

# A Guide to Ship Navigation Techniques



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## **A Guide to Ship Navigation Techniques**

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# AUTHOR PAGE:



About the Author  
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# CHAPTER 1:

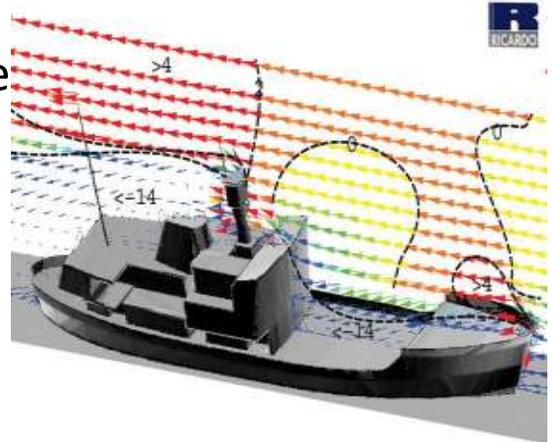
## Navigation With Wind

A navigation or deck officer has to be extremely careful while steering a vessel from its course no matter where the ship is – at mid sea, crossing channel, or entering/ leaving a port.



The team at the bridge should be efficient enough to sail the ship in all kinds of waters and weather. One of the natural factors about which every navigator should be very careful while steering a ship is – the wind. Vessels such as containers and Ro-Ro ships have large freeboard and are thus more affected by winds.

This exposed area of the ship is also known as the windage area for the effect of wind is more prominent. The wind effect on the same ship will be different at different places, depending upon the draught condition of the ship. A wind with force of 3-4 on the Beaufort scale will have similar effect in light condition as with wind force of 7-8 when the ship is down to her marks.



When ship is at slow speeds during manoeuvring or near to the coast, wind direction is easy to find; but this is not the case when out at high seas. The direction of the wind perceived when standing on deck is its relative direction. This is the resultant of the true direction of the wind and the course steered by the ship.



It is very important for the ship's navigator to steer the ship considering the wind effects so that the ship can be steered efficiently without any difficulty. Following are the techniques a navigator must master to control a ship under wind effects.

### **Ship underway with wind from right astern**

When the wind is blowing from the right astern, steering the ship becomes easy; however, in case of head wind, the stern part of the ship has the tendency to pay off on either sides. This is a difficult situation to tackle and getting the ship back on course is no piece of cake.

Such effect is more often seen on ships where the accommodation area is at the aft region. Moreover, the wind in such case has no braking effect.

Note: Given a choice between head wind & wind from right astern, the head wind is preferred for berthing.



### **Ship underway with wind from abeam**

When the ship is underway with the wind flowing from abeam, the steering of the ship is not affected. However, depending on the strength of the wind, the ship drifts sideways due to leeway and this has to be accounted for while handling the ship.

### **Ship underway with wind on the bow**

Here again in lighter conditions, the effect on the ship's stem is larger and this tends the ship's head to swing away from the wind (leeward). This requires the weather helm (helm on the side of the wind) to be steered continuously.

### **Ship underway with wind on quarter**

When the wind is pushing the ship's stern away to leeward, the stern tends to swing towards the leeward. The ship is therefore steered towards the wind and the ship is required to be given a lee helm.



## Vessel under sternway

When the ship is going astern, it rarely goes at a great speed. When going astern most ships also tend to swing to the starboard. The effect of the wind is therefore a little more complex.

In ballast condition where the wind catches the bow, which it often does, the stern is pulled into the wind. This effect is quite definite & rapid.

All ships turn around a pivoting point. This point is an imaginary reference and is fixed from observations of the ship turning around. It is known that when going astern the pivoting point moves aft.

Effects of wind can be used -

As a  
**BRAKE**

For  
Tight  
Turn

For  
Manoeuvre

“This effect must be remembered while manoeuvring for anchoring, berthing etc.”



# CHAPTER 2:

## Navigation with Current



In this chapter we take into consideration a totally different aspect which also plays an equally important role while manoeuvring a ship at the sea. Let's find out how a ship can be controlled under various effects of ocean currents.

## The effects of ocean currents

Ocean currents play a very important role in ensuring the stability of the ship.

The effect of currents therefore must also be considered when handling ships in waters.

Effect of currents are important especially when the ship is under the effect of on-shore winds, near off-shore platforms, while manoeuvring in narrow channels and open seas, or in inland waters or harbours.



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When the ship is in harbour or in inland waters and the current is at constant strength and direction, the ship's handling becomes considerably easier.

“Such conditions exist only in comparatively narrow channels of rivers. Navigational officers should take into account different current streams that can exist over a small area, within which the vessel has to manoeuvre.”

