PORT REVEL
SHIPHANDLING

COURSE MANUAL

2006

SOGREAH
CONSULTANTS

CONTENTS

FOREWORD

This Course Manual is the result of a co-operative effort of present and former instructors of the Port Revel Shiphandling Training Centre:

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- Bernard GILAND (former pilot in Dunkirk)
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- Jean François MASSON (former pilot in Brest)
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- Michel SABATIER (former pilot in Sète)
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with a major initial contribution of Captain Jean SOMMET, one of the designers of the centre,

with the continuous technical support of Pierre François DEMENET, hydrodynamics expert at Sogreah,

with the support of the successive managers of the centre:

- Robert SIMIAND (1967-1980)
- Jean GRAFF (1981-2002)
- Arthur DE GRAAUW (2002-present), editor of this manual.

and with the experience of more than 5000 trainees over the past 40 years.

This course manual has been designed to help you to derive the maximum benefit from the time and effort you devote to this training on shiphandling, but please remember …

One must learn by <u>doing</u> the thing,

for though you think you know it,

you have no certainty until you try.*

Sophocles (400 BC)

* ***Disclaimer****: Shiphandling is an Art more than a Science, and therefore information given in this Manual must be validated and mastered at sea by the reader. Information given in this Manual cannot be used as such in any legal procedure against Sogreah or any of its clients.*

INTRODUCTION

1. WHY TRAINING ?

A good few years ago, a casual visitor wandering through the woods on the Chambaran plateau of the Dauphiné foothills in France might have been surprised to see several miniature ships calmly sailing on a lake there. They would have been steered by very serious-looking men whose behaviour and language clearly indicated that they were experienced mariners.

“Another bunch of nutcases – the privileged few indulging their latest craze," he might have murmured, going back to his more serious interest of flower spotting or mushroom collecting.

As maritime safety becomes an increasing concern, Port Revel is even more relevant than ever in training ships' captains and pilots to handle emergency situations.

But… why is training necessary?…

Because human error is still the main cause of accidents.

… and why train on manned scale models? …

Because this is still the best way to acquire certain reflexes which, when the time comes, will make all the difference between being good and being the best. Training on the scale models provides experience that could never be gained on real ships for the simple reason that neither ship-owners nor local authorities would allow such risks to be taken. Scale models allow the shiphandler to make mistakes. Scale models allow experimentation on ship behaviour to explore unknown fields beyond the limits of safety.

Training on the manned 1:25 scale models is a complement to training on electronic simulators (similar to those used in the aviation industry) as it provides *additional experience* through a feeling of *"déjà vu"*:

- *Nature is at work* on scale models, with random effects that are similar to those of real-life situations. The unforeseeable character of squalls, shallows, currents and waves calls for an immediate, appropriate reaction, without any repeat or automatic response. And when things go wrong on the scale model, *the pilot really feels his ship* run aground or collide with another ship or berth. Those who have experienced a situation of this kind know how much it motivates and convinces one to do better…

- For the same reason (natural phenomena) hydrodynamic effects are correctly reproduced on scale models and it is therefore unnecessary to transpose them in the form of complex equations. This gives a *better simulation of hydrodynamic effects* such as interactions between ships (for example in a canal), interactions between the ship and berth, little under-keel clearance and the use of anchor dredging or tugs in various operating situations.

- The scale effect of wind on a manned model is well known, but it is also well known that this is in no way detrimental to the use of manned models for serious and effective shiphandling training. Wind is a factor in the everyday life of pilots throughout the world. The design of manned model lakes is such that *the wind element will vary in different parts of the lake*. This allows a course to be structured in such a manner as to introduce wind as and when required. Extreme wind conditions are encountered in the real world. If they occur at a manned model centre, with care they can be used in various scenarios to demonstrate how well control can be maintained.

- Therefore the ship models behave exactly like real ships, only much faster. Reality will be much slower than the model, thus leaving quite a lot more time to react. Manned models *sharpen the shiphandlers' natural senses* of perception and anticipation and enable an appreciation of the ships behaviour as a whole.

- The time scale also means that it is possible to perform *five times as many manoeuvres*. In other words, it is possible to perform as many manoeuvres in a 35 hour course as in 175 hours on the real ship. If you then consider the cost of scale models compared to computer models as a *cost per manoeuvre and per pilot*, it might happen that scale models are even cheaper than computer models!!

Manned models are considered by ships' captains and pilots - shiphandlers par excellence - as the *next best thing to a full-scale prototype* for studying and understanding a ship's behaviour.

Port Revel is *a permanent forum of ideas*, an ideal meeting place where information and experience can be exchanged, or as a pilot once pointed out: "In regular life, a practising pilot is always alone. He has no-one around to comment on or discuss a particular manoeuvre. The only times when a manoeuvre is analysed and commented is after an accident, when there is an inquiry. And that always takes place in a mood of tension. What I appreciate at Port Revel is that pilots observe your work in a calm, dispassionate and therefore constructive climate."

If we may take the opportunity to list the strengths of Port Revel, we would say that:

- we have trained over 5000 experienced pilots and captains since 1967 (mainly from the USA, Canada and Europe),
- many of them are now coming for the second (and even third) time in their career,
- our refresher courses are tailored to reproduce local navigation conditions,
- our instructors are highly experienced maritime pilots,
- our fleet of 9 models at scale 1:25 reproducing 20 different vessels is by far the biggest,
- our 2 escort tugs are operated by a real tug master at the pilot's orders,
- we have inherited Sogreah's near-century of experience with scale models, numerical simulation, port planning, design & construction,
- our 4 ha (10 acres) lake is most versatile with very little interference from wind,
- our lake features more shallow water areas,
- our lake includes a wave generator and a current generator,
- our DGPS allows accurate debriefing of the exercises performed on the lake.

A few words of background history …

After three years spent with Esso captains at the end of the 1960s, the Centre was taken over by Sogreah in 1970.

During the 1970s, most students were captains, while the first pilots came to discover the centre.

During the 80s, the ratio of 9 captains to 1 pilot was reversed.

In the 90s, the first refresher courses were organised for pilots, who returned every 5 years. These courses are less directive and leave more room for customisation, which is a way of optimising port operations to increase port accessibility.

During the current decade, we have seen a change in our relations with pilots. We are now moving towards a closer partnership in which pilots use our installations at their convenience. Courses and equipment are specially designed in close collaboration with the pilots.

2. PRESENTATION OF THE CENTRE

2.1. WHERE AND HOW THE TRAINING IS DONE

2.1.1. THE LAKE AND ITS EQUIPMENT

Port Revel is located on a man-made lake of about 10 acres (4 ha) that was remodelled in order to reproduce real sailing conditions.

At scale, the water area represents a navigable zone of about 3 by 2 nautical miles, allowing several models to sail at the same time at normal manoeuvring speeds.

The lake has the following permanent equipment and features:

a) the different types of moorings which exist in ports or near the coast:
   - open wharves,
   - solid quays,
   - artificial islands (steel structure),
   - conventional buoy moorings,
   - single point (bow) moorings,

b) the different types of buoyed channel (deep water and shallow water) with different widths, and a length of ship canal (representing, for example, a bend of the Suez Canal),

c) a wave generator designed to produce waves of varying period and height (maximum about 6 m at full scale, or 24 cm for the models),

d) a "port" (boat house) for shelter and maintenance of the models,

e) a "track recording system".

This equipment is supplemented by a number of leading marks on land, and an observation tower.

2.1.2. THE MODELS

The fleet of Port Revel is at present made up of nine ships: seven of these models represent at scale real oil tankers or bulk carriers ranging from 17,000 to 400,000 dwt. The eighth is a replica of the liquid natural gas (LNG) carrier *"Ben Franklin"* (120,000 m3). The ninth is a replica of a 4,400 TEU post panamax container ship, the *"CGM-Normandie*". This ship can be used with a bridge at the bow to reproduce a car carrier or a cruise ship, including the “pods”.

All models but the Normandie are fitted with diesel motor and steam turbine, and the Normandie can be controlled from the front deck like a car carrier and a cruise ship, so that the fleet in fact reproduces 20 different vessels.

In 2006, the Normandie will be fitted with optional “pods” in order to reproduce the behaviour of a cruise ship.

The models are fitted out with all the conventional features found on board a real ship:

- a "bridge", comprising:
  - the helm (wheel) and rudder angle indicator,
  - the "chadburn" (transmission of orders to engine room) and indicator of propeller rpm,
  - the compass,
  - the electronic log (speed indicator),
  - an anemometer,
  - bow and stern thruster controls (these thrusters can simulate the action of tugs),
  - remote control of anchors;

- an "engine", replaced on the model by an electric motor supplied by a series of batteries on board, which serve as part of the ship's ballast,
- a rudder,
- a bow thruster (some of the models also have a stern thruster),
- mooring lines, including anchors and chain,
- windlasses.

Obviously, the rudder and engine response times are respected. These are adjustable, as is the "power" of the engine, so as to reproduce the characteristics of turbine or diesel engine propulsion.

The crew of each model is made up of two trainees: one is "embarked" on the bridge, and acts as captain. He has the same angular vision, hence the same perspective, as on the real ship (the seat being vertically adjustable). The other trainee fulfils the functions of "helmsman" and "chief engineer". His eyes are at deck level so that he can follow and observe the manoeuvres performed by the captain and learn from them. It goes without saying that the helmsman must scrupulously and rapidly obey the orders given by the captain so as not to upset the normal progress of the manoeuvre.

2.2. HOW THE TRAINING CENTRE FUNCTIONS

The training course, which is in the hands of experienced instructors, all of them pilots holding a foreign-going master's licence, is divided into teaching of theory and practical exercises on the lake.

The participants work in teams of two, the teams being changed every day. All exercises are carried out at least twice, with each trainee in turn acting as captain (the other trainee acting as helmsman/observer). The teams use three or four different ships each day. Criticism and comments are given on the spot by the instructor assigned to the team or by discussions on the records taken by the track recording system. Provision is also made in the training course for imposed exercises and for a certain amount of free practice time.

