

Chapter 14

Ship Characteristics in Piloting

Up to this point it has been conveniently assumed that at the instant of an ordered course change the vessel came immediately to the new course, and that when a new speed was ordered, the ship attained that speed instantly. Such, of course, is not the case in "real life." To increase or decrease speed by 10 knots may require twenty minutes or more before the new speed is attained, depending on the size of the vessel, her initial speed, and the flexibility of the engineering plant. A course change of 90° may require half a mile or more of sea room to complete, depending on the type of ship, the rudder angle used, the wind and sea conditions, and various other factors. Each ship reacts in a different way to a given rudder or speed order and reacts differently under different conditions of wind and sea. A navigator must be able to take these factors into consideration in order to know what order must be given to achieve a desired result.

The term *handling characteristics* refers to the ways a vessel responds to engine and rudder orders. For naval vessels, these are called the *tactical characteristics* of the ship. Tables of tactical characteristics are maintained on the bridge of all U.S. naval vessels. Coast Guard regulations require that U.S. merchant ships post data on handling characteristics where they can easily be seen by bridge watchstanders. On smaller craft the data will not normally be formalized, but they do exist, even if only in the mind of the skipper.

When a ship is traveling singly in the open sea, her navigator may ignore the time and travel required to effect course and speed changes, for the scale of the plot is too small to be affected by the resulting errors. In restricted waters however, the situation is entirely different. Here, the navigator fre-

quently needs to know the vessel's position within a few yards, and the effect of the ship's travel in the time required to complete a change of course or speed is comparatively large enough that it must be taken into account. The term *precise piloting* is sometimes applied when taking into consideration these small, but very important, factors.

TURNING CHARACTERISTICS

1401 When approaching an anchorage, turning onto a range, piloting in a restricted channel, maintaining an intended track, or at any time when precise piloting is necessary, the navigator must allow for the turning characteristics of the ship. These characteristics are usually determined during the builder's trials of a new vessel (or for the first of a class of naval ships), but these values can vary somewhat as a ship ages or is modified, so they should be verified or updated when circumstances permit. Instructions for obtaining tactical data for U.S. Navy ships are contained in NWP 50-A, *Shipboard Procedures*.

The standard method of finding a ship's turning characteristics is to run tests in which the vessel is turned in various complete and partial circles under varying conditions and the results recorded for each. The minimum variables used are right and left rudder of specified angles, steady speeds of different value, and notable differences in draft and trim. When turning data is taken, the effects of differing wind and sea conditions should be evaluated as much as practicable. When actually navigating, course changes are not usually as much as 360°, but by studying the complete turning circle of your vessel, the ship's behavior for turns of any extent can be determined.

In considering the track actually followed by a ship during a turn, an understanding of certain definitions used by the U.S. Navy is helpful. Understanding these terms will help you to know how your vessel will respond under various conditions and help you to make appropriate allowance for these responses while navigating—both in the planning and execution stages. Once you have considered these things, it will be apparent why they cannot be ignored in restricted waters.

The *pivot point* of a vessel is the point about which the vessel turns when her rudder is put over. It is a point—a kind of “axis” about which a vessel rotates when it is turning—and is typically located about one-third of the way aft from the bow when a vessel is under way. On a typical destroyer, for example, the pivot point would be somewhere close to the center of the bridge when the ship is under way. It typically moves aft when a vessel slows down and will be about two-thirds of the way aft when a vessel is backing. The pivot point will also vary from one vessel to another and may vary for a given vessel under different conditions of a longitudinal trim. The bow of a vessel moves inside the track followed by the pivot point and the stern “skids” along outside it, something like a car oversteering on a slippery road.

Turning circle is the path inscribed by the vessel's longitudinal center of gravity in making a turn of 360° or more at a constant rudder angle and speed. Although not technically correct, when a vessel is moving forward you may assume this path to be inscribed by the vessel's *pivot point*, since that is easier to identify (or estimate) than is the longitudinal center of gravity. The diameter of a turning circle for a given ship will vary with both her rudder angle and her speed through the water.

Advance is the distance gained in the original direction until the vessel steadies on her new course; it is measured from the point at which the rudder is put over. The advance will be maximum when the ship has turned through 90° (see fig. 1401a).