The main difference between currents and winds is that currents affect the ship in definite and predictable ways, unlike the wind does.

Even in open waters, when the ship is approaching a rig or a mooring buoy, due allowance should be made for the effect of the current for a safer manoeuvre.

Current from ship's ahead will reduce the ship's speed over ground, improve ships response to the rudder, and also give more time to assess and correct developing situations.



### **Shallow Water Effects on Ships – Ship Squat**

When a ship proceeds through water, it pushes the water ahead. This volume of water returns down the sides and under the bottom of the ship. The streamlines of return flow are speeded up under the ship, causing a drop in the pressure and resulting in the ship dropping vertically in the water.



When the ship drops vertically in the water, it trims both forward and aft. This overall decrease in the static under keel clearance, both forward and aft, is called Ship's Squat. Learn more about [Ship's Squat here](#).

If the ship moves forward at a greater speed in shallow water, where the keel clearance is 1.0 to 1.5 metres, then there are high chances of grounding at the bow or stern due to excessive squat.



### **What are the factors that govern Ship's Squat?**

- The main factor on which the ship's squat depends is the ship's speed. Squat varies approximately with the speed squared.
- The blockage factor "S" is another factor to be considered while understanding ship squat. The blockage factor is defined as the immersed cross-section of the ship's mid-ship section divided by the cross-section of water within the canal or river.
- The blockage factor ranges from about 8.25b for super tankers, to about 9.50b for general cargo ships, to about 11.25 ship-breadths for container ships. The presence of another ship in a narrow river will also affect squat, so much so that squats can double in value as the ship pass or cross the other vessel.

### **How to find out if a ship has entered shallow water?**

1. Wave generation from the bottom of the ship increases, especially at the forward end of the ship.
2. Ship becomes more sluggish to manoeuvre.
3. Draught indicators or echo-sounders will indicate changes in the end draughts



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- 4.** Propeller rpm indicator will show a decrease. If the ship is in “open water” conditions i.e. without breadth restrictions, this decrease may be up to 15% of the service rpm in deep water. If the ship is in confined channel, this decrease in rpm can be up to 20% of the service rpm.
- 5.** There will be a drop in ship’s speed. If the ship is in open water conditions this decrease may be up to 35%. If the ship is in a confined channel such as a river or a canal then this decrease can be up to 75%.
- 6.** The ship may start to vibrate suddenly. This is because of the water effects causing the natural hull frequency to become resonant with another frequency associated with the vessel.
- 7.** Any rolling, pitching and heaving motions will be reduced as ship moves from deep water to shallow water conditions. This is because of the cushioning effects produced by the narrow layer of water under the bottom shell of the vessel.
- 8.** The appearance of mud cloud will be visible in the water around the ship’s hull when the ship is passing over a raised shelf or a submerged wreck.



- 9.** Turning Circle Diameter (TCD) increases. TCD in shallow water could increase 100%.
- 10.** Stopping distances and stopping time increase, as compared to when a vessel is in deep waters.
- 11.** Effectiveness of the rudder helm decreases.

“The vessel's turning circle will increase and the rate of turn will decrease due to squat effect”



# CHAPTER 3:

## Stopping Distance



Every vessel shows different characteristics when it comes to the distance covered when a stop signal is given due to difference in dimensions, loading and ballast conditions.

It is very important for a navigating officer [to learn the principles of passage planning](#) and understand his ship's characteristics as a small mistake in understanding may lead to [collision](#), grounding or other kind of mishaps.

### Stopping distance of ships

As we all know, ship like any other transport utility does not have brakes to make them stop immediately. When the engine is given stop order, the ship will continue moving in the same direction due to inertia and will come to stop after moving for some distance.

Every ship has two different stopping distances–



**Inertia Stop**

**Crash stop**



As described above, when the engine of the ship is stopped, the ship will continue moving in the same direction for some more distance due to inertia. Here no astern command is given (used to produce “braking effect” for ships), and hence ship will travel more distance in the inertia stop method.

### **Inertia Stop**

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### **Crash Stop**

Crash stop is usually the term used when the ship has to suddenly stop in emergency situation. Here the engine, which is moving in an ahead direction is given an order for full astern, leaving the rudder in the mid ship position to stop the ship within minimum distance and shortest possible time. To know the complete procedure of crash stopping read – [crash manoeuvring](#).



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In general operation i.e. berthing or departure of the ship from port or manoeuvring through channel or narrow passage, the above two methods are combined for a swift navigation of the ship i.e. in between giving an astern kick to stop and slowing down the ship's speed for better manoeuvring.