2.3. DEVELOPMENTS AT PORT REVEL

Like any other facility which aims to give efficient service, Port Revel is constantly being improved.

- the instructors have become more skilled and proficient in the delivery of the courses and in their ability to structure specific and customised courses as required,
- lake facilities have undergone changes, such as the creation of extensive shallow water areas with currents, and are such that in many cases they are able to mimic specific port scenarios,
- model electronics have become more sophisticated in order to reproduce real ship manoeuvring behaviour,
- tugs have become an integral part of the courses, providing very effective and realistic capability for berthing / unberthing operations and escort work,
- pod propulsion is now available, keeping manned models up to date with modern trends.

Two other major developments are described in detail below:

- the Centre has acquired two tractor tugs,
- the infra-red track recording system, allowing identification of the model’s position and path on the lake has been replaced by a DGPS system.

2.3.1. TRACTOR TUGS

Conventional harbour tugs are difficult to simulate at scale, even at the large scale of 1/25 in use at PORT REVEL. If the vessel's hull is at scale (in order to represent the correct under-water resistance) the available bollard pull is too small and not realistic. To be able to produce a realistic bollard pull at scale, the size of the model tug would have to be increased (accommodation of a large "engine" and batteries), which is also unrealistic.

This explains why the larger models at the centre were systematically equipped with transverse thrusters (bow and stern - see above). Thus, the push or pull forces produced by the tugs, perpendicular to the ship's longitudinal axis could be simulated.

Since the advent of the large **"Tractor-Tugs"** using different propulsion systems it is now possible to simulate realistically this new type of vessel at scale 1/25.

This is why Port Revel acquired **two tractor tugs**, one of the **VOITH-SCHNEIDER** type, the other being a **Z-PELLER drive tug**.

These models are of course too small to be manned. They are radio-controlled by the instructors. They are able to provide a bollard pull of about 100 newtons (≈ 10 kg) i.e. a force close to 150 tons at full scale which at the present time is well in excess of the bollard pull of the existing tug.

With these models the Port Revel centre is in a position to provide an "escort" for the larger tanker or LNG tanker models, and to experiment realistically all types of emergency manoeuvres in restricted water conditions in case of black-outs and/or engine or rudder failures.

2.3.2. TRACK RECORDING SYSTEM

The trainee at the helm of Port Revel's ship models often has only a partial view of the manoeuvres he performs. Indeed, his constant attention is required by the "real" difficulty of manoeuvring the models, as well as by the fact that time is "shortened". On the lake, everything happens five times faster than in reality, and a manoeuvre which takes one hour at full scale is completed in 12 minutes on the lake, although requiring exactly the same number of orders from the captain of the model.

At the same time, certain parameters, in particular the variation of turning circle diameter with depth, are difficult to evaluate and quantify on the basis of visual impressions only.

It is therefore most advantageous for the trainee to have a trace of the course followed and the manoeuvres undertaken, instead of having to depend on his memory or on that of the instructor in charge of training.

This is why the centre was equipped with a *track recording system* which enables reproduction, in digital or graphic form, of the course followed by the model, with simultaneous recording of the following useful parameters:

- orders given to helm and engine (in the form of rudder angles and propeller speeds),
- speed and heading of the model,
- wind speed and apparent direction,
- use made of thrusters (bow or stern).

A **DGPS** system allows two models to be followed at the same time. The average accuracy of this system is better than ± 1 cm on the lake, corresponding to ± 0.25 m at full scale.

2.4. WHAT RESULTS CAN BE EXPECTED

Since the models are in similitude with reality, they react in the same way as real ships. They can thus reproduce most of the manoeuvres and operations likely to be performed by captains or pilots in restricted waters.

Use of the scale models at Port Revel allows:

- practical demonstration after a theoretical exposé of the fundamental principles of shiphandling,
- familiarisation with the limit conditions of the ship and the shiphandler, which cannot be acquired at full scale without running serious risks. Running aground at Port Revel causes hardly any damage to the ship model, while in real life the consequences can be catastrophic; the "Torrey Canyon", "Amoco Cadiz" and "Exxon Valdez" disasters are still present in all our memories,
- performance of as many manoeuvres in 35 hours on the lake as in 175 hours on a real ship, thanks to the "shortening" of time (time factor 1:5); this represents a considerable advantage, since the trainees can thus practise a large number of different exercises in the course of a short week's training; carrying out the same manoeuvres on a real ship would obviously be prohibitive in cost terms.

While on the subject of this time "shortening" factor, it should be noted that the manoeuvres force the trainee to react five times more quickly than in reality. Experience has shown that this constraint, which introduces an additional safety factor, causes only passing difficulties, which are easily overcome by the majority of trainees after a short period of adaptation.

SHIPHANDLING REFERENCES

1. *"Harbor pilotage and the handling and mooring of ships"*
   Richard A.B. Ardley
   Faber and Faber Ltd., 24 Russel Square, London
   R. Maclehouse and Co. Ltd.
   The University Press, Glasgow
   1952

2. *"Naval shiphandling"*
   R.S. Crenshaw
   US Naval Institute, Annapolis, Maryland, U.S.A.
   1965

3. *"La manoeuvre des navires"*
   P. Célérier
   Que Sais-je ? - Presses Universitaires de France
   1965

4. *"The Theory and Practice of Seamanship"*
   G.L. Danton
   Routledge & Kegan Paul, London
   1966

5. *"An agony of collisions"*
   P. Padfield
   Hodder & Stoughton, London
   1966

6. *"Ship Handling in Narrow Channels"*
   Carlyle J. Plummer
   Cornell Maritime Press, Cambridge, Maryland. U.S.A.
   1966

7. *"Tugs, towboats and towing"*
   E.M.Brady
   Cornell Maritime Press, Centreville, Maryland, U.S.A.
   1967

8. *"1st International Symposium*
   on Ship Approach and Berthing Manoeuvres"
   Proceedings
   Grenoble, Sept. 19-23, 1977

9. *"Practical ship-handling"*
   Malcolm C. Armstrong
   Brown, Son & Ferguson, Ltd, Glasgow
   1980

10. *"Constant radius turns"*
    Benny Petterson & Sven G. Glydén
    Sweden,
    1982

11. *"Behavior and Handling of Ships"*
    Henry H. Hooyer
    Cornell Maritime Press, Centreville, Maryland, U.S.A.
    1983

12. *“Shiphandling with tugs”*
G.H. Reid
Cornell Maritime Press, Centreville, Maryland, U.S.A.
1986

13. *“The Nautical Institute on pilotage and shiphandling”*
G.G.Greenfield, Chairman
The Nautical Institute, London
1990

14. *“Manoeuvring technical manual”*
Capt. Dipl.-Ing J. Brix, Editor
Seehafen Verlag, Hamburg
1993

15. *“Le surenfoncement des navires”*
René G. Hervieu
Ed. Masson, Paris
1993

16. *"Shiphandling for the Mariner"*
D.H. MacElrevey
Cornell Maritime Press, Centreville, Maryland, U.S.A.
1995

17. *“The shiphandler’s guide”*
R.W.Rowe
The Nautical Institute, London
1996

18. *“Tug use in port”*
H. Hensen
The Nautical Institute, London
1997

19. *“Ship manoeuvring principles and pilotage”*
P.R. Williamson
Whiterby & Co Ltd, London
2001

20. *“The tug book”*
M.J. Gaston
Patrick Stephens Ltd
2002

21. *“Anchor Practice”*
David J. House
Whiterby & Co Ltd, London
2002

22. *“Ship knowledge – A modern encyclopedia”*
K. van Dokkum
Dokmar, The Netherlands
2003

23. *“Ship dynamics for mariners”*
Ian C. Clark
The Nautical Institute, London
2005

24. *“Ship to Ship transfer guide (Petroleum)”*
ICS & OCIMF
Witherby & Co Ltd, London
2005

UNIT 1 – THE MANNED MODELS

The slides hereafter clarify the following aspects:

