Skilful Vessel Handling

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Manoeuvring of vessels that are held back by an external force

This consideration is written in belated wisdom according to the accident of Bourbon Dolphin in April 2007

When manoeuvring a vessel that are held back by an external force and makes little or no speed through the water, the propulsion propellers run up to the maximum, and the highest sideways force might be required against wind, waves and current.

The vessel is held back by 1 800 meters of chain and wire, weight of 300 tons. 35 knops wind from SW, waves about 6 meter and 3 knops current heading NE has taken her 840 meters to the east (stb), out of the required line of bearing for the anchor.

Bourbon Dolphin running her last anchor. The picture is taken 37 minutes before capsizing. The slip streams tells us that all thrusters are in use and the rudders are set to port. (Photo: Sean Dickson)

Lack of form stability I

Emil Aall Dahle

It is Aall Dahle's opinion that the whole fleet of AHT/AHTS's is a misconstruction because the vessels are based on the concept of a supplyship (PSV). The wide open after deck makes the vessels very vulnerable when tilted. When an ordinary vessel are listing an increasingly amount of volume of air filled hull is forced down into the water and create buoyancy – an up righting (rectification) force which counteract the list.

Aall Dahle has a doctorate in marine hydrodynamics, has been senior principle engineer in NMD and DNV.

Lack of form stability II

A PSV or an AHTS have very little stabilizing buoyancy because the after deck is so close to the surface and got so little volume. Aall Dahle recommends that the rails on the after deck should be reconstructed to floating boxes which would lead to a radically better form stability.

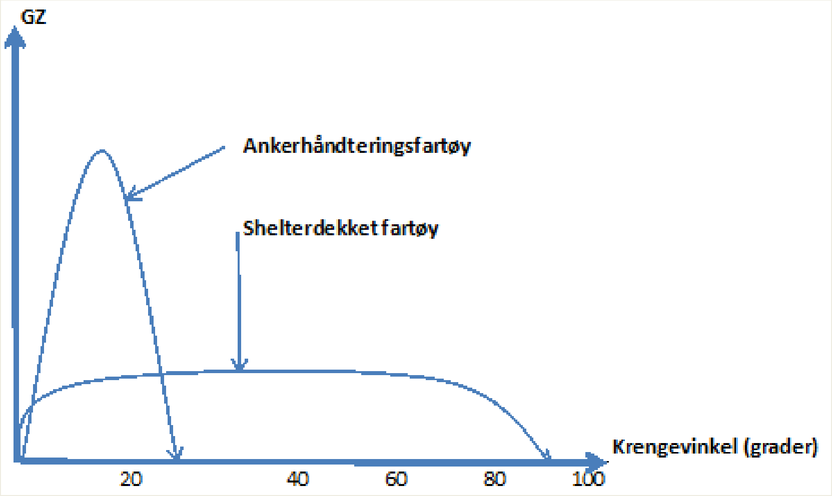
Olympic Zeus has got airtight volume in the rail with airtight entry. It is a question of only one thing – volume!

Altering the vessel's water level when listing

Ian Clarke og Michael Hancox

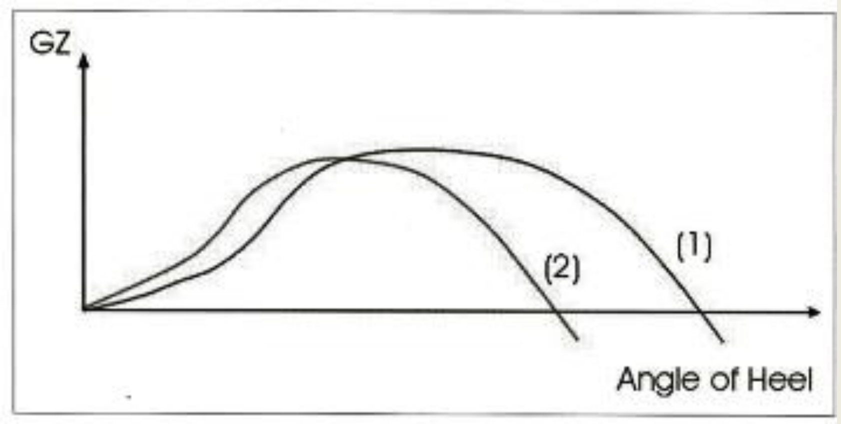
Two British experts, Ian Clarke og Michael Hancox, are as well anxious about the change in the water level of the AHTS's when listed. When recovering buoys and heavy anchors over the stern roller, it is necessary to stern trim. According to Clarke and Hancox it is very dangerous to stern trim in connection with difficult towing operations.

