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INTRODUCTION

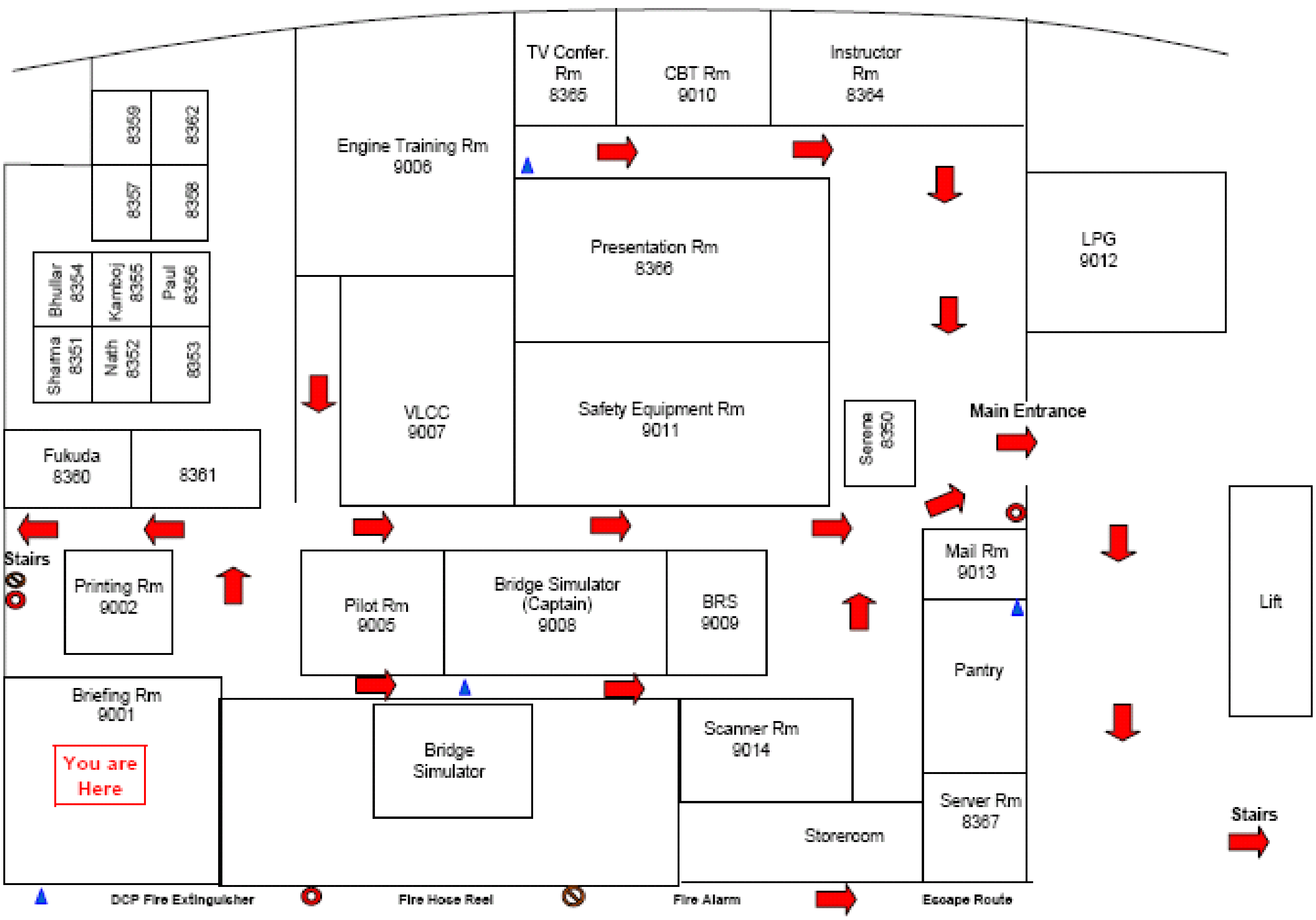
“ Ship handling is an art rather than a science.

However, a ship handler who knows a little of the science will be better at his art.

Knowledge of the science will enable easy identification of a ship’s maneuvering characteristics and quick evaluation of the skills needed for control.

A ship handler needs to understand what is happening to his ship and, more importantly, what will happen a short time into the future. “

NYKSM Training Centre Level 4
Emergency Escape Plan



Chapter I: FACTORS AFFECTING THE SHIP HANDLING

1. Linear Motions

Heave: The up and down motion along the vertical axis.

Sway: The lateral (side-to-side) motion along the horizontal axis.

Surge: The forward and backward motion along the longitudinal axis. The distance gained or lost while changing speed.

2. Rotational Motions

Pitch: Rotation about the horizontal axis. The bow and stern move up and down in opposite directions.

Roll: Rotation about the longitudinal axis. The sides move up and down in opposite directions.

Yaw: Rotation about the vertical axis. The bow and stern move side to side in opposite directions.

3. Underwater Hull Geometry:

Length to beam (L/B), beam to draught (B/T), block coefficient, prismatic coefficient (ratios of the ship's volume of displacement against the volume of a rectangular block or a prism) and location of longitudinal centre of buoyancy, all give an indication of how a ship will handle.

- High values of L/B are associated with good course directional stability. Container ships are likely to have a L/B ratio of approximately 8, while harbour tugs, which need to be able to turn quickly and where course stability is not required, have a value of 2.5 to 3.
- High values of B/T increase leeway and the tendency for a ship in a beam wind to 'skate across the sea surface'. A B/T ratio of over 4 is large. Most merchant ships have a B/T ratio in the range of 2.75 to 3.75. A 22-metre fast motor yacht will have a B/T ratio of about 5.75.
- Ships with large block and prismatic coefficients have poor course stability and a readiness to turn. When turning, they will do so easily. Large tankers have these characteristics. Ships with a large protruding bulbous bow are likely to have their longitudinal centre of buoyancy far forward. As a result, the ship will show a tendency to turn.

4. Pivot Point (PP) and Centre of Lateral Resistance (CLR):

- *Pivot Point* (PP) is the imaginary point about which the ship rotates, a point along the fore and aft axis of a turning ship that has no sideways movement, having for reference the surface of the water.

- The pivot point is generally *at 1/3 ship's length from the bow when the ship is moving ahead, and between 1/4 ship's length from the stern and the rudder post when going astern*. But if a powerful and effective lateral force is applied at one end of the vessel, the position of the pivot point will shift at about 1/3 ship's length from the other end of the ship (relative to the applied force). Therefore, the position of the pivot point is also function of the efficient lateral force(s) applied on the ship, and not only caused by the headway or sternway.

- At port maneuvering speed, the centre of leverage (point of the ship where an effective lateral force causes no rotation) is close to midship; it will move forward less than 10% of ship's length, if the vessel is trimmed by the head, and it will move aft if the vessel is trimmed by the stern. *This point is called Centre of Lateral Resistance (CLR).*

- At any given moment, the CLR of a vessel is that point where, if you apply an effective lateral force, no rotation (if the vessel has a steady heading) will occur. Acting on this point, a lateral force has no arm lever, therefore no turning moment, it only pushes the vessel sideways. A force acting ahead of the CLR will rotate the ship in a different direction than the same force acting astern of the CLR would do. *The lateral resistance is also called hydraulic lift*.

- The position of the CLR depends on:
• the centre of gravity
• the centre of the underwater surface area (hull shape and trim)
• the pressure fields around the hull

- The starting point of the CLR is a point between the centre of gravity of the ship and the centre of underwater surface area, when these two do not coincide.
- The position of the centre of the underwater surface for one ship is mainly affected by the trim. A trim by the stern moves the CLR point more aft. A trim by the head moves it more forward.
- The pressure field (bow wave, stern sub-pressure) under headway shifts the CLR forward. This is mainly due to the positive pressure built around the bow (in a forward motion) which creates a *more resistant* surface for the hull to lean on

when pushed sideways. The same principle applies when going astern. For practical shiphandling purposes, the shift of the CLR due to the speed is rarely more than 10% of the ship's length in the direction of the ship's movement.

The CLR is the *leaning point* for arm levers, it is not the pivot point. Actually these *two points almost never coincide*.

- The PP can even lie outside of the ship's physical limits; the position of the pivot point at any given moment depends on:
• the hull underwater resistance to lateral movement,
• the efficient lateral force(s) applied on the vessel,
• the inertia of rotation of the vessel;

- In order to estimate the position of the apparent pivot point we must assess how a lateral force will affect the rotation of the vessel and the sideways movement of the vessel. The position of the pivot point will also vary with ship's speed: an increase in speed will shift the PP in the direction of the ship's movement.

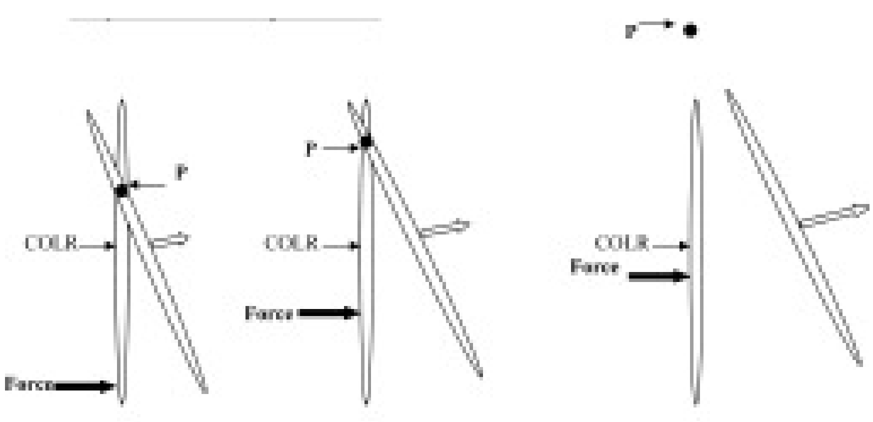


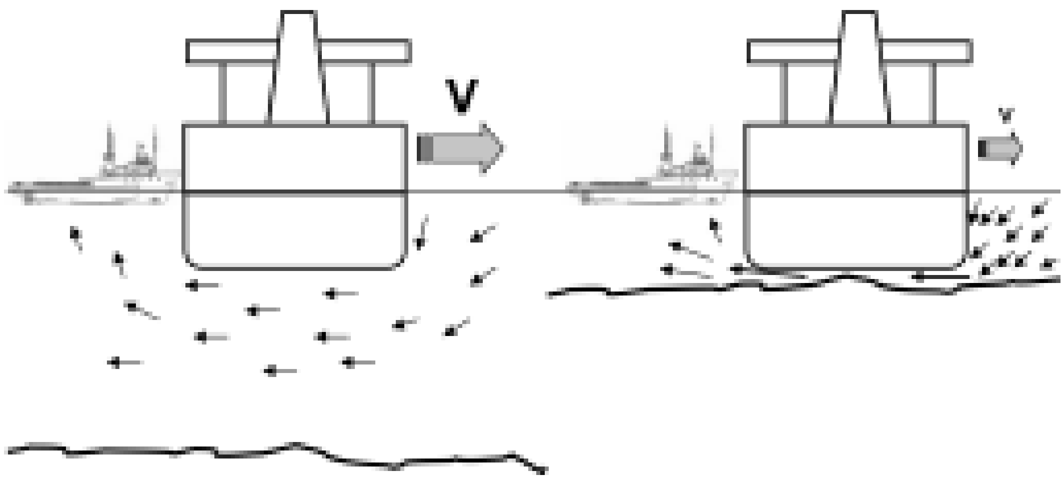
Fig. 9 Fig. 10 Fig. 11

- A lateral force acting away (fig. 9) from the CLR will, for the same angle of rotation, push the CLR relatively less sideways than a force acting closer to the CLR. This results in a pivot point further at the opposite end of the vessel (fig.10). The closer to the CLR the force is acting, the further away from the opposite end the pivot point will be, this can even result in a pivot point outside of the vessel physical limits (fig. 11). This principle is very helpful when using tugs.

5. Hydraulic Lift – Lateral resistance

The “lift” *is the resistance of the water to any lateral movement of the vessel*.

- The hydraulic lift varies with:
• The shape of the hull: a more profiled (narrow) hull will induce relatively more lift. Let’s compare two ships with the same length, same draft, the first one having twice the beam of the second one. After the ships have developed sideways motion, it is harder to stop the drift of the wider ship (twice heavier) for approximately the same lateral resisting force (L x draught = surface area of the wall of water).
• The under keel clearance: little under keel clearance means more lift (the narrow space under the keel makes it difficult for the water to flow from one side of the ship to the other, so it is harder to push the ship sideways).



A higher lift means a pivot point closer to the CLR

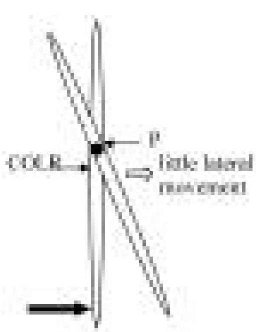


Fig. 13 High lateral resistance

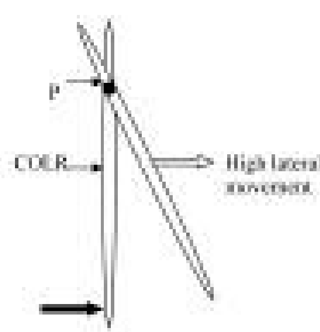


Fig. 14 Low lateral resistance

- For the same change of angle, the CLR of a vessel with high lift will drift less sideways than a vessel with low lateral resistance when submitted to a lateral force. This results in an apparent pivot point closer to the CLR for a vessel with high lift than the vessel with low lift.

6. Motion of the ship when lateral force(s) are applied:

6.1. The rotation effect

- Let's consider a solid bar free to move on an friction free surface. Let's push it sideways with some anti-clockwise rotation. Now stop the force acting on it and watch the resulting movement: The center of gravity is moving to the right and the bar rotates around it. The point that has no speed (having for reference the ice surface) is "P", the apparent pivot point.

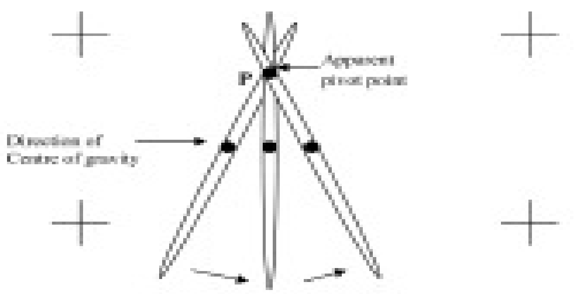


Fig. 15 Body thrown sideways and rotating on a friction free surfac

- When a ship is being handled at low speed (when the pressure fields on the hull are actually very low), it is mainly due to the above effect that the "apparent pivot point" seems to move astern if the vessel is moving astern and turning, and ahead if the vessel is moving ahead and turning.

6.2. The ship generated sideways current

- Let's consider a ship turning, and moving ahead. The "sweeping" movement of the stern creates a vacuum which in turn drags a mass of water towards the quarter shipside. The outer shipside also pushes a mass of water away. We will call it the ship generated sideways current . Let's now stop the force creating the turning movement.

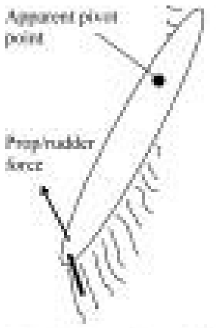


Fig. 15 Ship moving ahead And turning

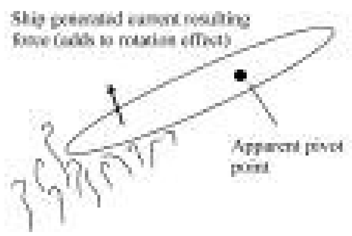


Fig. 16 Ship turning after acting force is stopped

- The ship, with its rotational inertia, keeps on turning, but the rate of turn will reduce due to water friction. The ship generated sideways current with its own inertia, will catch the stern and continue to push it sideways, while the forward part of the ship is in undisturbed water. This force, acting more or less sideways on the stern contributes in moving the apparent pivot point more forward.

- The ship generated sideways current effect is relatively more important on a deeply laden vessel than on a wide light barge. On the latter, the rotation effect will be more noticeable. The result, however, is the same: an apparent pivot point located forward.

Note: *The ship generated sideways current can have surprising effects when an efficient side force (strong tug, for example) is applied, at the shoulder on a ship with headway or at the quarter on a ship with sternway, for long periods. The ship can develop a swing in the opposite direction!*

7. Practical observations and how they meet the theory

Ship generated sideways current and stern seeking to go up-wind with astern movement

1) A ship adrift is pushed sideways in a beam wind. Its motion creates a *ship generated sideways current*.

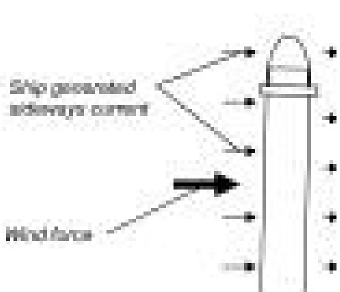


Fig. 17

2) The vessel is going astern (we neglect here the effect of the transverse thrust), pulling the aft part of the vessel out of the ship generated sideways current. The stern being now in an area of relatively undisturbed water, the rest of the vessel still in the local ship generated current, a turning couple is created, bringing the stern up-wind.

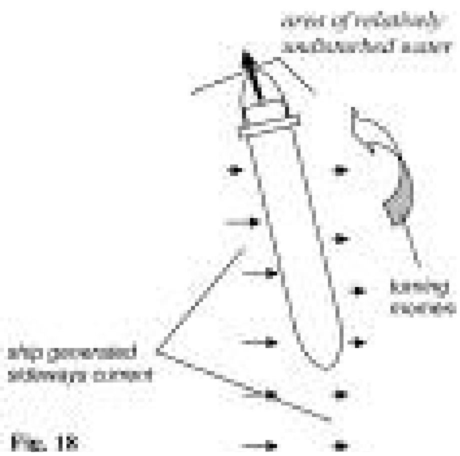


Fig. 18

As the stern is progressively directed into the wind, it gets out of and produces less ship generated sideways current. Another force couple is developing: the component of the propeller pull which is directed in the opposite direction of the wind is increasing, causing an arm lever of a length “d” between the propelling force and the centre of windage (fig. 19).

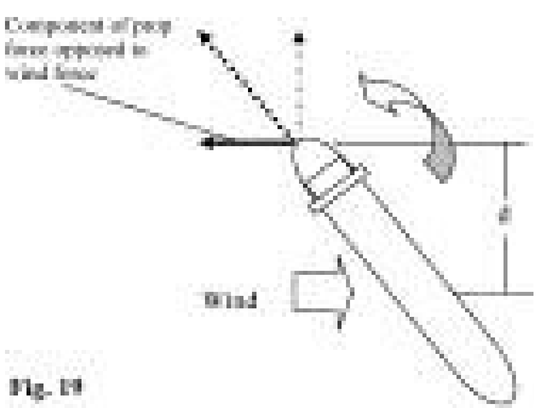


Fig. 19

“Donkey” - like behavior of a ship pushed sideways by a forward escort tug (this phenomenon was described in 2001 in the text: Unpredictable behavior; example of a reason to reconsider the theory of maneuvering for navigators by Capt. Max J. van Hilten of the Maritime Pilots’ Institute, Netherlands)

1) The ship is moving ahead. The forward escort tug will start pushing in order to direct the bow to port.

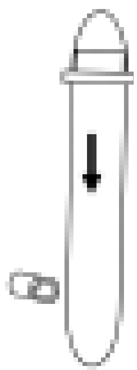


Fig. 20

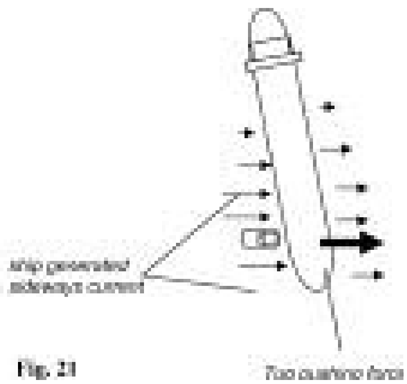


Fig. 21

2) The tug pushing has the following effect on the ship:

• sideways motion of the ship to port,
• rotation of the ship to port, since the force is acting forward of the CLR.
• due to the sideways motion, the ship is displacing a mass of water sideways with her, pushing it on port side and pulling it on starboard side.

3) As the ship moves ahead, the bow will float in an area of relatively undisturbed water. The stern instead will be affected by the ship generated sideways current that has started to develop in 2), causing a turning moment that will reduce the port swing and can even initiate a starboard swing. When the ship starts a starboard swing, the stern, due to the rotation, keeps on generating more sideways current than the forward part of the vessel, thus amplifying the turning moment.

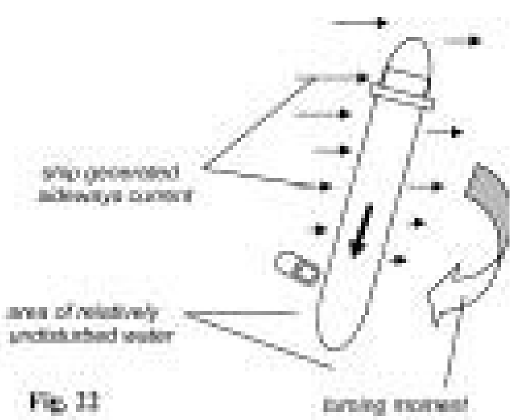
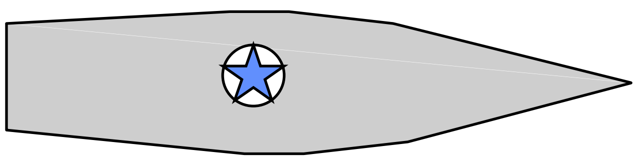
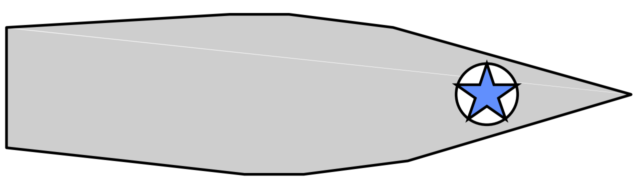


Fig. 22

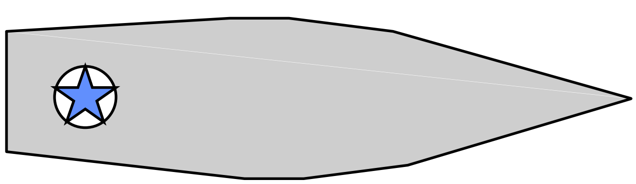
- The similar effect is sometimes observed when leaving a berth stern to tide, having a tug made fast on the quarter and pulling. If the tug is used for a prolonged period to open the stern towards the centre of the river, (with the engines of the ship astern) the forward part of the vessel will be more affected by the ship generated sideways current than the stern. This will cause the bow to go after a while in the same direction as the tug pull.



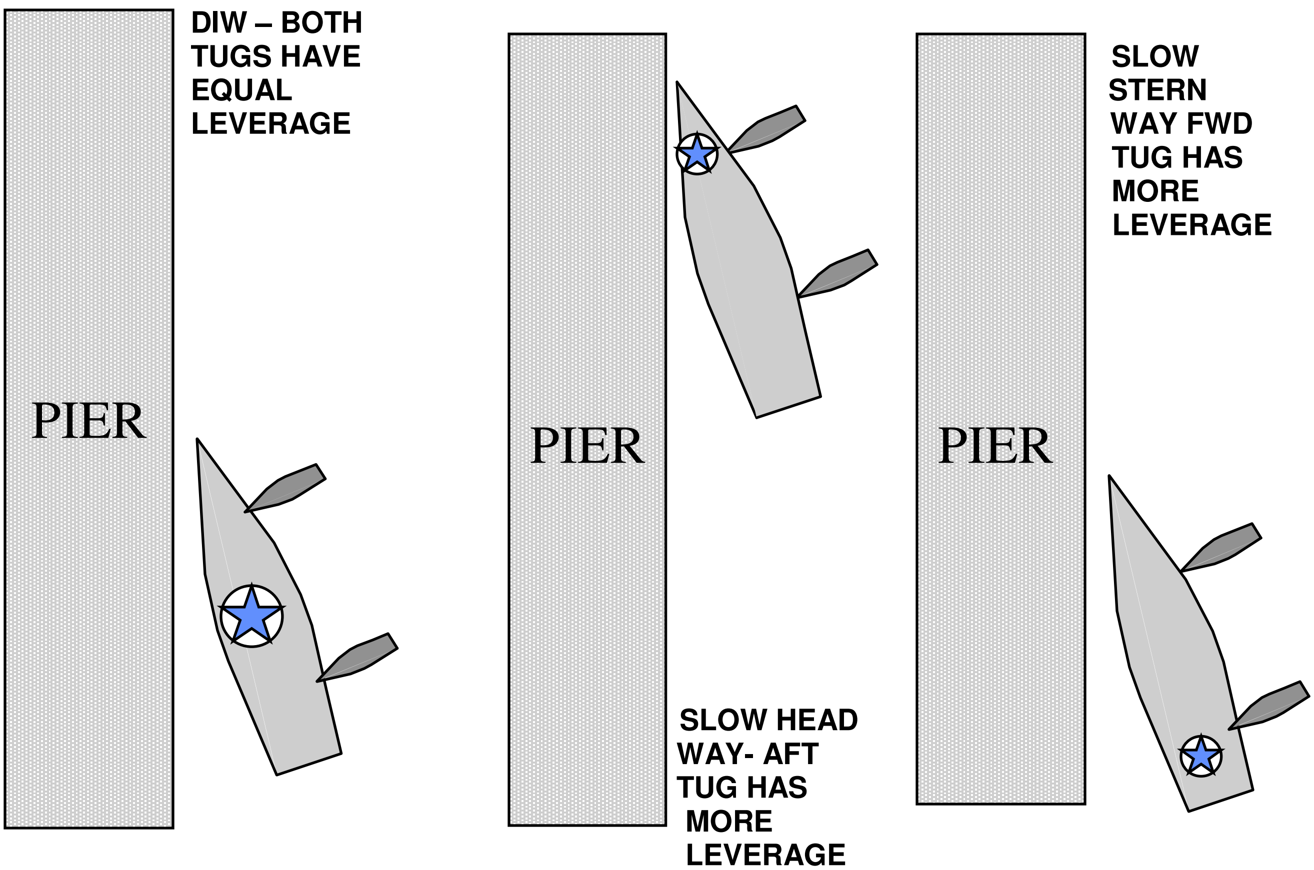
VESSEL "DEAD" IN THE WATER



AHEAD MOVEMENT... LONG STEERING LEVER FROM PROPS/RUDDERS



ASTERN MOVEMENT... NO EFFECTIVE STEERING LEVER UNTIL SOME STERNWAY



Chapter II: SPEED MANAGEMENT

1. Approach speed:

Many berthing accidents occur because the speed of approach is too high. The master should advise the pilot of the ship's stopping distance and general maneuvering characteristics, giving particular emphasis to speed, corresponding engine revolutions and to the critical range. When close to a dock, speed should be the minimum necessary to maintain control.