1. THE SHIPS

2. THE LAKE

3. SIMILARITY PRINCIPLES

THE PORT REVEL FLEET

SHIP : / Size :		PEMBROKE-SHIRE 17 000 dwt		BERLIN 38 000 dwt		GRENOBLE 43 000 dwt		GILDA (70% loaded) 125 000 dwt		BRITTANY (on ballast) 190 000 dwt		EUROPE 255 000 dwt		ANTIFER 400 000 dwt		BEN FRANKLIN 120 000 m^3		NORMANDIE 4 400 TEU 53 000 dwt	
	Unit	**Real**	**1/25**	**Real**	**1/25**	**Real**	**1/25**	**Real**	**1/25**	**Real**	**1/25**	**Real**	**1/25**	**Real**	**1/25**	**Real**	**1/25**	**Real**	**1/25**
Length betw.perp.	m	**159**	*6.25*	**201**	*8.05*	**191**	*7.62*	**269**	*10.75*	**305**	*12.20*	**329**	*13.17*	**337**	*13.47*	**256**	*10.24*	**261**	*10.45*
Breadth	m	**21.40**	*0.86*	**28.80**	*1.15*	**29.50**	*1.18*	**42.00**	*1.68*	**47.20**	*1.89*	**51.80**	*2.07*	**70.00**	*2.80*	**41.00**	*1.64*	**37.10**	*1.484*
Loaded Draught	m	**8.00**	*0.32*	**10.92**	*0.43*	**11.54**	*0.46*	**15.52**	*0.62*	**18.45**	*0.74*	**19.98**	*0.80*	**21.96**	*0.88*	**11.10**	*0.44*	**12.40**	*0.496*
Loaded Displ.	ton	**22 000**	*1.43*	**51 000**	*3.26*	**55 000**	*3.52*	**149 000**	*9.55*	**225 000**	*14.40*	**291 000**	*18.60*	**471 000**	*30.13*	**90 000**	*5.79*	**75 000**	*4.672*
Aft Ballast Draught	m	**-**	-	**7.70**	*0.30*	**7.32**	*0.23*	**11.59**	*0.46*	**11.90**	*0.48*	**11.59**	*0.46*	**12.81**	*0.50*	**-**	-	**-**	-
Forward	m	**-**	-	**5.00**	*0.20*	**5.80**	*0.29*	**7.37**	*0.30*	**10.37**	*0.41*	**9.15**	*0.37*	**8.24**	*0.34*	**-**	-	**-**	-
Ballast Displ.	ton	**-**	-	**29 000**	*1.83*	**31 000**	*1.95*	**88 000**	*5.61*	**131 000**	*8.39*	**144 000**	*9.23*	**219 000**	*14.05*	**-**	-	**-**	-
Normal Shaft.H.P.	S.H.P.	**6 400**	*0.082*	**17 500**	*0.224*	**17 500**	*0.224*	**24 000**	*0.308*	**32 000**	*0.41*	**32 000**	*0.41*	**45 000**	*0.57*	**32 000**	*0.41*	**52 000**	*0.66*
Engine type	Turb/Motor	**-**	*T & M*	**-**	*T & M*	**-**	*T & M*	**-**	*T & M*	**-**	*T & M*	**-**	*T & M*	**-**	*T & M*	**-**	*T & M*	**-**	*M*
Rudder type	-	**-**	*Normal*	**-**	*Normal*	**-**	*Normal*	**-**	*Becker*	**-**	*Normal*	**-**	*Normal*	**-**	*Normal*	**-**	*Schilling*	**-**	*Normal*
Ang. Rudder Rate	Deg/sec	**2.3**	*11.5*	**3.1**	*15.5*	**2.6**	*13.0*	**3.5**	*17.5*	**2.5**	*12.5*	**2.6**	*13.0*	**2.1**	*10.5*	**2.6**	*13.0*	**2.8**	*14*
Anchors	-		-		*Manual*		*Manual*		*Electr.*		*Electr*		*Electr.*		*Electr.*		*Electr.*		*Electr.*
Bow Thruster	S.H.P.	**-**	-	**1 500**	*0.019*	**1 100**	*0.014*	**1 500**	*0.019*	**3 000**	*0.038*	**3 000**	*0.038*	**6 000**	*0.077*	**1 500**	*0.019*	**2 750**	*0.0176*
Stern Thruster	S.H.P.	**-**	-	**-**	-	**-**	-	**1 500**	*0.019*	**3 000**	*0.038*	**3 000**	*0.038*	**6 000**	*0.077*	**1 500**	*0.019*	**-**	*0.0176*
Block Coefficient	-	0.80		0.79		0.82		0.83		0.83		0.83		0.89		0.76		0.60	




UNIT 1 – Monday morning

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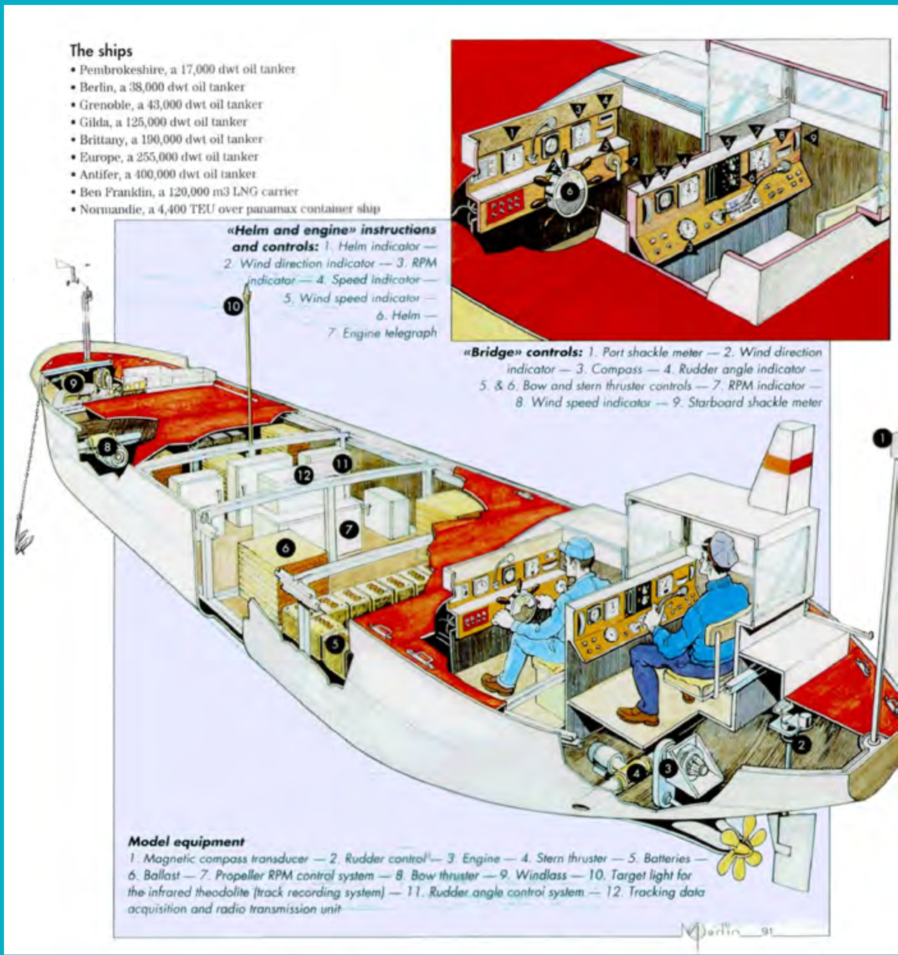
TYPICAL SHIP ARRANGEMENT



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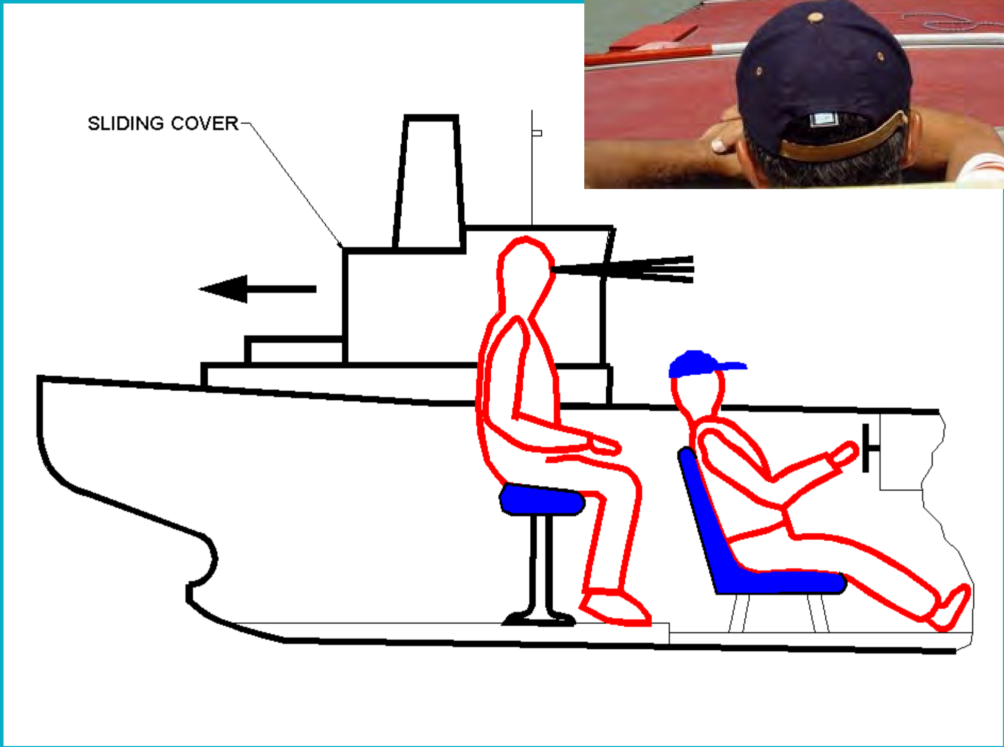
In carrying out a given operation with the model, such as mooring alongside a wharf for instance **exactly the same instructions are given** to the engine room and helm as on a real ship, but there is only one fifth of the time available in which to give them.

The instructions given depend on the Master's knowledge of his ship, sea and weather conditions, and on the ship's position and surroundings. The ship's position is worked out from estimated distances and positions of buoys, beacons, etc. with respect to the ship. In order to ensure correct position estimation on the model, the Master sits in it with his eyes exactly where the bridge would be on the real ship, so that he sees all the land and seamarks from the same angles as in real life, i.e. **his field of view is exactly the same as from the real bridge**. For this reason, it is important that the students remain in the position assigned to them in the model (also as they are part of the ballast).