Aall Dahles GZ-kurve



Emil Aall Dahle sketch the difference between the angle of heel of an AHTS and a shelter deck ship.

Stern trim



"Due to the requirement to carry deck cargoes on the afterdeck of an Anchor Handling and Supply Vessel and the location of liquid and bulk tanks at the after end, this type of vessel will, when loaded, generally have a stern trim.
A vessel trimmed by the stern will, when heeled, be subjected to a premature immersion of the deck edge aft, compared to a vessel at even keel.
It may be expected that the GM value and the stability at small angles may be greater in this trimmed condition, however deterioration in the GZ curve will result.
The figure shows the GZ curves for a vessel on an even keel (1) and for a vessel trimmed by the stem (2). Clearly the trimmed vessel will have:

- *A reduced area under the righting lever curve (GZ Curve).*
- *A reduction in the angle of heel for the maximum righting arm.*
- *A reduction in the initial metacentric height (GM).*

For operational reasons, a stern trim is preferable for the Anchor Handling Vessel."

(From *Practical Introduction to Anchor Handling and Supply Vessel Operations* by Gary Ritchie, 2007)

Bollard pull and shaft generator loss I

The towing power of the Bourbon Dolphin was reduced from 180 tons down to 125 tons because of heavy use of thrusters and winch force

For operations with use of thruster, each shaft generator supply power to a forward and stern thruster, and to electrical motors for a winch.

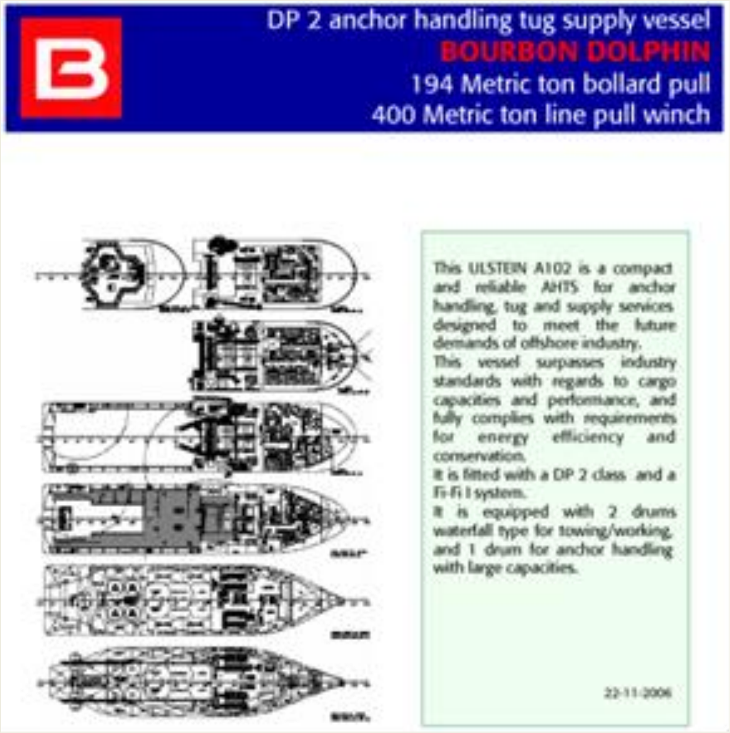
Shaft generators have the capacity to cover 100 % thruster and winch use.
By increasing the load on the axle generators bollard pull will be reduced because the propeller pitch is automatically adjusted to control 100 % load on the main engines, which operate at constant speed. The higher the load on the axle generators, the less is left for bollard pull.

For example, at maximum use of thrusters and maximum load on the winch, it will only remains 62 % of the maximum performance to the main propellers. The towing power of the Bourbon Dolphin is thus reduced from 180 tons down to 125 tons. Vessel certified bollard pull thus appears rather as a theoretical than a real reference for anchor handling operations where one would expect heavy use of thrusters.

Bollard pull and shaft generator loss II

Operator requirements for Bourbon Dolphin was a bollard pull of 180 tons, which can be said to be marginal in relation to the contract, which required a bollard pull of 195.9 tons by detachments from the anchor. Most anchor handlers are in the spot market and it is rarely the case of long term contracts. It is in the spot market operator retrieves the necessary tonnage to a mission and adequate bollard pull is a significant competitive advantage.

It is understandable that the companies want to present the vessels at their best in the market but one should realize that a certified bollard pull that is not real when using thruster and winch, may endanger ship and crew.



The vessels certified bollard pull appears rather as a theoretical than a real reference. We see here that the company Bourbon Offshore enters the bollard pull of Bourbon Dolphin to 194 tons which is included azimuththruster, and without any effect on tunnel thrusters or winch.

