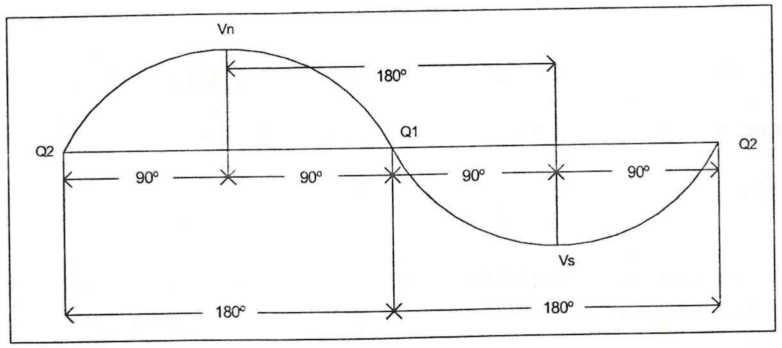
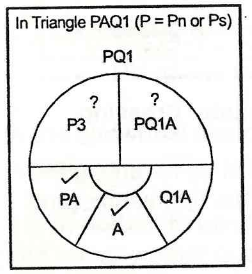


Figure 3.18 - Great Circle Vertices and Equator Crossing

3.5.5.1 Longitude of Equator Crossing

If the vertex is not required, the longitude can be determined directly. In triangle PAQ1 in Figure 3.16, PA is known and so is the initial course angle A. In this case a side of 90° is being used with Napier's Rules. The result may have to be taken off from 180° in order to obtain the correct meridian East or West of position A (see Example 3.12). Note that course A is an exterior angle. In a case where course A is the interior angle of the triangle (where crossing point lays on the track between A and B, see Example 3.11), a minus (-) should be applied to the right hand side of the equation. The angle (P3) so obtained is the d.long between A and Q1 and the direction is always from A to Q1.

Using Napier's Rule: sin mid part = product of tan of adjacent parts



sin (co – PA) = (-) tan P3 x tan (Co - A)
cos PA = (-) tan P3 x cot A
tan P3 = (-) cos PA ÷ cot A
tan P3 = (-) sin lat A x tan A

tan d.long P3	=	(-) sin lat A x tan A

d.long APQ1 = P3 should be applied to longitude of A to obtain longitude where the Great Circle track crosses the equator.

3.5.5.2 Course at Equator Crossing

If the vertex is known, this course is 90° minus the latitude of vertex. Take care when naming the course so that it is in the correct direction of progress of track. For example, when crossing from N to S with E d.long, course = S xx° E.

However, if the vertex is not required, the course can be determined directly. In triangle PAQ1, PA is known and so is the initial course angle A.

Using Napier's Rule: sin mid part = product of cos of opposite parts

sin PQ1A = cos (co - PA) x cos (co - A)
sin PQ1A = cos lat A x sin A

sin PQ1A	=	cos lat A	x	sin A

3.5.6 Latitude at a Meridian

The Great Circle track is transferred to a Mercator chart as a series of short rhumb lines. For this reason, meridians are selected with a d.long of 5° to 10°, depending upon the speed of the ship. Latitudes are determined for these meridians using Napier's Rules.

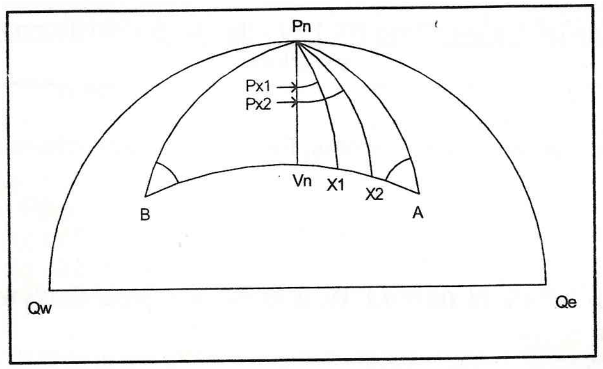
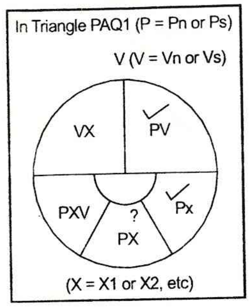


Figure 3.19 - Great Circle Waypoints

In triangle PVX, PV is known (co-lat of Vertex). The second known value is d.long between longitude of the vertex and the longitude of the meridian in question, i.e., the angle VPX = P_X. The side PX needs to be determined, which is the co-lat of the parallel at X.

Using Napier's Rule: sin mid part = product of tan of adjacent parts



sin (co - PX)	=	tan PV	x	tan (co - PX)
cos PX	=	tan PV	x	tan lat X
tan lat X	=	cos PX	x	tan lat V

tan lat X	=	cos d.longPX	x	tan lat V

This method makes use of the position of vertex.

In a particular question: if vertex is not required to be worked out, a direct formula can be used to obtain this latitude.

$$\tan \text{lat X} = \frac{(\tan \text{lat A} \times \sin \text{d'long BX}) + / - (\tan \text{lat B} \times \sin \text{d'long AX})}{\sin \text{d'long AB}}$$

For Latitudes with same names, use plus. For Latitudes with different names, use minus

Example 3.11

A ship in position 04° 45´ N, 081° 13´ W, is to follow a Great Circle track to 41° 48´ S, 176° 35´ E. Find:

- *Distance*
- *Initial and Final Courses*
- *Position of Vertex in the Southern hemisphere*
- *Longitude where GC crosses the equator*
- *Course when GC crosses the equator*
- *Latitude where GC crosses the 120° W meridian.*

A	Lat	04° 45´ N	PA	85° 15´	Long	081° 13´ W
B	Lat	41° 48´ S	PB	131° 48´	Long	176° 35´ E
					d.long (P1)	102° 12´ W

Distance

cos AB= (sin PA sin PB cos P1) + (cos PA cos PB)

= (sin 85° 15´ sin 131° 48´ cos 102° 12´) + (cos 85° 15´ cos 138° 48´)

= - 0.21219086

AB = 102.2507733 = 102 15.05 x 60 = 6135´.1

Dist = **6135´**

Initial Course

$$\cos A = \frac{\cos PB - \cos PA \cos AB}{\sin PA \sin AB}$$

= [cos 131° 48´ – (cos 85° 15´ cos 102° 15´.05)]

÷ (sin 85° 15´ sin 102° 15´.05)

= -0.666372396

A = 131°.7876982 = 131° 47´.3

Course = 132° T or S 48° W

Using A B C:

A = $\frac{\text{tan lat A}}{\text{tan d.long P1}}$ = $\frac{\tan 04° 45´}{\tan 102° 12´}$ = -0.01796547N

B = $\frac{\text{tan lat B}}{\text{sin d.long P1}}$ = $\frac{\tan 41° 48´}{\sin 102° 12´}$ = 0.914762279S

C = A ~ B = - 0.896796808 S

tan Co A = $\frac{1}{\text{C x cos lat A}}$ = $\frac{1}{0.932727749 \times \cos 4° 45´}$

= 1.118922731

= 48° 12´.7

Course = **S 48° W**

Final Course

$$\cos B = \frac{\cos PA - \cos PB \cos AB}{\sin PB \sin AB}$$

= [cos 85° 15´ – (cos 131° 48´ cos 102° 15´.05)]

÷ (sin 131° 48´ sin 102° 15´.05)

= - 0.080471926

B = 94° 36´.9 (this is the interior angle. Exterior angle = 180° - 94° 36.9)

= 85° 23´.1

Course = 274°.5 T or N 85°.5 W

Using A B C:

A = $\frac{\text{tan lat B}}{\text{tan d.long P1}}$ = $\frac{\tan 41° 48´}{\tan 102° 12´}$ = - 0.193311952N

B = $\frac{\text{tan lat A}}{\text{sin d.long P1}}$ = $\frac{\tan 04° 45´}{\sin 102° 12´}$ = 0.085013547N

C = A ~ B = - 0.108298405 N

tan Co B = $\frac{1}{\text{C x cos lat B}}$ = $\frac{1}{-0.108298404 \times \cos 41° 48´}$

= - 12.38637637

= - 85° 23´.1 (- sign indicates that it is an exterior angle)

Course = **N 85°.5 W**

Vertex

cos lat V = cos lat A x sin A

= cos 04° 45´ x sin 131°.7876982

= 0.74305834

lat VS = 42° 00´.4 S

tan P2 = $\dfrac{1}{\text{sin lat A} \times \text{tan A}}$

= $\dfrac{1}{\sin 4^\circ 45' \times \tan 131^\circ.7876982}$

= - 10.79261029

= - 84° 42´.4 (- sign indicates it is an exterior angle)

= 84° 42´.4 E

long VS = 081´ 13´ W ~ (180° – 84° 42´.4) (to apply westerly)

= **176° 30´.6 W**

Longitude at Equator crossing

tan d.long P3 = - sin lat A x tan A

= - sin 4° 45´ x tan 131°.7876982

= 0.09265599

= 5° 17´.6 W (see 3.5.5.1)

long Q1 = 081´ 13´ W ~ 5° 17´.6 W

= 086° 30´.6 W

Check from Vertex Meridian:

= 176° 30´.6 W ~ 90° **= 086° 30´.6 W**

Course at Equator crossing

sin PQA = cos lat A x sin A

= cos 4° 45´ x sin 131°.7876982

= 0.743058264

= 47° 59´.6

course = S 48° W

Check from Vertex Latitude:

= 90° ~ 42° 00´.4 S = S 47° 59´.6 W **= S 48° W**

Latitude at 120° W

d.long PX = Vertex meridian ~ 120° W

= 176° 30´.6 W ~ 120° W = 56° 30´.6

tan lat X = cos d.long PX x tan lat V

= cos 56° 30´.6 x tan 42° 00´.4

= 0.496951508

lat X = **26° 25´.5 S**

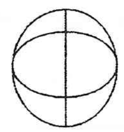
These problems can be worked out using templates that only require entry of figures into cells. These templates can also be created as computer spreadsheets.

Example 3.12

A ship has to follow a Great Circle track from 32° 54´ N, 141° 48´ E to 36° 42´ N, 120° 37´ W. Calculate the distance, initial and final courses, position of vertex and the latitude where the track crosses the 180° meridian.

Template for Great Circle Calculations

lat A	32 54 N	PA	57 06	long A	141 48 E
lat B	36 42 N	PB	53 18	long B	120 37 W
				d.long ^	097 35 E



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

Distance				
sin PA		sin	57 06	1
sin PB		sin	53 18	2
cos ^P1		cos	097 35	3
	1 x 2 x 3 = 4			-0.08883914
cos PA		cos	57 06	5
cos PB	x	cos	53 18	6
	5 x 6 = 7			0.32461471
cos AB	4 + 7			0.23577557
AB		cos⁻¹	76 21.8	
Distance	AB x 60		4581.8 =	4582

Initial Course - Using A B C method				
tan lat A		tan	32 54 N	9
tan^P₁		tan	097 35	10
A	9 + 10 = 11		N	-0.08613
tan lat B		tan	36 42 N	12
sin ^P₁		sin	097 35	13
B	12 + 13 = 14		N	0.751954
C	11 ~ 14 = 15		N	0.838081
cos lat A		cos	32 54 N	16
tan I Co	1 + (15 x 16)			-1.42112
I Course =		tan⁻¹	54 52	N 55 E

Final Course - Using A B C method				
tan lat B		tan	36 42 N	17
tan ^P₁		tan	097 35	18
A	17 + 18 = 19		N	-0.09923
tan lat A		tan	32 54 N	20
sin ^P₁	÷	sin	097 35	21
B	20 + 21 = 22		N	0.652637
C	19 ~ 22 = 23		N	0.751871
cos lat B			36 42 N	24
tan F Co	1 + (23 x 24)			1.658838
F Course =		tan⁻¹	58 55	S 59 E

Vertex				
Latitude				
cos lat *A*		cos	32 54 N	25
sin *A*	x	sin	54 52	26
cos lat *V*	25 x 26			0.68665377
Lat V =		cos⁻¹	46 38 N	
Longitude				
sin lat A		sin	32 54 N	27
tan *A*	x	tan	54 52	28
tan ^P₂	1 + (27 x 28)			1.29549773
d long^P₂		tan⁻¹	52 20.1 E	
long A			141 48 E	
Long V				165 51.9 W

Equator Crossing				
Longitude				
sin lat A			32 54 N	29
tan^*A*			54 52	30
tan d.long ^P₃	29 x 30			0.771904
d.long ^P₃		tan⁻¹	37 39.9	31
	180 - 31		142 20.1	32
long Q	long A~32		075 51.9	W
Course				
cos lat A			32 54 N	33
sin ^*A*			54 52	34
sin ^PQA	33 x 34			0.686654
PQA		sin⁻¹	43 21.9	S 43 E

Waypoint Latitudes				
long V			165 51.9	W
long of X			180	
d.long^P_X			14 08.1	
cos d.long^P_X		cos	14 08.1	35
tan lat V		tan	46 38	36
	35 x 36			1.026649
lat X		tan⁻¹	45 45.2	

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

3.6 Composite Great Circle

There are occasions when a limit is imposed on a ship, or the Master may not want to proceed to a higher latitude. In order to obtain the shortest possible distance, a composite route is followed, i.e. a combination of one or two Great Circle legs and a parallel leg.

Limits may be imposed on the maximum latitude a ship can sail due to:

- Load Lines
- C/P Clauses
- Insurance – Trading Warranties
- Crew Agreement Clauses
- Routeing advice
- Recommended route
- The need to avoid dangers
- The need to avoid unfavourable weather

The limiting latitude is the vertex of the Great Circles. Since the course at the vertex is 90°, Napier's Rules may be used to perform calculations.

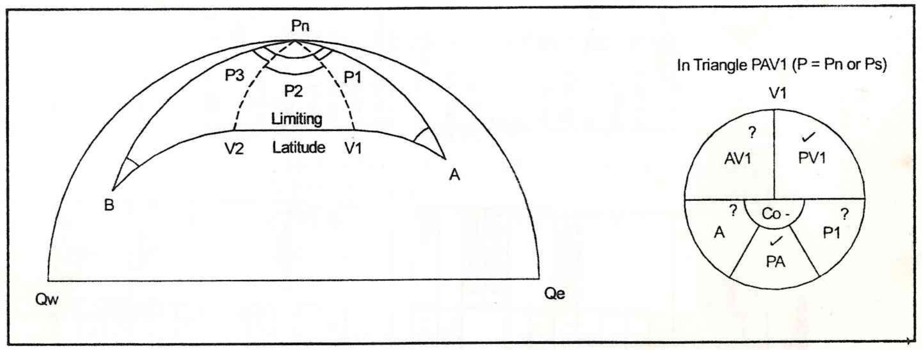


Figure 3.20 - Composite Great Circle

In triangle PAV1, sides PA and PV1 are known. Side AV1 gives the first distance, angle A the initial course and angle P1 the d.long. Remember to only work with PV1 and PA.

For distance:

Using Napier's Rule:		sin mid part = product of cos of opposite parts		
sin (co - PA)	=	cos PV1	x	cos AV1
cos AV1	=	cos PA	÷	cos PV1
cos AV1	=	sin lat A	÷	sin lat V1

$$\cos AV1 = \frac{\sin \text{lat } A}{\sin \text{lat } V1}$$

For course:

Using Napier's Rule:		sin mid part = product of cos of opposite parts		
sin PV1	=	cos (co - PA)	x	cos (co - A)
cos lat V1	=	sin PA	x	sin A
sin A	=	$\frac{\cos \text{lat } V1}{\cos \text{lat } A}$		

$$\sin A = \frac{\cos \text{lat } V1}{\cos \text{lat } A}$$

For d.long:

Using Napier's Rule:		sin mid part = product of tan of adjacent parts		
sin (co – P1)	=	tan PV1	x	tan (co - PA)
cos P1	=	cotan lat V1	x	cotan PA
cos P1	=	$\frac{\tan \text{lat } A}{\tan \text{lat } V1}$		

$$\cos P1 = \frac{\tan \text{lat } A}{\tan \text{lat } V1}$$

Readers should attempt to derive equations for triangle PBV2. In this case, the d.long would be the angle P3.

The third leg, V1V2, can be calculated using the parallel sailing formula.

d.long P2	=	d.long P – (P1 + P3)
distance V1V2 (dep)	=	d.long P2 x cos limiting lat

Total distance AB = AV1 + V1V2 + V2B

Example 3.13

Find the distance, initial course and final course along the composite Great Circle track between Cape Agulhas (34° 54´ S, 020° 01´ E), and Cape Leewin (34° 26´ S, 115° 04´ E) applying 40° S as the limiting latitude.

$\cos AV1 = \dfrac{\sin lat\ A}{\sin lat\ V1}$

= sin 34° 54´ ÷ sin 40°
= 0.890100967
= 27° 06´.8

Distance = 1626´.8

$\cos BV2 = \dfrac{\sin lat\ B}{\sin lat\ V2}$

= sin 34° 26´ ÷ sin 40°
= 0.879679276
= 28° 23´.8

Distance = 1703´.8

$\sin A = \dfrac{\cos lat\ V1}{\cos lat\ A}$

= cos 40° ÷ cos 34° 54´
= 0.934027545
= 69° 04´.3

Course = S 69° E

$\sin B = \dfrac{\cos lat\ V2}{\cos lat\ B}$

= cos 40° ÷ cos 34° 26´
= 0.928781131
= 68° 14´.7

Course = N 68° E

$\cos P1 = \dfrac{\tan lat\ A}{\tan lat\ V1}$

= tan 34° 54´ ÷ tan 40°
= 0.831378821
= 33° 45´.5 E

$\cos P3 = \dfrac{\tan lat\ B}{\tan lat\ V2}$

= tan 34° 26´ ÷ tan 40°
= 0.817029513
= 35° 12´.7 W

d.long P2	=	d.long P – (P1 + P3)
	=	95° 03´ – (33° 45´.5 + 35° 12´.7)
	=	**26° 04´.8**
distance V1V2 (dep)	=	d.long P2 x cos limiting lat
	=	(26° 04´.8 x 60) x cos 40°
	=	**1198´.7**

Total distance AB = AV1 + V1V2 + V2B

= 1626´.8 + 1198´.7 + 1703´.8 = 4529´.3

= **4529´**

3.7 Practical Applications

3.7.1 Use of Gnomonic Chart

Gnomonic charts are based upon perspective projection of the surface on to the tangent plane of the sphere. These charts are for polar-regions, high latitudes covering ocean areas and port plans.

A straight line drawn on a gnomonic chart represents a Great Circle. The meridians will not be parallel unless the tangent point of projection is on the equator. As the meridians are at an angle, rhumb lines will not appear as straight lines. Similarly angles are also distorted, except at the tangent point of the projection.

The ocean charts cover a very large area and are of a small scale. The graduations are different and need care when plotting or reading off the position. Meridians and parallels are drawn as solid lines at five degree intervals. The intersections of intermediate meridians or parallels are indicated by crosses at their junction points. Some charts have 30´ marked as dots. In Figure 3.21, the position of 36° 30´ S, 020° 15´ E has been plotted.

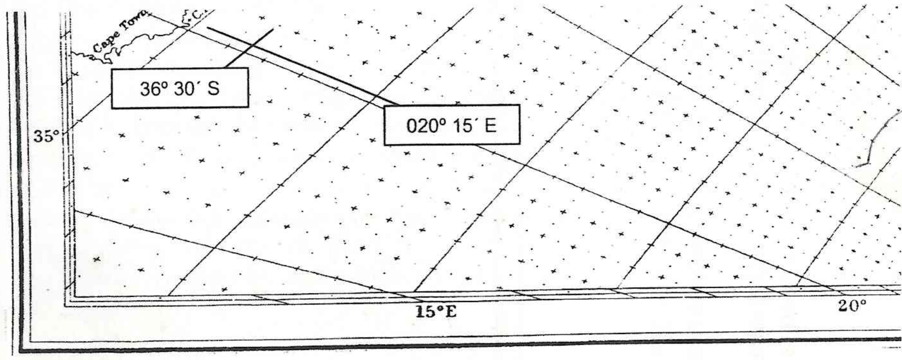
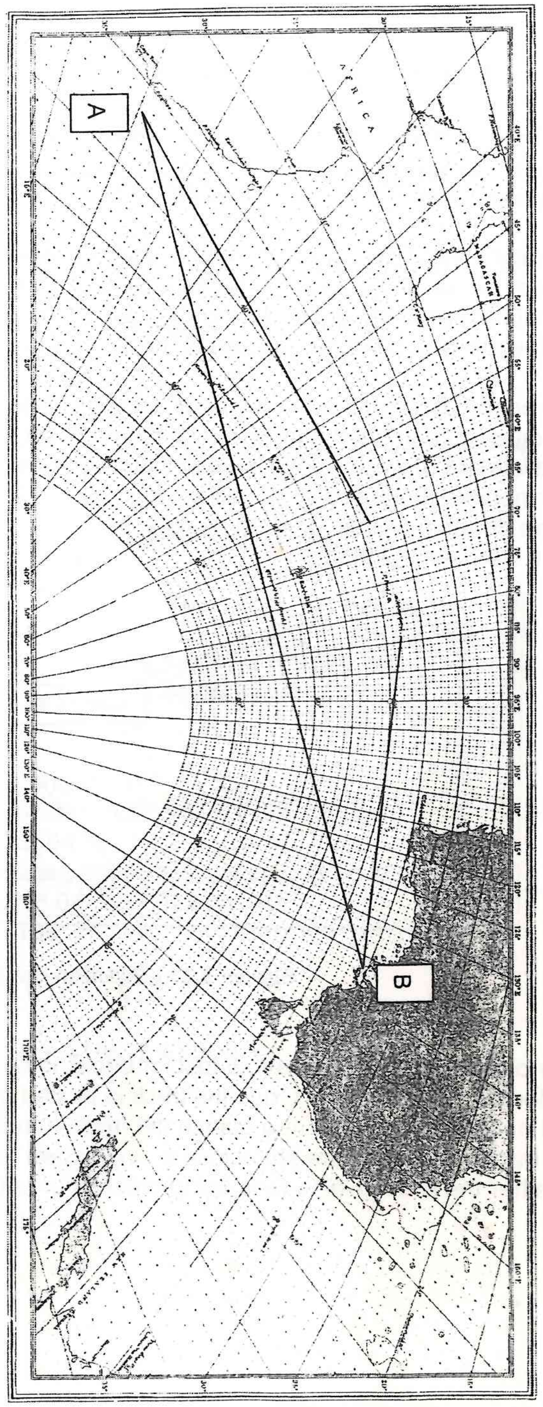


Figure 3.21 - Position on Gnomic Chart

A gnomonic chart is a valuable tool for deciding on the route to be taken without performing calculations. Once the track is plotted on a gnomonic chart, the Master and navigators can see at a glance the maximum latitude to be reached and whether the track would take the ship close to any known hazards. It can also be seen whether the limiting latitude is being crossed or not.

Figure 3.22 - Plotting of Great Circle and Composite Tracks



A great circle track from Position A: 36° 30´ S, 020° 15´ E to Position B: 35° 30´ S, 136° 30´ E is created by joining A to B with a straight line. It would be noticed that the maximum latitude reached is 54° 10´ S.