ON BOARD ACCOMMODATION



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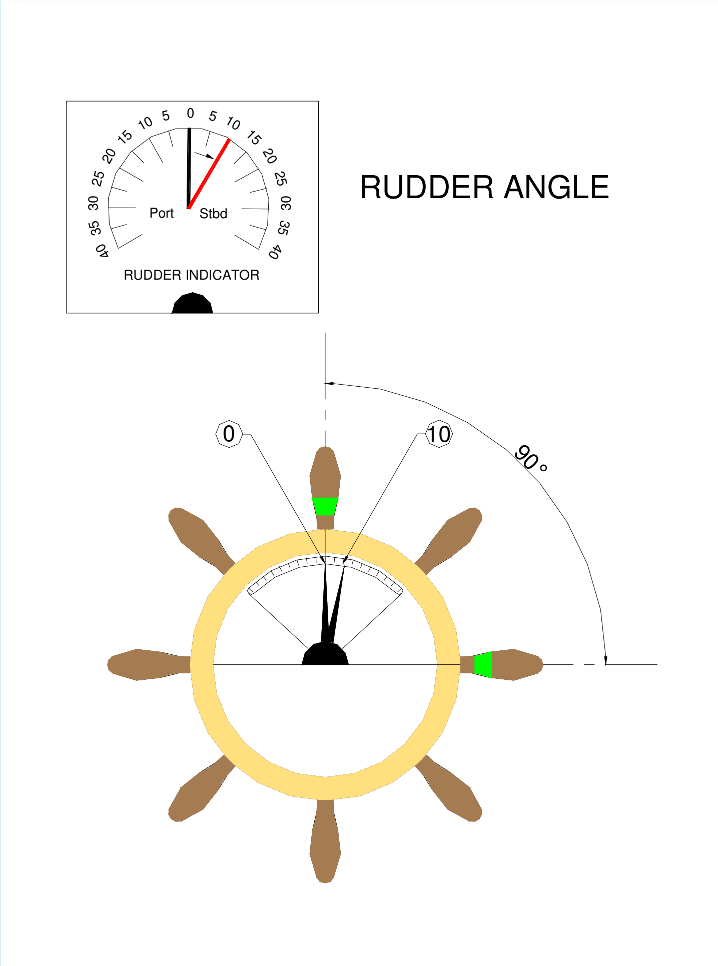
Each model is designed so that **the Master is at bridge level**. He calls out his instructions to the "crew", i.e. the Principal Operator, who steers the ship and operates the engine room telegraph. On larger models, there is a Second Operator to see to the windlass forward, but on smaller models, it is attended to by the Master or the Principal Operator.

An instrument panel gives continuous **full scale** indications of propeller r.p.m, rudder angle, ship's heading and speed, and wind velocity.

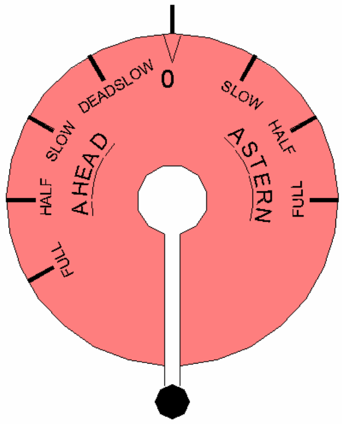
The sliding cover is positioned to correctly reproduce the effect of wind.

RUDDER ANGLE

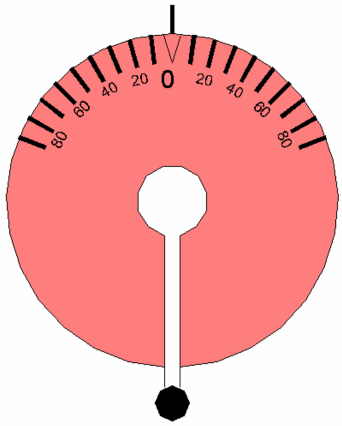


TELEGRAPH

Conventional



Bridge control



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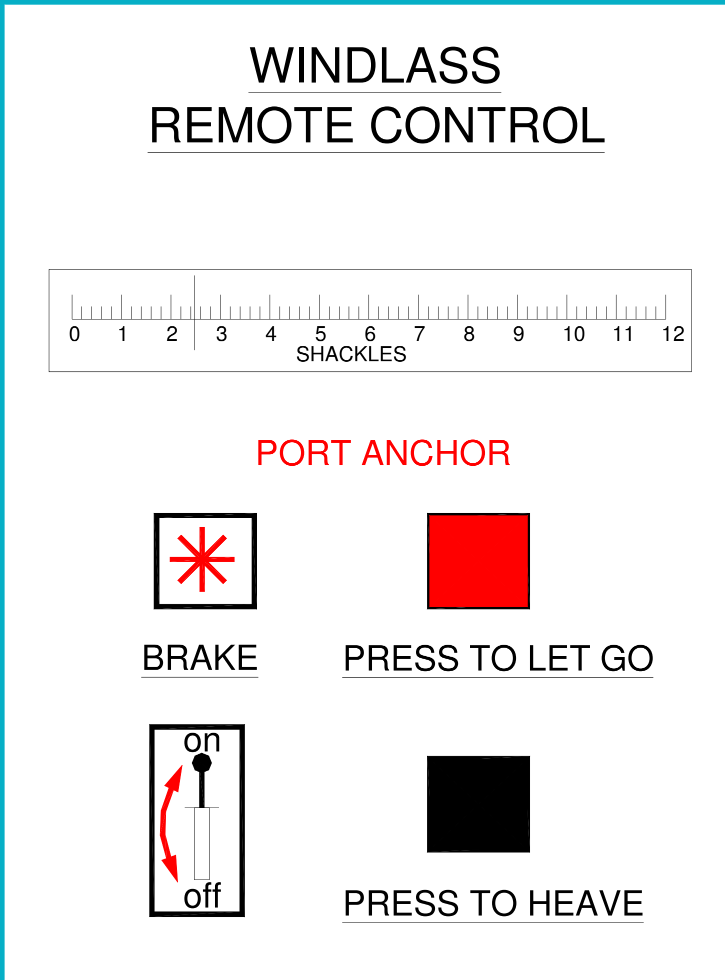
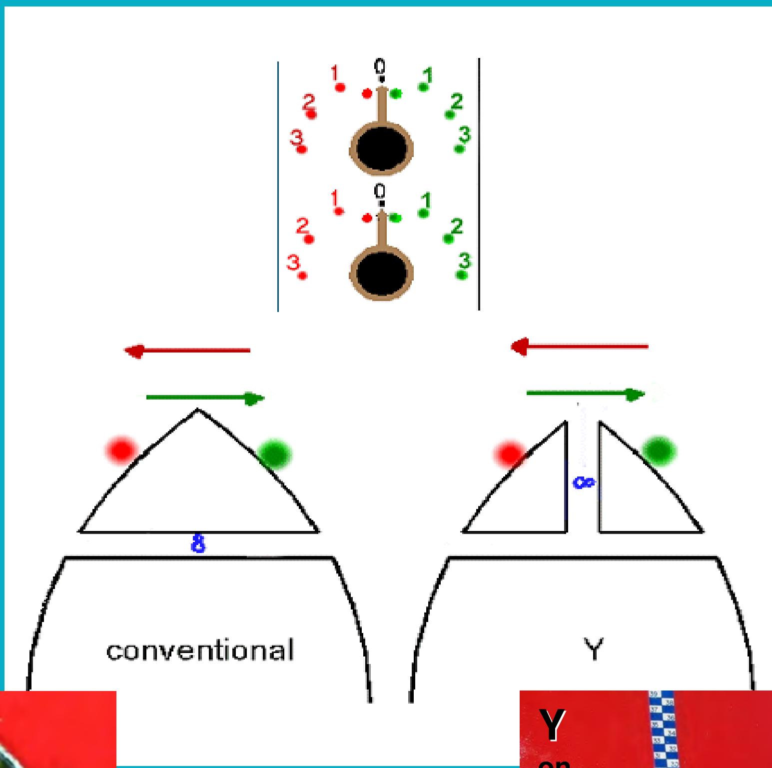
ANCHORS



WINDLASS
REMOTE CONTROL
0 1 2 3 4 5 6 7 8 9 10 11 12
SHACKLES
PORT ANCHOR
BRAKE
PRESS TO LET GO
on
off
PRESS TO HEAVE

BOW THRUSTER



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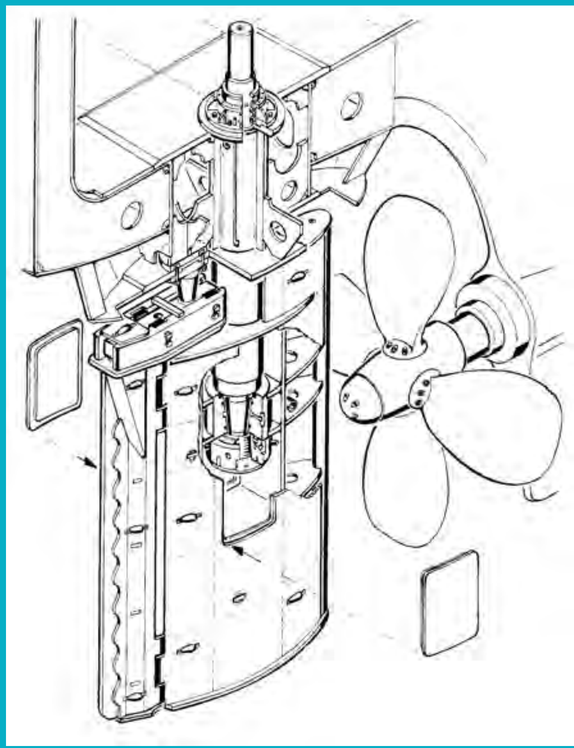
BECKER RUDDER



http://www.becker-marine-systems.com

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This type of rudder is articulated with a simple mechanical arrangement which moves the hinged tip of the rudder at a higher ratio than the main spade. This is normally double, so that a rudder angle of 35° will result in the tip moving at 70° from the fore and aft line.

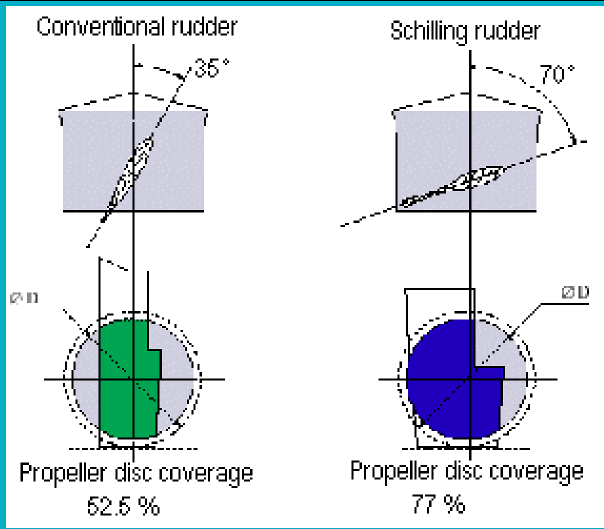
Becker rudders with guarantee best possible manoeuvrability of your vessel with lowest possible fuel consumption.