2. Control while slowing:

- It can be difficult to reduce speed and maintain control. This is because reduction in propeller speed reduces water flow over the rudder and the rudder becomes less effective.

- The normal procedure for stopping is to put engines astern. However, when a propeller rotates astern, water flow over the rudder is broken and the ship will be less responsive to helm.

- In addition, there is the disruptive effect of transverse thrust. For this reason, it is essential to plan a stop by reducing speed in good time. Also, it should be appreciated that putting engines to full astern during an emergency could result in a loss of steerage.

3. Kick ahead:

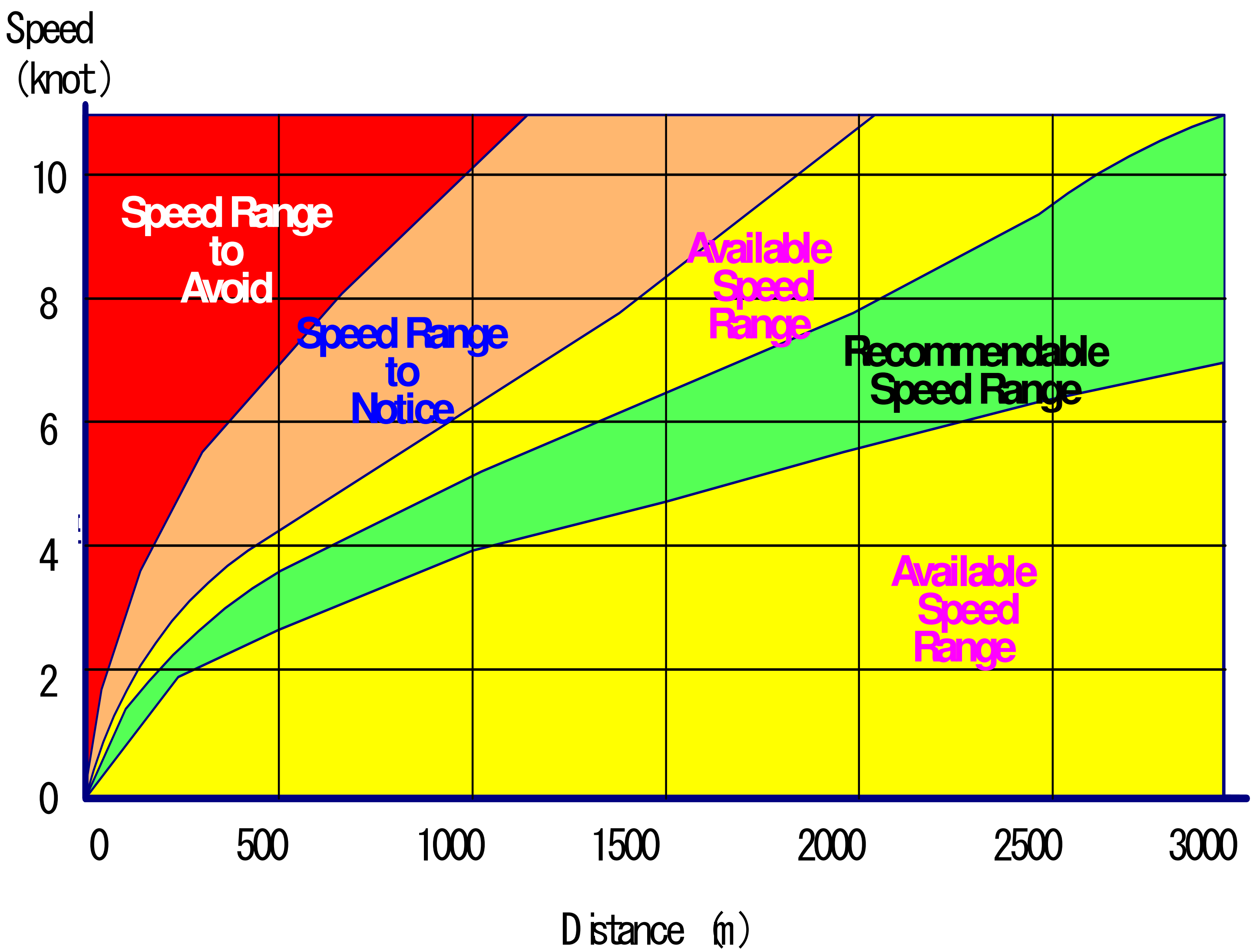
- The 'kick ahead' is used when a ship is moving forward at very slow speed due to minimal water flow over the rudder and the ship is not responding to helm. It is also used to initiate a turn. Engines are put ahead for a short burst with the objective of increasing water flow over the rudder, but without increasing the ship's speed. Engine power is reduced before the ship's longitudinal inertia is overcome and she begins to accelerate.

- When using the 'kick ahead', it should be borne in mind that prolonged and frequent kicks ahead will increase the ship's speed. Apply full rudder to provide maximum steering force. Anything less than hard over during turning will allow a greater proportion of the power to drive the ship ahead. It is important to reduce engine power before reducing helm.

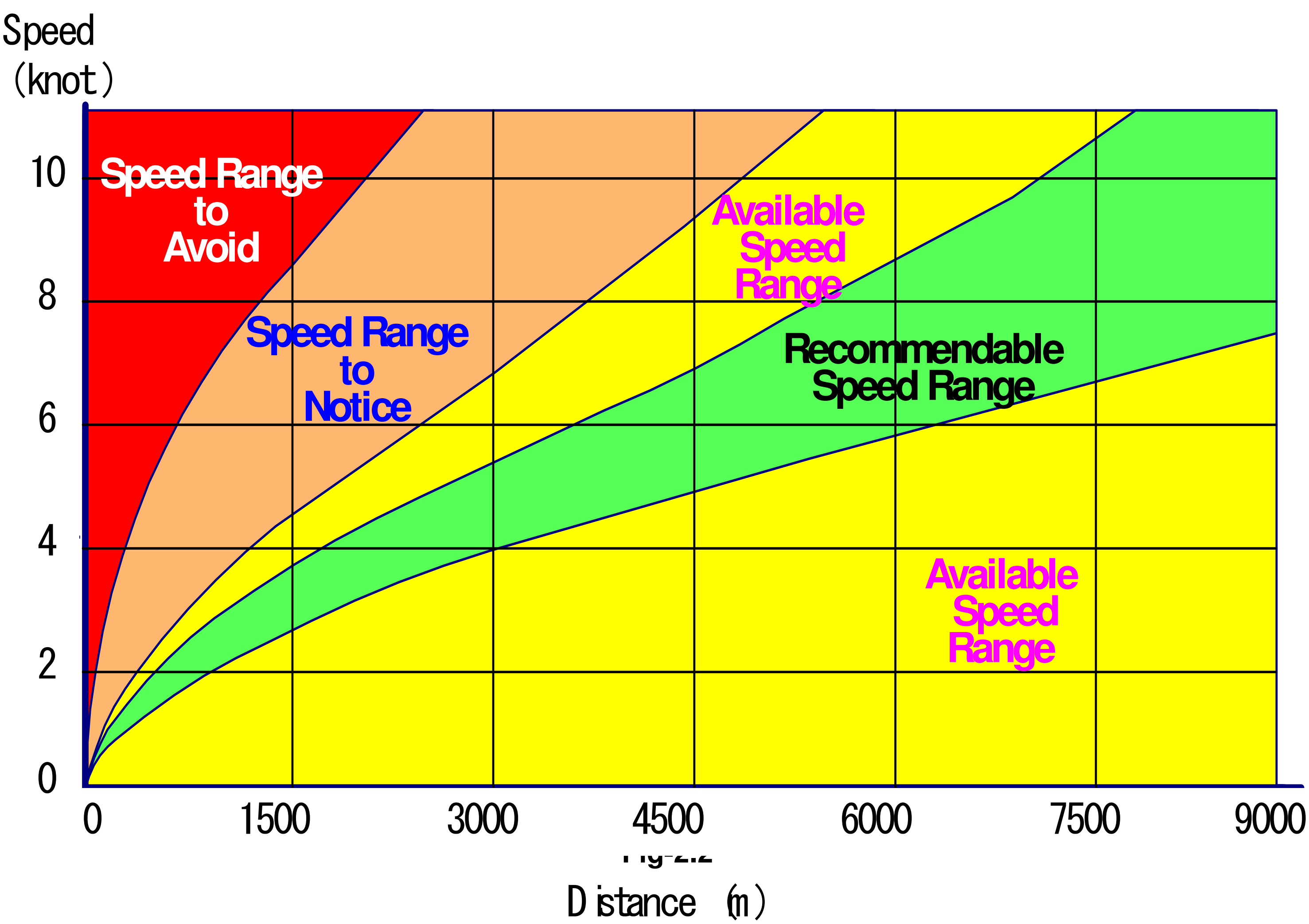
- In case of "Kick ahead", hard over, while having sternway (after an engine turning astern, causing stern motion, is followed by bold ahead engine movement with rudder hard over), the turbulence around the rudder, caused by the opposite flows of the surrounding water (coming from aft) and the propeller thrust, reduces its efficiency.

- The ability of a conventional rudder to initiate rotation is then very poor. However, with a powerful twin screw, and / or a high efficiency rudder, can be produced enough efficient lateral force to move the pivot point ahead, *even with the vessel still having stern way*.

4.1. Recommended Approach Speeds (CTNR, PCC, LNG, LPG, BULK ships)



4.2. Recommended Approach Speeds (VLCC, VLOC, CAPE BULK)



5. Slow Speed Control:

- To estimate a speed and knowing when to reduce speed when approaching berth is not always easy, confidence can only come with experience.
- On large ships such as VLCC some guidance may be available from reliable Doppler logs, but on many ships a Doppler log is not available. In any case full reliance on instruments is not wise and is no substitute for experience. Pilots often jumping from one ship to another sometimes several ships may

have to adjust and develop the feel for the type of ships; therefore Master has to pay special consideration towards effective & safe speed management.
- It is desirable to balance safe and effective speed of approach against a realistic time scale. It would be unwise for example, to conduct a 3mile run-in at a speed of one knot, it is therefore impossible to give exact figures, the requirements is dictated to a large degree by variable factors such as type of ships and tonnage, draft, shaft horsepower and environmental conditions. –
- Generally speaking ships of less than 40,000dwt for example are inclined to run their way off relatively quickly when engine speed is reduced, whereas larger ships carry their way for much larger distances and their speed must be brought firmly under control at greater distances from berth: fig (5.1)

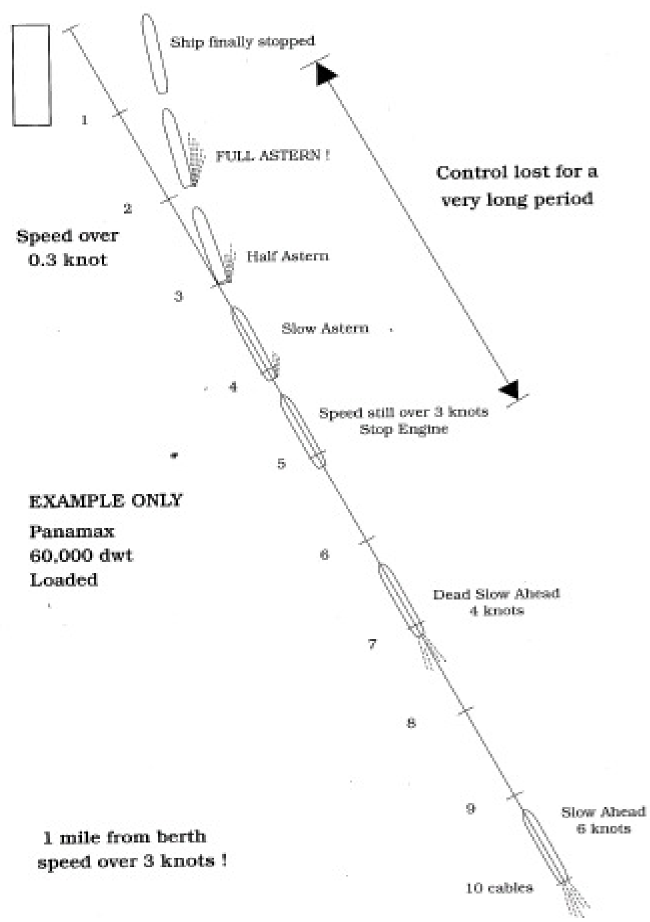


Fig-5.1

- We can illustrate some important points, in this example we have a medium sized ship with a single right handed and fixed pitch propeller and a single conventional rudder, at one mile from berth approaching at 6 knots speed, it is well in excess of the ships dead slow speed of 3 knots, as the ship approaches

the half mile mark, speed is still over 3 knots despite a rapid reduction in rpm. It is now necessary to stop the engine and sustain prolonged period of stern power to stop the ship in time.
- During this substantial time frame the ship is affected by transverse thrust, wind, tide and bank or shallow water effects, the ships gets effectively out of control an area of uncertainty for Master, if we can reduce this prolonged period of increasing stern power and thus retain control, so much the better.

- In the fig (5.2) below we see the same ship, again 1 mile from berth but this time at its dead slow speed of 3 knots or less, before it approaches the ½ mile mark it may also be necessary to stop the engine to further reduce the headway and allow plenty of time for adjusting approach and positioning for the berth.

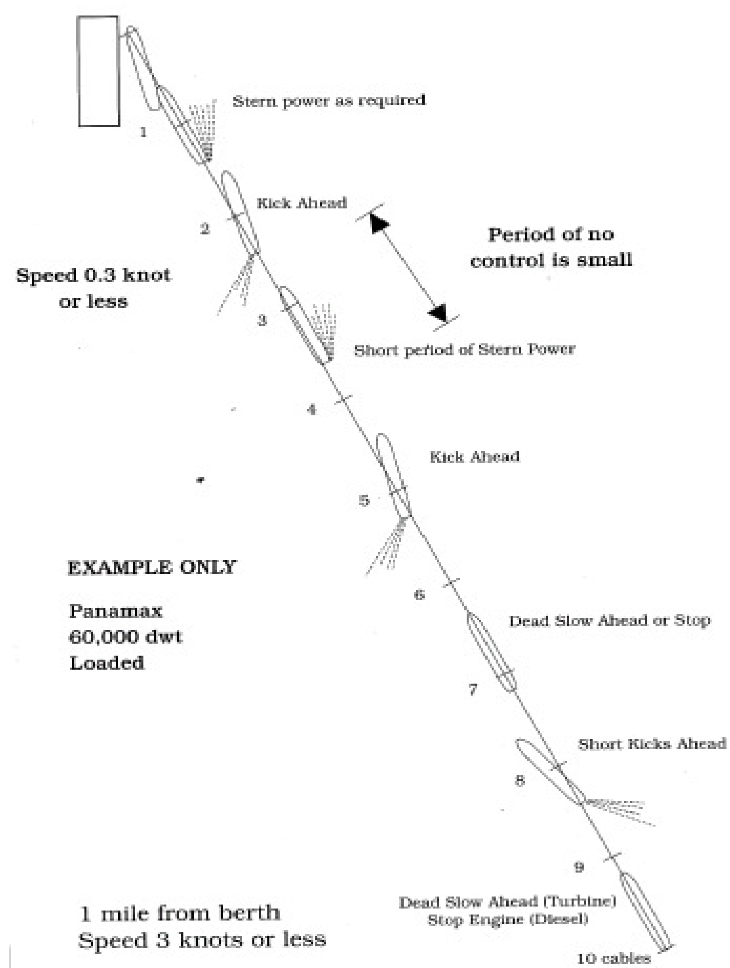


Fig-5.2

- One of the biggest worries is the loss of rudder effectiveness and the fear that we can not keep control of the ships head at very slow speeds, particularly without any tug assistance, for variety of reasons such as poor steering, wind, tide, shallow water or directional control the bow may well begin to develop an unwanted sheer, it may be desirable to adjust the attitude of approach. Control is best achieved by applying full rudder and utilizing a short but substantial burst of engine power. This is called slow speed control.

(Refer to Appendix 1 - Method of Reducing Speed Gradually – ZZ-S-P-07.20.02 / Form No.: S-072002-02FIG)

6. Lateral Speed Control (for Berthing):

Lateral vessel's speed can be controlled using tugs, rudder & propeller effects, as well as wind and current effects. Below Table is the recommended lateral berthing speed as per Company requirements (***GI/FLT/016/12*** - Lateral Approach Speed while Berthing).

Lateral Berthing Speed		
Distance	**VLCC / TKR / Bulk Carrier**	**PCC/CNTR/Gen**
200m	**20 cm/sec**	**-**
100m	**15 cm/sec**	**20 ~30 cm/sec**
50m	**10 cm/sec**	**15 cm/sec**
25m	**5 cm/sec**	**10 cm/sec**
final (<10m)	**max 5 cm/sec**	**max 8 cm/sec**

Chapter III: ANCHORAGE MANEUVER

1. Anchoring Plan:

The master shall prepare a plan for anchoring in accordance with the following:

- Selection of Anchorage
- Determining of Anchoring Method (single anchor, double anchoring, two-anchor mooring or any other appropriate anchoring)

- Deciding Which Anchor To Be Used (which anchor to be used considering the anchoring method, direction of approach, tidal current set, frequency of use of both anchors until now, etc.)
- Deciding on Extension of Anchor Chains (give consideration to the duration of anchoring, room of the anchoring area for use, weather conditions while the ship is at anchor and holding power of the anchor, etc.)
- Arrival at Anchorage (prepare a plan for the gradual decreasing of the speed suitable for the maneuverability of the ship).

2. Critical Wind Velocity for dragging anchor:

(Refer to Appendix 2 - Determination of Critical Wind Velocity for Dragging Anchor - ZZ-S-P-07.20.02 / Form No.: S-072002-05FIG, and Appendix 3 – Safety Bulletin GEN 2007 001: Determining Critical Wind Velocity for Dragging Anchor).

To avoid any disasters resulting from dragging anchor, Master shall calculate the critical wind velocity for dragging anchor. This should be utilized in developing the anchoring plan and the anchor watch instructions / checks. It should also be noted that this calculation provides only a guidance to grasp the wind velocity for dragging anchor and that the ship may even start to drag its anchor if the wind velocity is lesser than the critical wind velocity. It should be carefully examined to determine whether safe anchoring can be maintained especially when heavy weather is forecasted.

a) Note that the critical wind velocity is subject to preconditions such as size or shape of the ship, depth of water, bottom sediment, etc.

b) The followings to be considered when examining risk of dragging anchor:
i) Even if the wind velocity is not more than the critical wind velocity, the ship may drag or damage her anchor due to other additional factors such as swells, waves, currents, age & condition of anchor itself, its chain, shackles etc.
ii) It is very difficult to heave up anchor if the weather, especially the sea condition, becomes heavy or unfavorable.

3. Preparing To Cast Anchor (Drop Anchor):

- The Master, at an appropriate time before arriving at the anchoring area for use, shall station the forecastle chain-party at forward and advise the chief officer of the anchors to be used, expected number of chains to be laid out, expected depth of anchoring area for use, and any other necessary information.

- The Chief Officer (or Officer as assigned by Master), after taking up the station at forecastle, checks the number of crew members there and reports to the bridge. He shall confirm from Master regarding the anchors to be used, expected depth of anchoring area and expected length of anchor chains to be laid out. In addition, in consultation of master, he directs the deck crew members to be ready to cast anchor in accordance with the SMS procedures, and report about the ship's way to the bridge at appropriate times judging from the state of the cutwater.

4. Determination of Amount of Anchor Chain To Be Laid Out:
(Examples as Guidance)

For Normal Anchoring: S = 3D + 90 m
For Rough Weather Anchoring: S = 4D + 145 m
S: Length of Anchor Chain Laid Out (m)
D: Depth of Water (m)

(Refer to Appendix 4 - Determination of Holding Power of Anchor - ZZ-S-P-07.20.02 / Form No.: S-072002-04FIG, and Appendix 5 – Anchor Chain Weight and Type Table).

(Also refer to Appendix 6 - SMS Tools: Calculation of Holding Power and Wind Pressure Force – excel format calculation sheets).

5. Anchoring in Deep Water:

Lowering of the anchor in deep water shall be done in accordance with the following procedure:

5.1. When the *depth of the water exceeds 25 meters*, walk back the anchor under water close to the sea bottom (10 to 5 meters) and then let it go;

5.2. When the *depth of the water exceeds 50 meters*, walk back the anchor until it reaches the sea bottom and pay out the anchor chain under power to the scheduled amount of chain to be laid out while laying the anchor chain along the sea bottom; and, when paying out the anchor chain, speed over the ground shall be 0.5 knots or less.

(Refer to Appendix 7 – Calculation of Maximum Anchoring Depth basis Windlass Power, and Calculation of Load on the Windlass).

Maximum Anchoring Depth Guidelines & Calculation (GI/FLT/039/11)

==

As far as practicable, vessels shall avoid anchoring in depths greater than the Maximum Anchoring depth, calculated basis 80% of the Lifting Load of the Windlass.

Maximum Anchoring depth, based upon 80 % of the Liftable Load of the Windlass = 111.6 metres

Maximum anchoring depth, based upon 90 % of the Liftable Load of the Windlass = 134.4 metres

Contact Vessel Manager immediately if vessel is unable to obtain suitable anchoring position with depth less than 134.4 metres (basis 90 % of the Liftable Load of the Windlass)

6. Points To Be Observed When Anchoring:

- Avoid anchoring for short periods unless as per Charterer's and/or Owner's requirements. Master shall avail berthing information and vessel's schedule well in advance so as to adjust speed and arrive at the pilot station on time.
- Pay due consideration to the condition of hydraulic gear, windlass motors, anchors, cable, and brake lining;
- The anchor chain is liable to be subjected to an unexpected load causing the anchor to drag in the initial stage of laying out the chain after the anchor is let go, or causing the chain to lie curved or snaked on the sea bottom so that a good hold of the anchor cannot be obtained;
- When the current is from the side of the ship, since the lee way becomes bigger as the ship loses her way becomes smaller, approach the anchorage keeping course with a sufficient inertia, face the current immediately before, and when the ship stops, pay out the anchor of the side of the current for about 1.5 times the depth of the sea, then stop the anchor and face the bow into the current. After that pay out the chain while slowly going astern;

- Try as much as possible not to have the current from behind, but if this is unavoidable, lessen the way of the ship and let go the anchor on the turning side of the ship at a short distance from the scheduled anchorage; and
- PCC vessels are more susceptible to winds due to large superstructure and are likely to encounter difficulty in holding anchor when the wind velocity exceeds **12m/sec**.

7. Weighing Anchor (Heave up the Anchor):

- Start the windlasses and test operate them to check that there is nothing wrong with them;
- For security and emergency purposes while anchoring, put the opposite side anchor on S/B. (Check the space between the stopper and the anchor chains on S/B. The putting on or taking off of the stopper shall be done according to the directions of the master.);
- After engaging the gears, release the brakes and remove the stopper; and – where applicable – request the bridge for a supply of sea water to wash the anchor chain.
- Check the tension on the anchor chain and, if necessary, request the bridge for the use of the engine, and report to the bridge the direction in which the anchor chain is extended and the state of the heaving in process (at every shackle).
- Officer stationed on the forecastle, after weighing anchor shall confirm by visually sighting that the anchor is not damaged and is clear of all obstructions.

8. Points To Be Observed When Weighing Anchor:

- When the wind or current is strong, the anchor will drag as the chain is being hove up and the ship will start to go astern. In such a case, use the engine at appropriate times to reduce the load on the windlass;
- When the ship heads, while heaving anchor, in a direction excessively different from the one she intends to proceed after the anchor is up, carry out anchor weighing operation to help her turn to the favorable direction by using the engine and rudder in combination in its process;
- When weighing anchor in swells, the windlass motors are subjected to excessive forces, so be careful about the damage they are liable to incur; and
- When rough weather is expected, do not lose the right opportunity to weigh anchor.

9. Checking of Anchor cable, links and D-Shackle:

The condition of all moving parts, confirming the proper condition of cables and fittings, detection of twists in the cables, cracks in stud link welds, spile and other 'locking' pins that hold Kenter-type joining shackles together and the pin of the 'D'

shackles shall be checked at every opportunity and reported to Bridge. The diligence of the Chief Officer in proper inspection and reporting may prevent the loss of the anchor, or worse.
A spare Kenter-type shackle shall always be kept on board.

10. Inspecting Anchor:

When the ship remains at anchor for a long period, if prevailing circumstances permit, the master should temporarily heave up her anchor and let go again at the interval mentioned below as a standard in order to maintain good anchoring condition:
- In a river or estuary where tidal current is significant: every 3 days;
- At area where there is a lot of moving muddy sand in sea bed: every 5 days;
- Other area: once every 1 week.
- If 10 completed 360° turns are made earlier than above listed intervals.

(Refer also to ***GI/FLT/039/11*** - Guidelines on calculation of Maximum Anchoring Depth, basis vessel's Windlass power)

Chapter IV: BERTHING MANEUVER

1. Golden Rules for Berthing:

- Plan your passage from berth to berth, discuss the passage & berthing plan with the pilot, clarify your doubts if any, and pay attention to the dangers that may be encountered.
- Consider the usage of tugs, where wind & current or the ship’s handling characteristics create difficult berthing conditions, estimate the windage & use this estimation to determine the number of tugs required.
- Avoid un-necessary high speeds - when working with tugs, when using bow thruster, when under keel clearance is small, when navigating in narrow channel & when close to other ships.
- Test your Main Engines astern before required to be used.
- Remember that a ship will want to settle with the pivot point to the windward side and in alignment with, the point of influence of wind, which changes with wind direction and the ship’s heading.
- Remember that at low speed, current and wind has a greater effect on maneuverability of the vessel.
- Always anticipate well ahead and expect the unexpected to occur, do not ring “Finished with engines” until every mooring line has been made fast.

1.1. NYKSM Maneuvering Standard (GI/FLT/011/12):

- "NYKSM Maneuvering Standard" comprises of essential instructions and procedures which should be observed by the Bridge Team Members (including Pilots) on board NYKSM managed vessels, as over the past few years, many serious navigational incidents have occurred during maneuvering in port and/or under pilotage.
- "NYKSM Maneuvering Standard" helps the Master and other Bridge Team Members to challenge the pilot in cases where he intends to conduct some unsafe maneuver or non-necessary deviation from safe navigation practices.
- Master is requested to assert with Pilots to follow the passage plan and the berthing / un-berthing procedure.
- Contents of "NYKSM Maneuvering Standard" shall be confirmed and studied by the Bridge Team Members.
- Pilot's signature on the Pilot card serves as evidence of pilot having read and understood the company's requirements as included in this standard.

(Refer to Appendix 8 – NYKSM Maneuvering Standard).