A composite great circle track between the same positions with limiting latitude of 40° S, reaches the parallel at 052° 30´ E and leaves it at 105° 30´ E. These points should only be used to make routing decisions. When

In the case of composite tracks, the points where the limiting latitude will be joined and left on a composite Great Circle track can be identified. As the scale of the charts is very small, the tangents to the limiting latitude parallel should be drawn with care. When reading the longitude in case of vertex, if it is not possible to make out the meridian, then two points where the track cuts a common parallel should be marked carefully. The longitude of these marks should be determined. The required meridian is half the d.long between these two meridians. In no case should a linear measurement be used to determine the longitude.

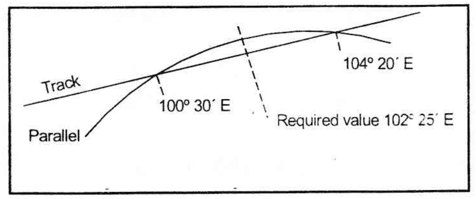


Figure 3.23 - Selecting the Required Meridian of Vertex

Once the route has been decided, the gnomonic chart can assist with plotting the selected Great Circle, or composite route, to a Mercator chart. After deciding on the d.long interval, the latitudes can be read off from the gnomonic chart. It is good practice to select the whole longitude degrees at 5° or 10° intervals and not a d.long from the start position. These waypoints can then be transferred to a Mercator chart for plotting a succession of small rhumb lines. It is very important to know the route the ship would be following, even on small scale ocean charts. It is poor practice to follow GPS bearing to the next waypoint without having any route plotted on an ocean chart. The plotting of tracks on the charts is always done after careful scan of the charts for hazards. Similarly, the practice of using Mercator plotting sheets for position fixing on ocean passages, instead of the navigational chart, should never be allowed.

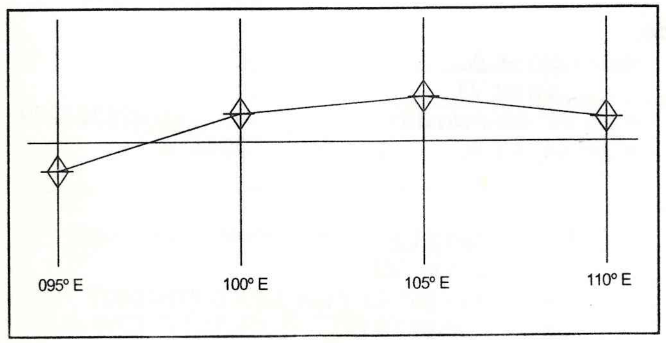


Figure 3.24 - Waypoints on Mercator Chart for Plotting Rhumb lines

3.7.2 Modifying the Routes

It may be necessary to modify the recommended route in order to comply with over-riding operational conditions.

Example 3.14

A ship is on a voyage from Brisbane (Australia) to Valparaiso (Chile). The Master wishes to take advantage of the shortest possible route without contravening Load Line Rules. The ship is loaded to the Summer marks. 245 tonnes of fuel and water must be consumed, before the ship can enter the Winter zone at 33°S. The ship has a service speed of 16 knots and consumes 25 tonnes of fuel and water per day.

Departure position	*26° 49′ S*	*153° 10′ E*
Landfall position	*33° 00′ S*	*071° 37′ W*

Calculate the shortest legal distance for the voyage.

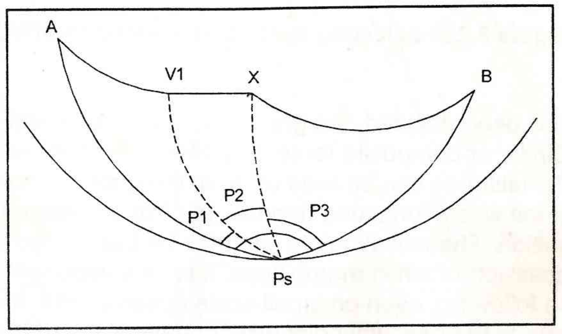


Figure 3.25 - Sketch for use with Example 3.14

Time required to consume 245 tonnes = 245 / 25 = 9.8 days
Distance to be travelled in this time = 9.8 x 24 x 16 = 3763′.2

For distance:

cos AV1 = $\dfrac{\text{sin lat A}}{\text{sin lat V1}}$

cos AV1 = sin 26° 49′ / sin 33° = 0.828323229
AV1 = 34° 04′.4 x 60 = 2044′.4

For d.long:

cos P1 = $\dfrac{\text{tan lat A}}{\text{tan lat V1}}$

cos P1 = tan 26° 49′ / tan 33° = 0.77840407
P1 = 38° 53′.1 E

Remaining distance to sail along parallel of 33° S = 3763′.2 – 2044′.4
= 1718.8

d.long (P2) = dep / cos lat = 1718′.8 / cos 33° = 2049′.4 = 34° 09′.4 E

long X = long A ~ (P1 + P2) = 153° 10′ E ~ (38° 53′.1 + 34° 09′.4)
= 226° 12′.5 – 360° =133° 47′.5 W

PX = 90° – 33° 00′ = 57°
PB = 90° – 33° 00′ = 57°
P3 = 133° 47′.5 W ~ 71° 37′ W = 62° 10′.5

cos XB = (cos P3 x sin PX x sin PB) + (cos PX x cos PB)
= 0.624944715
XB = 51° 19′.3 x 60 = 3079′.3

Distance = 3763′.2 + 3079′.3 = 6842′.5

Answer = **6843′**

Note: The landfall position latitude and the limiting latitude are the same. Some individuals make the mistake of continuing to proceed along the parallel of latitude. Remember that parallel is not a Great Circle, therefore it is not short. However, if this question involved limiting latitude other than for Load Line reasons, the only choice would have been to proceed along the parallel after the first composite Great Circle leg.

Example 3.15

A ship has to undertake a passage from Cape Town (33° 53′ S, 018° 26′ E) to Adelaide, South Australia (34° 38′ S, 138° 23′ E), through the South Indian Ocean during the month of January. The C/P limits the ship from crossing the parallel of 40 S. Identify the route to be followed from the extract of Ocean Passages and calculate the distance on the route, complying with CP instructions.

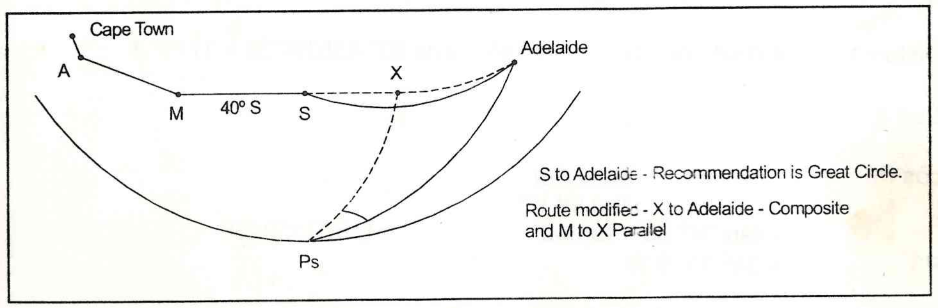


Figure 3.26 - Sketch for use with Example 3.15

The ship proceeds to WPT A (36° 45′ S, 019° 00′ E) and then to WPT M (40° 00′ S, 055° 00′ E) following rhumb lines. From waypoint M, the ship proceeds along the parallel of 40° S up to the point where it can follow the last leg as a composite Great Circle.

Note: Since the ship cannot cross 40° S parallel, WPT S is not really material. It would be appropriate to determine a new point from where to commence the final composite Great Circle leg. Once this new point is known, the d.long between WPT M and this new point can be used to determine the parallel distance. A sketch of the potential problem could avoid unnecessary steps.

Leg 1

Cape Town		33° 53´ S		018° 26´ E
WPT A		36° 45´ S		019° 00´ E
	d.lat	02° 52´ S, 172´	d.long	000° 34´ E 34´

Mean lat = 33° 53´ S + ½ (02° 52´) = 35° 19´ S

dep = d.long x cos Mean lat = 34 x cos 35° 19´ = 27´.74

tan co = dep / d.lat = 27´.74 / 172´ = 0.161296289
Co = S 9°.162680246 E

Distance = d.lat / cos co = 172´ / cos 9°.162680246 = **174.2**

Leg 2

WPT A		36° 45´ S	MP 2359.87		019° 00´ E
WPT M		40° 00´ S	MP 2607.64		055° 00´ E
	d.lat	03° 15´ S (195´)	DMP 247.77	d.long	036° 00´ E (2160´)

tan co = d.long / DMP = 2160´ / 247.77 = 8.717762441
Co = S 83°.45629729 E

Distance = d.lat / cos co = 195´ / cos 83°.45629729 = **1711´.1**

Leg 3

cos P3 = $\frac{\text{tan lat B}}{\text{tan lat V2}}$
= tan 34° 38´ / tan 40° = 0.823159436
P3 = 34° 35´.9 W

Long of point = 138° 23´ E ~ 34° 35´.9 W = 103° 47´.1 E

d.long leg 3 = 103° 47´.1 E ~ 055° 00´ E = 48° 47´.1 (x 60) = 2927´.1

Distance (dep) = d.long x cos lat = 2927´.1 x cos 40° = **2242´.3**

Leg 4

cos BV2 = $\frac{\text{sin lat B}}{\text{sin lat V2}}$
= sin 34° 38´ / sin 40° = 0.884152901

BV2 = 27°.85254331 (x 60) = 1671´.2 Distance = 1671´.2

Total distance = 174´.2 + 1711´.1 + 2242´.3 + 1671´.2 = 5798´.8 = **5799´**

Authors Note:

This chapter has covered the calculations involved in sailings, along with few practical hints. It is very important to practice these and learn the calculations. The results of calculations and plotting are an essential element of the planning of the route.

4 Ocean Routeing

Ocean routeing is a part of passage planning but, since it is more complex, it demands special consideration. For an ocean passage the entire expanse of the ocean lies in front of the mariner. There are climactic patterns as well as day-to-day changes in the weather. There are ocean currents and wind-driven currents, navigational hazards and there is the distance. All of these and other factors need to be considered when an ocean route has to be selected.

4.1 Use of Charts and Publications

Since both climatic patterns and ocean current circulation are uniform for most of the time, we can follow general recommendations for ocean routeing. A number of charts, publications and associated materials can be specifically used for the ocean route.

4.1.1 Ocean Passages for the World

Ocean Passages of the World is published by the UKHO and contains information on planning ocean passages, oceanography and currents. It provides recommended routes and distances between the principal ports of the world, which are shown as diagrams and chartlets for power vessels and sailing ships. Power vessels are divided into two categories:

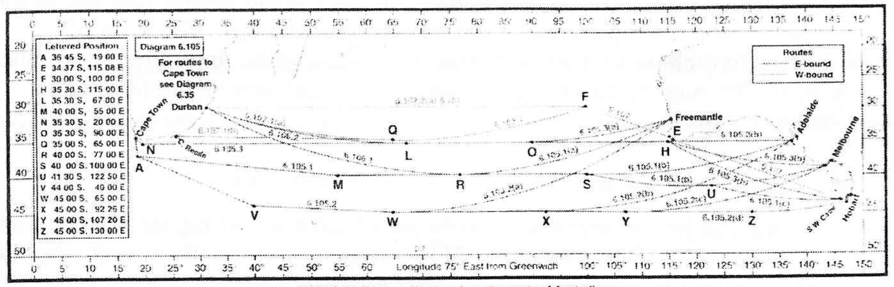
Full powered	Able to maintain a sea-going speed above 15 knots.
Low powered	Having a sea-going speed of not more than 15 knots

Generally, the routes are for power vessels of a moderate draught, using a value of 12m. The routes for low-powered vessels are also shown where appropriate. Routes for sailing vessels should also be referred to when considering routes for low powered vessels.

Routes are given reference numbers and are based upon principal ports and selected waypoints. Distances are provided with a reasonable level of accuracy. Details of winds, weather, currents, ice and other hazards that may be encountered are included. Some of this information is in chart format.

There are areas where routes are different on the eastbound and westbound directions. Similarly, there are different choices available for routes in the same direction, between same ports or waypoints.

In Figure 4.1, a chartlet (diagram 6.105 on page 132) from Ocean Passages of the World has been reproduced. This diagram shows the eastbound routes as 6.105 and 6.106 and a number of derivatives of these routes for example, 6.105.1, 6.105.1(a), 6.105.1(b). Route 6.107 and its variations are the westbound routes between same ports.



6.105 Cape Town → West and south coasts of Australia
6.106 Durban → West and south coasts of Australia
6.107 West and south coasts of Australia → Durban and Cape Town

Figure 4.1 - Chartlet from Ocean Passages of the World

The routes are between Cape Town and the ports on the West and South coast of Australia. The reasons for the choices are:

6.105.1
Going across the Agulhas current takes advantage of the east-going Southern Ocean current and westerly winds, yet keeps the vessel out of the influence of the extreme winds South of 40ºS. It will be Summer Zone from 16 Oct to 15 Apr, otherwise it is mainly through Winter Zone. Example 3.15 in Chapter 3 was based on this route, but with a changed Zone.

6.105.2
Going across the Agulhas current is the shortest route, but it takes the vessel into boisterous winds to the South. The route takes advantage of the east-going Southern Ocean current and the westerly winds.

6.105.3
The longest route of all in 6.105 range. Initially, against the Agulhas current and not taking good advantage of the east-going Southern Ocean current and westerly winds. But it avoids the strong winds and associated heavy seas of the Southern Ocean. Regardless of the time of year, it is within the Summer Zone.

6.107
A long Westbound route that avoids the east-going Southern Ocean current and westerly winds. This route keeps the vessel out of the influence of the extreme winds and associated heavy seas and also keeps it well within the Summer Load Line Zone. For Cape Town, it takes full advantage of the Agulhas current when on the coast.

4.1.2 Charts

4.1.2.1 Routeing Charts

These are provided by the BA for five areas covering the oceans of the world. Some other Hydrographic services provide their own ocean routeing charts.

A chart is provided for each month of the year for each of the areas. The title of the chart, boundaries and inset plans indicate the area of coverage. The date of publication is at the bottom and the last minor-correction date and other information is at the bottom left, outside the margin. A key of symbols and instructions are provided on the chart.

There are a number of inset windows that provide information:

- Percentage frequency of wind at Beaufort force 7 and higher is enclosed by green contours. Some selected TRS tracks for the month in past years are indicated by red arrows
- The frequency of low visibility percentage of less than 5 nm in green contours, and the percentage frequency of fog with visibility of less than 0.5 nm in red contours
- Mean air temperature °F in green contours and mean air pressure mb in red contours
- Mean sea temperature °F in green contours and Dew point temperature °F in red contours.

Shipping routes and distances are indicated as solid lines with arrows pointing in the direction of route. A single arrow indicates that the route should be used one way TO, and arrows in both directions indicate that it can be used in both directions, TO and FROM. A straight line indicates a rhumb line route and a curved line indicates a Great Circle route. Distances are stated between ports or waypoints.

Load Line zone boundaries are shown with:

- Effective dates
- Parallels of latitude and meridian values
- Latitude and longitude values at the change in boundary direction.

Zones are colour-coded: [Tropical-Green] [Summer-Pink] [Winter-Blue]

Date line information is provided on Pacific Ocean charts only.

Ocean currents are shown as green arrows in the direction of predominant ocean currents. The rates are stated at the tail of the arrow. > ½ indicates that the rate is over half a knot but less than 1 knot. < ½ indicates the rate is less than half a knot.

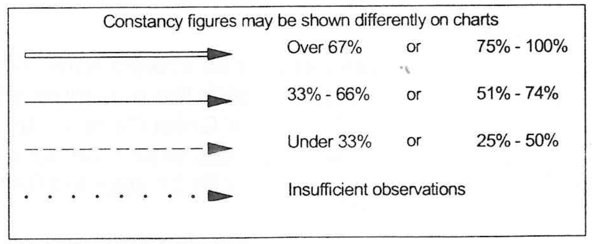


Figure 4.2 - Predominant Current Arrows on Routeing Charts

Extreme iceberg limits and Maximum pack ice limits are shown in red.

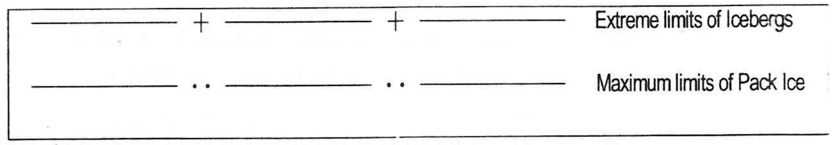


Figure 4.3 - Iceberg and Pack Ice Limits on Routeing Charts

Wind information is in red and is presented in a wind rose format (See Figure 4.4), generally at 5° of latitude and longitude, with more on some coastal regions. The frequency is shown on a scale on the charts, which is 2 inches to 100%. Wind strength is indicated by length of the arrow. From the arrow head to the circle, the frequency is 5%.

The direction of wind is indicated by the direction of the arrow. Arrows fly with the wind. The thickness and style of the arrow indicates the force of the wind.

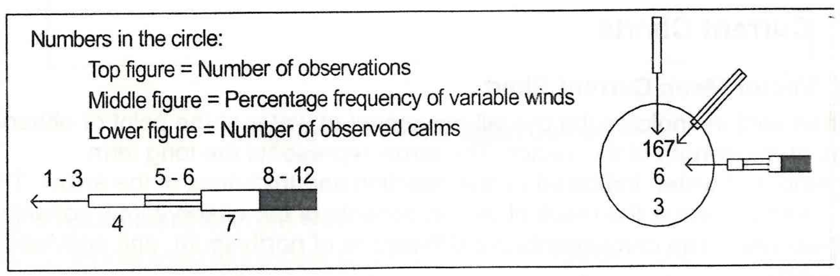


Figure 4.4 - Wind Rose with Wind Force Arrow

4.1.2.2 Gnomonic Charts

On Gnomonic charts, Great Circle tracks appear as straight lines. When plotting Great Circle tracks, these can be used to determine the maximum latitude to be reached and the proximity to hazards. Composite Great Circle routes can also be plotted to obtain a general idea about the longitudes where the track joins and leaves the limiting latitude. In both the cases waypoints can be selected for transfer to Mercator charts.

4.1.2.3 Ocean Charts

These are the 4000 Series of charts that cover the oceans' areas. The Catalogue of Admiralty Charts and Publications can be used to select the appropriate ocean charts. The charts are based upon limited information and may not contain every hazard. But the known hazards, such as islands and rocks, are included. Scan the chart carefully before plotting a course on an ocean chart.

Authors Note:

When crossing the oceans, it is important to plot courses on the charts as it allows the chart to be scanned for hazards. It is poor practice to steer to a GPS waypoint without having a course on an ocean chart.

Limit the use of Mercator plotting sheets to navigation-related plots. They are not for plotting positions or courses.

4.1.2.4 Load Line Zone Chart

These provide the limits of the International Load Line Zones. Where used with gnomonic and ocean charts, they allow the planning of a legal passage that complies with load line zones. The dates of seasonal zones must be checked carefully. A copy of the load line zone chart is included in the Ocean Passages of the World and the boundaries are shown on routeing charts as well.

4.1.3 Current Charts

4.1.3.1 Vector Mean Current Chart

The mean vectors indicate the overall movement of water at the point of observation, which is at mid-length of the vector. The arrow represents the long term displacement of water, indicated by the direction and thickness of the arrow. The vector mean current is the result of all components of the observations considered for a given area. The components are differences of north/south, and east/west movements.

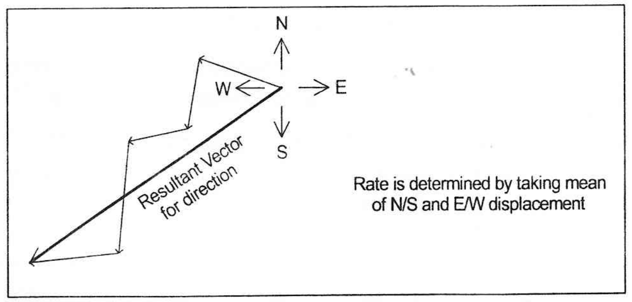


Figure 4.5 - Resultant Direction

The charts are used to indicate general circulation. In addition, they can be:

- Used to find the average drift of objects over a long period of time:
  - Drifting ships or other derelicts
  - Survival craft for search and rescue purposes
  - Iceberg movement.
- They are also used to find the overall movement of water over a given period for example, the speed of a current in miles-per-day.

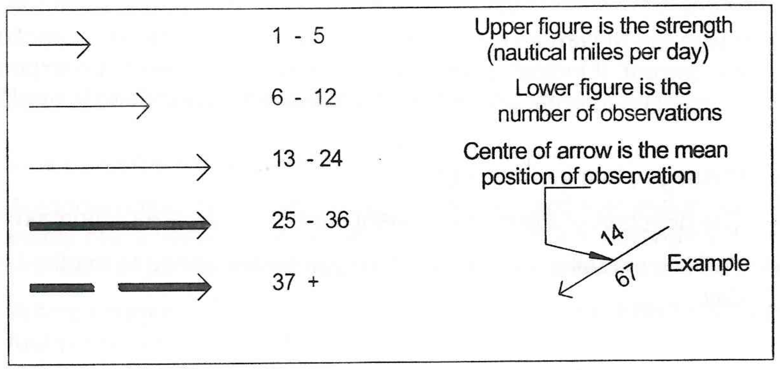


Figure 4.6 - Vector Mean Current

4.1.3.2 Predominant Current Chart

This is the format used to indicate currents on ocean routeing charts. The arrow points in the appropriate direction and the main body of the arrow indicates the change in direction in that locality. The rate may be indicated at the tail, either as a whole figure (or as a fraction).

The constancy is represented by the thickness of the arrow.

- High constancy is when a large percentage (over 75% or 67%) of observations confirm the water movement in the indicated direction
- Low constancy, where a small percentage (less than 50% or 33%) of observations confirm water movement in the indicated direction, shows a variability in rate and direction.

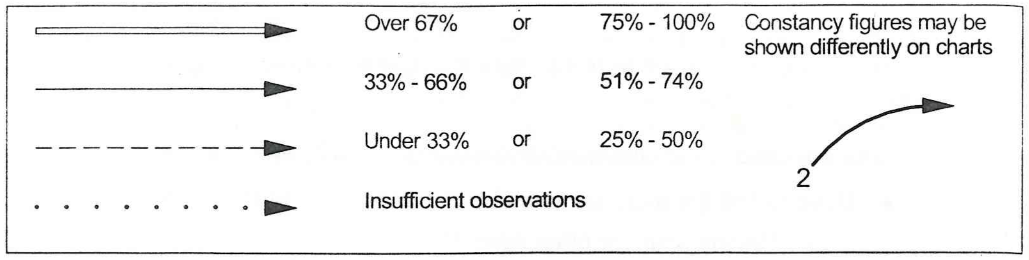


Figure 4.7 - Predominant Current Arrows

The predominant direction is established by examining the number of occasions the current sets within a 90° sector of compass, say between north to east. The sector is rotated by 15° so that data of a total of 24 sectors is available.

The sector with the maximum number of observations provides the direction of the predominant current. It indicates the current that is most likely to be experienced at a point of expressed interest and will be most useful to navigators. It would be used for:

- Passage planning/routeing
- The direction of the most-frequent currents in an area (approximate only)
- The current values in knots, which can be converted to nautical miles-per-day.