Thrusters I

Sharp or conical inlet

The effect of a tunnel thruster is largely determined by the degree of suction on the suction side of the tunnel and deflection of the slip stream from thruster propeller on the push side. A well designed inlet can give a contribution of 25-35 % of the total thruster power.

Three variants of inlet:

Sharp inlet, where the tunnel opening in the ship side has the same diameter as the rest of the tunnel.

Conical (tapered) inlet, where one has a bevel edge with a length of approx. 10 % of the diameter of the tunnel, with a base of approx. 45°.

Radius inlet, that has a rounded, smooth transition to the side of the ship, and where the transition has an overall length of 8-12 % of the diameter in the tunnel.

(Photo: Brunvoll)

Thrusters II

Sharp or conical inlet

When we compare these different types of inlet and imagine a vertical vessel side, we find that a conical inlet provides an extra effect of 8 % compared to a sharp inlet and an inlet radius an extra effect of 10-14 % . Today tunnel thrusters are produced with sharp or conical (tapered) inlet because tunnel thrusters with radius inlet is far too expensive to produce.

Examples of tunnel thrusters with conical inlet. (Photo: Brunvoll)

Loss of Thrusters I

When the vessel is using thrusters to pull the bow to starboard (SB), we find the following: Without water speed a suction is created around the periphery of SB thruster inlet. On the outlet side the slip stream from the thruster will stand almost perpendicular to the ship's center line. With speed through the water it will on the suction side be more suction in front of the inlet, while the suction behind the inlay (in the aft part of the traveling direction) will be greatly reduced.

The suction stream is slowed by speed power and the thruster receives correspondingly less water to work with.

On the outlet side/push side towards port (BB), with speed through the water you will get a small and favorable pressure increase in front of the outlet, while at the back of the outlet (in the aft part of the speed direction) it will be a large area with suction because the current rate here will increase.

The Thruster propellers water flow will be deflected from the tunnel entrance, and move alongside the ship. The thrusters push will be reduced and the effect of sideways movement against SB will decrease.

Loss of Thrusters II

The Coanda effect

There are a number of conditions that will lead to loss of thruster effect. In comparing the various inlets we assume a vertical vessel side, which is a purely theoretical exercise that gives maximum effect. The spun angles and waterline angles are of great importance. Whether the frames in the bow is U- or V-shaped, gives us different loss of effect from the bow thrusters.

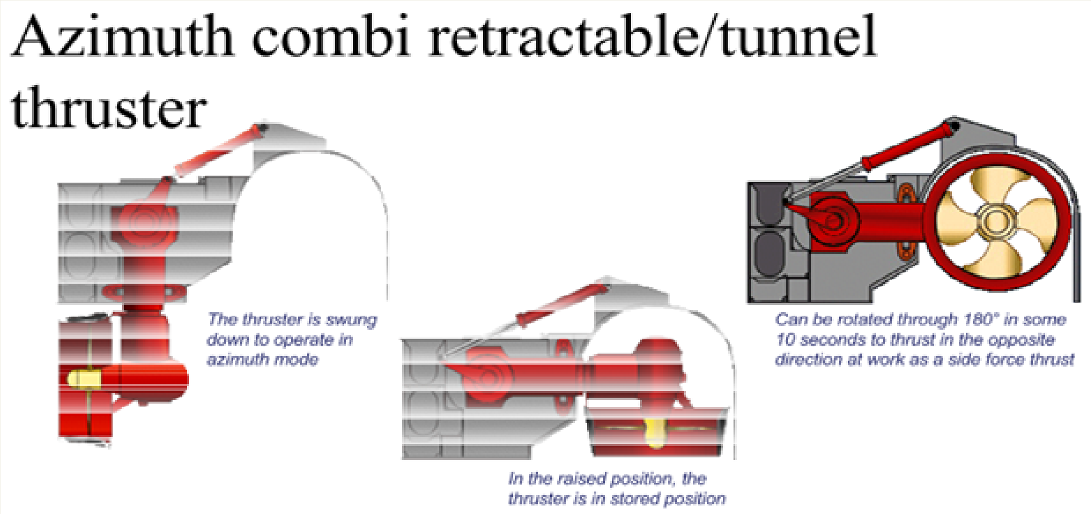
With V-shaped ribs the inlet/outlet are very different in terms of underneath the tunnel opening contra above the tunnel opening, and we get a greater degree of deflection of the slip stream from the thruster propeller.

The so-called Coanda effect, water (slip stream) from the thruster propeller is deflected upwards along the ship's side and gives loss of thruster.

Tunnel thrusters aft on the supply fleet are usually placed in a "skeg", a box keel. If the tunnel is located high in the box keel with small distance to the ship's bottom, there is a risk that the slip stream is deflected upwards (Coanda effect) and this will then give a loss of thruster effect.