2. Ship Handling Forces:

2.1 Controllable Forces

2.1.1 Forces created by PROPELLER:

- Propeller longitudinal thrust is the force caused by the displacement of water along the propeller shaft to thrust the ship ahead as the ship moves in the direction of the low pressure area. The after face of the propeller blade creates a high pressure area.
- Propeller transversal thrust is the force that moves the stern of the ship in the direction of screw rotation. Side thrust produced by the screw's rotation through the water. The twin-screw ships cancel side force created by the rotating the screws in opposite directions.
- Propeller Wash is the turbulence produced by the screws turning against the water. While twisting or operating astern, it negatively effects a short radius turn by decreasing the efficiency of the rudder.
- Propeller Pitch is the distance a propeller would travel in one revolution if water were a solid medium.

- Cavitation: Cavities or bubbles around a propeller which are a result of the pressure on the lower and upper blade surfaces being unequal. It is caused by blade tip speed being excessive or by the vessel riding high in the water.
- The propeller will generate both longitudinal and transverse forces, initially transversal forces are more noticeable.

- Twin screw ships can oppose the longitudinal forces to create a twisting moment – one propeller “ahead” and the other “astern”.
- Crenshaw compares side force (transverse force) to a paddle wheel affect with the propeller walking across the bottom.
- When going ahead, a right hand screw will force the stern to starboard and the bow to port. A left hand screw does the opposite.

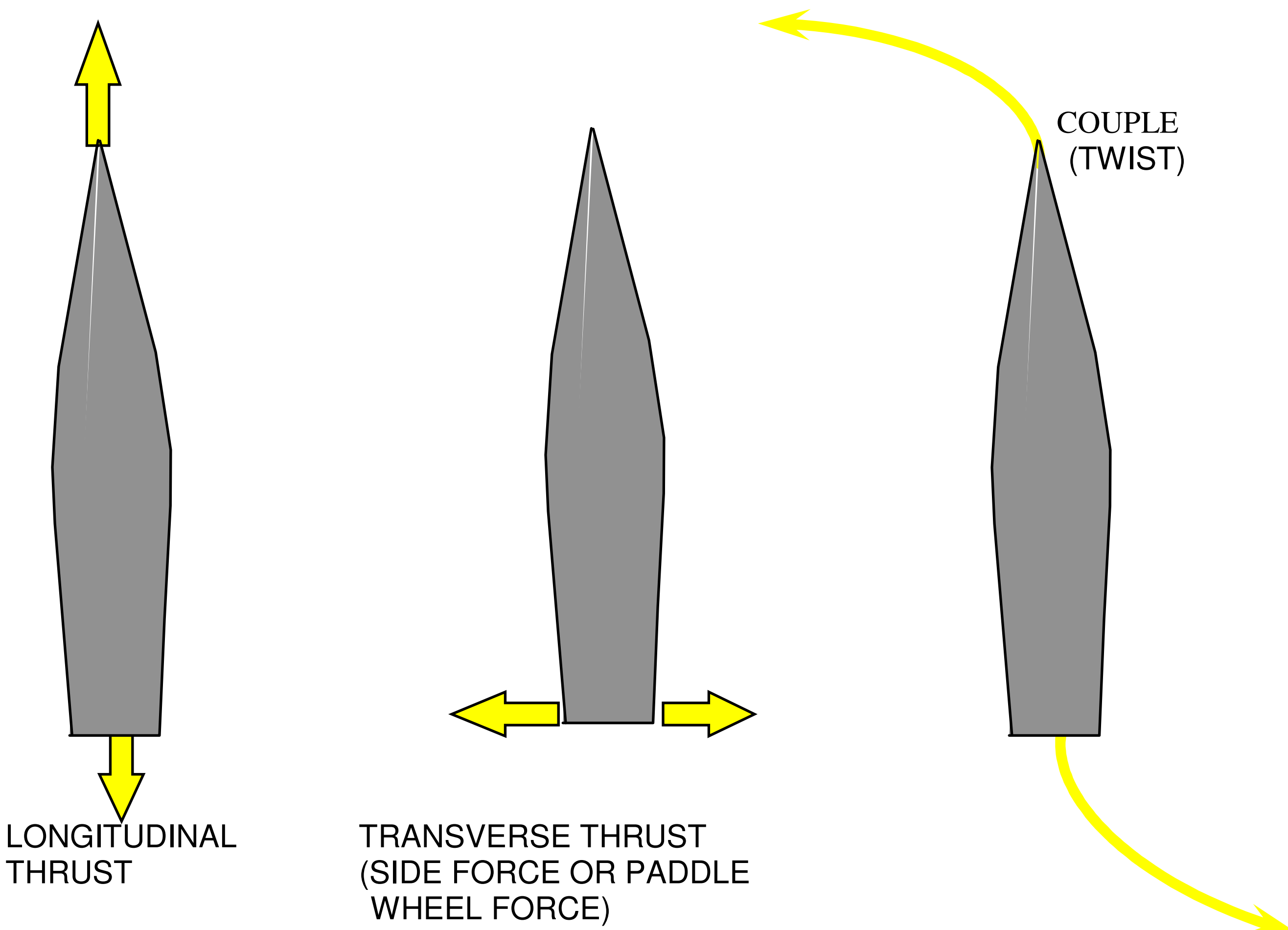


Fig. Propeller Forces

2.1.2 Forces created by Rudder – RUDDER Effectiveness:

- The rudder acts as a hydrofoil. By itself, it is a passive instrument and relies on water passing over it to give it 'lift'. Rudders – to be most effective – are placed at the stern of a ship for this reason and to take advantage of the forward pivot point, which enhances the effect.

- Water flow is provided by the ship passing through the water and by the propeller forcing water over the rudder in the process of driving the ship. The optimum steerage force is provided by water flow generated by a turning propeller. Water flow is vital in maintaining control of the ship. While water flow provided by the ship's motion alone can be effective, the effect will diminish as speed is reduced. Obstacles that deflect flow, such as a stopped propeller in front of the rudder, particularly when the propeller is large, can reduce rudder effectiveness. Reduced or disturbed flow will result in a poor response to rudder.

- Conventional rudders are described as 'balanced'; part of the rudder area is forward of the pintles to help the rudder turn and to ease the load on the steering motor. This arrangement provides for better hydrodynamic loading. A flap (Becker rudder) can be fitted to the rudder's trailing edge. The flap works to increase the effective camber of the rudder and to increase lift.

- With propeller stopped, the only flow across the rudder is created by the ship's motion through the water (there is no side force).

- Rudders can be defined by what is known as the 'rudder area ratio', which is a ratio of the surface area of the rudder divided by the ship's length and draught. The rudder area ratio gives an indication of the likely effectiveness of a rudder. Merchant ship ratios range from 0.016 to 0.035. The larger the ratio, the greater the effect the rudder will have.

- When vessel is going astern, the discharge current is not directed against the rudder and effectiveness is dependent entirely on the ship's sternward velocity to create flow across the rudder. In addition, when engines are initially backed, the pivot point moves aft, reducing the lever arm of forces applied to the stern.

- Screw current can be used to "pump to the rudder" to swing the head over. A "kick ahead" on the engine with the rudder over will swing the head in the direction of the rudder without creating significant ahead motion.

- Once sternway is achieved, the low pressure side of the rudder is reversed. Left rudder will force the stern to port; right rudder will try to turn the stern to stbd.

2.1.3 Forces created by BOW / STERN THRUSTERS:

- Lateral thrusters can be fitted in the bow or the stern and are most effective when a ship has neither headway nor sternway. They create a turning effect by providing a side force at their location. Their effectiveness will depend upon the distance between the thruster and ship's pivot point. When berthing a ship that has a single bow thruster, and no stern thruster, it is important not to become too focused on the bow, because this can be controlled with the thruster. Plan to get the stern alongside as a priority, and a tug may be needed to control the stern.

- Pure rotation can only be induced by two lateral thrusters, one forward and one aft, opposing each other;

- Bow thruster will lose its effectiveness as a ship's speed increases. Depending on the hull and thrust tunnel design, thrust effectiveness can be lost at between 2 and 5 knots. The reason for this is the merging of the slipstream from the thruster with the general flow around a forward moving hull, plus the position from the pivot point when vessel is moving ahead.

- When the ship starts moving ahead, will be a high speed stream of water expelled from the thruster bends along the hull (fig. 23). Its high velocity flow creates a low pressure area that "pulls" the bow in a direction opposite to the side we want to thrust it. The result is that the two forces tend to annihilate each other and the net thrust force is very weak.

- When the vessel is moving astern (fig. 24), the vacuum effect created by the thruster is much less significant since the hull area over which it acts is quite smaller (area between the bow thruster opening and the stem).

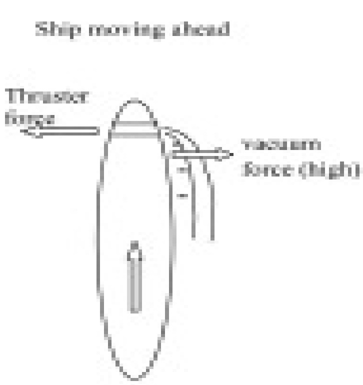


Fig. 23

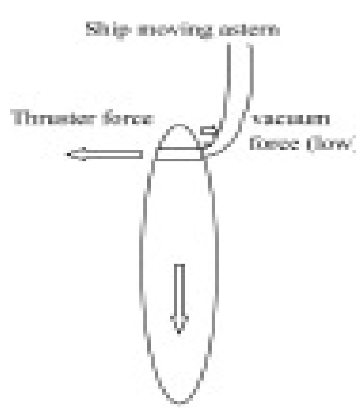


Fig. 24

Thrusting when stopped – When stopped and thrusting, a ship's pivot point is likely to be amidships. If a bow thruster is put to starboard on a stopped ship, the ship's bow will move to starboard.

Thrusting with headway – The pivot point will be forward of the midship, so thrusting will not be very effective, especially at high speeds.

Thrusting with sternway – The pivot point is aft and the thruster will be effective, acting as a form of 'rudder', but its effectiveness will be also reduced with sternway increasing.

2.1.4 Forces created by TUGBOATS:

- Tugs are usually employed according to the practice of the port after taking into account the capabilities of the available tug types.
- Towage has a number of potential hazards, and tug masters will give priority to the safety of their own tugs in dangerous situations.

- Factors to take into account when determining the number of tugs:
• practice in the port for the particular size of ship and the designated berth
• under-keel clearance
• anticipated strength and direction of wind / current and their effect
• windage area, stopping power and handling characteristics of the ship, etc.

- In general, tugs have difficulty operating at high speed. Interactive forces between the ship and the tug can become very large, particularly at the ends of the ship. High speed increases the possibility of capsizing a conventional tug.

- The effectiveness of a tug is proportional to the distance between its point of contact and the ship's pivot point. (For instance, 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).

- When a tug attached by a line leading forward applies a turning force there will also be an increase in the ship's speed (transversal and longitudinal vectors).

2.1.4.1 Working with Tugs: Points to remember:

• Anticipate any changes in tug positioning on the ship and allow sufficient time for the tugs to reposition and be ready to assist.

- Be aware of any space or other limitations that may give the tug master difficulty in carrying out the ship's requirements.
- *Tugs are most effective when a ship is navigating at slow speed, and more effective when pushing, compared to pulling.*
- It is important for masters to discuss with a pilot the position where a tug will attach before the tugs arrive. A tug acting with a long lever from the ship's pivot point will be more effective than a tug with a short lever. The effectiveness of a tug will depend upon the position where it is attached (may be placed to control the bow, or aft to decelerate the vessel, etc.).
- Propeller wash from tugs operating close to a ship, and pulling, could initially cause a ship's bow or stern to move away from the tug.
- Conventional tugs connected by a line can exert an unwanted force on a small ship, which may require corrective action.
- Masters should understand the different performance characteristics of tugs and that conventional tugs are likely to be less maneuverable than water tractor tugs. Ships' masters can decide on the number of tugs employed but have not much influence on the tug type.

2.1.4.2 Steering a ship going astern with tug alongside:

It is possible to steer a ship with a tug, even if positioned at approximately 1/4 L from the stern where the pivot point supposedly lies when a ship is moving astern. When the tug is pushing, you do not get a bodily movement as traditional theory suggests but a movement of the stern in the direction of the action of the tug. The arm lever is short. The CLR is lying a little aft of midship since the ship is going astern slowly. The rotation produced is small and the side movement important, the pivot point is consequently somewhere between the bow and 1/3 L from the bow (if this pushing force is applied long enough for an important *ship generated sideways current* to appear, the rotation of the vessel may stop).

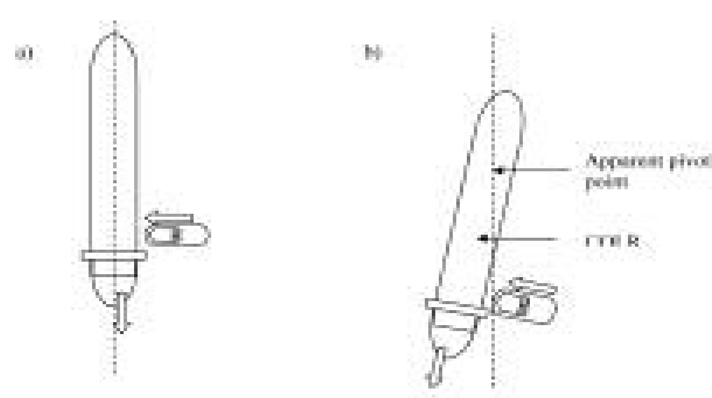


Fig. 26 Tug pushing on the quarter while moving astern

2.1.4.3. Handling the Tugs during Simulator Exercises

USE OF TUG BOATS

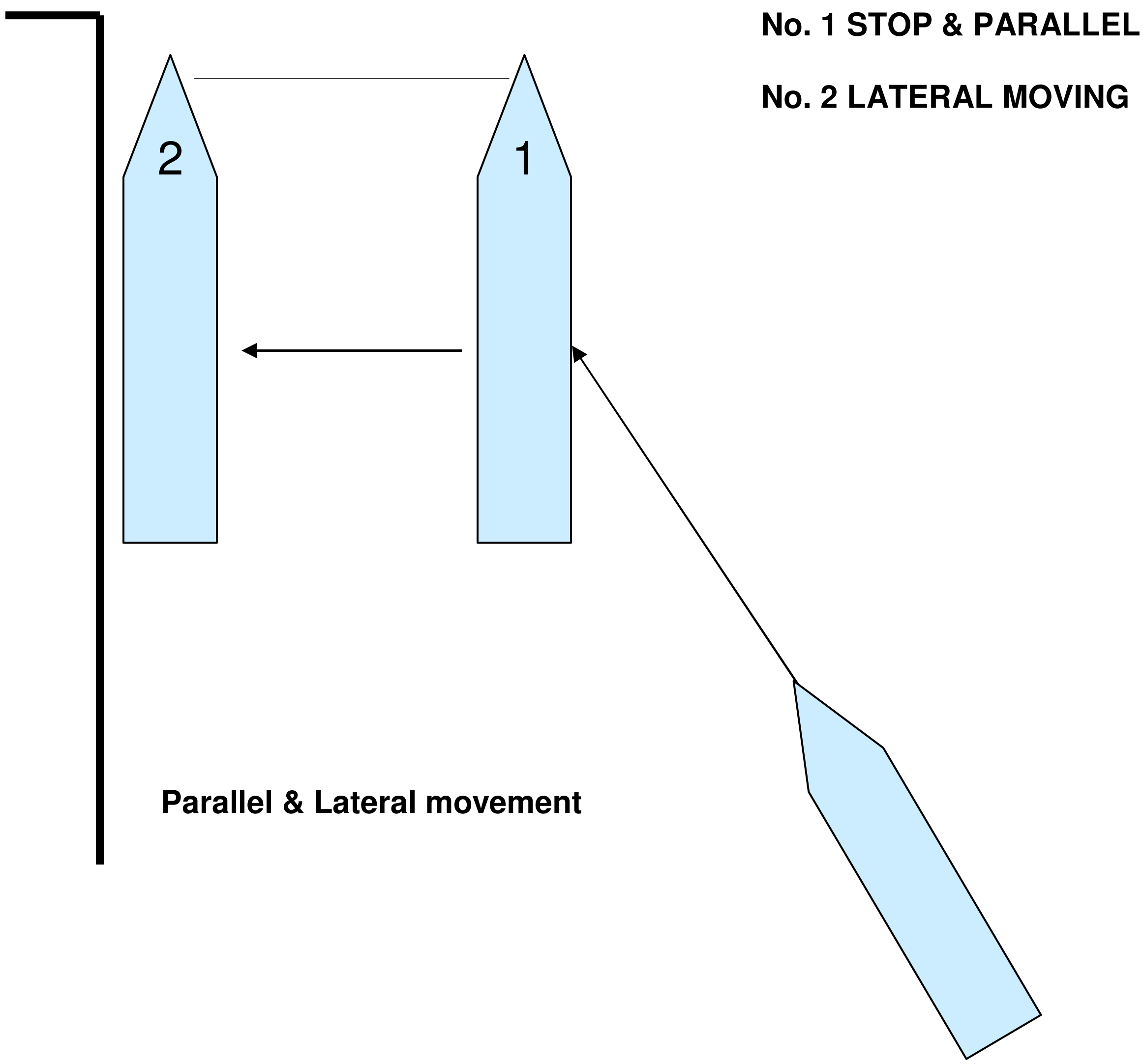
Radio check
Take tug line (location)
S/b push or pull (direction)
Push or pull (direction/power)

TUGS NAME
No.1 ～ No.6
(Direction/location)
Clockwise 1～12 o'clock

POWER TABLE

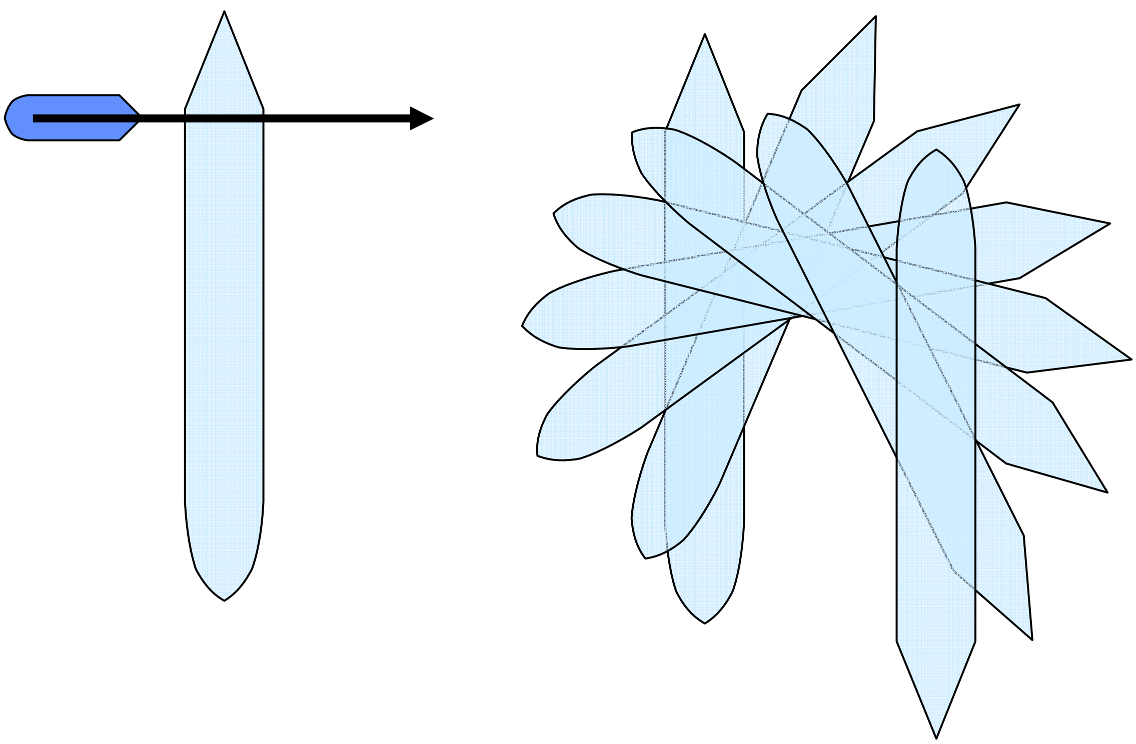
	4,600HP		3,500HP	
	PUSH	PULL	PUSH	PULL
FULL	60	54	50	45
HALF	45	41	38	34
SLOW	30	27	25	23
D.SLOW	15	13	13	11
OMEGA3	12	11	6	6
OMEGA2	7	6	3	3
OMEGA1	1	1	2	1
HANGING	0	0	0	0

SIMULATOR PROCEDURE STANDARD BERTHING PLAN



SIMULATOR RESULTS FOR USE OF TUGS

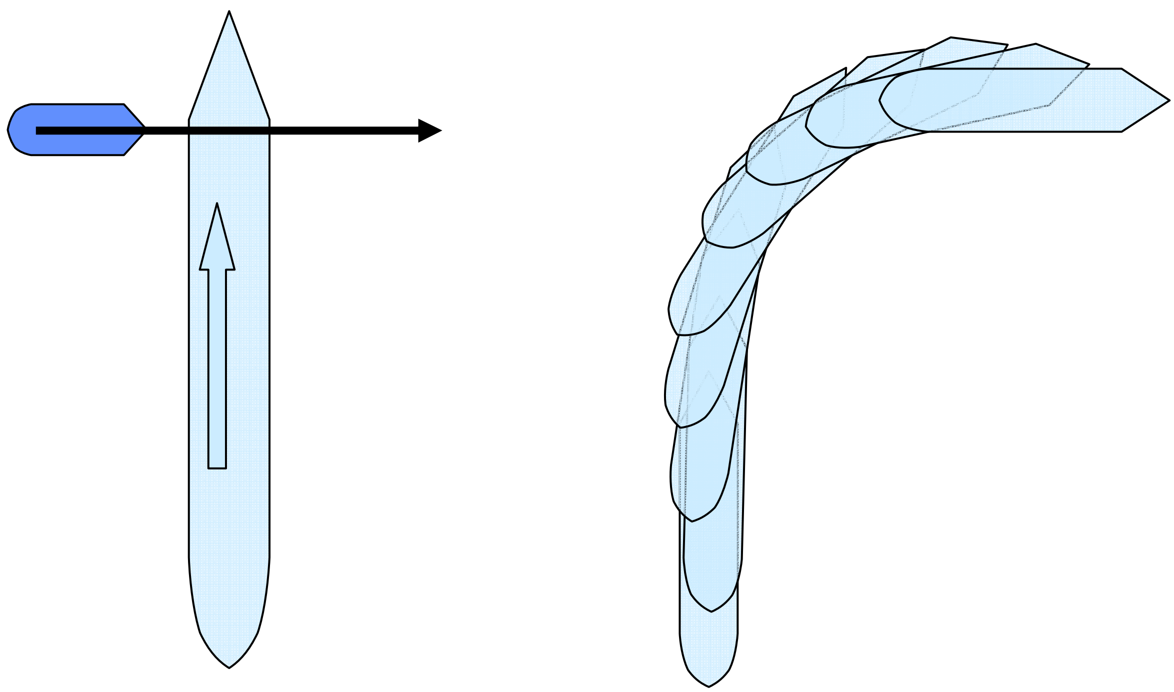
Results from Simulator Trials, For Use of Tugs



Tug pushing at the bow

Tug pushing at the bow
Ship's speed : 0 knots
Main engine : stopped
Rudder : amidships
External forces : nil
Tug power : full
Turning by 180°

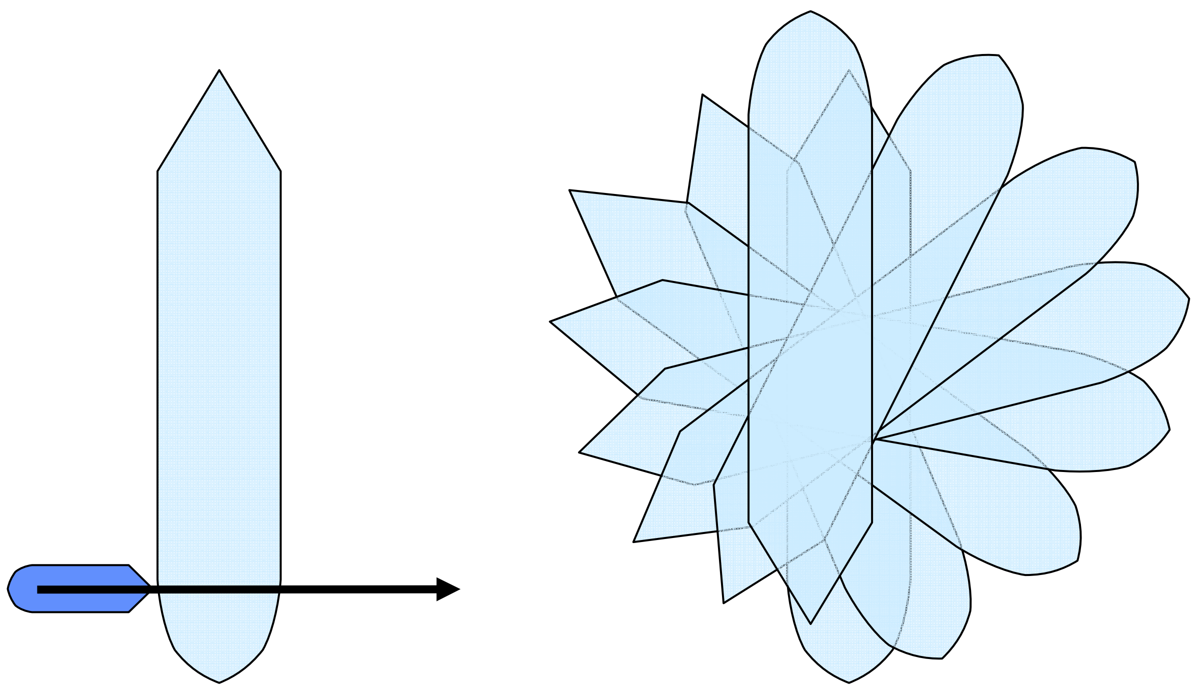
Ship Handling – Use of Tugs



Tug pushing at the bow

Tug pushing at the bow
Ship's speed : 2 knots
Main engine : stopped
Rudder : amidships
External forces : nil
Tug power : full
Turning by 90°

