12.4.3.4 Parallel Sweep (Track) Search

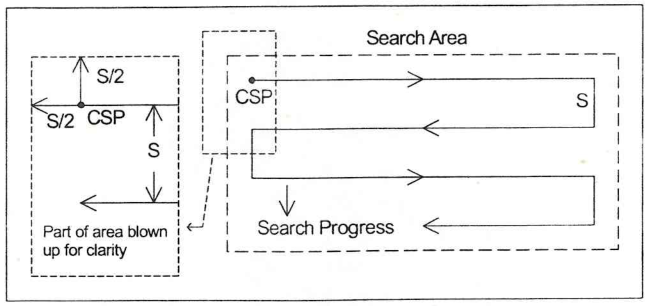


Figure 12.6 - Parallel Sweep (track) Search

This pattern makes use of search legs that are parallel to each other and it is employed where a large area has to be searched and the survivor location is uncertain.
The area may be assigned to individual search units on-scene at the same time, after it is divided into smaller sub-areas.
The CSP for each ship is S/2 inwards from edge of the area. All turns and outermost legs are planned at not more than S/2 inwards of the edges.

Where the search pattern is being used by more than one unit in a co-ordinated search, the search speed is the maximum speed of the slowest ship, unless a different speed has been ordered.

This pattern has a few variations. It may be used by:

- A single ship (Fig 12.8)
- A number of ships within individual allocated areas (Fig 12.9)
- A number of ships searching in a co-ordinated manner (Fig 12.10).

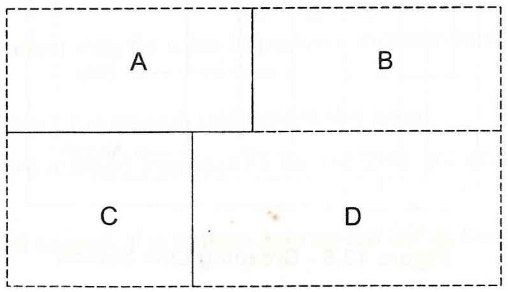


Figure 12.7 - Sub-Divided Areas (search)

NB: It must be borne in mind that a co-ordinated search can only commence when all of the participating units are present at the scene.

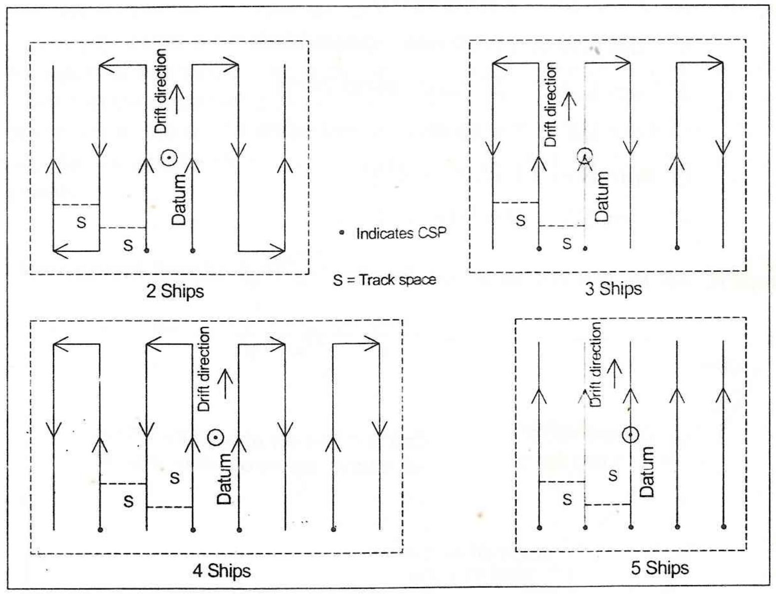


Figure 12.8 - Parallel Track Search

12.4.4 Practical Application

The drift rates available or calculated are only estimates and may not match the actual situation. There may be errors in the transmitted position of the distressed vessel (e.g., DR or position based upon a less accurate system, etc). A longer time interval will cause errors to be more pronounced. For example, a survival craft or a vessel may not drift exactly down wind. It could drift in a number of directions due to 'sail' and 'flag' effects.

For the following example, the assumptions are:

- The distress vessels position for 0900 GMT (position source unknown)
- Abandoned in a 15 person liferaft, without drogue
- Visibility 5NM
- Current 135°T x 3Kts
- Wind, N'ly 21kts
- A wind driven current in SSE direction at 1kt
- Initial search interval of 1.5 hour

- 6 participating ships are approaching:
  - "A" from NW in 1 h 30 min, speed 18kts
  - "B" from E in 1 h 50 min, speed 24kts
  - "C" from SE in 2 h 10 min, speed 12kts
  - "D" from S in 2 h 25 min, 25kts
  - "E" from SW in 2 h 10 min, 18kts

Datum: Ship "A" will be the first to arrive. For Figure 12.9, liferaft leeway will be 1.5kts.

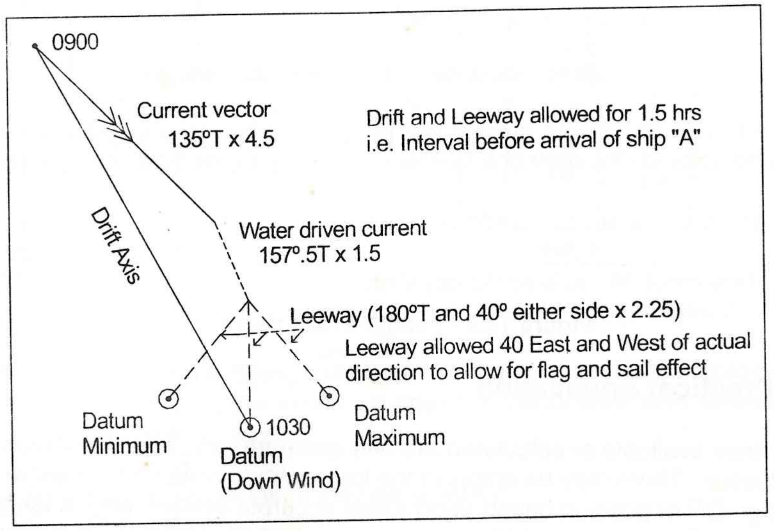


Figure 12.9 - Drift Calculations

Track spacing:
From Table 12.1, a 15 person liferaft in 5′ visibility requires a track spacing of 4′.0.

From Table 12.2, the weather correction factor is 0.9. Therefore, the track spacing to be applied is = 4.0 x 0.9 = 3′.6

Area: Ship "A" can search = 3.6 x 18 x 1.5 = 97.2 NM2

Radius: = √97.2 / 2 = 4′.9

If there is uncertainty about the position of the distressed unit and significant time has elapsed since the incident, the wind effect on the search object may be different. For this reason, the minimum and maximum datum points of the Down Wind datum have been established, simply by allowing leeway vectors 40° from the down wind direction.

There may be a number of other factors that introduce errors in the calculations. Search planners allow for these factors and work out the maximum allowable error radius for each of the three datum points. These radii are used to draw error circles from the three datum points. The search area is then obtained by enclosing the error circles in the smallest possible rectangle. In actual fact there may be numerous datum points on the arc between the down wind and the two extreme datum points.

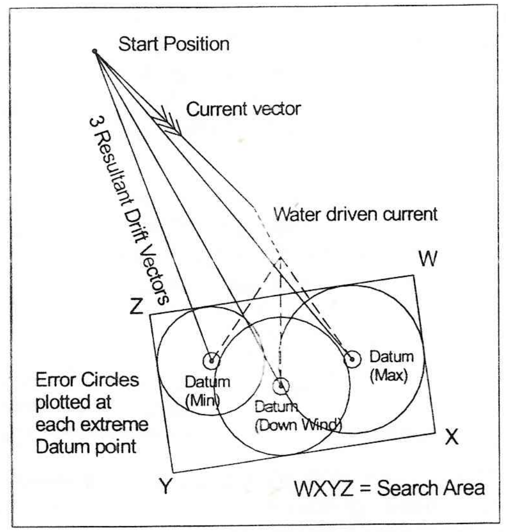


Figure 12.10 - Search Areas

Orientation of the search area should be in line with the drift axis. This would cause the search and search patterns to be oriented to the drift axis. It is less likely to that a search object will be missed when searching along the drift axis.

The search area should be sub-divided and allocated to individual units. Ship "A" should reach Datum (or CSP) and commence an expanding square search. As the other units arrive, they should commence a parallel sweep search within their allocated area. In this case all of the units should search at their maximum speed.

Figures 12.10 and 12.11 are not to scale and are provided to help clarify the concept.

The above plan helps with the maximisation of the use of the available resources and completion of a search in the minimum possible time. In reality, all situations are likely to be different, but the application of basic principles will help to plan effectively. To maximise the use of available resources, ships may be grouped for a search according to similar speeds, as a group of fast ships will cover more area than a mixture of fast and slow ships in a co-ordinated search.
To reduce the time element, the OSC may give directions to a ship or group of ships to begin searching an area close by, prior to their formally arriving on-scene.

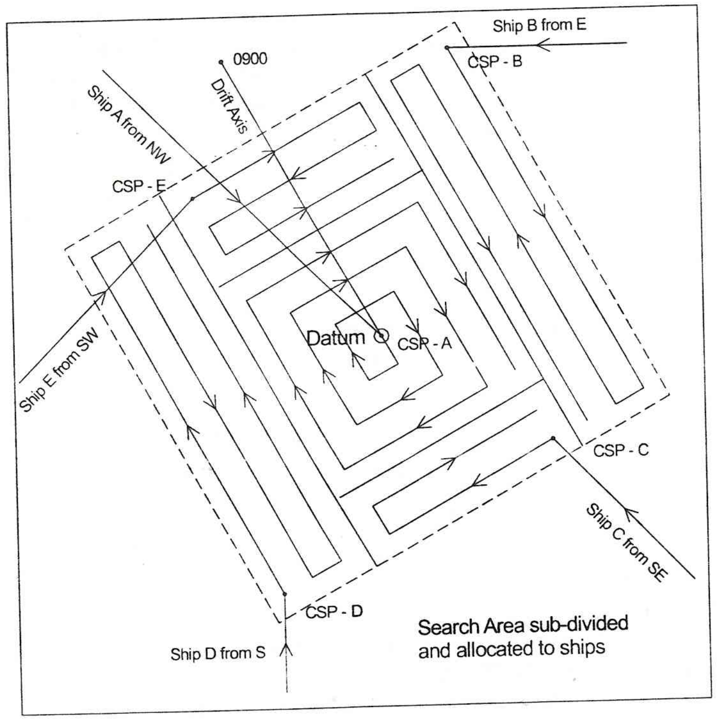


Figure 12.11 - Search Area Sub-Divisions

12.4.5 Records

- A summary of communications relating to distress, urgency and safety traffic
- A reference to important service incidents

A record of every signal of distress or message that a vessel, aircraft or person is in distress at sea, observed or received, should be entered.

Where a Master receives a distress signal at sea, or information from any source that a vessel or aircraft is in distress, but is unable or, in special circumstances, considers it unreasonable or unnecessary to go to the assistance of the persons in distress, he should make a statement of his reasons for not going to the assistance of those persons in the OLB.

12.4.6 Radar Use

If the position of the incident is not known reliably and Search and Rescue aircraft are not available, a radar search may be effective when several assisting ships

are available. No prescribed pattern has been provided, but the vessels can search the area, remaining abreast of each other in a loose line fashion, maintaining a track spacing between them of the expected detection range multiplied by 1.5.

12.4.7 Aircraft Assistance

Aircraft participating in Search and Rescue activity can be very useful. They are much faster, compared with surface craft and they can search larger areas in shorter time periods. Because of their altitude they have a longer visible horizon. This is another aid in searching larger areas in less time although it will depend upon visibility levels and the size of the search object.

Once the search object is located, helicopters can carry out the rescue and the number of persons to be lifted will be dependent upon the type and available capacity of the helicopter. Fixed wing aircraft can drop supplies and messages to survivors. They can also guide surface vessels to the rescue point.

12.4.8 Conclusion Of The Search

12.4.8.1 Successful

It must be ensured that all survivors are accounted for. Once the distressed craft or survivors have been sighted, and if the detecting vessel is unable to carry out the rescue, the best method should be assessed by the OSC and the most suitably equipped craft on scene directed for rescue. Sometimes, however, the detecting vessel may have to make an effort to effect the rescue when more suitably equipped craft are not available.

The information on the survivors and the incident should be promptly relayed to the SMC once the survivors have been debriefed and questioned on:

- The ship or aircraft in distress, and the number of persons on board
- Whether survivors or survival craft have been seen

When all rescuing action is complete, the OSC should immediately inform all search facilities that the search has been terminated.

The OSC should inform the SMC of the conclusion of the search and give the following details:

- Names, destinations and ETA of ships with survivors, along with the identities and number of survivors in each
- Physical condition of survivors and whether medical assistance is required
- The state of the distressed craft and whether it is a hazard to navigation, in which case its position should be communicated.

12.4.8.2 Unsuccessful

The search should be continued until all reasonable hope of effecting a rescue has passed. An important factor will be the possible survival time under the current circumstances. The OSC may have to make the decision on whether or not to terminate an unsuccessful search.

The factors to consider when terminating are as follows:

- The probability that the survivors were in the search area
- The probability of detection of the search object
- The time remaining that the search facilities can remain on scene
- The probability of the survivors still being alive

After consultation with other craft and land-based authorities, the OSC may terminate the active search, advise assisting craft to proceed on passage and inform the land-based authority. The coast station should transmit URGENCY message to all ships in the area asking them to continue to keep a look-out. For coastal incidents, the OSC should consult with land-based authorities about the termination of the search.

12.5 Rendezvous

Mariners or specialist agencies at sea may be required to rendezvous with another vessel or vessels (units), intercept them for operational reasons, or provide assistance. Practical use and experiences vary as some mariners may never rendezvous during their entire career at sea, but they should be prepared for such operations. All navigating personnel, especially at management level, are usually tested on rendezvous during certificate of competency examinations, as any unit may be called upon to assist when required.

Due to the urgency associated with most of these operations, it is essential to rendezvous or intercept in the shortest time. Other than for saving lives at sea or intercepting for special purposes, units participating in routine operations should rendezvous at the earliest time to conserve fuel, save time and maintain commercial deadlines.

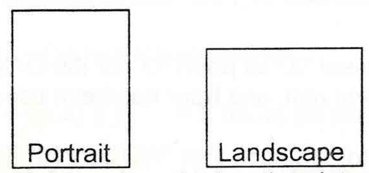
Where possible, both units should set course for each other and proceed at the best speed. However, most problems or operations are not that simple, and quite often one unit will be on a steady course and speed, with the other setting the course to rendezvous. In the case of search and rescue and other emergencies, the approach will be at the unit's best speed under the circumstances, or at the speed required to rendezvous at an agreed time. However, in some operations, a unit may be required to determine its speed in order to rendezvous at a required time.

There is more than one method of carrying out the plots. Calculations may also be used to obtain course and or speed. The methods of determining the course and speed required will vary with the operational requirements. There may be situations when the assisting unit is required to rendezvous at the earliest time possible. In other cases, rendezvous may have to be planned for a predetermined time, such as sunrise. Each of these methods will be discussed separately. The problems could be to find the course, speed, time and position of rendezvous:

- With one unit maintaining course and speed
- With wind and/or current
- With one unit altering course and/or speed; the other making the approach
- When taking up station with another unit on a steady course speed
- When changing station and working with another unit
- To rendezvous at a specific time with one unit maintaining course and speed

The unit requiring assistance may maintain her course and speed either because of the weather or because it may be heading for a port of refuge. The assisting unit will have to adopt a different approach if the unit requiring assistance is capable of making way, or is required to make way through the water. If the unit requiring assistance is not making way through the water, the rendezvous will be just a matter of setting course for the position where the unit requiring assistance has stopped or is drifting to.

Plotting can be carried out using a radar plotting sheet, which most mariners prefer, graph paper or even a plain sheet. Some may prefer to calculate instead. Before commencing the plot, prepare a mental picture as to how the plot will develop so that the problem or requirement can be fully understood. Choosing an appropriate scale is always the first step, unless the distances involved happen to be within the scale of the plotting sheet. When using a graph or plain paper, a choice has to be made whether to use portrait or landscape layout.



From the problem, one could determine whether the plot would develop more on a North/South or East/West axis. With the former, portrait would be the preferred choice, and landscape as a preferred choice for the latter.

Where graph paper or a plain sheet is used, North should be marked clearly on the paper, along with the scale used for plotting. The choice of scale should be given careful consideration. The larger the scale, the better the result. Similarly, a plotting interval may have to be decided to allow a reasonable sized plot to be formed, to aid clarity and accuracy.

12.5.1 Plotting Method

Plotting can be done using either relative or true motion. True motion should be used when wind and/or current are affecting the units involved in the operation. For the majority of the problems, however, relative plotting can be used.