4 knots speed

The effect of one tunnel thruster when the vessel makes more than three or four knots through the water, is marginal. The water flow of the thruster propellers will have little effect for sideways movement. Similar situations occur with bow thrusters on supply vessels that for instance lies and loads of strong swell at a rig, with the bow against the waves. If the speed of the vertical movement of the bow exceeds three to four knots, a similar marginal effect is experienced. The inflow of water from the suction side decreases, the thruster propellers water stream on the push side is deflected respectively upward and downward along the ship's side, and the sideway effect is small.



From left to right: 1. The thruster is swung down to operate in azimuth mode. 2. In raised position, the thruster is in stored position. 3. Can be rotated through 180° in some 10 seconds to thrust in the opposite direction at work as a side force thrust.

Loss of Thrusters IV

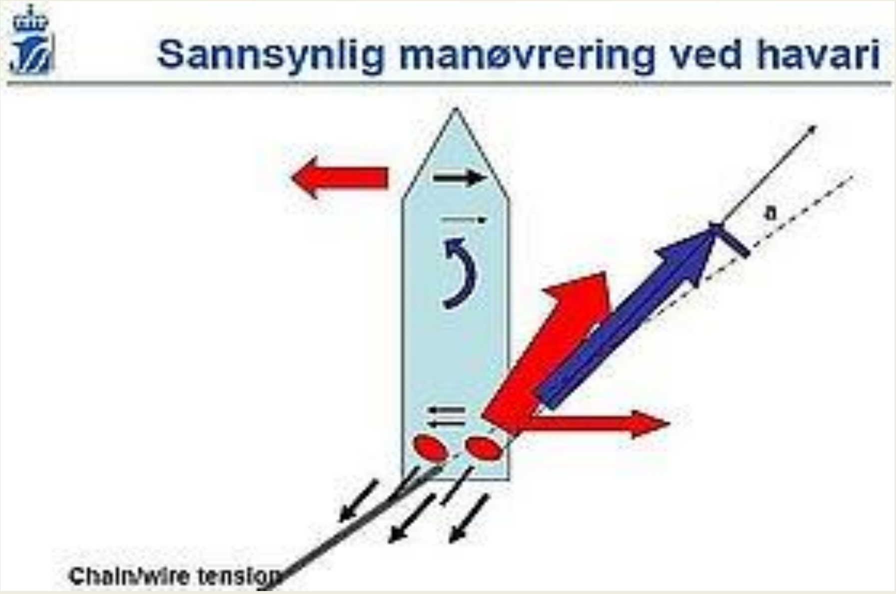
Stern thrusters are useless on vessels that is held back by an external force, because of induced currents, i.e water suction, from the propulsion propellers

Stern thrusters are useless on vessels that are held back by an external force, because of induced currents, i.e water suction, from the propulsion propellers.

When the propulsion propellers run up to the maximum, for example when running the chain, the vessel is held back of the external force, and there is little or no propulsion through the water, from 0 to 0.25 knots. The thrust force of the stern thrusters is significantly reduced due to induced currents, i.e "the water suction" from the propulsion propellers. It is of no use to utilize power through the shaft generators to the stern thrusters when propulsion propellers are utilized to the maximum. All available power should be taken from the propulsion propellers. Experienced officers agree that stern thrusters are useless when running out anchors, then rudder is only used on auto header together with forward thrusters, or azimuth. This ties in well with our desire to take out all of the available power through the propulsion propellers.

Faulty manoeuvring I

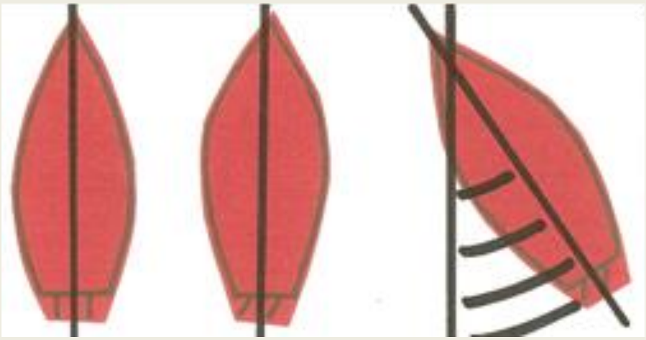
When the vessel makes little or no speed through the water and the propulsion propellers run up to the maximum, the highest sideways force is achieved by taking out all available power from the propulsion propellers in combination with the rudders and the forward thrusters while manoeuvring the vessel on autoheading.