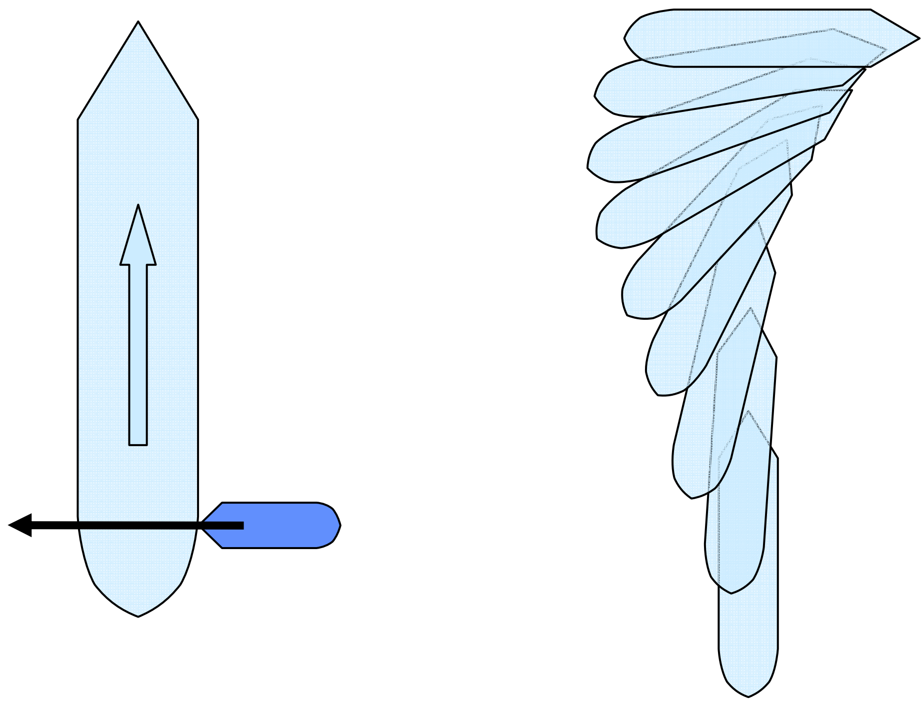
Ship Handling – Use of Tugs



Tug pushing at the stern

Tug pushing at the stern
Ship's speed : 0 knots
Main engine : stopped
Rudder : amidships
External forces : nil
Tug power : full
Turning by 180°

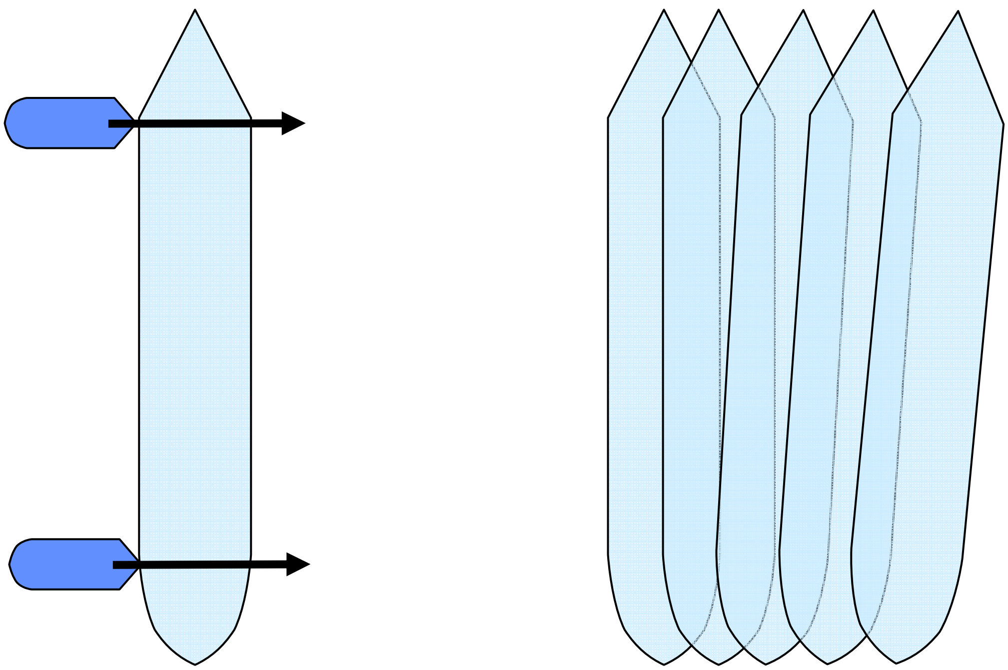
Ship Handling – Use of Tugs



Tug pushing at the stern

Tug pushing at the stern
Ship's speed : 2 knots
Main engine : stopped
Rudder : amidships
External forces : nil
Tug power : full
Turning by 90°

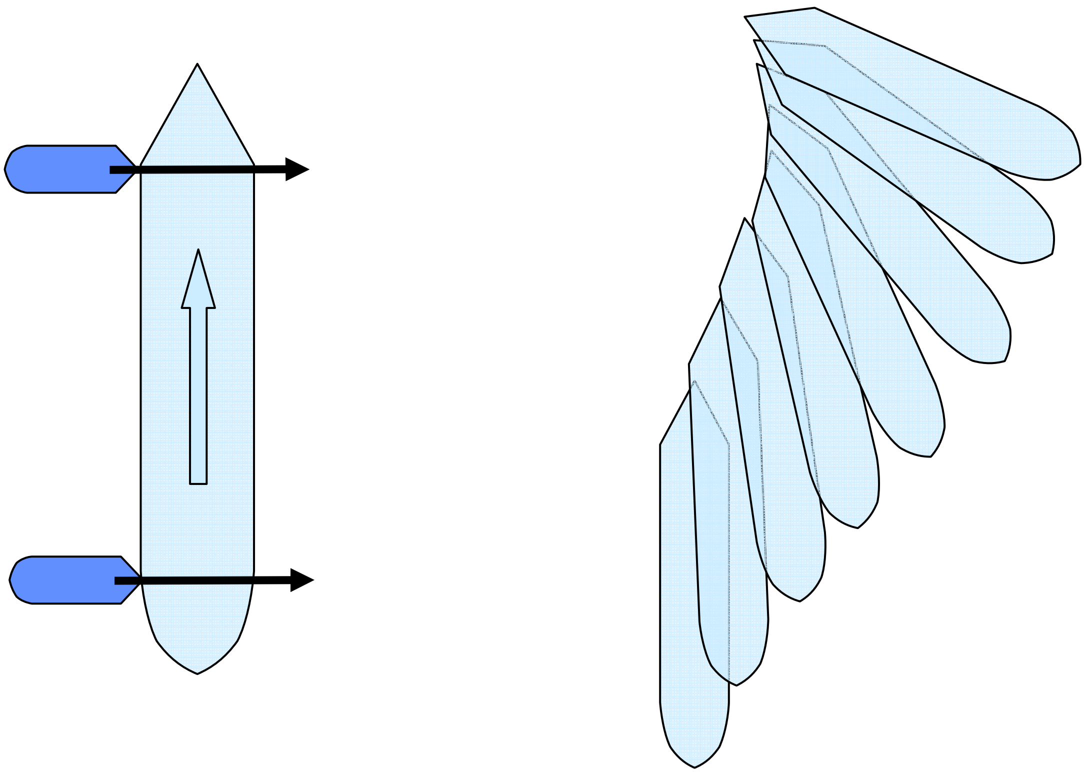
Ship Handling – Use of Tugs



Tugs pushing at the bow & stern

Tugs pushing at the bow & stern
Ship's speed : 0 knots
Main engine : stopped
Rudder : amidships
External forces : nil
Tug power : full (both)
Parallel pushing – 3b shift of cg

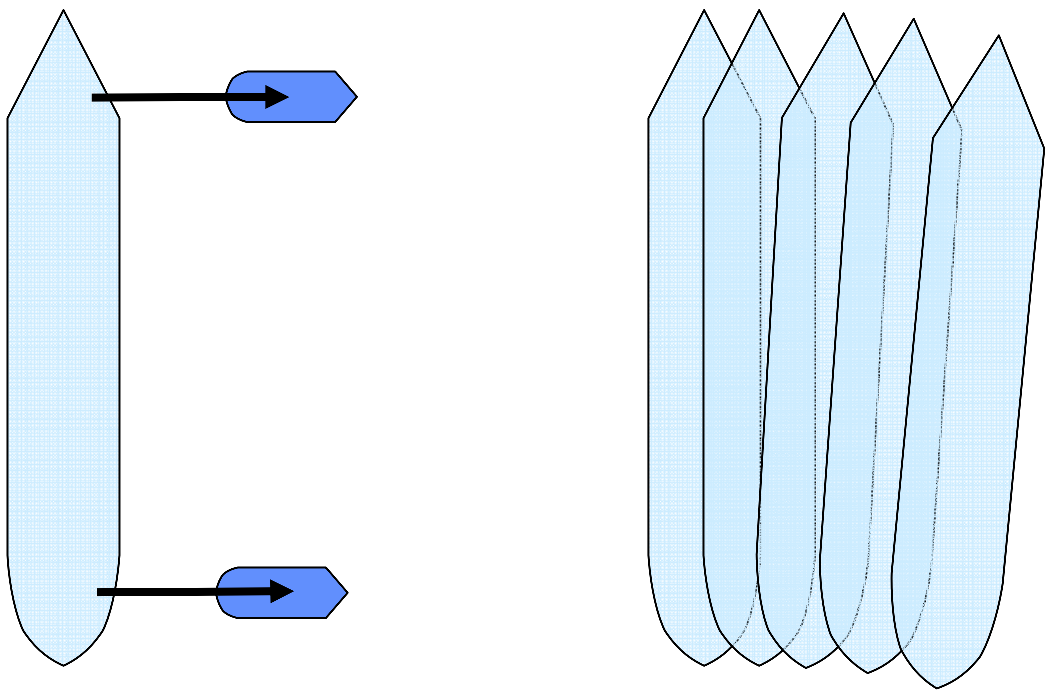
Ship Handling – Use of Tugs



Tugs pushing at the bow & stern

Tugs pushing at the bow & stern
Ship's speed : 2 knots
Main engine : stopped
Rudder : amidships
External forces : nil
Tug power : full (both)
Parallel pushing – 3b shift of c**g**

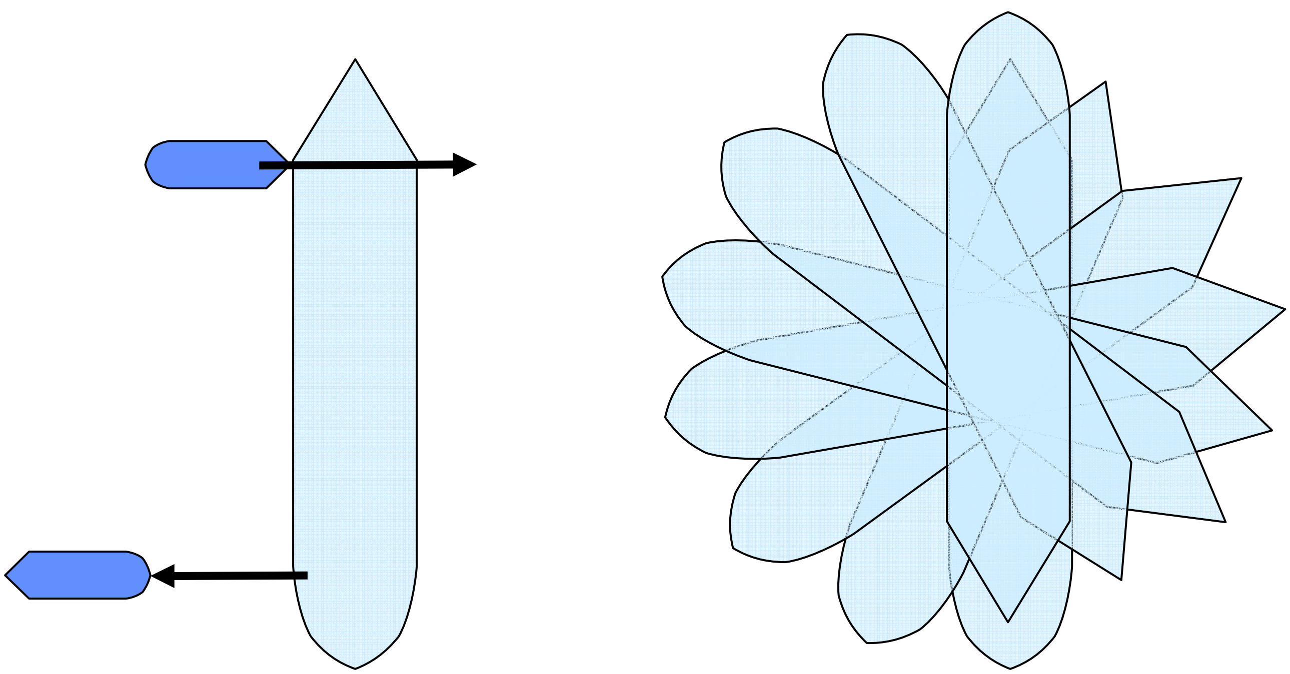
Ship Handling – Use of Tugs



Tugs pushing at the bow & stern

Tugs pulling at the bow & stern
Ship's speed : 0 knots
Main engine : stopped
Rudder : amidships
External forces : nil
Tug power : full (both)
Parallel pulling – 3b shift of cg

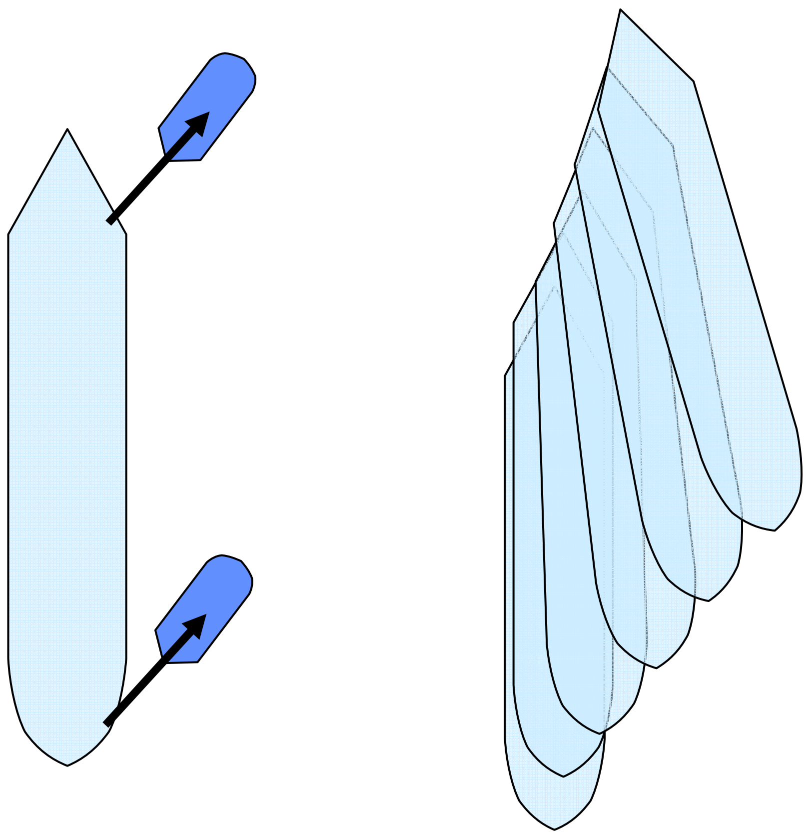
Ship Handling – Use of Tugs



One pushing at bow & other pulling at stern

One tug pushing at the bow &
Second tug pulling at the stern
Ship's speed : 0 knots
Main engine : stopped
Rudder : amidships
External forces : nil
Tug power : full (both tugs)
Turning by 180°

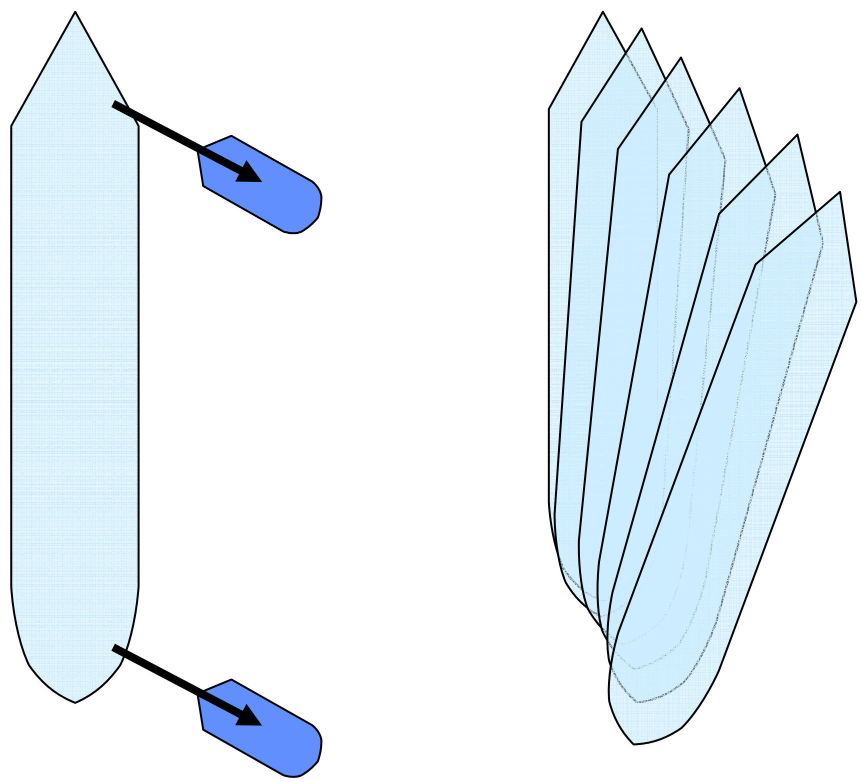
Ship Handling – Use of Tugs



Tugs puling at bow & stern at 60°

Tugs pulling at the bow & stern - 60° forward of abeam
Ship's speed : 0 knots
Main engine : stopped
Rudder : amidships
External forces : nil
Tug power : full (both)

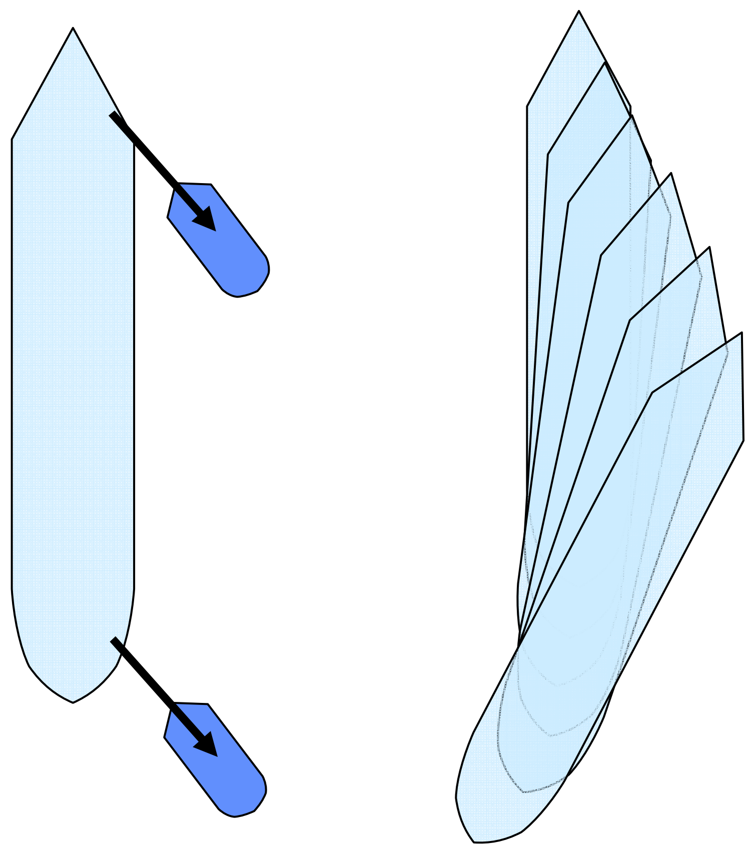
Ship Handling – Use of Tugs



Tugs pulling at the bow & stern at 30°

Tugs pulling at the bow & stern - 30° abaft of beam
Ship's speed : 0 knots
Main engine : stopped
Rudder : amidships
External forces : nil
Tug power : full (both)

Ship Handling – Use of Tugs

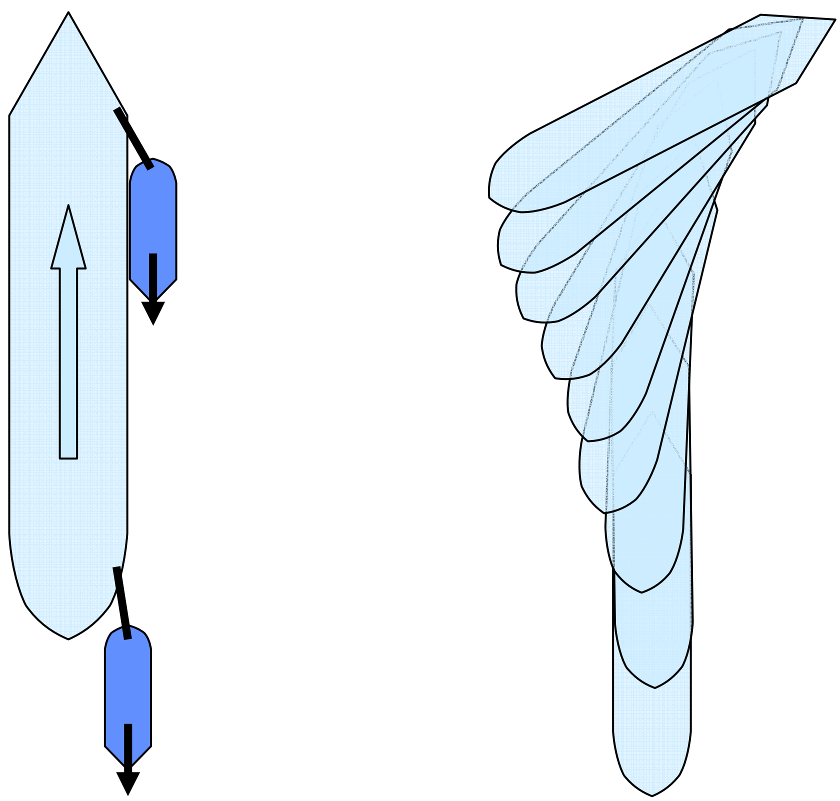


Tugs pulling at the bow & stern at 60°

Tugs pulling at the bow & stern - 60° abaft of beam

Ship's speed	: 0 knots
Main engine	: stopped
Rudder	: amidships
External forces	: nil
Tug power	: full (both)

Ship Handling – Use of Tugs

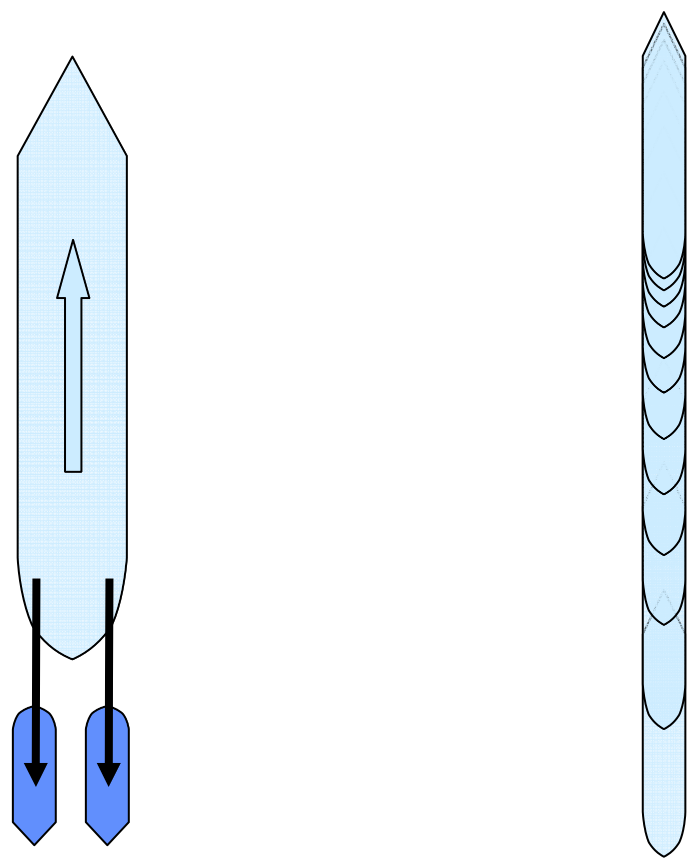


Tugs pulling at bow & stern at 6 o'clock

Tugs pulling at bow & stern – 6 o'clock
Ship's speed : 2 knots
Main engine : stopped
Rudder : amidships
External forces : nil
Tug power : full (both)

Ship stopped in about 3 ship's length

Ship Handling – Use of Tugs

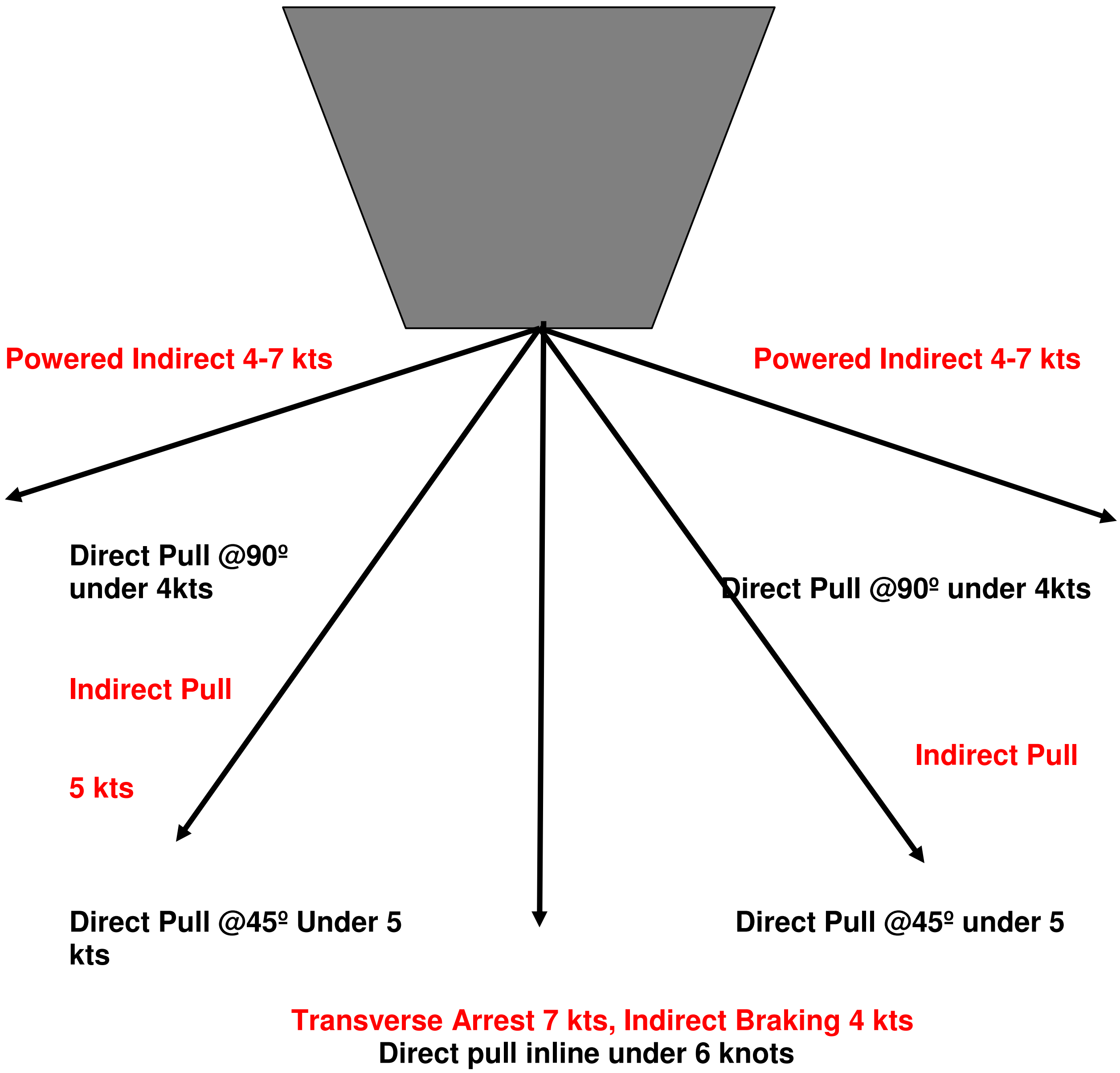


Tugs pulling at stern at 6 o'clock

Tugs pulling at stern – 6 o'clock
Ship's speed : 2 knots
Main engine : stopped
Rudder : amidships
External forces : nil
Tug power : full (both)