Transfer is the distance gained at right angles to the original course, measured from the line representing the original direction of travel to the point of completion of the turn. Transfer is maximized at 180° .

Tactical diameter is the distance gained to the right or left of the original course when a turn of 180° has been completed.

Final diameter is the distance perpendicular to the original course between tangents drawn at the points where 180° and 360° of the turn have been

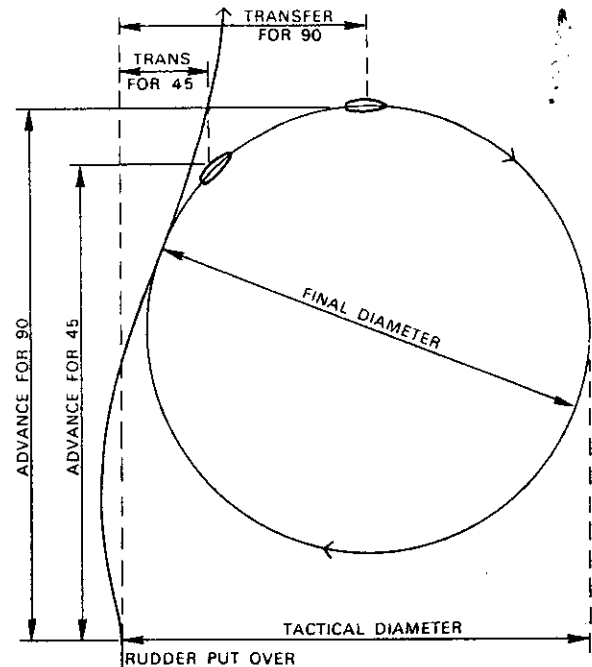


Fig. 1401a. Advance, transfer, and tactical and final diameters.

completed. Should the ship continue turning indefinitely with the same speed and rudder angle, she will keep on turning in a circle of this diameter. It will nearly always be less than the tactical diameter.

Standard tactical diameter is a specific distance chosen to be uniform for naval vessels of a particular type. Using this will ensure that naval vessels will maintain their relative positions when turning together.

Standard rudder is the amount of rudder angle necessary to cause the ship to turn in the standard tactical diameter at standard speed.

Angle of turn is the arc, measured in degrees, through which the ship turns from the original course to the final course (see fig. 1401b).

The speed at which a ship makes a turn may affect the turning diameter markedly, particularly if the *speed-length ratio* (ratio of speed to the square root of the length) is high enough. Thus a 300-foot ship at 30 knots has a considerably larger turning circle than at 15 knots. A short vessel will have a smaller turning circle than a longer one with the same general tonnage.

Sample Turning Data

1402 Figure 1402 is a partial set of typical data on the turning characteristics of a naval ship using standard rudder at standard speed. Other values would be applicable for different speeds and rudder

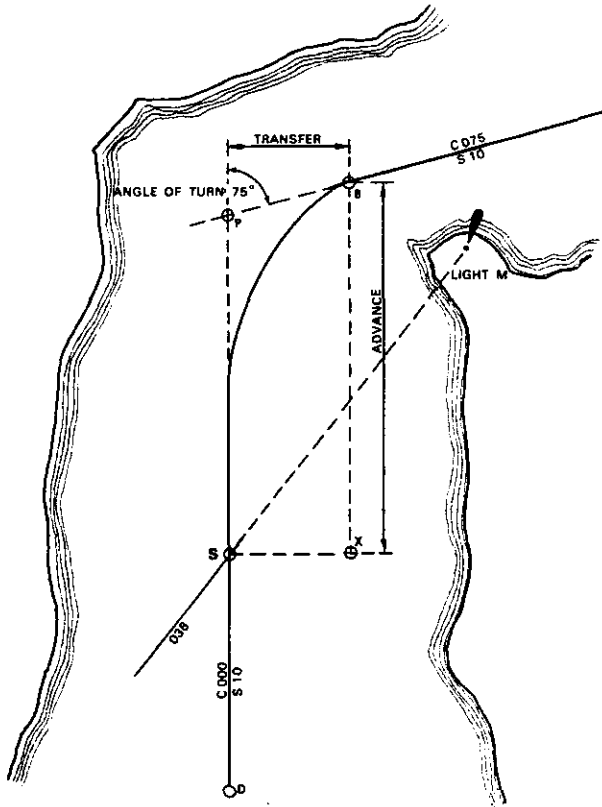


Fig. 1401b. Angle of turn, advance, and transfer.

angles. These figures are representative of one particular ship and are for use only with problems in this book. Note that the table has been prepared for every 15° of turn. Data required for increments between these 15-degree points may be obtained by interpolation.