4.1.3.3 Current Rose Chart

These charts provide data on the variation of ocean currents at the point of observation or interest. The information is presented in the form of a current rose. It is based on all observations recorded at 0.5 knots or more.

The data is presented in 16 divisions of the compass and may present either amalgamated or further sub-divided directions.

The length of the arrow is determined by calculating an average rate based upon the percentage frequency of all observed figures in that direction.

For passage planning and routeing purposes, these are used to determine the variation likely to be experienced in the currents in a given locality.

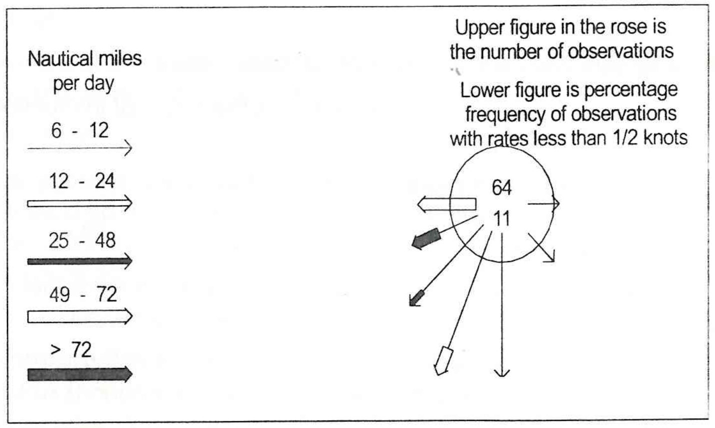


Figure 4.8 - Current Rose with Current Rate Arrows

4.2 Choice Of Routes

Safety is the most important consideration in routeing. However, in addition to safety, a number of other factors need to be considered. In particular, there are the economic and commercial constraints. The ship and her cargo are expensive property and there is a need to avoid a poor insurance claim record and liability claims.

4.2.1 Operator Considerations

The company concerns can be summarised as:

- A good-weather route can help to avoid wear and tear and ensure the safety of the vessel. This will also reduce the risk of damage to the ship and her cargo. Maintenance costs and insurance claims will be minimised
- Where engines run at optimum cost effective speed, a route that minimises fuel consumption is economical
- Passenger comfort is important and this is only possible if the route avoids heavy weather
- A ship can only proceed to ice areas where strength and classification allow it
- Due to commercial considerations, the owners will generally want to spend the least time on passage, which requires the ship's speed on passage to be the maximum. However, berth availability, weather conditions (i.e. fog or heavy seas) and fuel consumption may determine a more optimum speed
- The reputation of owners or operators may be affected if an incident attracts adverse publicity.

4.2.1.1 Commercial Questions

Commercial managers work within a number of parameters:

- The company policy on routeing, which is the basis of instructions to the ship
- Freight against fuel and running costs 1: The passage of the ship through different load line zones? How much extra cargo can be lifted if the vessel needs to follow a longer passage to keep within a desired zone?
- Freight against fuel and running costs 2: How much extra fuel is going to be consumed to achieve comfort on a longer fair-weather route?
- C/P: can the ship proceed at the agreed speed as determined by the C/P and can the ship reach port within Laytime Cancellation (LAYCAN)?
- Expert advice: what are costs and benefits of shore routeing?
- Damage or delay: will the cost of insurance claims or repair bills on a least-time route exceed the claims for a delay on a fair weather route?

4.2.2 Master's Considerations

The Master can select from a choice of ocean routes. These routes may be based on constant or variable factors.

4.2.2.1 Constant Factors

- Displacement of the ship
- Draught of the ship
- Engine power of the ship
- Ports to be called at
- Least depth/shallow water along the route
- Hazards along the route
- Land, islands or reefs along the route
- Load Line zones
- Tidal heights and times
- Currents of the ocean
- Climatic conditions
- Ice limits
- Cargo and/or passenger care requirements/instructions.

4.2.2.2 Variable Factors

- Present and forecast weather, which affects (or may affect) the sea state and the swell may require a reduction of the speed or may cause damage
- Effects of reduced visibility on speed of progress (safe speed)
- Navigational warnings or reports
- War zones
- Piracy attacks or other hostile activities

4.2.2.3 Shipboard Routeing

The Master can choose a route from the shortest, quickest, at a constant speed or based upon weather. Information on the weather being experienced will also dictate routeing. A route may be an optimum route based upon favourable current, distance and climatic conditions. The weather forecasts can be used to strategically modify the route further, reducing the risk of damage to the ship and her cargo.

4.2.2.4 Facsimile Charts

The facsimile receiver can provide the ship with significant weather-related information that can be used for routeing decisions. These are the common types of facsimile charts that are transmitted for the use of ships:

- Surface Weather Analysis is a synoptic chart that provides weather patterns for a specific time, based upon observations made a few hours before transmission
- Surface Weather Prognosis is a 24 or 36 hour outlook of expected future weather
- Extended Surface Prognosis provides projected weather for 2 to 5 days
- Satellite Weather Images provide an indication of any disturbances through cloud cover and the TRS view from space
- Ice Charts show the limits of pack ice and any known iceberg locations
- Sea Temperature charts provide surface temperature contours and forecasts for a specified period
- Wave Analysis charts provide contours of wave heights and direction of movement, based upon a synopsis made a few hours before transmission
- Wave Prognosis charts forecast wave contours with heights and direction of movement.

All of these can influence routeing decisions and, in particular, the wave analysis and prognosis charts help estimate the ship's speed from the ship's performance curves. Provided the information was obtained on a regular basis, a knowledgeable Master should have no difficulty in taking routeing decisions.

4.2.3 Shore-Based Routeing

Forecasters and routeing experts use these technical developments to provide routeing advice to ships :

- Weather satellites
- Extensive databases on oceanographic and meteorological conditions
- Weather and wave modelling on computers
- An extensive knowledge of the ship's behaviour in varying circumstances
- Better communications.

Services are provided by a number of government agencies and private establishments. The 'METROUTE' service of the UK is provided only on receipt of a special request.

4.2.3.1 Types Of Routes

These form the basis of the aimed level of service provided by the routeing service:

- 'Constant speed' is often a C/P requirement and, if not maintained, could incur a financial penalty
- 'Least time' is used to keep the passage time to a minimum and is a preferred choice for large ships carrying liquid bulk cargoes, large parcels or dry bulk cargoes. Such routes may incorporate a fuel saving option
- 'Least damage' is preferred for vessels that carry cargo that is liable to be damaged by the movement of the vessel in heavy sea, for example, Ro-Ro ships carrying expensive cars
- 'Least time and least damage' is intended for keeping both damage and financial claims low and is preferred by most users of shore based routeing.

Some vessels may have special requirements:

- Deep water route
- Ice free route
- All weather route (e.g., passenger ships)

4.2.3.2 Considerations for Advice

The considerations of a routeing service when advising the vessels are:

- Safety of the vessel, passengers, crew and cargo
- The dangers from ice, fog and storms
- Speed and past performance of the vessel
- Classification of vessel
- Company and charterer's preferences
- Master's experience and preference

- Present weather
- Forecast weather for time of the voyage
- Proximity to hazards
- Endurance and bunker capacity
- Economics of cargo and operations
- Prognosis charts of wave heights
- Recommendations from Ocean Passages for the World and routeing charts.

4.2.3.3 Routeing Procedure

The service may be contracted for a single voyage, period of time charter, for a ship throughout or for the entire fleet. Usually, the contract is made by the company, but sometimes it may be made by the Master.

4.2.3.4 On Contract

Once a vessel contracts for service, the routeing service requires some basic information for entering into their database. The service has to be advised of the company's preferences and given the vessel's particulars and performance under different condition, that is the speed of the ship at different draught or displacement conditions. They will also need the ship's trial manoeuvre data, data from log books and observations, the time since drydocking and the performance curves. The details of method of obtaining the service and the information that will be required when this is done are available in ALRS Vol 3.

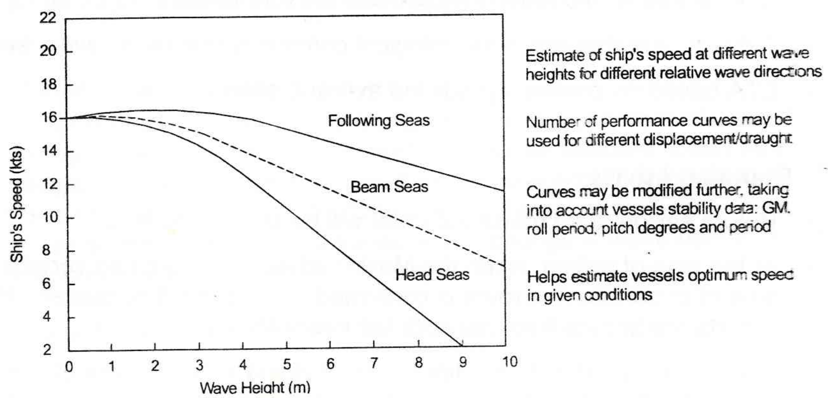


Figure 4.9 - Performance Curves for Head, Beam and Following Seas

4.2.3.5 Subsequent Information

Before sailing:

- Ship's particulars (name, call sign, contact details)
- Port of departure
- Port of destination
- Date and time of departure
- Condition of the vessel (loaded/ballast, draught, freeboard, summer displacement)
- Type of cargo (weather sensitive/dangerous – angle of repose, high density cargo)
- Vessel's required ETA, if any
- Vessel's speed – C/P requirement
- Weather and sea conditions to be avoided
- Other requirements – maintenance, passenger comfort
- Vessel's meteorological equipment (if the vessel is a meteorological observation station).

While on passage, noon position reports are sent from the vessel with these details:

- Date / Time UTC
- Name of the vessel / call sign
- Position
- Course and speed (daily average and present speed)
- Average and Present meteorological conditions (pressure, wind, swell)
- ETA based on present / predicted average speed.

4.2.3.6 Routeing Advice

- Before sailing, the provisional route will be sent to the ship
- At the time of sailing, when the Master advises the routeing service of the time of departure, the route is confirmed, or updated if necessary. Weather reports are sent to ship and updated every 48 hours
- The vessel updates its position to the routeing service every 24 hours (or earlier if required) and routeing advice is received every 48 hours or earlier, as necessary.

4.2.3.7 Voyage Assessment

Shore weather routeing is based on information regarding the ship and the actual weather as well as the forecast weather conditions. When the voyage is complete,

Voyage Assessment Information is provided by the routeing service to the vessel or its owners.

Preliminary Voyage Analysis

This is a descriptive account of the route, explaining the reasons for the choice of the advised route and including a summary of relevant weather conditions. It compares the estimated average speed with the performance speed of the vessel using direct routeing.

Voyage Abstract

It notes the vessel's noon positions along the route, the weather experienced and provides estimates of how weather and currents affected the vessel's progress.

Routeing Chart

This is a plot of the vessel's noon positions and the weather experienced.

Hindcast Charts

These are provided on request and compare weather and progress along the advised route with that likely to have been experienced along an appropriate alternative route. The comparison shows how much time the ship may have saved by following the advised route.

Voyage Analysis

This can be provided on request for any voyage, whether or not it has been routed by the service. It is designed to be used for bunker or speed claims and is similar to a Voyage Abstract.

Routeing Summaries

This is a seasonal summary of the routes followed by a client's vessel(s) and is produced on request. It assists in assessing the benefits of using the service.

4.2.3.8 Least Time Track

One of the essential elements of any routeing is the development of Least Time Track. Using experience and the available information onboard, it can be produced by the navigator. The information required by the navigator for constructing a least time track is the ship's performance curves with different relative wave directions and how the waves and swell will affect speed with a change in wave height. A wave prognosis chart is also required.

A Least Time Track can be built from the guidance in Figure 4.10:

- From the departure position, several tracks towards the general direction of destination are generated at approximately 15° intervals
- The tracks are drawn on a transparent overlay and are placed over a prognosis chart to analyse the conditions that will be encountered by the vessel during the voyage on the above tracks

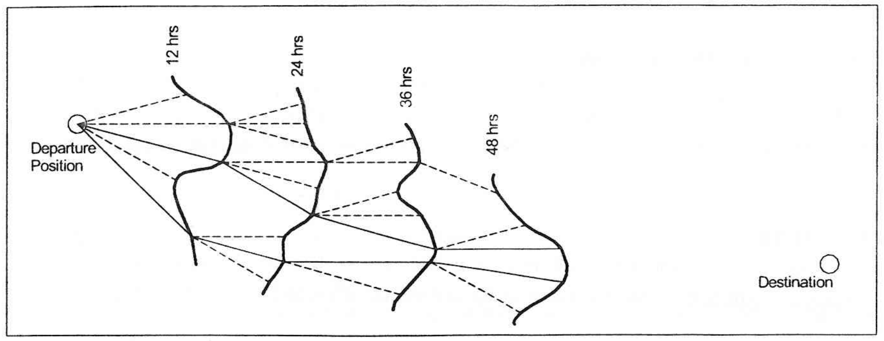


Figure 4.10 - Construction of Times Fronts for Least Time Track

- After studying the prognostic wave height charts and the vessel's performance curves, plot the estimated 12 hour run distance on each of the tracks
- These positions are joined together to form a line known as The Time Front
- Obviously bad tracks are discarded
- From each of several positions on the time front, tracks are drawn at 15° intervals and the estimated 12 hour run is plotted again
- This procedure is repeated twice more at intervals of 12 hours. This enables a 48 hours contour to be drawn up
- The position on the 48 hours contour that is nearest to the vessel's destination is the point that the Master is advised to route by
- After 12 hours, the ship's actual position is marked on the chart and the exercise is repeated
- When estimating distance and speed on the projected tracks, allowance is made for fog, ice, storms, winds, currents, wave heights and swell and the other navigational hazards expected to be encountered, in accordance with the forecast

4.2.3.9 Advantages

Routeing advice from shore is based on strategic decisions by well experienced professionals who have at their disposal extensive databases of oceanographic and meteorological information. However, the ship's Master may be taking decisions on the basis of present weather and near-future expectations.

Routeing advice can be useful towards:

- Safety as the ship keeps clear of extreme weather conditions reducing the probability of severe catastrophic damage
- Reduction in ship's hull metal fatigue
- Reduction in ship and cargo damage fewer emergency repairs
- Reduction in machinery wear and tear, extending ship-operating life
- Saving in fuel consumption and costs leads to lower operating costs
- Saving of time providing lower operating costs
- Better scheduling of port operations and routine dry docking meaning no lost-passage time
- Passenger and crew comfort, enhancing the efficiency and health of the crew and the well-being of the passengers
- Scheduled maintenance
- Reductions in insurance premiums due to a reduction in claims
- Reduction in litigation due to a reduction of claims against ships.

4.2.3.10 Disadvantages

- Routeing advice is for guidance only and final responsibility rests with the Master. Therefore, the Master needs to consider the advice carefully before using it to select the vessel's route
- It is possible that, even with routeing advice, the vessel is unable to avoid the worst weather on the strategic route. Better average weather would have been possible on the more traditional optimum route
- As a result of poor strategic planning, the advice may take the vessel towards an impossible position with no possibility of better options
- The Master and the rest of the bridge team have to spend time on extra reports and communication with the routeing service
- In certain parts of the world where the weather remains fair, it can be an unnecessary expense.

4.3 Oceanographic and Climatic Data

It is not necessary for a navigator to learn the oceanographic and climatic data of the entire world, but he should know how to find the data and use it to its full advantage. He must appreciate that the conditions being experienced at a given time may not be the same as the information in the published data. The variation may be due to differences in weather conditions from the stated climatic conditions, seasonal changes and extra (or insufficient) heating of the landmasses and the sea.

The navigator must always be ready for any deviation from the norm and take corrective action in time to keep the ship away from danger. Variations may affect the performance of the vessel and the navigator should be ready to adjust the plan to accommodate those differences and minimise waste.

The following sections provide a brief summary of the general oceanographic and climatic data of the main frequented ocean areas by using brief text notes, simple maps and bullet points in a tabulated format.

As January and July represent the extremes of climatic data and its effects on the ocean currents, these are the maps that have been provided. The maps are only approximate and may not show all the islands or the exact coastlines.