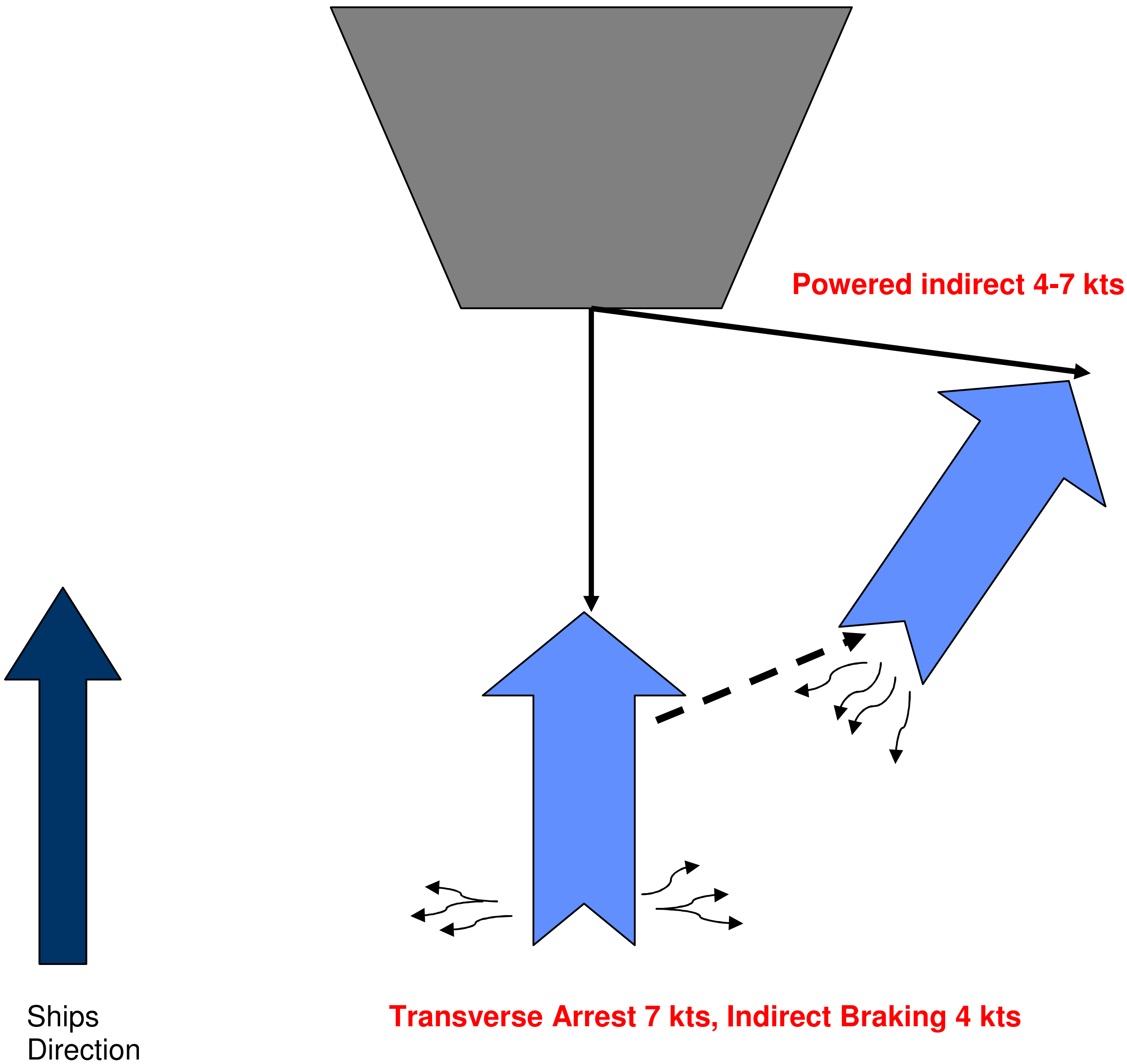
Ship stopped in less than 3 ship's length

Standard Commands for Tractor Tug Operations



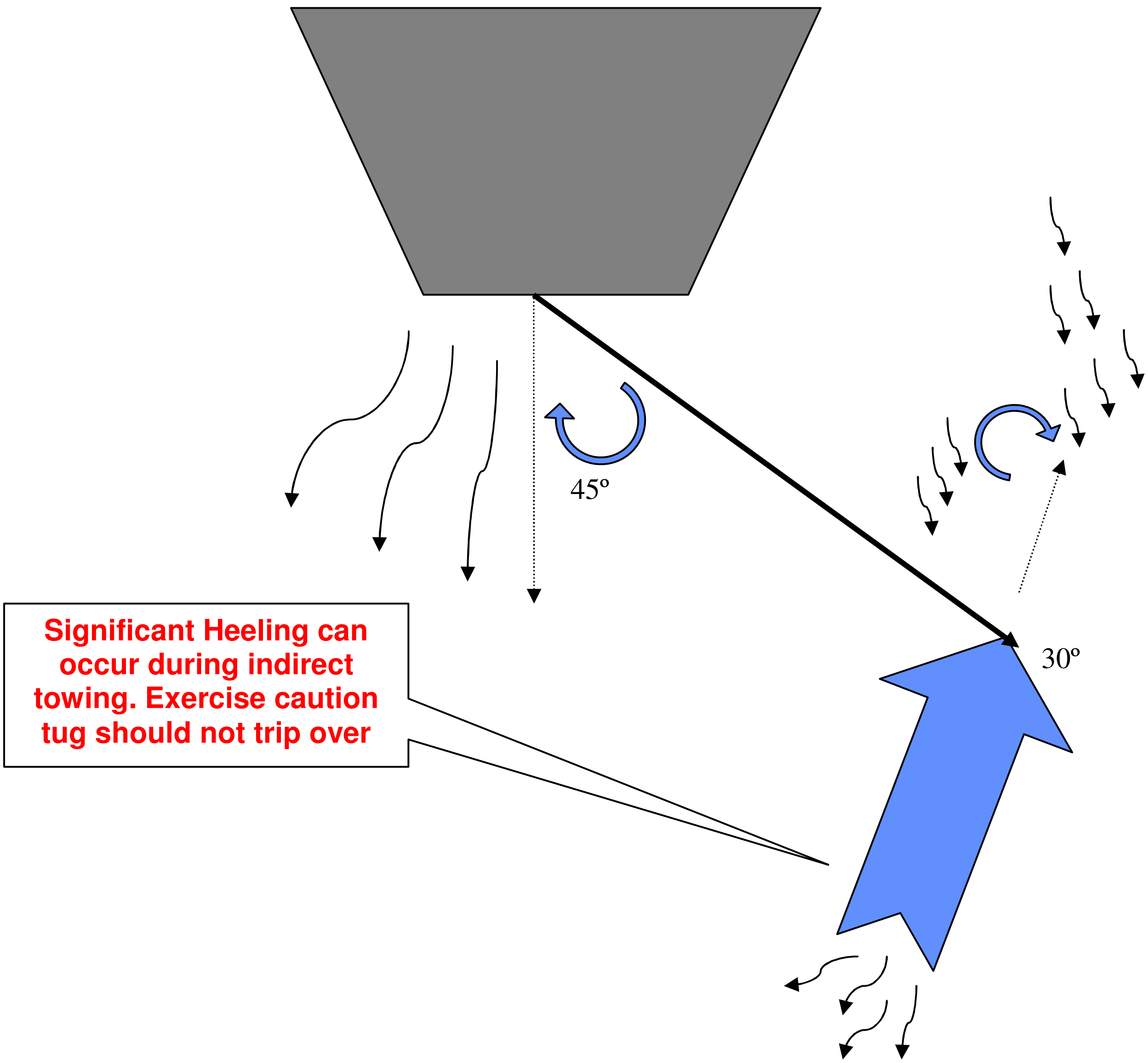
Standard Operation for Tractor tug operations

Full Powered Indirect Towing

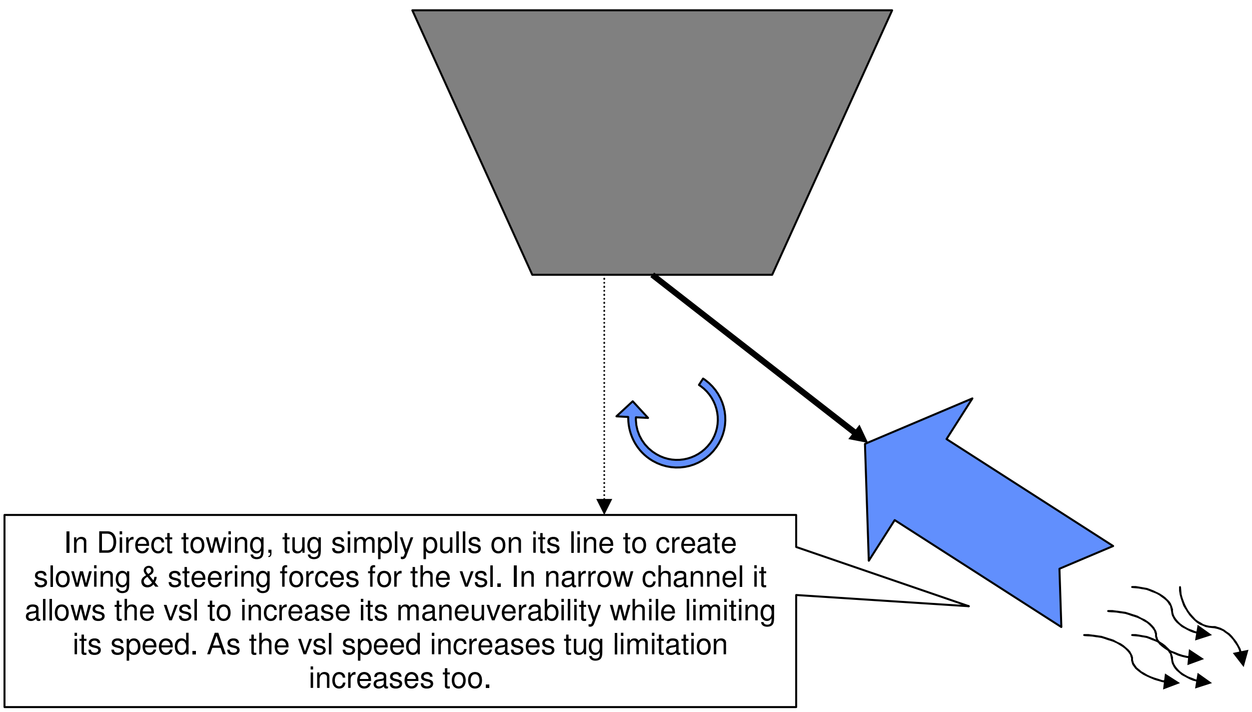


Direct pull inline speed below 6 knots

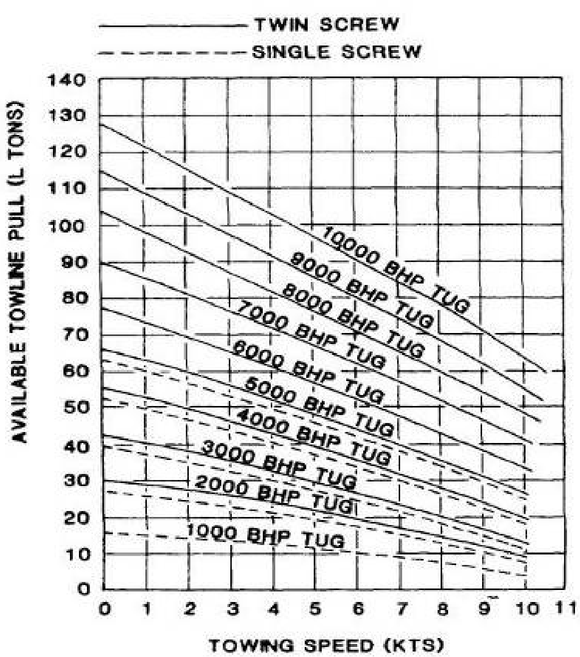
Indirect Towing



Direct Towing



Tug Bollard Pull Vs Towing speed for CPP & Nozzles



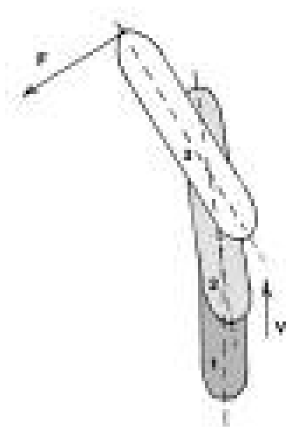
2.1.4.4. Experiments on small-scale models:

The following experiments were undertaken at the Ilawa shiphandling center in Poland in July 2005, using a small-scale bulk carrier loaded to an even keel.

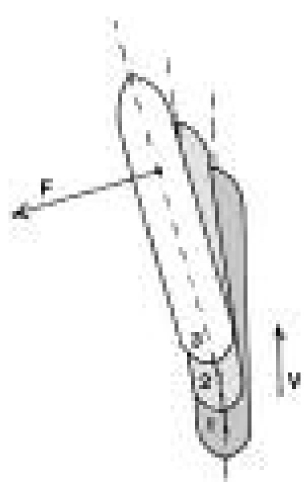
The aim of the experiment was to apply really effective side force on different points of the ship when she was making way through the water. For this we used a hand pulled towing line oriented at 90 degrees from the ship axis. By using a line, the results are not altered by hull/working force hydraulic interactions (as produced by tugs or bow thrusters).

Four tests were made:

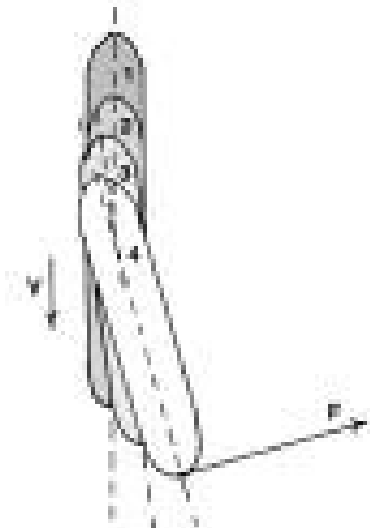
1) Headway (5 knts) and steady, engine stopped, pulling at the bow:



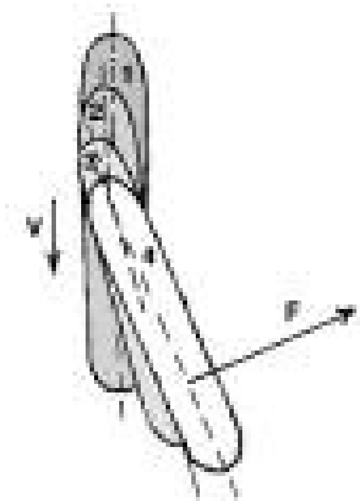
2) Headway (5 knts) and steady, engine stopped, pulling at 1/3 L from the bow:



3) Sternway (5 knts) and steady, engine stopped, pulling at the stern:



4) Sternway (5 knts) and steady, engine stopped, pulling at 1/4 L from the stern:



__Results / conclusion__:
- When the force is applied at the extreme end of the ship (tests 1 and 3), the pivot point is at the opposite end of where the traditional theory expects it to be.

- When the force is applied on the pivot point (tests 2 and 4), the expected result (traditional theory) of a ship only moving bodily sideways (since there is no arm lever), does not occur. There is a moment of rotation, therefore an arm lever. The pivot point is also at the opposite end of the one where the force is applied.

2.2. UN-CONTROLLABLE FORCES

- These forces are not always a disadvantage, sometimes they can be used for berthing & un-berthing. Alternatively these forces can be compensated by steering drift angle or a minimum vessel's speed to maintain her steering.

2.2.1 WIND Effect

- Wind has a significant effect on a ship. It causes heading changes and leeway. Failure to compensate correctly for wind during berthing is a significant cause of berthing accidents. The difficulty in allowing for wind arises from the variable effect that wind can have on a ship because of changes in heading and speed.
- Wind has special significance in handling of high free-board vessels such as PCC. The effects vary with the relative wind direction and the speed of the ship.
- Although wind force and direction can be estimated from various information sources, the actual / local conditions can change rapidly and with little warning. Control of a ship can be easily lost during the passage of a squall.
- There is an obvious need to understand how wind will affect your ship, and how this effect can be difficult to predict.

- For example, it might appear logical that the effect of wind on a vessel stopped in the water would cause the bow to swing towards the wind. However, experience shows that different ships stopped in the water may lie with the wind forward of the beam (various angles) rather than fine on the bow.
- Vessels with relatively high free-board (PCC, Containers, Passengers, LNG, and other vessels in ballast) may have significantly large windage area, which will affects the safety of maneuvers. It is especially difficult to predict the effect of wind on a partially loaded container ship

- For example, a container vessel with a wind area of 6000m² and a wind abeam of 25 knots has to reckon with additional lateral force of at least 60 tones. It is useful to know these forces and moments to decide the number of tugs required during berthing.

2.2.1.1. CLR and Point of influence of the wind W

- The force of the wind causes the ship to drift and, by doing so, hydrodynamic forces act on the underwater hull to resist the effect of the wind. The point of influence of these underwater forces is known as the *centre of lateral resistance* (CLR) and is the point on the underwater hull at which the whole hydrodynamic force can be considered to act.
- Similarly, there is a *point of influence of wind* (W) which has an important relationship with the CLR. W is likely to alter frequently as it will change in relation to the wind direction and the ship's heading.

- To anticipate the effect wind will have on a ship's heading, *W must be viewed in relation to CLR*. Ship handlers prefer to refer to pivot point (PP) rather than CLR when discussing the effects of wind on a ship with headway or sternway.

However, *a stopped ship does not have a pivot point and for this reason CLR should always be used. Therefore CLR is used for a stopped ship and PP for a ship with motion*.

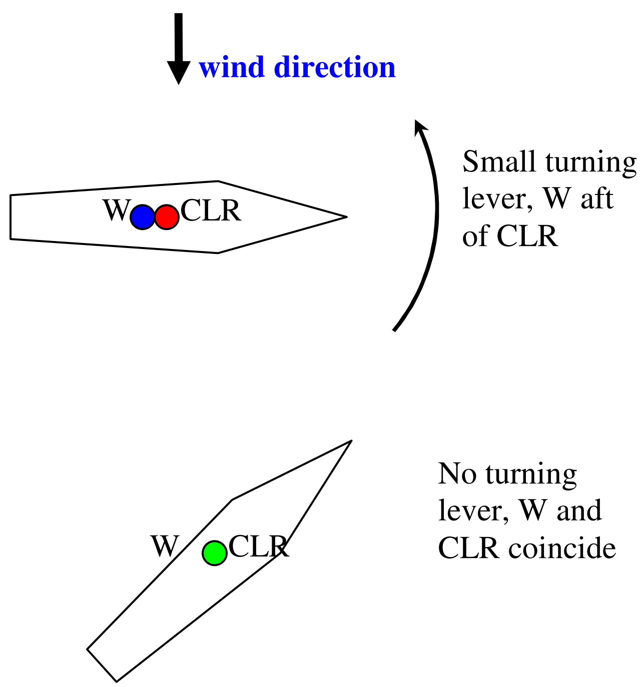
- The point of influence of wind (W) is that point on the ship's above-water structure upon which the whole force of the wind can be considered an act; W moves depending on the profile of the ship presented to the wind.

- When a ship's beam is facing to the wind, W will be fairly close to the mid-length point, slightly aft in the case of ships with aft accommodation and slightly forward if the accommodation is forward.

Important: a ship will always want to settle into a position where the pivot point and point of influence of wind in are in alignment.

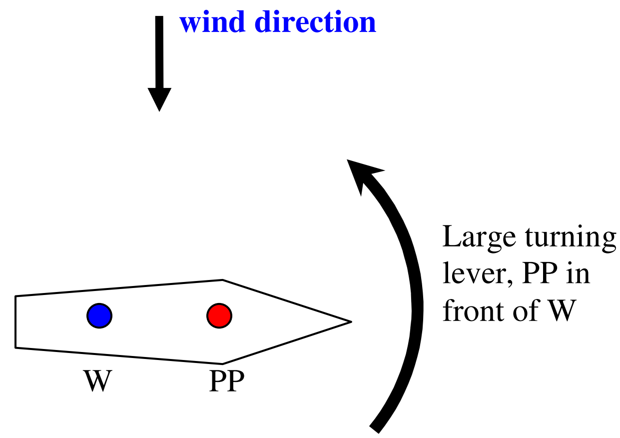
Case 1: Ship stopped – ship with accommodation aft:

- On a stopped ship with the wind on her beam, W will be close to the ship's mid-length. When stopped in the water, the CLR is also at its mid-length. The difference in location between the two points produces a small couple, and the ship will turn with its head towards the wind. As the ship turns, W moves until it is close to the CLR, when the couple reduces to zero. The ship will settle on this heading, usually with the wind slightly forward of the beam.



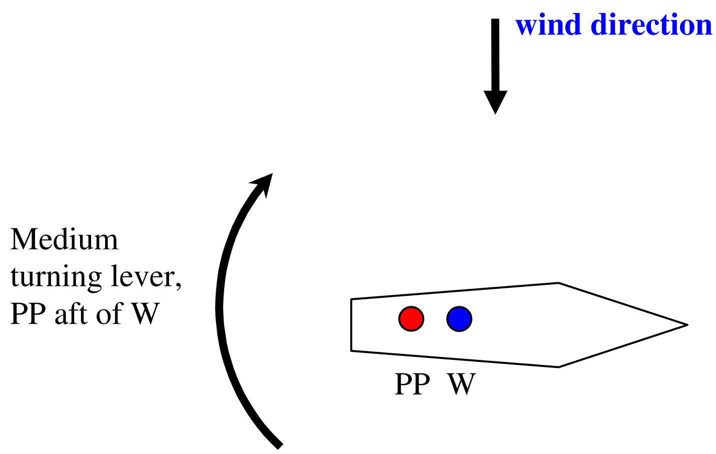
Case 2: Ship with headway – ship with accommodation aft:

- If a ship has headway, PP is forward and the lever between W and PP is large. The resultant force will cause the ship's head to turn to the wind.



Case 3: Ship with sternway – ship with accommodation aft:

- If a ship has sternway, PP is aft of W and the ship's stern will seek the wind. However, and for the majority of ships, the complexity of the aft-end accommodation structure can cause W to move further aft as the ship turns. Eventually, the ship may settle with the wind broad on the quarter rather than the stern.



2.2.1.2. Force of the Wind

- Wind force can be estimated by the formula: **F = (V2/18,000) x windage area**, where F is the wind force in tones / square metre, V is the wind speed in m/s (metres/second) and windage area is the area of ship exposed to the wind in square metres.

Note: we may estimate windage area for a beam wind by multiplying length by freeboard and adding the profile area of the accommodation. For a head wind, multiply beam by freeboard and add the area of the bridge front.

- And, as per practical experience and seamanship, double the figure obtained for F and order one or more tugs with the nearest bollard pull.

- This calculation gives an estimate of the total force of wind on a ship's side, and will give an indication of the total power that tugs will need in order to overcome this force.

- As shown above, a ship will always want to settle on a heading where the ship's pivot point is in alignment with the position of the wind's point of influence. When navigating on such a course, a ship will show good course-keeping properties.

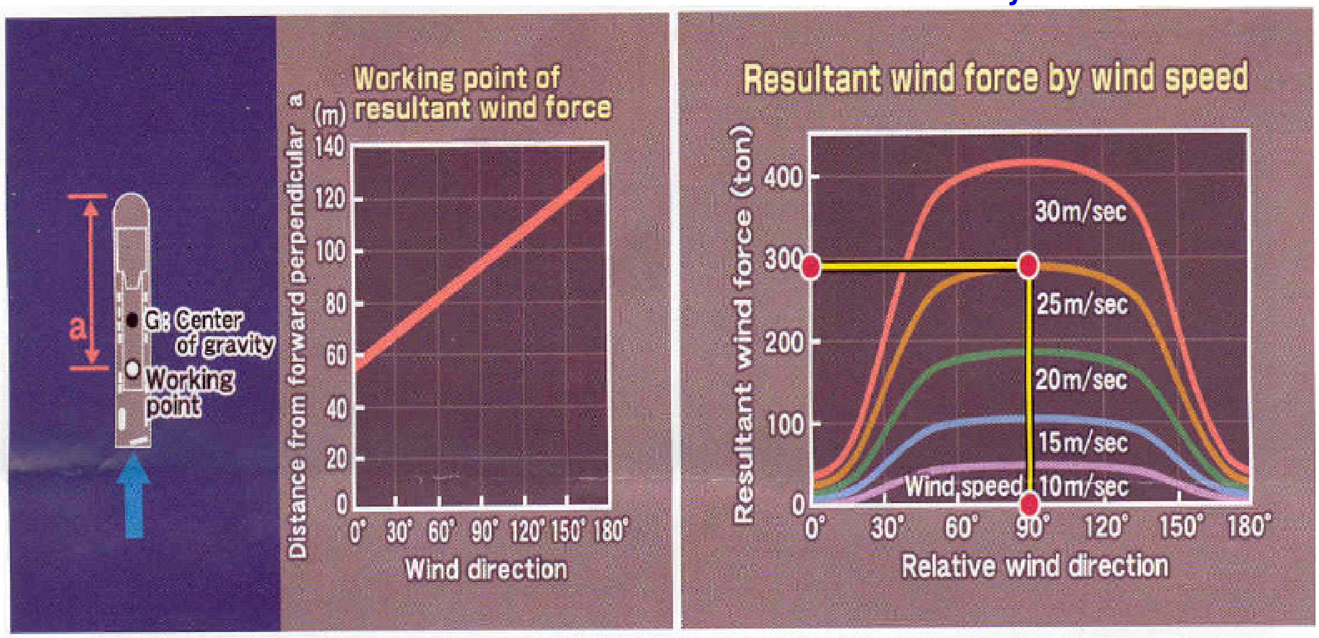
- As a result, it is preferable to berth with head to wind with headway and to berth with stern to wind with sternway. In addition, knowledge of the location of W, compared with PP, makes it possible to predict whether the ship's head or stern will 'go to wind' as a ship is stopped. The ship will want to settle with P in alignment with and to windward of W.