USING A TURN BEARING

1403 From the preceding discussion it can be seen that during conditions when precise piloting is required a navigator must know at what point the rudder must be put over, so that when allowance has been made for the advance and transfer of the ship, she will steady on the desired heading at the

time the new desired track is reached. Having determined this point on your plot, your next task is to establish a means by which you will know when you have arrived at that point so that you will know it is time to put your rudder over to begin your turn. This is accomplished by selecting a prominent mark, such as an aid to navigation or a landmark ashore, and predetermining the bearing to that mark from the point at which the turn is to begin; this is the *turn bearing*. Many navigators prefer using an object upon which the turn bearing is taken that is abeam at the time of starting the turn; this gives the greatest rate of change of bearing and hence an easily and precisely determined point for turning. If the vessel is known to be on track when approaching the turn point, a beam point works well, but if the vessel is off track before the turn, it will still be off track after the turn. Choosing an object that is nearly parallel to the new course actually works better in these circumstances. If practicable, you should choose an object on the side of the channel *toward* which the turn is to be made (the inside of the turn), since the conning officer will be giving that side the greater part of her or his attention. In figure 1401b, the navigator has selected Light M for this purpose, which is a compromise between parallel and beam. The ship is standing up the channel on course 000° T and, after rounding the point of land marked by Light M, will come to new course 075° T to continue up the river.

To allow for the turning characteristics of the vessel, the navigator would draw the desired course line up the next reach of the river, then draw a line parallel to the vessel's present track at a distance out to the side equal to the transfer for a 75° turn (513 yards from the table in fig. 1402). The intersection of this line with the final course, 075° T, will be the point B at which the turn will be completed. From this point, the navigator would measure back along the line drawn parallel to the present track a distance equal to the advance (1,007 yards from fig. 1402) locating point X. From point X, drawing a perpendicular to the original course line will locate

Standard Tactical Diameter, 1500 Yards—Standard Rudder 15°					
Angle of Turn	Advance	Transfer	Angle of Turn	Advance	Transfer
15°	500	38	105°	993	853
30°	680	100	120°	933	1013°
45°	827	207	135°	827	1140
60°	940	347	150°	687	1247
75°	1007	513	165°	533	1413
90°	1020	687	180°	367	1500

Fig. 1402. Typical amounts of advance and transfer for various angles of turn for a specific vessel.

the point at which the rudder must be put over to complete the turn at the required point. The bearing from that point to Light M is the turn bearing— 038° T in this case.

When actually moving up the channel, the navigator will make continuous observations on Light M. It should be apparent that the bearings will initially be less than 038 but will gradually get closer to it as the vessel continues northward. When Light M bears 038 (at point S in fig. 1401b) the order "Right Standard Rudder" would be given. When the turn is complete, the ship will be heading on the final course of 075 at point B. The solid line SB represents the actual track of the ship through the turn.

Some mariners use a method known as the *slide bar* technique to assist the navigator in quickly revising a turn bearing if the vessel is off track just prior to a turn. Draw the slide bar parallel to the new course through the turning point on the original course (see fig. 1403). You may then determine a new turn bearing by dead reckoning ahead from your last fix. From the point where the DR intersects the slide bar, determine the bearing from that intersection to the navigational aid being used for your turn bearing. Because charts often get cluttered around turn points, it helps to draw the slide bar using a different color from the one used to lay down your track; this will distinguish the two and avoid confusion.

Yet another related technique is the use of a radar range on an identifiable (stationary) target ahead or astern. By knowing the range at which the object

should be when the turn is to commence, you may use that figure as the determinant for commencing your turn when that actual range is reached.

ANCHORING IN A SPECIFIC SPOT

1404 Charts showing specific anchorage berths are published by NOS, NIMA, and/or local maritime authorities for a port. They are simply harbor charts with anchorage berths overprinted in colored circles of various diameters corresponding to the swinging area required by vessels of various types and sizes. The center of the circles marks the center of the berth, and each berth is designated by a number or letter printed inside the circle.