NMD reconstruction of the assumed manoeuvering during the Bourbon Dolphin accident. (Sjø08 - Sjøsikkerhetskonf.25.9.2008)

Faulty manoeuvring II

The vessel is steered by propeller water from the propulsion propellers



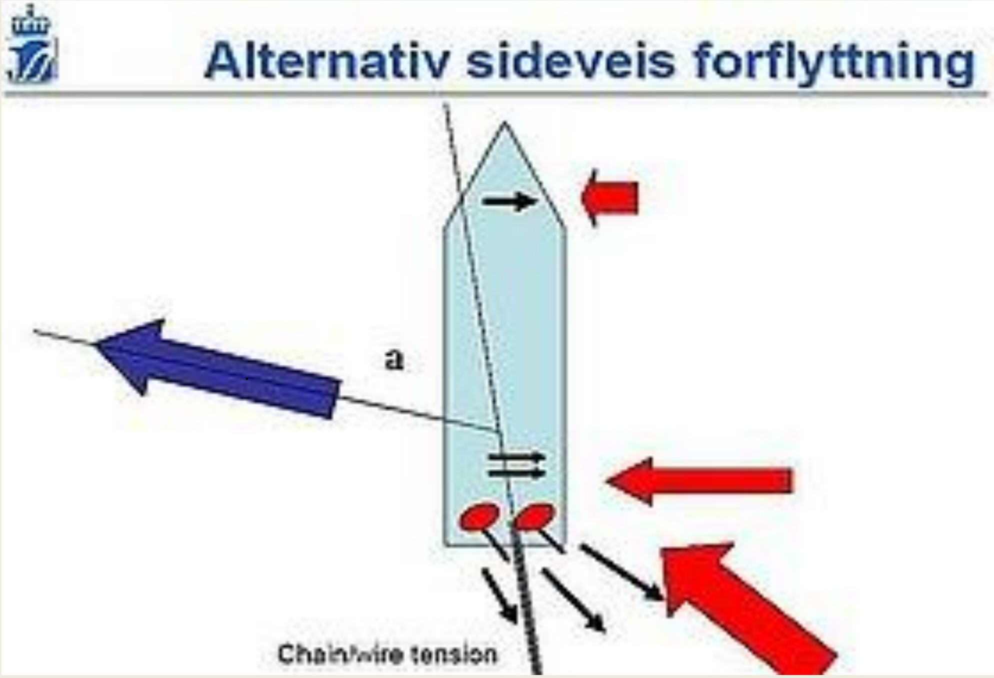
A vessel making way through the water is controlled by the stern.

A vessel making way through the water is controlled by the stern, stern is pushed to the opposite side of desired direction of travel.

When the external force prevents the vessel from moving the stern in a certain speed over distance, the rudders, alt. the azipods, should be turned towards the opposite side of desired direction of travel, this will achieve biggest sideways power.

Opposite rudder I

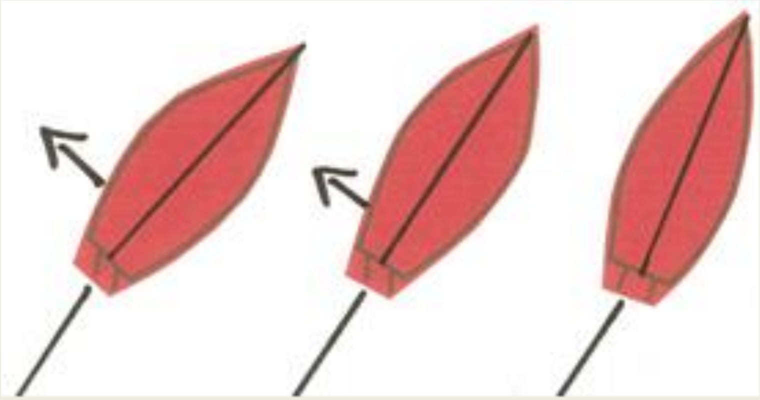
To achieve maximum lateral force towards portside from the propulsion propellers, rudders, alternatively Azipods, should be turned to starboard.



NMD illustration of alternative sideways manoeuvering. (Sjø08 - Sjøsikkerhetskonf.25.9.2008)

Opposite rudder II

Propeller water pushes the vessel's stern sharply to port



Rudders, alt. azipods, is turned towards the opposite side of the desired direction of travel for maximum sideways power. We see that the angle of attack from the chain also becomes more accurate.

Steering to starboard causes the water from the propeller to push the vessel's stern sharply to port. This sideway force is substantial in relation to the vessel's total towing power. Wind and waves from the west, and currents towards the east, will push the vessel to starboard. Rudder to port will enhance this further.