Figure 4.11 - Oceanographic and Climate Data Map 1

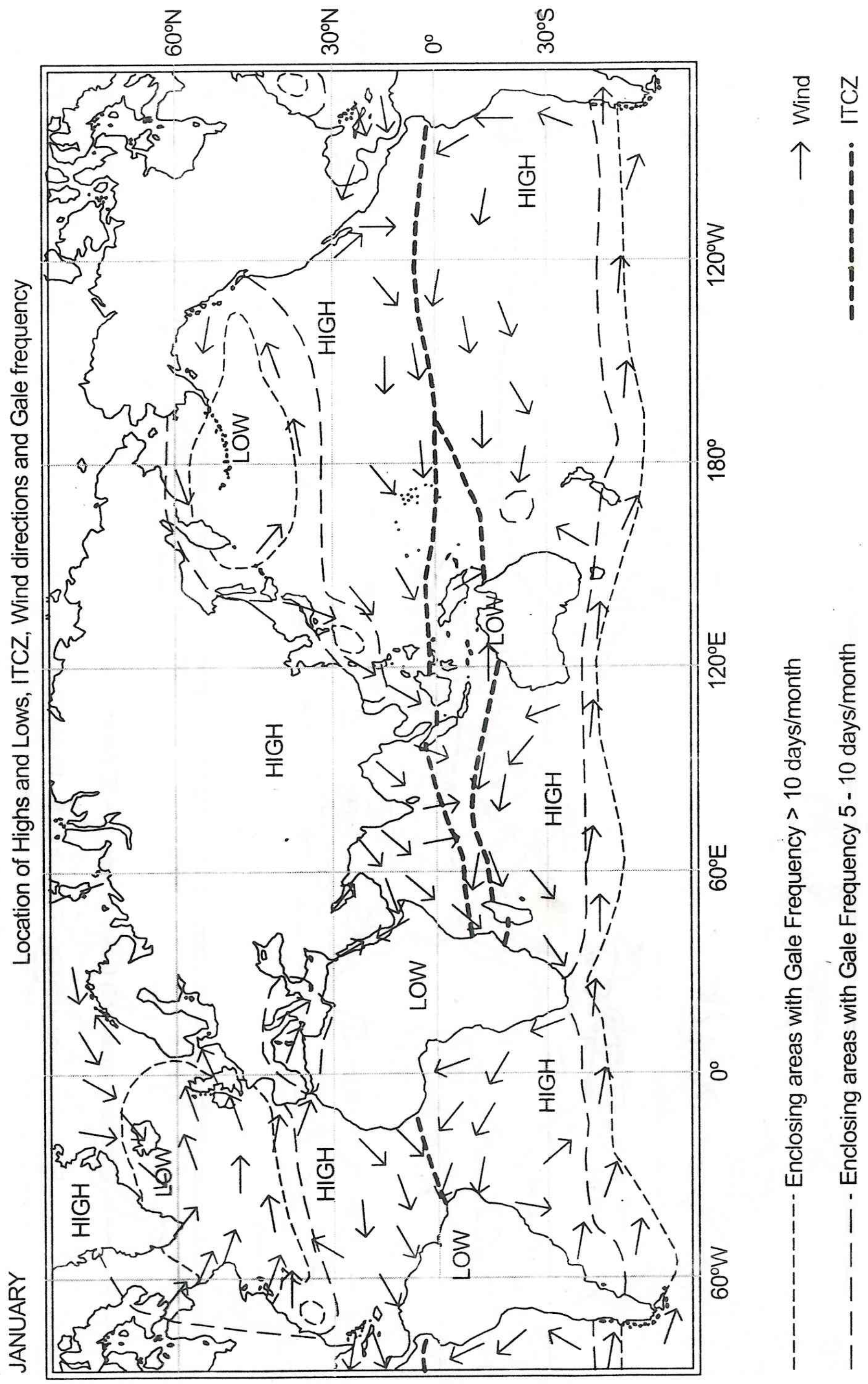


Figure 4.12 - Oceanographic and Climate Data Map 2

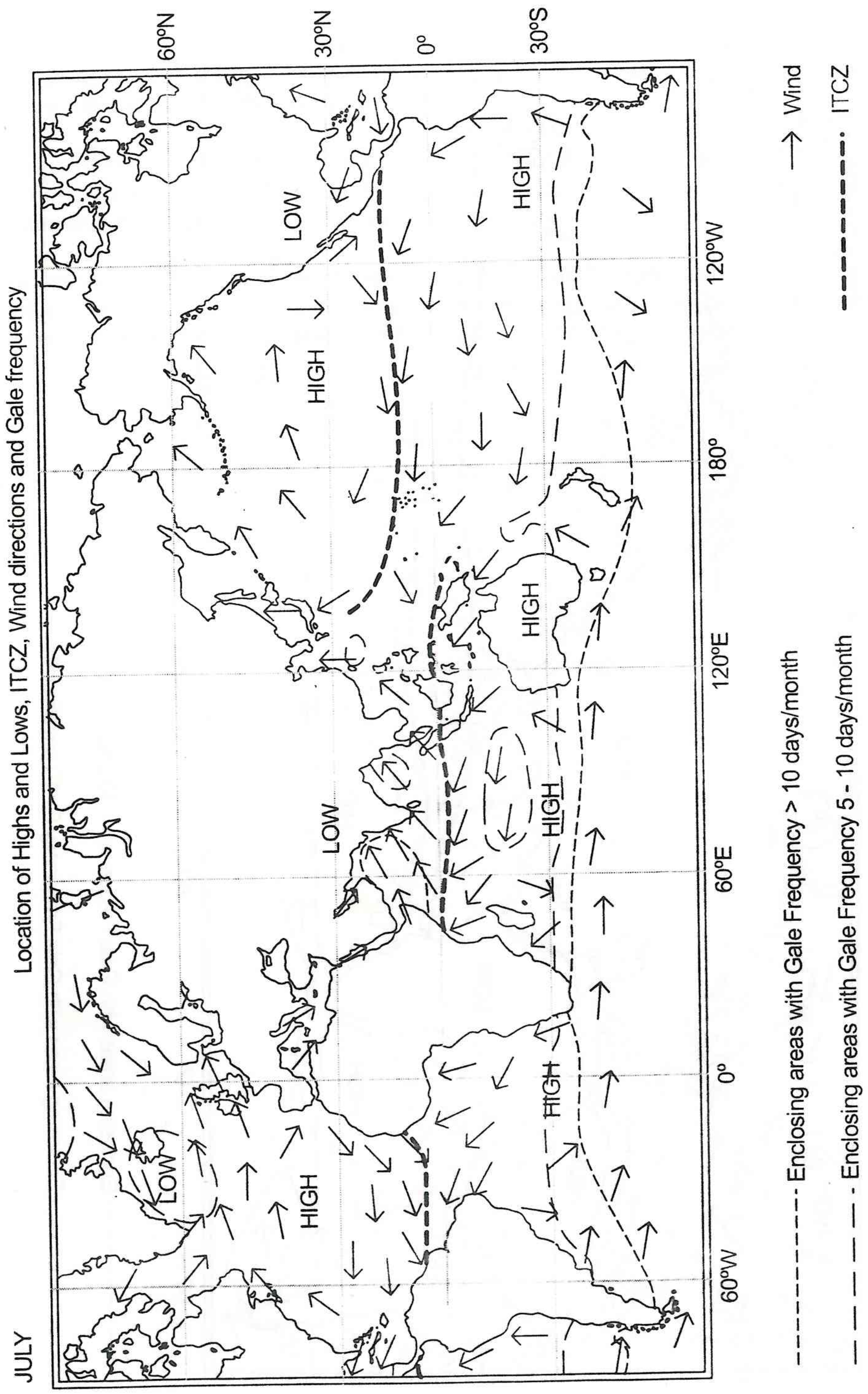


Figure 4.13 - Oceanographic and Climate Data Map 3

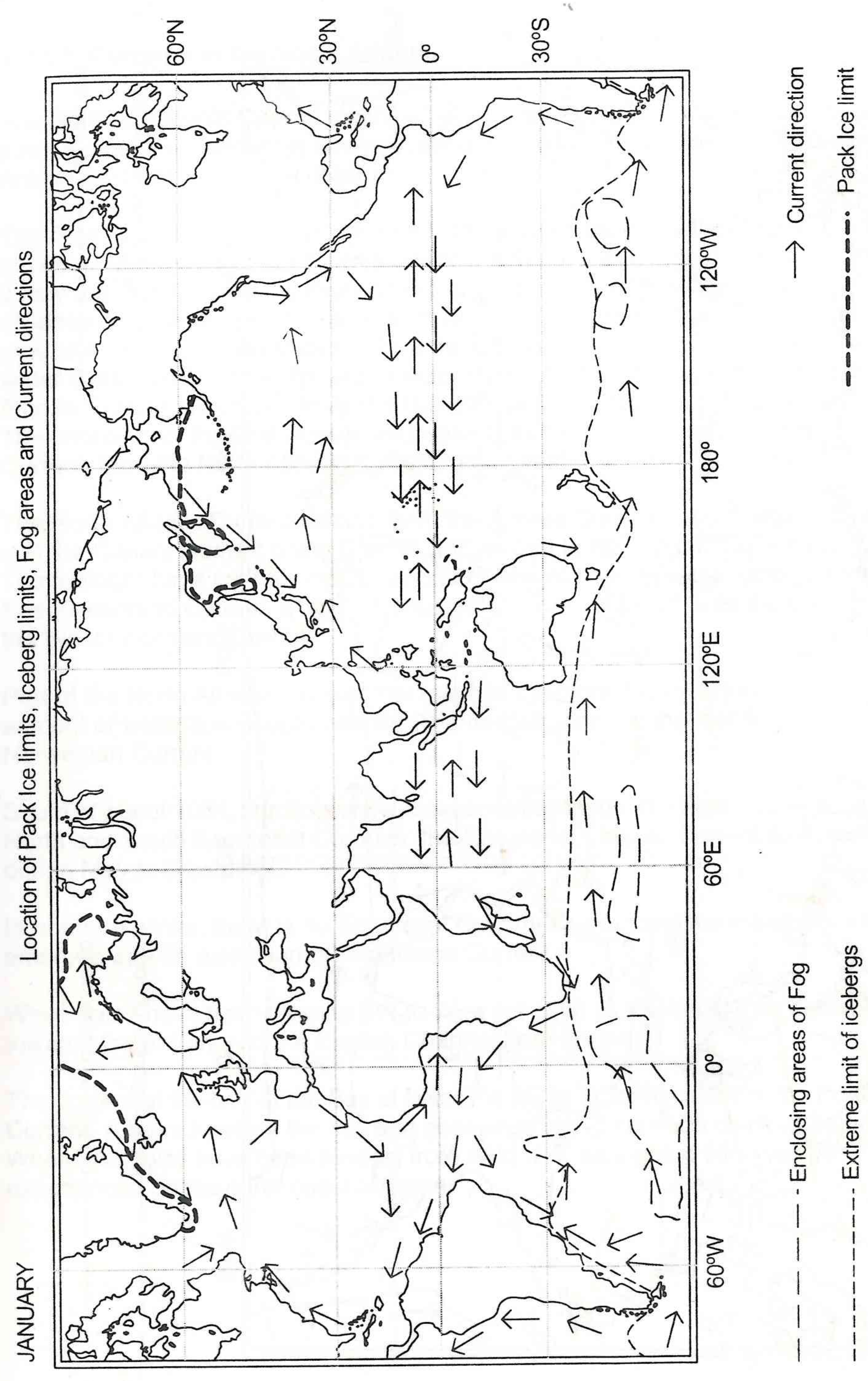
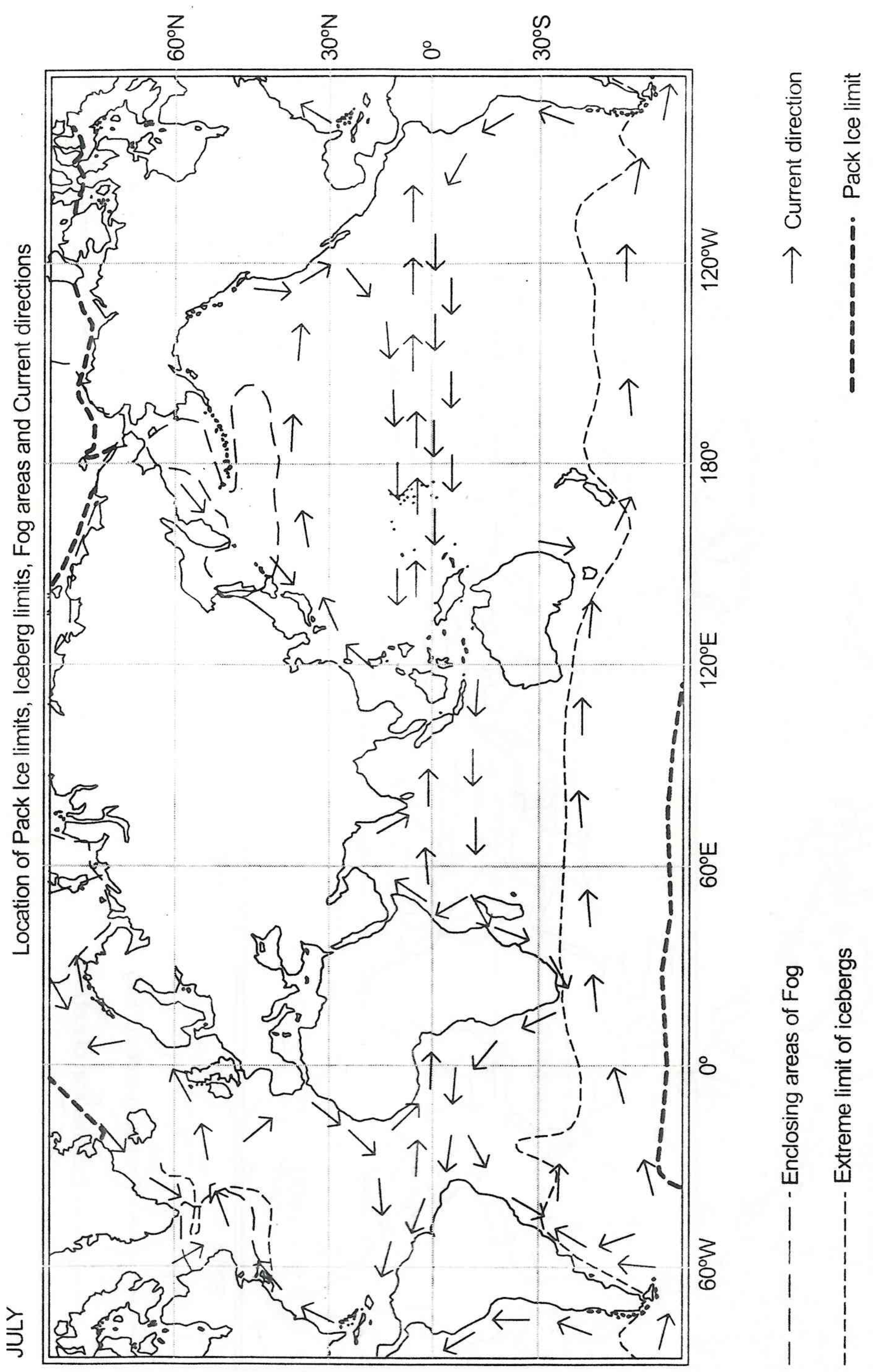


Figure 4.14 - Oceanographic and Climate Data Map 4



4.3.1 Ocean Currents and Climatic Data

4.3.1.1 Currents in the North Atlantic

The North Equatorial Current originates northward of the Cape Verde Islands and flows almost due west at an average rate of 0.7 knots. This current goes through the Antilles and enters the Gulf of Mexico.

The South Equatorial Current originates off the west coast of Africa, south of the Gulf of Guinea and has a generally westerly flow at an average rate of 0.6 knots, although it may reach more than 2.5 knots off the east coast of South America, where it divides in two, flowing north and east of Brazil. The northern branch mainly turns around from May to November to form the Equatorial Counter Current, while some water goes past Guyana. The water entering the Gulf of Mexico exits in the form of Florida Current, which becomes the Gulf Stream going NNE to NE at 3 to 3½ knots. The remnants of the Gulf Stream and water from the St Lawrence and the Labrador Current, form the North Atlantic Current, going east.

The North Atlantic Current splits to form the Azores Current, the Portugal Current and the Canary Current going S to SE and, in part to NE to form the Irminger Current. The Irminger turns counter-clockwise on to the east coast of Greenland to form the East Greenland Current, which continues to the west coast of Greenland, forming the West Greenland Current.

Part of the North Atlantic Current that reaches the North Sea splits into two. A small amount of water flows south past the Thames Estuary and the rest flows north as the Norwegian Current.

South of about 10°N, currents show a seasonal variation. Between the west-flowing North and South Equatorial Currents, the Equatorial Counter Current flows East only during May to November.

In northern winter, there is no Equatorial Counter Current and the water generally emerges with an extension of the Guinea Current.

When gales have been blowing SW to W, a set of up to 1½ knots may be expected towards the entrance to the English Channel from the west.

The current at the NW of the Bay of Biscay is SE to S, forming part of the Portugal Current. A branch enters the bay and goes west along the north coast of Spain. Where the gales have been blowing from W to NW, east-going sets may be experienced on the north coast of Spain.

4.3.1.2 North Atlantic Weather

SUMMER (MAY - SEPTEMBER)	WINTER (NOVEMBER - MARCH)
ITCZ: • The ITCZ remains N of the equator throughout the year. • This is an area of calm and light variable winds, also called the Equatorial trough and Doldrums. • Visibility is very good except in rain • The monsoon during the summer is the SW monsoon. • Cloudy weather, heavy rainfall • During April and May, severe squalls, violent thunderstorms during summer. • Winds are SW'ly	ITCZ: • The ITCZ remains N of the equator throughout the year. • This is an area of calm and light variable winds, also called the Equatorial trough or Doldrums. • Visibility is very good, except in rain • The monsoon during the winter is the NE monsoon. • Winds are dry and light N'ly over Liberia and Mauritania and S and W in the Gulf of Guinea • Weather generally fine, moderate visibility with haze • During October and November, there can be severe squalls and violent thunderstorms.
NE TRADES: • The NE trade winds extend from the ITCZ and up to 30°N. • The normal wind force is 4, but it may increase to 7 or decrease to 2. • In the NE trade winds area, there is fair weather, little rain, small amount of clouds. • Haze occurs frequently. • Visibility is good, except in rain	NE TRADES: • The NE trade winds extend from the ITCZ and up to 30°N. • The normal wind force is 4, but may increase to 7 or decrease to 2. • In the Gulf of Mexico the phenomenon of very strong or gale force winds occur, called the Northers. • In the NE trade winds area, there is fair weather, little rain, and a small amount of cloud. • Haze occurs frequently. • Visibility is good, except in rain.
VARIABLES OR HORSE LATITUDES: • Light or variable winds area extends from NE trade wind N limit to 32°N. • The predominant wind is between N and NE. • Hurricanes occur in the W part of the Atlantic Ocean. • Areas affected are the Caribbean Sea, Gulf of Mexico, Florida, Bahamas and Bermuda. • They occur from May to December. • Greatest frequency is from Aug to October.	VARIABLES OR HORSE LATITUDES: • Light or variable winds area extends from NE trade wind N limit to 28°N. • The predominant wind is between N and NE. • Hurricanes occur in the W part of the Atlantic Ocean. • Areas affected are the Caribbean Sea, Gulf of Mexico, Florida, Bahamas and Bermuda. • They occur from May to December.

WESTERLIES: • Area affected is the N part of Atlantic Ocean. • Unsettled weather as a result of continuous passage of depression in E to NE direction. • July is the quietest month. • In July the strongest area remains SW of Iceland. • The frequency of winds of force 7 is only about 7 days a month. • Overcast skies, rain or snow, large clouds.	WESTERLIES: • Area affected the N part of Atlantic Ocean. • Unsettled weather as a result of continuous passage of depression in E or NE direction. • There is a high frequency of strong winds/ gales are common especially in winter. • The stormiest belt extends roughly from the vicinity of Newfoundland to the channel between Iceland and Faroe. • Stormy winds of force 7 or over can be expected 16-20 days per month in January.
FOG AND VISIBILITY: • The area E and S of Newfoundland is most affected by fog. • Fog is very prevalent in spring and early summer. • It is experienced more than 10 days per month.	ICE: • Iceberg limits are reduced and are frozen into pack ice. • Ice information service is available from CRSs (Refer ALRS). • International ice patrol is operated by USCG (Details in ALRS and Sailing directions). • Ice advisory service is operated by Canadian coastguard (Refer to Sailing directions, ALRS, Ice Navigation in Canadian waters).

4.3.1.3 Currents in the South Atlantic

The Benguela Current sets NW on the SW coast of Africa. The South Equatorial Current is fed by the Benguela Current and the Guinea Current. The branch of South Equatorial Current going SSW on the east coast of South America is the Brazil Current.

The Falkland Current flows N to NNE on the east coast of Argentina and Uruguay. It meets the Brazil current and they both turn east to form the very slow-moving South Atlantic Current.

The Southern Ocean Current flows E to ENE from 55°S south of Cape Horn to 40°S close to south coast of Africa.

4.3.1.4 South Atlantic Weather

SUMMER (NOVEMBER - MARCH)	WINTER (MAY - SEPTEMBER)
There is no ITCZ and therefore, no TRS.	There is no ITCZ and therefore, no TRS.
SE TRADES: • The SE trade winds extend from the equator to 30°S. • The average wind force is 2 to 3. • Slight to moderate swell.	SE TRADES: • The SE trade winds extend from the equator to 20°S. • The average wind force is 2 to 3.
VARIABLES: • S limit of SE trades to 31°S • Slight to moderate swell.	VARIABLES: • The S limit of the SE trades to 26°S.
WESTERLIES OR ROARING FORTIES: • W'ly winds predominate S of 35°S • There is a continuous passage of depressions from W to E, so the direction and strength of the wind varies. • Depressions move from Cabo de Hornes to S. Georgia and then along 50°S. • Gales are very prevalent S of 40° S from mid summer onwards. • Wind force 7 prevails for 7 - 9 days a month. • S of 43°S and E of 40°W the frequency rises to about 15 days per month. • Fog is common in summer and is associated with winds from warm latitudes. • 40°S to 50°S mainly moderate but often with a heavy swell. • 50°S to 60°S heavy swell, strong winds and abnormal waves (In the vicinity of shoal waters – Gough Is.)	WESTERLIES OR ROARING FORTIES: • W'ly winds predominate S of 35°S • There is a continuous passage of depressions from W to E, so the direction and strength of the wind varies. • Depressions move from Cabo de Hornes to S. Georgia and then along 50°S. • Gales are very prevalent S of 40° S from mid summer onwards. • Wind force 7 prevails for 7 - 9 days a month. • S of 43°S and E 40°W the frequency rises to about 15 days per month. • In winter, this frequency is S of a line joining Falkland Islands and Cape of Good Hope. • 40°S to 50°S mainly moderate but often with a heavy swell. • 50°S to 60°S heavy swell, strong winds, abnormal waves (In the vicinity of shoal waters – Gough Is.)
ICE: • The approx mean limits of pack ice are indicated on routeing charts, Climatic chart and U.S. Marine climatic atlas. • The pack ice limit is usually 100nm from the coast during the summer. At times this may expose the coast line as well • Icebergs are of immense size and are most likely to be encountered in the lower latitudes. They have been sighted as far as 31°S off the coast of S. America (Argentina, Brazil). • The normal iceberg limits are 35°S.	ICE: • The approx mean limits of pack ice are indicated on routeing charts. Climatic chart and U.S. Marine climatic atlas. • The main shipping routes of the S. Hemisphere are not affected by pack ice but its presence prevents the use of GC track between Cape of Good Hope and Cabo de Harnos especially in winter (Mar/Apr). • Icebergs are of immense size and are most likely to be encountered in the lower latitudes. They have been sighted as far as 31°S off the coast of S. America (Argentina, Brazil). • The normal iceberg limits are 35°S.

4.3.1.5 Currents in the North Indian Ocean during Summer (SW Monsoon)

The Equatorial Jet between 2ºN to 2ºS goes east and appears twice during the transition periods between the monsoon seasons.

There is a clockwise flow on the coastal regions of the Arabian Sea and the Bay of Bengal to clear the water that has been pushed by the SW monsoon. The Somali Current flows in a NE direction at high rates averaging 3 knots with a maximum of 8 knots. At times, the actual Somali Current differs from its general trend. During June, this current usually sets up another clockwise flow, between 2ºN and 6ºN and south of Suqutra, as it leaves the coast of Africa. This usually happens into July as well. Late July and August see a change as the Somali Current turns at about 10ºN.

General easterly sets occur in the open waters of the Arabian Sea and the Bay of Bengal. During June, the Equatorial Jet gradually ceases and a weak westerly set replaces it. In later parts of September, the next phase of Equatorial Jet may begin to set.

4.3.1.6 Currents in the North Indian Ocean during Winter (NE Monsoon)

General westerly sets occur in the open waters of the Arabian Sea and Bay of Bengal. The Equatorial Jet usually continues east up to late December, then is replaced by a broad westerly flow in January which continues up to March. The coastal currents change direction:

- Anti-clockwise in December and January
- Clockwise in February and March. Early February in Bay of Bengal and enc March for Arabian Sea.

There is a SW flow off the coast of Somalia south of about 8ºN and to the north it sets NE. The NE flow shifts to about 4ºN in March.

During the northern winter, the North Equatorial Current flows west.

4.3.1.7 Currents In The South Indian Ocean

The South Equatorial Current of the Indian Ocean runs west well south of the equator when compared to similar currents in the Atlantic and Pacific Oceans. To the north of the South Equatorial Current, an east-going Equatorial Countercurrent, ½ to 1 knot – sets during the NE monsoon season, especially in the west parts of the Indian Ocean. This Countercurrent merges into the Equatorial Jet, at 1 to 2 knots, at the start and end of the NE monsoon.

The South Equatorial Current splits twice. Once when a small branch flows along the east coast of Madagascar and second, at the African east coast. Some water branches N into the East African Coast Current and the other forms the SSW flow in the Mozambique Channel as the Mozambique Current. The SSW flow on the east and west sides of Madagascar join to form the Agulhas Current, averaging 2 to 3 knots with a maximum of 5 knots. A part of Agulhas Current helps to form the Benguela Current and a small part turns to flow east with the Southern Ocean Current.

During autumn and winter on the west coast of Australia, sets off the coast are south and turn south east off Cape Leeuwin. During spring and summer, some coastal eddy and some northerly flow (N of 33°S) is present. To the west of 113°E, there is a tendency for a N to NW set which joins the South Equatorial Current. When this N to NW current is more constant, it is termed the West Australian Current.

4.3.1.8 Indian Ocean Weather

SUMMER (MAY - SEPTEMBER) **(S. winter)**	**WINTER (NOVEMBER - MARCH)** **(S. summer)**
NORTH INDIAN OCEAN • The SW monsoon prevails. • Period is June to September. • In the Arabian Sea, TRS season is May/Jun/Jul/Oct/Nov • In Bay Of Bengal, TRS season May-November. • The North Equatorial current is absent. • The Equatorial Counter Current is absent. • Both are replaced by the Indian SW monsoon current flowing W, all to the N of Equator. • Strength of winds averages force 6 – 7, for about 10 days a month. The worst area is Suqutra. • In the Arabian Sea, the wind force is 4 – 6 and above force 7 for 5 to 10 days per month. • The Bay of Bengal wind force is 4 - 5 and reaches force 7, 5 to 10 days in July. • Cloudy and unsettled weather with heavy rainfall. • Good visibility except in rain. • Visibility reduced in Apr/May by dust haze. • Inter-monsoon season prevails in April/May. • The swell is governed by the prevalent monsoon.	NORTH INDIAN OCEAN • The NE monsoon prevails. • Period is November to March. • The North Equatorial Current is replaced by the NE Monsoon Current flowing west. • The Equatorial and South Equatorial Currents are also present. • Wind force is 3 - 4, direction N and NE. • The weather in the Arabian Sea and Bay of Bengal is generally fine. • The Inter-monsoon season prevails in October. • Visibility is reduced by rain in winter. • The swell is governed by the prevalent monsoon.

SOUTH INDIAN OCEAN • ITCZ is S of the equator • TRS season is from Nov to April. • Tropical storms are known as cyclones. In the Australian area, they are called hurricanes. • Weather similar to Doldrums; calm weather, light variable winds, heavy shower, squalls and thunder storms. • The NW monsoon prevails (NE monsoon in N. Hemisphere) • Wind at light force, except in TRS. • Cloudy unsettled weather. • Good visibility, except in rain.	SOUTH INDIAN OCEAN • ITCZ is S of equator • TRS season is Nov – April. • Tropical storms are known as cyclones. In the Australian area they are called hurricanes. • Weather as that of Doldrums; Calm weather, light variable winds, heavy shower, squalls, thunder storms. • NW monsoon prevails (NE monsoon in N. Hemisphere) • Wind light force, except in TRS. • Cloudy unsettled weather. • Good visibility, except in rain.
SE TRADES: • Extends from the equatorial trough to 30°S. • Force 3 – 4.	SE TRADES: • Extends from equatorial trough to 27°S. • Force 4 – 5
VARIABLES: • Extends between the S limit of the SE trade winds and 35°S. • Light and variable winds. • Fair weather.	VARIABLES: • Extends between S limit of SE trade winds and 30°S. • Light and variable winds. • Fair weather.
WESTERLIES: • Extends between the S limit of variables and N Limit of Polar easterlies. • Winds are westerly and depend on the east-moving gales • The centre of most of these depressions pass to the S of 50°S. • Wind force 7 is experienced for >6 -12 days per month S of 40°S. • Weather is variable with overcast skies, rain or snow associated with fronts of east moving depressions.	WESTERLIES: • Extends between the S limit of variables and N Limit of Polar easterlies. • Winds are westerly and depend on east- moving gales • The centre of most of these depressions pass to the S of 50°S.. • Gales are prevalent in winter where the wind is at force 7 for 12-16 days per month. • Weather is variable. Overcast skies, rain or snow are associated with fronts of east-moving depressions.
ICE: • The greatest extent of pack ice is from Aug-Sept and runs from about 55°S 000° to 58°S 050°E, 60°S 110°E. • The GC routes between S. Africa and Australia are obstructed. • Icebergs mean limit reaches farthest N between 20°E and 70°E in Nov and Dec, when it runs from 44°S in the longitude of Cape Agulhas.	ICE: • The GC routes between South Africa and Australia are obstructed. • Icebergs mean-limit is everywhere S of 50°S.