In harbors for which no standard anchorage chart is available, berths are assigned by giving the bearing and distance of the berth from a landmark or aid to navigation, together with its diameter. It is the duty of the navigator to cause the ship to be maneuvered in such a manner that the anchor may be let go in the center of the ship's assigned berth. This should be accomplished with a maximum permissible error of 10–50 yards (9–46 m), depending upon the type of ship.

There are a number of terms associated with the anchoring process.

Approach track is defined as the track that a vessel must make good in order to arrive at the center of her assigned berth.

While taking bearings, the navigator is not normally standing at the same spot on the vessel where

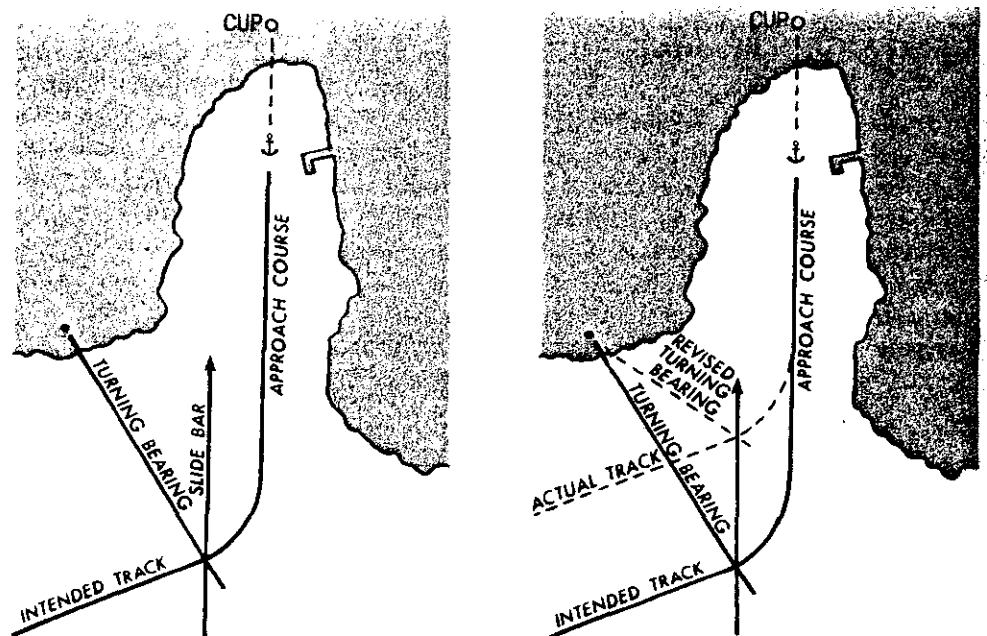


Fig. 1403. The slide bar technique.

the anchor will be let go. To compensate for this separation, the navigator should draw a *letting-go circle* around the center of the berth while preparing for anchoring. The radius of that circle is equal to the horizontal distance from the point on the vessel where the anchor will be let go (the "hawsepipe" on a naval vessel) to the point where the instrument that will be used in taking bearings is located (a gyro repeater on the port bridge wing, for example). Obviously, the distance between the two locations can be very large on an aircraft carrier and virtually insignificant on a small craft.

The *letting-go bearing* is a bearing to any convenient landmark from the point of intersection of the letting-go circle and the final approach track. As with a turn bearing, the selected object should, if possible, be near the beam to maximize effectiveness.

The *letting-go point* is the intersection of the approach track and the letting-go circle.

Range circles are distance circles of varying radii plotted from the center of the berth with distances

measured from the letting-go circle. In other words, you will measure the distance between the letting-go point and the center of the berth and add that amount to each of your measurements for range circles; then place one point of your dividers on the center of the berth while inscribing the arcs of the range circles. The letting-go circle is then labeled 0 yards, while the other range circles are labeled with their distance from the letting-go point (even though they were inscribed using the center of the anchorage). This may seem confusing at first, but if you think about it for a moment, it makes sense. Range circles are used as references to let the navigation team know where the vessel is in relation to the drop point for the anchorage.

Preparations

1405 When the ship has been ordered to anchor in a specific berth (see fig. 1405), the navigator consults the chart and prepares for the approach to the anchorage.

