LOSS PREVENTION

Voyage Planning and Chartwork

SHIPOWNERS

SECURITY FOR SMALL & SPECIALIST VESSELS

NOT TO BE USED FOR NAVIGATION.

Foreword

The Shipowners' Club provides P&I insurance for small and specialist vessels and, as such, the majority of our entered vessels trade in coastal waters. The art of navigation planning is second nature to most deep-sea mariners but it can be something of a mystery to those crews who do not need to use this particular skill very often aware to the fact that the locally tracked waters are so familiar.

Our Condition Survey Programme often highlights the fact that crew have a limited understanding of the rudiments of basic navigation and we also see claims arising where poor navigation is a main contributing factor. A better understanding of the subject will hopefully help reduce the incidence of such claims.

The purpose of this booklet is to introduce the basics of practical navigation, such as chartwork and voyage planning. We hope that it will give a better understanding on the subject.

This booklet is one of three publications in a series and it is envisaged that together they will help eliminate some of the difficulties that befall those not so well versed in marine navigation.

We remain forever indebted to Captain H. Subramaniam for compiling this booklet series for us. Captain Subramaniam was a distinguished member of the nautical fraternity in a career spanning over 6 decades, including over 30 years of teaching experience. Apart from this series, he also authored eight textbooks on the operation of merchant ships which continue to be used by seafarers across the globe. It was his ability to put a subject across in a nutshell that made all his books easy to understand and helpful to those these are intended for.

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Part 1: Basic Navigational Knowledge

Chapter 1

Traffic Separation Schemes (TSS)

TRAFFIC SEPARATION SCHEME (TSS)

A Traffic Separation Scheme (TSS) is a system that enhances navigational safety in areas of high traffic density by directing ships going in opposite directions to follow traffic lanes like on roads. The lanes do not normally cross each other except for when they have to do so for specific purposes such as entering or leaving port.

DETAILS OF TSS's

Details of TSS's are available in the appropriate Pilot Book (sailing directions) and will also be marked on navigational charts. They can also be found in the IMO ship routing guide.

COLREGS REGARDING TSS

Rule 10 of the International Regulations for the Prevention of Collision at Sea (COLREGS) gives guidance on the use of TSS.

MARKINGS ON CHARTS

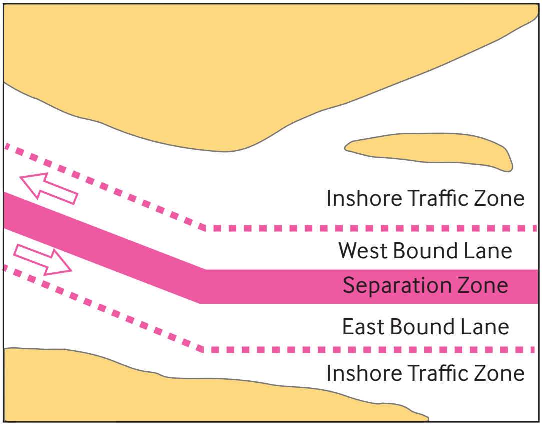
TSS's are marked on navigational charts (diagram 1) in magenta colour; however other details on the chart are still visible. Direction of traffic flow is indicated by arrows. The outer boundaries are shown in magenta-coloured dashed lines whereas the separation zone is depicted by a solid broad stripe. In some cases, where the breadth of the channel is restricted, the divider may be shown as a line instead of a zone.

AREAS OF A TSS

A TSS consists of three areas (diagram 1):

- Two lanes of traffic in opposite directions.
- One divider called a separation zone or buffer zone.
- Inshore traffic zone.

Diagram 1



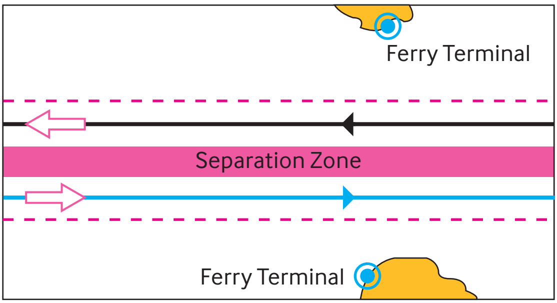
TSS's are intended for use at all times, day or night, in all weathers and in all conditions of visibility.

TRAFFIC LANES

All vessels shall:

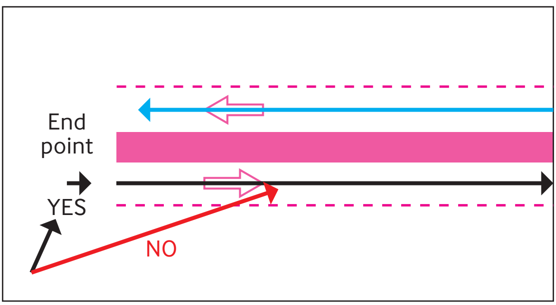
- Proceed along their respective lanes in the direction marked on the chart.
- As far as practicable, keep well clear of the separation zone or line, except to avoid immediate danger (diagram 2).

Diagram 2



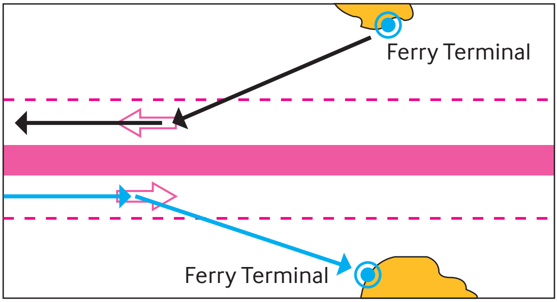
- Normally enter or leave a traffic lane at its terminal point (diagram 3).

Diagram 3



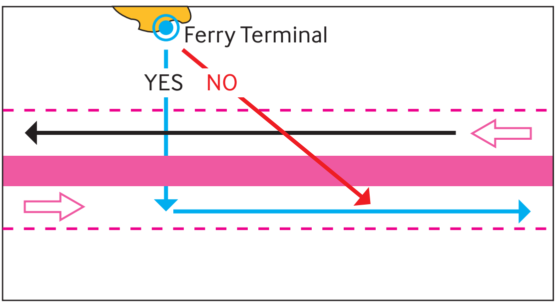
- If joining or leaving from either side of a traffic lane, do so at a very small angle to the general flow of traffic (diagram 4).

Diagram 4



- If it is necessary to cross a traffic lane, do so at right angles to the general flow of traffic (diagram 5).

Diagram 5



INSHORE TRAFFIC ZONES

Small vessels (less than 20m in length), fishing and sailing vessels are permitted to use the inshore traffic zone. When outside the inshore traffic zone, they shall not impede the safe navigation of vessels using the TSS.

Larger vessels (more than 20m in length) may use the inshore traffic zone for the following reasons:

a. To enter or leave a port.

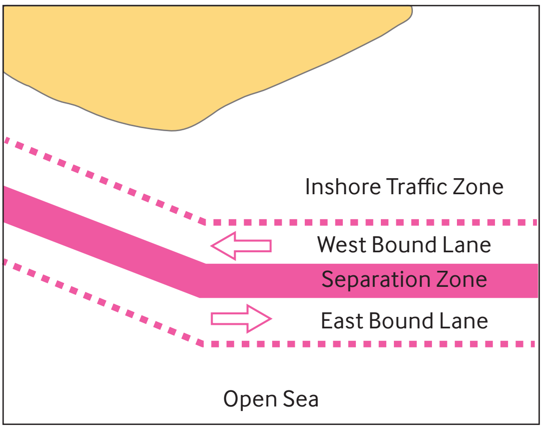
b. In cases where the inshore traffic zone lies in between two adjacent ports and when it is not practicable to use the TSS.

c. To avoid immediate danger.

WHEN NOT USING THE TSS

In some locations, such as off the south coast of Sri Lanka, the inshore traffic zone may be only to one side (diagram 6). The other side is open sea. In such cases, ships on the open sea side, when not using the TSS, must keep well clear to avoid confusion.

Diagram 6



CAUTION WHILE USING A TSS

Just as traffic violations on the road are recorded by hidden cameras, floating traffic in most TSS areas are monitored by designated shore stations such as VTS (Vessel Traffic Services) and VTIS (Vessel Traffic Information Systems).

These stations record the radar video track and VHF conversations. Proof of violations is thus available and shore authorities may levy hefty fines on the Master for violations. They may also forward evidence to the vessel's flag state which may take such violations seriously and inflict further punishments.

Chapter 2

Buoyage

A navigational buoy is an artificial, floating, navigational mark, anchored to the seabed, to assist in the safe passage of ships navigating in that area. It can be identified by any or a combination of the following:

- Shape
- Colour
- Topmark (a distinguishing coloured shape on top)
- Characteristics of its light (if fitted).

Buoys are used to indicate many aspects, including channels, dangerous rocks or shoals, speed limits, TSS's and submerged shipwrecks. Some are only intended to be visible during the day (day marks); others have some combination of lights, retro-reflectors, bells, horns, whistles, radar reflectors and racons so that they can be utilised at night and in conditions of reduced visibility.

Buoys are shown on nautical charts using symbols that indicate their colour, shape and light characteristics and are usually identified by a name or a number.

Navigational buoys and other floating marks are useful tools. However, caution should be exercised and they should not be solely relied on for navigation - for example buoys may be moved out of their correct location due to a collision with vessel, storms or other factors.

In addition, buoys and other floating marks should always be passed at a safe distance. Passing too close is dangerous because of possible fouling with the buoy's anchor chains.

BUOYAGE SYSTEMS

The International Association of Lighthouse Authorities (IALA) has standardised the names given to each type of buoy and has specified its shape, colour and the characteristics of its light depending on its purpose.

TOPMARKS

Buoys may have a distinguishing shape positioned on top called a topmark. These may be in the form of a can, cone, sphere, "**X**" shape or "**+**" shape.

RETROREFLECTORS

These are waterproof coatings/tapes applied to some navigational buoys. When light falls on a retroreflector, it reflects light back in the direction from which it came – hence the prefix "retro".

RACONS

These are radar transponders and are used to mark navigational hazards. They transmit specifically assigned morse code alphabet(s), when interrogated by a ship's radar, which have been specifically assigned to them. The Morse alphabet can then be seen on the ship's radar display.

In the IALA Maritime Buoyage System, there are six types of buoy in use:

1. Lateral system
2. Cardinal system
3. Isolated danger mark
4. Safe water mark
5. Special marks
6. Emergency wreck marking buoys

1. Lateral marks

Lateral marks are used to mark boundaries of channels. There are two regions where lateral marks are in use to denote the two sides of a channel as below (diagrams 7 to 14).

- **IALA Region B**: in use in the Americas (landmasses of North America and South America with their associated islands and regions), the Philippines, South Korea and Japan. These regions place conical red marks to starboard and cylindrical green marks to port when approaching a harbour from seaward.
- **IALA Region A**: in use everywhere else. They place conical green marks to starboard and cylindrical red marks to port when approaching a harbour from seaward.

If it is not clear which direction is seaward, the chart of that area will clarify on which side to pass each buoy.

Diagram 7: Region A

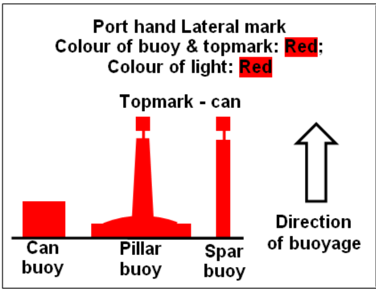


Diagram 8: Region B

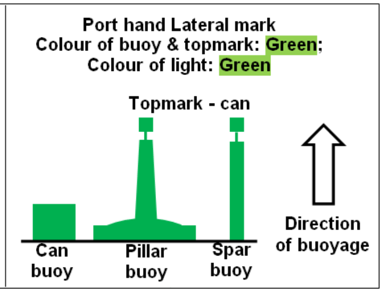


Diagram 9: Region A

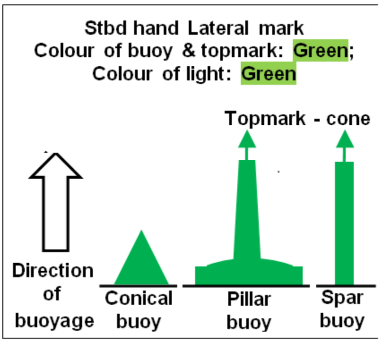


Diagram 10: Region B

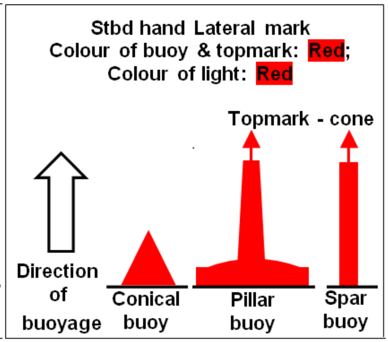


Diagram 11: Region A

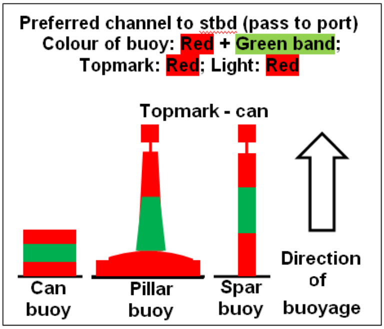


Diagram 12: Region B

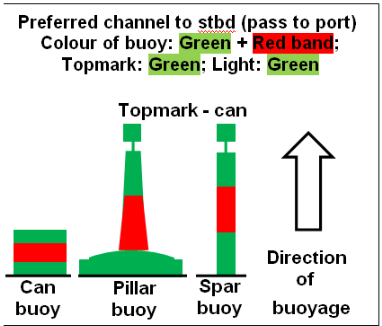


Diagram 13: Region A

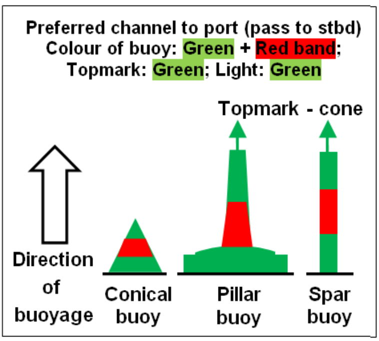
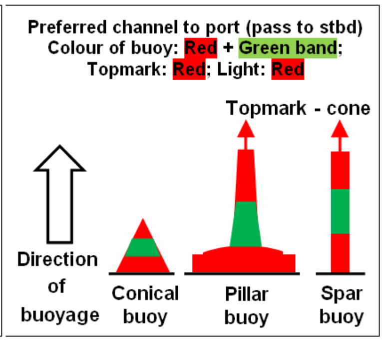


Diagram 14: Region B



2. Cardinal marks

Cardinal marks indicate the geographic direction of safe and navigable water with respect to a danger or chosen location which is called "Point of interest" or POI.

Through the POI, four lines are drawn in the NE, SE, SW and NW directions.

The four quadrants so formed are named N, E, S and W (see diagram 15).

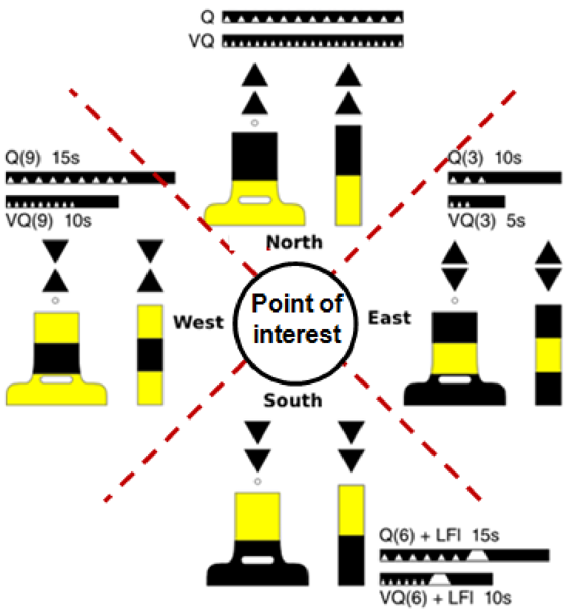
When a North cardinal mark is sighted, the deepest safe water lies to the north of the POI.

When an East cardinal mark is sighted, the deepest safe water is to the east of the POI, and so on.

The colours and topmarks in each quadrant are as shown in diagram 15.

Lights, if fitted, will be white in all quadrants but the rhythm will be as shown in diagram 15, where Q means quick flashing, VQ means very quick flashing and LFl means a long flash.