Rendezvous is, in reality, a meeting of two units at sea and it could be more simply considered as a collision between the two units. For a collision to occur, both units have to be on a steady bearing. This steady bearing, in terms of radar plotting, is the relative approach, represented by the OA vector, or line. If the WOA triangle was constructed, OA would represent the relative approach, WO the course/speed of the unit maintaining course and speed, which is usually plotted at the centre of the sheet, and WA would provide the course and speed required to rendezvous. The rendezvous is based on the maintenance of a steady bearing between the vessels. The position of both of the vessels for a common time must be known. A worked example explains the method for determining the approach course.

Example 12.1

Vessel "X" receives a call for assistance from vessel "Y" at 0800 hours. Vessel "Y" has a fire on board and is bearing 220° T x 48 nautical miles from vessel "X". Vessel "Y" is steaming at 12 knots on a course of 270° T, because of an easterly wind. If the maximum speed of "X" is 24 knots, what course must it set in order to rendezvous at the earliest time? What is the ETA of "X" at the rendezvous position?

Solution and comments

On a plotting sheet or graph paper, plot "X" and "Y" relative to each other, using an appropriate scale. For the adjacent sketch, a scale of 1:6 has been used, i.e. 8 miles on the sheet = 48′ (8 x 6). This scale should be used throughout.

If using a radar plotting sheet, plot vessel "Y" at the centre (point A′) and then vessel "X", such that "Y" is 220°T x 48' from "X". "Y" is moving at a steady course of 270° T @ 12 knots.

Choose the position of vessel "X" as point "O" for the OAW triangle. Choose a plotting interval. For this first plot, one hour has been used.

Produce "WO" and link it to "O", such that "WO" is 270° T and 12 miles (2 miles on plot). 12′ represents the distance travelled by "Y" in one hour.

Using a distance of 24 miles, i.e. the distance travelled by "X" in one hour, draw an arc from "W" on the "OA" line. Join "W" to "A". Determine the direction of "WA".

"WA" is the course to steer by "X" in order to rendezvous with "Y" at the earliest time. From the plot, the course is 242° T.

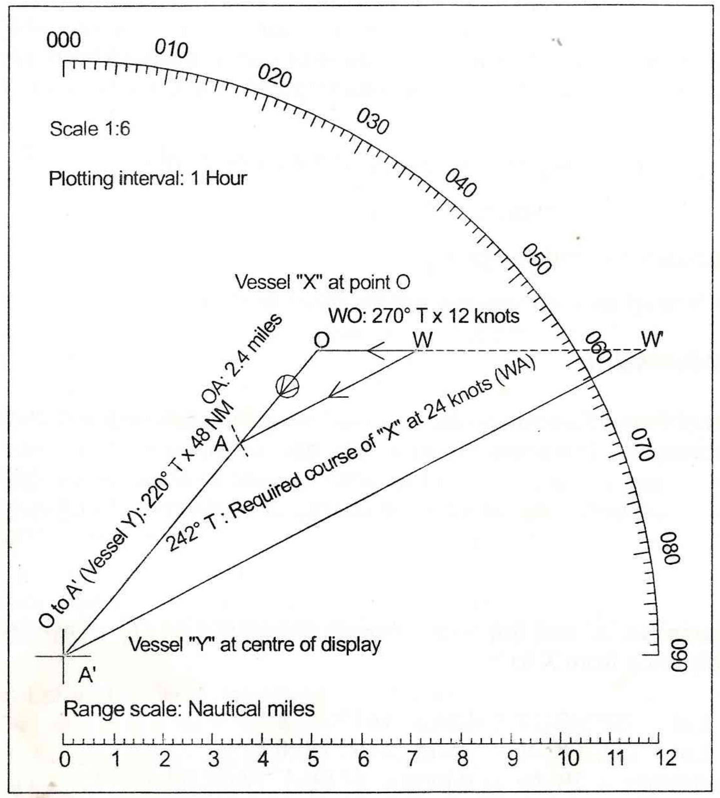


Figure 12.12 - Plot for example 12.1

The time of rendezvous can be best determined by using the relative approach speed "OA". From the plot distance "OA" is 14′.4. The total distance of OA′ is 48′.0. The distance OA is covered in one hour, so total time can be determined:

Time to R/V = (OA′ ÷ OA) x Plotting interval

= (48 ÷ 14.4) x 1 = 3 hours 20 minutes

0800 + Time to R/V = ETA at Rendezvous

0800 + 0320 = **1120**

In some cases the geographical position of the two vessels may be known, rather than the bearing and distance. The following example demonstrates the steps involved in solving such a problem.

Example 12.2

On 12 November at 1400 GMT, 'own vessel' is in position at 32° 40´N, 141° 22´E and has a maximum speed of 18 knots. A distress call is received from a vessel on fire at position 33° 08´N, 140° 13´.6 E, heading 235°T at 6 knots. Find the following:

- *The course to steer to rendezvous at the earliest time*
- *The ETA of rendezvous*
- *The position of rendezvous*
- *The time when both vessels will be close to within 2 miles of each other*

Solution and comments

The principles of Plane Sailing can be used to find out the bearing and distance between both vessels. The positions described above can be plotted directly on a Mercator chart. Using a Mercator chart avoids the need to work out the mean latitude and the conversion of departure to d.long, or vice versa. For this example, we will work from a plotting sheet or graph paper and will use Plane Sailing techniques.

Identify 'own ship' as "X" and the ship requiring assistance as "Y". Calculate the bearing and distance from X to Y.

"X"	Lat	32° 40´ N	Long	141° 22´ E
"Y"	Lat	33° 08´ N	Long	140° 13´.6 E
	d.lat	28´ N	d.long	1° 08.4´ W (or 68.4´ W)

Use mean latitude to convert d.long into departure.
M Lat 32° 54´ N

Dep = d.long x Cos Mean Lat = 68.4 x Cos 32° 54´ = 57´.4 W
To find bearing of Y from X:
Tan θ = Dep ÷ d.lat = 57.4 ÷ 28 = 2.051071429
θ = 64° Bearing = N 64° W or 296° T
Distance = d.lat ÷ Cos θ = 28 ÷ Cos 64° = 63.9 nautical miles

Select a suitable scale to fit easily on the plotting sheet or graph paper. The scale should be as large as possible to ensure greater accuracy. A scale of 1:4 has been used in this instance.

Using a bearing of 296° T and a distance of 63´.9, "X" and "Y" can be plotted relative to each other on a plotting sheet or graph paper. d.lat and Departure can be used directly to plot "X" and "Y" on graph paper, but it is better to confirm the positions using range and bearing. Note that the plot has been made off centre. For larger distances, off centre plots are preferred. For better accuracy a plotting interval of 4 hours has been used. If graph paper or a plain sheet is used, a landscape orientation is preferable.

The position of vessel "Y" is represented by A´ and vessel "X" as O. At "O", draw 'WO' in the direction of the course of B, 235° T. Measure off 24 miles (6 knots x 4 hrs). WO is 235° T x 24´.

Using a compass (or dividers) measure 64 (18 knots x 4 hrs) miles and with "W" as centre, draw an arc to cut OA´ at point "A", such that WA = 64 nautical miles. The direction of WA is the course to be steered by vessel "X" in order to rendezvous with "Y" at the earliest time. (279°T from plot)

To determine time of rendezvous, measure OA. (38´.2)

Time to R/V = (OA´ ÷ OA) x Plotting interval = (63.9 ÷ 38´.2) x 4 = 6 h 40 m
Time of R/V = 1400 + Time to R/V (1400 + 0640) = **2040 GMT**

The position of rendezvous can be determined by applying run to either of the two vessels from their start position. Their course and distance can be used to obtain d.lat and Departure. If we run vessel "Y" to the rendezvous position, it should travel a distance of 40´.0 (6 knots x 6h 40m) on a course of 235° T.

d.lat = Dist x Cos θ = 40´.0 x Cos 235° = 22.9´ S
Dep = Dist x Sin θ= 40´.0 x Sin 235° = 32´.77 W
For Latitude: Lat Y ± d.lat = Lat R/V (33° 08´ N – 22.9´S) = **32° 45´.1N**

Find Mean Lat and convert departure into d.long
Mean Lat = Lat Y ± ½ d.lat = 33° 08´ N - 11´.45 S = 32° 56´.55 N
d.long = Dep ÷ Cos Mean Lat (32´.77 ÷ Cos 32° 56´.5) = 39´.0 W
Long Y ± d.long = Long R/V (140° 13´.6 E - 0° 39´.0 W) = **139°34´.6 E**

In the above example, d.lat, Departure, the conversion of d.long into Departure and vice versa can be done using the Traverse Table. For the time when both vessels are at 2 miles, draw an arc of radius 2 miles from O and call it A". OA´ - OA" = 61.9
Time to 2 miles = (OA" ÷ OA) x Plotting interval = (61.9 ÷ 38´.2) x 4 = 6 h 29 m
Time at 2 miles = 1400 + Time to 2 nm (1400 + 0629) = **2029 GMT**

Because of the nature of the triangles in the plot, it is possible that the assisting vessel has two choices of course to the rendezvous. In such cases, the course giving the earliest rendezvous should be steered.

Such a situation will usually arise when the course of the vessel requiring assistance is converging on the assisting vessel. On the adjacent diagram, the arc centred at W will cut OA´ at two different points. "A" should be selected as the point nearer to point A´ because the faster of the two possible approach speeds, i.e., OZ or OA, would be preferred. OA is greater, so the course to steer is WA and not WZ. (see figure 12.14)

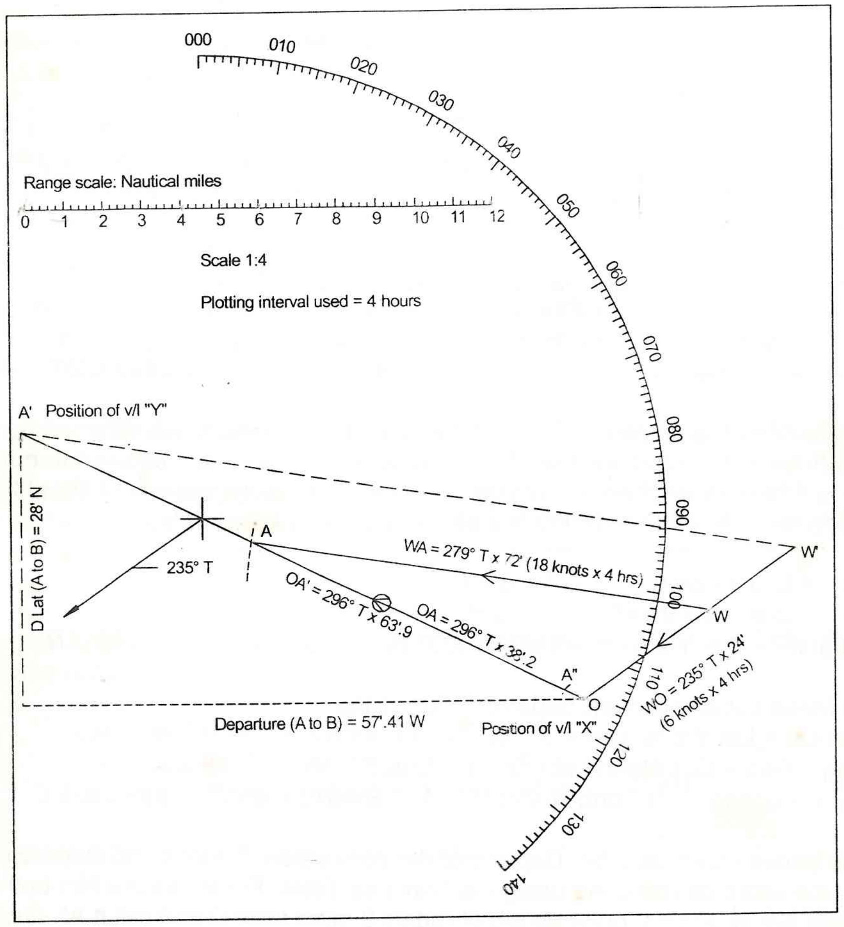


Figure 12.13 - Plot for Example 12.2

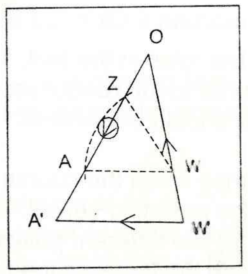


Figure 12.14 – Two Choices of Course

12.5.2 Effect Of Wind And Current

If wind is present, it will probably affect both units differently, depending upon their windage area and displacement/draught. Units that are disabled, requiring assistance and at the mercy of the weather will be set by the wind. The unit providing assistance will have to counteract the leeway caused by wind in order to rendezvous in the least time.

The current will generally influence both units at the same rate, providing that both units are in an area experiencing the same current. It should also be understood that current affects surface craft and not aeroplanes or helicopters. This will be demonstrated in the following examples.

Example 12.3

At 0900, a liferaft is bearing 100° T, a distance of 55 miles from a ship. A northerly wind is causing the liferaft to drift at the rate of 3 knots. The ship is expecting a leeway of 6° due to wind. Find the course for the ship to steer by and the earliest time it will rendezvous with the liferaft. The maximum speed of the ship is 17 knots.

Solution and comments

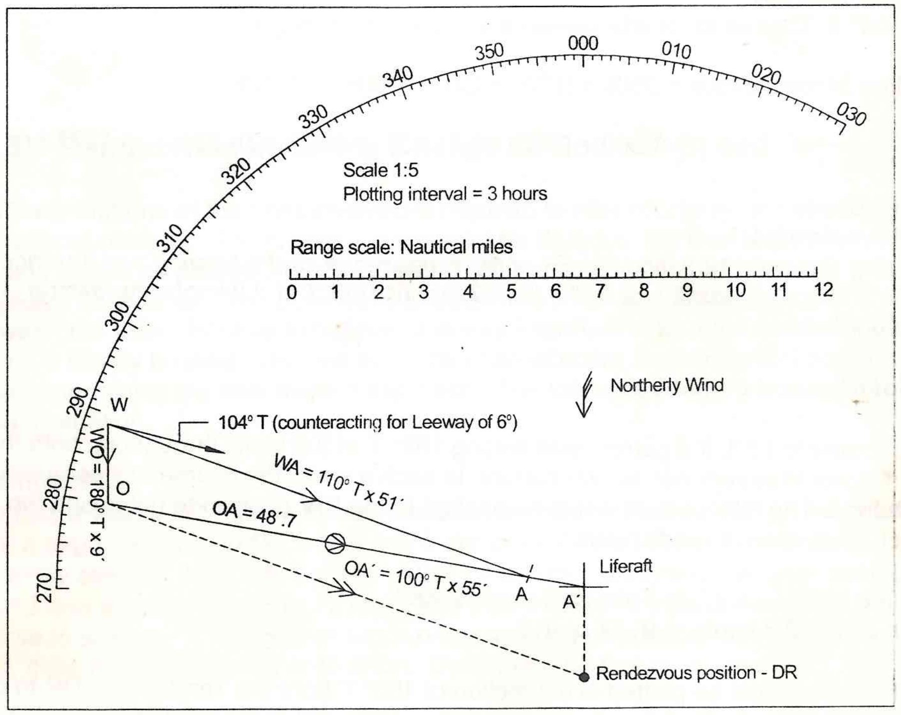


Figure 12.15 - Plot for Example 12.3

Using a suitable scale on a plotting sheet or graph paper, the ship and liferaft positions should be plotted relative to each other, using a bearing of 100° T and a distance of 55 miles. The liferaft should be at the centre, as its movement is going to remain steady.

From O, plot the liferaft's drift of 3 knots going South, as the wind is from the North. A suitable time interval should be selected (such as 3 hours to get a drift of 9´ [3 x 3]) in order to plot a reasonable triangle for better accuracy. Project the liferaft's progress for calculated drift (9´) and call it point W. WO is 180° T x 9.

Use the ship's speed of 17 knots for the same time interval (i.e. 3 hours) and work out the distance to be travelled by the ship in 3 hours (3 x 17 = 51´).
Measure a distance of 51´ on the compass, centred at point W, and draw an arc to cut OA´ at A. OA is the course to rendezvous with the liferaft. From the plot, the course obtained is 110° T.

Since the ship will experience a leeway of 6° with a Northerly wind, the course to steer will be:

110° T
<u>- 006°</u> Leeway
104° T (Course to steer)

Time of rendezvous = 0900 + [(OA´ ÷ OA) x plotting interval]

= 0900 + [(55 ÷ 48.7) x 3] = 0900 + 3h 23m = **1223 hrs**

Example 12.4
Using Example 12.3, find the EP of the rendezvous as the bearing and distance from the ship's start position at 0900, if a current of 155° T at 2.8 knots was setting throughout.

Solution and comments

In Example 12.3, if a current was setting 155° T at 2.8 knots throughout, both the units would experience similar current. In such a case, the course to steer would not change. The total current would be applied to the R/V position to determine the actual position of rendezvous.

