from the two angles. The first method requires a special tool called "three-arm protractor." These days, inexpensive plastic ones are available for under \$20. In the old days, the instrument was made with extreme precision and was called a "station pointer." We have one of these dated 1942 at the school, but we use the plastic one for actual navigation. The second method is done with a simple protractor and ruler, or just any straight edge and a compass rose on the chart.

The virtue of the method, besides its precision result, is it not affected by compass errors and is actually faster than taking compass bearings in many situations. Generally it is best to take the sights as rapidly as possible when you are moving, because correcting for vessel motion is more complicated for these sights. The fix is especially well suited for checking a GPS position from a stationary location, or to check to see if you have dragged your anchor.

The disadvantage of the method is that not all landmarks that meet the angle requirement will yield a good fix. The principle of the method is based on the geometric fact that any 3 points in a plane define a unique circle and if you measure the angle between two of these points from the third one, you can compute or construct the circle that passes through all three. We measure the angle between A and B, and from that we can construct the circle that passes through points A, B, and our location. We then do this with B and C and our fix is the intersection of the two



6-25. Schematic overview of the three-body problem. Top section is the lay of the land as seen on a chart. Below it is what the navigator might see. The sextant is held horizontally to measure the angles between the center and the left and right targets. The fix is highly accurate, but there are limits on what targets qualify for a strong fix. Solutions are shown in figures 6-26 and 6-27.



6-26. Three-body fix solved with a three-arm protractor. Inexpensive 3-arm units are available in plastic for under \$20. Alternatively, the problem can be solved by direct plotting with a protractor and draftsman's compass as shown in figure 6-27.

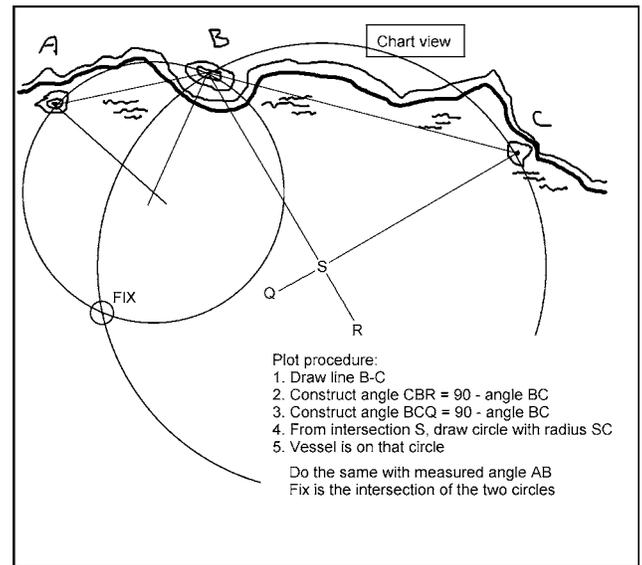
circles of position. Generally you can assume that if the circles intersect at an angle of greater than  $20^\circ$  or so, you have a good fix, if you plot carefully.

If your position, however, is near the circle defined by the points A, B, and C that you selected, then no fix can be achieved. With little practice it is easy to see how this works, and if you have chosen poor targets, you can see how to make better choices. Three objects more or less in a line will always work well.

Note that if you get stuck with wanting to plot one of these solutions and do not have a draftsman's compass to draw the circle, you can tape or tie a pencil to one leg of your dividers, or just punch two holes in a piece of cardboard with the divider tips and then use a pencil point in one and the divider point in the other for a convenient "compass." A pencil and a piece of string can also work if used carefully.

If you try this under varying circumstances, you will run across nuances in the plotting procedures, depending on where you are located relative to the bodies, but for objects more or less in line that are less than  $90^\circ$  apart, the results shown in 6-27 are typical.

(Be careful you do not get trapped into the interesting geometry problems and solutions that are involved in various special cases and lose sight of the goal. It is a fascinating problem that mathematicians and navigators have pondered over for many decades.)



6-27. Graphic solution to the three-body problem. There are numerous solutions. This one was the most popular in the old days, and remains the easiest if we do not include numeric computations in the process. With an actual Lat and Lon for each of the targets, the problem can be solved analytically with the Starpath StarPilot navigation calculator.