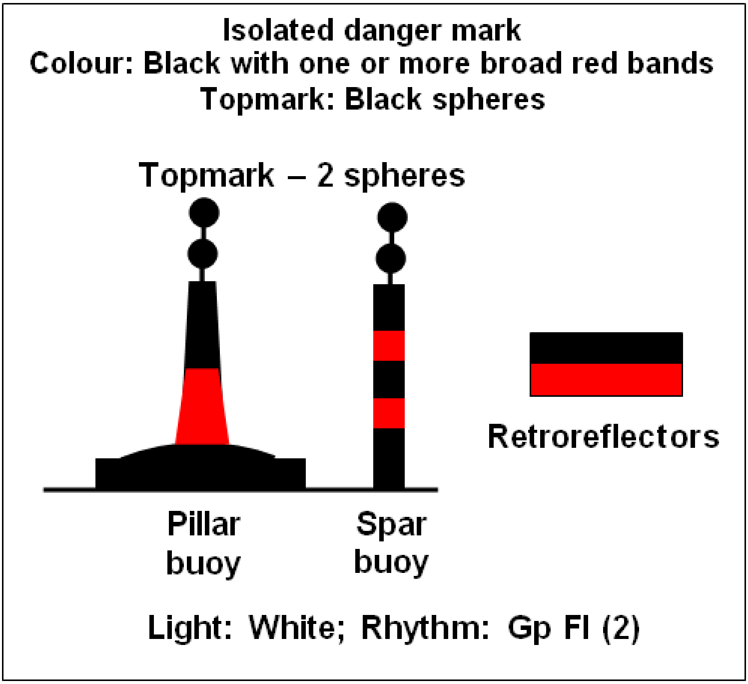
Diagram 15



3. Isolated danger marks

These indicate a danger with navigable water all around it (see diagram 16). Its colour is black with one or more broad red bands. Its topmark consists of two black spheres. If a light is fitted, it would be white and group flashing two.

Diagram 16

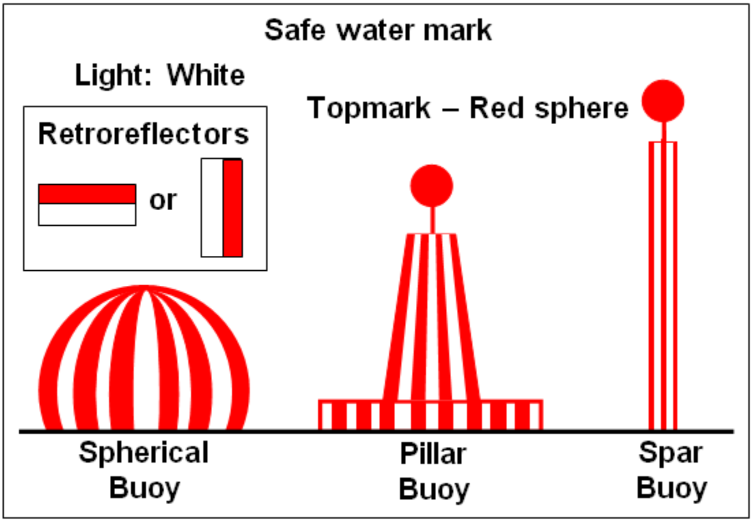


4. Safe water marks

These indicate safe water all around, such as the middle of a channel (see diagram 17).

Its purpose should not be confused with that of an isolated danger mark, which marks a danger with deep water all around it.

Diagram 17



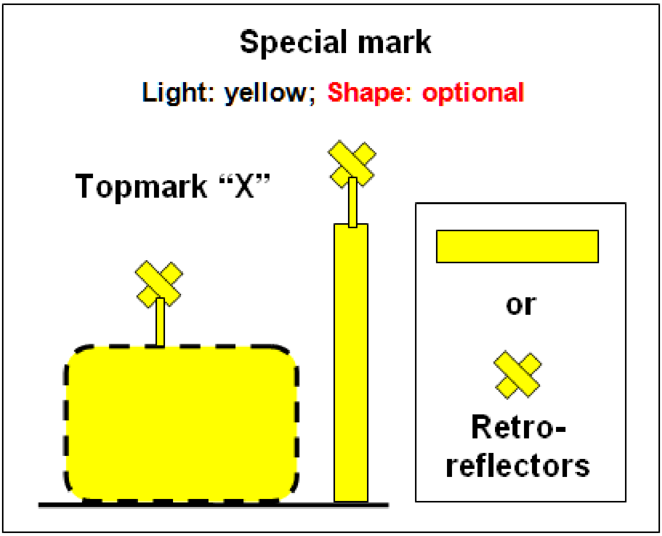
5. Special marks

These are not meant to assist navigation but instead denote special areas as indicated on a chart (diagram 18). They may be marks for:

- An Ocean Data Acquisition System (ODAS).
- Traffic separation, where conventional channel marking may cause confusion.
- Spoil grounds (places where various materials, such as those obtained from dredging, are dumped).
- Military exercise areas.
- Cable or pipelines.
- Recreation zones.

The shape is optional but must not be similar to the navigational marks so as not to be confused.

Diagram 18



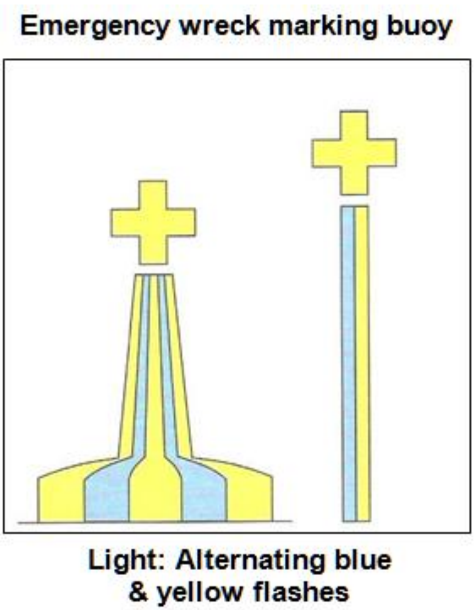
6. Emergency wreck marking buoy

The emergency wreck marking buoy was introduced by IMO on the recommendation of the IALA in 2006. It is a highly conspicuous visual and radio aid. It will be placed as close to the wreck as possible, or in a pattern around the wreck, and within any marks that may be subsequently installed (see diagram 19).

The emergency wreck marking buoy will stay in position until:

- The wreck is included in the weekly Admiralty Notices to Mariners.
- The wreck has been fully surveyed and exact details, such as position and available depth, are known.
- A permanent mark has been installed.

Diagram 19



Chapter 3

Voyage Planning

Voyage planning consists of the preparations made to ensure safe navigation of a vessel from one port to another. This is effectively done after undertaking a risk assessment of the intended voyage and taking in due consideration for potential hazards that may be encountered. This is then preserved as a formal record.

The voyage should be planned from the berth at the departure port to the berth at the arrival port and should include river passages and movement within port limits at both ends, even if a pilot will be on board during these times.

The voyage plan must be made by a competent person after obtaining broad guidelines from the Master regarding the general route, under keel clearances, distance off dangers and air drafts.

Due consideration must be made for ship type, ship size, draft, speed, navigational aids on board and weather conditions.

The voyage plan must be established well in advance of the voyage as the Master will need to check and verify it. This will then be discussed with all the navigational watchkeeping officers before commencement.

Preparing a voyage plan should consist of three parts:

1. Assessment of intended voyage.
2. Preparation of the passage plan.
3. Monitoring of the passage plan.

1. Assessment of voyage

1) The following need to be consulted:
   - A small-scale chart that includes both the departure and arrival locations. (Nautical tables give the latitude and longitude of most ports in the world.)
   - Distance tables to obtain the distance by more than one route. The shortest route is usually considered first.
   - *Ocean Passages for the World*, if the voyage is expected to cross an ocean.
   - The appropriate pages of the Pilot books, especially the ones pertaining to the departure and arrival ports.

2) The voyage must be planned appropriately using the sailing draft and minimum UKC (Under Keel Clearance) to be maintained and distance to keep away from dangers.

3) After the route has been decided, the necessary voyage-specific charts and publications need to be placed on board ensuring they are the latest editions. If any are not on board, every effort must be made to obtain them prior to departure.

4) It must be ensured that all the charts and publications are up to date. If not, they must be corrected as a top priority.

5) All bridge equipment must be checked to ensure that it is working satisfactorily and that consumable spares, such as paper rolls and bulbs, are available on board.

2. Preparation of passage plan

Courses must be drawn taking into account the following points:

1) Distances of hazards en route that are near the course line, marking them clearly on the charts.

2) Adequate UKC at all times. In cases where high sea waves or heavy swell is expected, deeper water would be required.

3) Where strong onshore breezes are anticipated, the vessel must be navigated as reasonably far off as practicable so there is time to act in case of engine or steering failure.

4) The set and rate of current as taken from the *Tidal Stream Atlas* or Pilot books must be shown on the chart, at critical points on the route.

5) Alteration points should, as far as possible, have two or more means of position fixing, day or night, in clear or restricted visibility – visual, radar, sounding contours, GPS.

6) Radar conspicuous points and racons should be marked for position fixing and parallel indexing.

7) TSS should be entered at end points but if not practicable to do so, they must be entered or departed at a small angle to the traffic flow. Crossing any lane must be, as far as practicable, at right angles.

8) Against each course line, the true course in three figures and the distance to run should be marked.

9) All shallow areas on either side of the course line should be shaded as 'No-go' areas.

10) The 'vessel reporting points' stating the VHF channel to use and a sample message containing as much correct data as practicable, should be marked on the chart.

11) Most companies have a standard format in which the passage plan has to be presented for formal approval by the Master and for record purposes.

12) A meeting should then be called to discuss the voyage plan with all the navigational watchkeeping officers and the same must be recorded.

3. Monitoring the passage plan

1) It is necessary that during the course of the voyage, the vessel's progress should be checked against the passage plan.

2) Monitoring of the vessel's position is of paramount importance. The frequency and method of position fixing should be conducive to the proximity of hazards, land, traffic density and visibility. The frequency of position fixing should ideally be written on the relevant chart and reflected on that particular leg of the passage plan.

3) Ideally, the chart should be marked out with the various available position fixing means in line with the passage plan.

4) Sufficient lookouts on the bridge as well as safe speeds suitable for the prevalent conditions are to be complied with.

5) Regular checks on the vessel's navigation equipment are required to detect any sudden failure.

6) Any deviations from the passage plan are to be brought to the Master's attention without delay and the passage plan must be amended to incorporate these deviations.

NAVIGATION WITH A PILOT ON BOARD

In many ports, pilotage is compulsory. The pilot has considerable experience in handling different types of vessel and has vast knowledge of port – the local language, the capability of tugs available, the tidal flows, local winds, shallows and other dangers to navigation that may exist in the port. The pilot's presence is of great help to the bridge team.

COMMAND OF THE VESSEL

Though it appears that the pilot has control over the course, speed and movement of the vessel, the Master retains full command and is responsible for the vessel even when the port regulations require that a pilot **must** be employed.

PILOT BOARDING AND THEREAFTER

The pilot boat may state the course and speed for the Master to maintain and the side on which to rig the pilot ladder. A responsible person must meet the pilot at the top of the ladder and escort him to the bridge. This is important so that the pilot does not lose his way and waste time. Also, in case he slips and falls either while boarding the vessel or on the way to the bridge, the ship's officer would render help and be a reliable witness in subsequent inquiries and claims, if any.

As soon as the pilot arrives on the bridge:

1. Once introductions are over, the Master tells the pilot the present manoeuvring status, for example: "Heading 120° True, Telegraph on Slow Ahead".
2. The pilot then indicates the first course and engine order, for example: "Steer 140° Full Ahead please". The OOW (officer of the watch) ensures that this is carried out.
3. The OOW makes an entry: POB (short form for pilot on board) Mr .... and the ship's time next to it in the Movement Book (called the Bell Book on some ships).
4. The OOW gives two copies of the Pilot Card to the pilot. The pilot reads, signs and returns one copy to the OOW. This card has been prescribed in IMO regulations and contains important details to enable the pilot to handle the vessel safely. Diagram 20 gives the details that a Pilot Card should contain.

Diagram 20

Pilot Card PAGE 1

Ship's name ______________________ Date ______________

Call sign ____________ Deadweight ____________ tonnes Year built ______________

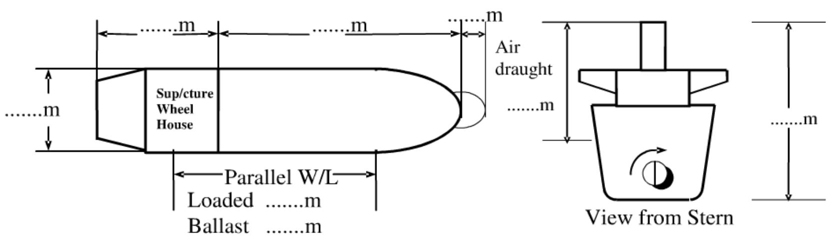
Draught aft______m______ft______in, Forward_____m_____ft_____in, Displacement________tonnes

SHIP'S PARTICULARS

Length overall ____________ m, Anchor chain: Port________shackles, Starboard_________shackles,

Breadth ____________ m Stern_________shackles

Bulbous bow Yes/No {1 shackle = _______m/________fathoms}



Type of engine_________________________ Maximum power__________kW {__________HP}

Manoeuvring engine order	Rpm/pitch	Speed {knots}	
		Loaded	Ballast
Full ahead			
Half ahead			
Slow ahead			
Dead slow ahead			
Dead slow astern		Time limit astern	____________ min
Slow astern		Full ahead to full astern	____________ s
Half astern		Max. no. of consec. starts	
Full astern		Minimum RPM/knots	____________ /
		Astern power	____________ % ahead

Pilot Card PAGE 2

STEERING PARTICULARS

Type of rudder______________________ Maximum angle_____________________°

Hard-over to hard-over ___________________s

Rudder angle for neutral effect___________________°

Thruster Bow_________kw__________hp Stern__________kw_________hp

CHECKED AND READY

Anchors	☐		
Whistle	☐	Rudder Indicator	☐
Radar	☐ 3 cm ☐ 10cm	Rpm/pitch Indicator	☐
APRA	☐	Rate of turn Indicator	☐
Speed Log	☐ Doppler: Yes/No	Compass system	☐
Water speed	☐	Constant gyro error	± ________°
Ground speed	☐	VHF	☐
Dual-axis	☐	Elec. Pos. fix. System	☐
Engine telegraph	☐	Type_________________	
Steering gear	☐		
No. of power units operating	☐		

OTHER INFORMATION:

The pilot then discusses, with the Master and the OOW, the passage plan that he intends to follow – the route, wind and tidal information, any crucial points on the route and the number of tugs needed.

The vessel then proceeds on "Master's orders and pilot's advice". The OOW remains in charge of navigation, under the overall command of the Master. He should plot positions regularly and ensure that the navigation is being done safely and as per the discussed plan. If in doubt, he should clarify with the pilot, and, if necessary, inform the Master.

When the manoeuvre is complete, and the pilot leaves the bridge, he should be escorted out of the vessel by a responsible person, and the entry "Pilot away" should be made in the Movement Book.

Part 2: Chartwork

Chapter 4

Static Chartwork – Calculation of Position

INDICATION OF POSITION

The position of a ship is its precise location in units of latitude and longitude, and is expressed in degrees and minutes (to one or two decimal places). Seconds of arc are **not** used in chart work.

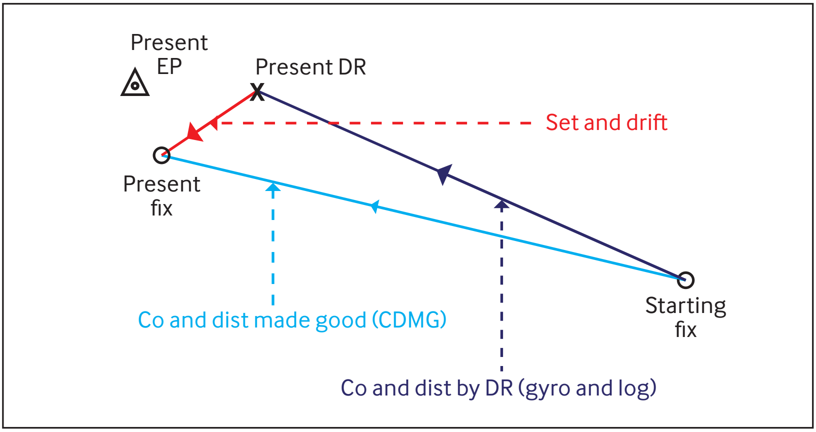
There are three basic types of position (see diagram 21):

- **Dead reckoning (DR) position**
  This is arrived at after applying the true course steered and the distance by log to a known starting position. Since the ship may have experienced effects of wind and current, it may not actually be at the DR position. The DR position should be indicated on a chart by an 'x', and the time marked near it. The course and distance between two DR positions is called the ship's movement through the water.