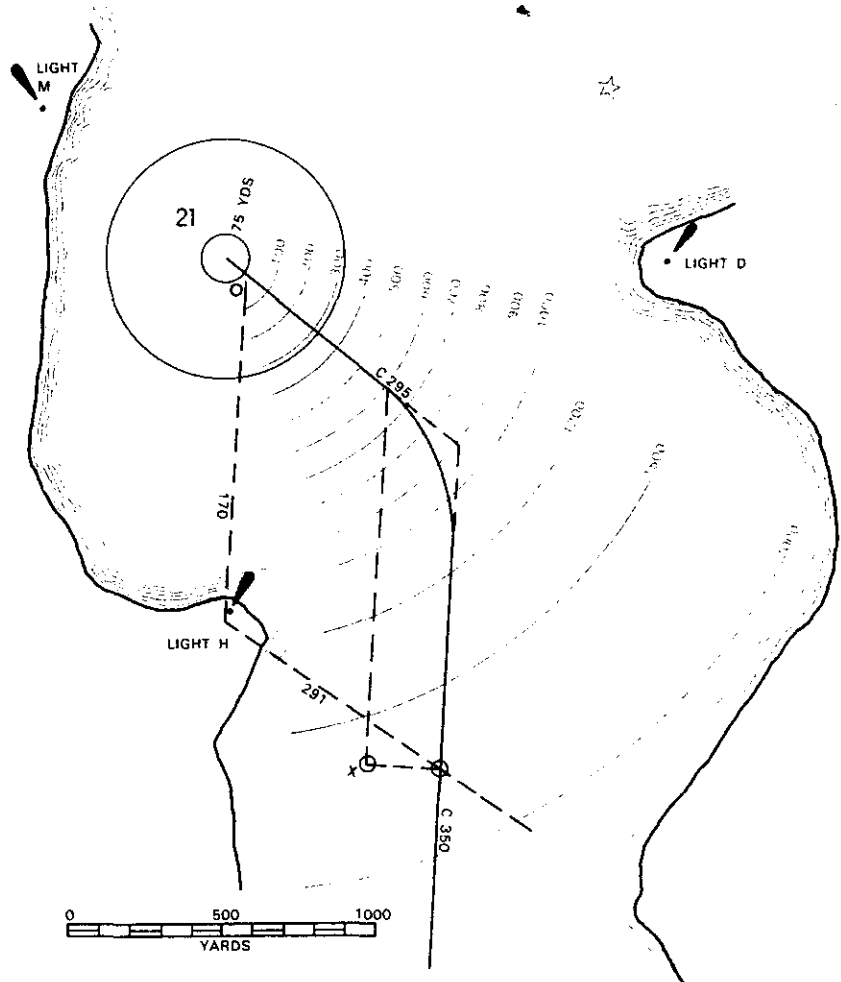


Fig. 1405. Anchoring in an assigned berth.

The letting-go circle is plotted as described above.

Next comes the approach track, selecting an appropriate course that will make best use of available landmarks and navigational aids for fixing the ship's position en route, and for locating turn bearing marks at predetermined points where turns are necessary. The approach track must be long enough for the final turn to have been completed and any last-minute adjustments of track accomplished before reaching the center of the berth. The final approach should, if possible, be made with the vessel heading into the current (or into the *wind* if it is expected to have more of an effect than the current). It is also desirable for the approach track to be headed directly toward an identifiable aid to navigation or landmark during the final leg; as the approach is made, the constant bearing (termed a *head bearing*) of the aid or landmark can then be maintained. If no such aid is available, or if the aid previously selected becomes obscured, the positions of consecutive fixes with respect to the approach track (to the right of it or to the left of it) will permit the navigator to recommend a change of course to conn the ship back on the approach course.

Range circles of varying radii are also plotted. In most cases it is necessary to draw in only the arcs of the range circle adjacent to the approach track rather than the full circles. In practice it is customary to draw arcs every 100 yards out to 1,000 yards, then at 1,200 yards, 1,500 yards, and 2,000 yards.

When planning to bring a ship to anchor, the navigator should determine the depth of the water and the characteristics of the bottom as they may be shown on the chart, as well as the nature of and distance to any nearby areas of shoal water or other hazards.

Using the planned drop point as a center, a radius equal to the ship's length plus the horizontal component of the length of anchor cable to be used is plotted; called a *swing circle* this construction allows the chart to be closely examined to be sure that no hazards exist within this circle, nor does it infringe on any other charted anchorage.