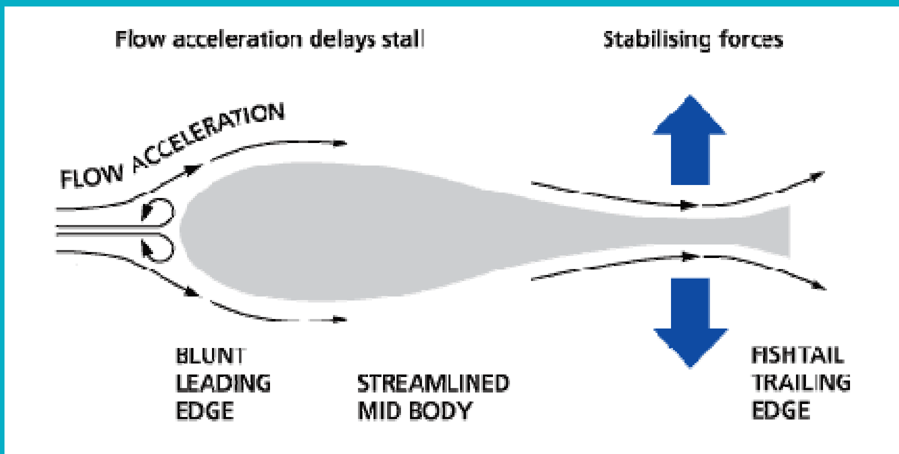
These are the advantages:

- Optimum balance and flap area
- Minimum additional resistance induced during manoeuvring
- Minimum size of steering gear
- Highest securing against flexural vibration
- Best values of natural vibration
- Highest safety against cyclic stresses
- Maximum security in case of damage
- Durable in ice
- Easy maintenance of link system

PORT REVEL
Shiphandling

SCHILLING RUDDER





http://www.becker-marine-systems.com

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With 70° max rudder angle, the Schilling rudder has a 77% propeller disk coverage instead of 52.5% for a conventional rudder with 35° max rudder angle.

The unique profile of the Schilling rudder incorporates a rounded leading edge promoting good flow properties at all rudder angles and a fishtail trailing edge that accelerates the flow and recovers lift over the aft section of the rudder. This induces:

- Significantly reduced overshoot angles.
- Exceptional full speed course keeping ability.
- Improved crabbing and zero speed control.
- Enhanced turning capability with significantly reduced turning circles at speed.
- Reduced head reach and lateral deviation.

And remember **Capt Hans Hederström's (Wallenius) advice**:

- do not use full helm unless you want a stern thruster effect,
- maximum side force is obtained with a 40° helm.

PORT REVEL
Shiphandling

PORT REVEL FLEET

PEMBROKESHIRE	17,000 dwt	-
BERLIN	38,000 dwt	-
GRENOBLE	43,000 dwt	-
GILDA	125,000 dwt	BECKER Rudder
BRITTANY	190,000 dwt	On heavy ballast
EUROPE	255,000 dwt	-
ANTIFER	400,000 dwt	-
BEN FRANKLIN	120,000 m^3 Gas	SCHILLING Rud.
NORMANDIE	4,400 TEU	6,000 m^2 sail surf.
VOITH TRACTOR	TUG : Up to 150 t	Voith propeller
RASTAR	TUG : Up to 110 t	Reverse Z-peller

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The ships are accurately constructed to conform with the principles of similarity and are fitted with indicators showing wind speed, ship speed, rudder angle and propeller r.p.m. (rate of turn indicator) and wind direction. Information given by the indicators is at **full scale**.

All models but the Normandie are fitted with **diesel motor and steam turbine**, and the Normandie can be controlled from the front deck like a car carrier and a cruise ship, so that the fleet in fact reproduces 20 different vessels.

In 2006, the Normandie will be fitted with **optional "pods"** in order to reproduce the behaviour of a cruise ship.

All but the Pembrokeshire are fitted with a bow thruster. The Antifer, Europe, Brittany, Gilda, Ben Franklin and Normandie are fitted with bow and stern thrusters.

Superstructure, where fitted, is made so that the captain's eyes are at the same level (in scale) as they would be in the real ship, so that he has **the same angular vision**. On the Brittany and the Normandie, it is possible to have the bridge forward.

PEMBROKESHIRE
(ship's dimensions in metres)

		PEMBROKESHIRE 17,000 Dwt
Length B.P.		6.25 159
Breadth		0.86 21.40
Load draught		0.32 8.00
Load disp. M/T		1.43 22,352
Ballast draught	F	
	A	
Ballast disp. M/T		
Normal S.H.P.		0.082 6.400
Angular rudder rate (Deg/sec)		
Bow thruster S.H.P.	Sternthruster S.H.P.	
Block coefficient		0.8

BERLIN

(ship's dimensions in metres)

Sitting on the

PIVOT POINT …

		BERLIN 38,000 Dwt	
Length B.P.		8.05 201	
Breadth		1.15 28.80	
Load draught		0.43 10.92	
Load disp. M/T		3.26 50,901	
Ballast draught	F	0.20 5.00	
	A	0.30 7.70	
Ballast disp. M/T		1.83 28,637	
Normal S.H.P.		0.224 17.500	
Angular rudder rate (Deg/sec)		15.5 3.1	
Bow thruster S.H.P.	Sternthruster S.H.P.	0.019 1,500	
Block coefficient		0.785	

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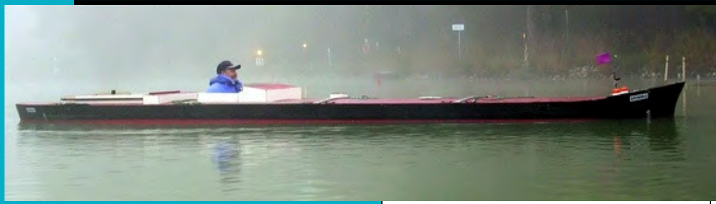
GRENOBLE

(ship's dimensions in metres)



		GRENOBLE 43,000 Dwt
Length B.P.		7.62 191
Breadth		1.18 29.50
Load draught		0.46 11.54
Load disp. M/T		3.52 54,492
Ballast draught	F	0.23 5.80
	A	0.29 7.32
Ballast disp. M/T		1.95 30,510
Normal S.H.P.		0.224 17.500
Angular rudder rate (Deg/sec)		13.0 2.6
Bow thruster S.H.P.	Sternthruster S.H.P.	
Block coefficient		0.8

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GILDA

(ship's dimensions in metres)

		GILDA 125,000 Dwt	
Length B.P.		10.75 269	
Breadth		1.68 42.00	
Load draught		0.62 15.52	
Load disp. M/T		9.55 149,144	
Ballast draught	F	0.30 7.37	
	A	0.46 11.59	
Ballast disp. M/T		5.61 87,600	
Normal S.H.P.		0.308 24.000	
Angular rudder rate (Deg/sec)		17.5 3.5	
Bow thruster S.H.P.	Sternthruster S.H.P.	0.019 1,500	0.019 1,500
Block coefficient		0.829	

The Gilda has an optional BECKER rudder

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BRITTANY

(ship's dimensions in metres)

			BRITTANY 190,000 Dwt	
Length B.P.			12.20 305	
Breadth			1.89 47.20	
Load draught			0.74 18.45	
Load disp. M/T			14.40 225,044	
Ballast draught		F	0.41 10.37	
		A	0.48 11.90	
Ballast disp. M/T			8.39 131,064	
Normal S.H.P.			0.41 32.000	
Angular rudder rate (Deg/sec)			13.0 2.6	
Bow thruster S.H.P.	Sternthruster S.H.P.		0.038 3,000	0.038 3,000
Block coefficient			0.826	

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EUROPE

(ship's dimensions in metres)

		EUROPE 255,000 Dwt	
Length B.P.		13.17 329	
Breadth		2.07 51.80	
Load draught		0.80 19.98	
Load disp. M/T		18.60 290,576	
Ballast draught	F	0.37 9.15	
	A	0.46 11.59	
Ballast disp. M/T		9.23 144,272	
Normal S.H.P.		0.41 32.000	
Angular rudder rate (Deg/sec)		13.0 2.6	
Bow thruster S.H.P.	Sternthruster S.H.P.	0.038 3,000	0.038 3,000
Block coefficient		0.832	

ANTIFER

(ship's dimensions in metres)

<table>
<tr><td colspan="2"></td><td colspan="2">ANTIFER
400,000 Dwt</td></tr>
<tr><td colspan="2">Length B.P.</td><td colspan="2">13.47
337</td></tr>
<tr><td colspan="2">Breadth</td><td colspan="2">2.80
70.00</td></tr>
<tr><td colspan="2">Load draught</td><td colspan="2">0.88
21.96</td></tr>
<tr><td colspan="2">Load disp. M/T</td><td colspan="2">30.13
470,713</td></tr>
<tr><td rowspan="2">Ballast draught</td><td>F</td><td colspan="2">0.34
8.24</td></tr>
<tr><td>A</td><td colspan="2">0.50
12.81</td></tr>
<tr><td colspan="2">Ballast disp. M/T</td><td colspan="2">14.05
219,456</td></tr>
<tr><td colspan="2">Normal S.H.P.</td><td colspan="2">0.57
45.000</td></tr>
<tr><td colspan="2">Angular rudder rate (Deg/sec)</td><td colspan="2">11.5
2.3</td></tr>
<tr><td>Bow thruster S.H.P.</td><td>Sternthruster S.H.P.</td><td>0.077
6,000</td><td>0.077
6,000</td></tr>
<tr><td colspan="2">Block coefficient</td><td colspan="2">0.886</td></tr>
</table>

BEN FRANKLIN

(ship's dimensions in metres)