Time to R/V x set = Total Drift experienced
3h 23m x 2.8 knots = 9´.47 or 9´.5

This drift should be plotted in a direction of 155° T from the rendezvous DR to obtain the EP. From the plot, bearing and distance of the EP of the rendezvous from the ship's start position at 0900 is **116° T x 64´.7.** Also notice that the ground tracks in the examples 12.3 and 12.4 are different.

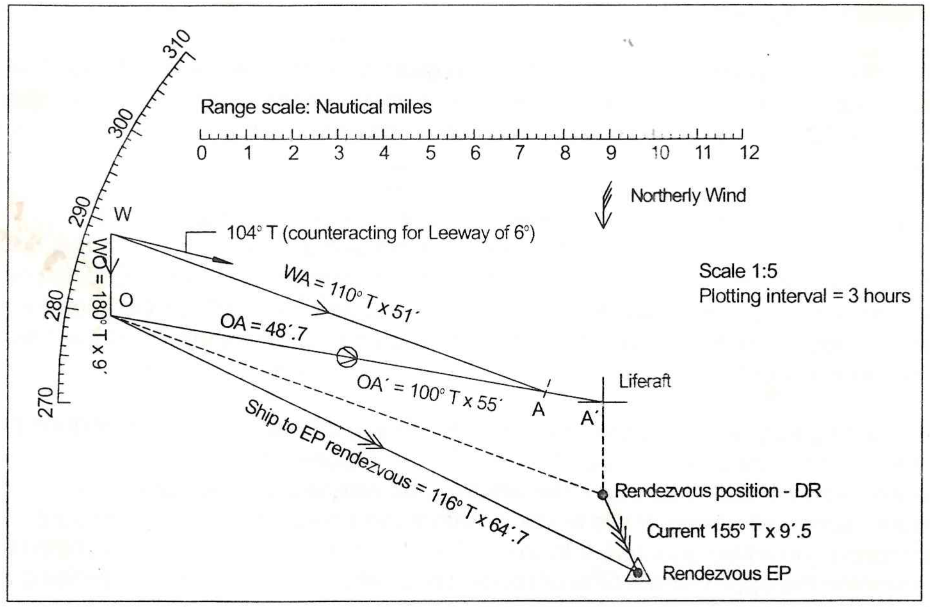


Figure 12.16 - Plot for Example 12.4

12.5.3 Rendezvous Involving Change Of Course / Speed

It is likely that one of the units involved is required to alter course and/or speed for operational reasons. To achieve a successful rendezvous, the final tentative track of the unit should be plotted after the alteration of course and/or speed and it should be projected backwards. The purpose is to determine the final relative approach between the units. For this to happen, it is very important to assume that both units are on a steady bearing. Use will be made of an effective position (ghost position) when determining the final relative approach. The following example addresses such a situation.

Example 12.5
At 1100, a vessel "X" with an injured seafarer on board is bearing 305° T, 48 miles from a large survey ship "Y", which has a doctor on board. The survey ship is presently steering 240° T at 9 knots. After 1 hour, the survey ship will alter course to 000° T and increase speed to 12 knots and then maintain it throughout. Find the course to steer by "X" in order to rendezvous as soon as possible with the survey ship, if the maximum speed is 15 knots. Determine the time of rendezvous.

Solution and comments

At 1100 hours, position A1 on the plot, survey ship "Y" is on a course of 240° T at 9 knots. After one hour, i.e. travelling 9 miles, it alters course to 000° T and increases speed to 12 knots at position A2. This change may not allow relative approach to be used.

Using a scale of 1:6, from the point of course and speed alteration – A2, the new course, 000° T at 12 knots, is projected to A3, as well as in a reciprocal direction at the new speed for 1 hour to point A´. The position derived from the reciprocal course and distance is the effective position of the survey ship for 1100, and is used for the relative approach. Some navigators refer to such a position as the ghost position, as it is imaginary only.

For plotting purposes, it is assumed that the survey ship is on a course of 000° T at 12 knots throughout and was at A´ at 1100. It is important to note that this assumption will only hold true if the rendezvous was to take place after the course/speed alteration. If it is to occur before the alteration, then the standard approach should be adopted. If there is any uncertainty a simple plot may help to determine the approximate time of rendezvous, which will be useful for deciding on the final approach. From the centre, plot the bearing and distance of the vessel "X", i.e. 305° T x 48´. This is shown as a pecked line on the plot and with the point O.

Join OA´. This is the effective relative approach between both the ships.

Draw WO at O, which is 000° T x 12´, as the plotting interval of one hour has been used and it has been assumed that the survey ship is on a course of 000° T at 12 knots throughout.

Using W as the origin, mark A along the line OA´, such that WA is 15´, as the maximum speed of vessel "X" is 15 knots.
Direction of WA represents the course to steer by "X" to rendezvous at the earliest time. From the plot WA is **118°.5 T.**

Time of rendezvous = 1100 + [(OA´ ÷ OA) x plotting interval]
= 1100 + [(54.1 ÷ 24.1) x 1] = 1100 + 2h 15m = **1315 hrs**

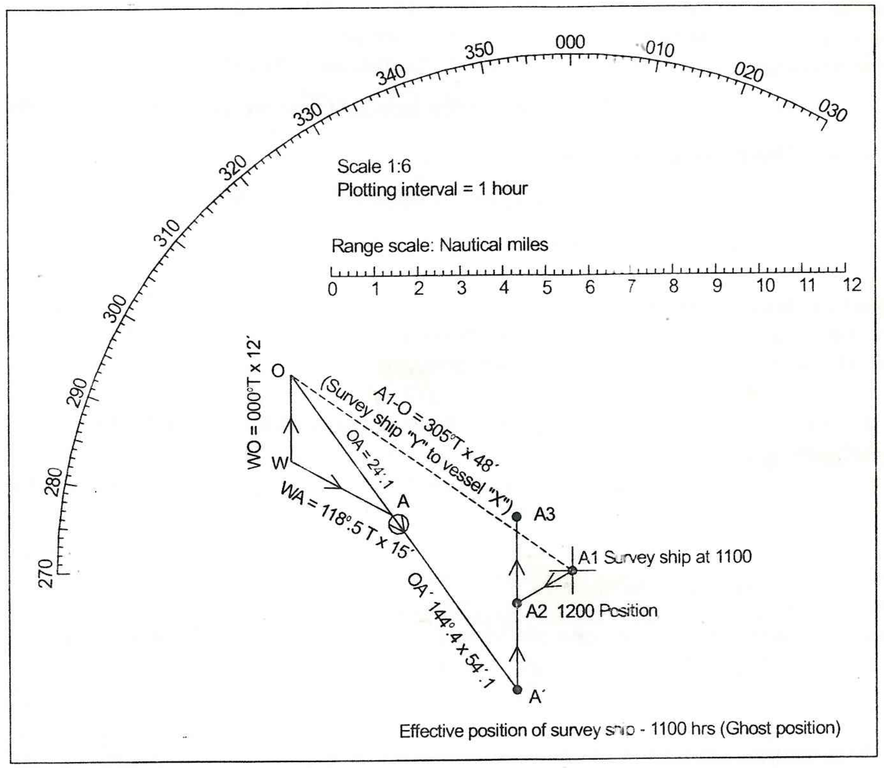


Figure 12.17 - Plot for Example 12.5

12.5.4 Station Keeping

Other than for direct rendezvous, units are also expected to know how to approach each other to provide assistance, receive or supply stores, participate in search and rescue, or for any other operational reasons. The aim is to position the unit as advised. Units may be required to reach a particular station or change an existing station for a new one. This positioning could be in the form of true or relative bearing and the distance from either of the units.

In such scenarios or problems, since the required station is related to one of the units in the form of a bearing and distance, it moves at the same course and speed as the unit to which it is related. The movement of this point is the same as WO.

Example 12.6
Your vessel is engaged on Ministry of Defence assigned duties. At 0400 GMT, your vessel has been ordered to come 2.5 miles to the port beam of an RFA vessel to

receive stores by helicopter. The RFA vessel is heading 350° T at 10 knots and is bearing 290° T from you at a distance of 22 miles.
Your maximum speed is 15 knots. Find the following by plotting:

- *The course to steer to reach the advised station as early as possible*
- *The ETA at the station*
- *The distance that you expect to pass astern of the RFA vessel*
- *The CPA from the RFA*

Solution and comments
Choose a suitable scale. For the example, plot 1:2 has been used. Plot the course of the RFA vessel from the centre of the sheet.

Plot the bearing and distance between both vessels as line O-RFA, with O representing your vessel.

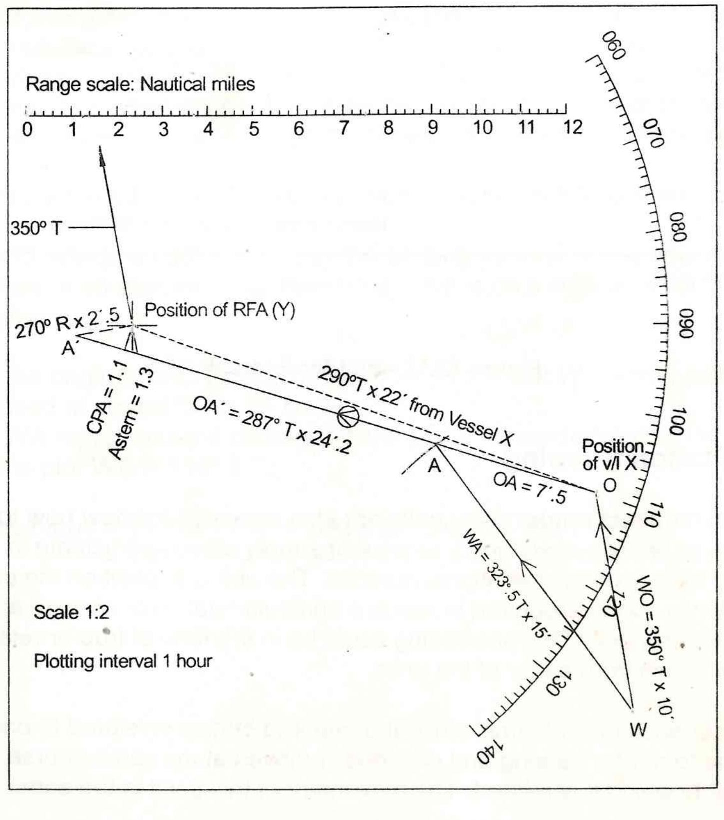


Figure 12.18 - Plot for Example 12.6

Since you are expected to position yourself at 2´.5 miles to the port beam of the RFA vessel (270° R x 2´.5), measure the distance 2´.5 miles to the port beam of the RFA

vessel at point A´. Join OA´. This is the relative approach as seen on the radar of the RFA. Your vessel would be seen as moving along this line from the RFA.

The plotting interval used is 1 hour. At O, plot WO in direction of 350° T x 12´.

From W, mark 15´ along the line OA´ and identify it as A. Join WA. WA is the course to steer to reach 270° R x 2´.5 from the RFA. From the plot the course is 323°.5 T.

For ETA: Time to station (A´) = (OA´ ÷ OA) x Plotting interval
= (24.2 ÷ 7.5) x 1 = 3h 14m
ETA = 0400 + 0314 = **0714 GMT**

For distance astern: Draw a line reciprocal to the course of the RFA to meet the line OA´. Measure the distance of this line. From the plot, it is **1´.3.**

For CPA: Draw a line from the centre to be perpendicular to the OA´ and reaching OA´. Measure the distance of this line. This is the CPA and is **1´.1.**

Example 12.7
At 1600 hours, two vessels are engaged on a parallel track search on a course of 160° T and a speed of 12 knots. The assisting vessel is 2´ to the port beam of the On Scene Co-ordinator's (OSC) vessel. Because of the improved conditions of visibility, the assisting vessel is advised to take up a new station 6´ on the port beam of the OSC's vessel.

Assuming that any alterations are instantaneously effective, find the course and speed of the assisting vessel to take up new station at the earliest time, whilst maintaining the same relative bearing from the OSC's vessel. The maximum speed of the assisting vessel is 15 knots. Find the time when the assisting vessel would be on the advised station.

Solution and Comments

Plot the course of the OSC's vessel, 160° T, from the centre of the plotting sheet. Considering the distances, the scale of the plotting sheet could be used directly and a smaller plotting interval of half an hour has been used.

Plot the port beam bearing for the OSC's vessel, i.e. 270° R. On this line, mark distances of 2´ and 6´. The line has been marked solid and thick between these two distances. This is the relative approach (OA) as seen from the OSC's radar.

The point 2´ on the port beam is marked O and indicates the position of the assisting vessel at 1600. The point 6´ on the port beam is identified as A´ and indicates the position where the assisting vessel will take up the advised station.

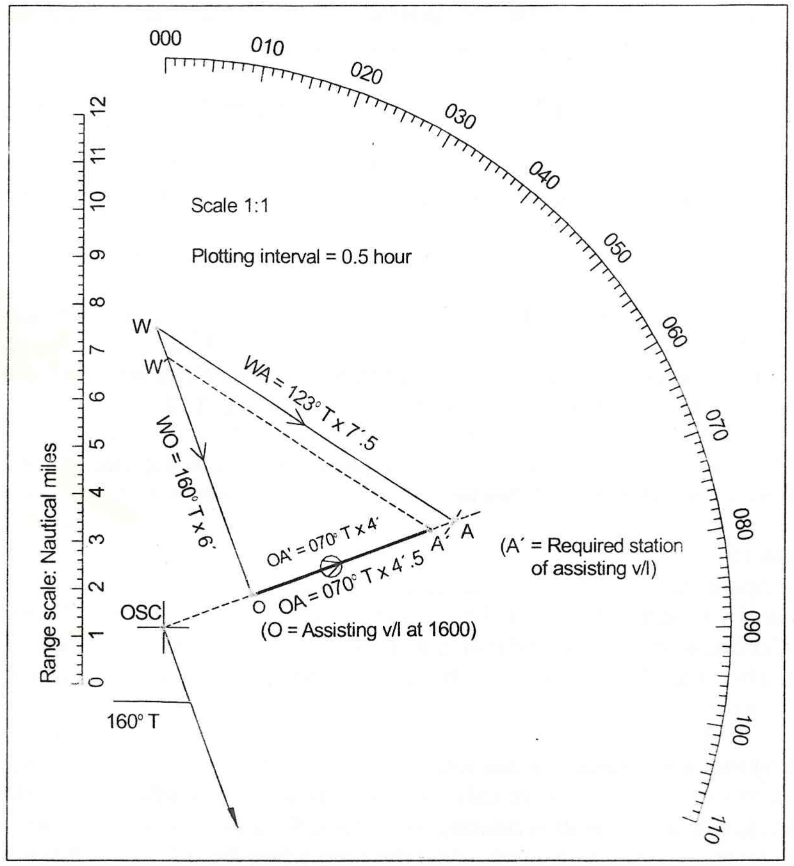


Figure 12.19 - Plot for Example 12.7

Choose WO of 6′ and plot it at O, such that WO is 160° T x 6′. With W as centre, mark the point A on the extended OA′ line. WA (7′.5 – half of the speed for half an hour plot) represents the course of the assisting vessel to take up the advised station at the earliest time.

From the plot, the course is **123° T**, at the maximum speed of the assisting vessel, which is **15 knots.**

For time: Time to station	= (OA′ ÷ OA) x Plot interval	
	= (4′ ÷ 4′.5) x 0.5	
	= 26m 40 s	= 27m approx
Time at station	= 1600 + 0027	= **1627 hrs**

Example 12.8

The above Example 12.7 may be modified. The time statement may read, Find the time of alteration, such that the assisting vessel is at the advised station precisely at 1630 hours.

The plot and calculations remain as above, the only change would be the final step involving "Time at station".

Time at station = 1630 - 0027′ = **1603** hrs
(Note that the time taken to station would be the same.)

Example 12.9

The above example 12.7 may be modified further. "Find the course and speed, such that the assisting vessel completes the manoeuvre in half an hour".

Solution and Comments

Repeat the steps in Example 12.7 above up to plotting the WO, such that WO = 160° T x 6′. Join W to A directly. As the assisting vessel has to complete the manoeuvre in half an hour and since the plot has been done with a plotting interval of half an hour, WA represents a run for half an hour.

Direction of WA represents the course and the length of WA (x 2, as plot has been done for half an hour) represents the speed of the assisting vessel to take up the advised station and to complete the manoeuvre in half an hour.