Note: High free-board ships may suffer more from leeway than from heading change.

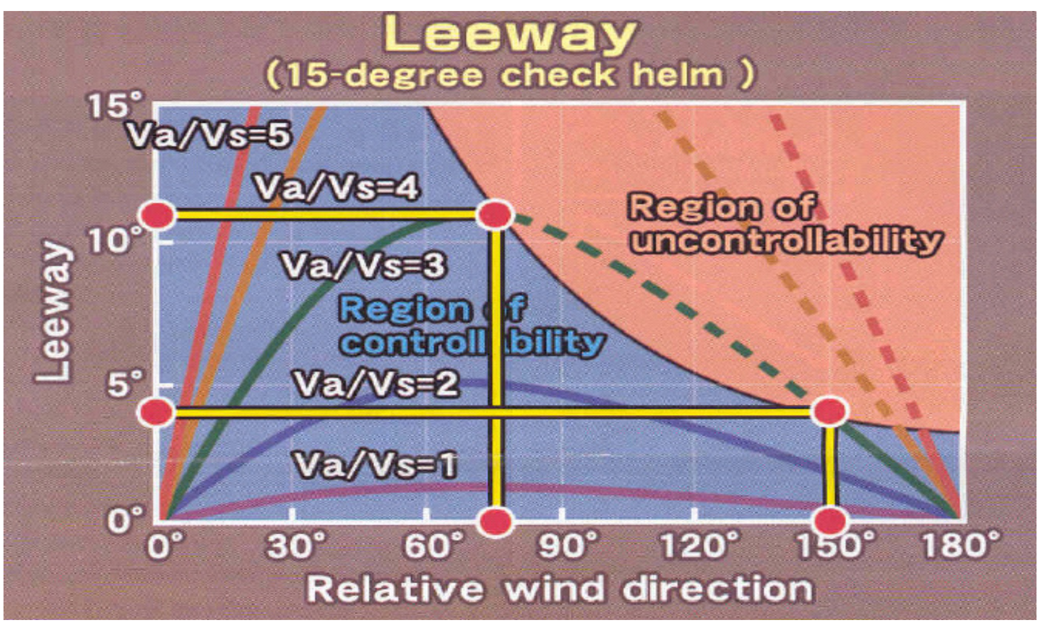
- A ship is most vulnerable when presenting its broadside, the area of greatest windage, to the wind. In strong winds, it will be difficult to counteract the effect without proper tug assistance or the use of thruster(s).

- If close to a berth, it is essential that mooring lines are set as quickly as possible. Ideally, plan the maneuver so as to present the minimum profile to the wind, i.e. head to wind, or at least reduce to a minimum the time the wind is at a broad angle to the ship.

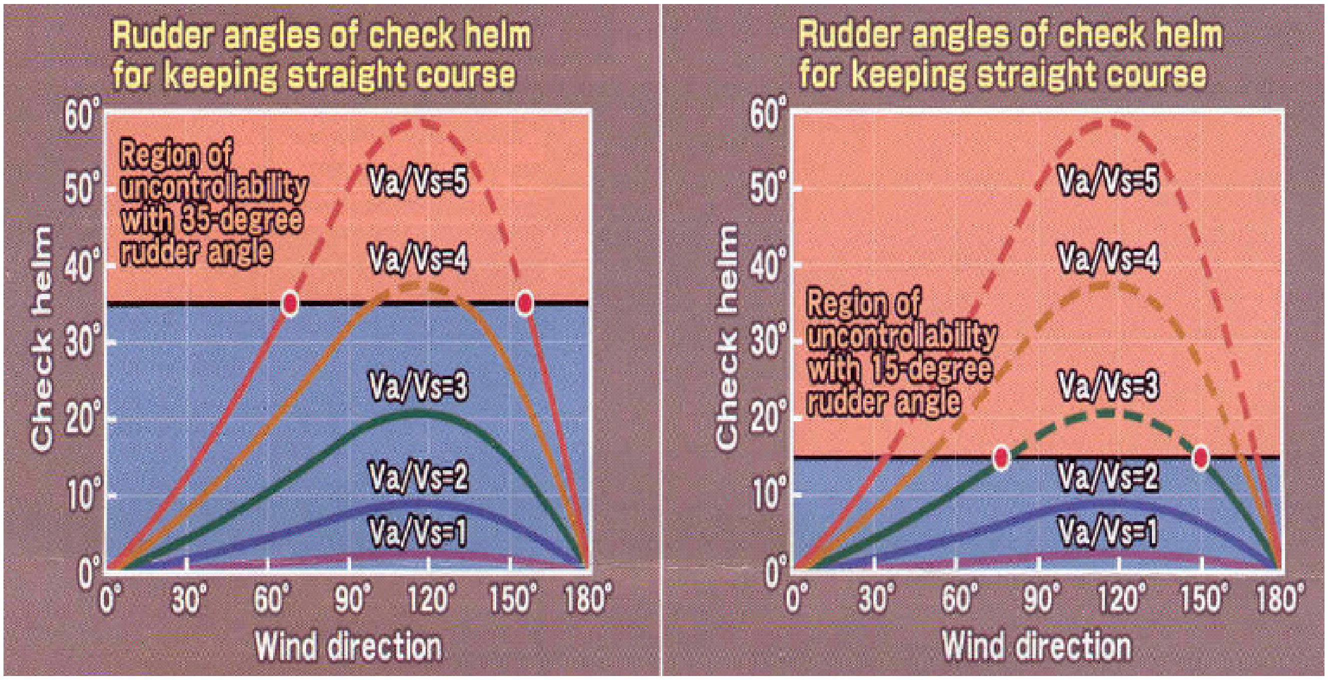
2.2.1.3. Wind Pressure Effect on PCC while underway



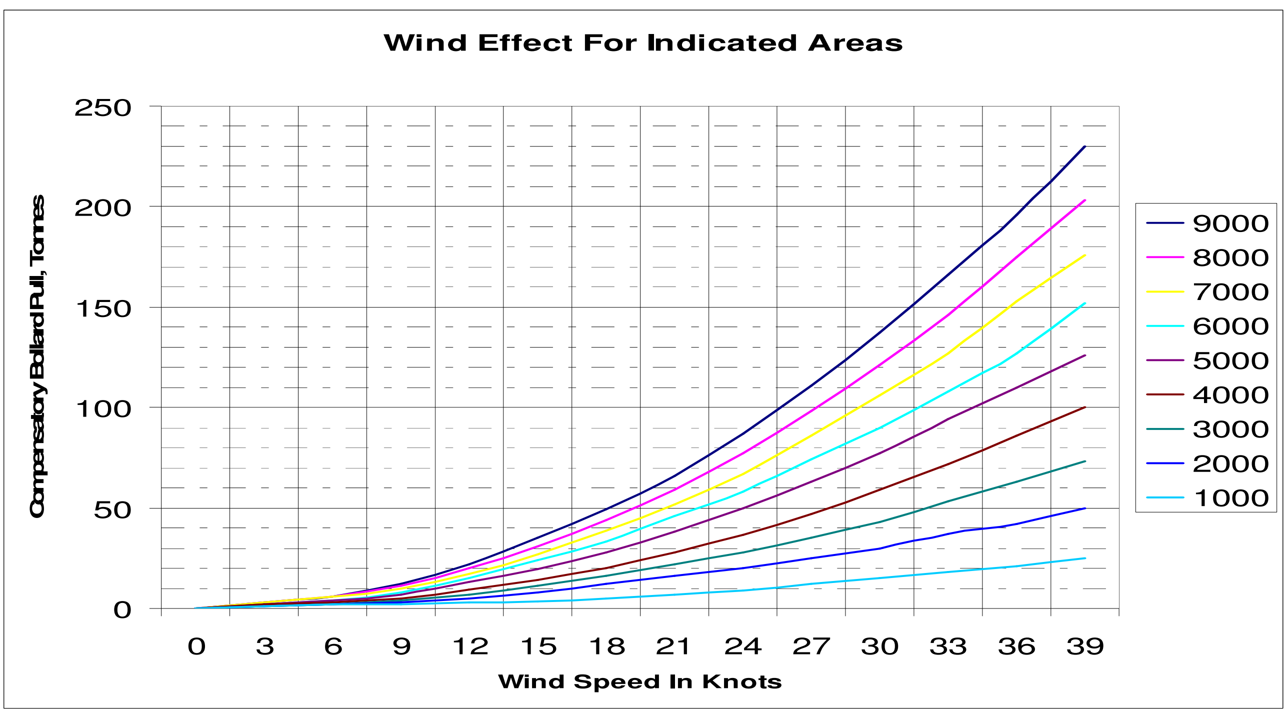
The working point of unified forces (resultant wind force) is located at a distance of “a” from & moves with wind direction. The resultant wind force acting on the working point varies with wind speed and direction, reaching a maximum when the beam wind is acting on the largest wind affected area.



The graph shows the relation between controllability limit and leeway when the maximum rudder deflection of check helm is limited to 15 degrees.



The rudder deflection of check helm is indicated on the longitudinal axis and wind direction on the horizontal axis, curves on controllability limits are shown on the graph using the parameter of each Va (wind speed in knot) and Vs (ship speed in knot) ratio 1 to 5.



2.2.1.4. Berthing in Strong Winds: Points to Remember

• Ensure that conditions are safe and suitable for the envisaged maneuver. It will be cheaper to delay the ship until the wind moderates than to deal with the aftermath of an accident.
• Wind force acting on a ship increases with the square of the wind speed. Doubling the wind speed gives four times the force. Gusts of wind are dangerous.
• Take evasive/corrective action early. Attach tugs early and before are needed.
• Tugs should be of sufficient strength not only to counteract the effects of wind but to get the ship to the required destination.
• The berthing plan should be devised to minimize the adverse effect of wind and to maximize its assistance.
• A ship is more vulnerable to wind at slow speed. As speed reduces hydrodynamic forces reduce, and the effect of wind on heading and leeway increases.
• Take corrective action as soon as it becomes obvious that it is needed. The earlier that action is taken, the less that needs to be done. The longer things are left, the more drastic will be the action needed to correct the situation.
• Kicks ahead are effective in controlling a ship in windy conditions.
• Consider any special circumstances where wind may affect ship handling. Trim, freeboard and deck cargo can vary the position of W and the force of the wind on the ship, and change the ship's natural tendency in wind.

For example, significant trim by the stern can cause W to move ahead of PP. In these circumstances the bow will have increased windage. Consequently, if the ship is heading into wind, the bow may show a tendency to blow downwind, even if the ship has headway.

• The windage area, and hence the force of the wind on the ship, will vary with the heading relative to the wind. The maximum force on the ship is when the ship is broadside to the wind.
• Good control is easy to achieve when the ship's head is to wind and the ship has headway. Control is difficult when wind is following and strong turning forces are created.
• Apply large passing distances when it is windy. Always pass any obstructions well upwind. Gusts and squalls can arrive very rapidly and with little warning. When wind has caused a ship to move rapidly to leeward, it can be difficult to overcome the motion and return to a position of safety.
• Allow plenty of distance from the berth when wind is onshore. If berthing in an onshore wind, it is best practice to stop half a ship's length from the berth and then come alongside in a controlled manner.

2.2.2 CURRENT Effect

- A feature of any river berth is the current. It is common for a river berth to lie in the same direction as the prevailing current so that the current can assist with berthing. In this case, a berth can be approached bow into the current in order to give the advantage of relatively high speed through the water with a reduced speed over the ground.

Consequently, steerage at low ground speed is improved by the good water flow over the rudder, and the ship will be easier to stop.

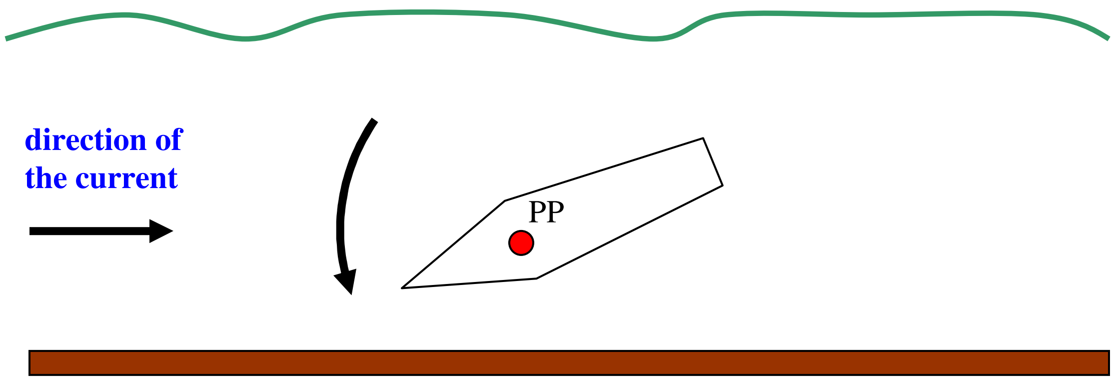
- Advantage of berthing heading in current is that it can be used to push a ship alongside. Position the ship off the intended berth but at a slight angle towards it. Then allow the current to produce a sideways movement towards the berth.
- Masters should note that currents are usually complex, with varying rates and directions that can change hourly. Local knowledge is essential.

<u>Important</u>: a ship making headway into a current, but stopped over the ground, will have a forward pivot point.

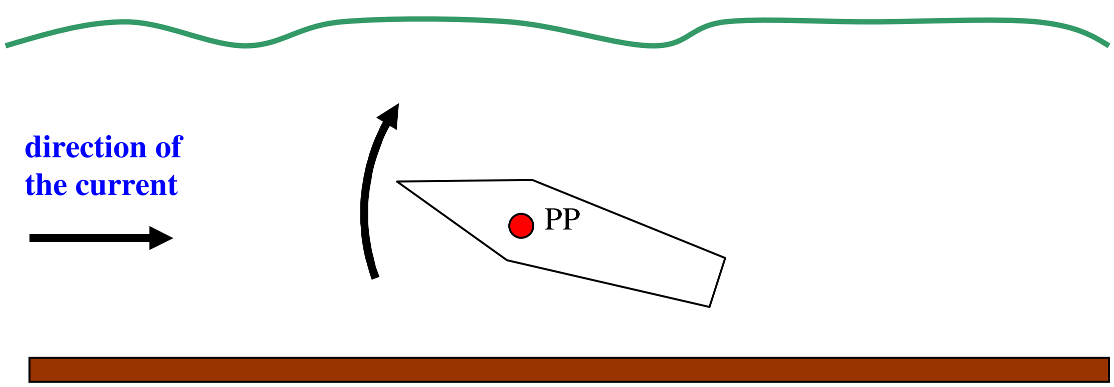
2.2.2.1. Berthing in Current:

- Berthing with a following current is difficult, since the ship must develop sternway through the water in order to be stopped over the ground. In these circumstances, a tug should be used to hold the stern against the current.

- Berthing with head in the current directions is easier, however, should be avoided too large angle between the berth and the direction of the current, or else it may cause the ship to move rapidly sideways.

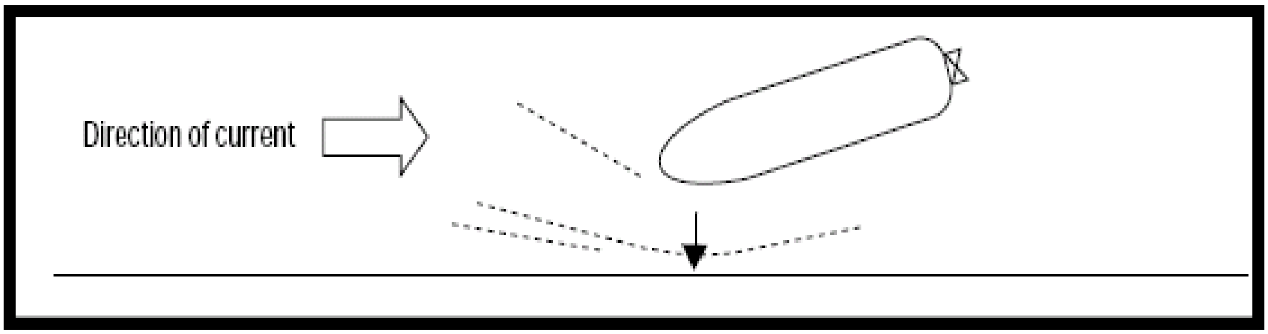


- On the other hand, if during berthing the bow's angle to the berth is over corrected then the ship could move away from the berth as the wedge of water between ship and berth becomes established. This may cause the ship's stern to strike the berth.

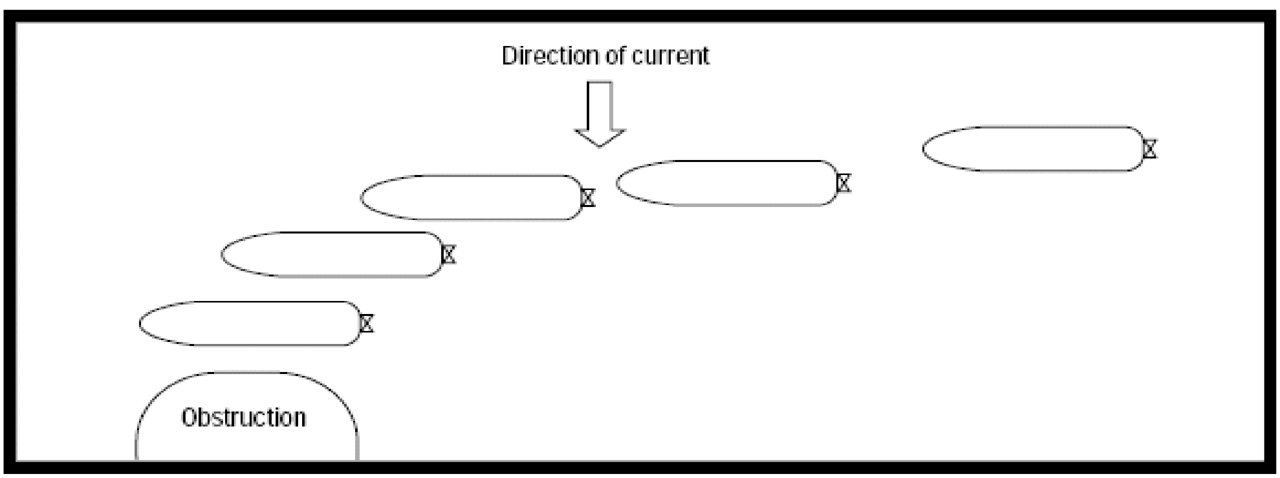


2.2.2.2. Berthing in Current: Points to Remember

• In many places a counter current flows in opposition to the main current close to the bank. Most of the time only local knowledge will provide this information.
• Current can vary with depth of water and large deep draught ships can experience different current effects at differing parts of the hull.
• When close to the berth in a head current, there is a danger that flow inshore of the ship becomes restricted and the ship is subject to interactive forces that can cause the ship to either be sucked towards or pushed away from the berth.

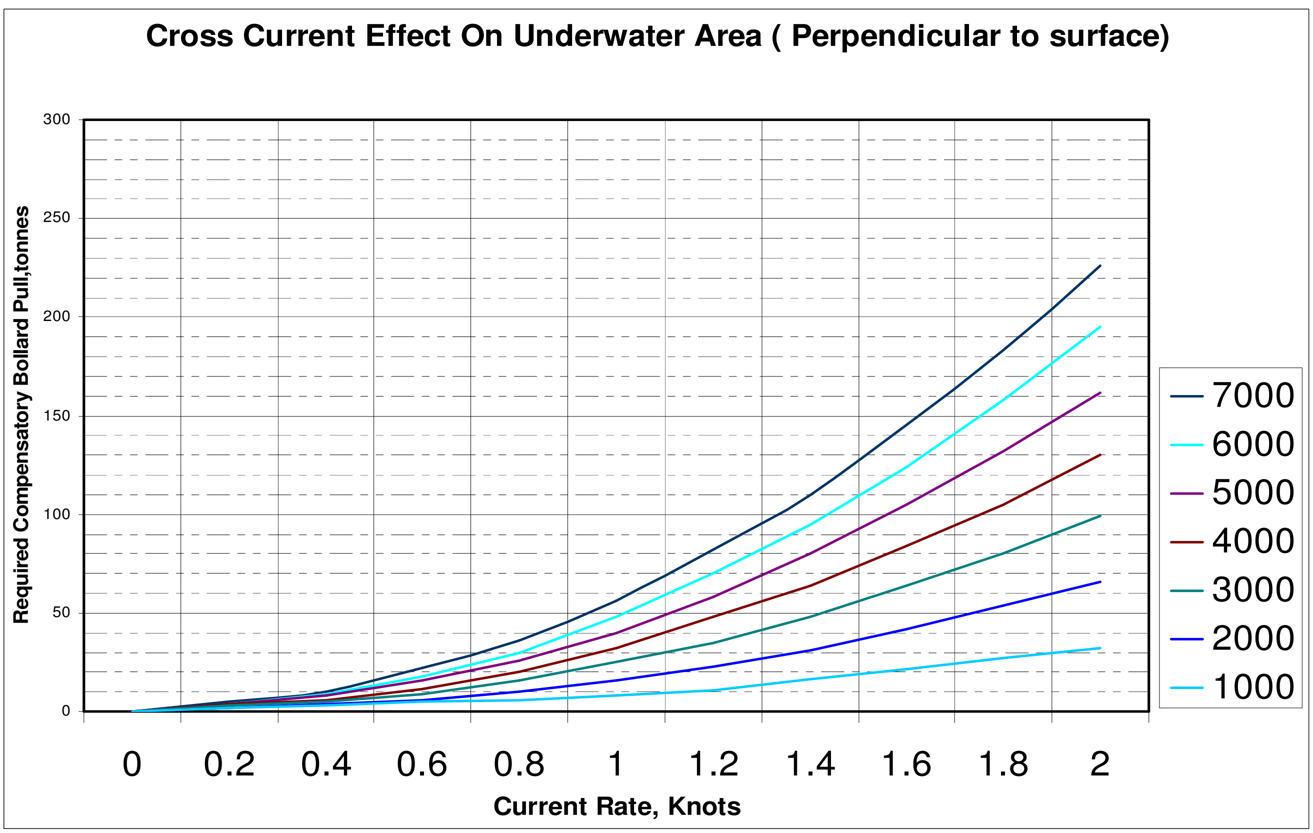


• As speed is reduced, take care that the increased proportion of the ship's vector which is attributable to current does not set the ship close to obstructions.



• Always make a generous allowance for current. Its effect on the ship increases as the ship's speed reduces. A mistake made during berthing is often impossible to correct. Remember that current predictions are just predictions and actual meteorological conditions may result in a greater or lesser rate than forecast.

2.2.3. Cross Current Effect and Bollard Pull Calculation



REQUIRED BOLLARD PULL TO COMPENSATE FOR CURRENT

Refer to <u>Appendix 9</u>: Calculation of Tugs Required (for Bollard Pull)

The above curves assume a depth to draught ratio > 6.0
For other depth to draught ratios, the required bollard pulls for perpendicular cross currents should be increased by the following factors:

FOR D/d RATIO OF 1. 5 FACTOR IS APPROX – 2.75

FOR D/d RATIO OF 1. 2 FACTOR IS APPROX – 3.75

FOR D/d RATIO OF 1. 1 FACTOR IS APPROX – 4.625

D / d	F
1.0	6.0
1.01	5.87
1.02	5.73
1.03	5.59
1.04	5.45
1.05	5.32
1.06	5.18
1.07	5.04
1.08	4.91
1.09	4.77
1.1	4.625

D / d	F
1.11	4.54
1.12	4.45
1.15	4.19
1.2	3.75
1.25	3.59
1.3	3.42
1.35	3.25
1.4	3.09
1.45	2.92
1.5	2.75

First let us discuss about various stages where tug assistance is required, depending on local conditions………………

The phase whereby a ship has reasonable speed……….

Ships can use their engines & rudder to compensate for, drift forces caused due to **….**

Wind,
Current,
Waves
By steering drift angle, depending on the condition, tugs can or may assist.

The intermediate stage………..

When ships have to reduce speed while entering dock, harbour basin, turning circle or approaching berth. When ships have to be stopped within certain distance. When reducing speed, ships steering performances also decreases, thereby allowing the influence from wind & current to increase.
To compensate for the uncontrollable forces, tug assistance is needed more frequently & to larger extent.

The final stage, when berthing or un-berthing………..

When Ships are practically dead in water, such as in the turning basin, or while berthing & un-berthing.

- Ships are very restricted in maneuvering performance.
- Ships are unable to compensate for wind & current forces.

Therefore tugs have to assist fully.

“Bollard pull” requirement based on environmental conditions & displacements

Let us do some calculations……..

Ships affected by wind, current

Container ship: length overall 294m, length between perpendiculars 281m,beam 32m, draught 12.5m, water depth 13.8m.
Top of container to waterline approximately 22m, onshore wind right angles to berth , wind speed 30 knots, with cross current of 0.5 knots

Calculate the required bollard pull???

Refer to the graphs in your handouts

Ratio draft/water depth 13.8/12.5 = 1.1 → (4.625)
Area above water approx 294 x 22 = +/- 6500 m^2
Underwater area approx 281 x 12.5 = +/- 3500 m^2
Displacement = 75,000 t

When towing on a tug line or pulling at ships side on medium length towline, the following compensatory total bollard pull is required.
The on shore wind (figure in handbook) = 100 tons

The crosswise current (figure in handbook) = 10 x 4.625 = 47 tons
Total bollard pull required = 147 tons*

* To compensate for wind & current, four tugs with at least 40 tons bollard pull are needed. Allowance of 20% should be made for the reserve power for the tugs.

“Bollard pull” of the Bow thruster

100 HP of a bow thruster is about 1.1 tons of force
100 KW of a bow thruster is about 1.5 tons of force
In the earlier example of a container ship, if it was equipped with a bow thruster of 2500 HP (1840KW) then 28 tons less pull is required forward.

“Bollard pull” required in a cross current

VLCC: length overall 350m, length between perpendiculars 315m,beam 52m, draught 22m, water depth 24m.
Onshore wind right angles to berth, wind speed 12 knots, with cross current of 0.5 knots

Calculate the required bollard pull ???