BEN FRANKLIN 120,000 m3 GAS CARRIER		
Length B.P.		10.24 256
Breadth		1.64 41.00
Load draught		0.44 11.10
Load disp. M/T		5.79 90,424
Ballast draught	F	NO CHANGE
	A	NO CHANGE
Ballast disp. M/T		NO CHANGE
Normal S.H.P.		0.41 32 000
Angular rudder rate (Deg/sec)		13.0 2.6
Bow thruster S.H.P.	Sternthruster S.H.P.	0.019 1,500 / 0.019 1,500
Block coefficient		0.756

The Ben Franklin has a SCHILLING rudder

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NORMANDIE container ship and …
(ship's dimensions in metres)

car carrier and …
cruise ship …

		NORMANDIE 4,400 TEU	
Length B.P.		10.45 261.40	
Breadth		1.484 37.10	
Load draught		0.496 12.40	
Load disp. M/T		4.672 73,000	
Ballast draught	F		
	A		
Ballast disp. M/T			
Normal S.H.P.		0.66 52 000	
Angular rudder rate (Deg/sec)		14.0 2.8	
Bow thruster S.H.P.	Sternthruster S.H.P.	0.018 2,750	0.018
Block coefficient		0.602	

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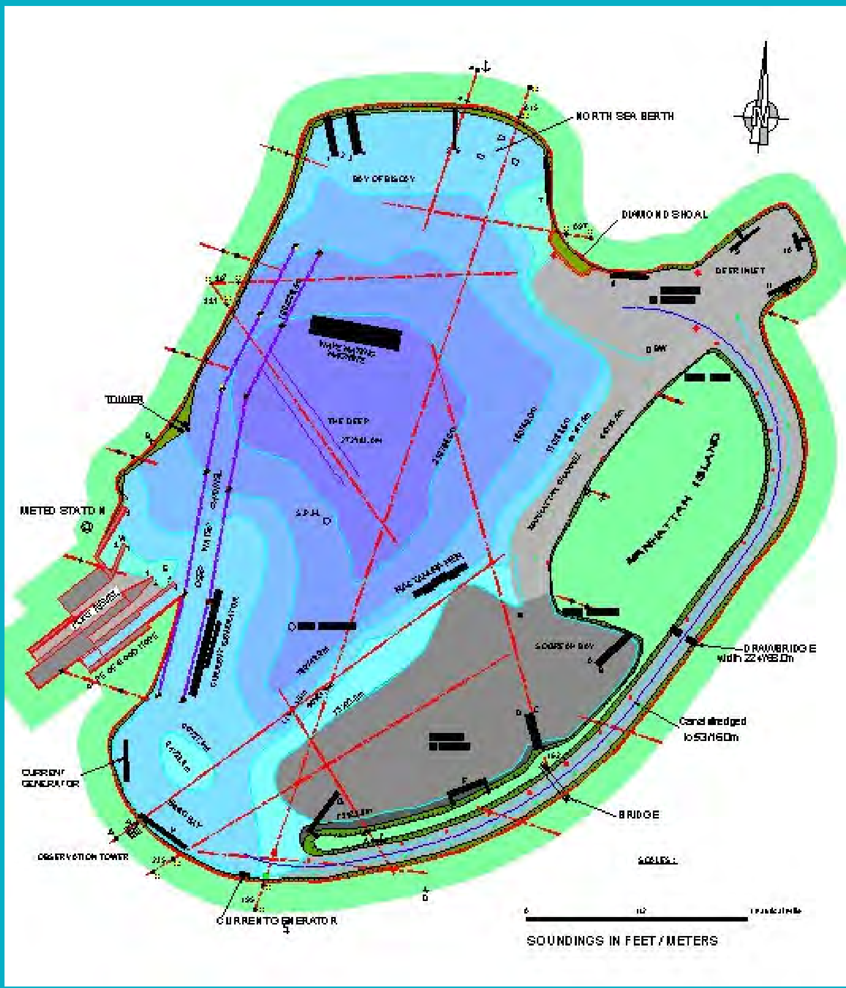
Port Revel by air (2003)

Equipment on the lake:

1. Wave generator and current generator
2. Over 25 berths and piers
2. Island type pier with three berths (Ras Tanura)
3. Single point mooring tower(North Sea Type)
4. Floating single point mooring buoy (SPM)
5. Two buoyed channels
6. Canal section
7. Draw-bridge in the canal
8. Lock (Albert dock)
9. Track Recording System (DGPS)

THE LAKE OF PORT REVEL



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The lake is located near Grenoble (France) where the wind regime is very mild. Moreover, the lake is sheltered by a forest. Hence uncontrolled **wind effects** on ships are reduced to a minimum.

The physical dimensions of the lake are approximately 3 miles x 2 miles in the 1/25 scale which you will be using.

A Suez-sized canal with bends has a length of 4 scale miles.

The lake features extensive **shallow water areas**, channels and many berths.

It also includes wave and current generators.

MONDAY : transits

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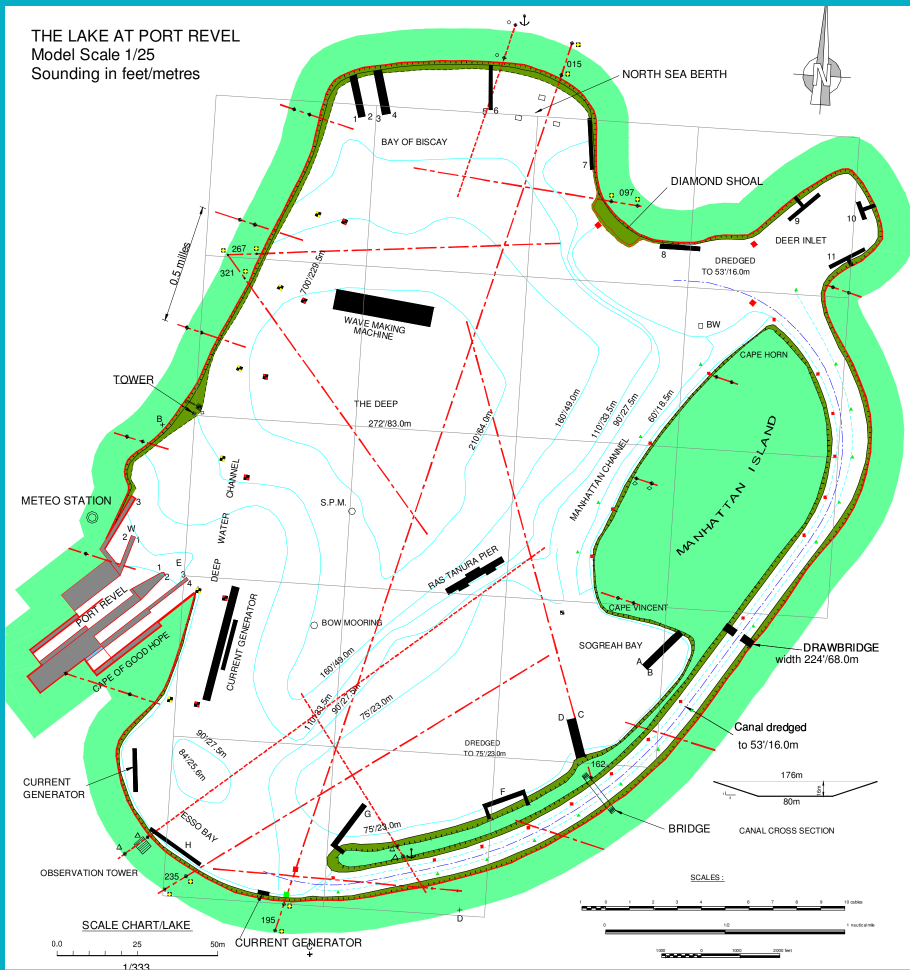
A very accurate track recording system was installed in 2000. The position of 2 ships can be determined with an **accuracy of 25 cm** (10 inches) at full scale, anywhere on the lake.

Ship positions and headings are sent to the base along with data on rudder angle, rpm, wind speed and direction, ship speed, etc.

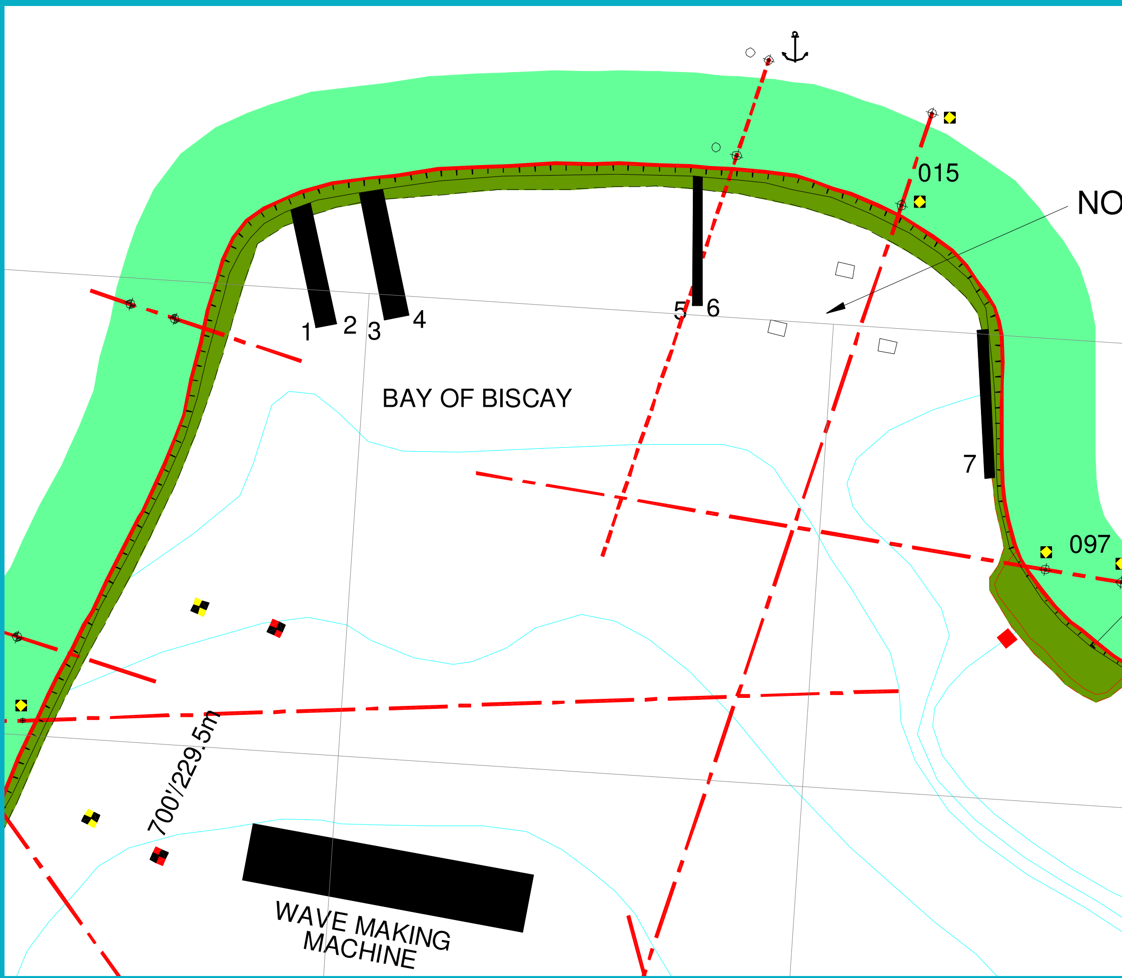
Outputs of manoeuvres are provided and discussed with the students at the end of each day.