4.3.1.9 Currents in the North Pacific Ocean

The North Equatorial Current flows westward in the general area of the NE Trades. The South Equatorial Current also flows westward in the area of SE Trades. In between the two is the weaker east going North Equatorial Countercurrent, at around 5°N to 7°N.

The North Equatorial Current curves towards the Philippines and Taiwan, where it deflects further north to become Kuroshio (also called Japan Current), which moves NE. The Tsushima Current flows NE along the west coast of Japan. Water from Kuroshio curves east and widens between the Aleutians and the Hawaiian Islands. This is known as the North Pacific Current. As the North Pacific Current approaches the west coast of North America, it turns SE to become the California Current. During the winter, the Davidson Current flows northerly inside of the California Current.

The Aleutian Current flows east and the Alaska Current flows north along the coast of Alaska. The Kamchatka Current flows SW along the Russian coast to the north of Japan.

4.3.1.10 Currents in the South Pacific

The Southern Ocean Current flows easterly around latitude 45°S. The Peru Current flows N to NW and feeds into the South Equatorial Current, which is west-going at the equator.

The East Australian Current flows S along the coast. From Australia to New Zealand, it is called the Tasman Front and on the east coast of New Zealand, it becomes the East Auckland Current.

4.3.1.11 North Pacific Weather

- The ITCZ remains permanently N of the equator at Longitude E of 160°W.
- To the W of 160°W, it lies in the S. hemisphere from about Nov or Dec until Apr or May.
- In the Northern summer, it is virtually non-existent W of 150°E.
- NE trade winds blow on the equatorial side to 30°N.
- Wind force 3 – 4, but often freshens to 5 - 6
- The NE monsoon begins generally in September in the north and is close to equator.
- In the summer of the N. hemisphere, the SW monsoon is present.
- Fog is prevalent during summer.
- The foggy season reaches its maximum in April off Hong Kong. And in the Japan Sea, fog is about 3 - 4 days per month and 5 -7 days per month off Northern Honshu.
- After July, the fog incidents drop sharply.
- Wind force is 3 - 4 in the South China Sea and force 3 elsewhere.
- TRS is prevalent in summer, when winds may reach force 7 and above.
- TRS are known as Typhoons in the West part and Hurricanes in the East part.
- The areas affected by Typhoon are the Caroline Islands, the Mariana Islands, the Philippines and the S. China Sea near the coasts of China and Taiwan, the China Sea and Japan.
- TRS activity is between June and October.
- September is the month of greatest frequency of TRS.
- The visibility along the Chinese coast is reduced by sea fog.
- Variable belt is from 25°N to 30°N in winter and 35° - 40°N in summer.
- Light and moderate winds are prevalent.
- Winds in summer are generally light and rarely reach force 7, unless associated with tropical storm.
- At the height of winter season in January, wind forces reach 7 or above in the areas N of 40°N.
- The weather considerably varies in the westerlies during summer and winter.
- N of 40°N there is a continuous passage of depressions from the vicinity of China and Japan in a NE direction towards the Aluetian Islands and south of Alaska.
- Strong winds and gales are frequent E of Japan, S of Aluetian and the Alaska peninsula where the wind force reaches force 7 or above more than 12 days a month.
- Visibility is reduced by rain and snow.
- In summer, depressions are less frequent and their tracks are further North than in winter.
- Polar easterlies. In winter, since most depressions travel South of Aluetian Islands, the winds in the Bering Sea are mostly easterly.

4.3.1.12 South Pacific Ocean Weather

- ITCZ remains North of Equator throughout the year when E of 160°W.
- To the W of 160°W, it lies in the S. hemisphere from about Nov/Dec until Apr/May.
- Weather is typical of ITCZ, calm, light variable wind and fine weather alternating with squalls, heavy rain and thunderstorms.
- The vessel will be in the SE Trade winds zone throughout her passage.
- There is a High on 30°S, W of Chile.
- The SE trade wind limit is from the equator to 20°S.
- The direction of trade winds is south easterly.
- The average strength of the trade winds is about force 4, but they often strengthen to about force 6.
- Winds of force 7 or more are unlikely for more than 2 days per month.
- Over the open oceans, weather is fair with occasional showers.
- Skies are half-covered with small cumulus clouds.
- There is slight haze that reduces the visibility to 8-15 nm.
- Cloudy weather with overcast skies is common when approaching the coast of South America.
- Fog and mist occur towards the coast of S. America over the cold waters of the Peru Current, but are rarely found elsewhere.
- 20°-30°S is an area of variable winds.
- The tropical storm area is W of 155°W and S of 8°-10°S.
- The storm period is from December to April.
- The greatest frequency of storms is from January to March. However, they are not unknown at other times.
- The south equatorial current sets WNW – WSW at moderate to high constancy.

4.4 General Hazards to be Found on an Ocean Passage

This is a brief summary of the hazards that may be encountered on an ocean passage. The list is not exhaustive.

- Sparse hydrographic information, some hazards may still be uncharted
- There may be lot of islands at short distances in the archipelagic waters
- Some islands may be unlit and therefore, not visible during darkness
- Some islands may be very low and may not be visible at reasonable distances or picked up by radar at safe distances
- Fishing craft in the vicinity of coasts and small islands. They may have no lights, they may have inadequate lights or they may be improperly marked
- Leisure crafts may be present in the vicinity of coast, small islands and at times, even in the open seas
- Cruise ships may pass very close to islands or coast and may emerge suddenly, having been obscured by landmarks
- Some charts may be based on very old surveys

- Some charts may be very old and with an inadequate scale
- The discrepancy between charted and actual positions (as derived from modern navigation systems or celestial observations) may be very large. There is no data available for correcting such positions
- Cross currents, especially in vicinity of islands, can set a vessel towards danger. Some of these currents may be very strong
- Traffic may cause concerns, especially when crossing regular shipping lanes (across or going head-on) in frequent-shipping lanes
- Force of wind in areas where gale force or stronger winds are likely
- Tropical revolving storms. Vessels at times on certain headings may encounter the same TRS twice, both before and after re-curvature
- Large waves and heavy swell
- Areas where abnormal waves or Tsunamis may occur
- Visibility affected by rain, falling snow, fog, sand storms and haze
- Cloudy conditions or poor visibility may prevent celestial observations
- Thunderstorms, sudden squalls and water spouts
- Icebergs and other forms of ice
- Areas of offshore activity and survey
- Absence of adequate areas for choosing a suitable landfall position
- Armed attacks, piracy and armed robbery, and other security concerns
- Possibility of debris falling following satellite launch.

You must appreciate that this list is generic and that the actual hazards on a passage may not include all these items. For example, there is no ice in the Caribbean Sea or other low latitudes. Similarly, there are no TRS or issues with unlit islands in the South Atlantic.

Authors Note:

Do not include irrelevant points like these in passage plans as their presence undermines the value of the input effort.

4.4.1 Recap of Factors for Choice of Routes

The shortest route is not always the quickest. Take these factors into account when choosing a route:

- Distances by various routes
- Recommendations from Ocean Passages of the World
- Load Line zones
- Proximity to navigational hazards such as ice, offshore activity and hostile activity
- Availability and consumption of bunkers, along with intermediate bunkering ports
- Prevailing weather conditions, particularly the presence of storms or depressions
- Climatic conditions, including general wind circulation and state of the sea
- Favourable or adverse currents
- Type of cargo
- Advice and recommendations by routeing services
- The Charterer's instructions
- Company preferences or limiting factors, including insurance policy warranty limits
- Time available
- Position-fixing reliability
- Damage likely to be sustained
- Maintenance work planned during the voyage
- Comfort of crew and passengers
- The points where stores and bunkers are to be replenished
- The amount of traffic likely to be encountered
- Draught at various stages of the voyage.

EXAMPLE 4.1:

A vessel has the option of three routes for an ocean passage as follows. Here we can see the effect of distance, wind and current on passage time:

Speed = 16 Knots

Distance	3130	3220	3450
Steaming time	8d 3h 38m**	8d 9h 15m	8d 23h 38m
Current	Against 2 kts**	Against 1 kt	Favour 0.5 kt
Current time factor	+ 24h 27m**	+ 12h 35m	- 6h 44m
Wind effect on speed	Against 0.5 kt	Against 0.5 (50%)	Against 0.5 (15%)
Wind time factor	+ 6h 7m	+ 3h 9m	+ 1h 1m
Time on passage	9d 10h 12m	9d 0h 59m	8d 17h 55m

**Time lost due to current calculation: 8d 3h 38m x 2knots = 391′.27 ÷ 16 knots
= 24h 27m

The time on passage will give an indication of the optimum choice. In addition, fog and swell may also adversely affect the progress. Other factors from the above list should be considered when deciding the route.

Author's note

Modern ship designs and high costs of construction, expensive cargo, ever-increasing liability payments, increased costs of fuel, costs and time-out for repairs, unnecessary waiting times, cut-throat competition and heightened media interest all put pressure on the Master and the ship's operators to demonstrate a performance level at which there would appear to be little room for error.

Use of efficient methods of planning a proposed transit before and during the voyage - plus a careful study of all the elements (particularly weather) - provides an opportunity for the optimum conditions to be used to best advantage, ensuring safety and with reasonable operating costs.

5 Bridge Procedures

To achieve consistency and minimise accidents, it is important that all mariners follow similar procedures. Proper training and availability of written procedures ensures that operations are carried out safely and with consistency. In addition, the application of some basic principles of management can help to create an environment that is mutually supportive and efficient.

5.1 Bridge Organisation

General principles of safe manning should be used to establish the levels that are appropriate to any vessel. At all times, vessels need to be navigated safely and in compliance with the International Regulations for Preventing Collisions at Sea.

The need to maintain a proper lookout should determine the basic composition of the navigational watch. There are a number of circumstances and conditions that could influence the actual watchkeeping arrangements and bridge manning levels at any time.

Effective bridge team organisation will manage all of the resources that are available and promote good communication and teamwork. Efficient bridge resource and team management should eliminate the risk that an error on the part of one person results in a dangerous situation.

5.1.1 Navigational Watch Composition

The bridge team may vary in composition, depending on the navigational situation and the human resources available. At various stages of the passage, these may include:

- Master
- OOW
- Helmsman
- Lookout(s)
- Additional officer
- Pilot

There will be circumstances when the Master is required on the bridge, because of

- Passage planning requirements
- The Master's watch instructions
- Standing orders under developing circumstances
- Because the OOW thinks that Master's presence is essential.

In this case, control remains with the OOW until the Master expressly takes command, which should always be logged. The OOW now takes the supportive role, but remains responsible for the actions of the watch members. There will be occasions when an additional officer will be summoned to the bridge to double-up the watch. Situations that demand the presence of an additional officer on the bridge might be a combination of:

- Restricted visibility
- Heavy traffic
- Navigation through congested waters.

For prolonged periods in such conditions, even the Master will require relief and a rota should be established where the Master and the junior navigation officer share one watch and the senior and junior navigation officers share the other. There may be certain high-risk situations when the Master and two watch officers will be required on the bridge at the same time.

In such circumstances, the roles of the team members need to be clearly defined. In most cases, these will be set by company policy, but which may also vary with the individual Master or practice on the vessel and prevailing circumstances. In each case, it is imperative that all members of the team fully understand their role to avoid either overlapping or even ignoring certain functions.

The Master or senior navigation officer would control movement of the vessel as defined by the International Regulations for Preventing Collisions at Sea, traffic schemes and the planned passage. Overall responsibility for watch organisation and safe navigation of the vessel rests with this person.

The junior navigation officer takes up the supportive role and will report relevant information to the Master/senior navigation officer and make sure it is acknowledged.

The junior navigation officer will fix the vessel and advise the Master/senior navigation officer of the position and provide other necessary information. The junior navigator, who may be responsible for all internal and external communications, will ensure that helm and engine orders are complied with, make logbook entries and perform the other duties required of OOW.

Where an additional officer is required, support to the Master and the OOW could be available through radar-based information and backup on the chart. Such an officer would be of assistance with both internal and external communications.

In compulsory Pilotage waters, the Pilot becomes an important member of the bridge team. A preliminary plan should be prepared that covers Pilotage waters and the roles of the bridge team personnel. The responsibility for the safety of the vessel remains with the Master or OOW, even when pilot is on board. In effect, the Pilot is employed in an advisory capacity. However, there are areas in the world (for example, the Panama Canal), where the Pilotage authority accepts full responsibility for the vessel in a case where a Pilot's decision may damage the vessel, her cargo or other property.

5.1.1.1 Factors for Navigational Watch Composition

When determining the adequacy of the navigational watch for ensuring proper lookout and execution of other routine bridge related duties, the Master should take the following factors into account:

- The size of the vessel and field of vision available from the coning position
- The bridge configuration that might hinder detection by sound or vision
- State of visibility, state of sea and weather condition
- Traffic density and other activities at sea in the vicinity of the vessel's track
- Traffic separation or routeing schemes and the attention required in these
- The fitness for duty
- Experience of each OOW
- Familiarity of each OOW with the vessel's equipment, procedures and manoeuvring characteristics
- Rudder and propeller control and manoeuvring characteristics
- Activities taking place on the bridge, for example, communication and the availability of additional help
- The operational status of bridge instrumentation and controls, including alarms
- Knowledge of, and the Master's confidence in, the professional competence of the vessel's officers and crew
- Additional workload caused by the nature of the vessel's functions, including immediate operating requirements and anticipated manoeuvres
- Any other relevant standard, procedure or guidance related to watchkeeping arrangements and fitness for duty.

When deciding on the composition of the bridge watch, which may include appropriately qualified ratings, these factors must be considered:

- The bridge must not be left unattended at any time
- Daylight/darkness, visibility and weather conditions
- Need for the OOW to carry out additional duties in proximity to navigational hazards
- Use and operational condition of navigational aids (such as radar or electronic position-indicating devices) and any other equipment affecting the safe navigation of the ship
- If the ship is fitted with operational autopilot
- The need to perform radio duties
- Unattended machinery space (UMS) controls, alarms and indicators provided on the bridge, procedures for their use and any limitations they may have

- Any unusual demands on the navigational watch that may arise as a result of special operational circumstances.

5.1.1.2 Change in Watch Levels

Circumstances change during the voyage and it may be necessary to review the manning levels of a navigational watch. The following factors can be categorised as a change in circumstances, (but the list is not exhaustive).

- Prevailing traffic conditions
- Prevailing weather conditions
- The nature of the waters in which the vessel is navigating
- Fatigue levels and workload on the bridge
- Changes to the operational status of the bridge equipment
- Emergency situations
- Activities with which the vessel is involved.

5.1.1.3 Sole Lookout

In open sea conditions or when well away from dangers during daytime, the OOW may be the only person responsible for navigation. Although the lookout may be employed on other bridge-related duties at this time, he may be summoned (when required) by the OOW.

In such situations the vessel would be steered by autopilot. This is permitted under the STCW '95 Code. If this is to be practised on any vessel, the shipboard operational procedure manual or the Safety Management System should give clear guidance. The Master's standing orders should also clarify the precise procedure to be followed. This guidance is also required:

- The circumstances under which sole lookout watchkeeping can commence.
- How sole lookout watchkeeping should be supported.
- The circumstances when sole lookout watchkeeping must be suspended.

The Master should be satisfied with regard to the following conditions on each occasion before sole lookout watchkeeping may commence.

- That the OOW has had sufficient rest before commencing his watch
- That the OOW confirms it is well within their capacity to maintain a proper lookout and remain in full control of the prevailing circumstances
- That the OOW is aware of the back up assistance that has been designated for the bridge and who they should call for assistance
- That all designated backup personnel are aware of response times, the limitations on their movements, and can hear alarms or communications from the bridge. There should be two-way radio contact between the bridge and one of the designated persons
- That all essential equipment and alarms on the bridge are fully functional.

This is an example of a guide to watch-composition in varying conditions:

Open sea – Day	OOW on bridge, lookout on call in close proximity to bridge and with a radio. The Master on call.
Open sea – Night	OOW and lookout on bridge. The Master on call.
Coast – light traffic	OOW and lookout on bridge. The Master on call.
Coast – heavy traffic	OOW, lookout and helmsman on bridge. The Master where required.
Congested waters	The Master and the 3rd Officer or the Chief Officer and the 2nd Officer, plus lookout and helmsman on the bridge (6 hour watches, if for a prolonged period).
Restricted visibility	Master and 3rd Officer or the Chief Officer and the 2nd Officer, the lookouts and helmsman on the bridge (6 hour watches, if for a prolonged period).

5.1.2 Engineering Watch

Watch arrangements in the engine room depend on whether the ship is UMS classified or not. On a UMS classified ship the engine room may be unattended, particularly at night. For ships that are not UMS classified, round-the-clock watches are maintained in the engine room. There will be circumstances where watchkeeping arrangements will be over and above the normal routine of watchkeeping in the engine room.

The Master needs to ensure that adequate watches are being maintained in the engine room. This is achieved by advising the Chief Engineer of the prevailing circumstances and conditions and any factors affecting the safety of the ship. Circumstances that demand manoeuvring the engine on standby (SBE) will call for extra and expert help in the engine room. Any manning constraints in the engine department should be kept in mind when demanding watchkeeping in the engine room. However, the safety of the vessel comes first and foremost.

This is a guide to watch arrangements for machinery spaces:

Open sea	UMS – Engineers on routine maintenance and attending to alarms
Coast- Light traffic	UMS – Engineers on routine maintenance and attending to alarms
Coast – Heavy traffic	Engine watch – duty engineer in engine room
Restricted visibility	SBE – duty engineer in engine room
Approach channels	SBE – senior engineer, junior engineer
Pilotage waters	SBE – senior engineer, junior engineer

The bridge team should keep the engine room informed of any change in circumstances that will require a change in machinery status or an SBE for manoeuvring. This notice time may be specified in the SMS or, if not, it should be agreed between the Master and the Chief Engineer, based upon engine specifications and manning levels in the engine room.

For SBE, the engineers will:

- Change the main engine from heavy fuel oil to diesel oil
- Keep the starting-air bottles topped up
- Have the start air compressor running
- Check lines and valves to ensure smooth and uneventful manoeuvring
- Standby at the engine control and telegraph for running the engine required to the instructions from the bridge.

The bridge team may not have advanced warning of emergencies or difficult conditions developing. Where they do, they should advise the engine room of the required changes as soon as possible.

The OOW should keep the engine room and duty engineer informed about developments. Communications between the bridge and the engine room should include (but not be limited to).

- Synchronisation of clocks
- Testing controls
- ETA and ETD - and any changes to these times
- Exact times when the SBE is required for ending the sea passage
- Requirements of any services, for example running pumps, power in deck machinery
- The development of emergencies
- Time to anchoring or time to berthing
- The ship entering or leaving a special area and the distance from land for pollution prevention purposes
- Any deviations from normal plans, for example the pilot's boarding time.

In case of UMS operations, if engineers are required to enter the machinery space to attend alarms, the bridge must be notified and the 'dead man alarm' should be activated immediately on arrival in the machinery space and should be reset within specified intervals. Failure to do so may require a search for the engineer inside the machinery space.

5.1.3 Fitness for Watch and Rest Periods

The STCW '95 Code advises governments to set a maximum blood alcohol level of 0.08% for ship's personnel during watchkeeping and to prohibit the consumption of alcohol within 4 hours of starting a watch. Some companies, flag state administrations and port states may exercise more stringent policies.

The STCW '95 Code has laid down regulations for mandatory rest periods for members of bridge team in order to prevent fatigue.

The STCW Code has stipulated that:

- Rest periods of at least 10 hours in any 24-hour period are required
- If rest is taken in two periods, one of those periods must be at least 6 hours
- The minimum period of 10 hours may be reduced to not less than 6 consecutive hours provided that any such reduction does not extend beyond two days, and that not less than 70 (in case of UK 77) hours rest is provided during each seven-day period.

The OOW must ensure that the mariner assigned to watchkeeping duties:

- Has been given instructions in keeping lookout
- Knows what is expected of a mariner
- Knows how and what observations to report
- Is suitably dressed and protected from the weather
- Is complying with the working hours legislation and that frequent relief is possible.

5.2 Keeping Watch

The officer in charge of the bridge watch and all supporting the watch should be aware of the SMS procedures, layout of the bridge and the use of the equipment.

5.2.1 Familiarisation with Bridge Equipment

The OOW should fully understand the operation of this equipment:

- Bridge and deck lighting
- Emergency arrangements in the event of main power failure
- Navigation and signal lights, including searchlights, signalling lamps and morse light and sound signalling apparatus and whistles
- Fog bell and gong system
- Safety equipment, including LSA equipment , pyrotechnics, EPIRB and SART and bridge fire detection panels
- General and fire alarm signalling arrangements
- Emergency pump, ventilation, water-tight door controls and internal ship communications facilities, including portable radios
- Emergency hand-powered or wind up phone system
- Public address system
- External communication equipment, including VHF, GMDSS and AIS

- Alarm systems on bridge
- Echo sounder, electronic navigational position fixing systems gyro compass/repeaters, magnetic compass, off-course alarm
- Radar, including ARPA
- Speed/distance recorder, VDR (see 1.9)
- Steering gear, including manual, auto-pilot, emergency changeover and testing arrangements
- Engine and thruster controls
- IBS functions (if fitted) and automatic track-keeping system (if fitted) (see 9.4)
- ECDIS and electronic charts (if fitted) (see 9.3.3)
- Location and operation of ancillary bridge equipment (for example, binoculars, signalling flags and meteorological equipment)
- Stowage of chart and hydrographic publications.

5.2.1.1 Steering Gear Tests

After prolonged use of the autopilot, and before entering coastal waters, test the steering gear at all of the manual steering positions on the bridge. In coastal and congested waters more than one steering gear power unit should be used when such units are capable of simultaneous operation. 12 hours before departure, check and test the steering gear, including the operation of these (as applicable):

- The main steering gear
- The auxiliary steering gear
- The remote steering control systems
- The main steering position on the bridge
- The emergency power supply
- The rudder angle indicators in relation to actual rudder position
- The remote steering gear control system power failure alarms
- The steering gear power unit failure alarms
- Automatic isolating arrangements and other automatic equipment.

Conduct similar checks and tests before arrival.

Checks and tests should also include:

- The full rudder movement (according to the specifications of the steering gear)
- The timing of rudder movement from hardover-to-hardover, to ensure compliance with the requirement
- A visual inspection of the steering gear and its connecting linkage
- The operation of the means of communication between the steering gear compartment and the bridge/engine room control.

5.2.1.2 Changeover Procedures

The change-over from automatic to manual or vice-versa should be done by either the Master or the OOW. If not, the change should be under their supervision. All officers concerned with the operation or maintenance of the steering gear should acquaint themselves with the change-over procedures. Instructions for changing-over from automatic to manual steering (and vice-versa) should be posted at the steering control position on the bridge.