“The stopping distance data and chart are given in sea trials of the ship and are made handy on bridge for reference.”

The data may differ when used due to variation in weather condition, ships loading, stability and other factors; however, deck officers can compare the trail data and make use of it in practical situations.



### Few Practical Examples

- Depending upon the loading condition and the speed of the ship, the stopping time will be different when these two conditions are changed.
- Also ships fitted with diesel machinery will have stopping distances approximately 70% of those fitted with [Steam Turbine machinery](#).
- When the ship's hull has been due cleaning (dry dock) for longer time, the stopping distance and time will be less as compared to when the ship is just out of dry dock. This is because the hull resistance is more in ships with [dry-dock](#) done long ago.
- The wind direction and sea condition also plays an important role as wind and waves acting from behind the ship will increase the stopping distance and vice versa.
- It is important for a navigation officer to know the surrounding of the ship and how the ship will react to changes in speed and loading conditions.



# CHAPTER 4:

## Use of Thrusters



“Thrusters are type of propellers, smaller in size, which help in better manoeuvrability of the ships at lower speeds.”

Thrusters are fitted normally in the fore and aft parts of the ship. These points of location help to create a turning effect and assist the ship in changing the lateral direction during berthing or departing the jetty.

The bow thruster is solely introduced in ships to avoid, or in better words, to minimize the use of expensive tug boats as most of the port state authorities around the world have compulsory requirements to use tug boats for safety purpose.

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It is extremely important that the navigating officer on bridge understands the significance of assisting machinery such as bow thrusters during the most critical operation performed by ship and its staff – The berthing of the ship.

### **Following points must be considered while berthing the ship using bow-thruster:**

- While using thrusters ensure that the ship's speed is not more than 4 knots as above this the effect caused by thrusters would reduce. This happens because of the merging of the thruster stream with the general water flow on the side of the ship's hull due to its forward movement.
- When using a single forward thruster, it is important to concentrate more on the astern as the bow can be controlled by the forward thruster. In such situation, always prioritize to berth or bring the astern of the ship alongside first and then control the ship's bow.
- When turning the ship with two thrusters located at fore and astern, the pitch of the thrusters must be opposing each other, creating a turning moment. Massive cargo ships must be assisted by the tugs at the astern part to control the stern movement.



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- When using the bow thruster while the ship is at stop, the astern part will act as a pivotal point. If the thruster is put in the port side, the ship will turn in the same direction.
- When using the thruster with ship running headway, the thruster's effect will be slightly less as both the pivotal and thrusting points are now in forward position.
- When using bow thruster with ship travelling sternway, the pivotal point will be the ship's stern, which will turn in the same direction as that of the thruster and act as a rudder.
- It is very important to have an efficient steering gear system as the ship turning by use of thruster is highly dependent on how responsive the rudder (steering gear system) is.
- Thrusters are used while anchoring the ship. They assist in turning the bow of the ship away from falling anchor to avoid damage by the anchor chains.