Shallow water effects on e.g. turning circles are clearly experienced by the pilots.

PORT REVEL


THE LAKE AT PORT REVEL
Model Scale 1/25
Sounding in feet/metres
NORTH SEA BERTH
BAY OF BISCAY
DIAMOND SHOAL
DEER INLET
DREDGED TO 53'/16.0m
WAVE MAKING MACHINE
THE DEEP
272'/83.0m
TOWER
METEO STATION
PORT REVEL
CAPE OF GOOD HOPE
CURRENT GENERATOR
DEEP WATER CHANNEL
S.P.M.
BOW MOORING
RAS TANURA PIER
MANHATTAN CHANNEL
MANHATTAN ISLAND
CAPE HORN
CAPE VINCENT
SOGREAH BAY
DRAWBRIDGE
width 224'/68.0m
Canal dredged
to 53'/16.0m
BRIDGE
CANAL CROSS SECTION
ESSO BAY
OBSERVATION TOWER
SCALE CHART/LAKE
1/333
CURRENT GENERATOR
SCALES :
0.5 miles

PORT REVEL - North



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Piers 1 to 3

Piers 1 & 2

Pier 3

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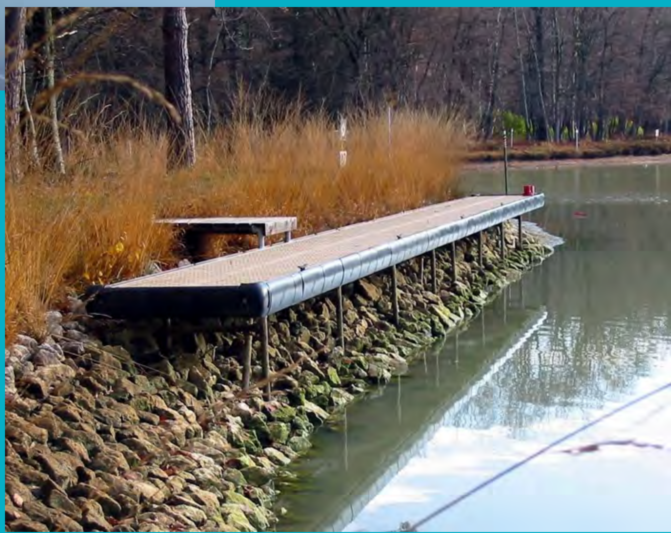
Unit 1 Page 25

Piers 5 to 7

Piers 5 & 6

Pier 7



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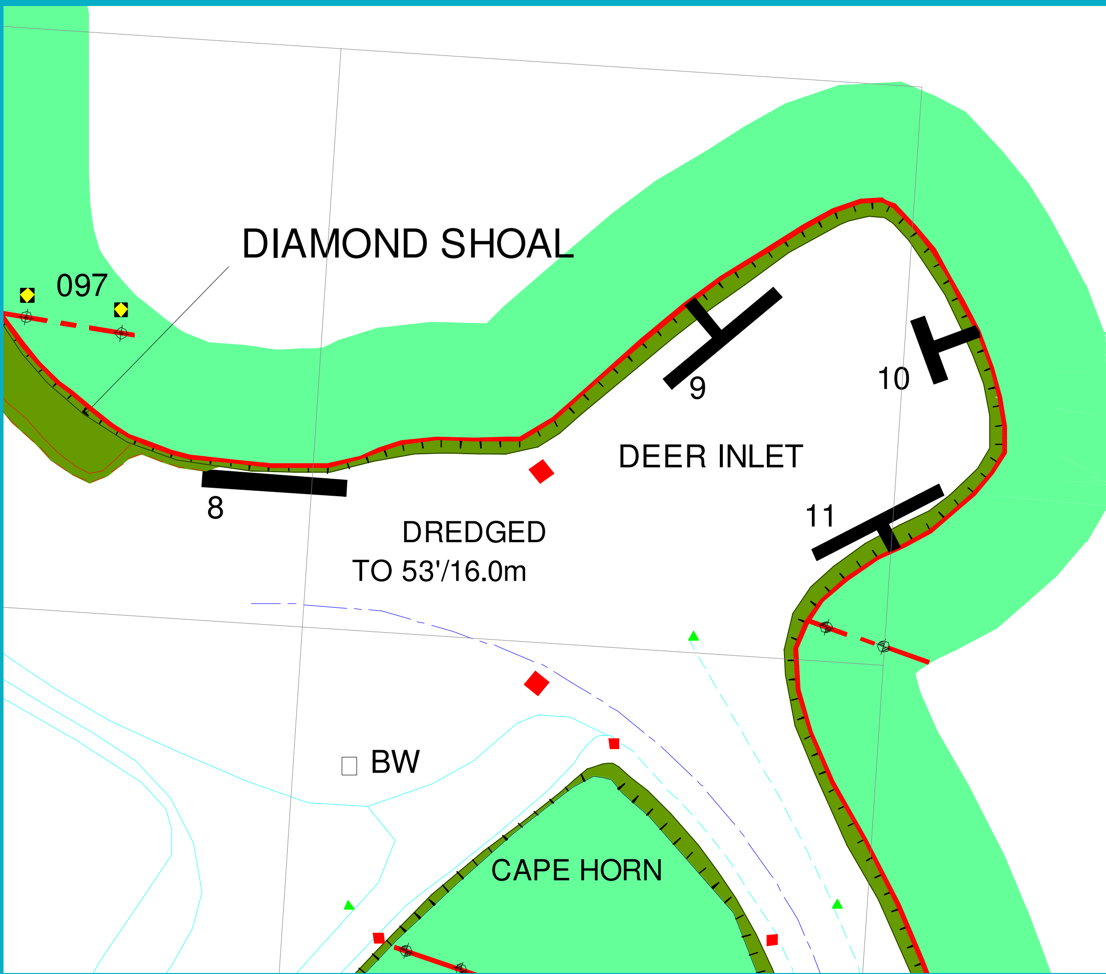
PORT REVEL - NE