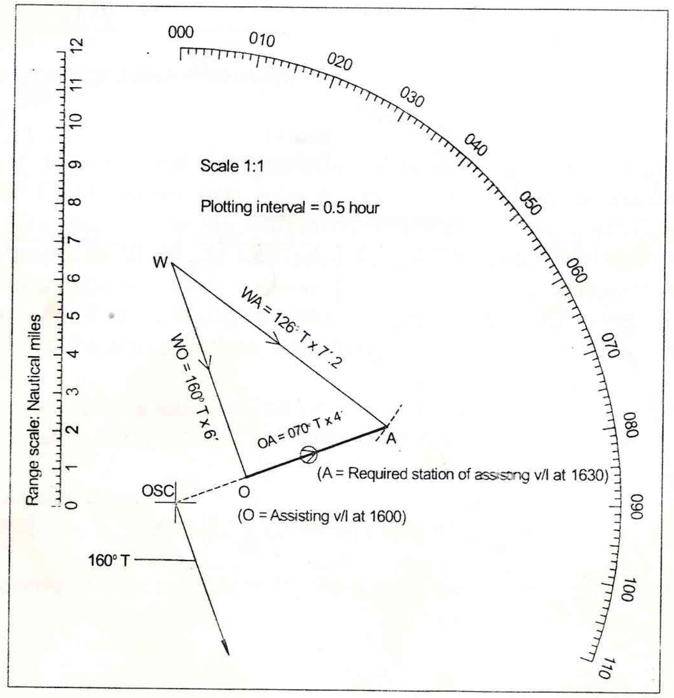


Figure 12.20 - Plot for Example 12.9

From the plot, the course is **126° T** and speed is 14.4 knots (7′.2 x 2). No calculation is required for time as the manoeuvre has been set as half an hour.

Example 12.10

At 1100 hours, two vessels are engaged in a parallel track search on a course of 150° T at 10 knots, during a search and rescue operation. The assisting vessel is 3′ on the port beam of the OSC's vessel and has a maximum speed of 13 knots. The assisting vessel is advised to shift station to a position 3′.5 due west of the OSC's vessel with immediate effect. Find the course the assisting vessel must take in order to complete the manoeuvre in the shortest time, assuming any alteration is instantaneously effective.

Find the time when the assisting vessel:

- *Will be on the new station*
- *Will be seen if the visibility was 2 miles*
- *Will be astern of the OSC's vessel*

At what distance will the assisting vessel pass astern of the OSC's vessel?

Solution and Comments

Draw the course of the OSC's vessel at the centre. Plot the position of the assisting vessel 3 miles to the port beam of the OSC's vessel (270° R x 3′). Identify it as point O.

Plot point A′, 3′.5 due west of the OSC's vessel. Join O to A′. OA′ is the relative approach as seen from the OSC's radar.

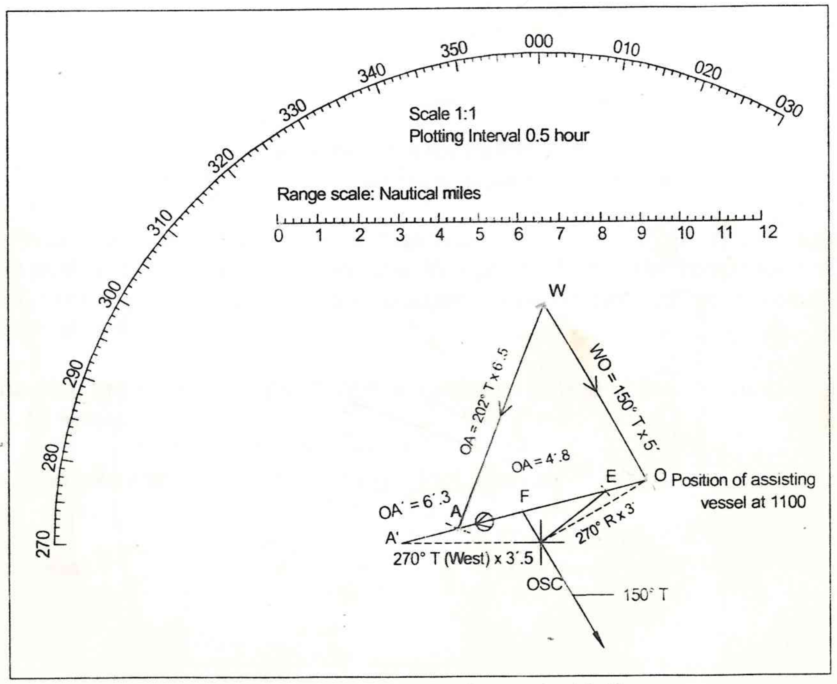


Figure 12.21 - Plot for Example 12.10

At O, plot WO, 150° T x 5′. As the OSC's vessel is conducting a search at 10 knots, point O is moving at the same speed. A plotting interval of half an hour has been used.

From W, draw an arc on the line OA′ using 6′.5 as radius (half of speed). Identify this point as A. Join W to A. WA is the course of the assisting vessel at 13 knots to enable her to take up position at the advised station at the earliest time. From the plot the course is **202° T.**

Complete the other construction. From the centre, draw an arc along the line OA′, with 2′ as radius, and identify this point as E. Draw the reciprocal of the heading line from the centre to meet the OA′. Identify this point as F. Measure OA′, OA, OE and OF. Also measure the distance of the centre to F.

These are OA′ = 6′.3, OA = 4′.8, OE = 1′.1, OF = 3′.1 and Centre-F = 0′.9

Times:

At new station = 1100 + [(OA′ ÷ OA) x 0.5] = 1100 + [(6.3 ÷ 4.8) x 0.5]
= 1100 + 0039 = **1139 hrs**

When visible = 1100 + [(OE ÷ OA) x 0.5] = 1100 + [(1.1 ÷ 4.8) x 0.5]
= 1100 + 0007 = **1107 hrs**

When astern = 1100 + [(OF ÷ OA) x 0.5] = 1100 + [(3.1 ÷ 4.8) x 0.5]
= 1100 + 0019 = **1119 hrs**

The distance when passing astern = **0′.9**

Example 12.11

Three ships, X, Y and Z, are engaged in a line abreast parallel track search on a course of 090° T at 10 knots, with a track spacing of 4′, during a search and rescue operation at 1200 hours. X is the Northern most of all and is the OSC's ship, with Y in the middle and Z to South. At 1230, due to the deterioration of visibility to 2′.0, Z is advised to shift station to a new position, 2′.5 on the starboard quarter of X. If the maximum speed of Z is 13 knots, find the course required of Z in order to complete the manoeuvre in the shortest time, assuming any alteration is instantaneously effective.

Find the times when the ship Z will be on the new station.

Find the time and bearing when Z will sight ship Y, if visibility is 2′.0.

Solution and Comments

Plot the three ships, X, Y and Z as in the example statement.

By now the reader should be able to complete the basic plot, mark the respective points O, A′, A and W, and determine the course to steer at 13 knots, which is 031°.5T.

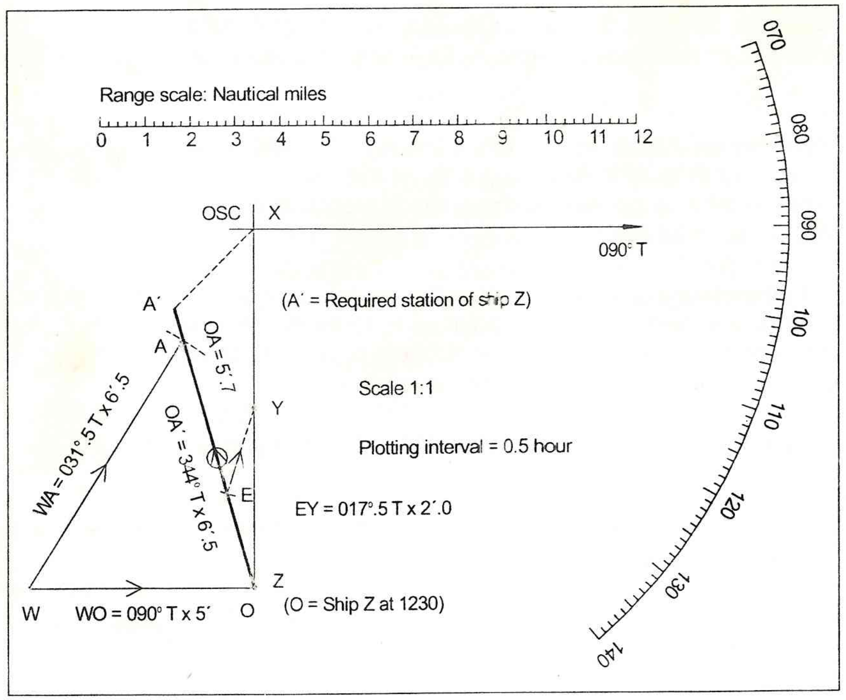


Figure 12.22 - Plot for Example 12.11

The required distances for time are OA′ = 6′.5, OA = 5′.7, OE = 2′.2

Times:
At new station = 1230 + [(OA′ ÷ OA) x 0.5] = 1230 + [(6.5 ÷ 5.7) x 0.5]
= 1230 + 0034 = **1304 hrs**

When visible = 1230 + [(OE ÷ OA) x 0.5] = 1230 + [(2.2 ÷ 5.7) x 0.5]
= 1230 + 0012 = **1242 hrs at a bearing of 017°.5** T

12.5.5 Rendezvous At A Specific Time

In this type of problem, the assisting vessel usually maintains course and speed, and the vessel requiring assistance heads for a position, advised by the assisting vessel at a determined time.

The usual examples for the determined time could be sunrise, civil twilight or one hour before sunrise.

Some navigators find such problems very complicated, although in reality, the work is rather simple.

It only requires the working out of sunrise time and plane sailing and the calculation can then be performed in five steps:

1. Work out time of sunrise for the ship required to maintain its course and speed, based upon the position stated in the problem (1st approximation).
2. From sunrise, work out the time and distance it is required to run, and obtain position reached.
3. Based upon the new position, work out the refined time of sunrise for the ship required to maintain course and speed (2nd approximation).
4. From the refined sunrise, work out the time and distance it is required to run, and obtain the refined position reached.
5. Between the other ships position and the position of the first ship at sunrise, work out course distance and speed.

Example 12.12
At 0450 GMT on 18 June 2006, a tanker in position 39° 42′ N, 145° 06′ W has an injured seafarer requiring urgent medical attention onboard.

At the same time a passenger vessel in position 40° 00′ N, 148° 07′ W heading 076°T at 26 knots, has a doctor on board and has agreed to assist. It will maintain course and speed.

It has been agreed that the transfer will take place at sunrise next morning. Find the following:

- *GMT of sunrise*
- *Rendezvous position*
- *The course and speed of the tanker in order to rendezvous at sunrise.*

Solution and Comments

Step 1	1st Approximation	
	h m	
LMT sunrise for 40° N (19-6-06)	04 31	
Increment for	00 00	
LMT sunrise for 40° 00′ N	04 31	
Longitude in time (148° 07′ W) +	09 52	
GMT sunrise (1st approx)	**14 23**	based on position at 0450 GMT
Initial GMT	04 50	
Difference	**09 33**	
Speed	26 knots	
Distance to run	248′.3	

Step 2

For course 076°T and distance 248′.3. d.lat and Departure are:
d.lat = Cos Course x Distance = Cos 076° x 248′.3 = 60′.1 N (1° 0′.1)
Dep = Sin Course x Distance = Sin 076° x 248′.3 = 240′.9 E

Latitude = Lat of Pass V/L ~ d.lat
= 40° 00′ N ~ 01° 00′.1 N = 41° 00′.1 N

Mean Latitude = 40° 30′.05 N

d.long = Dep / Cos Mean Lat
= 240′.9 / Cos 40° 30′.05 N = 316′.8 E = 005° 16′.8 E

Longitude = Long Pass V/L ~ d.long
= 148° 07′ W ~ 005° 16′.8 E = 142° 50′.2 W

Step 3 2nd Approximation for a refined time of sunrise

LMT sunrise for 40° N	04 31	
Increment for 01° 00′.1 -	00 03	
LMT sunrise for 41° 00′.1 N	04 28	
Longitude in time (142° 50′.2 W)+	09 31	
GMT sunrise (2nd Appx)	**13 59**	based on 1st approximation of position
Initial GMT	04 50	
Difference	09 09	
Speed	26 knots	
Distance to run	237′.9	

Step 4
For course 076°T and distance 237′.9, d.lat and Departure are:
d.lat = Cos Course x Distance = Cos 076° x 237′.9 = 57′.6 N
Dep = Sin Course x Distance = Sin 076° x 237′.9 = 230′.8 E

Arrived latitude = Lat of Pass V/L ~ d.lat
= 40° 00′. 0N ~ 57′.6 N = **40° 57′.6 N**
Mean Latitude = 40° 28′.8 N
d.long = Dep / Cos Mean Lat
= 230′.8 / Cos 40° 28′.8 N = 303′.4 E = 005° 03′.4 E
Arrived Long = Long Pass V/L +/- d.long
= 148° 07′ ~ 005° 03′.4 E = **143° 03′.6 W**

The cargo vessel will have to head for the position of the passenger vessel at Sunrise (1359), i.e., 40 57′.6 N, 143 03′.6 W (Rendezvous position).

Step 5

Cargo vessel's position at 0450 GMT	39° 42′ N	145° 06′ W
Passenger Vessel's position at Sunrise	40° 57′.6 N	143° 03′.6 W
d.lat	01° 15′.6 N d.long	002° 02′.4 E
	(75′.6)	(122′.4)
	M Lat 40° 19′.8 N	

Dep = d.long x Cos M Lat = 122′.4 x Cos 40° 19′.8 = 93′.3
Tan Course = Dep / d.lat = 93′.3 / 75′.6 = 1.23413 Course = N 51° E

Distance = d.lat / Cos Course = 75′.6 / Cos 51° = 120.1 Nautical Miles
Speed = Distance / Time = 120.1 / 09 09 = 13.13 Knots

GMT Sunrise = **1359**	Course = **N 51° E**	Speed = **13.1 Knots**
Rendezvous Position	Lat = **40° 57′.6 N**	Long = **143° 03′.6 W**

Example 12.13

At 1835 GMT, 06 May 2006, a passenger ship steaming at 25 knots is in position 38° 24′N 052° 42′W following a Rhumb line for a landfall at 40° 43′N 074° 00′W.

A seriously injured seafarer on a bulk carrier is to be transferred to the passenger ship, which has a doctor on board, at sunrise the next morning. The bulk carrier, at 1835 GMT, is in position 36° 48′N 058° 26′W.

- *Calculate the LMT sunrise for the passenger ship*
- *Calculate the rendezvous position*
- *Calculate the course and speed required of the bulk carrier in order to rendezvous successfully.*

Solution and comments
In this problem the course of passenger ship is not stated and needs to be worked out using Mercator Sailing between its position at 1835 and landfall.

Position at 1835	38° 24′N	MP 2484.26	052° 42′W
Landfall position	40° 43′N	MP 2663.85	074° 00′W
d.lat	02° 19′N	DMP 179.59 d.long	21° 18′W
	(139′)		(1278)

Tan Co	= d.long / DMP	= 1278 / 179.59	= 7.116209
Course	= 82°	= N 82° W	= 278°T

The position and times are for 06 May 2006, so the sunrise time required will be for 07 May 2006. By observation of the Nautical Almanac (HMSO) 2006, it will be noticed that 07 May 2006 is not the middle of the three days. It may be required to interpolate between the times of sunrise for 05 May 2006 and 08 May 2006 as they are the middle days on the corresponding pages (Pages 93 and 95).

The time of sunrise is required for Latitude 35°N and 40°N, so times are observed as follows:

	05 May	08 May	07 May
LMT for 35° N	0505	0503	= 0504
LMT for 40° N	0456	0452	= 0453

Step 1 1st Approximation

LMT sunrise for 35°N (07-5-06)		05 04	
Increment for 3° 24´	-	00 07	
LMT for 38° 24´N		04 57	
Longitude in time (052° 42´W)+		03 31	
GMT	07	08 28	based on position at 2130 GMT
Initial GMT	06	18 35	
Difference		13 53	
Speed	x	25	
Distance to run		347´.1	

Step 2

For course N 82° W and distance 347´.1, d.lat and Departure are:

d.lat = Cos Course x Distance = Cos 82° x 347´.1 = 48´.3 N
Dep = Sin Course x Distance = Sin 82° x 347´.1 = 343´. 7 W
Latitude = Lat of passenger ship ~ d.lat
= 38° 24´N ~ 48´.3 N = 39° 12´.3 N
Mean Lat = 38° 48´.15 N
d.long = Dep / Cos Mean Lat
= 343´.7 / Cos 38° 48´.15 = 441´.0 = 7° 21´ W
Longitude = Long of passenger ship ~ d.long
= 052° 42´ W ~ 7° 21´ W = 060° 03´ W

Step 3 2nd Approximation for a refined sunrise time

LMT sunrise 35° N (07-5-06)		05 04	
Increment 4° 12´.3	-	00 09	
LMT sunrise 39° 12´.3 N		04 55	
Longitude in time (060° 03´ W) +		04 00	
GMT	7	**08 55**	based upon 1st approximation position
Initial GMT	6	18 35	
Difference		14 20	
Speed	x	25	
Distance to run		358´.3	

Step 4

For course N 82° W and distance 358´.3 d.lat and Departure are:

d.lat = Cos Course x Distance = Cos 82° x 358´.3 = 49´.9 N
Dep = Sin Course x Distance = Sin 82° x 358´.3 = 354´.8 W
Arrived Latitude = Lat of passenger ship ~ d.lat
= 38° 24´ N ~ 49´.9 N **= 39° 13´.9 N**
Mean Latitude = 38° 48´.95 N
d.long = Dep / Cos Mean Lat
= 354´.8 / Cos 38° 48´.95 = 455´.3 W = 7° 35´.4 W
Arrived Longitude = Long of passenger ship ~ d.long
= 052° 42′ W ~ 7° 35´.4 W **= 060° 17´.4 W**

Step 5

The bulk carrier will have to head for the position of the passenger ship at Sunrise (08 55), i.e., 39° 13´.9 N, 060° 17´.4 W.