- **Estimated position (EP)**
  The EP is the position arrived at after applying the true course steered and the distance by log, making allowance for an estimated direction and strength of current experienced, to a known starting position. Since the effects of wind and current have been estimated, the ship may not actually be at the EP. The EP should be indicated on the chart with a spot enclosed within a triangle, and with the ship's time near it.

- **Fix**
  A fix is the actual position of the ship as obtained accurately by one or more means. A fix is usually indicated on the chart with a spot enclosed within a circle, and with the ship's time near it.

Diagram 21



KEY TERMS FOR CHARTWORK

Set and drift of current

This is the effect that the current has on the ship's movement. It is the offset from the DR position to the fix at that time.

At any point in time, if the DR position is considered as the starting position and the fix is the position arrived, then the course and distance from the DR to the fix is the set and drift of the current.

Course and distance made good (CDMG)

This is the course and distance from the starting fix to the end fix. CDMG is also called the **ship's movement over the ground**.

TIPS ON THE USE OF A PARALLEL RULER AND SET SQUARE

Notes on the use of a parallel ruler

One of the aspects of chartwork is drawing lines of position (LOPs) on the chart to determine location, measure distances, avoid hazards and find a safe route to a destination.

To lay off a bearing or course, the parallel ruler is placed on the nearest compass rose at the desired angle, e.g. bearing to be drawn is 073°(T), accuracy is ensured by seeing that the parallel ruler passes through 073°, the centre of the compass rose, and also 253° (073° +180°).

The parallel ruler is moved to the desired location and the line is drawn.

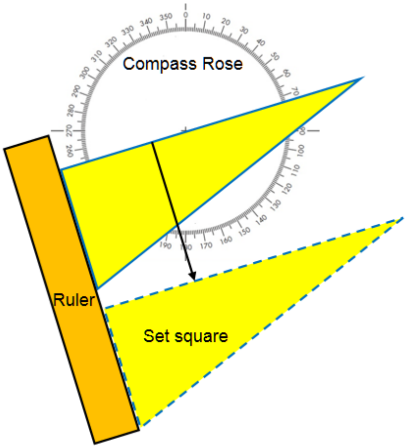
Notes on the use of large set square and ruler

Using the same bearing as before, 073°(T) (diagram 22), the set square is placed on the nearest compass rose and one side is aligned along 073°. Accuracy is ensured by seeing that the side of the set square also passes through the centre of the compass rose and 253° (073° + 180°).

The ruler is placed alongside another side of the set square, abutting it. Holding the ruler firmly with the left hand, the set square is moved to the desired position. If required, the set square can be moved sideways by holding the set square firmly in position and shifting the ruler to another side of the set square.

A large set square and a ruler are very light and easy to use; hence less susceptible to damage. They are also inexpensive and easily available.

Diagram 22



To keep movement error to a minimum, the compass rose nearest the desired location is chosen.

Bearings on the chart

Bearings are used to plot the course from the ship to the object on the chart. A lighthouse bearing 073° means that if the vessel proceeds **from** current position **to** the lighthouse, the course would be 073(T)°.

When a lighthouse bears 073°, and the ship's position needs to be determined, the parallel ruler is placed in the direction 073°, the ruler is transferred to the lighthouse, and then a line is drawn in the reciprocal direction of 253°(073°+180°).

Values of latitude and longitude

These are read off the respective latitude and longitude scales on the boundaries of the chart.

Ship's time

The ship's time should be inserted next to the ship's position on the chart.

All times entered on the chart, in ship's logbooks and all other records on the ship, are by the ship's clock, i.e. ship's time, not GMT.

HOW TO FIND THE POSITION OF A SHIP BY TWO BEARINGS

Demonstration 1 (diagram 23)

Lighthouse A bears 300°(T) and charted object B bears 044°(T).

Find the position of the ship on the given chart.

Step 1: Draw bearing A

Place the parallel ruler on the nearest compass rose and align it to 300°(T). Ensure accuracy by seeing that the parallel ruler passes through 300°, the centre of the compass rose, and 120° (300°-180° = 120°). Move the parallel ruler to lighthouse A and draw the line 120° from A representing the bearing of 300° of lighthouse A from the ship.

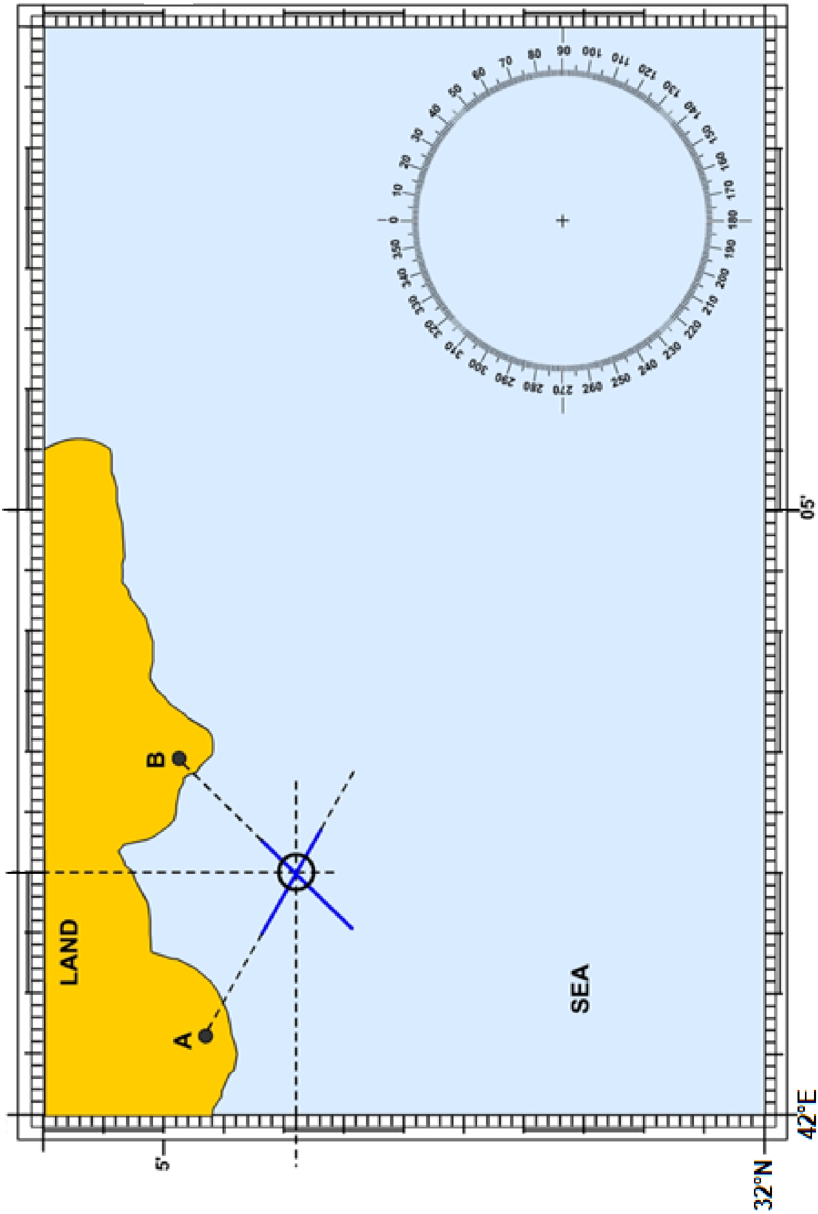
Step 2: Draw bearing B

Put the parallel ruler on the nearest compass rose and align it to 044°(T). Ensure accuracy by making sure that the parallel ruler passes through 044°, the centre of the compass rose, and 224° (i.e. 044°+180° = 224°). Move the parallel ruler to object B and draw the line 224° representing the bearing of 044° of object B from the ship.

Step 3: Obtain the position of your ship

The intersection of the two bearings is the position of the ship. Its latitude and longitude are read off as Lat 32° 03.9'N, Long 42° 02.0'E.

Diagram 23



TRANSIT BEARING

What is a transit bearing?

When two charted objects appear to be in one line from the ship, they are said to be in transit. The direction of the line passing through the two objects is fixed and can be read off the chart. While the ship is passing the stationary object, if the compass bearing is observed when the objects appear in transit, the compass error can then be deduced.

Demonstration 2 (diagram 24)

On the given chart, lighthouses C and D were observed to bear 242°(G) when in transit. Find the gyro compass error.

If at that time charted object E bore 319° (G), find the position of the ship.

Step 1: Obtain value of transit bearing

Join the two given points C and D on the chart and produce the line to the approximate position of the ship. Read its value from the compass rose. In this case it is 243°(T). This is the first LOP.

Step 2: Obtain compass error

Since the compass bearing is 242°(G) and the transit bearing is 243°(T), the gyro error is 1°(L).

Step 3: Draw bearing of E

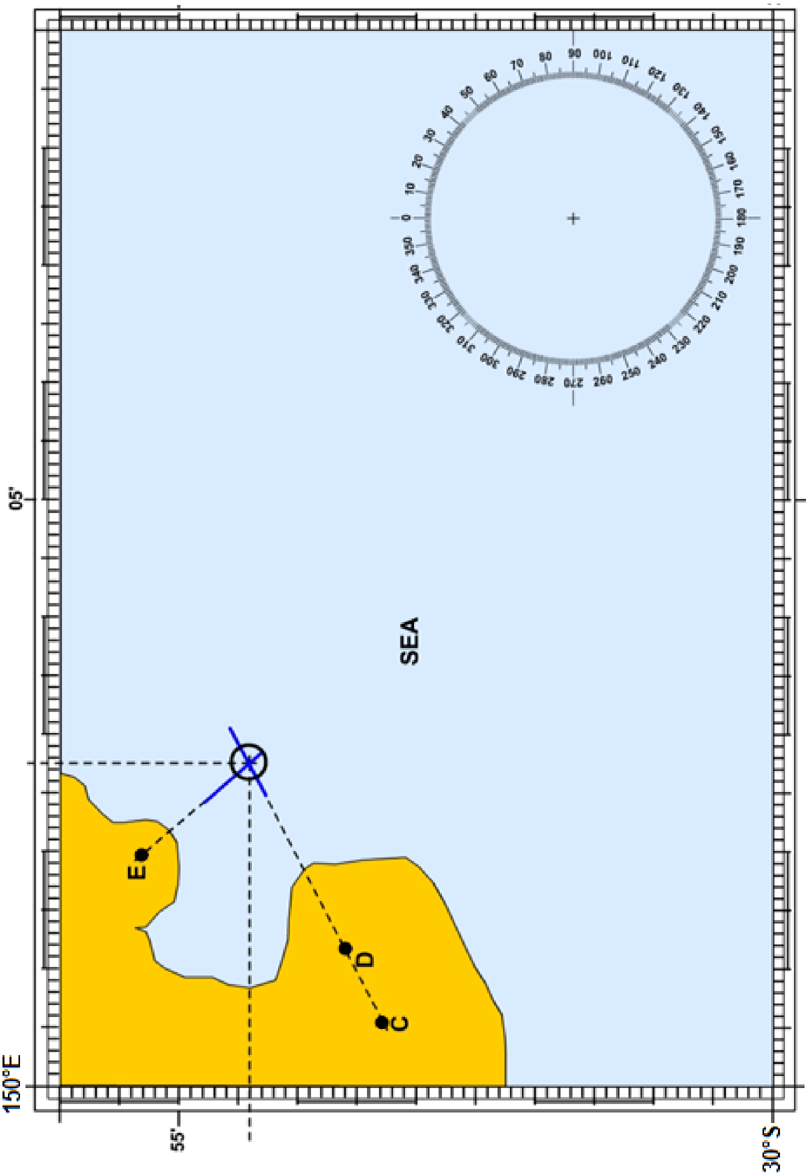
Observed Brg	319° (G)
Gyro Error	1° (L)
True Brg	320° (T)

Lay off bearing of object E. This is the second LOP.

Step 4: Obtain the position of the ship

The point of intersection of the two LOPs is the ship's position. Its latitude and longitude are read off as: Lat 29° 55.6'S, Long 150° 02.75'E.

Diagram 24



POSITION BY CIRCULAR LOPS

A) Position by distances off

If the distance (or range, abbreviated to R) of the ship from a charted object is known, the circle drawn with that point as centre and radius R, is the LOP of the ship. In other words, the ship is somewhere on the circumference of that circle. That point where two such LOPs cross is the position of the ship.

Demonstration 3 (diagram 25)

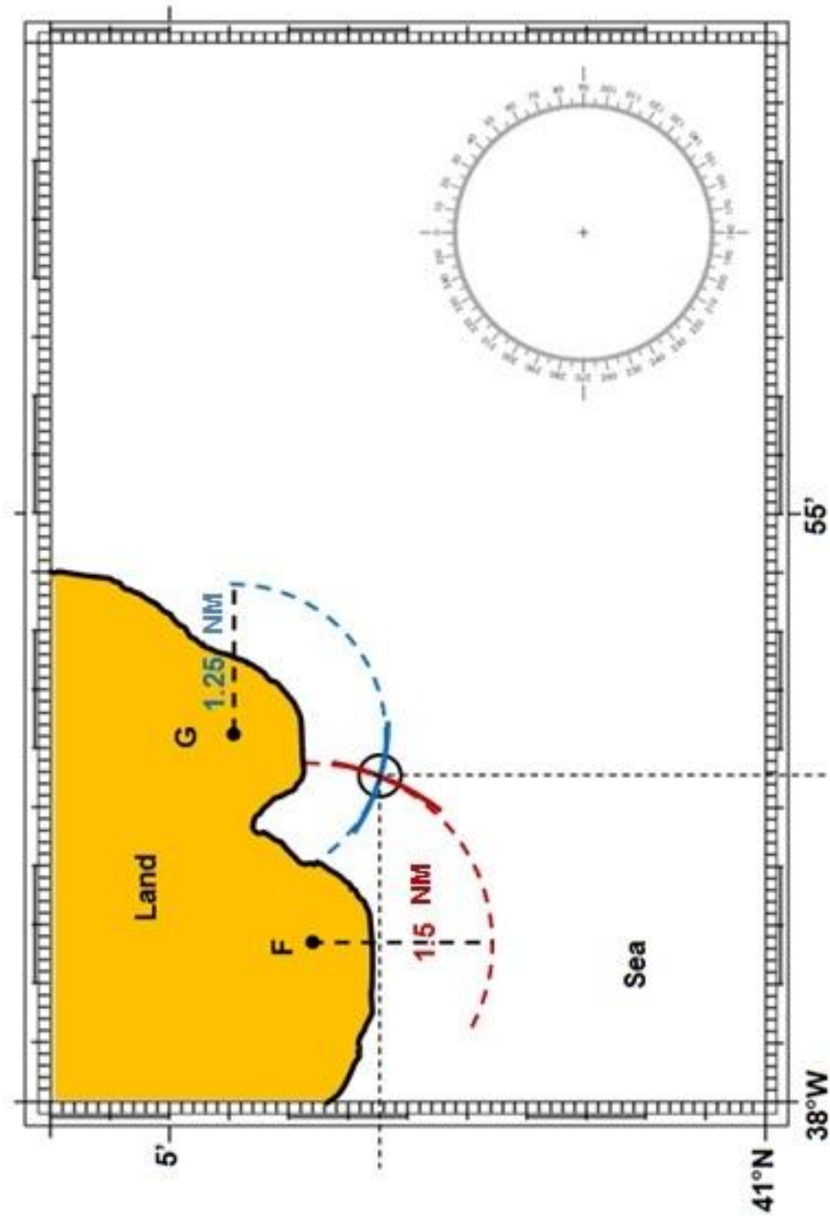
Point F is 1.5 NM off and point G if 1.25 NM off. Find the position of the ship.

Step 1: Draw first circular LOP
With centre F, radius 1.5 NM, draw an arc.