5.2.1.3 Emergency Steering Drills

Emergency steering drills should take place at least every three months (and 24 hours before entering US Waters). They must include direct control from the steering gear compartment, the communications procedure with the bridge and, where applicable, the operation of alternative power supplies. As many deck officers, cadets and ratings as possible that are responsible for steering should take part in these drills. The dates on which these checks and tests are conducted and the date and details of emergency steering drills carried out must be recorded in the official logbook.

5.2.1.4 Auto Pilot Regulations

- Automatic pilot should not be used in coastal or estuarial waters unless a change-over can take place within 30 seconds
- Hand-steering should be engaged once every watch
- If the ship is being steered on automatic pilot, the services of a qualified helmsman should be available to the OOW. The helmsman may be engaged on duties in the immediate vicinity of the bridge so that the OOW can summon him at any moment
- The change-over from automatic to manual steering should take place under the supervision of the Master or OOW. Instructions for change-over should be displayed at (or near) the steering console.

(US Regulation: If the ship is being steered by automatic pilot and the hand-steering wheel is turned, an alarm should sound).

5.2.2 Keeping the Watch

The OOW is the Master's representative and is responsible at all times for the safe navigation of the ship and for compliance with the International Regulations for Preventing Collisions at Sea.

As the Master's representative, the OOW is in charge of the bridge and the bridge team for that watch until properly relieved by the Master or another watchkeeping officer. The OOW should ensure that bridge watch manning levels are at all times safe for the prevailing circumstances and conditions, in compliance with shipboard operational procedures and the Master's standing orders. Procedures for handing over the watch and calling for support on the bridge should be in place and understood by the OOW.

5.2.2.1 Duties of the OOW

In order to maintain a safe navigational watch, the OOW will perform watchkeeping, navigation and GMDSS radio watchkeeping duties, including:

- Maintaining a lookout
- General surveillance of the ship
- Monitoring the progress of the ship and fixing position
- Collision avoidance in compliance with the International Regulations for Preventing Collisions at Sea
- Recording bridge activities
- Making periodic checks on the navigational equipment in use.

The navigational duties of the OOW are based upon the needs to execute the passage plan safely and to monitor the progress of the ship against that plan.

Under GMDSS, the OOW will be responsible for maintaining a continuous radio watch at sea. During distress incidents, one of the qualified radio personnel should be designated to have primary responsibility for radio communications. On passenger ships, that person can have no other duties during a distress situation.

The OOW needs to understand the means and best practices of controlling the speed and direction of the ship, the handling characteristics and stopping distances. Helm, engines and sound signalling apparatus are at the OOW's disposal and he should not hesitate to use them at any time.

The OOW also needs to be fully conversant with shipboard obligations with regard to pollution prevention, reporting and emergency situations. The OOW should know the location of all of the safety equipment on the bridge and how to operate that equipment.

In certain circumstances, a helmsman will have to be employed in addition to the lookout. (Note: a helmsman is not a lookout).

It is the responsibility of the officer of watch to ensure that the vessel is being steered safely and efficiently. The OOW also needs to ensure that the helm orders are clearly understood and complied with as required.

5.2.2.2 Additional Duties

There may also be a number of additional duties for the OOW to undertake while on watch. General communications, cargo monitoring, the monitoring and control of machinery and the supervision and control of ship safety systems are typical examples. Additional duties should, under no circumstances, interfere with the exercise of primary duties.

5.2.2.3 Bridge Attendance

The OOW should not leave the bridge unattended. However, if it is safe to do so, on a ship with a separate chartroom the OOW may visit that room for short periods of time to carry out necessary navigational duties.

5.2.2.4 Changing Over the Watch

The OOW should not hand over the watch if there is any reason to believe that the relieving officer is unfit - or is temporarily unable - to carry out the watchkeeping duties effectively. If there is any doubt, the OOW should call the Master. Reasons for unfitness for duty could be illness, the effect of drink, drugs or fatigue.

The OOW should understand the Master's night orders or standing instructions, if any, before taking over the watch. Before taking over the watch, the relieving officer must be satisfied as to the ship's position and confirm its intended track, course and speed, and engine controls as appropriate, noting any dangers to navigation he may expect to encounter during the watch. The relieving officer should also be satisfied that all other members of the bridge team for the new watch are fit for duty, particularly with regards to their adjustment to night vision.

If a manoeuvre or other action to avoid a hazard is taking place at the moment the OOW is being relieved, handover should be deferred until that action has been completed.

5.2.2.5 Calling the Master

In accordance with standing orders or special instructions, the OOW should notify the Master if unsure of the appropriate action for the safety of the ship. Guidance on specific circumstances for calling the Master or other back-up support should be given in the SMS, supported by standing orders and bridge orders as appropriate. The Master should always be notified in these circumstances:

- If movement of other ships or traffic condition is causing concern
- If difficulties are experienced in maintaining the course
- If restricted visibility is encountered or expected
- When making landfall

- When a distress signal or unusual warning is received
- On failure to sight land, a navigational mark or obtain soundings by the expected time
- If, unexpectedly, land or a navigational mark is sighted or a change in soundings occurs
- On breakdown of the engine(s), propulsion machinery remote control, steering gear or any other essential navigational equipment, alarm or indicator
- If radio equipment malfunctions
- In heavy weather, if there is doubt about the risk of weather damage
- If the ship meets any hazard to navigation, such as ice or a derelict
- In any other emergency or position of doubt.

The OOW will continue to be responsible for the watch, despite the presence of the Master on the bridge, until informed specifically that the Master has assumed that responsibility and that this is mutually understood. That the Master has taken control on the bridge should be recorded in the logbook.

5.2.3 General Watchkeeping

5.2.3.1 Maintaining a Look-Out

The bridge team on watch must give their full attention to lookout duties. In compliance with the International Regulations for Preventing Collisions at Sea and general watchkeeping standards, a proper lookout must be maintained at all times to serve the purposes of:

- A continuous state of vigilance by sight and hearing and by all other available means, watching for any significant change in the operating environment
- Appraisal of a situation and the risk of collision, stranding and other dangers to navigation
- Detection of ships or aircraft in distress, shipwrecked persons, wrecks, debris and hazards to safe navigation.

On ships with fully enclosed bridges, sound reception equipment should be in operation continuously, and should be correctly adjusted to ensure that all audible sounds on the open deck can be clearly heard on the bridge.

5.2.3.2 Sole Lookout

Under the STCW '95 Code, the OOW may be the sole lookout in daylight provided that on each occasion, "the situation has been carefully assessed and it has been established without doubt that it is safe to operate with a sole lookout".

Take full account of all relevant factors, including but not limited to:

- State of weather
- Visibility
- Traffic density
- Proximity of dangers to navigation
- The attention required when navigating in or near traffic separation schemes.

When deemed necessary, summon assistance immediately to the bridge. If sole lookout watchkeeping practices are to be followed, provide clear guidance on how they should operate in the SMS

5.2.3.3 General Surveillance

If circumstances and navigational safety allows, the OOW should endeavour to maintain general surveillance of the deck and cargo during the watch. The OOW needs to maintain a high level of general awareness about the ship and its routine – that is, day-to-day operations. This may include maintaining a general watch over the ship's decks to monitor, where possible, people working on deck, and any cargo or cargo handling equipment. The OOW may have to carry out such surveillance before watch, especially in cases of heavy weather. Special watchkeeping arrangements may be appropriate in waters where there is thought to be a risk of piracy or armed attack.

Whenever work is being carried out on deck in the vicinity of radar antennae, radio aerials and sound signalling apparatus, the OOW should be particularly observant and should post appropriate warning notices on the equipment controls. If possible, disconnect the power supply to that equipment. If these items of equipment have to be used, the work should stop.

5.2.3.4 Recording Bridge Activities

A formal record of navigational activities and incidents, which are of importance to the safety of navigation and are part of passage plan execution, should be kept in appropriate logbooks.

Paper records from course recorders, echo sounders and NAVTEX receivers should be retained for the period stipulated in the SMS. These paper records should be dated and time-marked.

To allow the ship's actual track to be reconstructed at a later stage, sufficient information concerning position, course and speed should be recorded in the bridge logbook or using approved electronic means. All positions marked on the navigational charts also need to be retained until the end of the voyage. The Voyage Data Recorder (VDR) would automatically record most of these, but the above practice confirms that the watch officers are performing their tasks efficiently.

5.2.3.5 Periodic Checks On Navigational Equipment

Operational checks on navigational equipment should be undertaken when preparing for sea and prior to port entry. After lengthy ocean passages and before entering restricted coastal waters, it is important also to check that full engine and steering manoeuvrability is available. The OOW should undertake daily tests and checks on the bridge equipment, including the following:

- When the automatic pilot is in use, manual steering should be tested at least once a watch
- Gyro and magnetic compass errors should be checked once a watch, where possible, and after any major course alteration
- Compass and gyro repeaters should be synchronized. This procedure includes any repeaters mounted off the bridge (such as in the engine control room) or at the emergency steering position.

Checks on electronic equipment should both confirm that the piece of equipment is functioning properly and that it is successfully communicating to any bridge system to which it is connected. Built-in test facilities provide a useful health check on the functional state of the piece of equipment and should be used frequently. Electronic equipment systems should be checked to ensure that configuration settings, important for correct interfacing between pieces of equipment, have not changed. To ensure adequate performance, information from electronic equipment should always be compared and verified against information from different independent sources.

Good practice also requires the OOW to check that orders are being correctly followed. For example, rudder angle and engine rpm indicators provide the OOW with an immediate check on whether helm and engine movement orders are being followed.

5.2.3.6 Manoeuvring Data

The ship's manoeuvring data is contained on the Pilot Card and Wheelhouse Poster. Some ships also have a manoeuvring booklet, and the OOW needs to be familiar with this data. On the Pilot Card, you must record the ship's draught and any permanent or temporary idiosyncrasies that could affect manoeuvrability. For example, a ship may have a tendency to steer to port at full speed and but steer to starboard at slow speed.

To control the main engines effectively, the OOW should be familiar with their operation from the bridge and with the operation of the propeller mechanism. The OOW should also be aware of any limitations the system may have, and appreciate that the type and configuration of the ship's engines could have implications when changing speed. Direct-drive diesel, diesel through gearbox/clutch, turbo-electric and gas turbine engines all have relatively quick responses to change, provided that the engines are on stand-by. Geared turbines are less responsive.

5.3 Navigation

It is important that the OOW executes the passage plan as prepared and monitors and records the progress of the ship, relative to that plan. If the OOW has to make a temporary deviation from the passage plan for any reason, he should return to the original plan as soon as it is safe to do so. At the first opportunity, the OOW should advise the Master of the actions taken. The plan will need to be formally amended and a briefing made to the other members of the bridge team. In good practice, the amendment should have been available as a contingency plan. Good navigational practice demands that the OOW:

- Understands the capabilities and limitations of the navigational aids and systems being used and continually monitors their performance
- Uses the echo sounder to monitor changes in water depth
- Uses dead reckoning (DR) techniques to check position fixes
- Cross checks position fixes using independent sources of information. This is particularly important when electronic position-fixing systems such as GPS or Loran-C are used as the primary means of fixing the position of the ship
- Uses visual navigation aids to support electronic position-fixing methods i.e., landmarks in coastal areas and celestial navigation in open waters
- Does not become over reliant on automated navigational equipment, including ECDIS, thereby failing to make proper navigational use of visual information.

Care should also be exercised when taking geographical positions from electronic position-fixing systems, like GPS, and plotting them on to charts. The OOW should bear in mind that:

- If the chart datum differs from the datum (usually WGS84) used by the electronic position-fixing system, a datum shift will have to be applied to the position co-ordinates before they are plotted on the chart. It should be noted that where an appreciable datum shift does exist for a particular chart, a 'satellite-derived position' note, providing latitude and longitude datum shift values, will appear on the chart
- On charts whose survey source data is very old, the accuracy of those charts may be poor in certain areas. Under these circumstances, the OOW should not rely totally on position-fixing using electronic systems, and should (where possible), use visual and radar navigational techniques to maintain a safe distance off the land.

5.3.1 Navigation in Coastal or Restricted Waters

As a general rule, navigation should be carried out on the most suitable large-scale charts onboard, and the position of the ship should be fixed at a planned frequency. All relevant navigation marks should be positively identified by the OOW before they

are used. Visual and radar position fixing and monitoring techniques should be used whenever possible.

In coastal waters, the OOW should be aware that ship routeing schemes and ship reporting systems, that require reports to be made to coast-radio and vessel-traffic stations, may exist.

Knowledge of the ship's draught, stability conditions and manoeuvring characteristics is also important. As the ship enters shallow water, squat may have a critical effect on the manoeuvrability of the ship and cause an increase in draught. Squat effect varies in proportion to the square of the ship's speed, and will therefore reduce as speed is reduced.

5.3.2 Anchoring

When approaching an anchorage, the passage and anchoring plan should be followed. Account should be taken of the following when preparing the anchor plan:

- Speed reduction in ample time
- Direction and strength of wind, current and tidal stream
- Height of tide
- The tidal stream when manoeuvring at slow speeds
- That there is adequate sea room, particularly to seaward
- The depth of water, nature and type of seabed and the scope of cable required.

Before entering a restricted area and making the final approach:

- The engine room and anchor party should be informed of the time of anchoring
- Anchors, lights/shapes and sound signalling appliances must be ready.

On anchoring, a fix on the anchor let go position should be made and the ship's swinging circle marked. The anchor position should be communicated to the port authority or VTS. While at anchor, the OOW should:

- Determine and plot the ship's position on the appropriate chart. Take bearings of fixed navigational marks or readily identifiable shore objects to maintain a check on the anchor position and to ensure that the ship does not drag its anchor. Make checks on the UKC. Use the GPS anchor alarm to check the position, particularly when using DGPS mode
- Observe meteorological and tidal conditions and the state of the sea
- Pay particular attention to the anchor position after a change of tide
- Record any wind shift or change of weather
- Ensure that the state of readiness of the main engines and other machinery is in accordance with the Master's instructions.

- A proper lookout must be maintained and ship inspection rounds periodically made, particularly if the ship is anchored in waters that could present a risk of attack by pirates or armed robbers
- Ensure that the ship exhibits the appropriate lights and shapes and that sound signals are made in accordance with all applicable regulations
- Take measures to protect the environment from pollution by the ship, complying with applicable pollution regulations
- Notify the Master and take all counter measures if the ship drags its anchor
- Immediately notify the Master if either sea conditions or visibility deteriorates.

5.3.3 Towing And Navigation

A vessel may be required to use the services of tugs for various reasons. These can be divided into two broad categories, Ocean and Harbour/Coastal. These two categories can be subdivided further:

Ocean	Towing ships in distress or in danger. Towing ships for delivery to repair facilities. Towing dumb lighters (barges) for cargo transport. Towing larger off shore installations (rigs).
Harbour/Coastal	For ease of ship handling (pulling, pushing). Escort services. Towage services into and out of harbour. Standby services. Supply and handling. Engagement in event of grounding or collision.

5.3.3.1 Factors Influencing Choice of Tugs

In harbour tugs will be provided by the port authority or the terminal operator. Consider these factors:

- Size (displacement) and type of the vessel requiring assistance
- Sea room available for manoeuvring
- Proximity of dangers
- Bollard-pull of the tugs available
- Manoeuvring/handling characteristics of the tugs available
- Prevailing weather conditions
- Effects of current or tidal stream
- Windage area – loaded or in ballast/high sided (draught, freeboard)

In the event of ocean towage, the tug will be contracted by the owners/managers. Consider these questions:

- Size (displacement) and type of the vessel to be towed
- Length of the voyage
- Speed at which towage is to take place (power)
- Climatic and prevailing weather conditions
- Power available on the towed vessel
- Whether the towed vessel is to be manned
- Can the towed vessel be steered
- Can the towed vessel use her anchor
- Proximity of dangers
- Fuel capacity of the tug
- Fire fighting capabilities of the tug
- Handling capabilities of the tug

5.3.3.2 Navigational Considerations

Harbour or coastal, consider these points:

- Identity of the tugs
- Communications (VHF channels and vocabulary)
- Engagement position
- Engines on standby
- Readiness of ship's crew (deck party)
- Location of securing tugs lines, tugs or ships lines
- Speed and heading at the point of engagement
- Possibility and awareness of interaction
- Speed during the operation
- Execution of planned manoeuvres
- Possibility and awareness of girting
- Recommendations in the sailing directions
- Signals and flags to be displayed
- Command authority (obviously the ship)
- Contingency planning
- Area of operation
- Route to be followed

- Proximity of hazards
- UKC
- Times of engagement and termination
- Prevailing weather
- Record keeping

Ocean:

- Identity of the tug(s)
- Communications (VHF channels)
- Rendezvous position (in the event of ocean towage the towed vessel would likely be disabled and will therefore require the tug(s) to come to her)
- Destination and any impending hazards
- Any intermediate destinations for refuelling
- Climate, prevailing and forecast weather
- Proximity of hazards
- Preparation and agreement of the passage plan
- Recommendations laid down in the sailing directions
- Advice and recommendations (tow is categorised as a low powered vessel) in the Ocean Passages for the World (shortest route may not be the quickest route)
- The speed of towing in different weather conditions
- Contingency planning for emergencies / bad weather / parting of tow line
- Continuous radio contact between two vessels
- Command authority (if the tow is unmanned all responsibility lies with the tug)
- Possibility of steering the tow
- Life saving appliances for the crew of tow
- Agreement on direction and speed of commencement of towing operation (usually upwind)
- Agreement on procedures to be followed while altering course (should be done in small steps, gradually)
- Monitoring of the strain on the towline (on long ocean passage, preferably some part of the towline should be in water)
- Recommendations obtained from weather routeing services
- Hazards (ice, fog, strong winds) on the route
- Expected traffic
- Allocations of duties

- Readiness of anchors of tow in shallow waters
- Record keeping.

5.3.3.3 Signals and Communications

Night: If the length of tow exceeds 200 m, the towing vessel will display 3 masthead lights in a vertical line. If she is 50 m or more in length, another masthead light is required. The other lights are side lights, stern light and a towing light vertically above the stern light. The vessel being towed will display side lights and a stern light.

Day: If the length of tow exceeds 200 m, the towing vessel and the vessel being towed will display a black diamond where it can be seen most clearly.

If the towing vessel is restricted in her ability to manoeuvre, the towing vessel will display red, white and red all round lights in a vertical line. During daytime, she will display a black ball, a diamond and a ball in a vertical line where they can be seen most clearly.

At night, use a search light to illuminate the towline.

A SECURITE message can be transmitted to inform shipping in the vicinity. It can also be used to keep the coast stations notified of progress.

In case of ocean towage, special attention should be paid at the start, during passage through shallow waters, coastal waters and at the termination. If the tow is in confined waters at the start, it would be essential to use harbour tugs for assistance till the ship is in clear waters and the ocean-going tug can then exercise control over her. The same routine may be followed at the termination if the ship is to proceed in confined waters. In confined waters, the length of the towline will have to be shorter as it should never drag along the seabed. As the length reduces, strain will increase, and so speed should be eased to minimise the strain.

5.3.4 Offshore Navigation

Navigation in the vicinity of offshore installations needs careful consideration. Proximity to busy shipping lanes makes matters worse. Special care needs to be exercised if approaching this type of vessel.

Offshore exploration in an area starts with a seismic survey. This may be performed by towing an object at the end of a very long wire and caution must be exercised around them.

5.3.4.1 Rigs

Mobile rigs are used for drilling wells. Jack-up rigs can be used in depths down to about 120m and are towed into drilling position, where their steel legs are lowered to the seabed. The drilling platform is kept jacked-up clear of the water. Semi-submersible rigs consist of a platform on columns that rise from a caisson submerged deep enough to avoid many of the effects of sea and swell. These can be used in up to 1700m in an anchored mode. In dynamic positioning (DP) mode, they can be used in depths greater than 1700m. Drill ships are used in depths of less than 200m through the use of an 8-point anchor system. With dynamic positioning, drilling can be done in depths of between 2000m and 6000 m below the seabed.

- Rigs are marked by illuminated name panels, lights, obstruction lights and fog signals. Flares burn at times for the disposal of unwanted oil or gas. Mobile rigs on station are not charted
- Buoys and other obstacles are often moored near rigs and anchors wires, chains and obstructions often extend as far as one mile
- A standby vessel and other small craft may be in attendance. Installations usually have a safety zone
- The rig should be given a wide berth
- During the course of development, large structures may be moved without notice. On some charts, such areas are designated development areas and their limits are shown. Mariners are strongly advised to keep outside of the development areas
- Drilling could be done at an angle to the vertical, extending well beyond the base of the rig
- Positions are given by Radio navigational warnings or Temporary notices. NAVTEX. In Navarea I these are published weekly in SafetyNET and are reprinted in Section III of Admiralty Notices to Mariners

5.3.4.2 Wells

Numerous wells could be drilled during a development. Some are sealed with cement below the seabed and abandoned (Plugged and Abandoned). Those required at a later date are termed Suspended wells. These usually extend 2m to 6m above the sea bed. In some cases, an extension could be 15m above the seabed. Those in use are termed Production wells and may be protected by a 500m exclusion zone. Production wells, and in some cases, Suspended wells, are marked by buoys or light-buoys. Wells are shown on a chart as a danger circle.

5.3.4.3 Platforms

Piled steel structures have legs drilled into the seabed. Concrete structures stay in position by gravity. Tension Leg platforms consist of semi-submersible platforms secured to flooded caissons on the seabed below by wires, kept in tension by the buoyancy of the platform.

A number of wells may be drilled from one rig. A template placed on the seabed below the rig is used to guide the drill. A template may be as much as 15m above the seabed. Platforms may stand in singles or in complex structures connected with bridges or underwater cables.

Platforms are marked by:

- Illuminated name panels displaying the registered name (at least one panel visible from any direction)
- A white light flashing Morse code (U) every 15 seconds. Visible 15 miles all round the horizon. Elevation 12m to 30m
- Secondary lights with the same characteristics, but only visible for 10 miles. They are automatically brought into operation on the failure of the lights
- Red lights, flashing Morse code (U) in unison with each other, every 15 seconds, visible 2 miles, exhibited from the horizontal extremities of the structure that are not already marked by main light or lights (obstruction lights)
- Fog signals sounding Morse code (U) every 30 seconds, audible at a range of at least 2 miles

In addition to the list above, the platform may well also be burning gas

Platforms are charted and may be mentioned in sailing directions. Drilling rigs or barges, which may be up to 1 mile from them, may not be charted. This ancillary equipment may be marked by buoys.

5.3.4.4 Mooring Systems (Single Point Moorings - SPM)

Catenary Anchor Leg Moorings (CALM) have a large buoy on the surface that does not turn when the ship swings to wind or tide. It is moored by 4 or more anchors which may lie up to 400m from the buoy. Mooring hawsers and cargo hoses lead from the buoy through a turntable mounted on top.

A Single Anchor Leg Mooring (SALM) has a rigid frame with a buoyancy device at its upper end. Its lower end is secured on a large steel or concrete base resting on the seabed. The upper connects to a mooring buoy by a chain or wire span. Oil flows into the frame through a universal joint. The buoy may swing with the vessel and is likely to tilt in that direction. It is particularly suited to loading from deep water sub-sea wellheads.