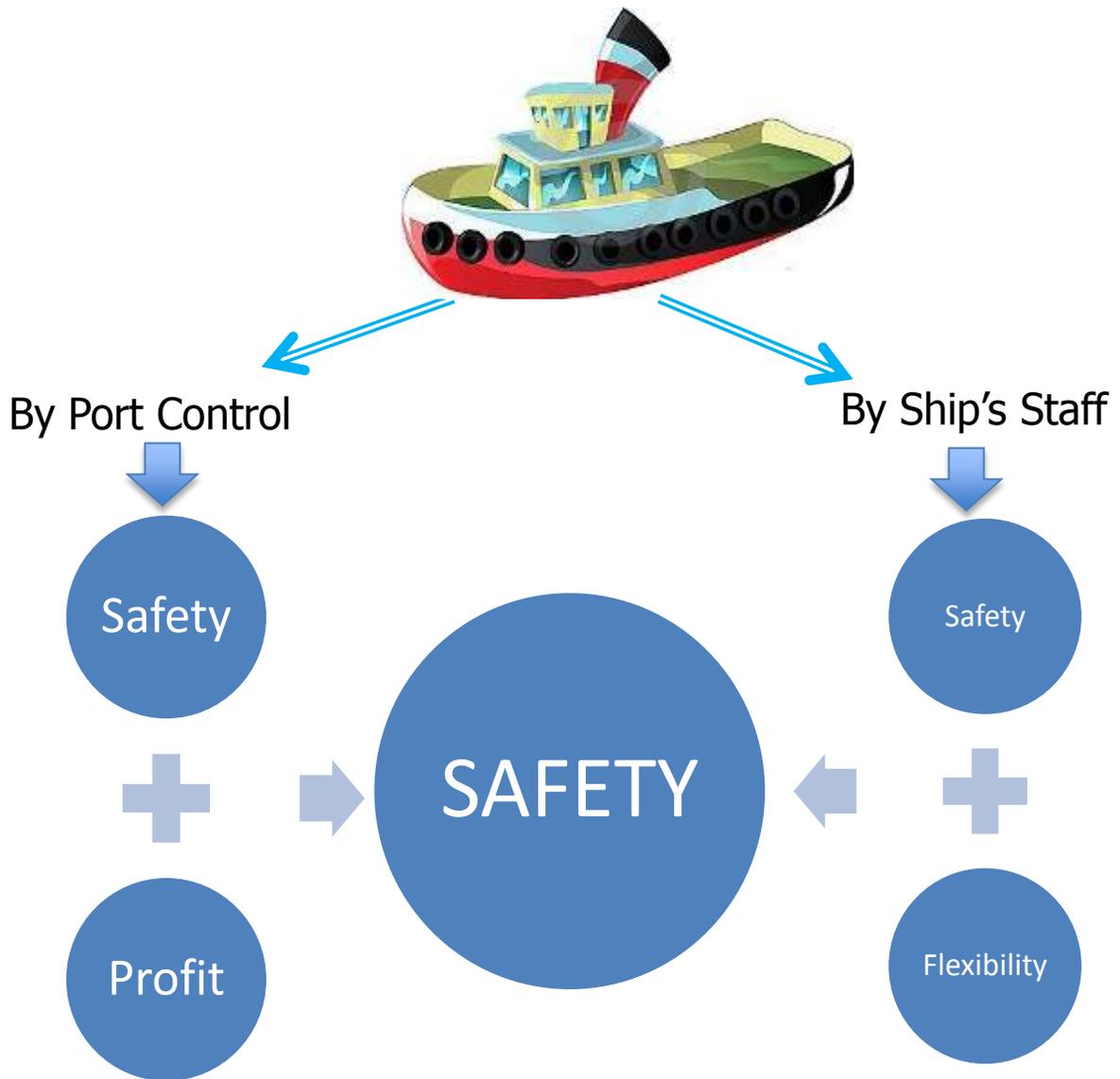
# CHAPTER 5:

## Tug Assistance



Tugs are important for both sides involved in the manoeuvring operation of the ships i.e. the ship' staff and the port.

## Use of Tug



**“Safety is the most important aspect taken into consideration for using tugs in port and ship berthing operations.”**



### Selecting the Number of Tugs

Tugs are extremely helpful for manoeuvring, but are a monetary burden on ship owners as each tug taken for assistance is charged a handsome amount. However, they ensure the most important factor - safety of the ship and the port, which compensates the monetary part.

The selection of the number of tugs depends on various factors:



During operation, tugs are used at slow speed to prevent forces between the tug and the ship from becoming large enough to capsize the tugs. It is very important to remember that the effectiveness and safe operating condition of tugs depend on the distance between the point of contact and the ship's pivot point.



### **Precaution to be taken during Tug Operation**

- Ship must be operated at low speed (below 5 knots) to effectively use the tugs.
- Master of the ship and the Tug operators must discuss the location of tug attachment before the operation starts as the turning lever is decided by the position of the tugs.
- Those operating the ships must have knowledge about the operational capabilities of different kind of tugs. Conventional tugs are less flexible than water tractor tugs.



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- Always have a lookout on the tug from the ship and give sufficient time to the tugs for attaching, repositioning, and pulling/pushing operations.
- Remember to decide and control the ship's speed when the tug attached is leading forward as it may result in increase in ship's speed.
- Keep checking the space limitations while the ship is close to the jetty or other ships.
- The forces generated by tugs' propeller at stern or bow may cause the ship to move away from the direction of pull.
- When the ship has headway with two tugs attached, one forward and one aft, the aft tug will have more effect than the forward one because the distance from the after tug connection to the ship's pivot point is greater. If both tugs are applying the same power, the result will be a swing of the ship in favour of the aft tug.



# CHAPTER 6:

## Berthing Without Tugs



The navigating officer of the ship must know how to control a ship in different types of berthing conditions, keeping in mind the safety of the ship and its crew.

There can be situations when there is no availability of tugs for berthing of ships. In such cases, the navigating officer must be skilful to steer the ship and berth her to its assigned jetty.