Basic Twin Screw Handling I

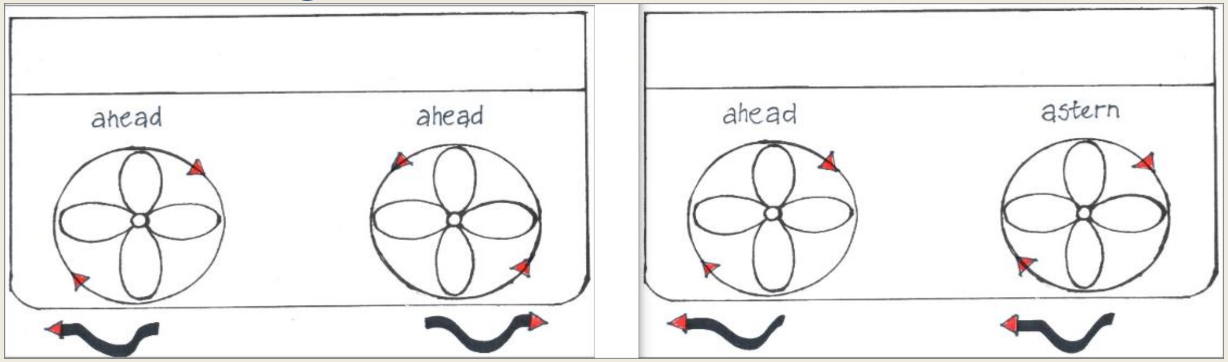
Vessels fitted with fixed pitch propellers meet different effects according to inward or outward turning screws. When the ship is moving forward with a single screw there is a thrust in one direction which is overcome by the rudder, but takes effect when the ship is moving astern.

Vessels equipped with twin screws are called inward turning when, viewed from astern when pushing ahead, the starboard propeller turns counter clockwise while the port propeller turns clockwise.

Conversely, the outward turning twin screw has the starboard propeller turning clockwise and the port propeller turning counter clockwise when pushing ahead.

When one engine is set ahead and the other is set astern on twin screw vessels, the stern will tend to move towards the side of the ahead engine because of the turning effect due to the screws being off centre.

Inward Turning Screws



Basic Twin Screw Handling II

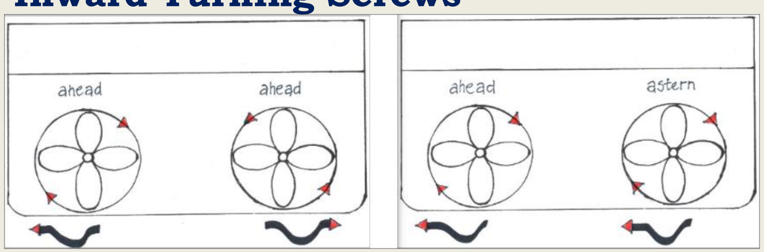
The distance between two propellers is the lever between two forces acting oppositely to turn the ship. The effectiveness of the turn is proportional to the distance between the two propellers and the rpm of the propellers. Therefore, the ship with propellers further apart will have more effective turning.

With inward turning screws the screw effect will counter the tendency of the ship to turn due to the off centre position of the screws. The transverse thrust will push the stern to the opposite direction of the desired turn and make the turn more difficult.

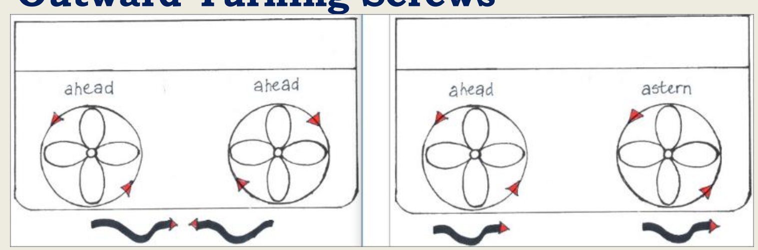
With outward turning screws the screw effect will add to the tendency of the ship to turn due to the position of the screws. The effects will be opposite if the ship is going astern.

On a ship with inward turning screws it is supposed to be possible to make the ship move sideways, or "crab" without the assistance of a bow thruster. In fact the Becker rudder was supposed to have been developed for just this purpose for marine operations completely unrelated to the oil industry.