Ratio draft/water depth 24/22 = 1.09 → (4.77)
Area under water approx 315 x 22 = +/- 6900 m²
Displacement = 245,000 t

When towing on a tug line or pulling at ships side on medium length towline, the following compensatory total bollard pull is required.

The crosswise current (figure in handbook) = 15 x 4.77 = 72 tons
The onshore wind = 28 tons
Total bollard pull required = 120 tons*

** Allowance of 20% should be made for the reserve power for the tugs.*

What happens if under keel clearance is reduced to
1.0 meter & cross current is increased to 1.5 knots???

Let us Calculate the required bollard pull ???

Ratio draft/water depth 23/22 = 1.04 → (5.45)
Area under water approx 315 x 22 = +/- 6900 m²
Displacement = 245,000 t

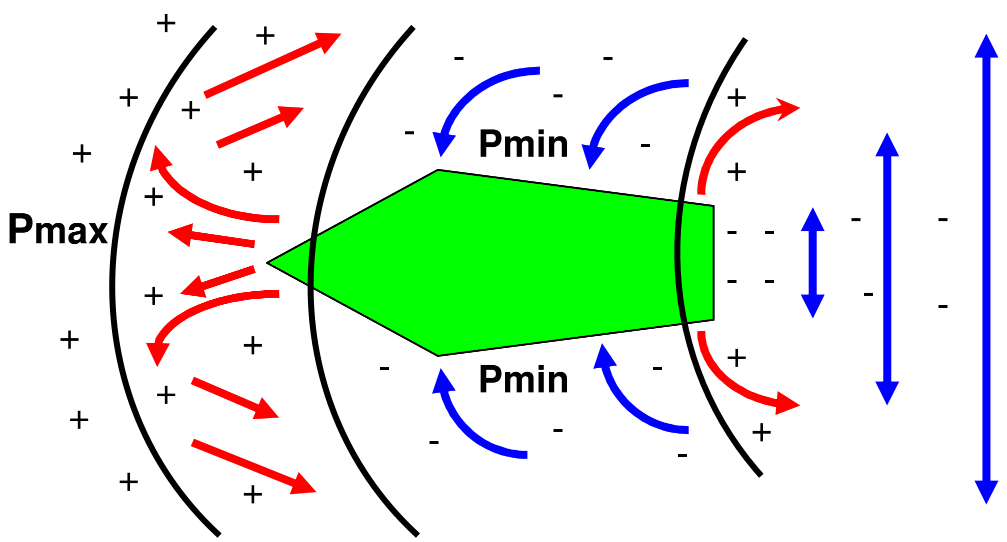
When towing on a tug line or pulling at ships side on medium length towline, the following compensatory total bollard pull is required.

The crosswise current (figure in handbook) = 130 x 5.45 = 709 tons
Total bollard pull required = 851 tons*

** Allowance of 20% should be made for the reserve power for the tugs*
** Assuming Tug power is 40 tons, therefore required number of Tugs for berthing is 21 !!*

2.3. SEMI – CONTROLLABLE FORCES – Hydrodynamic Effects

When a ship is making way, surrounding water is displaced ahead, towards the sides and under the ship's keel, exerting the flow of water relative to the moving ship. The pressure distribution that develops around the ship moving through water distorts the water line by raising the level of the high pressure regions and lowering it along the length of the hull, particularly amidships.



While vessel making headway, are formed the bow waves: moving abt 45deg with longitudinal axe, and stern waves: moving perpendicular to the vessel's heading. In shallow / confined waters, this waves will affect more the vessel's steering, comparing to deep / large waters.
SPEED CONTROL will have a great influence: less speed, less effect !

2.3.1. Water Depth – Shallow Water Effects:

- Water depth has a profound effect on maneuvering. In a harbour, water depth may vary from deep to conditions in which there is danger of touching bottom.

- The behavior of the ship changes with changes in water depth: a ship's resistance increases as water depth reduces. The increase becomes significant when the *water depth is less than twice the mean draught*.

The effect of this increased resistance is a reduction in speed, and as depth and under keel clearance reduce, turning ability deteriorates, virtual mass increases (increase in a ship's mass resulting from water being dragged along with the ship) and the effect of the propeller transverse thrust on yaw alters.
- As a result, a ship can become very difficult to control during a stopping maneuver as the rudder loses the beneficial effects of the propeller slipstream, and the bias off-course may become more pronounced.

- The increase in virtual mass is most noticeable when a ship is breasting on to a quay or jetty. Virtual mass in sway motion is invariably large, increasing as under keel clearance reduces. Consequently, any impact with a quay wall, jetty or fender will be much more severe if under-keel clearance is small.
- Similarly, when a large ship moored in shallow water is allowed to move, the momentum can be considerable.

- Water depth limits a ship's speed. There is a maximum speed that a conventional displacement ship can achieve in shallow water which can be less than the normal service speed. This is called the "*limiting speed*".

Limiting speed needs to be considered during passage planning. Knowledge of areas where ship's speed is limited by water depth is important because any increase in engine power to overcome the limiting speed will greatly increase wash.

In simple terms, the limiting speed can be calculated from the formula:

$$\mathbf{V_{lim} = 4.5\ h}$$

where h is the water depth (in metres) and Vlim is speed (in knots).

- In shallow water, and because of insufficient engine power, a conventional ship may be unable to overcome the limiting speed. However, some powerful ships such as fast ferries can overcome limiting speed, but in doing so may produce dangerous wash.

2.3.2. Squat (Please refer to Appendix 10: Pilot Card with Squat Calculation)

- Squat is the increase in draught and trim that occurs when a ship moves on the surface of the sea. At low speed, a ship sinks bodily and trims by the head. At high speed, a ship bodily lifts and trims by the stern. At especially high speed, the ship can plane. However, squat is greatest in shallow water where the resulting increase in draught and trim can cause grounding.
- The overall effect of the pressure distribution is to create a local depression of the mean level that coincides with the ship and travels along with it. Furthermore, the drop in the water level is concentrated amidships, where immersed hull volume is greatest, and the ship will also move bodily downwards to maintain its full buoyancy, including a change of trim. This effect is irrelevant in deep water, but it becomes significant when the ship moves into shallow water, which results in reduction of under keel clearance.

- The squat is conspicuous in shallow water. Trim by the head is prominent in the low speed range, trim by stern by high speed range. As the Froude number approaches 0.25 (a ship of 300m length with its speed about 26 knots), the bow of the ship tends to float, and the stern tends to sink abruptly.
- However large sized ships usually navigate shallow water at stand by speed, and most ships are considered to be proceeding with the trim by the head, because the squat is mainly related to large sized ships and with full load conditions, it is important to obtain the amount of the bow sinkage, as most of the ships tend to be trimmed by the head.

- Squat provides a *further limit on speed in shallow water*, consideration of grounding due to squat being especially important if the under-keel clearance is 10% or less of the draught and the speed is 70% or more of the limiting speed.

In shallow water, squat can be estimated by adding 10% to the draught or 0.3 metres for every 5 knots of speed.

2.3.3. Waterway Width:

- If the waterway is restricted in width as well as depth, this can also have an effect on performance. If the underwater midship area of the ship is significant compared to that of the waterway (over 20%, say) then this ‘blockage’ will further increase resistance, increase squat and create a ‘backflow’ of water between the ship and the waterway.
- This will cause silt to go into suspension or deposit on the bed of the channel, and may erode the waterway. It may also cause bank material to be transferred to the bed of the waterway.

2.3.4. Bank Effect:

- A further effect: the ship may steer away from the bank. This 'bank effect' is due to backflow between the bank and the ship creating a low pressure region amidships. This causes the ship to be 'sucked' towards the bank, and a pressure wave between the bow and the bank (the 'bow cushion') pushes the bow away from the bank and the stern is drawn in.
- Bank effect increases with increases in speed, blockage (i.e. when the cross-sectioned area of the ship is large relative to the cross-sectioned area of the bank) and low under-keel clearance. If speed is too high, bank effect can be severe and sudden, catching the ship handler unaware.
- It is advisable to slow down and to steer towards the bank. By so doing, it may be possible to strike a balance, with the ship running parallel to the bank. Bank effect is also felt on bends in a waterway when proximity to the outer bank may 'help the bow round' a tight bend.

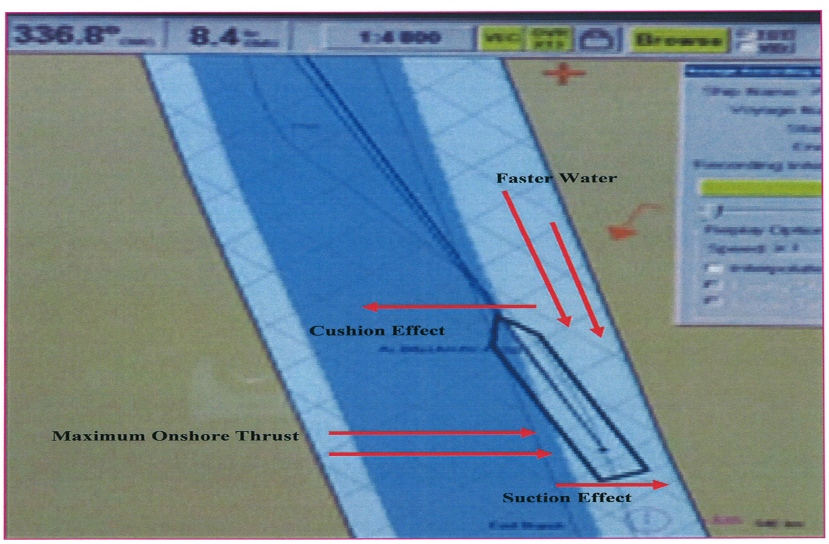
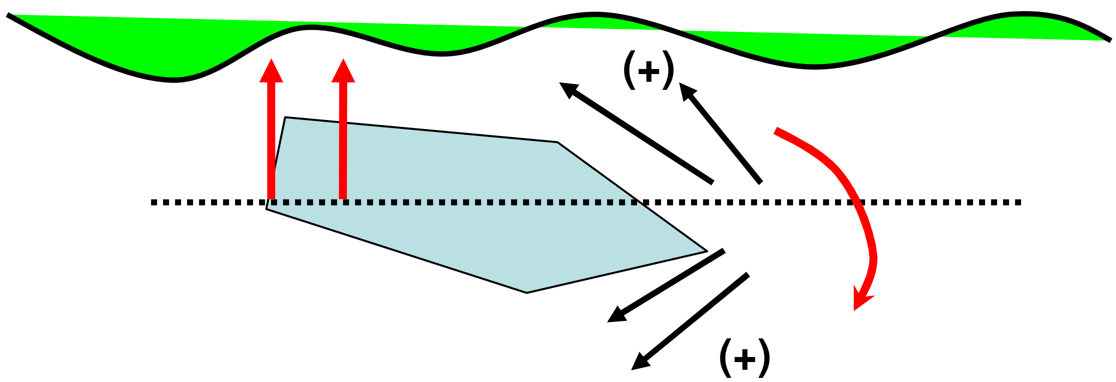


Diagram indicating concept of Bank Effect

- The general bank effect is a build-up in the water level ahead of the vessel and a lowering astern.
- A surging effect and a streamlining (Venturi effect) arises due to the restricted flow of the water on one side of the vessel → an increase in velocity of the water in that side.
- The stern moves towards the bank (Suction Effect) and the bow away from the bank (Cushion Effect) due to the differences in pressure around the ship.



- The interaction between vessel and bank due to the difference in pressure created by the water flow along the vessel's hull. The effect is stronger when distance between vessel and bank is smaller, and when the water depth is less.

2.3.5. Interaction with Other Ships:

- Just as ships can interact with banks, they can also interact with other ships. The same basic physical factors are involved: shallow water, speed and distance.
- When one ship comes too close to another at high speed, then one or more things can happen: the ship may turn towards, or be drawn towards the other ship, or both ships may sheer away from each other, or the ship may turn towards (across) the other's bows, depending on ship's sizes, relative positions, distance between ships and relative speed.
- These hydrodynamic effects are collectively known as '*interaction*'. They can and do lead to collisions or contact. Interaction is accentuated by shallow water when a large hydrodynamic effect can render a ship almost impossible to control.
- To minimize their effect, it is essential that masters anticipate the situation, that speed is reduced before the encounter, if practicable, and that the maximum passing distance is maintained. This is especially true when overtaking.

- Interaction is more of a problem when overtaking than when crossing on a reciprocal course, because the forces have more time to 'take hold' of the other ship. But it should be remembered that both ships are affected by the interaction and both should take care to minimize its effect.

2.3.5.1. Passing Effect

Stage 1 It is important, when meeting another ship, not to work over to the side of the channel too early or too far. If the ship gets to close to a shallow water or bank, it can experience bank effect and unexpectedly sheer across the path of the approaching ship with serious consequences. As the bows of both ships approach each other, the combined bow pressure zones between them will build up and encourage the respective bows to swing away from each other, use of helm will be required to check the swing.

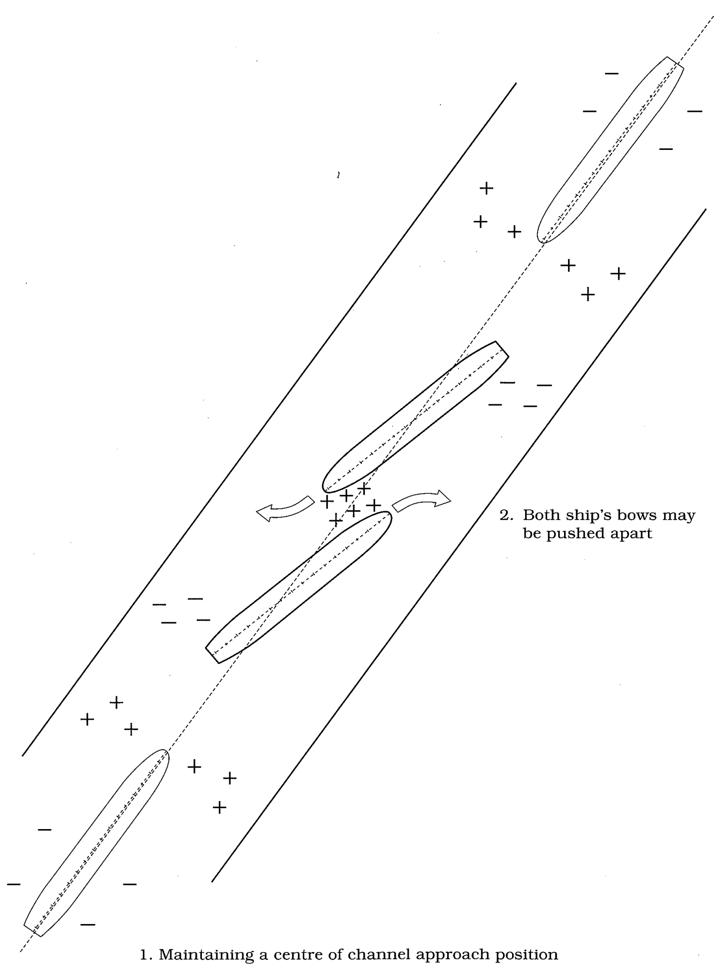


Fig - Stage 1 Passing

Stage 2 With the two ships nearly abeam of each other, a combined low pressure, or suction area exists between them and if the ships are too close, there is all the likelihood of them being sucked together in collision literally.

At this stage the bow of each ship will also begin to seek the low pressure area astern of the other. It is usual to feel this "turning in" towards the other ship as you pass and it is also helpful, because the ship is also back towards the center of the channel.

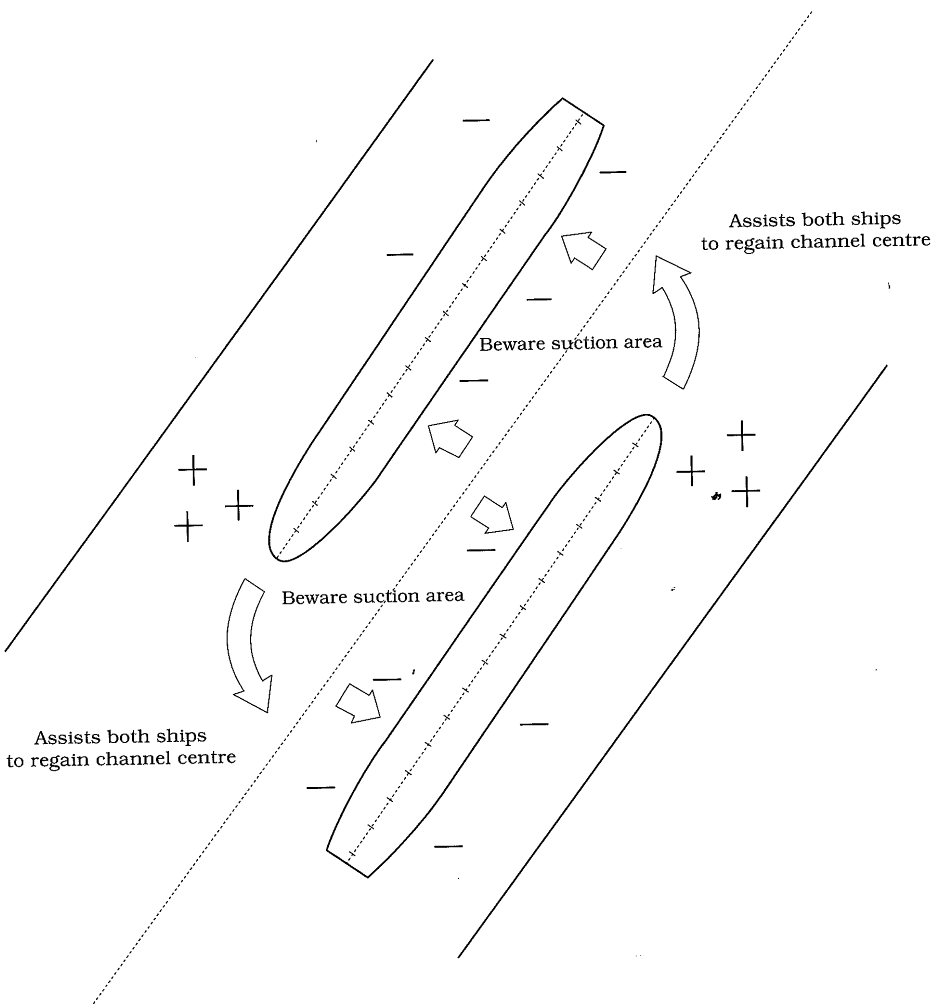


Fig - Stage 2 Passing

Stage 3 Having previously turned in towards the center of the channel, the opposite now occurs. As the two sterns pass each other, they are drawn together by the low pressure area between them and this has a tendency to realign the ships with the channel.

These effects are not always very noticeable, because the ships often pass through the pressure zones fairly quickly, even at relatively slow speeds, the effect however should always be anticipated and used correctly to advantage, corrective helm being applied when necessary.

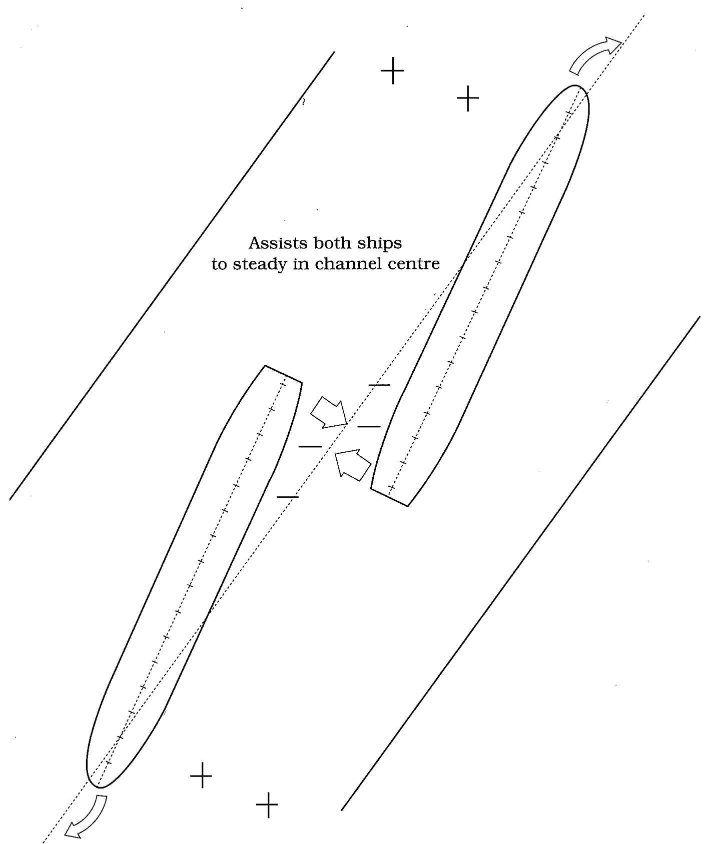


Fig -Stage 3 Passing

2.3.5.2. Overtaking Effect

Stage 1 The ship to be overtaken should not move over to the side of the channel without first considering the consequences of the bank effect and their danger of shearing across the path of the overtaking vessel. This particularly applies to smaller ships, which will easily be influenced by a large ship.

- As ship A approaches the stern of ship B its bow pressure zone will put pressure on the rudder of ship B causing it to shear across the path of the overtaking ship. The overtaking ship will also feel the low pressure area astern of ship B and exhibit a tendency to turn in.

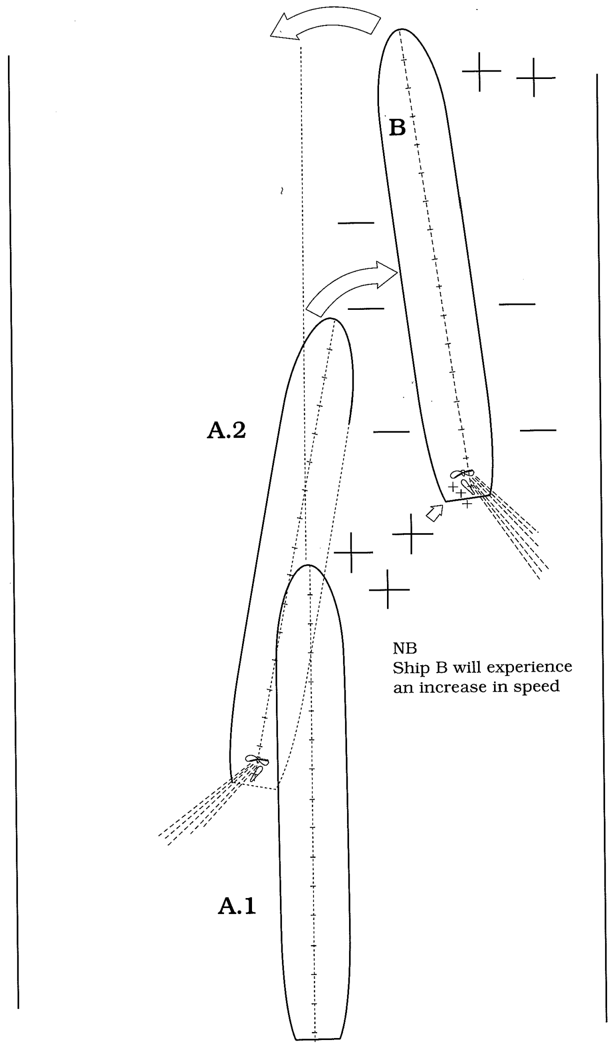


Fig-Stage 1 Overtaking

- Ship B may experience an increase in speed, as it is virtually pushed along by the pressure zone of the overtaking ship. *These may be very powerful forces and it may require full rudder and power to counteract them.*

Stage 2 when both ships are abeam of each other, a powerful pressure zone exists between their bows and a low pressure area between their sterns, these combined forces create a strong turning lever which is trying to swing the bows away from each other, this is a powerful force and vigorous corrective measured may again be needed.

- In addition to the turning forces, there is also an underlying suction area between the two ships which will, if they are allowed to get too close, draw then inexorably alongside of each other, if this doe happen, ship B normally dragged along with ship A and unless they both slow down together to reduce the suction area between them, it is difficult to get the two ships apart again.

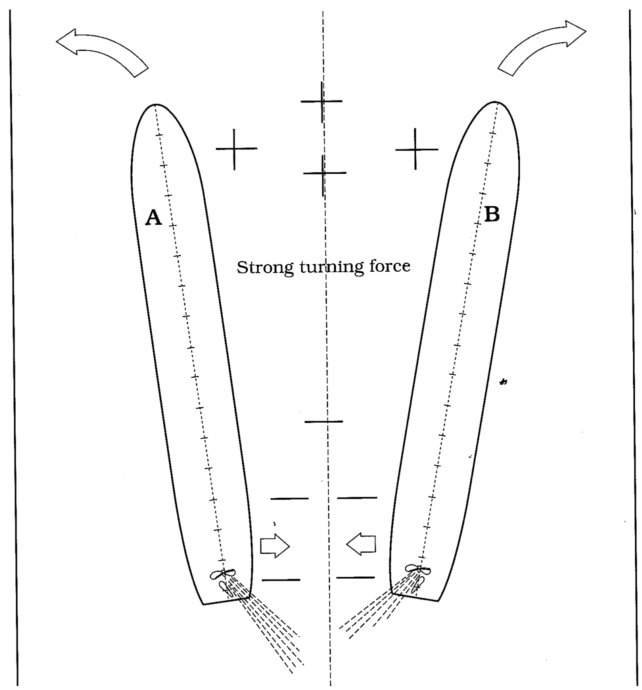


Fig-Stage 2 Overtaking

Stage 3 As the overtaking ship passes the other vessel, ship B may be influenced by the effects of two powerful forces. Firstly on one side, bank effect and secondly on the other side, the low pressure area of the passing vessel. This can combine as a very strong turning force and require bold corrective action. The rudder of the ship A may be adversely affected with positive pressure, as it passes through the pressure zone around the bow of the overtaken ship B particularly if that ship is large. This can cause the ship to turn unexpectedly across the path of the overtaken ship, as the ship B is drawn towards the suction area of the passing ship, it may experience a noticeable increase in speed.