Bulk carrier's position at 1835 GMT	36° 48´N	058° 26´W
Passenger ship's position at Sunrise	39° 13´.9 N	060° 17´.4 W
	d.lat 02° 25´.9 N (145´.9)	d.long 001° 51´.4 W (111´.4)

Mean Lat = 38° 00´.95 N
Dep = d.long x Cos Mean Lat = 111´.4 x Cos 38° 00´.95 = 87´.8 W
Tan Course = Dep / d.lat = 87´.8 / 145´.9 = 0.601782 = 31°.038
Course **= N 31° W** **= 329° T**
Distance = d.lat / Cos Course = 145´.9 / Cos 31°.038 = 170´.3
Speed = Distance / Time = 170´.3 / 14 20 = 11.88 knots

LMT Sunrise = **07th 0855 GMT** Course = **329° T** Speed = **11.9 kts**
Rendezvous position Lat = **39° 13´.9 N** Long = **060° 17´.4 W**

Example 12.14

A seriously injured seafarer on an oil tanker is to be transferred to a passenger ship with a doctor on board at sunrise.

At 0145 Zone Time, 06 May 2006, a tanker was in 35° 22´S 179° 32´W.

At the same time the passenger ship was in 35° 00´S 178° 30´E, on a course of 090° T, speed 27 knots. The passenger ship is to maintain its course and speed.

- *Calculate the time of sunrise for the passenger ship*
- *Calculate the rendezvous position*
- *Calculate the course and speed required for the oil tanker in order to rendezvous successfully.*

Solution and comments

This problem is complex, as the initial time given is the Zone Time. By observation of the longitude of both ships, it is evident that they are on either side of the 180° meridian, i.e:, the International Date Line. Hence the ship in the Eastern Hemisphere (the passenger ship) will be keeping to Zone –1200 and the ship in the western hemisphere (the oil tanker), will be keeping to Zone +1200. They will both have a common GMT. GMT is determined thus:

Zone Time	06 May	0145 (For oil tanker)
Zone		1200 (+) (as ship is in Western Hemisphere)
GMT	06 May	1345

It is necessary to interpolate between times for 05 May 2006 and 08 May 2006 as they are the middle days on the corresponding pages (Pg 93 & 95).

Sunrise is required for latitude 35° 00′ N for 07 May 2006, as the passenger ship (being in the Eastern Hemisphere) will be there on 06 May. Hence, times are observed as follows:

	05 May	08 May	Difference
LMT for 35° S	0639	0642	3 minutes for 3 days
(1 minute for 1 day)			
LMT for 35° S	0641 on 07 May 2006 & 0640 on 06 May 2006		

Step 1 1st Approximation

		h m	
LMT sunrise for 35° S (07 May)		06 41	
Longitude in time (178° 32′E) -		11 54	
GMT	06	18 47	based on position at 1345 GMT
Initial GMT	06	13 45	
Difference		**05 02**	
Speed	x	27	
Distance to run		135′.9	

Step 2

For course 090° T and distance 135′.9, d.lat and Departure are:

d.lat = Nil (as ship going 090° T)

Dep = Distance run = 135′.9 E

Latitude = 35° 00′ S (Mean Lat also = 35° 00′ S)

d.long = Dep / Cos Mean Lat

= 135′.9 / Cos 35° = 165′.9 E = 2° 45′.9 E

Longitude = Long of passenger ship ~ d.long

= 178° 30′ E + 2° 45′.9 E = 178° 44′.1 W (i.e. 360° – 181° 15′.9)

Step 3 2nd Approximation for a refined time of sunrise

As the passenger ship's new position is in the Western Hemisphere, the LMT will be taken for 06 May 2006.

LMT sunrise 35° S (06 May)		06 40
Longitude in time (178° 44′.1 W) +		11 55
GMT	06	18 35
Initial GMT	06	13 45
Difference		04 50
Speed	x	27
Distance to run		130′.5

Step 4

For course 090° T and distance 130′.5. d.lat and Departure are:

d.lat = Nil

Dep = Distance = 130′.5 E

Arrived Latitude = Lat of passenger ship (course 090° T) = **35° 00′ S**

Mean Latitude = 35° 00′ S

d.long = Dep / Cos Mean Lat

= 130′.5 / Cos 35° = 159′.3 E = 2° 39′.3 E

Arrived Longitude = Long of passenger ship ~ d.long

= 178° 30′ E + 2° 39′.3 E = (360° - 181° 09′.3) = **178° 50′.7 W**

Step 5

Tanker's position at 1345 GMT	35° 22′ S	179° 32′ W
Passenger Vessel's position at Sunrise	35° 00′ S	178° 50′.7 W
d.lat	00° 22′ S	d.long 0° 41′.3 W

Mean Lat = 35° 11.′0 S

Dep = d.long x Cos Mean Lat = 41′.3 x Cos 35° 11′ = 33′.75 W

Tan Course = Dep / d.lat = 33.75 / 22 = 1.5343185 Course= 56°.9

Course = **S 57° W** = **237° T**

Distance = d.lat / Cos Course = 22 / Cos 56°.9 = 40′.3

Speed = Distance / Time = 40′.3 / 04 50 = **8.33 knots**

Sunrise = **06th May 1835** Course = **237° T** Speed = **8.3 kts**

Rendezvous position Lat = **35° 00′ N** Long = **178° 50′.7 W**

12.6 Interception

Example 12.15

In conditions of restricted visibility, a support vessel is steering a course of 130° T at 15 Kts. It has a radar contact, which is later confirmed as being a vessel in distress, heading for a port of refuge. The radar observations are as follows:

Time	*Bearing*	*Range*
1310	*220°*	*11′.8*
1319	*230°.5*	*9′.6*
1328	*247°*	*7′.8*

The support vessel is advised to intercept and escort to port, maintaining station 1 mile to the starboard beam of the distressed vessel. Assuming that any alterations are instantaneously effective and the distressed vessel maintains its course and speed, find:

- *The course to steer at a maximum speed of 20 Kts, at 1337 to intercept and take station 1 mile on the starboard beam of the distressed vessel*
- *The time of taking station as advised*
- *The course and speed required to maintain station*

Tidal stream is slack and the wind is calm throughout.

Solution and Comments
Considering the distances, the natural scale of the plotting sheet can be used.

Plot the support vessel at the centre, A´.

Plot the observations and label them with the times, with the first one as O and the last as A. Join OA to obtain the relative approach of the distressed vessel. Extend this line to the point A1, which represents the position of distressed vessel at 1337. Plot WO, 130° T @ 15 Kts for 18 minutes (1310~1328), i.e. 4´.5. Join W to A to obtain course and speed of the distressed vessel. This is 051° T x 4´.95, giving its speed as 16.5 Kts.

From the centre plot a point one mile on the starboard beam of the distressed vessel. This would be 051° + 90° = 141° T. Identify it as point A2. Join A2 to A1 and extend it beyond A1. This line is the required relative approach to take up the interception station.

A 15 minute time interval has been used to complete the rest of the plot. Draw a line 051° T x 4´.1 (16.5 x 15/60) as W2A2. With W2 as centre and a radius of 5´ (20 x 15/60), draw an arc on the extended A1A2 line to obtain point O2. Join W2O2. This is the course the support vessel should steer at 20Kts to intercept and take station as advised.

Time of interception = 1337 + [(A1A2 ÷ O2A2) x 15] = 1337 + [(6´.4 ÷ 8´) x 15]
= 1337 + 0012 = 1349 hours

The course and speed required to maintain station are the same as the course and speed of the distressed vessel, i.e. 051° T @ 16.5 Kts.

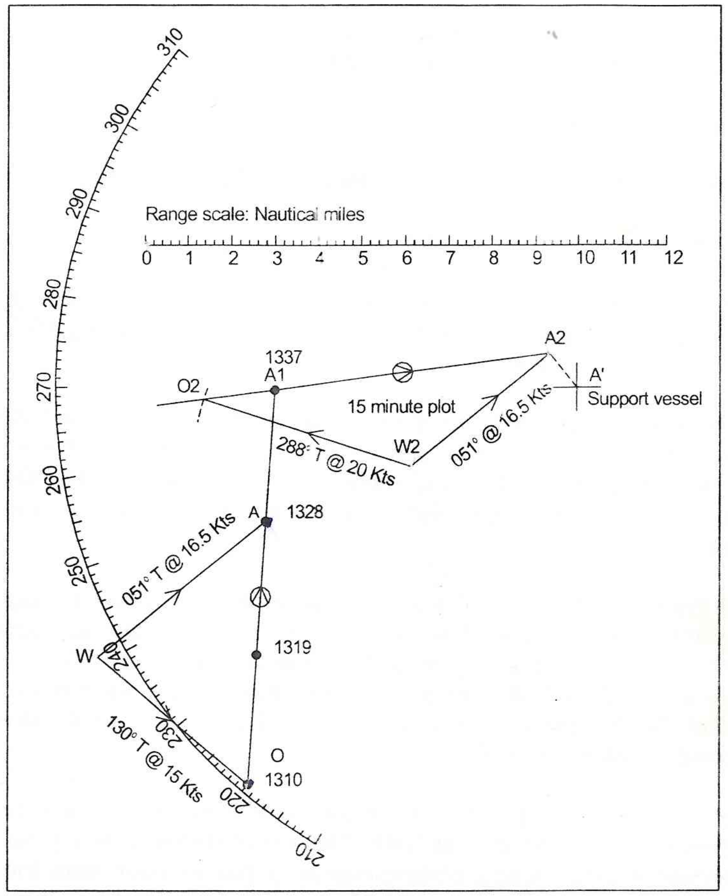


Figure 12.23 - Plot for Example 12.15

Example 12.16
A naval ship is patrolling on a course of 110° T, speed 9 knots, and is in a position bearing 350° T, distance 5´.5, from a lighthouse in position 25° 32´ N, 057° 43´ E. The naval ship observes a vessel on its radar as follows:

Time	*Bearing (°T)*	*Range (NM)*
1012	*055*	*10.0*
1024	*036*	*8.3*
1036	*012*	*7.8*

A decision is made to intercept this vessel for investigation. Assuming that any alterations are instantaneously affective, and that the observed vessel maintains its course and speed, find:

- *The course to steer from 1048 hours to intercept the observed vessel using a maximum speed of 27 knots*
- *The ETA at the interception position*
- *The interception position relative to the lighthouse*

The average estimated set of the tidal stream is 235° T at 3 knots for the naval Ship and 250° T at 2 knots for the observed vessel.

Solution and comments

Considering the distances involved, this plot can be completed on a radar plotting sheet, using its natural scale. This problem will best be dealt with in five stages. These have been indicated on the plot.

"1" Plot the lighthouse and the naval ship (A´) relative to each other. From the centre plot the lighthouse, such that the naval ship is bearing 350° T, distance 5´.5 from the lighthouse.

"2" Determine the naval ship position relative to the lighthouse at 1048 and its ground track by applying the course/distance steered (110° T x 5´.4) and the tidal stream (235° T x 1´.8) experienced for 36 minutes (1012~1048). The reciprocal of the relative movement of the lighthouse is the ground track of the naval ship.

"3" Plot the radar observations from 1012 to 1036. Draw a line through the same, OA, and extend to reach 1048, i.e. A1. This is the relative approach of the observed vessel. Apply the ground track of the naval ship (WO) to determine the water (WA2 = 274° T @ 8.5 Kts) and ground (WA) track of the observed vessel. For this purpose, tidal stream 250° T @ 2 knots would have to be applied for 24 minutes (0´.8).

"4" From the naval ship position (A´) draw a line to run through and beyond the observed vessels position at 1048. This would be the final approach line to intercept (A´O1). Using a plotting interval of half an hour, draw the observed vessels water track (W1A´ i.e. 4´.25) to join the centre. Apply the average drift being experienced by both vessels for a half-hour interval as W2W1 (250° T x 1´) and W2W3 (235° T x 1´.5).

With W3 as the centre and a radius of 13´.5 (½ of 27 Kts), draw an arc on the required interception line to obtain point O1. W3O1 is the course to be steered by the naval ship in order to intercept the observed vessel = 333° T.

A´O1 is the approach distance for half an hour. The ETA can be worked out:
ETA = 1048 + [(A´A1 ÷ A´O1) x 30] = 1048 + [(8´.7 ÷ 11´.4) x 30] = 1048 + 0023
ETA = 1111 hours

"5" Apply for 23 minutes, the course to steer (333° T), distance (10´.35) and the tidal stream experienced by the naval ship (235° T x 1´.15) to the lighthouse position at 1048, in order to determine the position at 1111 hours. The range and bearing of centre from this point is the position of the naval ship relative to the lighthouse, at the interception time, i.e. 344°.5 T x 11´.9

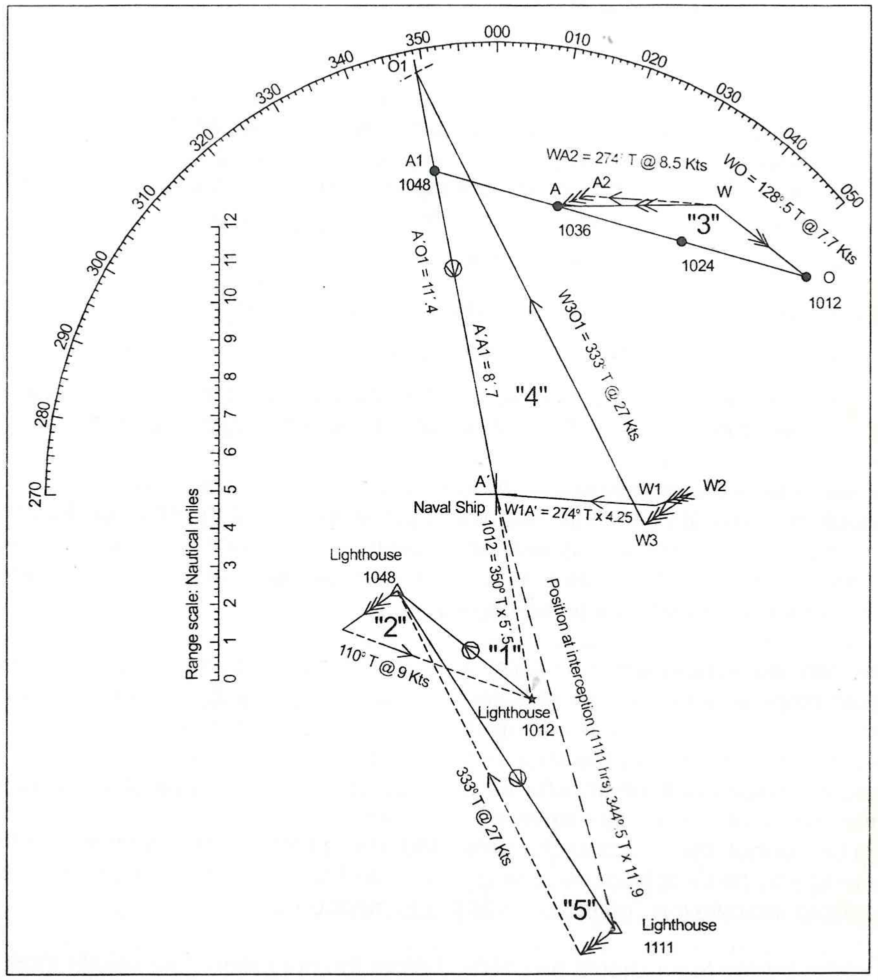


Figure 12.24 - Plot for Example 12.16

12.7 Rescue By Helicopter

Helicopters can be used for search and rescue at sea. Fixed-wing aircraft can be used to locate survivors and drop supplies, but cannot be used for practical rescue. The materials dropped might include liferafts, pumps, rations or communication equipment.

Helicopters have a limited range and can only be used in waters 200 to 550 miles from their base before needing to refuel. Helicopters may be civil or military.