Step 2: Draw second circular LOP
With centre G, radius 1.25 NM draw another arc.

Step 3: Obtain position of ship
Point of intersection is the position of the ship. The latitude and longitude are read from the chart as Lat 41° 03.25'N Long 037° 57.2'W

Diagram 25



B) Position by bearing and distance off

Demonstration 4 (diagram 26)

Point H on the chart bears 011°(C), 2.4 NM off. If variation is 3°W and deviation is 1°E, find the position of the ship.

Step 1: Calculate compass error

Variation	3°W
Deviation	1°E
Compass error	2°W

Step 2: Apply compass error to bearing of H

Compass error	2°W
Bearing of H	011°(C)
Bearing of H	009°(T)

Step 3: Lay off bearing of H

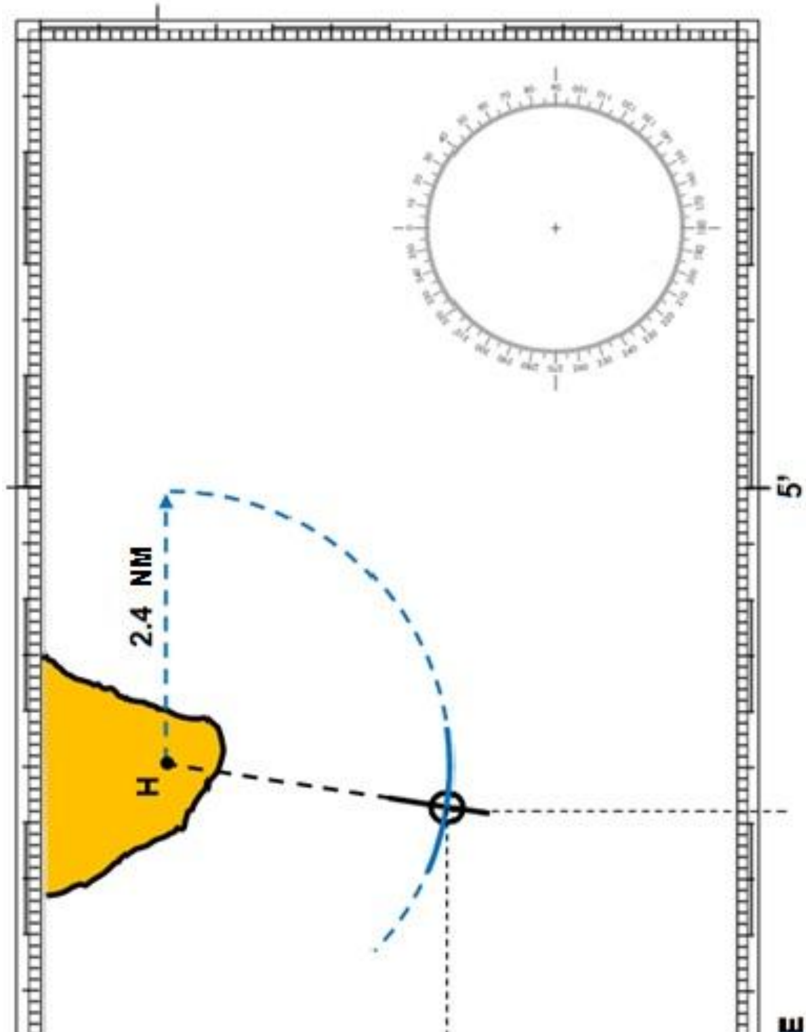
Step 4: Draw circular LOP

With centre H, radius 2.4 NM, draw an arc to intercept the bearing.

Step 5: Obtain the position

Point of intersection is the position of the ship. In this case, it is Lat 27° 57.5'S Long 010° 02.1'E.

Diagram 26



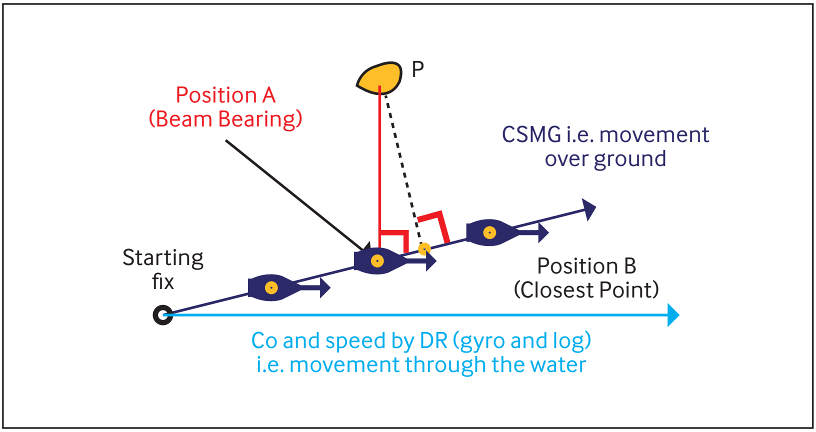
Chapter 5

Dynamic Chartwork – Chartwork on the move

BEAM BEARING

Beam bearing occurs when a charted object is 90° to the ship's head (diagram 27).

Diagram 27



Although the ship is steering 090°, it is making good a course of 075° as it is being pushed by a current.

When the ship is at position A, the point P on the chart is abeam on the port side.
P is on the perpendicular to course steered.

When the ship is at position B, it is at its closest point to P, also called passing distance.
P is on the perpendicular to course made good.

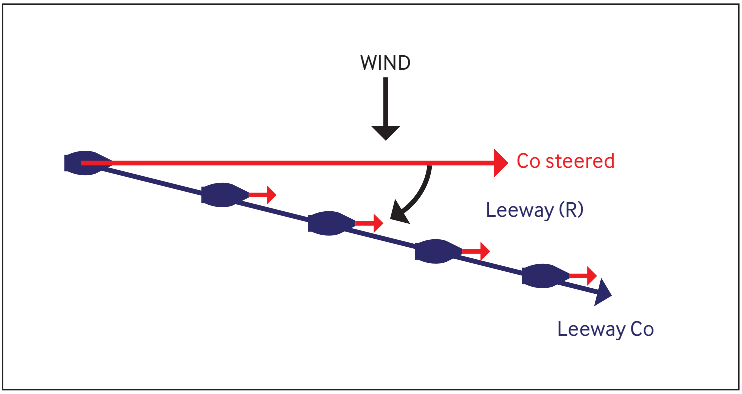
WORKING OUT LEEWAY

Simple explanation of leeway

Leeway is the angle between the course steered and the angle of progress of the ship. This can be understood better by an example (diagram 28).

The course would be 090°(T) and the **leeway course** would be 100°(T). The leeway is then said to be 10° to the right. The force pushing the ship to the right is the wind.

Diagram 28



Facts and assumptions regarding leeway

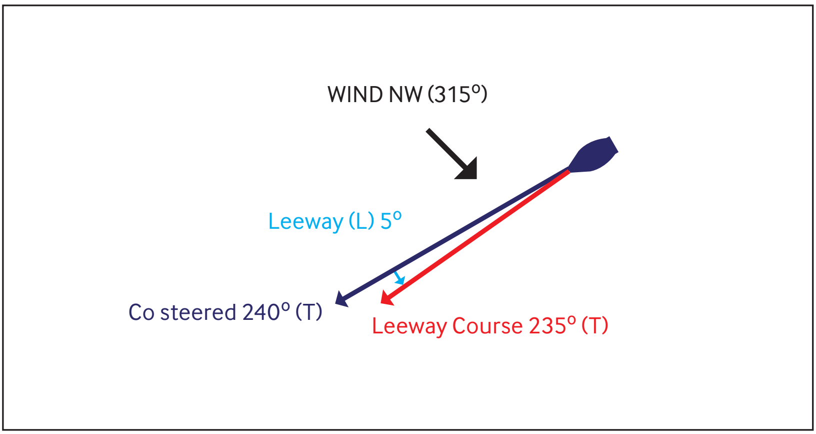
1. **Fact**: Wind is named by the direction from which it comes. If a small piece of paper is tossed in the air, and it blew towards SW, the wind must be coming from NE. The wind is named NE.
2. **Fact**: Wind from the port side would push the ship to starboard. Leeway is then termed 'Right'. Conversely, wind from the starboard side would push the ship to port. Leeway is then termed 'Left'.
3. **Fact**: Leeway is expressed in degrees right or left of the true course steered.
4. **Assumption**: Wind does not affect the speed of the ship. In reality, strong wind from ahead would cause an appreciable decrease in the speed made good, whereas wind from astern would not cause much increase in the speed made good. Since the effect of wind on the speed of the ship is not predictable, as there are far too many factors affecting this, we assume that wind does not affect the speed of the ship.
5. **Fact**: In open sea, the leeway can be estimated by looking at the wake of the ship. Wake is the trail on the sea water left astern. Comparing the wake and the direction of the keel of the ship would give the amount of leeway. Diagram 29 shows to be looking aft at the wake of the ship. The black line is the extension aft of the ship's fore and aft line. The yellow line shows the line of the wake. The white arrow shows the leeway, about 5° right in this case.

Diagram 29

Example of application of leeway

The ship is steering 240° (T). Wind direction is NW. Inspection of the wake indicates a leeway of 5°. Calculate the leeway course.

Diagram 30



Reasoning: Co 240° (T), wind from NW (315°). Since the wind is from the starboard side, ship will be pushed to port – the leeway will be to the left. (Diagram 30).

It is recommended to carry out calculations on a separate sheet not on the chart, in order to preserve the chart.

Calculation

Wind Direction	315°
True Course	240°
Leeway	5°
Leeway Course	235°

Examples of application of leeway

	1.	2.	3.	4.	5.
Wind Direction	040°	268°	139°	147°	000°
Course Steered	090°	195°	078°	200°	270°
Leeway	3°	5°	6°	4°	2°
Leeway Course	093°	190°	072°	204°	268°

Tidal streams

A tidal stream is the direction and rate of movement of the sea surface as a combination of several forces, mainly tide, wind and topography of adjoining land.

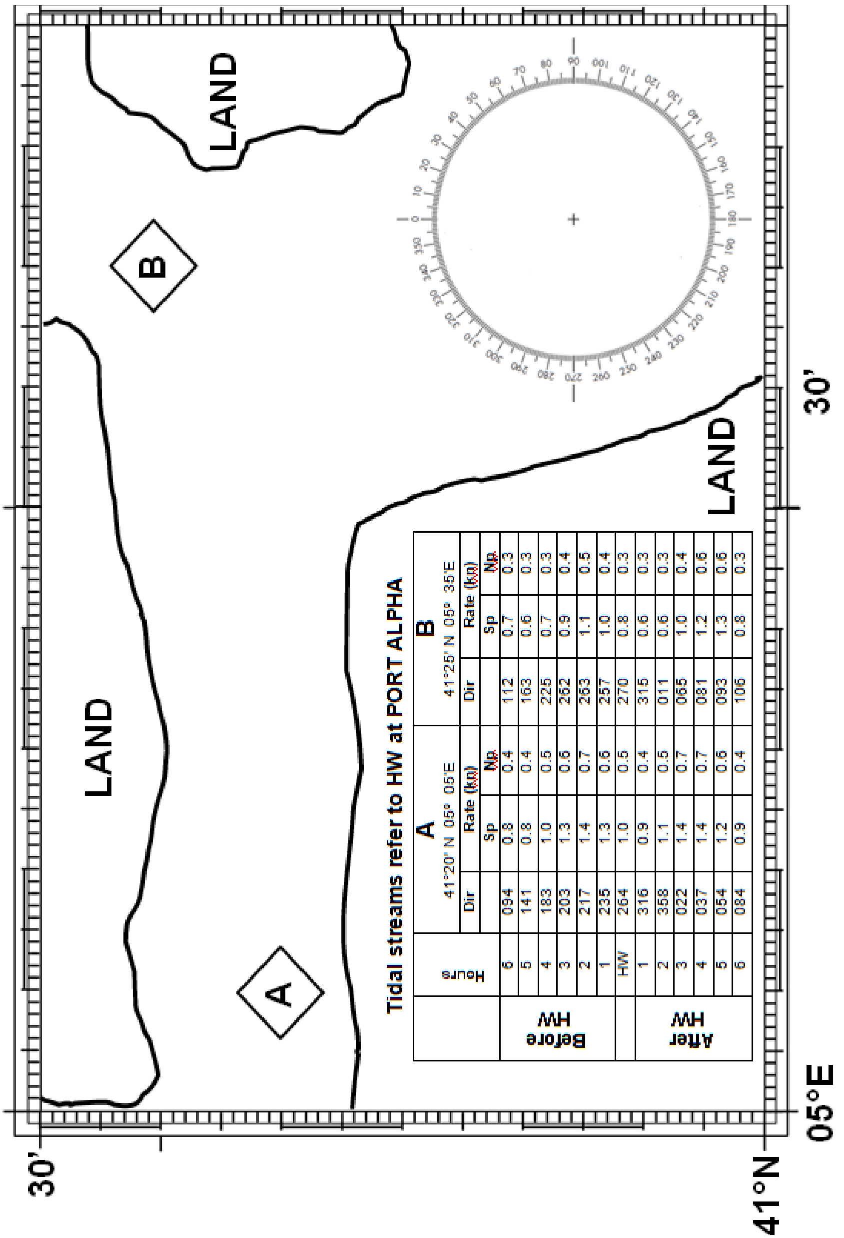
Indication of tidal data for critical areas

In critical areas, a diamond shape enclosing a letter may be shown. The tidal details of the area are indicated by the letter given in some non-operational areas, as shown in the chart in diagram 31. The direction and rate of the tidal stream at that location are tabulated for every hour before and after high water (HW) at a nearby major port, whose name is stated therein.

Prediction of set and rate

What is the direction and rate of current at position A at 0930 hours on 29 December in the chart in diagram 31?

Diagram 31



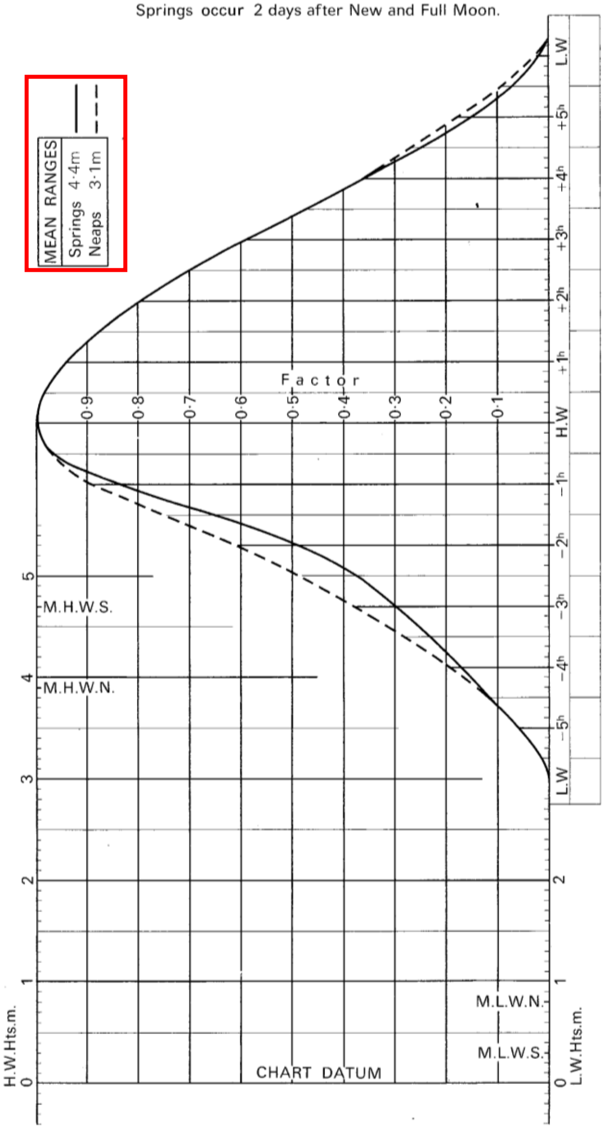
	Hours	A 41°20' N 05° 05'E Dir	Rate (kn) Sp	Rate (kn) Np	B 41°25' N 05° 35'E Dir	Rate (kn) Sp	Rate (kn) Np
Before HW	6	094	0.8	0.4	112	0.7	0.3
	5	141	0.8	0.4	163	0.6	0.3
	4	183	1.0	0.5	225	0.7	0.3
	3	203	1.3	0.6	262	0.9	0.4
	2	217	1.4	0.7	263	1.1	0.5
	1	235	1.3	0.6	257	1.0	0.4
	HW	264	1.0	0.5	270	0.8	0.3
After HW	1	316	0.9	0.4	315	0.6	0.3
	2	358	1.1	0.5	011	0.6	0.3
	3	022	1.4	0.7	065	1.0	0.4
	4	037	1.4	0.7	081	1.2	0.6
	5	054	1.2	0.6	093	1.3	0.6
	6	084	0.9	0.4	106	0.8	0.3

Diagram 32

PORT ALPHA

MEAN SPRING AND NEAP CURVES

Springs occur 2 days after New and Full Moon.