Inward Turning Screws



Outward Turning Screws



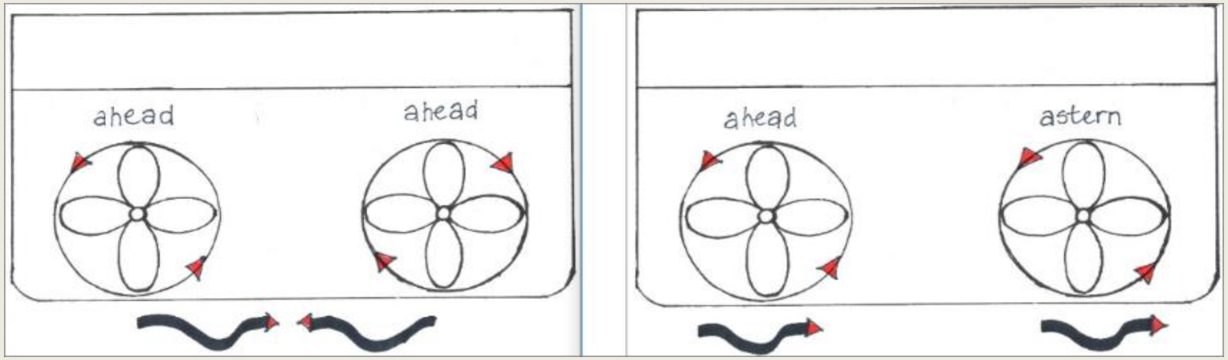
Basic Twin Screw Handling III

The principle is that even though the rudders and the screws are close together they still create a lever. If the rudders are placed amidships and the engines are set to cant the stern away from the quay, then the correct rudder setting is put on in the opposite direction the ship should move out bodily. If too much rudder is put on then the stern will begin to swing back, though the bow will be swinging out.

If the screws are outward turning, when one engine is ahead and one astern on a ship with fixed pitch propellers, then both screws will be turning the same way and both screws – and the transverse thrust - will be contributing to the turning effect.

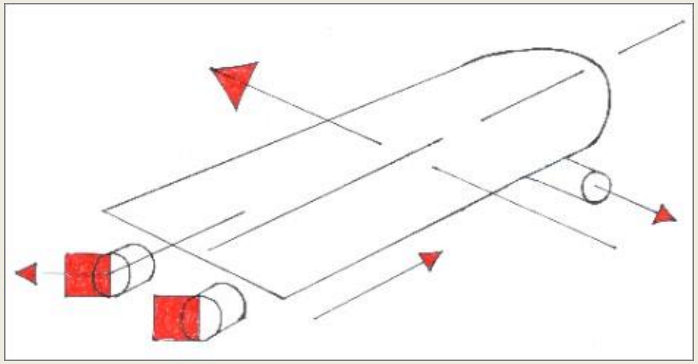
On a vessel with outward turning screws it is very difficult, almost impossible to make the ship move sideways, or "crab" without high lift rudder/Becker rudder, or without the assistance of a bow thruster. The reason is because the combined effect of the offset screws and the thrust from the propellers will tend to overcome the opposite effect of the rudders.

Outward Turning Screws



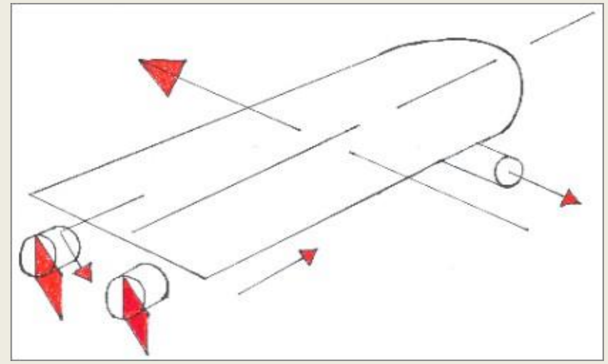
Use of linked (syncro) rudder, independent rudder and separate handling of screws, together with a bow thruster I

In the early days without bow thrusters the AHTS's and the PSV's were manoeuvered by use of independent rudder and individual handling of screws.



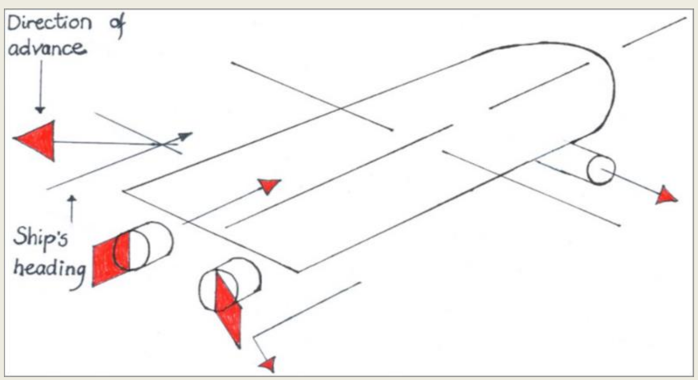
Walking sideways

Checking rate of movement by moving linked rudders to port. Engine power kept same.