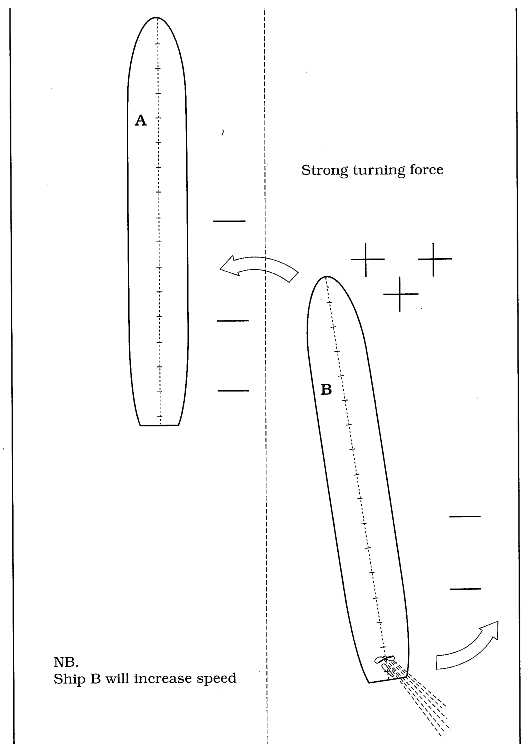


Fig- Stage 3 Overtaking

2.3.5.3. How to Reduce the Interaction?

- The overtaking / passing to be in straight river (no bents) as much as possible;
- The distance between ships to be as large as possible (more than 3 beams of overtaking vessel);
- The difference in speed between overtaking and overtaken vessel to be minimized;
- Rudder effect to be used in order to minimize the suction effect (anticipative action);
- Speed and heading control of both vessels;
- The ship should be navigated so that maximum amount of correcting rudder is always available, together with as much maneuvering room as possible;
- A sheer could be instantly corrected by increasing engine revolutions.

2.3.6. Approach Channels:

Approach channels allow a deep-draught ship to enter an otherwise shallow port and may provide many of the external factors that affect maneuvering.

- The width, depth and alignment of many approach channels are subject to rigorous analysis at the design stage so that they provide the minimum hazard to ships that move along them.
- They are designed for single or two-way traffic and their width, depth and alignment are an optimized compromise between acceptable marine risk on the one hand and economic acceptability (with regard to dredging costs) on the other.

2.3.7. Effect on Hull Resistance and Ship's Speed:

When a ship moves into shallow water, ship speed is reduced due to increased wave making resistance and the deterioration of propulsive efficiency.

From the results of speed trials, the following formula is proposed for the critical water depth affecting hull resistance:

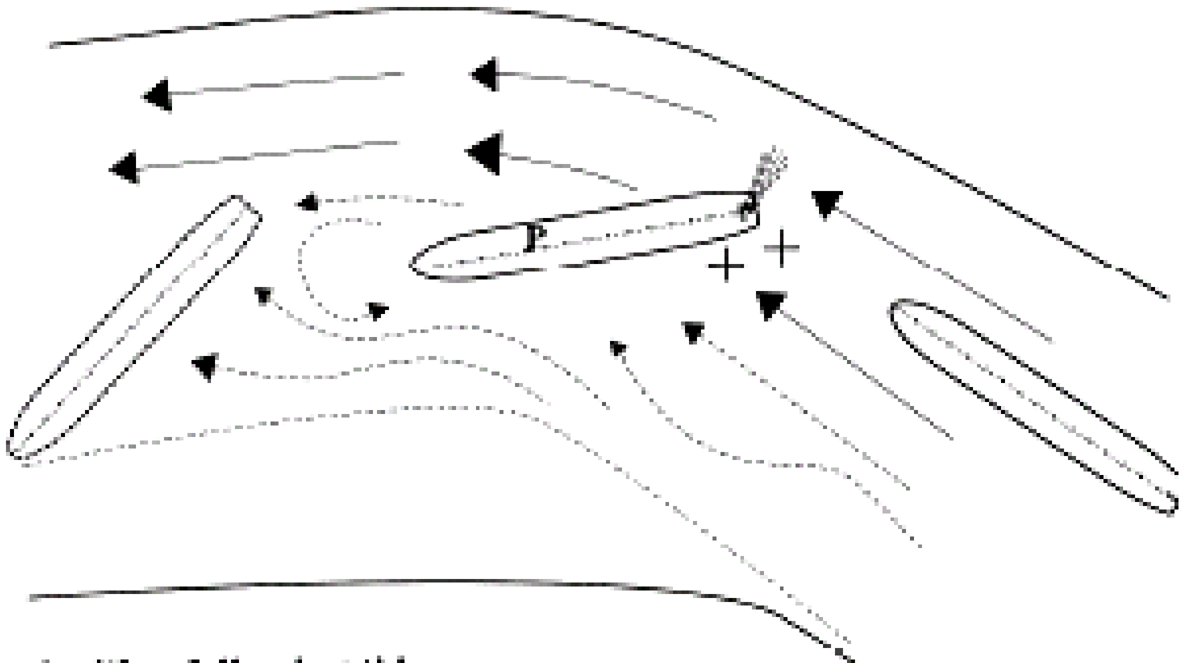
$H < 3\sqrt{Bd}$

H: Water depth (m)
B: Ship Breadth (m)
d: Ship Draft (m)

2. Ship Handling in Rivers / Channels

2.1. Maneuvering in a Following Current / Tide:

- A Ship can react both violently & rapidly to this force & it should never be underestimated.
- When a large ship is rounding the bend in a channel with strong following tide, the ship may be positioned in such a way that the larger under-water area is located aft, tide's effect is more on the stern.
- With the pivot point forward, the tide is thus creating a stronger turning lever, and a turning force of considerable magnitude is created.
- This swing can be corrected with a kick ahead of full power.



a) with a following tide

- *Therefore, if sufficient space is available, it may be prudent to steer the vessel at the outside of the bend.*

2.2. Maneuvering in Current / Tide from the Head:

- When a ship is negotiating a bend in channel with a tide from ahead, it is possible to get into the position where the ship is influenced by tides of differing strength.
- A turning moment which is opposing the intended turn and if it is not anticipated with appropriate helm and power, resulting in ship not responding & clear the bend which may lead to grounding.
- *It may be better to steer the vessel inside of the bend so that the bow does not enter the area of stronger tide at any time during the turn.*

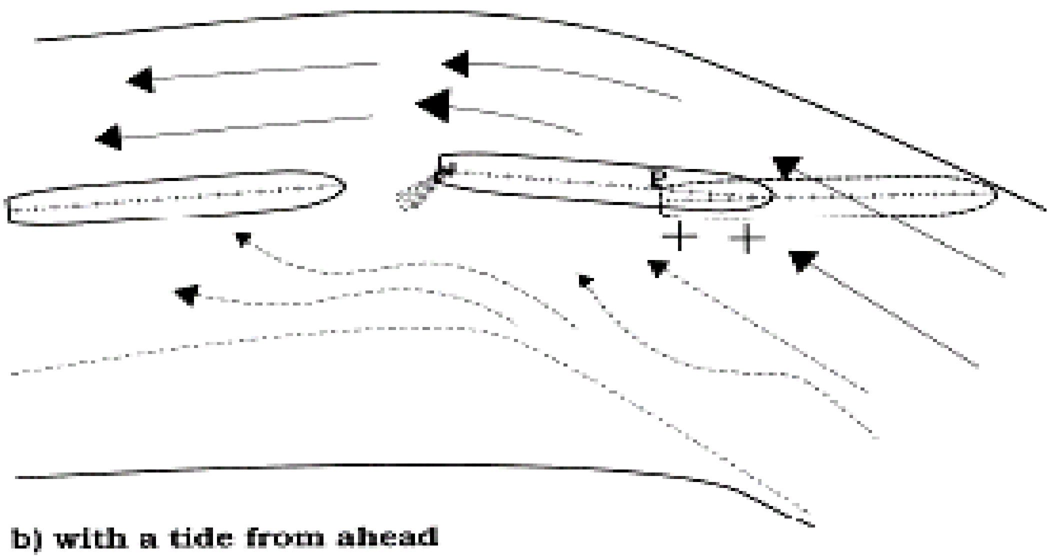
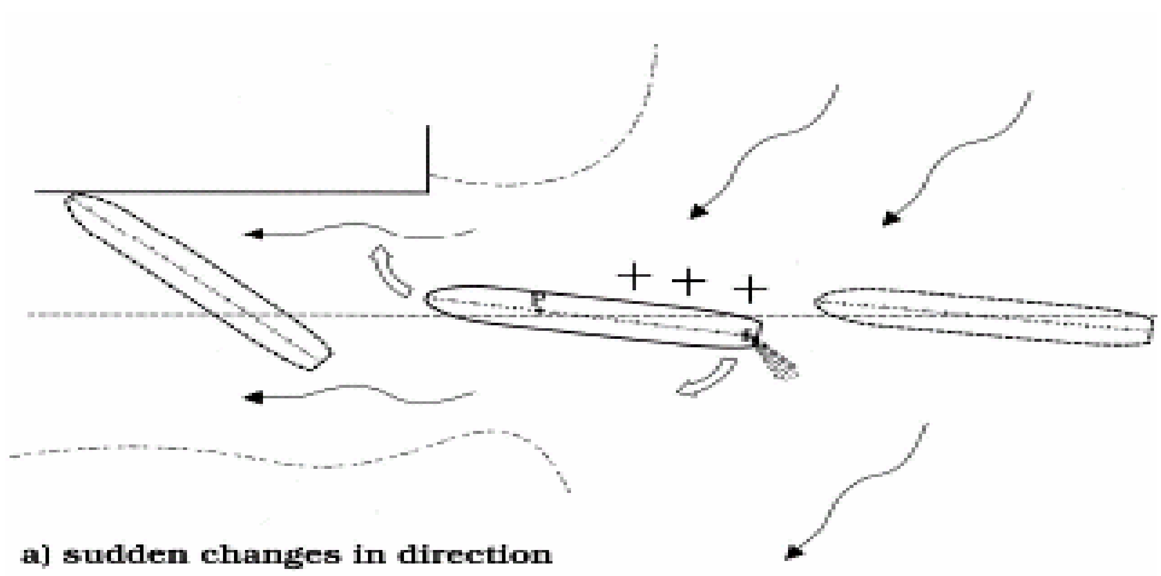


Fig: Maneuvering with a tide from ahead

2.3. Maneuvering with Sudden Changes of tide directions and strength:

Attention when vessel is approaching breakwaters, jetty-ends, or any other marine object that might stop or alter the speed / direction of the tide, and consequently with a sudden and unpredictable effect towards the vessels.



2.4. Particularities of ship's handling on rivers

- Different sectors may have different water flow and variable current velocity;
- Currents can be circular, especially in the river bents;
- Due to weather factors (rain) the water level can vary a lot in different periods;
- Due to high banks and reefs, the visibility can be affected, mostly on bents;
- The river bottom and banks are always exposed to depositions or erosions → consequently the velocity and direction of the river current may vary;
- In some areas, near the banks the water-flow may be opposite from the main flow (counter-current).

2.5. Characteristics of ship's handling on rivers

- Current velocity is NOT constant at the transversal section and it can change with the depth;
- Consequently, may cause a difficulties in a vessel's maneuver: sudden and un-expected reactions and effects.
- Shallow water and squat will affect the speed and the steering of the ship.
- River navigation will decrease the ship's speed with 20-30%, because the volume of water "pushed" by the vessel will form waves that will be reflected back from the banks to the vessel.
- When navigating close to the bank or close to another ships, the maneuvering capacity will be reduced due to suction effect.
- When making way through the water, a ship will push ahead and laterally a volume of water equivalent to the speed and hull's size → a (+) pressure in the bow and a (-) pressure (suction or vacuum) along sides and in the stern.
- Subsequently it will be created a water-flow opposed to the vessel's headway, its velocity depending on vessel's breadth, draft and speed (the water will tend to fill-up the volume left in the stern).

2.6. Effects of the River Current

- A berth can be approached bow into the current in order to give the advantage of relatively high speed through the water with a reduced speed over the ground.
- Consequently, steerage at low ground speed is improved by the good water flow over the rudder; also the ship will be easier to stop.
- Current can be used to push a ship alongside. Position the ship off the intended berth but at a slight angle towards it. Then allow the current to produce a sideways movement of the ship towards the berth.
- A ship making headway into a current, but stopped over the ground, will have a forward pivot point.

- Heading in the current, a vessel can use minimum engine ahead – and still have steering, due to water flow on the rudder
- Even if ship's speed = current speed (SOG = 0) the vessel can still steer;
- Turning diameter is smaller.

- A vessel with current from the stern is more difficult to control and maneuver, as rudder effect is weak, vessel more difficult to stop, and turning diameter is larger.

3. Tugs and Pilots: Legal Issues

3.1. Pilotage:

- The relationship between the master and the pilot is fraught with potential difficulties and conflict. The pilot directs the navigation of the ship, but the master still retains overall command and control.
- The freedom that the master gives to the pilot varies from master to master but also depends upon the circumstances in which the pilotage takes place. The master of a large foreign-going ship entering a difficult channel will tend to adopt a more passive attitude to the pilot than a coastal master who knows the area.

The way in which the law interprets this relationship, and the rights and responsibilities of each to the other and to third parties, differs from country to country and the following is therefore offered as a general overview. In many legal systems, the customary rules and statutory enactments provide a confused and sometimes contradictory picture, which tends to the conclusion that a master, when considering how to operate with a pilot, should be guided more by common sense and self-preservation than by precise legal principles.

- The pilot owes a professional duty of care to those whom he serves, which assumes a knowledge and awareness of local conditions. The pilot is therefore generally liable to the shipowner, and to third parties, for a failure to exercise such care. In practice, however, such a responsibility is largely illusory since the pilot, as an individual, has few assets with which to satisfy any award of damages.
- Also the extent of his liability is often restricted at law or limited in amount, although he may also be subject to criminal sanctions under any relevant legislation as a result of his actions.

- Where there is injury or damage to the property of a third party caused by the pilot's negligence, the third party will naturally look to the shipowner for compensation. There may be a possibility of a recourse action against the harbour authority, port commission or canal company that employs the negligent pilot. If, however, the relevant body merely acts as a licensing authority, it will not be liable for pilot error. Pilot associations are also generally immune from liability for the actions of their members.

- In terms of engagement, the master is only legally bound to employ a pilot in an area of compulsory pilotage. However, the master may be found liable for not employing a pilot where it can be shown that such failure caused or contributed to an accident.

- Whilst the pilot may assume control of the navigation of the ship, this does not relieve the master of his command of the ship. The master therefore retains both the right and the responsibility to intervene in the actions of the pilot, although it has been stressed on many occasions that the master is only justified in intervening, when the pilot is in charge, in very rare instances; for example, where he perceives the threat of an imminent danger to the ship or when the pilot is obviously incapacitated in some way.

- The pilot is responsible for, and should be left in charge of, navigation in terms of speed, course, stopping and reversing, but the ship's master is responsible for all other matters such as maintaining a proper lookout. And the pilot is entitled to expect a well-regulated and seaworthy ship, that provides him with proper assistance and information.

3.2. Towage:

Towage has been defined as "*a service rendered by one vessel to aid the propulsion or to expedite the movement of another vessel*".

Towage can take place in many different circumstances and can be part of a salvage or wreck removal operation following a casualty. It can also occur when a ship is in distress in order to avoid a casualty occurring. In the vast majority of cases, however, towage is a routine operation, particularly within the confines of a port. This is referred to as *customary towage*.

- An agent of the ship, or the charterer, usually requests the services of a tug for port towage. Once engaged, however, the tug may take its orders from any pilot on board the towed ship and therefore the presence of tugs adds to the complexities of the relationship between the master and pilot referred to above. The pilot should be fully aware of each tug's power and handling characteristics but the responsibility for engaging tug assistance, where required, rests with the ship's master, and the ship's master may be found negligent in not engaging a tug to assist where the circumstances warrant it and an accident occurs.

- Every shipowner should leave the question of tug assistance to the discretion of the master who must make a judgment based on the prevailing circumstances.

- The rights and responsibilities of the tug and the towed ship, with regards to each other and in relation to third parties, are generally dealt with in the applicable towage contract. In most cases, the contract will be based on industry standard terms that lay down clearly the division of responsibility between the two entities. Specific port user agreements exist, but standard form contracts, such as the UK Standard Towage Conditions, the Netherlands Towage Conditions or the Scandinavian Conditions, are used in most cases. These all favour the tug, although in the USA, the Supreme Court has held that any clauses in a towage contract purporting to relieve the tugowner of liability for negligence are invalid as being against public policy.

- In Japan, the tugowner must exercise due diligence to make the tug seaworthy at the time she leaves the port and is liable for any damage to the tow caused by any failure to do so. Generally, in the absence of clear wording to the contrary, a court will apply as an implied term of the towage contract that the tug owner warrants to exercise due diligence to make the tug seaworthy at the commencement of the towage.

3.3. Master – Pilot Relationship:

It is a given fact that invariably pilotage is compulsory and the majority of accidents during berthing occur with a pilot on the bridge. No berthing guide would be complete without reference to the master/pilot relationship.

- Efficient pilotage is chiefly dependent upon the effectiveness of the communications and information exchanges between the pilot, the master and other bridge personnel and upon the mutual understanding each has for the functions and duties of the others.
- Ship's personnel, shore based ship management and the relevant port and pilotage authorities should utilize the proven concept of "*Bridge Team Management*".
- The presence of a pilot on the ship does not relieve the master or officer in charge of the navigational watch from their duties and obligations for the safe conduct of the ship.

- Ships should provide the relevant port or pilotage authority with basic information regarding their arrival intentions and ship characteristics, such as draught and dimensions, maneuvering characteristics, etc.
- In acknowledging receipt of this information, the appropriate port or pilotage authority should pass relevant information back to the ship (pilot boarding point;

reporting and communications procedures; and sufficient details of the prospective berth, anchorage and routing information, etc) to enable the Master to prepare the passage plan to the berth.

- The Pilot and the Master should exchange information regarding the pilot's intentions, the ship's characteristics and operational parameters as soon as possible after the pilot has boarded the ship.

(***Refer to SMS procedures – Pilot Card and Master-Pilot Information Exchange <S-072003-01FRM>***)

- The exchange of information regarding pilotage and the passage plan should include all relevant information and clarification of any doubts; after taking this information into account and comparing the pilot's suggested plan with that initially developed on board, the Pilot and Master should agree an overall final plan early in the passage before the ship is committed.
- Contingency plans should also be made which should be followed in the event of a malfunction or a shipboard emergency, identifying possible abort points and safe grounding areas. These should be discussed and agreed as well between Pilot and Master.

- The pilot's primary duty is to provide accurate information to ensure the safe navigation of the ship. In practice, the pilot will often con the ship on the master's behalf. The master retains the ultimate responsibility for the safety of his ship. He and his bridge personnel have a duty to support the pilot and to monitor his actions.
- In supporting the pilot, the master and ship's personnel should ensure that the means of pilot embarkation and disembarkation are properly positioned, rigged, maintained and manned in accordance with IMO recommendations and, where applicable, other port requirements;
- The master should liaise with the pilot station/transfer craft so that the ship is positioned and maneuvered to ensure safe boarding.

- It is essential that a face-to-face master/pilot exchange results in clear and effective communication and the willingness of the pilot, master and bridge personnel to work together as part of a bridge management team.
- English language, or a mutually agreed common language, or the IMO Standard Marine Communication Phrases should be used, and all members of the team share a responsibility to highlight any perceived errors or omissions by other team members, for clarification.

- The necessity of co-operation and a close working relationship between the master and pilot during berthing and un-berthing operations is extremely

important to the safety of the ship. In particular, both the pilot and the master should discuss and agree which one of them will be responsible for operating key equipment and controls (such as main engine, helm and thrusters).
- The pilot should co-ordinate the efforts of all parties engaged in the berthing or un-berthing operation (e.g. tug crews, linesmen, ship's crew). His intentions and actions should be explained immediately to the bridge management team, in the previously agreed appropriate language.
- The Master, having the ultimate responsibility for the safe navigation of the ship has a responsibility to request replacement of the Pilot, should he deem it necessary.

4. Brief Explanation of Anchor Holding Power Calculation

- Rough calculations (3D+90m, 4D+145m, etc.) are used to estimate the length of anchor chain needed. Some considerations for 'equipment numeral' is given for the above figures; however, necessary length will differ by vessel conditions (ballast/laden and anchor holding factor / chain's friction factor, etc.)

4.1. Used Figures

- A necessary holding power is the sum of anchor holding power ad frictional resistance on the contracted length of the chain. We can get an estimate of holding power by performing the following calculations.

$$P = P_a + P_c = \lambda_a \cdot w_a + \lambda_c \cdot w_c \cdot L$$

- P: Total holding power (kg)
- P_a: holding power by anchor (kg)
- P_c: holding power by chain (kg)
- λ_a: Anchor holding factor
- λ_c: Chain holding factor
- w_a: Anchor weight (kg)
- w_c: Anchor chain weight(kg/m)
- L: Contacted length of the chain (m)

$$L = L_c - s$$

$$s = \sqrt{y\left(y + \frac{2\,T_o}{w_c}\right)} \quad \text{(m)}$$

- s: Catenary length against the external force(m)
- y: Depth(m) + Height of Hose pipe(m)
- T_o: Horizontal power to act on the hull (kg)
- w_c: Aerial weight per anchor chain 1m (kg)

Necessary chain length

$$S = s + l = \sqrt{y\left(y + \frac{2\,To}{wc}\right)} + \frac{P \cdot \lambda a \cdot wa}{\lambda c \cdot wc}$$

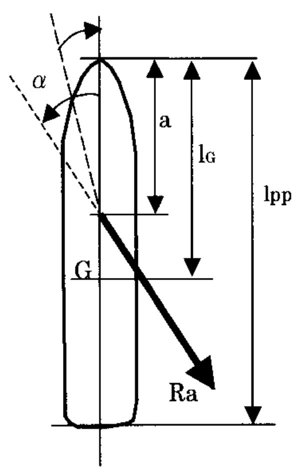
4.2. Wind Pressure Force Calculation

It is very important to understand how much wind pressure is placed on a ship during anchorage and berth in strong wind conditions. When wind hits a ship, pivot forces are given off by wind pressure and more steerage is needed to keep the intended course during harbor approach at low speed. In addition, more attention should be provided to potentially dragging anchor at anchorage. The results calculated using the below figures may differ from actual conditions.

Calculations

$$\mathbf{Ra = 1/2pa \cdot Ca \cdot Va^2 \, (A \cos^2 \theta + B \sin^2 \theta)}$$

Pa: Air density ($kg.sec^2/m^4$: Adopt 0.124 as a normal value)
Ca: A wind pressure coefficient
Va: Relative wind force (m/sec)
A: The front projection area on the water (m^2)
B: The side projection area on the water (m^2)



θ : Relative direction of the wind (deg)
Ra: Wind pressure resultant (kg)
α: The direction where wind pressure resultant

a: Distance from the bow to the wind pressure

Lpp: Length of perpendicular (m)

4.3. Wind Pressure Coefficient and the Direction Where Wind Pressure Resultant Acts

The following approximations are used:

① Wind pressure coefficient

General cargo vessel: $Ca = 1.325 - 0.05\cos 2\theta - 0.35\cos 4\theta - 0.175\cos 6\theta$

Passenger ship: $Ca = 1.142 - 0.142\cos 2\theta - 0.367\cos 4\theta - 0.133\cos 6\theta$

Bulker & Oil Tanker: $Ca = 1.20 - 0.083\cos 2\theta - 0.25\cos 4\theta - 0.117\cos$

② Distance from the bow to the wind pressure point

$$\mathbf{a/Lpp = 0.291 + 0.0023\theta}$$

③ Distance from the bow to the wind pressure point

$$\alpha = \{1 - 0.15(1 - \frac{\theta}{90}) - 0.80(1 - \frac{\theta}{90})3\} \text{ x } 90$$

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List of Appendices

APPENDIX 1: Guidelines for Safe Anchoring
Doc Ref No.: SB GEN 2012 016 and GI/FLT/037/12

APPENDIX 2: Method of Reducing Speed Gradually (Examples)
Doc ZZ-S-P-07.20.02, Form S-072002-02FIG

APPENDIX 3: Determination of Holding Power of Anchor
Doc ZZ-S-P-07.20.02, Form S-072002-04FIG

APPENDIX 4: Anchor Chain Holding Power and Wind Pressure Force
SMS Tools – Excel calculation sheets.

APPENDIX 5: NYKSM Maneuvering Standard
Standard Berthing and Un-Berthing Plans

APENDIX 6: Calculation of Tugs Required (for required Bollard Pull)
SMS Tools – Excel calculation sheet.

APPENDIX 7: Pilot Card with Squat Calculation (UKC Calculation tool)
SMS Tools – Excel calculation sheet.

APPENDIX 8: Owner's Instructions for all VLOCs / VLCCs: NYK Standard for VLOCs Passing the Malacca/Singapore/Sunda/Lombok Strait

APPENDIX 9: SAFETY REPORT: Reporting Bollard Strength on Nomination Sheets (Ref. No. 2012-08 / 01-Nov-2012).

APPENDIX 10: Contact incidents - HSEQ/ALL/021/13 dated 06-Feb-2013.

APPENDIX 11 (For LNG): Ras Laffan Port berthing criteria – SMUK/MOPS/OTHER/003/13 dated 09-May-2013.

APPENDIX 12: Reminder regarding compliance with SMS requirements pertaining to "Self-Pilotage" - HSEQ/ALL/059/13 dated 23-May-2013

BIBLIOGRAPHY:

- IMO Publication: "A Master's Guide to Berthing"
- American Bureau of Shipping: "Vessel Maneuverability"
- Capt Hugues Cauvier: "The Pivot Point" – Article published in "The Pilot" (The Official Organ of the UK Maritime Pilots' Association, October 2008)
- NYKSM Safety Management System – Various Forms and Instructions
- NYK Line – Various Instructions and Circulars

Various Case-Study are discussed, depending on Vessel's type

VLCC

- "TOSHI" nearmiss grounding, K Sea-Berth / Japan, overshoot position.
- "TOSA" alleged capsizing of fishing boat, Uotsuri / Japan.
- "TAKASUZU" contact with new terminal berth, Ningbo / China.
- "NIPPON" collision with fishing boat, off Kiire / Japan.
- "NIPPON" collision with Bulk-carrier "VTC Ace", Malacca Strait.

PCC

- "HEIJIN" grounding near breakwater, Zeebruge / Belgium.
- "HEIJIN" port anchor and 10 shackles chain lost, Cristobal / Panama.
- "JINGU" collision with fishing boat, South China Sea.
- "NADA V" collision with PCC "Grande Nigeria", Antwerp / Belgium.
- "GARNET LEADER" grounding, Oita / Japan.
- "KAIJIN" contact with berth and gantry crane, Chiba / Japan.
- "PLEIADES LEADER" contact with M/V "Sun Happiness", Nagoya / Japan

LNG

- "ECHIGO MARU" collision with fishing boat, Indian Ocean.

LNG Twin Screw

- "AL UTOURIYA" contact with canal edge port side, Suez Canal / Egypt.

CONTAINER

- "NYK SPRINGTIDE" contact with 2 ships, berth and gantry crane, Kobe / Japan.
- "IMARI" contact with Scow and Dredger, Shooters Island, New York / USA.
- Container vessel contact with shore fender, T05 Tanjong Pagar terminal, Singapore.

WOODCHIP CARRIER

- "CRIMSON MERCURY" contact with berth (no tugs used), Macapa / Brazil

BULK CARRIER

- 2 Bulk-Carriers involved in collision during anchorage maneuvers (arrival and departure).