A Single Anchor Leg Storage (SALS) is a SALM-type of mooring system that is permanently attached to the stem or stern of a storage tanker through a yoke supported by a buoyancy tank. Tankers secure to the storage tanker to load.

An Exposed Location Single Buoy Mooring (ELSBM) is used in deep water where bad weather is frequent and has a large cylindrical floating structure, which is surmounted by a helicopter platform. It has emergency accommodation and its anchors may lie up to half a mile from the structure.

A SPAR mooring is similar to ELSBM, but has a larger floating structure that accounts for its storage capacity, allowing continued production even in adverse weather. It is permanently manned.

An Articulated Loading Column (ALC) is a modification of SALM with the anchor span and buoyant frame or tube replaced by a metal lattice tower, buoyant at one end and attached to the other by a universal joint to a concrete-filled base on seabed. In bad weather, a tower may be inclined at angles of up to 20 degrees from vertical. Mooring Towers are not SPMs and are secured to the seabed, surmounted by a turntable, and used to moor ships.

5.3.4.5 Submarine Pipelines

Laid on the seabed for the conveyance of oil, gas and water, they may extend many miles into the sea and may be buried, trenched or stand up to 2m above the seabed. Pipes that were originally buried may become exposed over time. Some pipes have joints or manifolds that extend up to 10m above the seabed. Anchoring and trawling should not be carried out in the vicinity of pipelines. Pipes contain dangerous, explosive substances. In addition to the fire hazard, a ship may loose buoyancy due to gas leaking from a ruptured pipeline.

5.3.4.6 Navigation in Offshore Areas

- Navigational warnings for towing large objects, rig movements, establishment or changes to areas of activity, and seismic survey are usually provided. Update the charts with relevant warnings
- If a vessel needs to transit the area, the passage plan should be prepared to keep the vessel well clear of the safety zones and within the safety fairways
- Vessels should stay clear of safety zones as marked on the chart or advised by warnings. A minimum safe distance of 500m must be maintained in the absence of information on the safety zone. Safety zones and positions of structures + 500 m should be marked as no-go areas
- The passage plan notes should include warnings on reduced soundings and the use of echo sounder
- Notes should also include details on the identification of structures and warning on problems with identification. Alternate primary and secondary methods of monitoring, other than through the use of offshore structures, should be listed, including the use of visual, radar and electronic systems
- Maintain a sharp lookout in the area for the movement of support and supply vessels and buoys, some of which may not be lit
- "No anchoring" should be marked clearly. Base contingency plans on emergency actions other than anchoring
- When in the area, mark the direction of set due to current on the chart and update it with the direction of leeway (when in the area)
- Maximum speed, considering the manoeuvring characteristics of the vessel and proximity to hazards, should be noted in the passage plan
- Usual remarks like, notices, hand steering, the Master's calls, doubling watches and lookouts should also be entered in the passage plan.

Authors Note:

While the stipulated safety zone around an offshore platform is 500m, it is better practice to chart courses 1'-2' off such platforms as an approach of 500m will cause panic to the Stand-by vessel.

5.3.5 Collision Avoidance

It is beyond the scope of this book to discuss every regulation concerning collisions. Only the basic practices are given here and these are the ones that apply at all times in any scenario.

5.3.5.1 Signals

The OOW must always comply with the International Regulations for Preventing Collisions at Sea. Compliance not only concerns the conduct of vessels under the steering and sailing rules, but also covers displaying the correct light, shape, sound and light signals.

For example, a vessel drifting off a port with her engines deliberately shut down is not a 'vessel not under command' (NUC) as defined by rule 3(f) of the COLREGS. However, a vessel drifting with her engines under repairs is considered NUC.

Always observe caution when approaching other vessels. Vessels may not be displaying their correct light or shape signals or, when approached from a certain direction, their signals could be badly positioned and obscured by the ship's structure.

5.3.5.2 Lookout

Lookout should be maintained by all available means, including sight and hearing. Radar, AIS and VHF are useful in support. VHF radio should not be used for collision-avoidance purposes. Valuable time can be wasted attempting to make contact, since positive identification may be difficult and once contact has been made, misunderstandings may arise. This should apply even when identity is known through AIS. VHF calls for collision-avoidance should be avoided in restricted visibility. Action should be based upon COLREGS. A mutually-agreed solution that is contrary to COLREGS is NOT acceptable.

5.3.5.3 Safe Speed

In compliance with the International Regulations for Preventing Collisions at Sea, ships should proceed at a safe speed at all times. In restricted visibility, safe speed may require a reduction in service speed to reduce the stopping distance of the ship. Near ice, ships are specifically required to proceed at moderate speeds. Speed changes may be required to avoid a collision in circumstances where the ship is unable to alter course.

5.3.5.4 Risk Of Collision

In clear weather, the risk of collision can be detected early by taking frequent compass bearings of an approaching vessel to ascertain whether or not the bearing is steady and the vessel is on a collision course. Compass bearings eliminate the yaw of the ship's head. However, care must be taken when approaching very large ships, a ship under-tow or ships at close range. An appreciable bearing change may be evident under these circumstances but a risk of collision may still remain. In addition to a steady compass bearing, a reduction of range is also a significant factor for risk of collision.

5.3.5.5 Time to Take Action

The time to take action is important. The rules only suggest that it should be 'early' or in 'ample time'. There can be no clear mention of range or number of minutes before the risk of collision or close-quarters situation by when avoiding action should be taken. It all depends on how close a vessel is and at what rate it is closing.

If the bearing of a vessel at 10′ is steady and the range is only decreasing at 0′.5 per hour, there is no immediate risk of collision. But for the same vessel on a steady bearing, if the range was decreasing 3′ in 5 minutes, the situation is different and immediate action would have to be taken. 'Ample time' also means that the Master or the OOW has made a decision based on all of the available information, rather than in haste or with incomplete information. The stand-on vessel should be in no doubt at any time about the intentions of the give-way vessel.

5.3.5.6 Large Enough

The action should not just be large enough and readily apparent to another vessel observing, visually or by radar, it should be executed by the appropriate use of the helm as well. Avoid a succession of small alterations. A vessel planning to alter course by 60° and turning at the rate of 5° per minute is not making an alteration large enough to be readily apparent.

Another issue is that of relative plotting using radar. When own vessel is altering course, relative plotting cannot be performed. Similarly, if own vessel has not been on a steady course and speed for the period of observation, another vessel will not be able to calculate your course or speed accurately.

In general, early and positive action should always be taken when avoiding collisions. Once action has been taken, the OOW should always check to make sure that it is having the desired effect.

5.3.5.7 Passage / Safe Passage

A vessel's passage at a given time, can be described as the course being steered to maintain her charted track. Safe passage is based on the margins of safety, and the vessel must remain within these margins of safety after making an alteration to avoid another vessel. For example, a ship on a course of 040°T is on her passage. If the same ship has a margin of safety of 3 miles either side, and she can take action and

still stay within the margin of safety, her safe passage is within the margins of safety. This reasoning can also be used for vessels within a TSS.

- A vessel engaged in fishing is required to avoid impeding the passage of any vessel following the traffic lane. The vessel engaged in fishing is required to do so by allowing enough sea room for the vessel within the lane to maintain her course, that is, her passage
- A vessel of less than 20m in length (or a sailing vessel) is required to avoid impeding the safe passage of a power-driven vessel following a lane. If the power-driven vessel within the lane is able to take action and stay within the lane her safe passage the vessel less than 20m (or sailing vessel) may not have to take any action so long as there is no risk of collision or a close-quarters situation. However, if the power-driven vessel within the lane has traffic around her and/or is in close proximity to other hazards and may not be able to alter course, then her present course is her safe passage and should not be impeded.

In restricted visibility, conduct of vessels is specifically covered by the International Regulations for Preventing Collisions at Sea. In these conditions radar and in particular, automatic radar, plotting can be used effectively for assessing the risk of collision. The OOW should practice radar plotting and observation exercises in clear visibility, whenever it is possible.

In sea areas where traffic flow is regulated (such as port approaches and traffic separation schemes), it may be possible to anticipate movements from certain ship types. In these circumstances, it is good practice to allow extra sea room, if it is safe to do so.

5.4 Use of Pilot

5.4.1 Reasons

The employment of a marine pilot is of great assistance to the bridge team for the safe navigation of the ship. Pilots may be employed for a number of different reasons:

- Required by law under local regulation
- Local Knowledge
- Expertise in ship-handling and working with tugs.
- To overcome language difficulties and communication problems during piloting with
  - shore authorities, VTS
  - Tugs, Mooring Boats, Mooring Gangs

- Pilots have up to date information of hazards and have correct knowledge of local hydrographic details
- They are aware of local laws and regulations and variations to international regulations
- Know the latest weather forecast and local weather conditions

5.4.2 Initial Information Exchange

The ship is required to send some or all of this information to the pilotage or port authority before it can pick up a pilot. Details can be found in ALRS Vol 6.

- Ship identity: Name, Call sign, Flag, Agent, IMO Number, Ship type, Cargo type, Year built, Last port
- Communication info: Fax, Telex, VHF channel
- Pilot Boarding: ETA, Freeboard, Station
- Ship Particulars: Draught, Air draught, Length, Beam, Displacement, DWT, GT, NT
- Anchors and length of cable
- Manoeuvring details at current condition: Speeds, Min. Steerage speed, Propeller, CPP, Thrusters, Rudder, Hard over to hard over
- Main engine: Type, Power, Max No of engine starts, Time from full ahead to full astern
- Equipment defects.

The ship will need certain details from the pilotage or port authority. Some of this information will be available when making contact over the radio and some details will be provided by the pilot at the point of boarding.

- Name of the Pilotage Authority
- Pilot boarding instructions: Date, Time, Position, Side, Approach Course and Speed, Ladder, Height
- Berth and Tug Details: Prospects, Intended berth, Side alongside, Transit time, Tug engagement position, Number, Arrangement, Total bollard pull
- Local Weather and Sea conditions: Tide, Currents, Forecast weather
- Passage plan / emergency plan / abort point
- Regulations
- Traffic and Ship movement
- Communications and Reports
- Hazards / Navigational warnings.

5.4.3 Navigation With a Pilot on Board

Once the pilot has arrived on the bridge, he becomes a part of the bridge team. The pilot has a specialised knowledge of navigation in local waters and will advise the bridge team on the navigation of the ship. It is important that the responsibilities of the pilot and the Master are agreed and clearly understood.

The presence of a pilot does not relieve the Master or the OOW of their duties and obligations for the safety of the ship. Both should be prepared to exercise their responsibility to keep the ship away from danger.

5.4.3.1 Master/Pilot Information Exchange on Boarding

When the pilot is on board, the preliminary pilotage passage plan prepared in advance by the ship should be discussed and agreed by the pilot and the bridge team. There should be sufficient time and sea room to allow this to happen safely. Where lack of time or sea room prevent the plan from being discussed in detail, the main points should be covered immediately and the remainder discussed as soon as it is safe to do so. On a long pilotage passage, it may be appropriate to review and update the plan in stages.

Immediately on arrival the following information should be provided to the pilot:

- Current control particulars of the vessel, including course, speed, engine telegraph setting
- Completed Pilot Card, including ship's particulars, vessel's draught and displacement, air draught, manoeuvring characteristics, anchor details, bulbous bow, bow thrusters, type of anchors and no. of shackles on each
- Defects, if any, with relation to any bridge equipment and any machinery
- Intended passage plan to the berth
- Location of Life saving equipment that is intended for the Pilot's use in case of an emergency.

The Pilot should furnish the Master with:

- His identity
- His passage plan, including mooring plan, berthing details as to number of tugs, estimated time of deployment of tugs, where berthing to (port or starboard side), tide/current information, weather conditions, areas where speed alterations may be required
- Any new hazards affecting navigation (UKC, shoals, new wrecks, special operations being carried out, dredging, cable laying, maintenance of buoys)
- Any on-coming traffic likely to be encountered especially dredgers, RAM vessels, deep draught vessels
- Any new local regulations/laws effecting the vessel (any new reporting requirements)

The passage plan should be discussed and agreed with the pilot, including:

- Radio and Reporting points
- Bridge manning
- Use of tugs
- Berthing/Anchoring
- Expected traffic
- Change of pilot (if required)
- Crew for stations or standby
- Fenders.

5.4.4 Responsibilities

5.4.4.1 The Master

- In command of the vessel and responsible for overall safety
- Must ascertain credentials of the Pilot
- Must inform the pilot of the current status of the ship
- Discuss and agree the passage plan with the Pilot
- Ensures that the Pilot is informed of all essential and critical data regarding the vessel's manoeuvring and any peculiarities
- Monitors the advice of the Pilot and over-rides his actions (if required) to ensure the vessel's safety
- Ensure safe navigation of the vessel at all times, including UKC
- Ensures adequate manning arrangements for the entire operation
- Ensures that all personnel are well rested / fit for performing their duties safely, including the Pilot
- Ensures all navigational aids and machinery are operational

5.4.4.2 OOW

- Assists the Master and the Pilot with the safe navigation of the vessel
- Is the Master's representative and shall continuously monitor the vessel's progress as agreed in the passage plan
- Ensures the Pilot's instructions are carried out efficiently
- Shall immediately clarify any doubts with the Pilot and advise the Master immediately
- Monitors the performance of the helmsman and ensures the bridge equipment and engine status are in accordance with the Pilot's advice

- Liaises with deck and engine room personnel to arrange for relief
- Supervises the boarding and disembarkation of the Pilot
- Keeps the engine room and the deck team informed of progress
- Makes appropriate reports to VTS and to the port authorities
- Continuously monitors the vessel's position/UKC and ensures that the vessel is proceeding in safe waters at all times. Any deviation should be brought to the attention of the Master and Pilot immediately.

5.4.4.3 Pilot

- On boarding, must present his documents/identity card to the Master
- Obtains the vessel's course and engine status from the Master and ensures the vessel is on safe track
- Discusses and agrees the passage plan (tugs, lines, berthing side to, berth number)
- Obtains all essential and critical data regarding the vessel's manoeuvring and her machinery/equipment. Ensures the pilot card is received, then checks vessel's manoeuvring characteristics
- Provides the Master with all information about the pilotage period
- Advises the Master of any special requirements of the local laws/harbour authorities affecting navigation
- Informs the Master of the local weather and tidal conditions and their possible effects on navigation.

5.4.5 Monitoring the Pilotage

The safe progress of the ship along the planned tracks should be closely monitored at all times. This will include regularly fixing the position of the ship, particularly after each course alteration, and monitoring UKC.

Verbal orders from the pilot must be checked to confirm that they have been correctly carried out. This will include monitoring both the rudder angle and the rpm indicators when the helm and engine orders are given.

Communication between the pilot and the bridge team should be conducted in the English language, except where local regulations allow otherwise.

If the Master leaves the bridge, the OOW should always seek clarification from the pilot should he be in any doubt about the pilot's actions or intentions. If a satisfactory explanation is not given, the OOW should notify the Master immediately and take whatever action is necessary before the Master arrives. Whenever there is any disagreement with decisions of the pilot, the cause of concern should always be made clear to the pilot and an explanation sought.

The OOW should bear in mind that during pilotage, the ship will need to be properly secured for sea. Excessive use of deck lighting at night may cause visibility interference.

If for any reason the Pilot is incapacitated while the vessel is in compulsory pilotage waters, or the Master considers that the pilot is not fit or competent, these actions should be taken.

- The Master advises the Pilot positively about the concern and assumes control of the vessel
- The Master should call the Pilotage/Port authority and request a replacement Pilot
- Since it is a compulsory Pilotage area, the vessel shall not proceed any further
- The Master shall investigate the safe-anchorage option and anchor the vessel.
- If this is not possible, the vessel must be held in a safe location until the replacement Pilot arrives
- Relevant entries should be made in the log book
- The Master should keep the relevant authorities informed of the events and seek advice for further action.

5.4.6 Information on the Pilot Card

SHIP'S PARTICULARS:	ENGINE PARTICULARS:
• Name	• Type of engines
• Call sign	• Max power
• DWT	• Speed
• Draught	• Manoeuvring characteristics for each rpm from full ahead to full astern for loaded and ballast condition
• Displacement	• Time limit astern
• Year built	• Full ahead to full astern
• LOA	• Maximum number of consecutive starts
• Breadth	• Minimum rpm and speed
• Anchor chain Port and Stbd; number of shackles	• Critical rpm
• Bulbous bow	• Astern power
• Air draught	
• Bow to bridge distance	
• Bridge to astern distance	

STEERING PARTICULARS:	CHECKLIST FOR BRIDGE EQUIPMENT:
• Type of rudder	• A list of all bridge equipments
• Maximum angle	• Number of steering motors in operation
• Time for hard over to hard over	• Gyro error
• Rudder angle for neutral effects	
• Thrusters, Bow and Stern, KW and HP	

5.5 Standing and Night Orders

Shipping is governed by various conventions, codes and guidelines at national and international levels. These provide the framework within which the officers' duties are performed in routine and (sometimes) extra-ordinary circumstances. The owner's SMS provides operational procedures that will be based on the owner's navigation policy. These should work without conflict within the SMS and apply to every ship.

5.5.1 Standing Orders

The Company may have standing orders for navigation, however the Master should provide his own standing orders to explain his requirements to the officers. These can be said to be the abstracts of the Master's own experiences points that have caused concern to the Master in the past, or lessons that have been learned. Standing orders will be supplemented on a daily basis by night orders.

These orders set the general standards required of the watchkeepers. The standing orders will reflect the ship type, her trading pattern, the persons forming the bridge team and their experience and are specific to the ship and her crew. The Master must ensure that the officers understand the content of the orders. A copy should be available on the bridge and all the officers should sign it. The purpose is:

- To lay down ground rules for the Master's expectations of his officers in varying circumstances
- To reinforce practices that the Master expects to be followed
- To create a relationship in which mutual confidence is established
- To increase the responsibility of the officers without imposing limitations
- To ensure that a mistake by one person does not put the vessel in danger
- For officers to check their own work and verify that of others when handing over or taking over the watch. This should also apply to times under pilot
- The officers will know when the Master expects to be called and the Master knows that the OOWs will follow his instructions
- A copy is normally sent to the owners for their retention.

It is advisable to consider the special circumstances that exist every time a Master takes over command. These will relate to the particular ship and to the officers and to the crew serving on her. There is a temptation to use just one set of tried and tested Master's standing orders without any adjustment for each ship. This would be a mistake and a lost opportunity to address the special needs and the circumstances of each different command.

5.5.2 Night Orders

- These are specific instructions to watchkeeping officers in a given situation(s) and are supplementary to the standing orders
- They cover periods when the Master would be absent from the bridge at night
- These instructions will allow the OOW to take action to ensure safety of ship and allow sufficient time for the Master to take command of the vessel
- It must be understood that these instructions are to increase the responsibility of OOW and are not meant to impose limitations
- The information within the night order should not simply be a repetition of the aspects of passage plan that the OOW would already know. They should be instructions based upon the Master's knowledge and experience that would allow the passage plan and general navigational duties to be performed
- Details of times to serve various notices, call crew, call the Master, send or receive messages and the changes required in the status of machinery are common examples
- Operational circumstances during the night are also covered under these orders, for example, any ongoing operations. Night orders would give courses, rpm, manned/UMS, clock changes and anything that was going on, such as fire pump under repair, cargo ventilation, gas-freeing, hatch lids or doors that are deliberately left open. It may also include handling of the vessel during heavy weather or other hazardous situations
- Each OOW should sign the night order book
- It should be maintained as an important record of onboard events.

The aim of providing standing orders and night orders is to spell out the framework within which the OOW or duty officer is expected to work. It avoids any question of 'but I wasn't told to do so' by the officers.

5.6 Procedures

These are some of the essential standard procedures for important aspects of navigation. They are presented in subsets to allow ease of learning :

5.6.1 Restricted Visibility

Engine

- SBE
- Advise engine room of restricted visibility and that it is to be manned till further notice
- Reduce to safe speed

Personnel

- If the Master is not on the bridge, make sure he is informed
- Engage hand steering and post a helmsman
- Post additional lookouts.

Equipment

- Sound appropriate fog signals
- Switch on navigation lights
- Keep on radars at peak performance and commence systematic plotting of all targets in the vicinity.

Navigation

- Plot positions frequently

Navigation on Coast

- Obtain a visual fix before entering restricted visibility
- Employ parallel indexing techniques
- Run the echo sounder.

Deck

- Have anchors ready for letting go
- Close all watertight doors and hatches
- Order silence on deck.

Bridge

- Open bridge wing doors
- Run both steering motors
- Keep a check on all bridge equipment
- Radar-plotting for collision-avoidance should be on water-track speed
- Do not use VHF / AIS data for collision avoidance
- Comply with the provisions of COLREGS, in particular Rule 19
- Notify the Master if CPA of 2 miles with any target cannot be achieved
- Bridge manning to meet the manning levels / for restricted visibility.

5.6.1.1 Engine Failure

- Inform the Master
- Exhibit "NUC" signals
- If in shallow water, prepare for anchoring
- Make use of headway and steer vessel towards safety, using the rudder and bow thruster to best advantage.
- Commence sound signalling
- If appropriate, broadcast URGENCY message to vessels in the vicinity and port authority. If drifting onto a lee shore, send DISTRESS
- In harbour, call tugs immediately if they are not already alongside
- Plot and record the position of the vessel
- Note existing current, tidal stream, wind and weather
- Estimate the time available before vessel stands in danger
- Ask the Chief Engineer about the problem and for progress on restoring power
- Notify the company.

5.6.1.2 Steering Gear Failure

- Inform the Master and the engine room
- Engage emergency steering
- Use bow thrusters
- Exhibit "not under command" signals
- If in shallow water, prepare for anchoring
- Manoeuvre engine to take off the way, if required
- Commence sound signalling

- If appropriate, broadcast URGENCY message to vessels in the vicinity and port authority. If drifting onto a lee shore, send DISTRESS
- In harbour, call tugs immediately, if they are not already alongside
- Plot and record the position of vessel
- Note existing current, tidal stream, wind and weather
- Estimate the time available before vessel stands in danger
- Ask the Chief Engineer about the problem and for progress on restoring power
- Notify the company.

5.6.1.3 Extreme Weather Conditions

At Sea

- Notify the Master, all department heads and the crew
- Secure all moveable objects for heavy weather
- Secure accommodation and close all ports and deadlights
- Close all weather-deck openings
- Plot the position of the ship
- Adjust the course and speed as necessary
- Rig lifelines and hand ropes where necessary
- Obtain a weather report and forecast
- Make hourly entries of the observed weather in the logbook
- If required, make obligatory reports to other vessels in the vicinity and the nearest CRS
- Unless the vessel is stopped, avoid having the wind/seas abeam to prevent synchronous rolling and the possibility of the cargo shifting
- Steer with the wind at about 45° on the bow. The alternate heading is with the wind at about 45° on the quarter.

In or approaching port or coastal waters, additional actions

- Enquire if the port is open or closed
- If the port is closed, proceed towards a sheltered anchorage
- If alongside, consider proceeding to sea. However, as a minimum, double-up moorings and raise the gangway/accommodation ladder
- If necessary, stop cargo operations.

At Anchor, additional actions

- Heave up the anchor and put to sea, or pay out more cable, or consider coming to an open moor
- Use the engine to reduce the strain on the cable(s)

5.6.2 Weather Routeing

Consider all weather-routeing suggestions for relevance and effectiveness. Make course adjustments as advised - usually once within 48 hours. In extreme cases, your routeing service could also advise you to adjust the course within the 48-hour timeframe.