Step 1: Identify Nodal Port

From the tidal stream tables on the chart, note the nodal point on which the tables are based – in this case it is HW at Port Alpha.

Step 2: Obtain Mean Spring and Neap Ranges

From the tidal curves page of the nodal port (diagram 32), extract the values of mean spring range and mean neap range:

Mean ranges	
Spring	4.4 m
Neap	3.1 m

Step 3: Obtain HW and LW bracketing required time

Enter tide tables for Port Alpha for 29 December and obtain the HW and LW bracketing for the required time of 0930 hours. The extract is given here:

Time	Height
0505	4.4 m
1124	0.4 m

Step 4: Obtain interval from nearest HW

By inspection we obtain the interval from the nearest HW at Port Alpha. In this case, 0930 hours is about two hours **before HW**.

Step 5: Obtain tidal range

Obtain the tidal range. In this case, 4.4-0.4 = 4.0 m.

Step 6: To find predicted set

Enter the tidal stream table on the chart, for two hours before HW at Port Alpha, and obtain the predicted **set as 217°(T)**.

Step 7: To find predicted rate

Tabulate mean spring range, mean neap range and tabulated rates of tidal stream as follows:

	Range	Rate from table on chart
Mean Spring Range	4.4 m	1.4 kn
Mean Neap Range	3.1 m	0.7 kn
Range at 0930	4.0 m	1.2 kn by interpolation

Step 8: Obtain the values

The predicted set and rate at position A at 0930 hours on 29 December = 217°(T) 1.2 knots.

Course and distance between two points on a chart

This is a very basic procedure in chartwork.

Join the starting position and the destination.

Read off the true course using the parallel ruler or set square and ruler.

Apply compass error and calculate the compass course to steer.

Measure the distance between the two points with dividers against the latitude scale.

To find estimated time of arrival (ETA)

To find the ETA, divide the distance by the speed of the ship and obtain the passage time.

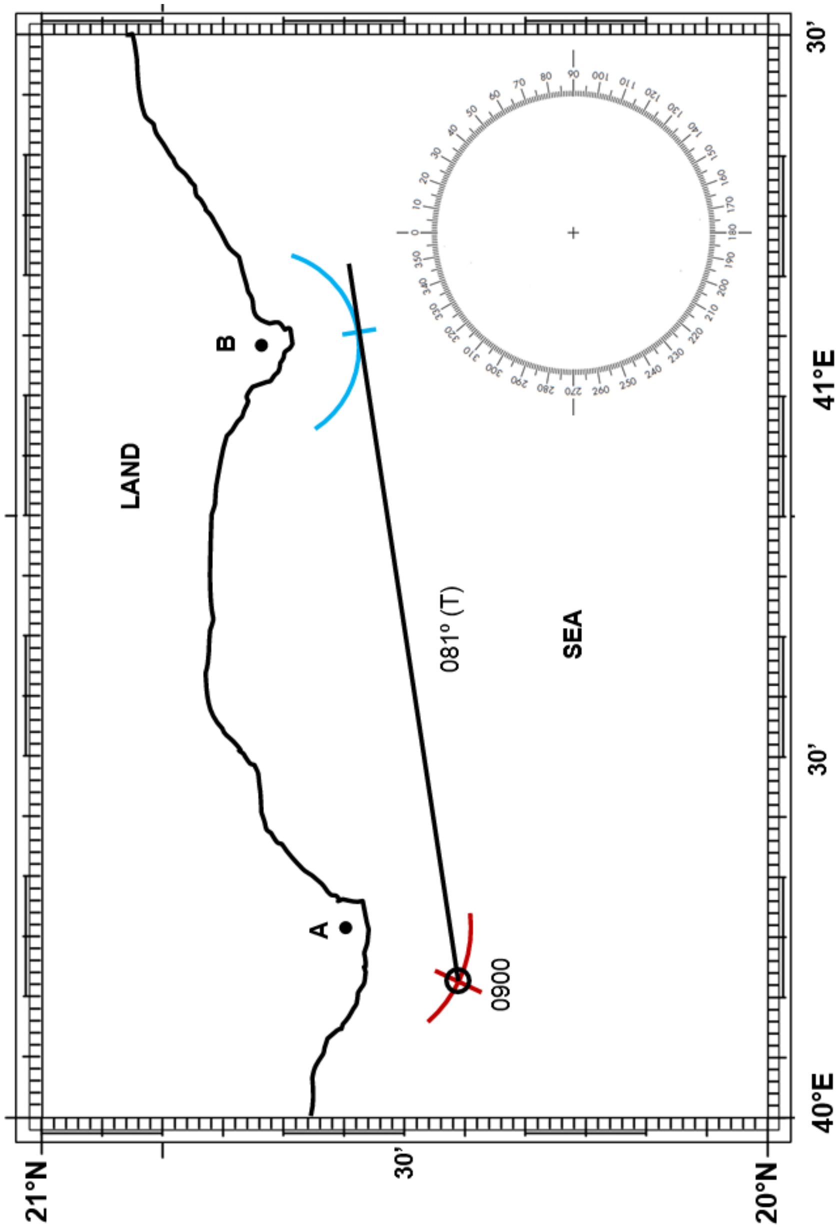
Add the passage time to the starting time to get the ETA.

Worked example

On the chart in diagram 33, at 0900 hours point A bore 025°(T) 10 NM off. Set course to pass 8 NM off point B. If gyro error is 1°(L), find the compass course to steer.

If the ship's speed is 12 knots, find the ETA at the destination.

Diagram 33



Step 1: Plot starting position

Lay off the given bearing and distance from point A.

Insert the time next to it.

Step 2: Lay off destination arc

Centre B, radius 8 NM, draw an arc.

Step 3: Draw the course

From the starting fix, draw a tangent to the arc at destination. This is the true course.

Step 4: Obtain the true course and compute the gyro course

True Course to Steer	081°(T)
Gyro Error	1°(L)
Gyro Course to Steer	080°(G)

Step 5: Obtain distance

Measure the distance along the latitude scale from the starting fix to the point of contact at the destination arc: in this case 54 NM.

Step 6: Calculate passage time

Passage time = distance to go ÷ speed = 54/12 = 4.50 hours = 4h 30m

Step 7: Calculate ETA

Departure Time	0900
Passage Time	0430
ETA	1330

Step 8: Obtain the values.

Course to steer = 080°(G); ETA 1330 hours.

THE MAIN TYPES OF PROBLEM IN CHARTWORK

Chartwork problems can be broadly categorised into three types:

1. Fixing the ship's position by various means when the ship is stationary. This has already been covered in Chapter 4.
2. Drifting, with or without position fixing, when the ship is moving - given the ship's movement through the water and expected movement over the ground while being affected by current and wind. This will be explained in this chapter.
3. Counteracting, with or without position fixing, when the ship is moving. To find the course to steer in order to achieve a given course made good, being affected by current and wind. This will be explained in this chapter.

DRIFTING DUE TO CURRENT

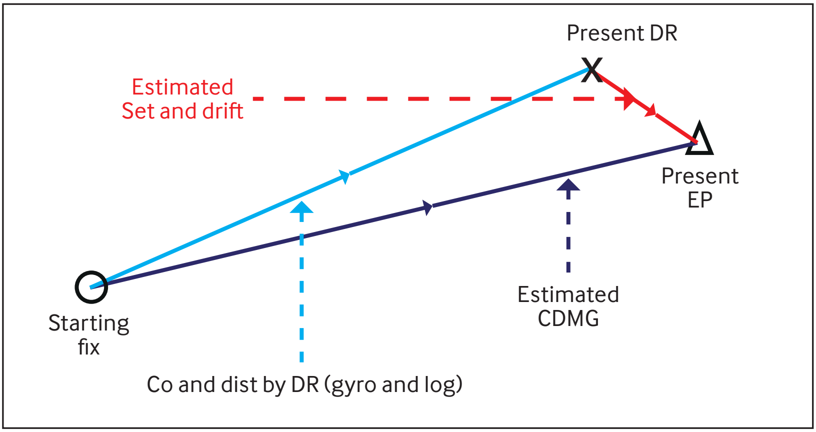
In this case, the ship's movement through the water is available which means the course steered and log speed or engine speed (speed as computed from the RPM of the engine).

The movement over the ground needs to be found (CSMG): with the water being affected by a current. The time interval may be as little as an hour, sometimes even less, depending on the scale of the chart.

The procedure

Refer to diagram 34. Choose an interval appropriate to the scale of the chart, usually one hour but on very large scale charts half hour may be sufficient. From the starting fix, lay off the DR position at the end of the chosen interval. From the DR position, draw the estimated set and drift of the current for the chosen interval. This is the EP at the end of the chosen interval. Join the starting fix and the EP and that gives the estimated course and distance made good (CDMG).

Diagram 34



Example of drifting due to current

Refer to diagram 35. The ship is in position A at 1000 hrs. Course of 069°(G) error 1°(L) is set. The ship's engine speed is 12 knots. A tidal stream is setting the ship 145°(T) at three knots. Find the CSMG. At what time would lighthouse B come abeam?

Step 1: Choose the plotting interval

Seeing the scale of the chart, one hour is appropriate.

Step 2: Find the true course steered

Gyro Course Steered	069°(G)
Gyro Error	1°(L)
True Course Steered	070°(T)

Step 3: Plot the starting position on the chart

In this case, the starting position is A at 1000 hours.

Step 4: Lay off the 1100 DR position at the end of the interval

In this case, the plotting interval is one hour. Hence lay off 12 NM on a course of 070 °(T).

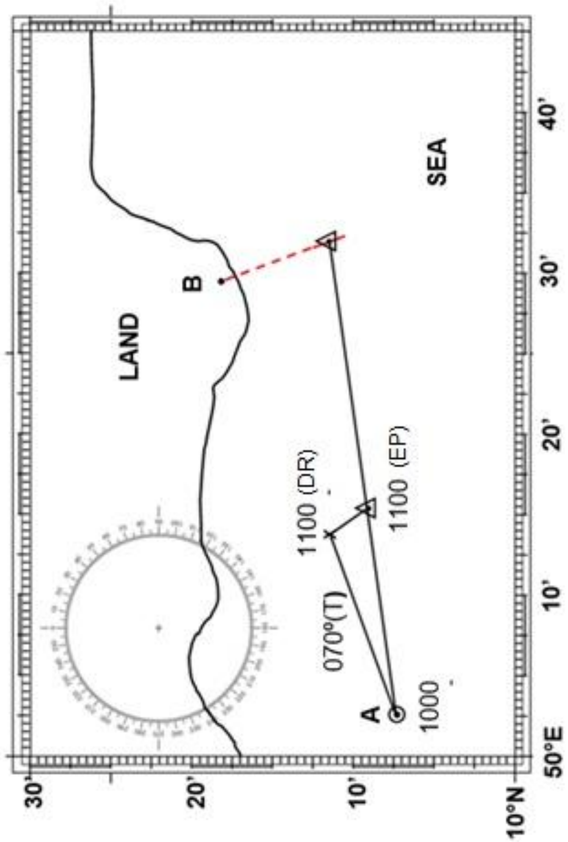
Step 5: Plot EP

From the DR position draw the set for one hour at 3 kn = 3 NM in the direction 145°(T).

Step 6: Obtain CSMG

Join the starting fix and the EP. That gives the estimated CSMG in one hour. In this case, CMG = 082°(T), distance = 13.0 NM.

Diagram 35



SMG = distance made good ÷ plotting interval = 13.0 ÷ 1 = 13.0 knots.

Step 7: Compute the beam bearing

Compute the beam bearing as follows:

Course Steered	070°(T)
Port Beam So Subtract 90°	-90°
True Beam Bearing	340°(T)

Step 8: Lay off abeam position

The point where the beam bearing cuts the course made good is the position when B would come abeam.

Step 9: Obtain the interval to steam

Measure the distance from A to the beam position.

Interval to steam = distance to beam bearing ÷ SMG = 30.0 ÷ 13.0 = 2.31 hours = 2h 18m.

Step 10: Compute ETA

Starting Time	1000
Steaming Interval	0218
ETA Beam Bearing	1218

Step 11: Obtain the values

CSMG = 082°(T) 13.0 knots.

ETA beam bearing of B = 1218 hours.

Example of drifting due to current and leeway

Refer to diagram 36. The ship is in position A at 1500. Course of 050°(G) error 1°(L) was set. The ship's engine speed is 16 knots. An estimated tidal stream is setting the ship 125°(T) at 2.5 knots. Leeway is 3° for a NW'ly wind. Find the CSMG. At what time would lighthouse B come abeam?

Step 1: Choose the plotting interval

Seeing the scale of the chart, one hour is appropriate.

Step 2: Find the true course steered

Gyro Course Steered	050°(G)
Gyro Error	1°(L)
True Course Steered	051°(T)

Step 3: Plot the starting position on the chart

In this case, the starting position is A at 1500 hours.

Step 4: Compute the leeway course

True Course Steered	051°(T)
Leeway (NW'ly wind)	3°(R)
Leeway Course	054°(T)

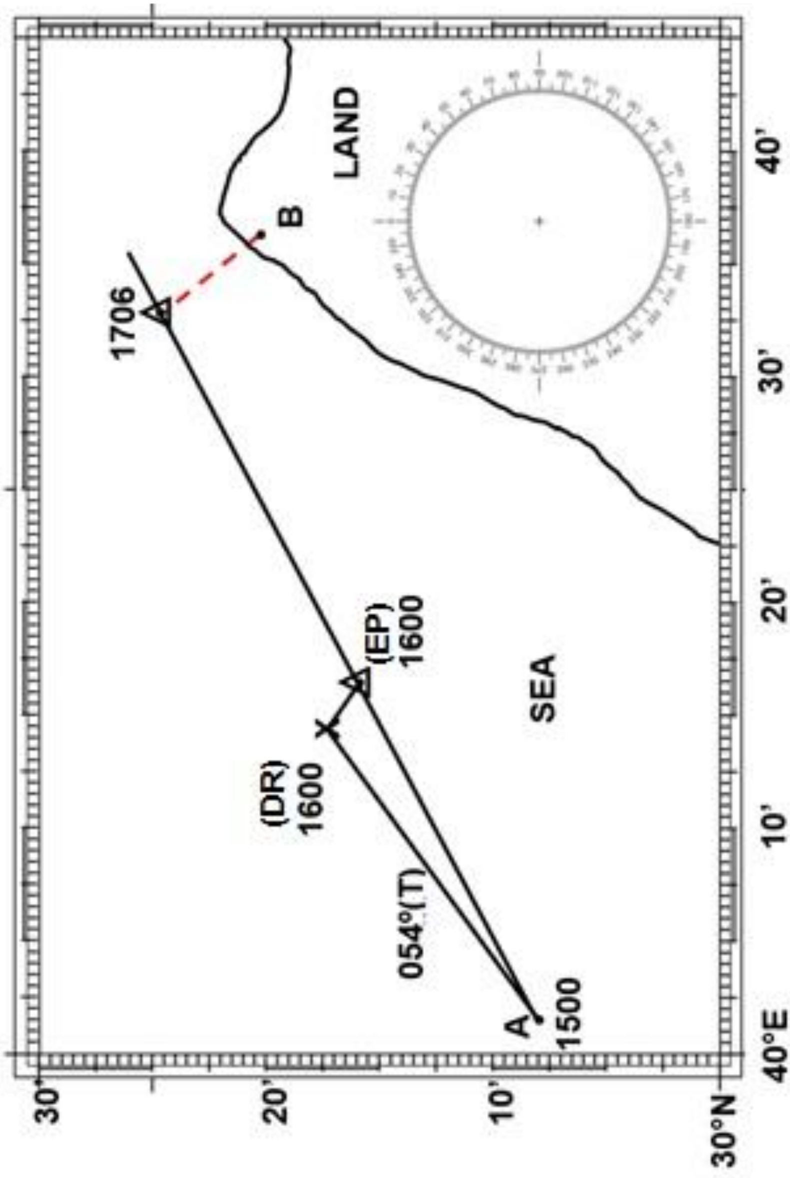
Step 5: Lay off the 1600 DR position at the end of the interval

In this case, the plotting interval is one hour. Hence lay off 16 NM on the leeway course of 054°(T).