12.7.1 Onboard Preparations

12.7.1.1 Bridge

Where possible, the ship must maintain a steady course as directed by the helicopter pilot. General guidance is based on the shipboard operating area.
The helicopter usually approaches from the port side of the ship. The ship should maintain relative wind as follows, where the operating area is:

- Aft: 30° on the port bow
- Midships: 30° on the port bow, or on either beam
- Forward: 30° on the starboard quarter
- Where this is not possible, the ship should remain stationery keeping its head into the wind. No attempt should be made to provide lee.

The sea area for operation should be selected carefully. It should be clear of navigational hazards and other shipping if possible, so that the ship has freedom of movement. The course and speed can be agreed in advance with the helicopter pilot and attempts should be made to maintain this, avoiding all delay, as helicopter flying time is dependent upon the fuel it carries.

Early communication with the helicopter is important. When requested, the ship should employ methods to identify itself. Position, heading, ETA, name, description, colour, special features, and transmission of a homing signal can assist the helicopter pilot to identify the ship. Details of the area of operation and persons/equipment to be transferred are important. The helicopter pilot may be advised of relative wind by displaying an air sock, international code flag, etc. Smoke from the funnel also indicates the same and where there is exhaust from the funnel, the wind should be at least two points off the port bow. The ship should also display signals to indicate it is "restricted in ability to manoeuvre".

All of the bridge team should be briefed before the operation. The vessel must be under the Master's orders and he must ensure that all safety and operational standards are complied with before engagement. The engine should be on standby and hand steering should be engaged before operations commence. Position monitoring should be continuous, along with situation awareness to keep the ship in the safe and clear area of operation. Extreme care must be exercised when using line throwing apparatus or any pyrotechnics.

12.7.1.2 Deck

The winching or landing area should be cleared, the yellow marking should be enhanced and upper parts of any obstructions should be conspicuously painted. All aerials and stays in the area should be struck, if possible. Obstructions that cannot be lowered should be well illuminated at night. Rails, etc. should be lowered or removed. All loose items should be removed from the area or secured firmly. The emergency and rescue party should be ready with the rescue boat, safety and fire fighting appliances.

12.7.2 Evacuation

A simple way to effect a rescue is for the helicopter to land on the distressed unit and take personnel onboard. This has the advantage of speed, but is subject to a suitable landing station being available onboard the distressed unit. Most units at sea lack this facility. However, large bulk carriers, oil tankers, container ships and some specialised ships have been operating with helicopter landing facilities for a while. It is now a requirement for passenger ships, and Ro-Ro ships carrying passengers, to be equipped with a helicopter landing area. There may be other restrictions to a helicopter landing on a distressed unit, such as fire, poor stability, weather or its location.

If a landing is not possible, the rescue will have to be carried out through winching. Usually the winching area is marked on the deck. Where and how to conduct operations will be at the pilot's discretion. The deck party should remain stationary and allow the helicopter to move to them. A winchman may be lowered with an additional strop, or just a strop at the end of the winch wire may be lowered. The survivor should put the strop under his/her arms and, after indicating readiness, should hold both arms against the side of the body. If the condition of the survivor does not allow a strop to be used, a stretcher will be lowered, along with a winchman, and the casualty will be strapped into the stretcher. (A helicopter will not normally lift marine Neil-Robertson type stretchers directly. The winchman may choose to transfer the casualty into the helicopter's own stretcher, or place the casualty and the ship's stretcher into the helicopter's own stretcher for lifting).

12.7.3 Hi-Line Technique

If there are obstructions on the ship, in the form or masts or rigging, the helicopter pilot may resort to a highline technique as it may not be possible to lower the winchman and/or strop directly to the deck. A rope extension of the winch wire may be lowered to the ship and should be handled by a member of the ship's crew. The slack is taken in as the helicopter pays out the winch wire. The extension rope should be coiled down onto the deck, clear of snags, but should not be made fast. The helicopter will descend after moving out to one side of the ship. As the descent is being made the ship's crew should continue to take in the slack. A winchman may be lowered with the strop. The earthing lead or winch hook should be allowed to touch the deck to disperse static electricity before the wire is handled.

After securing the casualty in the strop, the helicopter is signalled. The helicopter will then ascend and hoist the winch wire. At this stage, the extension rope should be paid out with enough weight on it to keep it taut. Two strops may be lowered if more persons are to be transferred, and the end of the extension rope should be kept in hand if possible, (but not secured) to facilitate the recovery of the strop for the next lift.

For ships with many obstructions on and around the decks, another alternative for transferring a casualty or casualties is by pre-transfer of the person(s) to the ship's boat and towing the boat astern on a long painter. The helicopter then winches the person(s) from the boat.

Example 12.17

At 1600 a helicopter is at bearing 330° T, 90′ from a ship. The ship has been advised to steer 270° T at 14 knots and is being set 345° T at 3 knots by a current. The gGround speed of the helicopter is 60 knots. What is the earliest time the ship can expect to rendezvous with the helicopter, and what will be the EP as a bearing and distance from the ship's position at 1600?

Solution and comments

In this example, the helicopter is making the approach and the ship would maintain its course and speed. The helicopter's position is O and the ship's position is A′. The current will only affect units floating in the water although the helicopter may be affected by wind.

Choose a suitable scale; 1:8 has been used for the example plot. Plot the ship's 1600 position at the centre and identify it as A′. From A′ measure 330° T x 90′. This is O and is the position of the helicopter. Join the two points as line OA′. This will be the relative approach line.

The ship's ground track has to be determined. To achieve a more accurate ground track, a triangle of 3 hours has been constructed. Draw a line in the direction of 270° T x 42′ (14 knots x 3 hours). The end of this line has been identified as point A1. From A1, draw set and drift, i.e. 345° T x 9′ (3 kts x 3 hrs). The end of this vector is the point A2. Join A′ to A2 to obtain the ground track of the ship. Measure A′A2 and divide it by three to obtain the ground speed of the ship; this is 15.1 knots and is the distance A′A3.

Using a plotting interval of one hour, draw WO (281°.1 T x 15′.1) at point O. With W as the centre, draw an arc on the line OA′ and call it point A. WA is the course of the helicopter (and is its ground track). Measure the distance OA, which is 68′.8

Time of rendezvous = 1600 + [(OA′ ÷ OA) x plotting interval]
= 1600 + [(90′ ÷ 68′.8) x 1]= 1600 + 1h 18.5m = **1718** hours

To obtain EP, draw a line parallel to WA from point O and run it to the ship's ground track. Measure the distance from A to EP, which is 19′.7

Another method of finding the EP distance is by multiplying the ship's ground speed by the time to rendezvous, i.e. 15.1 knots x 1h 18.5m = 19′.7

Therefore, the EP rendezvous **is 281°.1 T x 19′.7** from the ship's position at 1600.

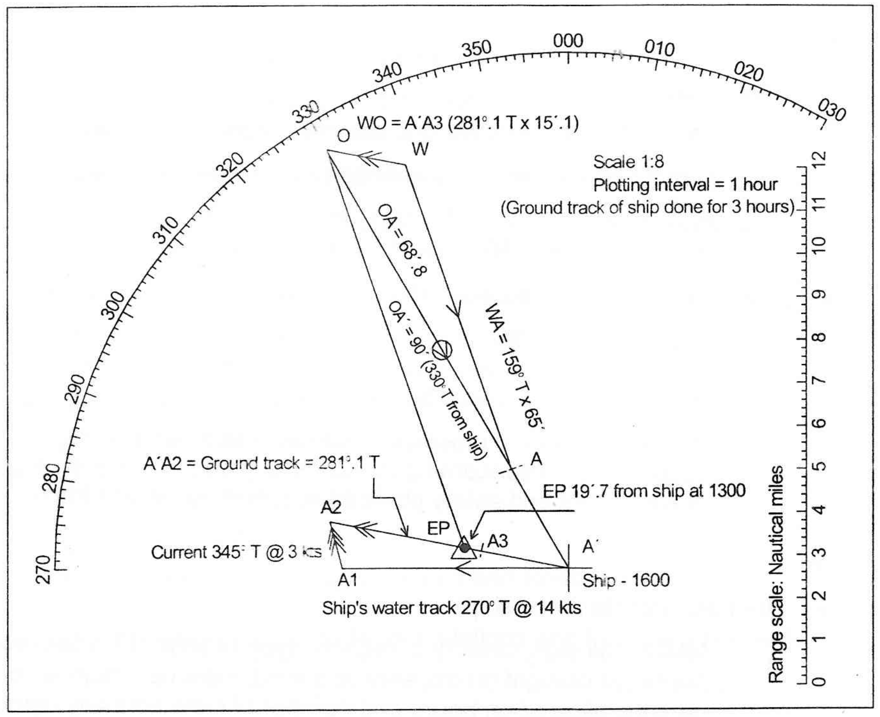


Figure 12.25 - Plot for Example 12.17

12.8 Search and Rescue Co-Operation Plans Aboard Passenger Ships

A plan for co-operation with the appropriate Search and Rescue services must be drawn up and carried by all passenger ships (Class I to Class VIA) using UK waters. International requirements also exist through SOLAS.

The plan must be agreed with the Search and Rescue service relevant to the ship's area(s) of operation. Ships that operate on inland waterways may have existing arrangements with the local Search and Rescue authorities (e.g., the Police) which are considered acceptable under the regulations. The plan must be available on board and the bridge is the correct location for it.

The plan should contain:

- List of contents
- Introduction
- Description of a Plan for Co-operation

The company

- Name and address
- Contact list
    - 24 hr emergency initial, and alternate, contact arrangements
    - Further communications arrangements (Phone/fax, etc)
- Chartlet(s) showing details of route(s) and Service(s) together with boundaries of relevant SRR (Search and Rescue regions)
- Liaison arrangements between the company and relevant RCCs
    - Provision of incident information – checklist detailing persons, cargo and bunkers on board, Search and Rescue facilities and any specialist support available at the time, etc.
    - Provision of liaison officer(s) – with access to supporting documentation concerning the Company and the ship(s); e.g. copies of fire control and safety plans as required by the flag state.

The ship

- The basic details of the ship
    - MMSI, call sign, country of registry, type of ship, GT, LOA, maximum permitted draught (in m), service speed, maximum number of persons allowed on board and number of crew normally carried
- Communication equipment carried
- A general plan of the decks and a profile of the ship, including basic information on:
    - LSA, FFA, helicopter deck and winching area with approach sector
    - helicopter types for which the deck is designed
    - means on board intended to be used to rescue people from the sea or from other vessels
    - a colour picture of the ship and whether the above details are transmittable by electronic means.

The RCCs

- SRRs along the route, a chartlet showing SRRs in the area(s) of the ship's operation
- Search and Rescue mission co-ordination (SMC), definition and summary of functions
- On-scene co-ordination (OSC), definition, selection criteria and summary of functions.

Search and Rescue facilities

- RCC/SCs along the route and their addresses
- Communications: equipment, frequencies available, watch maintained and contact list (MMSIs, call signs, telephone, fax and telex numbers)
- General description and availability of designated Search and Rescue units (surface and air) and additional facilities along the route, such as fast rescue vessels, other vessels, heavy / light helicopters, long-range aircraft and fire fighting facilities
- Communications plan
- Search planning
- Medical advice / assistance
- Fire fighting, chemical hazards, etc
- Shore reception arrangements
- Informing next of kin
- Suspension / termination of Search and Rescue action

The plan should include details on Media relations and Periodic exercises.

12.9 Man Overboard

The loss of a person from the ship, or a ship's boat, requires the Master of the ship to take measures for their recovery. The sequence of actions depends upon the time of notification of the bridge team, compared to the time of loss of the person. In cases where the watch officer witnesses the fall of the person, or has been notified immediately, the response is immediate.

12.9.1 In Open Waters

Initial actions are to be taken simultaneously (immediate response, when a person is seen to fall overboard or immediate report is made):

- Raise general emergency alarm
- Engage hand steering and shift helm hard over to the side on which person has fallen and commence Williamson's Turn
- Release bridge wing buoy with "man overboard signal"
- Note time and position. Press 'man overboard' key on position fixing device, or initiate auto waypoint, as appropriate
- Put the engine onto immediate standby

Specialised vessels may be able to execute a "single turn", to bring them back to the position where the person fell overboard, instead of using Williamson's Turn.

Subsequently:

- Post lookouts as high as possible and on all sides – keep the person in sight, use binoculars
- Hoist flag "O"
- Sound three prolonged blasts on the whistle, and repeat at intervals in restricted visibility
- Transmit DISTRESS message to vessels in the vicinity and shore authorities
- Muster the rescue boat crew, emergency and backup team
- Prepare the rescue boat for launching
- Reduce speed
- Establish communications with all teams using hand held VHF radios
- Rig scrambling nets and rope ladders on both sides to aid recovery
- Prepare stretcher, resuscitator, first aid kit and hospital
- Proceed with the man overboard to leeward and stop the vessel up wind for recovery

If the man overboard is not sighted, the vessel should commence a "Sector Search" to locate the person. In this case the length of each sector leg should be based upon time and not distance. For example, if a length of say 1 mile was selected, a full sector search would be 1 x 3 x 3 = 9 NM. Remember that a ship turning frequently by 120° will lose speed significantly. A ship capable of 16 knots may average about 9 knots in such a situation. So a distance of 9 NM would be covered in an hour. The initial Williamson's Turn would take between 5 to 15 minutes depending upon the size of the ship. Adding another hour to it could prove critical, especially in very cold sea conditions. Considering this, if the leg was of 2 minutes, 2 x 3 x 3 = 18 minutes would be the time taken for the search. It is important to appreciate that a person who falls overboard is unlikely to have drifted too much and the search should be focused on the position where the person was seen to fall overboard.

Where a person has been reported missing and has not been seen to fall overboard, the Master is still obliged to carry out a search to the last position at which the person was positively seen on board. It is very important to establish that the person is in fact missing. A full ship search should be conducted. Witnesses who sighted the person positively should be questioned carefully to establish the full facts. On board preparations should be as above.

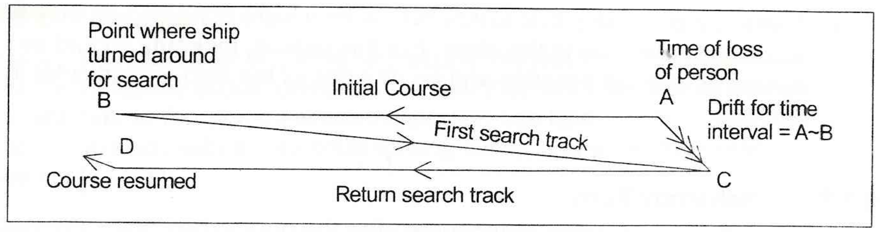


Figure 12.26 - Man Overboard

The ship should be turned around using a Scharnov Turn, as it is a delayed action and the distance lost would be less when compared to a Williamson's Turn. Once the ship losing the person has conducted an up and down search to the position at the time of the last known sighting of the person overboard, allowing for drift, it should resume its voyage. If the person is not found, the next port authorities will have to be notified. The Company should also be advised to provide a replacement at the next port. If the search is unsuccessful, the CRS should be advised to transmit URGENCY messages to shipping in the area advising a sharp lookout for a person in the water and to report sighting and effect rescue.

12.9.2 In Port

All of the manoeuvres described above are relevant, but instead of turning hard over and commencing a Williamson's Turn, speed should be reduced and a rescue boat launched in addition to calling the port authority. If a person falls overboard during mooring operations, a port tug or mooring boat should be called to recover the person from the water.

12.9.3 Man Overboard Manoeuvres

12.9.3.1 Williamson's Turn

This is used as an 'immediate action manoeuvre' just after a person has fallen overboard:

- Helm immediately hard over to the side on which the person fell. This has the advantage of pushing the stern away from the person in the water
- When the ship has turned 60° off original heading, the helm should be shifted hard over to the other side. (Note: The helm does not have to be shifted 60° for every ship. Masters should determine such helm angle during drills or other practice manoeuvres)
- When ship's heading is 20° short of the reciprocal heading, order helm amidships and steady up the ship on the reciprocal course. At the same time, speed reduction should be advised. (By this time, the ship would have lost a significant amount of its speed due to the turn. If propeller revolutions are not reduced, the ship would gain speed on a steady heading)
- At the final stages, the ship can be manoeuvred easily to create lee for person in water

- There is a possibility that lookouts may lose sight of person as they have to focus from one side to the other. For this reason, lookouts should be posted as high as possible and on all sides of the ship, in particular in the stern

12.9.3.2 Scharnov Turn

This is used as a delayed action manoeuvre after the person has been reported missing for a while.

- Helm hard over to one side and when the ship has turned 240° off the original heading, the helm should be shifted hard over to the other side
- When the ship's heading is 20° short of the reciprocal heading, order helm amidships and steady up the ship on the reciprocal course. At the same time, speed reduction should be advised
- This should never be used as an immediate action manoeuvre.

The Scharnov turn has the advantage of reducing distance loss during the manoeuvre. The Williamson's Turn has the advantage of bringing the ship back in to its wake, to the position where the manoeuvre was begun.