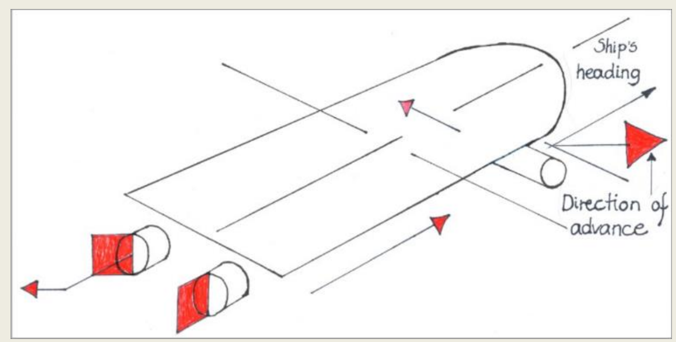
Walking sideways bodily to port

Linked rudders to starboard, more astern power required than ahead to stop advance.



Make sternway at angle to ship's heading

Starboard engine moves stern across to port. Bow thruster pushes bow to port. Port engine gives sternway.

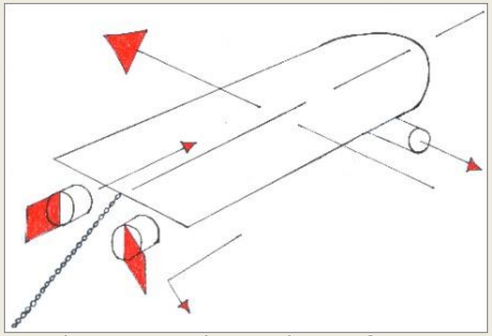


Advance at angle to ship's heading

Port engine and port rudder create movement of stern to starboard and ahead. Bow thruster pushes bow to starboard. Starboard engine check advance.

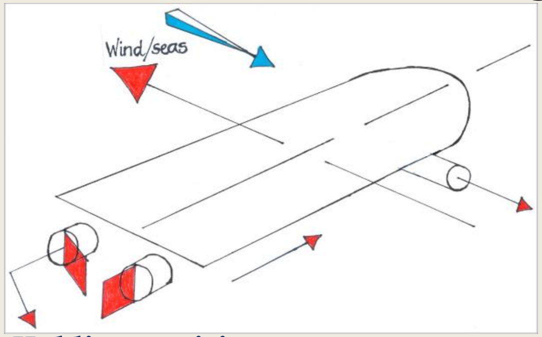
Use of linked (syncro) rudder, independent rudder and separate handling of screws, together with a bow thruster II

The combination of linked rudder and individual handling of screws is not often to be seen. You achieve less flexibility in situations with current and need of force on one screw. And it's more difficult to move astern while walking sideways.



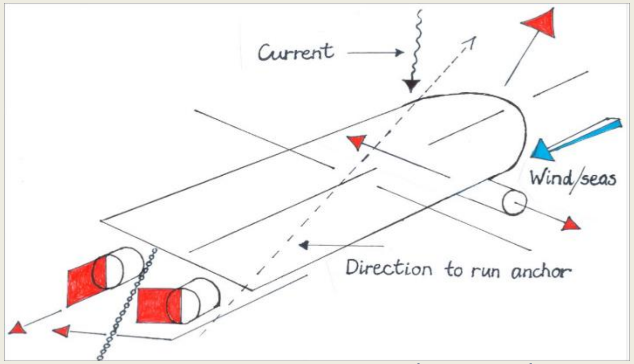
Running anchors I - Alteration of course

Port rudder amidships. Port engin maintains tension on towline. Bow thrusters pushing bow to port. Starboard rudder hard over to starboard pushes stern to port.



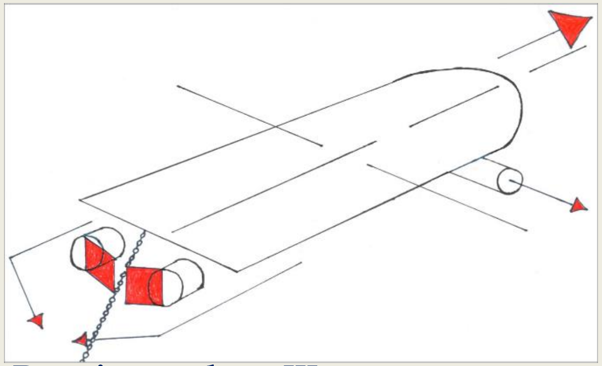
Holding position

Engine and thruster force balanced against wind and sea from port beam. Port rudder – starboard helm on starboard rudder amidships.



Running anchors II

Current from port bow – strong wind starboard side. *Angle boat across line to be followed to ease bow thruster. Get current on leebow to assist.*



Running anchors III

Rudders turned inboard – increase in ahead power on one engine moves stern to that side. Use bow thruster to push bow over – e.g. to move to port. Increase port engine power, bow thruster push to starboard.