Step 6: Plot EP

From the 1600 DR position draw the set for one hour at 2.5 knots = 2.5 NM in the direction 125°(T).

Diagram 36



LAND
SEA
A
B
1500
054°(T)
(DR)
1600
(EP)
1600
1706
30'
20'
10'
30°N
40°E
10'
20'
30'
40'

Step 7: Obtain CSMG

Join the starting fix and the EP. That gives the estimated CDMG in one hour. In this case, CMG = 062°(T), distance = 17.0 NM.

Speed made good = distance made good ÷ plotting interval = 17.0 ÷ 1 = 17.0 knots.

Step 8: Compute the beam bearing

Ship's Head	051°(T)
Stbd Beam So Add 90°	+90°
True Beam Bearing	141°(T)

Step 9: Lay off abeam position

The point where the beam bearing cuts the CMG is the position when B would come abeam.

Step 10: Obtain the interval to steam

Measure the distance from A to the beam position.

Interval to steam = distance to beam bearing ÷ SMG = 35.6 ÷ 17.0 = 2.09 hours = 2h 06m

Step 11: Compute ETA

Starting Time	1500
Steaming Interval	0206
ETA Beam Bearing	1706

Step 12: Obtain the values

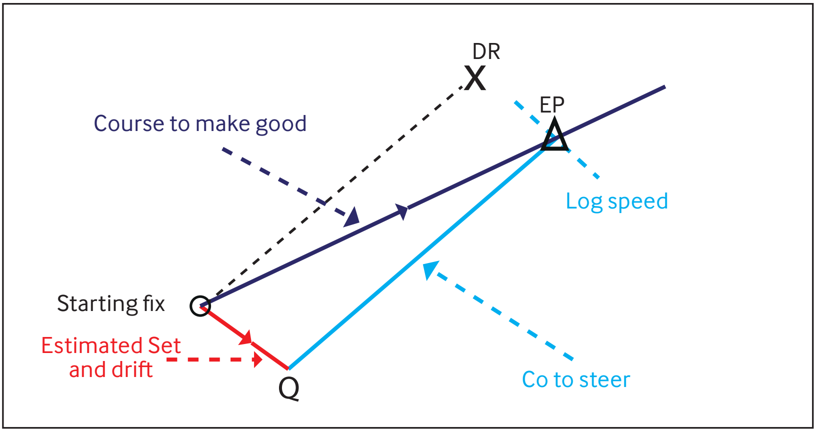
CSMG = 062°(T) 17.0 knots. ETA beam bearing of B = 1706 hours.

COUNTERACTING CURRENT

In this type of problem, given the log speed or engine speed, an estimated current and a **specific course to make good** towards the destination, it is required to find the course to steer and the SMG.

This problem seems the logical way to navigate. Decide where the ship has to go and reach there, **not drift and find out where it eventually reaches!**

Diagram 37



The procedure

Choose an interval appropriate to the scale of the chart, usually one hour but on very large scale charts half hour may suffice.

Refer to diagram 37. From the starting fix, lay off the desired course to make good. From the starting fix, draw the estimated set and drift of current for the chosen interval to point Q. Set a chart compass to the distance at log or engine speed for the chosen interval. Centre Q, cut off an arc on the course to make good. The point of intersection is the EP at the end of the chosen interval. The direction from Q to EP is the true course to steer to counteract the estimated current. The distance from the starting fix to the EP is the estimated distance made good during the chosen interval. This, converted to knots, is the estimated SMG.

The DR position at the end of the chosen interval

From the starting fix, draw the course steered and mark off the distance as per log or engine speed, as shown in diagram 37. This position would be the DR at the end of the chosen interval.

Example of counteracting current

Refer to diagram 38. At 0700, the ship in position A desires to pass 6 NM off Point B. A current is estimated to set 170° at two knots. If the ship's engine speed is 12 knots, find the gyro course to steer, if gyro error was 1°H.

At what time and distance off will Point B come abeam?

Step 1: Choose the plotting interval

Seeing the scale of the chart, one hour is appropriate.

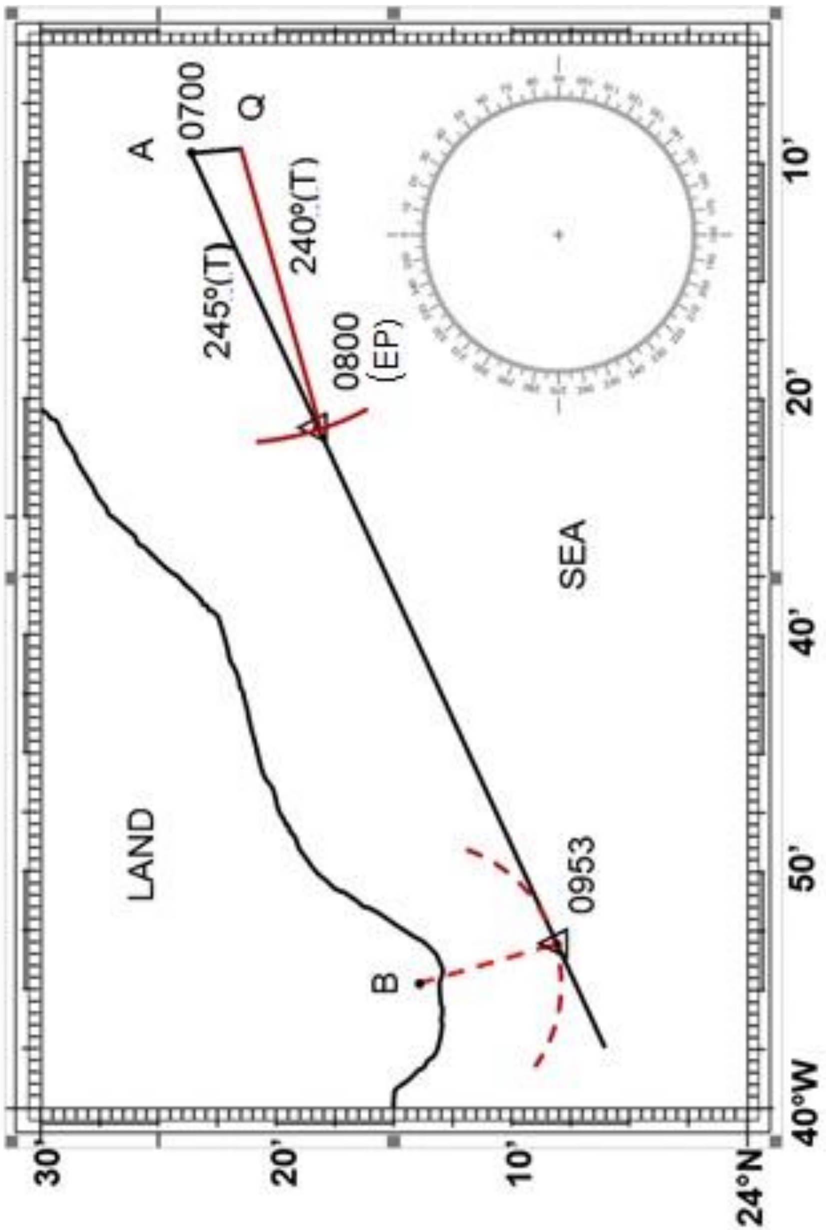
Step 2: Plot the starting fix and time on the chart

In this case, the starting fix is at A on the chart. Mark 0700 next to it.

Step 3: Lay off the course to make good

The distance to pass off B is 6 NM. Centre B, radius 6 NM, draw an arc. From the starting fix draw a tangent to this arc. This is the course to make good. It is 245°(T) in this case.

Diagram 38



A
0700
Q
245°(T)
240°(T)
0800
(EP)
SEA
LAND
0953
B
10'
20'
40'
50'
40°W
30'
20'
10'
24°N

Step 4: Obtain the true course to steer

At the starting fix A, draw the set and rate of current for the chosen interval which is 170°(T) x 2 NM in this case and call that point Q. With centre Q and radius = 12 NM, cut off an arc to cut the course to make good. The point of intersection is the EP at the end of the chosen interval, 0800 hours in this case. The direction from Q to the EP is the true course to steer.

Step 5: Calculate compass course to steer

True Course to Steer	240°(T)
Gyro Error	1°(H)
Gyro Course to Steer	241°(G)

Step 6: Obtain estimated SMG

The distance from the 0700 fix to the 0800 EP is the estimated speed made good, 12.5 knots in this case.

Step 7: Compute the beam bearing and distance

Ship's Head	241°(G)
Stbd Beam	+90°
Stbd Beam Bearing	331°(G)

The point where the beam bearing cuts the CMG is the beam position. Measure off the abeam distance which here = 6 NM.

Step 8: Obtain ETA at beam position

Interval to steam = distance to steam ÷ SMG = 36 ÷ 12.5 = 2.88 hours = 2h 53m.

Time of Starting Fix	0700
Interval to Beam Bearing	0253
ETA Beam Position	0953

Step 9: Compute the findings

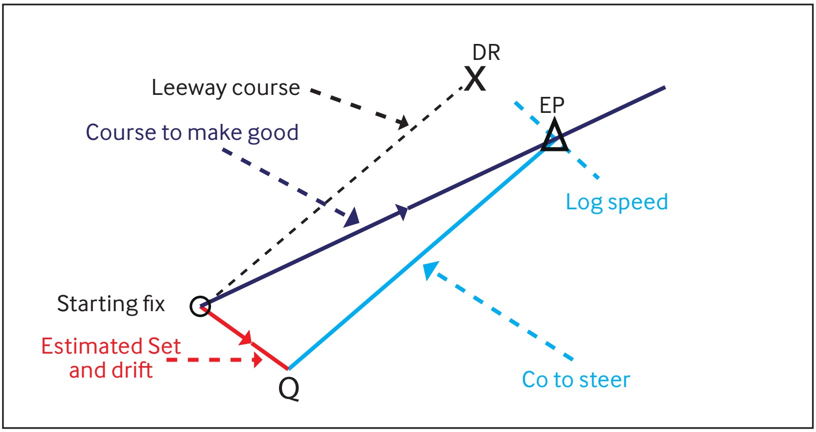
Gyro course to steer = 241°(G); beam position 6 NM off at 0953 hours.

Example of counteracting current and leeway

In this type of problem, given the log speed or engine speed, an estimated **current and leeway,** and a **specific course to make good** towards the destination, find the course to steer and the speed made good.

This type of problem is similar to the earlier type but leeway has been included.

Diagram 39



The procedure

First counteract the current

Refer to diagram 39. Choose an interval appropriate to the scale of the chart, usually one hour but on very large scale charts half hour may suffice.

From the starting fix, lay off the desired course to make good. From the starting fix, draw the estimated set and drift of current for the chosen interval (point named Q in diagram 39). Set a chart compass to the distance at log or engine speed for the chosen interval. Centre Q, cut off an arc on the course to make good. The point of intersection is the EP at the end of the chosen interval. The distance from the starting fix to the EP is the estimated DMG during the chosen interval. This, converted to knots, is the estimated SMG.

The direction from Q to EP is the true course to steer to counteract the estimated current.

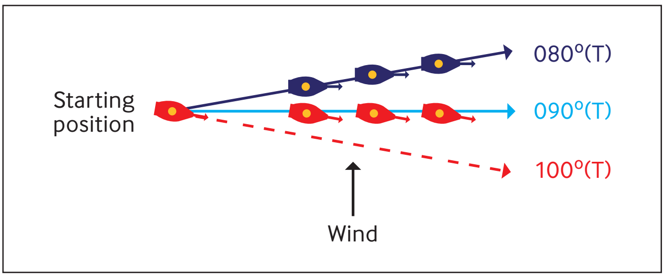
Next counteract leeway

Please refer to diagram 40. The ship, requiring to make good a course of 090°, is experiencing a very strong southerly wind. For this example, assuming this is a car carrier proceeding at slow speed, the leeway is observed to be large, 10° to the left in this case.

If the ship steered 090°(T), it will make good 080°(T) because of the wind, as shown by the dark blue outlines. To counteract leeway, the ship would have to steer 100°(T) so that the leeway course would be 090° as shown by the red outlines.

Applying what has been discussed earlier in this chapter, to counteract leeway alter course towards the wind by the amount of that leeway.

Diagram 40



How to remember whether leeway is to be applied before or after current

While the ship was **drifting** due to current and leeway. the leeway was applied first and current later. However, while **counteracting** current and leeway, current is counteracted first and leeway after that.

In order to remember this, there is a **slogan** with the acronym **CCLL** meaning Counteracting Current Leeway Later. So the opposite is done when drifting!

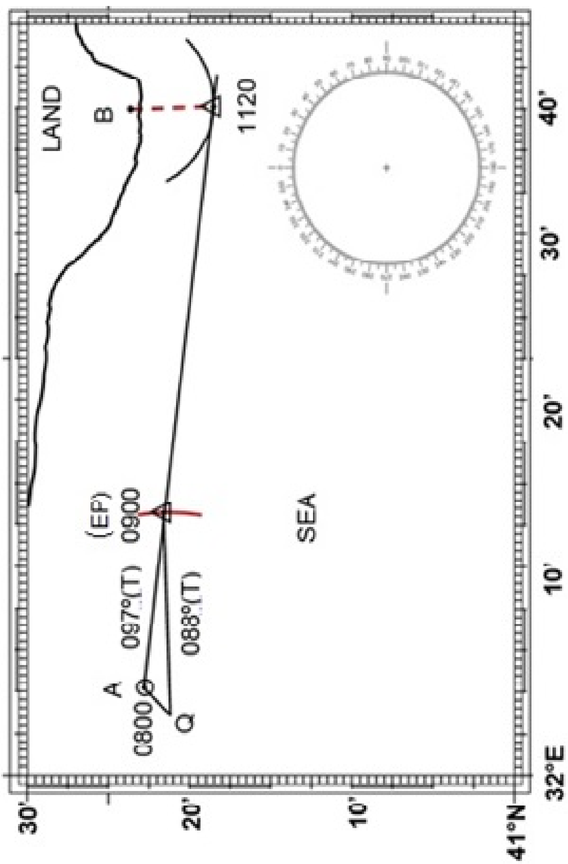
DR position at the end of the chosen interval

From the starting fix, draw the leeway course and mark off the distance as per log or engine speed, as shown in diagram 36. This position would be the DR at the end of the chosen interval.

Example of counteracting current and leeway

Refer to diagram 41. At 0800, in position A, the ship desires to pass 5 NM off Point B. A current is estimated to set 225°(T) at two knots. Leeway is 3° for a S'ly wind. If the ship's engine speed is 12 knots, find the compass course to steer, if variation is 4°(W), using the deviation card in diagram 42. At what time and distance off will Point B come abeam?

Diagram 41



Step 1: Choose the plotting interval

Noting the scale of the chart, one hour is appropriate.

Step 2: Plot the starting fix and time on the chart

In this case, the starting fix is at A on the chart. Mark 0800 next to it.

Step 3: Lay off the course to make good

The distance to pass off B is 5 NM. Centre B, radius 5 NM, draw an arc. From the starting fix draw a tangent to this arc. This is the course to make good. It is 097°(T) in this case.

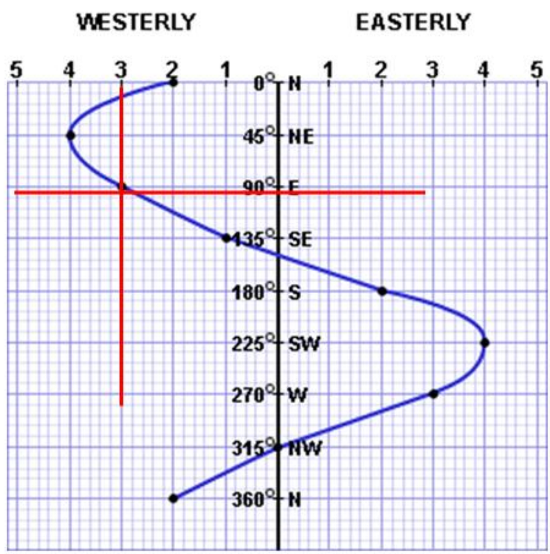
Step 4: Obtain the true course to steer

At the starting fix A, draw the set and rate of current for the chosen interval – 225°(T) 2 NM in this case– and call that point Q. Centre Q, radius = 12 NM, cut off an arc to cut the course to make good. The point of intersection is the EP at the end of the chosen interval, 0900 hours in this case. The direction from Q to the EP is the true course to steer to counteract current. In this case it is 088°(T).