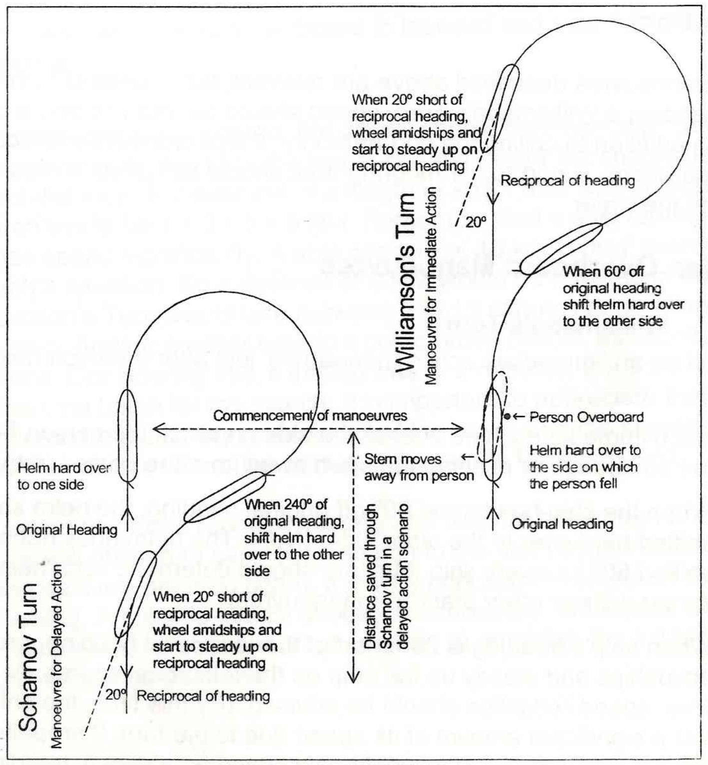


Figure 12.27 - Scharnov and Williamson Turns

12.9.3.3 Single Turn

This is another option for an immediate action manoeuvre. Specialised units which can turn very rapidly should complete the turn that has been initiated by shifting the helm hard over to the side on which the person has fallen. This should only be attempted on ships with a very small turning circle, and when the person overboard can be kept in view.

12.9.3.4 Single Delayed Turn

- Used as manoeuvre to turn ship around, when:
- there has been a brief delay in reporting the person overboard
- due to operational reasons, the ship cannot commence the turn immediately, e.g. presence of navigational hazards
- When ship has nearly turned around, the heading should be steadied to position the ship upwind of the person in water, so as to create lee.

Single turns are usually executed on the windward side when the person falls overboard on the lee side.

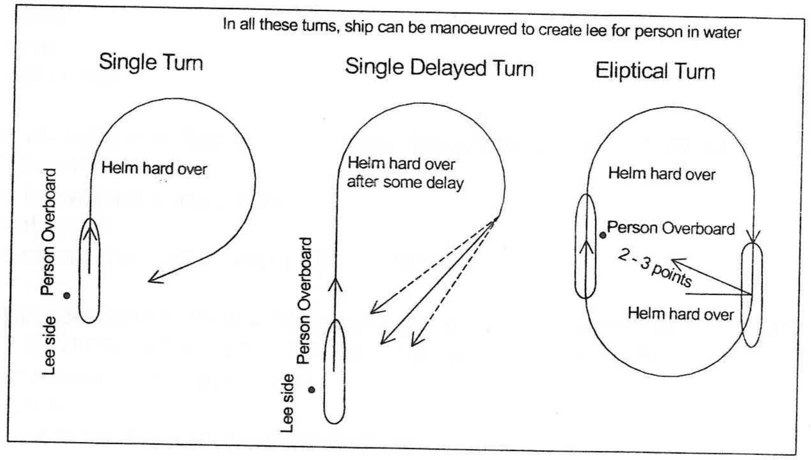


Figure 12.28 - Turns

12.9.3.5 Eliptical Turn (Double Turn)

This can be used as an immediate action manoeuvre or where there is a brief delay in reporting the person overboard

- The turn is commenced by shifting the helm hard over to the side on which person fell and allowing the ship to turn 180°. At this stage the ship is steadied up on the reciprocal heading
- When the person is 2 to 3 points abaft the beam, the helm is shifted hard over on the same side again to bring the ship on to the original heading

- This turn has the advantage of keeping the person on the same side. It is also preferable for use in traffic separation schemes or other circumstances when the ship needs to avoid heading into opposing traffic.

Authors Note

It is important to complete Search and Rescue operations in the shortest possible time in order to minimise the misery of those in distress. Making effective use of all available resources in a co-ordinated manner can expedite the operation and help bring it to a successful conclusion. The mariner needs to develop adequate skills to perform the expected tasks.

Further Exercises

These exercises are provided on each subject as an addition to those in the main text

1. A ship with a service speed of 14 knots has to follow a great circle track from a position off Rio de la Plata 34° 55´S 055° 58´W (Zone +0400) to a position off Cape Town 33° 50´S 018° 20´E (Zone -0200). Additional distance on the coast is 158 nm. Find the:
distance on passage
position of vertex
distance along the meridian from Gough Island (40° 20´S 009° 55´W)
ETA Cape Town if ship departed Rio on 5th May 2006 at 1400 local time

Hint: Add the additional distance to the distance between the two positions. For ETA, convert to GMT, add steaming time and then convert to local time.

2. A vessel has to follow a great circle track from 33° 50´S 032° 20´E to 04° 10´N 101° 50´E. Find the:
distance between the two positions
initial course
final course
position of vertex

3. A vessel has to follow a great circle track from 38° 35´S 135° 44´E to 08° 50´S 118° 10´W. Find the:
distance between the two positions
position of vertex
latitudes where the track crosses 160°E, 180° and 160°W

4. A vessel has to follow a composite great circle track from 40° 55´N 072° 50´W to 44° 55´N 008° 20´W with a limiting latitude of 46° N. Find the:
distance between the two positions
initial course
latitude where the track crosses the meridian of 055° 00´W

Hint: For "c", apply 1st d.long to the initial longitude to obtain the meridian of vertex (latitude of vertex is the limiting latitude)

5. A ship is on a voyage from Singapore to Panama Canal. The Master wishes to take advantage of the shortest possible route without contravening Load Line Rules. The ship is loaded to the Summer marks. 265 tonnes of fuel and water must be consumed, before the ship can enter the Winter zone at 35°N. The ship has a service speed of 16 knots and consumes 25 tonnes of fuel and water per day.

Departure position	20° 00´N	121° 50´E
Landfall position	20° 00´N	110° 00´W

Calculate the shortest legal distance on the passage if the additional distance on passage is 3641 nm. Calculate ETA Panama Canal (Balboa) (Zone +0500) if the ship departed Singapore (Zone -0800) on 3rd January 2006 at 1200 local time.

Hint: Add the additional distance to the distance between two positions. For ETA, convert to GMT, add steaming time and then convert to local time. This way the date line does not affect calculation.

6.
At 1000 hrs, a vessel is steering a course of 320°T at 10 knots in a TSS in conditions of restricted visibility. The vessel's track is 1′ inwards of the outer edge of the TSS. On a 12′ range scale, the following radar observations were made over a period of 12 minutes:

	A	B	C
1000	010° T x 10′	135° T x 7′	170° T x 7′
1012	010° T x 6′.9	133° T x 5′	180° T x 4′.7

Compile a radar report for 1012.
The Master wishes to disengage from the present situation. Determine a single alteration of course or speed to disengage from the present situation, assuming that the alteration is instantaneously effective. Comment on the new situation and suggest further course of action.

7.
At 1600 hrs, a vessel steering a course of 280°T at 12 knots is approaching a narrow channel in conditions of restricted visibility. Target A is a headland. On a 12′ range scale, the following radar observations were made over a period of 15 minutes:

	A	B	C
1600	290° T x 11′	280° T x 9′	130° T x 4′
1615	288° T x 8′	274° T x 5′	155° T x 1′.9

Compile a radar report for 1615.
Determine a single alteration of course or speed at 1620 to disengage from the present situation, assuming that the alteration is instantaneously effective. Comment on the new situation and suggest further course of action.

8.
A ship steering 165°T at 20 knots observes the following stars:

	Time	Bearing	Intercept
Star A	0545	200°T	1′.2 Towards
Star B	0551	105°T	1′.4 Away
Star C	0600	135°T	2′.6 Towards
Star D	0603	290°T	1′.3 Away

The DR position 22° 45′N, 064° 25′E was used for all intercepts. Find the vessel's position at 0600 hrs.

9.
At 1840 hrs, a vessel in DR 22° 50′S, 070° 12′E, on a course of 325°T at 20 knots, makes the following observations:

	Time	Azimuth	Intercept
Star A	1826	210°T	3′.4 T
Star B	1835	260°T	1′.6 T
Star C	1841	340°T	6′.0 T

The DR was used for all intercepts. Determine the observed position at 1835, if there was doubt that index error had been applied the wrong way.

10
At 1625 GMT, 04 May 2006, a passenger ship steering 180°T at 27 knots and is in position 21° 30′N 064° 40′E.

A seriously injured seafarer on a bulk carrier is to be transferred to the passenger ship with a doctor on board at sunrise next morning. The bulk carrier at 1625 GMT is in position 18° 30′N 063° 56′E.
Calculate the GMT sunrise for the passenger ship.
Calculate the rendezvous position.
Calculate the course and speed required of the bulk carrier in order to rendezvous successfully.

11.
Three ships, X, Y and Z, are engaged in a line abreast (co-ordinated) parallel track search on a course of 000° T at 12 knots, with a track spacing of 5′, during a search and rescue operation at 1400 hours. X is to the West, Y is in the middle and is the OSC's ship, with Z to East of all. At 1430, due to deterioration of visibility to 2′.0, Z is advised to shift station to a new position in the middle of tracks of X and Y, but to remain 2 miles behind. If the maximum speed of Z is 15 knots, find the course required of the Z in order to complete the manoeuvre in the shortest time, assuming any alteration is instantaneously effective. Find the time when the ship Z will be on the new station and its CPA with Y.

12.
On 19th June 2006, at 1000 GMT ship with a maximum speed of 18 knots, in 42° 30′N 020° 30′W, is required to rendezvous urgently with a ship bearing 190°T 60′ off, on a course of 260°T at 13 knots, in order to transfer an injured seafarer. Find:
Course to steer
The rendezvous position
The daylight remaining to complete the operation

Answers

1.
a. 3746´ (158 + 3588´.1)
b. 40° 39´.1S 020° 21´.0W (Initial course S 67° 42´.2E)
c. 9´.2 (N of Gough Island, if required to report) (latitude 40° 10´.8S)
d. Steaming time = 3746 / 14 = 11d 03h 34m

Departure	May	05	1400
Zone (+0400)		+	0400
Departure GMT			1800
Steaming time		11	0334
Arrival GMT	May	16	2134
Zone (-0200)		+	0200
ETA local time	May	16	2334

2.
a. 4533 (4532´.5)
b. N 75° E (74° 44´.5)
c. N 53° E (53° 28´.0)
d. 36° 44´.3S 006° 13´.9E

3.
a. 5808´ (5808´.1)
b. 41° 38´.1S 161° 54´.1E (Initial course S 72° 57´.7E)
c. Latitudes 41° 37´.1S (160°E), 40° 11´.8S (180°), 34° 38´.5S (160°W)

4.
a. 2780´ (1465´.5 + 652´.9 + 661´.1)
b. N 66° 49´.2E
c. 44° 57´.6 N (1st d.long = 33° 10´.5)

5.
Distance to travel to consume 265t = 265 / 25 = 10.6d x 24h x 16kts = 4070´.4
Distance to limiting latitude = 3203´.7
1st d.long = 58° 40´.9
Distance along parallel of 35°N = 866´.7 (4070´.4 – 3203´.7)
d.long for parallel sailing = 17° 38´.0
Longitude where GC can be followed = 161° 51´.1W
GC distance = 2868´.3
Total distance = 10580´ (4070´.4 + 2868´.3 + 3641´)

Steaming time = 10580 / 16 = 27d 13h 15m

Departure	Jan	03	1200
Zone (-0800)		-	0800
Departure GMT			0400
Steaming time		27	1315
Arrival GMT	Jan	30	1715
Zone (+0500)		-	0500
ETA local time	Jan	30	1215

6.

Target	A	B	C
Bearing	010°T, Steady	133°T, closing slowly	180°T , closing slowly
Range	6´.9, decreasing	5´, decreasing	4´.7, decreasing
CPA	0	0´.6	2´.2
TCPA	At 1039 in 27m	At 1042 in 30m	At 1032 in 20m
BCPA	010°T	050°T	242°T
Course	230°T	320°T	326°T
Speed	11.5	20	22.2
Aspect	R40°	R07°	G34°
Comments	Crossing stbd to port, and TSS at right angles.	Overtaking, same course	Overtaking, converging slowly

Hint: In TSS speed reduction is a good choice, but this will not improve the situation with B. Alteration to port will result in a smaller CPA with C, i.e., developing a close quarters with C. Alteration to starboard will take the ship out of the TSS.

Alter course 60° to starboard to 020°T.

New CPA	2´.4	1´.6	3´.6
TCPA	At 1032 in 15m	At 1031 in 14m	At 1023 in 6m
BCPA	306°T	200°T	210°T

The action will take the ship out of TSS. After 1032, adjust course to rejoin TSS at a small angle. (Join TSS at small angle from the side)

7.

Target	A	B	C
Bearing	288°T, closing slowly	274°T, closing slowly	155°T , closing slowly
Range	8´, decreasing	5´, decreasing	1´.9, decreasing
CPA	1´.0	1´.2	1´.4
TCPA	At 1654 in 39m	At 1633 in 18m	At 1624 in 9m
BCPA	205°.5T	200°T	197°.5T
Course	Set 021°T	128°T	284°T
Speed	Rate 3.4	4.6	21.2
Aspect	-	R34°	G51°
Comments		Crossing stbd to port	Overtaking, converging slowly

Hint: Should not alter course towards land, that is, to starboard. Alteration to port is also a poor choice as vessel C will be at CPA in 9 minutes and is abaft the beam.

Stop at 1620. (Slowing down to steerage way may be considered, but the CPA with B will be less).

New CPA	7´	2´.3	1´.4
TCPA	Past	At 1656 in 36m	At 1621 in 1m
BCPA	288°.5T	214°T	194°T

The ship is setting 021°T in the direction of land. Resume speed when B is at CPA and adjust course to pass headland at safe distance, allowing for the set.

8.
Position at 0600 = 22° 39´.9N 064° 23´.7E
Hint: C from DR, D run-back, A and B run-on.
Stars B and D on opposite horizon! d.lat 5´.1 S, dep 1´.2W

9.
Position at 1835 = 22° 49´S 070° 14´.1E (B-DR, A run-on, C run-back, azimuth <180°)

10.
GMT: 5th May 2006 at 0113
R/V Position: 17° 32´.4N 064° 40´E (No change in longitude as course is 180°T)
Course: S 36° E Speed 8.1 kts (Dist 71´.2).

11.
Course 305°T at 15 knots. Time 1507. CPA 1´.3.
Hint: Plot all the ships. Plot the new station for Z. Join old Z (O) station to new Z (A´) station. Measure CPA with Y along OA´ line.