5.6.3 Malfunction of Navigational Equipment

Position-fixing Systems

- Inform the Master and the ETO
- If operational, use a secondary method to plot positions
- In coastal waters, use visual means to plot positions
- Use the echo sounder
- If visibility is bad in coastal waters, increase the distance from the coastline or other obstructions
- In open waters, obtain positions by celestial observations
- Reduce speed if required
- Call and notify the ship-reporting system.

Gyro

- Inform the Master and the ETO
- Inform the engine room
- Engage hand-steering and steer by magnetic compass
- Establish a rota for hand-steering
- Once on each watch, and after every course alteration, calculate the compass error.
- Consider the effect of gyro failure on other navigation aids.

5.6.4 Piracy

Precautions Before Entry

- Brief all crew on the procedure to be followed in the event of an attack
- Seal all entrances and areas as detailed in the ISPS recommendation

- Test all internal and external communication facilities and make them ready for use
- Ensure all deck areas are well lit
- Test the search light and the Aldis lamp and make them ready for use
- Fire hoses should be rigged up, charged and ready for use around the vessel
- Set up an anti-piracy patrol. Provide hand-held radios for contact with the bridge
- Man the engine room. SBE, engines at full speed and ready for manoeuvring
- Double the bridge watches and post additional lookouts to monitor the vessel's position continuously
- Maintain a good listening watch on the radio for any reports of piracy
- If a suspicious craft approaches the vessel, immediately inform the Master and commence evasive manoeuvres. Inform the shore authorities and other shipping in the vicinity.

Precautions at Anchor or Alongside

- Maintain strict access controls at all gangways and access points.
- Place rat-guards on mooring ropes
- Seal fairleads and hawse pipes.
- At night, switch on all upper deck lights and rig extra lights near the ship's stern and the sides to illuminate dark areas. Use powerful search lights
- Lock all upper deck lockers and lock access to accommodation and technical areas
- Arm upper deck patrols with night sticks. Maintain patrols during the hours of darkness.

Precautions When Underway

- Consider passage through pirate-prone areas in daylight
- The vessel must proceed at the maximum safe speed
- Maintain a good radar and visual watch
- Give a wide berth to small stationary objects or boats, especially if they are unlit at night
- At night, switch on all upper deck lights and rig extra lights near the ship's stern and the sides to illuminate dark areas. Use powerful search lights
- Lock all upper deck lockers and lock access to accommodation and technical areas
- Maintain upper deck patrols during the hours of darkness.

5.6.5 Pre-Departure Procedures

The exact procedures to be followed before departure will vary with the ship type and her trading pattern. However, basic procedures will apply for every type of ship. These are the significant pre-departure checks:

- Watertight integrity of the vessel
- Readiness of ship's machinery and gear
- Availability of bunkers and stores for the voyage
- Controls testing. Any defects should be rectified
- Crew availability and readiness
- Security of cargo and stores
- Booking of pilot and tugs
- Draught and freeboard
- Tidal data, particularly of high water
- Ship stability
- Obtain NAVAREA, Coastal and Local warnings as well as weather forecast
- Passage plan finalised and bridge preparation. Carry out a set-up of the navigational equipment
- Crew and passenger lists
- Positive reporting by concerned departments regarding readiness
- Searches for stowaways, terrorist devices and contraband
- Port clearance.

5.6.6 Pre-Arrival Procedures

The exact procedures to be followed before arrival will vary with the ship type and her trading pattern. However, basic procedures will apply for every type of ship. These are the significant pre-arrival checks:

- Readiness of ship's machinery and gear
- Controls testing. Any defects should be rectified
- Anchors cleared and ready for use, mooring ropes on deck
- Obtain Coastal and local warnings and a local weather forecast
- Set up NAVTEX for the appropriate station
- Notice to the engine room and crew at appropriate stages
- Book the pilot
- Obtain berthing details and prospects
- Arrival-draught calculation

- Tidal data, particularly of high water
- Ship stability
- Passage plan finalised and bridge preparation. Carry out set-up of navigational equipment
- Crew and passenger lists
- Declaration for health, customs and immigration
- Positive reporting by concerned departments regarding readiness
- Searches for stowaways, terrorist devices and contraband.

These procedures are expanded in the SMS. Detailed checklists will be available onboard to ensure that full procedures are followed, nothing has been missed out and that no short cuts are being taken. On board the ship, it is the Master's responsibility to ensure that all of the requirements are complied with. Responsibility will have been delegated to the heads of departments and key individuals onboard ship. These heads and key individuals are responsible for making reports on readiness and the state of the ship to the Master.

It is understood that most shipboard operations are sequential and inter-related. Additionally, trading plans are generally known in advance. The Master and the ship's staff may plan pro-actively for the oncoming voyage and instruct Management and the Operational staff who (in turn) can advise the support staff.

5.7 Navigational Risk Assessment

Risk refers to the harm (or possibility of harm) that may be caused by a hazard. Risk assessment offers a planned foundation for the careful study of potential hazards to make sure that enough precautions are taken to reduce the risk and, where possible prevent it. Consider the significance of each hazard and decide if sufficient precautions have been taken to manage the risk. Use these five steps to assess a risk:

- Identify the hazards
- Consider the potential harm
- Evaluate the risks. Establish if existing precautions are sufficient
- Record all findings and measures of control
- Review the assessment and, if the risks are still not controlled, revise the plan until you reach a satisfactory conclusion.

The Navigation Officer will identify the hazards and assist in preparing contingencies. Once the hazards have been identified use control measures to manage risks through so that accidents can be avoided.

Risks can be divided into five zones:

Trivial Risks – Risks deemed unimportant. Action to reduce the risk is not normally required.

Tolerable Risks – Risks that can be tolerated/accepted without any possible harm but they should be monitored to maintain control. For example, transiting a narrow passage during the day as compared to a night transit in the same area.

Moderate Risks – Additional resources are required to achieve substantial control of the potential risk, with a possibility of an increase in cost. For example posting a helmsman.

Substantial Risks – Risks that are unacceptable and have to be reduced at any cost. For example, in restricted visibility, reduction of speed and doubling watchkeepers on the bridge.

Intolerable Risks – Risks that cannot be controlled or reduced due to the level of severity and the non-availability of resources. Under these conditions, the passage cannot continue. For example, when a ship meets very severe weather and has to seek shelter.

An example risk assessment is provided. Note that in the example risk assessment, the risk level has been re-assessed with the indicated control measures in place. If the control measures are not implemented, the risk assessment would not be valid and the risk level will vary.

Some companies provide generic risk assessments for most general hazards. Even in those cases, it is necessary to re-assess risks on a case-by-case basis and ensure control measures are in place.

5.7.1 Example Risk Assessment

PASSAGE PLANNING RISK ASSESSMENT

Risk Assessment Number ....
For Passage from .... to ....
On Voyage from .... to ....
Date: .... Assessed by: ....

Hazard: Failure of GPS when passing at close proximity to One Fathom Bank Light in the Malacca Strait
Risk: Unable to use ECDIS due to unavailability of GPS position, track control may cause vessel to run aground.

Risk Assessment:

Severity of Hazard				Likelihood of Harm			Risk Level
☑	5	Very High			5	Very Likely	
	4	High			4	Likely	
	3	Moderate	x	☑	3	Quite Possible	5 x 3 = 15
	2	Slight			2	Possible	
	1	Nil			1	Unlikely	

Control Measures:
Do not use GPS as the primary source of position fixing.
Ship's auto pilot not on 'track control'.
Both radars switched on – one used solely for position fixing.
Parallel Indexing in use with reference to One Fathom Bank Lighthouse
Calculate set and rate and apply as required.
Position fixing interval to reduce to 5 minutes.
Engines on Stand-by for immediate manoeuvring.

Re-assessment of Risks with Control Measures:

Severity of Hazard				Likelihood of Harm			Risk Level
	5	Very High			5	Very Likely	
	4	High			4	Likely	
	3	Moderate	x	☑	3	Quite Possible	2 x 3 = 6
☑	2	Slight			2	Possible	
	1	Nil			1	Unlikely	

Level	Rating	Action
1 – 5	Trivial	No further action required
6 – 10	Tolerable	Monitoring required to ensure that the controls are maintained
11 – 15	Moderate	Efforts to reduce risks required with attention to allocation of resources and amount of time required for reducing risk.
16 – 20	Substantial	Ship cannot proceed on passage without reducing the risk. Allocation of resources and time can increase to very high amount but ship may proceed on voyage once risks have been reduces.
21 – 25	Intolerable	Passage cannot be continued even with unlimited resources.

5.8 Hydrographic and Port Information

The present day Hydrographic data is gathered through surveys carried out by the Royal Navy, surveying organisations, foreign hydrographic authorities, observation stations, lighthouse authorities and exploration companies. In addition, reports made by mariners and leisure sailors are valuable as the voyages undertaken by these individuals are higher in number and in more varied locations.

It is important that reports are made of any differences between charted or stated information and what is actually observed. There are some natural changes that are taking place, as well as new developments that are bringing about the changes. Additionally, confirmation of positions and other remarks on the old publications is also of value.

To where the report should be sent depends upon the authority of the charts or the publications being used. If using BA/UKHO charts and publications, the report should be sent to the UK Hydrographic Office. The law of the coastal state may have to be taken into account.

It is important to note that certain observations require an immediate report to be made by radio because the information may be of special navigational significance to mariners, e.g., reduced depth, sighting or a sinking vessel in shallow areas, navigational aids out of position, etc. Such radio reports should be made to all ships in the vicinity and to the nearest coast station.

5.8.1 Hydrographic Information

5.8.1.1 Report

Report the information on form H.102 – HYDROGRAPHIC NOTE. It requires:

- The name of the ship or sender, along with the address
- Contact information: Telephone/Fax/Telex/email particulars
- General locality
- Subject
- Position in Latitude and Longitude
- BA Chart(s) affected, along with date of its edition
- Position fixing system used, along with the Datum set
- Latest weekly edition of Notice to Mariners held
- ENCs affected
- Latest update disk held
- Publications affected, along with edition number and the date of the latest supplement and the reference number, for example, the Light List No

- Details
- Replacement copy of chart No
- Signature of observer/reporter.

5.8.1.2 Details

What, where, when and how are important aspects of any observation. In case of soundings:

- The make, name and type of the echo sounder
- The echo sounder trace, annotated with date/time of the fix
- The number of revolutions per minute
- Depth observed
- Speed of sound in sea water
- Whether soundings have been corrected
- Setting of scale zero and whether depth was below keel or from sea surface
- Draught
- Time, which is very important for applying tidal data to the observation.

In the case of charted details, the alteration should be shown in red on the largest scale chart. Positions should be plotted on the largest scale chart, and a plotting sheet prepared to a suitable scale or on an ocean plotting sheet. Forward a cutting of the chart with the alterations. For positions:

- Geographical: Latitude and Longitude
- Astronomical: names, times, altitudes of heavenly bodies, prevailing conditions
- Visual Fixes: time and simultaneous observations by horizontal sextant angle, compass bearings, ranges and any corrections applied
- GPS: Datum, position shift on chart applied or not, make and model of receiver and PDOP, GDOP, HDOP values
- Other electronic systems: time, full details and if any errors have been applied.

5.8.2 Port Information

The form H102a must be forwarded, together with form H102, which contains the following details:

- Name of the port
- General remarks: principal activities and trade, latest population figures and date, number of ships or tonnage handled per year, Copy of port handbook if available

- Anchorages: designation, depth, holding ground and shelter afforded
- Pilotage: authority for request, embarkation position, regulations
- Directions: entry and berthing information, tidal streams, navaids
- Tugs: number of tugs available, max HP (Bollard Pull)
- Wharves: name, number, or position, length, depth, ht. above chart datum, facilities available
- Cargo handling: containers, lighters, ro-ro
- Cranes: brief details and maximum capacity
- Repairs: hull, machinery and under water. Docking or slipping facilities, size of vessels handled
- Rescue and distress: salvage, lifeboat, coast guard
- Supplies: fuel, fresh water, provisions
- Services: medical, de-ratting, consuls, ship chandlers
- Communications: road, rail, air services, nearest airport, port radio and information service with frequencies and hours of operating
- Port authority: contact details, designations
- Small craft facilities
- Views: photographs of significant features.

6 Radar Navigation

From its early beginnings, radar has experienced significant technological development. However, the basics remain the same and it continues to be a valuable aid for monitoring navigation, collision avoidance, security and surveillance, provided its limitations are fully understood.

This chapter looks at the value of radar, considers its limitations and discusses different displays

6.1 Radar Displays

Radar displays are categorised according to the motion they generate and the stabilisation input. The motion can be either relative or true. Stabilisation is further subdivided into course and speed. In the next section, a comparison is made, using sketches and a tabular list of advantages (left) against the disadvantages of radar (right).

6.1.1 Relative Motion

This display provides an immediate indication of the risk of collision or the Closest Point of Approach (CPA). The display usually originates from the centre, but off-centre operation is possible with head-up and north-up modes. Fixed objects generate echo movement in a direction reciprocal to the ship's ground track. Regardless of heading stabilisation, echo blur (or smear) does occur because of the relative motion of the echoes.

Head-up (Course-up, unstabilised) keeps the heading marker at 0° and the picture turns around it. This makes it unsuitable for narrow waters with frequent course changes.

Advantage	Disadvantage
Direct comparison with visual. Relative bearing provides a quick indication of bearing of the target relative to the ship's head.	Must check course for True bearings. Echoes 'Blur' (smear) when altering course or yawing. It is not possible to detect the relative motion of others when 'own ship's' heading is changing

Course-up (stabilised) has the picture stabilised and the heading marker mostly pointing upwards. When yawing, the picture remains still, but the heading marker moves. The system is reset to bring the course-up after an alteration of course.

Advantage	Disadvantage
Direct comparison with visual mostly, with provision to obtain true bearings. No blur or smear due to change of heading	The heading marker rotates when yawing or changing course, causing orientation problems for some users

North-up (stabilised) keeps the picture still and the heading marker shifts due to change of course or yawing.

Advantage	Disadvantage
Direct comparison with the chart. No smear due to the ship's own head movement. Increased bearing accuracy. Actual relative movement of echoes can be detected by the bearings and ranges of 'afterglow' as long as it remains on the same range scale	No direct comparison with visual. Some individuals may find problems with orientation. (this may be more prevalent on southerly headings)

6.1.2 True Motion

There is no effect on echoes when 'own ship' alters course. Discontinuity may occur when the centre spot is reset as this operation could occur at an awkward time. Plan the picture shift carefully, especially after the ship has settled on a new leg of the passage. When dealing with close-quarter or risk-of-collision situations, picture shifts should be performed at an appropriate window of opportunity and not left to the last moment. True motion allows for distinction between moving, fixed and stationary targets. Targets closing on a steady bearing are not immediately apparent. Errors in heading and speed input may cause a false movement to appear. Adjustments to remove the effects of wind, current or tidal stream are difficult to determine . Early warning is available due to the increased ahead-range capability, and there is no centering error.

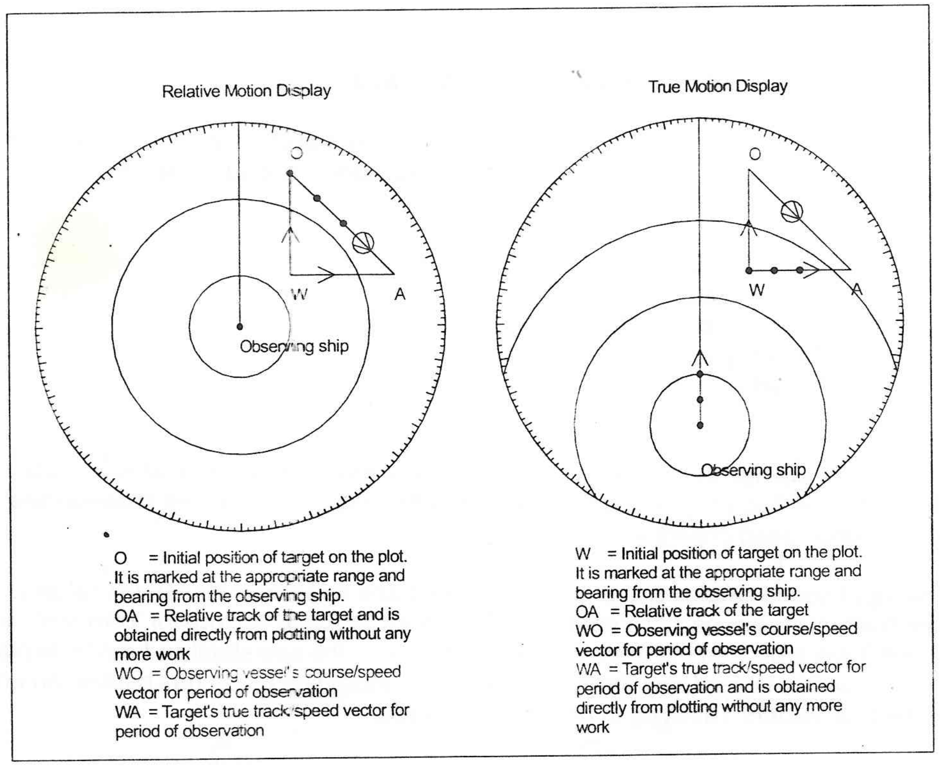


Figure 6.1 - Relative versus True Motion

Sea-stabilised (North-up)

Advantage	Disadvantage
Indicates the course of all contacts through the water. Set and drift are obtained at a glance by observation of the fixed contacts. True alterations of course and speed of echoes are displayed immediately.	Errors in compass and speed input cause false movement to appear on display.

Ground-stabilised (North-up)

Advantage	Disadvantage
Separation of stationary and moving targets. Useful in pilotage waters as ground speed is displayed for targets.	Will not indicate course and speed of ships through the water.

6.1.3 Interpretation of Vectors and Trails

On true motion, 4 targets have been used in figure 6.3 to illustrate the difference in vectors and trails with sea and ground stabilised modes, the tidal stream is 090°T x 3Kts.

0 – Own ship (000°T x 6 Kts)
1 – Fixed isolated beacon
2 – Target ship (180°T x 6 Kts)
3 – Target ship (245°T x 9 Kts)
4 – Target ship (Stopped in the water)

There is no change in relative vectors with sea or ground stabilised speed inputs. However, the true vectors and trails change when the input changes between sea and ground speed changes.

The input speed causes a change in the speed and heading output of the targets, which affects the aspect. To emphasise this point, the true vectors for 'own ship' and target 3 are produced in Figure 6.2 As can be seen, the sea stabilised mode displays the true vector without any error, but the ground stabilised mode has caused an error in the true vectors, resulting in an incorrect aspect.

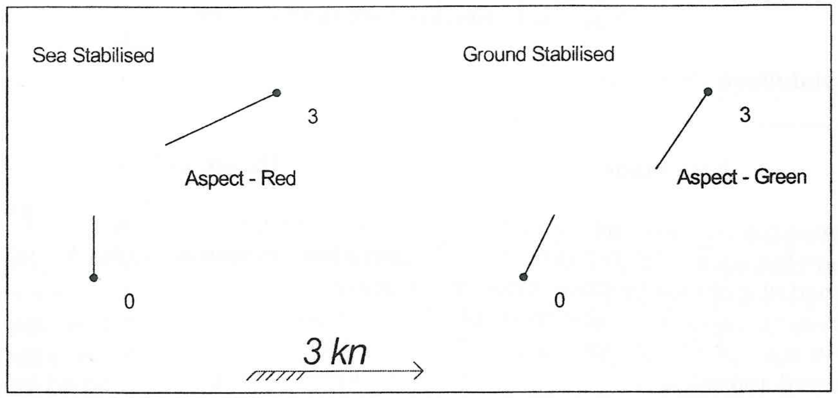


Figure 6.2 - Sea Stabilised Vectors

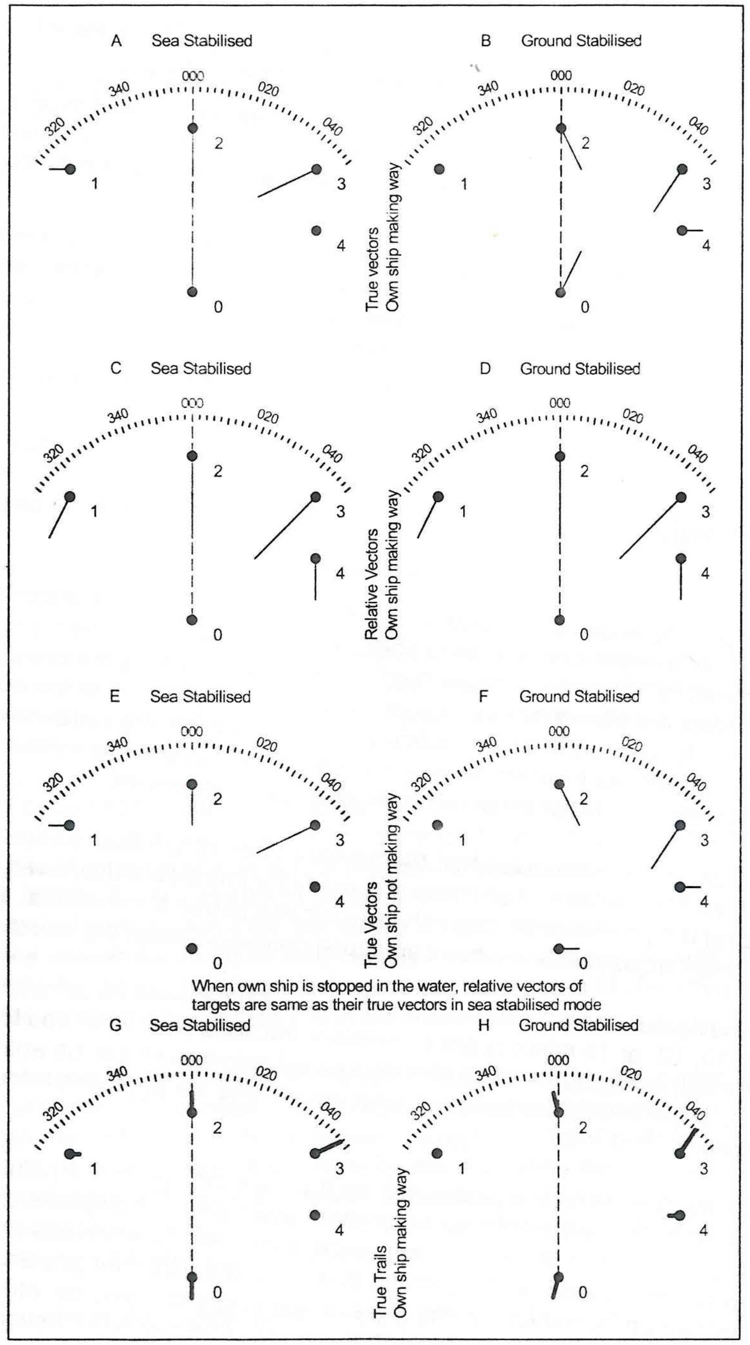


Figure 6.3 - Vector Diagram for Various Ground and Sea Stabilised States