Step 5: Counteract leeway

True Course to Steer to Counteract Current	088°(T)
Leeway 3° Wind S, Hence a/c to Starboard	3°(R)
True Course to Counteract Current and Leeway	091°(T)

Diagram 42



Step 6: Calculate compass course to steer

True Course to Steer	091°(T)
Variation	4°(W)
Magnetic Course to Steer	095°(M)
Deviation for Ship's Head	3°(W)
Compass Course to Steer	098°(C)

Step 7: Obtain estimated speed made good

The distance from the 0800 fix to the 0900 EP is the estimated speed made good, 10.5 knots in this case.

Step 8: Compute the beam bearing and distance

Ship's Head	091°(T)
Port Beam	-90°
Port Beam Bearing	001°(T)

The point where the beam bearing cuts the course made good is the beam position. Measure off the abeam distance which here = 35 NM.

Step 9: Obtain ETA at beam position

Interval to steam = distance to steam ÷ SMG = 35 ÷ 10.5 = 3.33 hours = 3h 20m.

Time of Starting Fix	0800
Interval to Beam Bearing	0320
ETA Beam Position	1120

Step 10: Compute the values

Compass course to steer to counteract current and leeway = 098°(C); beam position 5 NM off B will be at 1120 hours.

POSITIONS ON THE MOVE

The three-bearing solution

In navigation, while on a coastal passage, three bearings of the same object are used to obtain the CMG.

What is a three-bearing solution?

A three-bearing solution is a process whereby the ship's CMG can be deduced by observing three bearings of the same fixed shore object while steaming through an unknown current.

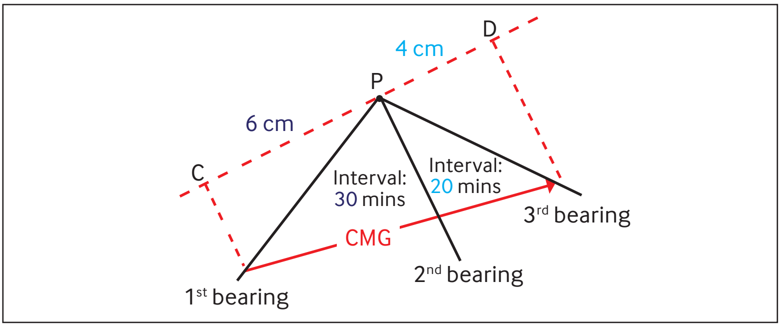
Conditions necessary for a three-bearing solution

The ship must maintain a constant course steered and engine speed during the process. There should be no drastic change in the shape of the coastline so that the current may be presumed to be constant during the interval between the first and third bearings.

Procedure

This is explained with reference to diagram 43. While on a coastal passage, three bearings of the same object at three different times should be taken.

Diagram 43



Draw the three true bearings of charted object P. At P, draw a perpendicular line to the middle bearing and on it, cut off distances on either side, in any units, in proportion to the intervals between the observations. Here the intervals are 30 minutes and 20 minutes. So cut off 6cm and 4cm. From these terminal points C and D, draw parallels to the middle bearing to intersect the first and third bearings. Join the intersectional points. This is the CMG.

Example of the three-bearing solution

In diagram 44, at 0400 point P bore 107°(T). At 0420 it bore 161°(T) and at 0435 it bore 191°(T). Find the CMG if the ship steered 065°(T) at 16 knots engine speed.

If at 0435, the distance off point P was obtained by radar to be 8.5 NM, find the set and rate of current.

Note: For understanding purposes, this particular problem may be split into distinct parts. The first part is a pure three-bearing solution where the given course steered and engine speed are of no relevance. The CMG can be obtained.

The second part is general chartwork involving drifting due to current. However, the working is shown in continuous sequence.

Step 1: Draw the three bearings
Draw the bearings 107°(T), 161°(T) and 191°(T) of point P.

Step 2: Calculate the ratio of the intervals
Ratio = first interval:second interval

= (0420-0400):(0435-0430) = 20:15 = 4:3

Step 3: Draw perpendicular, cut off proportions, and draw parallels
At P, draw a perpendicular to the middle bearing. Cut off four units and three units on either side respectively. Then draw parallels to the middle bearing.

Step 4: Obtain the CMG
Join the two points where the parallels intersect the first and third bearings. This line is the course made good. In this case, CMG = 053°(T).

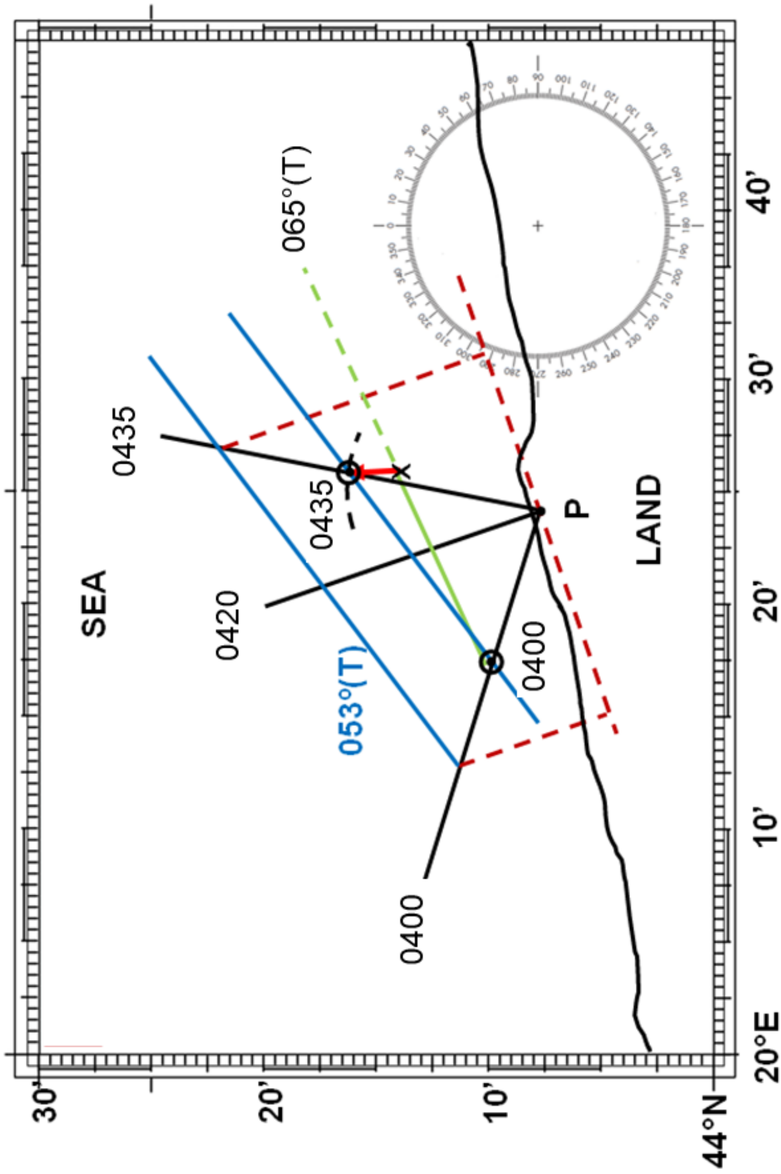
Step 5: Plot the given fix and compute the first fix
On the third bearing, cut off 8.5 NM from P. This is the fix at 0435.

Draw the CMG backwards from the 0435 fix and the point where it cuts the first bearing was the fix at 0400.

Step 6: Draw the 0435 DR and obtain set and drift
From the first fix, draw the course steered– 065°(T) – and distance for 35 minutes at 16 knots = 9.33 NM. This is the 0435 DR. Measure off the set and drift – 357°(T) 2.4 NM in 35 minutes or four knots.

Step 7: Compute the values
CMG = 053°(T); set and rate of current = 357°(T) at four knots.

Diagram 44



SEA
LAND
P
0435
0435
0420
0400
0400
053°(T)
065°(T)
30'
20'
10'
44°N
20°E
10'
20'
30'
40'

RUNNING FIX

Running fix is a process whereby the ship's position can be obtained by transferring an LOP to intersect another LOP with a steaming interval between them.

Caution when executing a running fix

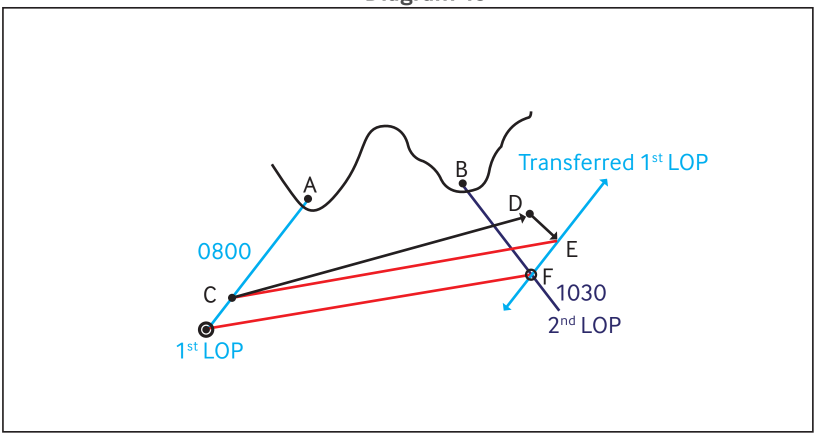
In all cases of transferring an LOP, whether in chartwork or in practical navigation, it should be assumed that the course is known during the interval between the two LOPs. The accuracy of the fix obtained rests on this assumption. Hence **do not** rely implicitly on a fix obtained through a running fix. The position must be verified by other means as soon as practicable.

Procedure

Reference is made to diagram 45. While on a passage, a bearing of charted object A is taken at 0800. At 1030, the bearing of object B is observed. Obviously B was not visible while observing A and vice versa, otherwise bearings of both fixes could have been obtained simultaneously. Draw both the LOPs. To perform a running fix, take any point C on the first LOP, and from this point draw the course steered at the engine speed for the interval of 2½ hours to a point D. From D, apply the set and drift of current for the interval of 2½ hours and refer to the point reached as E. Transfer the first LOP through E and the point at which this intersects the second LOP is the fix at 1030. CE is the CMG and SMG from 0800 to 1030.

If needed, draw a parallel to EC from F and the point at which it intersects the first LOP was the fix at 0800.

Diagram 45



Example of a running fix

In diagram 46, at 1500, point P bore 310°(T) while steering a course of 247°(T) at 15 knots. At 1900, point Q bore 030°(T). If a current was setting 020°(T) at two knots, find the position of the ship at 1900 and at 1500. Also find the course and speed made good.

Note: Points C, D and E are used here for easy identification during explanation only. They are not required to be marked on the chart.

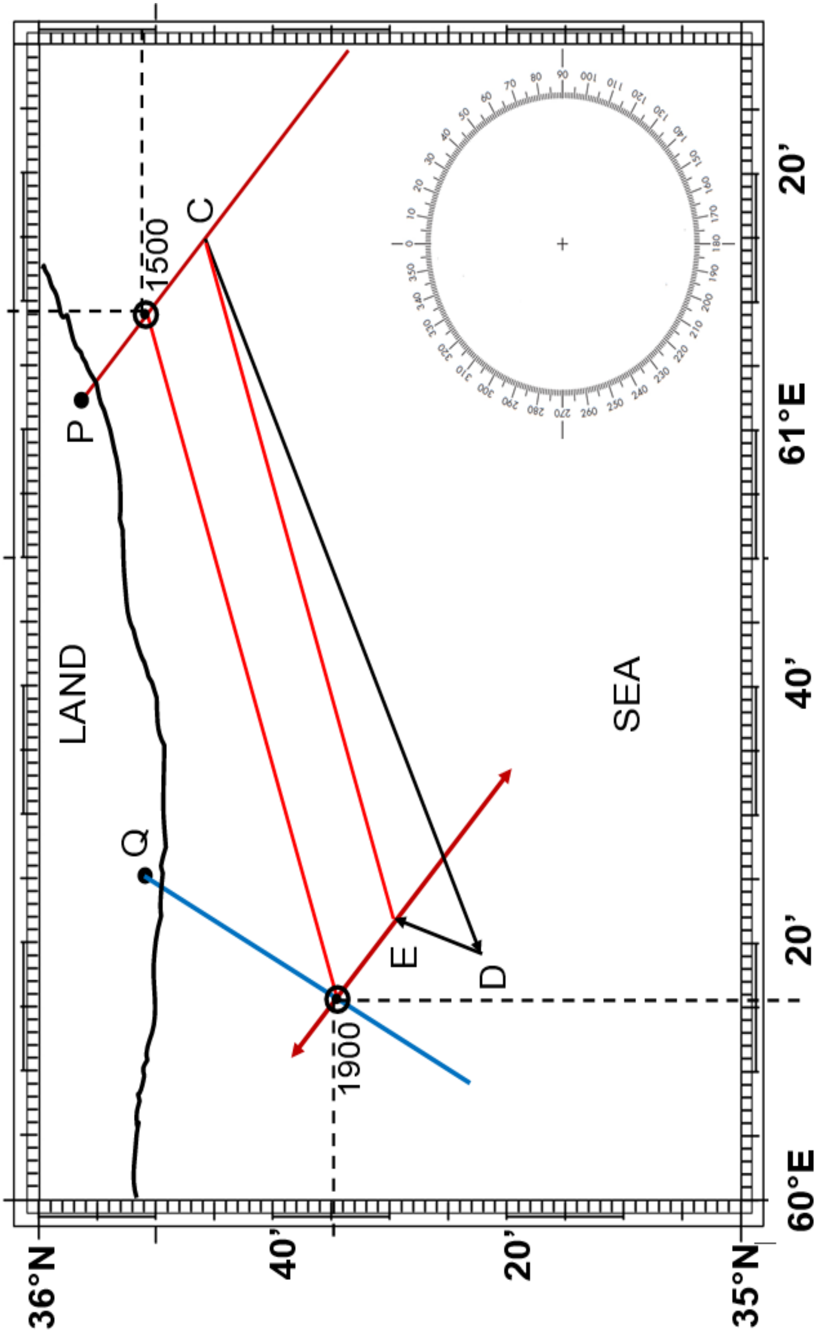
Step 1: Draw the two LOPs

Draw the given bearings of 310°(T) and 030°(T) through P and Q.

Step 2: Plot position to transfer 1st LOP

From any point on C (first LOP), draw the course of 247°(T) at 15 knots for fou hours to point D and thence the set and drift of current for four hours – 020°(T) at two knots to point E.

Diagram 46



Step 3: Obtain fix
Through point E, transfer the first LOP. The point of intersection of the transferred LOP and the second LOP is the fix at 1900. Read off its latitude and longitude.

In this case, lat 35° 35.0'N long 60° 15.5'E.

Step 4: Obtain CMG and SMG
The line CE represents the CDMG– 253°(T) 54.6 NM– that is 13.6 knots in this case.

Step 5: Obtain the earlier fix
From the 1900 fix, draw the CMG backwards to the first LOP. The point of intersection is the fix at 1500. In this case lat 35° 51.0'N long 61° 09.0'E.

Step 6: Compute the values
1900 position: lat 35° 35.0'N long 60° 15.5'E
1500 position: lat 35° 51.0'N long 61° 09.0'E
CMG: 253°(T): SMG: 13.6 knots.

DOUBLING THE ANGLE ON THE BOW

When passing a single charted object, where there is no other means to obtain another LOP to fix the position of the ship, doubling the angle on the bow can give us the ship's position.