The three important aspects important for berthing of ships without tugs are:

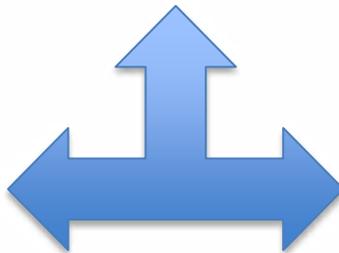
### Rudder



### Ship's Speed



### Thruster



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The bridge team must consider the factor of wind and current carefully while steering the ship as the additional support function- the tugs is not available.

There are two main scenarios for berthing a ship (for a Fixed Pitch Propeller, right handed single screw) without tug assistance-

- *Port Side Berthing*
- *Starboard side berthing*

### **PORT SIDE BERTHING**

When the ship is tied to the jetty from her port side, the ship is moved towards the berth at certain angle. The astern thrust thus generated is used to stop the ship's motion and to turn the bow towards starboard, which will turn the ship's astern to port side.

As soon as the ship is parallel to the berth, the ship can be carefully and slowly manoeuvred to its drafted position by astern kick, which provides the transverse thrust. The actual operation will highly depend on the berth position and available space.



## STAR BOARD SIDE BERTHING

It is important to balance the forward speed of the ship against the astern power needed to stop the same. The greater the forward speed, the greater is the astern power required to stop the ship. This result into greater effect of the transverse thrust, which brings the ship's bow close to the berth and throw the stern off.

Aim to approach the berth by keeping the ship parallel. The effect of transverse thrust will swing the bow towards the berth.

### **Do Not -**

#### **Increase the Approach speed**

Ship can hit the berth with her bow before stopping, or the large astern movement used to stop the ship and the resulting transverse thrust can cause the stern to hit the berth.

#### **Ahead kick near the berth**

If a sharp kick ahead is made close to the berth, the ship's bow can strike the berth.



### **Ignore the lateral motion**

When approaching port-side to the berth, the ship's lateral motion is to the port. Insufficient awareness of lateral motion can cause a ship to land heavily against the berth.

### **Stop too far**

If the ship is stopped with her bow at a distance from the berth, it will be difficult to position it close to the jetty. In such situation, move the ship laterally and swing the rudder to port for bringing the bow close to the jetty.

However, note that this will only cause her to move in a lateral direction, away from the berth as lateral motion is always at right angles to the direction of motion and away from the direction of turn. This will make the operation more complex and longer.

If berthing against a knuckle, it is important to land flat against the straight part of the quay, and not on the knuckle.



# CHAPTER 6:

## Berthing With Anchors

**“Anchors are considered as secondary but important berthing aid and are normally used when no tugs are available or in the absence of bow thrusters.”**



During all manoeuvring and harbour operations, one team is always assigned to anchor operation for emergency stop of the ship (during engine or steering failure).

### Dredging anchors

Dredging anchor is a popular technique used to manoeuvre large ships in constrained waterways. A large anchor is lowered from the bow of the ship to just touch the bottom without getting anchored or set. The ship's bow is then held stationary by the anchor and the ship pivots via the stern.

A bow anchor can be dredged from a ship going forward or astern. To overcome the anchor's drag, propulsive power is used giving good steering at low speed. When going forward, corrective action will be needed to prevent the bow from swinging to port or starboard. The intention is for the anchor to drag and not to dig in. If the anchor does dig in, it could cause the ship to stop and necessitate breaking the anchor out again.

“Digging in” can also damage the ship, anchor, or windlass. It is therefore important to use as little cable as possible - typically a length of cable that is between one and a half or two times the depth of the water.



### Emergency anchoring

During an emergency while manoeuvring, emergency anchoring is used to stop the ship as soon as possible to avoid collision and grounding. When this is done, first the anchor is dragged and after building up its holding power, the anchor will dig and start the breaking effect for the ship.

Extreme care must be taken not to have excessive forces or pressure in the anchor winches and machinery or else it may lead to accidents.

**“Local knowledge regarding the nature and condition of the seabed is important to avoid dredging in an area where the bottom is foul.”**



# CHAPTER 7:

## Safe Manoeuvring - Conclusion

For a Safe and smooth berthing or manoeuvring, always know and prepare beforehand the following:

- ✓ **Passage planning**
- ✓ **Weather condition**
- ✓ **Water depth and area for ship's movement**
- ✓ **Types of tug used**
- ✓ **Position for tugs**
- ✓ **Keep ready Emergency anchors**
- ✓ **Pre-checked and well operational mooring machinery**
- ✓ **Port / ship communication**

**“Ship Navigation is more of an art which is developed through experience rather than just knowledge. When both experience and knowledge are merged in the right manner, you can definitely master the ship's navigation techniques.”**



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