The navigator also plots a *drag circle*, using the actual anchor position as a center and the horizontal component of the anchor cable length plus the letting-go circle distance as the radius. Therefore, once anchored, any check bearing, taken to determine if the anchor is holding, must fall within this circle, which is of smaller diameter than the swing circle. If a bearing places you outside this circle, it is an indication that your anchor is not holding you securely in position and is probably dragging.

All of this information should then be passed to

the captain and other officers directly concerned with the anchoring. In naval vessels, a formal navigational brief is required to be held to ensure that all concerned are aware of the plan. This not only ensures that everyone involved knows in advance what their responsibilities are going to be, but also brings the plan under more scrutiny and thus improves the chances that potential problems or errors will be identified.

A good practice is to prepare a template for the anticipated anchoring. This template is constructed of clear plastic and replicates the planned approach—range rings, letting-go circle, and so on—in the same scale as the chart in use. By having this template at hand, if you find the planned anchorage unusable for some reason (another vessel is already anchored there, for example) you can quickly shift the template to a new location and use it to accomplish a safe anchoring.

Execution

1406 *Example:* A ship is assigned Berth 21 for anchoring (see fig. 1405). The initial approach into the harbor is on a course of 350° T. A final approach track directly toward Light M is possible and is selected. Distance from the hawsepipe to the gyro repeater used for taking bearings is 75 yards.

Required: (1) Approach track to the berth. (2) Turn bearing. (3) Letting-go bearing.

Solution: The selected approach track is plotted back from Light M through the center of the berth; its direction is measured as 295° . The letting-go circle with a radius of 75 yards is plotted around the center of the berth. The intersection of this circle and the approach track is the letting-go point and is labeled 0 yards.

The initial approach track into the harbor is plotted. By use of the table of the ship's characteristics, the navigator can determine the advance and transfer of the final turn at the speed to be used. With this data, he or she determines the point at which the turn is to be completed and the point at which the rudder is to be put over. The navigator then plots this and determines the turn bearing as 291° using Light H (selected because it best meets the criteria described above).

Range circles are plotted from the center of the berth, measuring the distances from the letting-go point as described above. Thus, the radius used to plot the "100-yard" range circle is actually $100 + 75 = 175$ yards; similarly, all other range circles are plotted with a radius 75 yards greater than the labeled distance to allow for the difference between the center of the berth (where you ideally want your

hawsepole to be when the anchor is let go) and the point from which you are taking your measurements (usually from the bridge, which can be some distance away—on an aircraft carrier, it can be more than a quarter of a mile).

As the ship enters the harbor and proceeds along the track, frequent bearings are taken and fixes plotted to ensure that the desired track is maintained. As the range circles are crossed, the navigator advises the captain of the distance to the letting-go point so that the speed may be adjusted to bring the ship nearly dead in the water when the letting-go point is reached.

When Light H bears 291° the rudder is put over and the turn commences. Upon completion of the turn Light M should bear 295° dead ahead. As the ship approaches the anchorage, the heading of the ship is adjusted so that a constant bearing of 295° is maintained on Light M. Bearings on Lights H and M are plotted continuously, and the captain is advised of the distance to go. When Light H bears 170° and Light M 295° , the vessel is at the letting-go point and the anchor is let go. At that instant, bearings are taken on all navigational aids visible so that the

exact location of the anchor can be accurately determined. The ship's exact heading at the time of the final fix are also observed and noted. A distance of 75 yards is then plotted from the fix, in the direction of the observed heading to determine the exact position of the anchor.

Answers: (1) Approach track is 350° initially, then (using light M) 295° for the final leg. (2) Turn bearing is 291° on Light H. (3) The letting-go bearing is 170° on Light H.

Procedures After Anchoring

1407 Immediately after the anchor is down and holding, and the intended length of anchor cable has been let out, the navigator should plot the actual position of the anchor from the bearings taken at the moment it was dropped. Using this as a center, the actual swing circle and drag circle should be plotted. Frequent fixes should then be taken using all available resources (visual, radar, etc.) to ensure that the vessel is remaining within the anchorage and not dragging anchor. As a backup, many GPS units have an alarm function that can provide a warning that the vessel is dragging anchor.