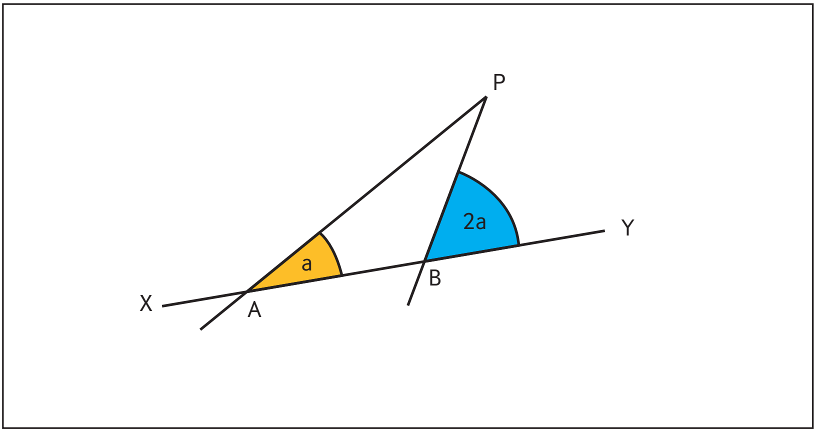
Procedure

On a steady course, when there is no current or leeway, a relative bearing of the single charted object is taken, and the time and log reading is noted. For this example, it is assumed that the first bearing is 30° on the port bow. The bearing of the object is continually watched and when it is double that of the first observation, 60° in this case, the time and the log are noted after reading. The distance run between the two observations is the distance off the object at the second observation.

Geometric proof

The geometric proof of doubling the angle on the bow is as follows:

Diagram 47



In diagram 47, P is the single charted object and direction XY is the course steered.

PA is the LOP when the quadrantal relative bearing was first observed, its value being 'a'.

B is the LOP when the bearing was observed to double, its value being '2a'.

Exterior angle PBY = interior opposite angle PAB + interior opposite angle APB

Or 2a = a + angle APB, or angle APB = a.

Since angle PAB = angle APB = 'a', triangle PAB is an isosceles triangle, wherein BA = BP.

Hence the distance off at the second observation is mathematically the distance run between the two observations.

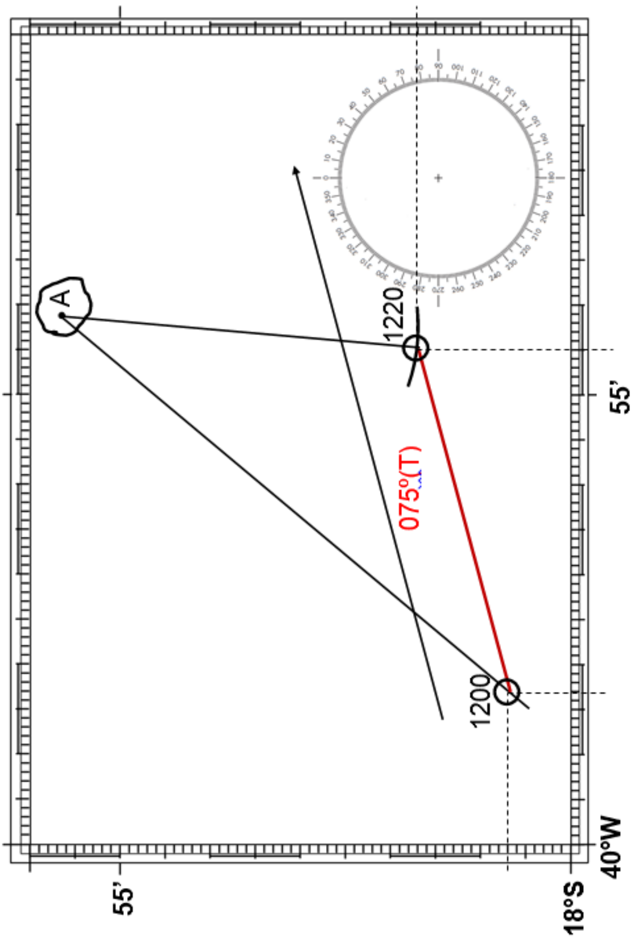
Approximations

It is assumed that the course and distance from A to B is known; however this may not be the case. There may be some current meaning the direction and rate is not known. Hence the accuracy of the position obtained cannot be relied up on implicitly.

Example of doubling the angle on the bow

Refer to diagram 48. While on a steady course of 075°(T) lighthouse A bore 35° on the port bow at 1200 ship's time. At 1220, the bearing doubled to 70°. If the ship's speed is 12 knots, find the position of the ship at 1220. Also find the position at 1200.

Diagram 48



Step 1:
Draw a line representing the course of 075^{o}(T) on the chart and write 075^{o}(T) next to it.

Step 2:
Draw the 1600 LOP, 35^{o} on the port bow = 040^{o}(T).

Step 3:
Draw the 1620 LOP, 70^{o} on the port bow = 005^{o}(T).

Step 4:
Calculate the distance steamed between the LOPs – 20 minutes at 12 knots which is 4 NM in this case.

Step 5:
With point A as a centre and radius 4 NM, draw an arc to intersect the 1220 LOP.

Step 6:
Identify the position of the ship on the chart and write down the time 1220 next to it.

Step 7:
Read off the position at 1220; Lat 17° 58.3'S Long 39° 54.5'W.

Step 8:
From the 1220 position, draw the course backwards to intersect the 1600 LOP.

Step 9:
Identify the position of the ship on the chart and write down the time 1200 next to it.

Step 10:
Read off the position at 1200; Lat 17° 59.3'S Long 39° 58.3'W.

Step 11:
Verify that the distance between the two positions on the chart is 4 NM. If this is not the case, then the working needs to be checked for errors.

USE OF A SINGLE LOP

A single LOP may have to be used in rare cases, such as restricted visibility, where only a reliable LOP is available but not a fix. It will then be required to arrive at a point safely based on this single LOP.

Example of the use of a single LOP

Refer to diagram 49. At 0400 hours, the ship is in DR position X in thick fog. A reliable single LOP 152°-332°(T) passing through position N near the DR is known. The GPS is malfunctioning and there are no radar-conspicuous objects in the vicinity. State the course and directions that should be followed to arrive at point P.

Step 1: Plot the data on chart

Plot the DR position X, draw the LOP through position N and call it AB.

Step 2: Transfer LOP

Draw the LOP through point P and call it PC.

Step 3: Draw perpendicular

From N, draw a perpendicular to PC and call it NO.

Step 4: Identify the first course and distance

The first course and distance to steam is the line NO. Measure off course and distance – 062°(T) 2.9 NM in this case.

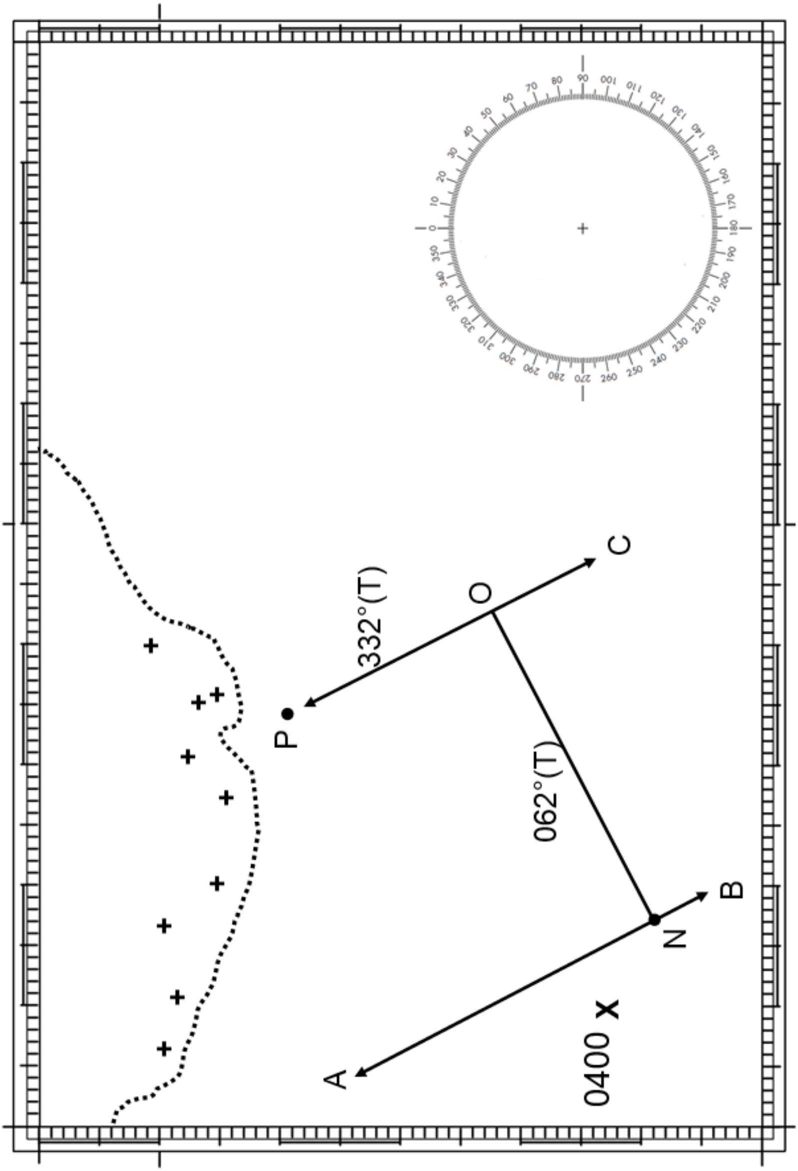
Step 5: Identify the second course

On arrival at O, alter course to OP. In this case, the course is 332°(T). The distance on this course is not known as it is unknown where on PC the ship is.

Step 6: Re-check

On the chart, re-check that the courses are safe and that there are no other dangers en route. If unsafe, then the course must be rectified.

Diagram 49



The rationale behind this procedure

The ship's position is not known; however it is known that the ship is somewhere on the LOP AB. By proceeding along the perpendicular to AB, it is logical that the ship would reach PC. Hence the ship's position is now somewhere on PC.

If the ship sails on OP, it is logical that point P will be reached. However, although the distance along this second course is not known, the ship would evidently arrive there.

The limitations of this procedure

In this procedure it is assumed that there is no current. Even if the current is known, in actual practice its value is only estimated.

If there are any dangers along the line NO, it may be prudent to sail first on course NB 152°(T) until the dangers have been safely passed and then on 062°(T) for 2.9 NM and finally 332°(T) to P.

CAUTIONARY NOTES

We trust that the contents of this book have helped to raise the navigator's awareness to coastal navigation. However we would like to emphasise that great caution is necessary whilst navigating a ship. The following points should be borne in mind:

- In actual practice, fixing position by two LOPs is not sufficient. An error in any one of them would result in an erroneous position. The error could be the result of several causes, such as the wrong identification of a charted object, the wrong reading of the compass card or an inaccurate compass error. A third LOP confirming the position obtained would be ideal.
- The position obtained should tally with the most recent fix obtained, ideally less than one hour previously – the course and speed made good should appear to be reasonable for consideration. Groundings have occurred in the past when the OOW plotted a position by visual bearings and neglected to compare this with the earlier progress. Had he noticed that his recent position, compared with the previous position, indicated a speed of 18 knots when his ship's speed should have been only 12 knots he would have been alerted of the error (diagrams 50 and 51).
- The position obtained should be checked by all available means – GPS, radar and soundings.
- Whenever something does not seem correct – e.g. position, course, speed, charted objects in sight, movement of other ships – the OOW should inform the Master immediately.

- The latitude and longitude of places on a chart depend on what mathematical shape is used to represent the earth (a roughly ellipsoidal, three-dimensional surface) on a chart or map (a flat, two-dimensional surface). Different shapes are used for mapping different areas of the world. Each shape, known as a reference ellipsoid, can be identified by its datum or origin. Satellite systems use a datum called WGS 84 (World Geodetic System introduced in 1984). In due course, all charts will also be based on WGS 84. In the meantime, it may often happen that the Geodetic System on which the chart has been constructed may be slightly different. In such cases, a note is given under the title of the chart stating the offset to be applied.
- For example, one such note may say: 'Satellite-derived positions: Positions derived from satellite systems based on WGS 84 can be plotted directly on this chart but such positions should be shifted 215°(T) by 0.8 miles to agree with this chart.' Diagram 52 depicts this chart. At 2200 hours the latitude and longitude by GPS indicates the ship in position A but after applying the datum correction the ship is actually at position B and heading towards shoals.

Diagram 50

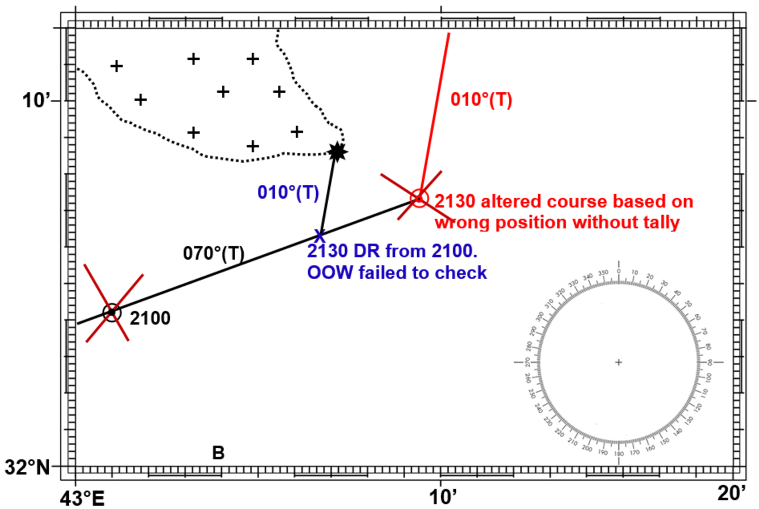
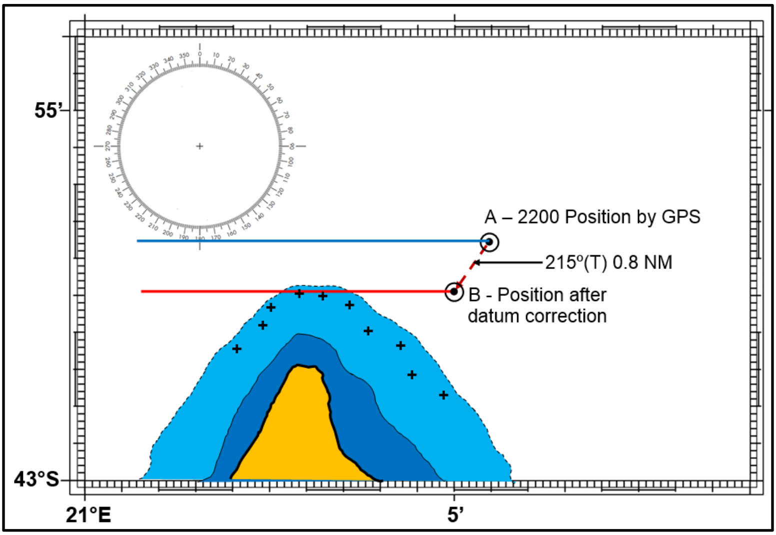


Diagram 51

Diagram 52



Annex

Case Study: Caution while using a TSS

THE INCIDENT

This claim involved a collision between a fishing vessel and a 17,000 GT product tanker. The Member's vessel, a stern trawler, was proceeding to her intended fishing grounds, which required her to cross a TSS. The Member's vessel contravened Rule 10c of the COLREGS by not crossing the traffic lane at right angles. The Master had left the wheelhouse and an inexperienced 17-year-old deckhand was alone on watch. A radar target was noted approximately three miles on the starboard bow, and after making a visual check, the watchkeeper made the assumption that the vessel would pass clear to starboard. Having made this assessment the watchkeeper paid no further attention to his lookout duties. More than one vessel was in fact within the immediate vicinity and the fishing vessel collided with another ship shortly afterwards. The watchkeeper realised a collision was to take place seconds before it actually occurred. He put the wheel over, but as he had not disconnected the auto pilot there was no response. Fortunately there was no loss of life, but each vessel sustained heavy damage.

OBSERVATIONS

The Member's vessel failed to navigate as required by COLREGS and should have crossed the TSS at right angles. The crew failed to maintain a proper lookout and this was compounded by the fact that an inexperienced crew member was left in charge of the watch while transiting an area of heavy traffic. Having noted a radar target on the starboard bow and made an initial assessment no further observations were made until it was too late. The importance of maintaining a proper lookout cannot be overemphasised nor can the need to monitor all vessels closely when navigating in busy waterways. Consideration should always be given to 'doubling up' watches in these circumstances.

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