12.
Course: 232°T
Position: 41° 15´N, 022° 38´.9W
Daylight remaining: 44 minutes (sunset = 1730 GMT, Time to R/V = 6h 46m)

Glossary Of Abbreviations

A:	After draught
AIS	Automatic Identification System
ALC	Articulated Loading Column
ALRS	Admiralty List of Radio Signal
AMVER	Automated Mutual Assistance Vessel Rescue System
ARCS	Admiralty Raster Chart Service
ARPA	Automatic Radar Plotting Aids
ASF	Additional Secondary Factor (Correction)
ATT	Admiralty Tide Tables
AUSREP	Australian Ship Reporting System
BA	British Admiralty
BCPA	Bearing of Closest Point of Approach
C	Compass (Course or Bearing)
°C	Degree Centigrade or Celsius
C/A	Coarse Acquisition
CALM	Catenary Anchor Leg Mooring
C_b	Cumulonimbus cloud
CD	Compact Disc
CES	Coast Earth Station
CIR	Cross Index Range
COLREGS	Collision Regulations (International regulations for preventing collisions at sea 1972)
conn	Conning (Control of the ship)
cos	Cosine (trigonometric function)
cot	Cotangent (trigonometric function)
C/P	Charter Party
CPA	Closest Point of Approach
CPP	Controllable Pitch Propeller
CRS	Coast Radio Station
CSC	Cargo Ship Safety Certificate
CSP	Commence Search Point
CZD	Calculated Zenith Distance
d	Day
D/F	Direction Finder
DGPS	Differential Global Positioning System
DMA	Defence Mapping Agency
DMP	Difference of Meridional Parts
DP	Dynamic Positioning
DR	Dead Reckoning
DSC	Digital Selective Calling
DTG	Distance To Go
DWT	Dead Weight Tonnage
E	East
EBL	Electronic Bearing Line
ECDIS	Electronic Chart Display and Information System
e.g.	for example

EGC	Enhanced Group Calling
EGNOS	European Geostationary Navigation Overlay Service
ELSBM	Exposed Location Single Buoy Mooring
ELT	Emergency Locating Transmitter
ENC	Electronic Navigation Chart
ENE	East North East
EP	Estimated Position
EPIRB	Emergency Position Indicating Radio Beacon
ERBL	Electronic Range and Bearing Line
ESE	East South East
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
ETO	Electro Technical Officer
F:	Forward Draught
°F	Degree Fahrenheit
FFA	Fire Fighting Appliances
G	Gyro (Course or Bearing)
GC	Great Circle
GDOP	Geometric Dilution of Precision
GHA	Greenwich Hour Angle
GHz	Gigahertz
GLONASS	Global Navigation Satellite System
GMDSS	Global Maritime Distress and Safety System
GMT	Greenwich Mean Time
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRI	Group Repetition Interval
GT	Gross Tonnage
h	Hour
hav	Haversine
HDOP	Horizontal Dilution of Precision
HF	High Frequency
hp or HP	Horse Power
HW	High Water
IALA	International Association of Marine Aids to Navigation Lighthouse Authorities
IAMSAR	International Aeronautical and Maritime Search and Rescue
IBS	Integrated Bridge System
ICS	International Chamber of Shipping
ID	Identity
IEC	International Electro-technical Commission
IHO	International Hydrographic Office
IMO	International Maritime Organisation
IRPCS	International Regulations for Preventing Collisions at Sea
ISM	International Safety Management (The international management code for the safe operation of ships and for pollution prevention)
ISPS	International Ship and Port Facility Security Code
ITCZ	Inter Tropical Convergence Zone
ITP	Intercept Terminal Point
kHz	Kilohertz

km	Kilometre
kn	Knot
kts	Knots
KW	Kilowatt
LANBY	Large Automated Navigation Buoy
LAYCAN	Laytime Cancellation
LEOSAR	Low Earth Orbit Search and Rescue Satellite
LIT	Longitude In Time
LHA	Local Hour Angle
LL	Lower Limb
LMT	Local Mean Time
LOA	Length Over All
LOP	Line Of Position
LORAN	Long Range Navigation
LR	Long Range
LSA	Life Saving Appliances
LW	Low Water
M	Metre
m	Minute
MARPOL	Marine Pollution Prevention Regulations
Max	Maximum
METROUTE	Meteorological Routeing Service
MCA	Marine Coastguard Agency (UK)
MF	Medium Frequency
MGN	Marine Guidance Note
MHHW	Mean Higher High Water
MHLW	Mean Higher Low Water
MHW	Mean High Water
MHWI	Mean High Water Interval
MHWN	Mean High Water Neap
MHWS	mean High Water Spring
MHz	Megahertz
MIN	marine Information Notice
MKD	Minimum Keyboard and Display
MLHW	Mean Lower High Water
MLLW	Mean Lower Low Water
MLW	Mean Low Water
MLWS	Mean Low Water Spring
MMSI	Maritime Mobile Station Identifier
MP	Meridional Part
MRCC	Maritime Rescue Co-ordination Centre
MSAS	Multifunctional Satellite-based Augmentation System
MSI	Maritime Safety Information
MSL	Mean Sea Level
MSN	Merchant Shipping Notice
MSR	Mean Spring Range
MTL	Mean Tidal Level
MTSAT	Multi-functional Transport Satellite
N	North
NBDP	Narrow Band Direct Printing

NE	North East
NLT	Not Less Than
nm	Nautical Mile
NMT	Not More Than
NNE	North North East
NNW	North North West
No	Number
NP	Nautical Publication
NT	Net Tonnage
NUC	Not Under Command
NW	North West
OOW	Officer Of the Watch
OSC	Ob Scene Co-ordinator
PC	Passenger Ship Safety Certificate
PDOP	Position Dilution of Precision North Pole
P_n	North Pole
PI	Parallel Indexing
P_s	South Pole
PPS	Precise Positioning Service
RAM	Restricted in Ability to Manoeuvre
RCC	Rescue Co-ordination Centre
RFA	Royal Fleet Auxiliary
RL	Rhumb Line
RN	Royal Navy
RNC	Raster Navigation Chart
ROR	Rule Of the Road
R/T	radio Telephone or Telephony
RTF	Radio Transmitter Frequency
s	Second
S	South
SA	Selective Availability
SALM	Single Anchor Leg Mooring
SALS	Single Anchor Leg Storage
SAR	Search and Rescue
SARSAT	Search and Rescue Satellite
SART	Search and Rescue Radar Transponder
SBAS	Satellite Based Augmentation System
SBE	Stand-by Engine
SE	South East
SEC	Safety Equipment Certificate (for cargo ships)
SES	Ship Earth Station
SD	Semi Diameter
SHA	Sidereal Hour Angle
sin	Sine (trigonometric function)
SITREP	Situation Report
SMC	Search and Rescue Mission Co-ordinator
SMS	Safety Management System
SOLAS	Safety of Life at Sea Convention
SPS	Standard Positioning Service
SRR	Search and Rescue Region

SRU	Search and Rescue Region
SSE	South South East
SSW	South South West
STCW	Standards of Training Certification and Watchkeeping
SW	South West
tan	Tangent (trigonometric function)
T	True (course or bearing)
TCPA	Time of Closest Point of Approach
TDMA	Time Distribution Management Arrangement
TRS	Tropical Revolving Storm
T&P	Temporary and Preliminary Notices
TSS	Traffic Separation Scheme
TTC	Tracking and Telemetry Control
TZD	True Zenith Distance
UAIS	Universal Automatic Identification System
UK	United Kingdom
UKC	Under Keel Clearance
UKHO	United Kingdom Hydrographic Office
UL	Upper Limb
UMS	Unattended machinery Space
μs	microsecond
US	United States
USA	United States of America
UT	Universal Time
UTC	Universal Time Co-ordinated
VDOP	Vertical Dilution of Precision
VDR	Voyage Data Recorder
VHF	Very High Frequency
vol	Volume
VRM	Variable Range Marker
VTIS	Vessel Traffic Information Service
VTS	Vessel traffic Service
W	West
WAAS	Wide Area Augmentation System
WGS	World Geodetic System
WNW	West North West
WO	Wheel Over
WSW	West South West
WWNWS	World Wide Navigation Warning Service
XTE	Cross Track Error

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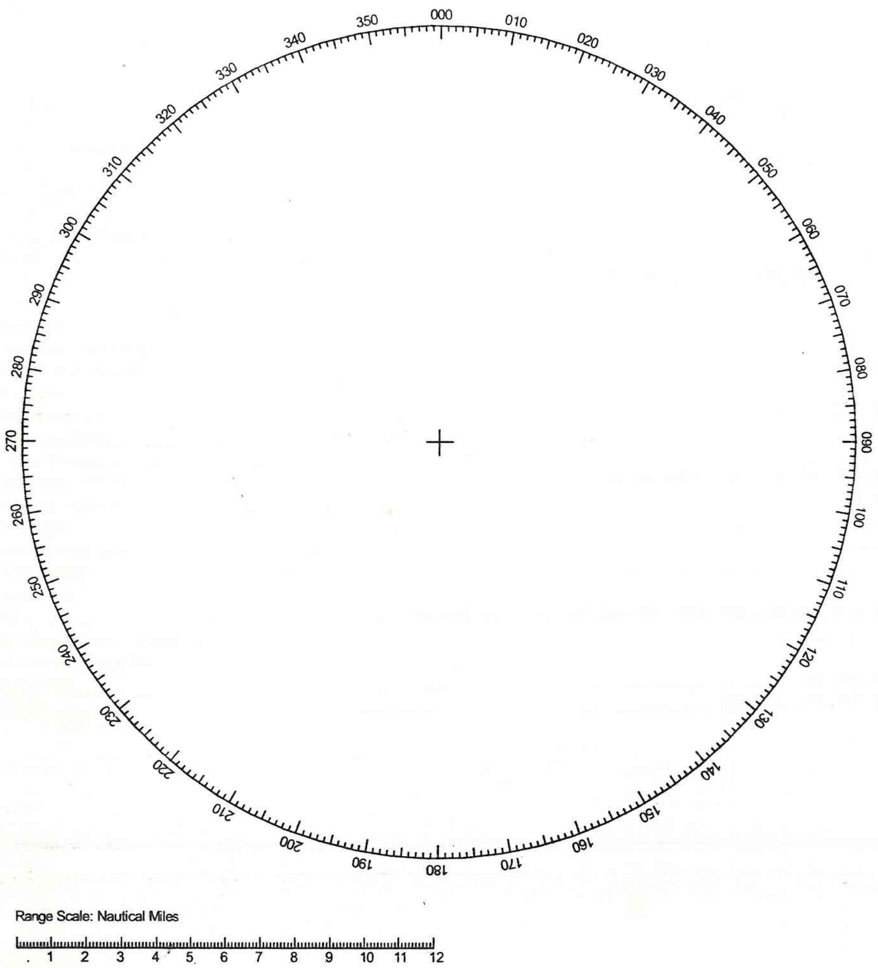
INDEX

Templates

RADAR PLOTTING SHEET



Target	1	2	3	4
Bearing				
Range				
CPA				
TCPA				
BCPA				
Course				
Speed				
Aspect				
Action / New CPA				
New TCPA				
New BCPA				

AZIMUTH

Date		A = tan lat ÷ tan LHA	
GMT		B = tan dec ÷ sin LHA	
GHA Sun		C = A ± B	
Increment		tan Az =1÷ (C x cos lat)	
Sub-total		Az	
Longitude		True Bearing	
LHA Sun			
Declination		Gyro Bearing	
d Corrn		Gyro Error	
Declination			

AMPLITUDE

Date		sin Declination	
Lat 63° 30´.5 N		cos Latitude	
LMT for 19th		sin Amplitude	
LMT for 22nd		Amplitude	
LMT Sunrise 62°			
Increment		True Bearing	
LMT 63° 30´.5 N			
LIT		Gyro Bearing	
GMT		Gyro Error	
Declination			
d Corrn			
Declination			

POLARIS

DR Latitude		Date and Z T	
DR Longitude		Zone	
Course / Speed		Greenwich date	
GMT		Altitude	
GHA Aries		Sext Alt	
Increment		IE	
Sub-total		Obs Alt	
Longitude		Dip	
- 360° ?		App Alt	
LHA Aries		T Corrn	
		True Alt	
		ao	
		a1	
		a2	
Azimuth			
Position line		Latitude	

MARQ ST HILAIRE

DR Latitude		Date and Z T	
DR Longitude		Zone	
		Greenwich date	
Body	1	2	3
C T			
C E			
GMT			
Almanac data			
Tabulated GHA			
Increment			
v Corrn / SHA			
GHA			
Longitude			
- 360° ?			
LHA			
Declination			
d Corrn			
Declination			
cos ZX			
CZD			
Altitude			
Sext Alt			
IE			
Obs Alt			
Dip			
App Alt			
T Corrn			
True Alt			
TZD			
Intercept			
Azimuth			
A			
B			
C			
tan Az			
True Az			
P/L			

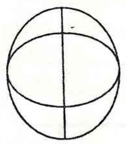
MERIDIAN PASSAGE / ANGLE ON SEXTANT POSITION AT MERIDIAN PASSAGE

DR Latitude		Date and Z T	
DR Longitude		Zone	
Course / Speed		Greenwich date	
For ITP			
d.lat			
dep			
mean lat			
d.long			
ITP			
1st Approx		1st run up posn	
LMT merpass		d.lat	
LIT		dep	
GMT		mean lat (from ITP)	
Initial GMT		d.long	
Run		1st run up Lat	
Speed		1st run up Long	
Distance Run			
2nd Approx		2nd run up posn	
LMT merpass		d.lat	
LIT		dep	
GMT merpass		mean lat (from ITP)	
Initial GMT		d.long	
Run		2nd run up Lat	
Speed		2nd run up Long	
Distance Run			
		Altitude	
Declination		Sext Alt	
d Corrn		IE	
Declination		Obs Alt	
		Dip	
Setting sextant		App Alt	
Lat		T Corrn	
TA = D – L + 90°		True Alt	
		L = D – TA + 90°	
Sext Alt		From Plot	
IE		dep	
Obs Alt		mean lat	
Dip		d.long	
App Alt			
T Corrn		For T bearing of	
True Alt		Position Line =	
(working back)		Observed Posn	
		Latitude	
		Longitude	

GREAT CIRCLE CALCULATIONS

Template for Great Circle Calculations

lat A	PA	long A	
lat B	PB	long B	
		d.long ^	



Mark A and B correctly considering the d.long and respective latitudes

Distance				
sin PA		sin		1
sin PB		sin		2
cos ^P1		cos		3
	1 x 2 x 3 = 4			
cos PA		cos		5
cos PB	x	cos		6
	5 x 6 = 7			
cos AB	4 + 7			
AB		cos $^{-1}$		
Distance	AB x 60			

Initial Course - Using A B C method				
tan lat A		tan		9
tan^P$_1$		tan		10
A	9 + 10 = 11			
tan lat B		tan		12
sin ^P$_1$		sin		13
B	12 + 13 = 14			
C	11 ~ 14 = 15			
cos lat A		cos		16
tan I Co	1 ÷ (15 x 16)			
I Course =		tan $^{-1}$		

Final Course - Using A B C method				
tan lat B		tan		17
tan ^P$_1$		tan		18
A	17 + 18 = 19			
tan lat A		tan		20
sin ^P$_1$	÷	sin		21
B	20 + 21 = 22			
C	19 ~ 22 = 23			
cos lat B				24
tan F Co	1 ÷ (23 x 24)			
F Course =		tan $^{-1}$		

Vertex				
Latitude				
cos lat A		cos		25
sin A	x	sin		26
cos lat V	25 x 26			
Lat V =		cos $^{-1}$		
Longitude				
sin lat A		sin		27
tan A	x	tan		28
tan ^P$_2$	1 ÷ (27 x 28)			
d.long^P$_2$		tan $^{-1}$		
long A				
Long V				

Equator Crossing				
Longitude				
sin lat A				29
tan^A				30
tan d.long ^P$_3$	29 x 30			
d.long ^P$_3$		tan $^{-1}$		31
	180 - 31			32
long Q	long A~32			
Course				
cos lat A				33
sin ^A				34
sin ^PQA	33 x 34			
PQA		sin $^{-1}$		

Waypoint Latitudes				
long V				
long of X				
d.long^P$_X$				
cos d.long^P$_X$		cos		35
tan lat V		tan		36
	35 x 36			
lat X		tan $^{-1}$		

d.long of all the required points can be obtained by taking the difference from vertex longitude.
Rest of the calculation is as above for all meridians

RENDEZVOUS - DOUBLE APPROXIMATION

TEMPLATE for Rendezvous problems involving Double Approximation

DATE ____ TIME ____ Z ____

(Optional)

	Middle Day 1	Middle Day 2	Required Day
LMT			
LMT			

Ship 1 — Passenger — To maintain course

To maintain course	lat		long		MP
If required Landfall	lat		long		MP
to work out course	d.lat		d.long		DMP

tan Course = d.long / DMP ____ Co = ____

Ship 2 — Bulk Carrier — To adjust course — Lat ____ Long ____

Step 1

SUNRISE 1st Approx	
LMT sunrise for	35°N (07-5-06)
Increment for	3° 24'
LMT for	38° 24'N
Longitude in time	052° 42'W
GMT	(07-5-06)
Initial GMT	(06-5-06)
Difference	
Speed	kts
Distance to Run	

Step 2

Course ____ Distance
d.lat = Distance x cos Co — x cos
dep = Distance x sin Co — x sin
Mean lat =
d.long = dep/cos Mean lat =

lat		long	
d.lat		d.long	
1st Approx lat		long	

Step 3

SUNRISE 2nd Approx	
LMT sunrise for	35°N (07-5-06)
Increment for	4° 12'.3
LMT for	39° 12'.3 N
Longitude in time	060° 03' W
GMT	(07-5-06)
Initial GMT	(06-5-06)
Difference	(Use for speed)
Speed	kts
Distance to Run	

Step 4

Course ____ Distance
d.lat = Distance x cos Co — x cos
dep = Distance x sin Co — x sin
Mean lat =
d.long = dep/cos Mean lat =

lat		long	
d.lat		d.long	
R/V Posn lat		long	

Step 5
Ship 2
R/V Posn

lat		long	
lat		long	
d.lat		d.long	
Mean lat			

dep = d.long x cos mean lat =
tan co = dep / d.lat =
Course =
Distance = d.lat/cos course =
Speed = Distance /Time =

Answers :
Time
R/V Posn
Course
Speed