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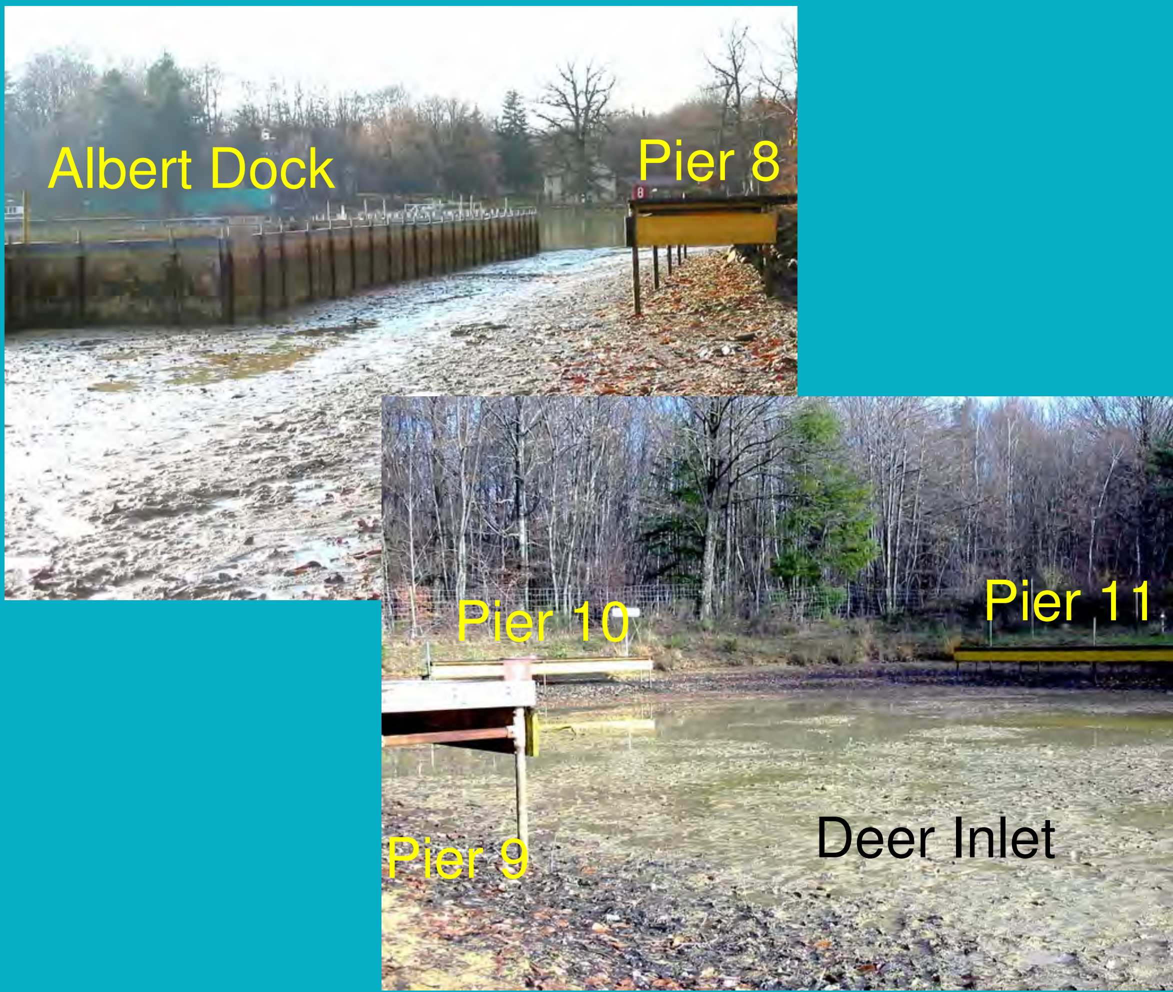
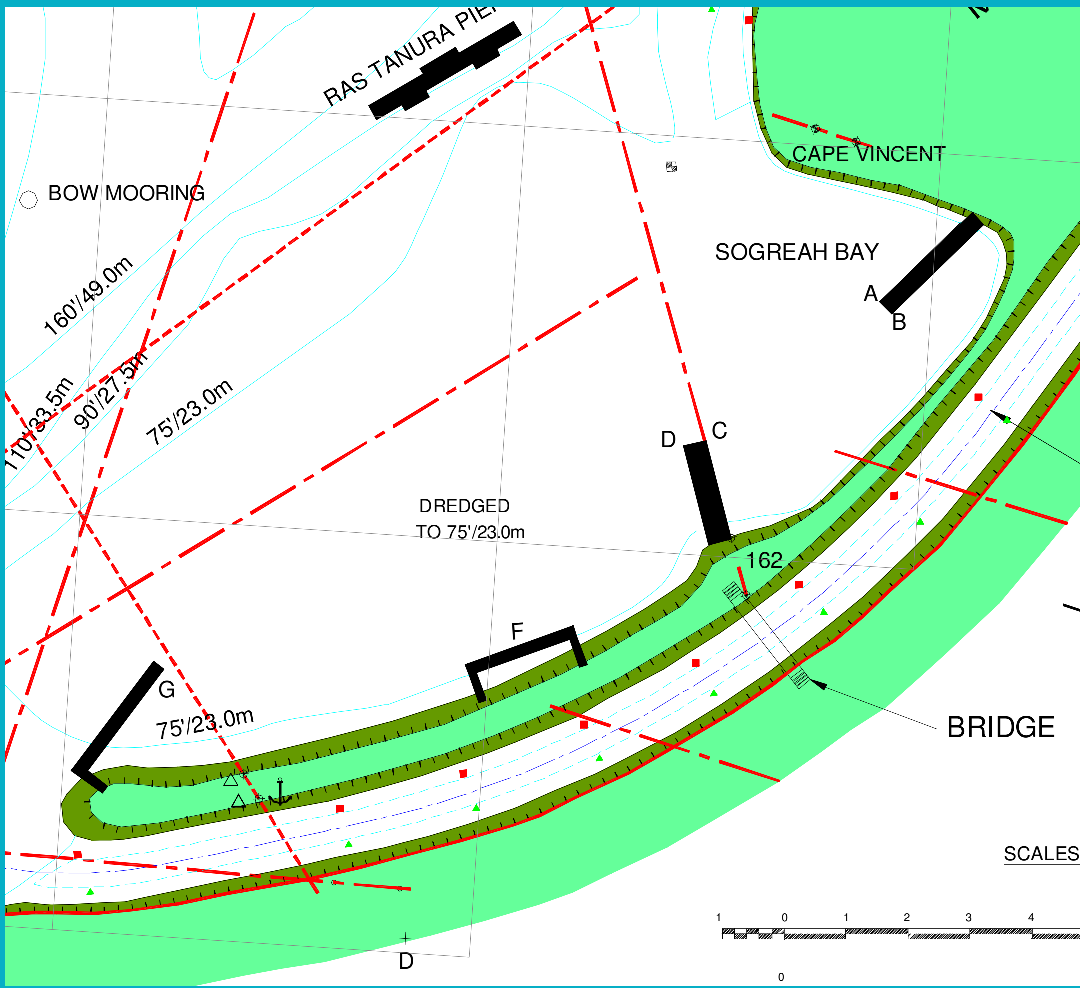
Piers 8 to 11



PORT REVEL - SE



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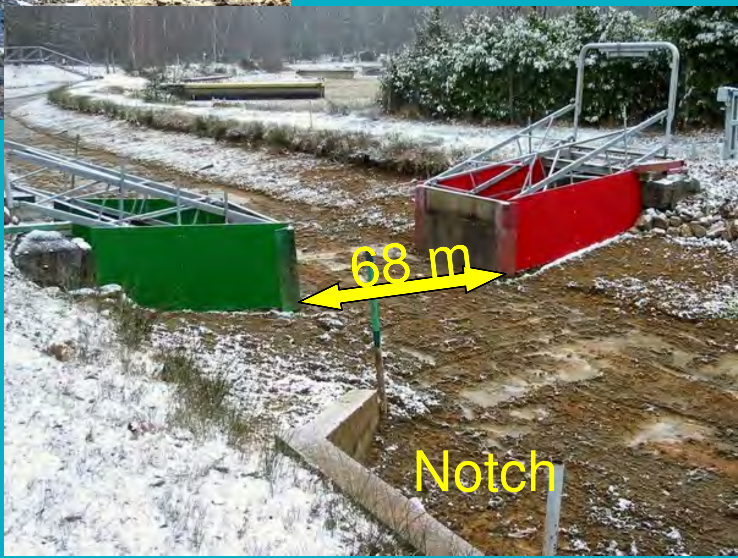
Unit 1 Page 29

Piers A to G

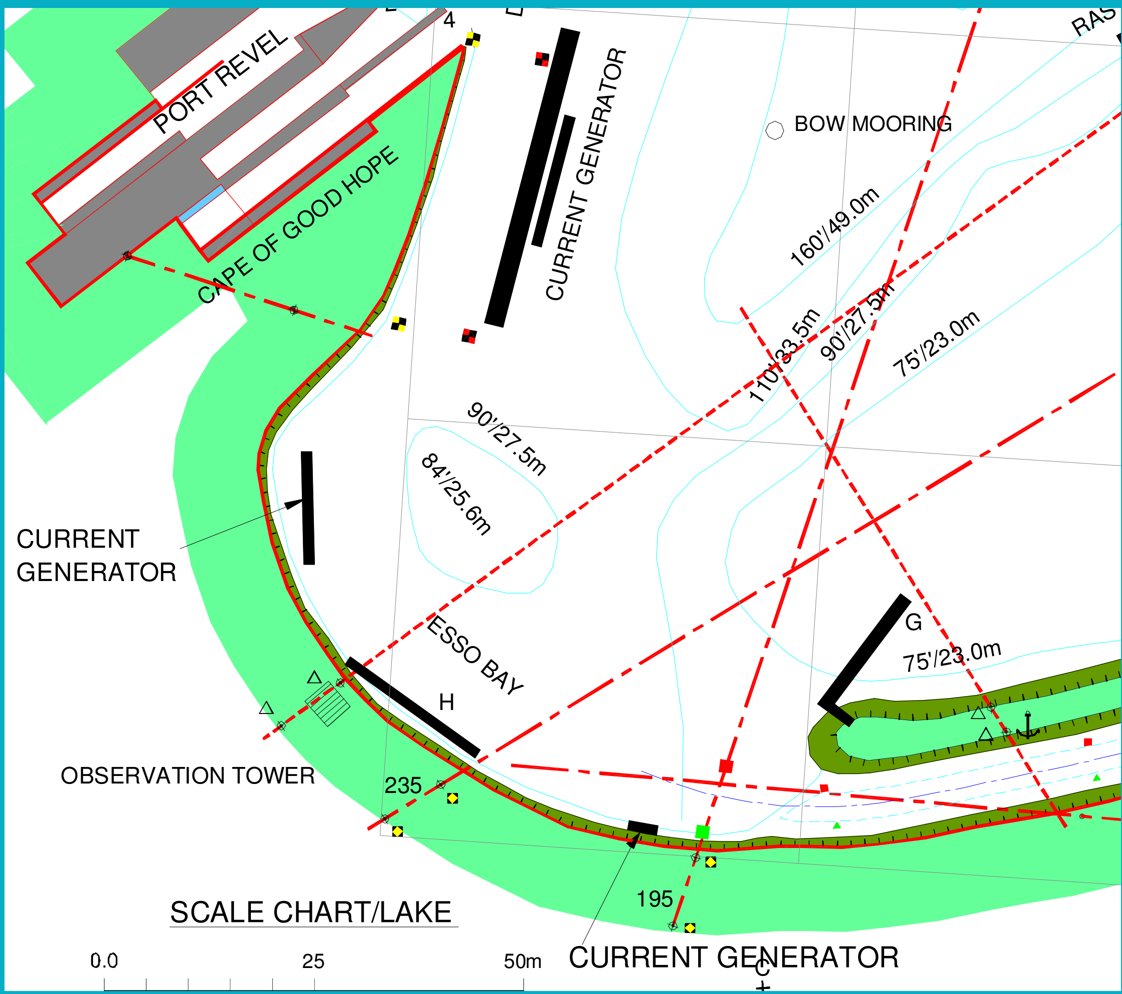
CANAL

Canal dredged to:
53 ft – 16 m
width:
262 ft – 80 m
length:
3.8 nm - 7 km



Drawbridge
width:
224 ft – 68 m

PORT REVEL - South



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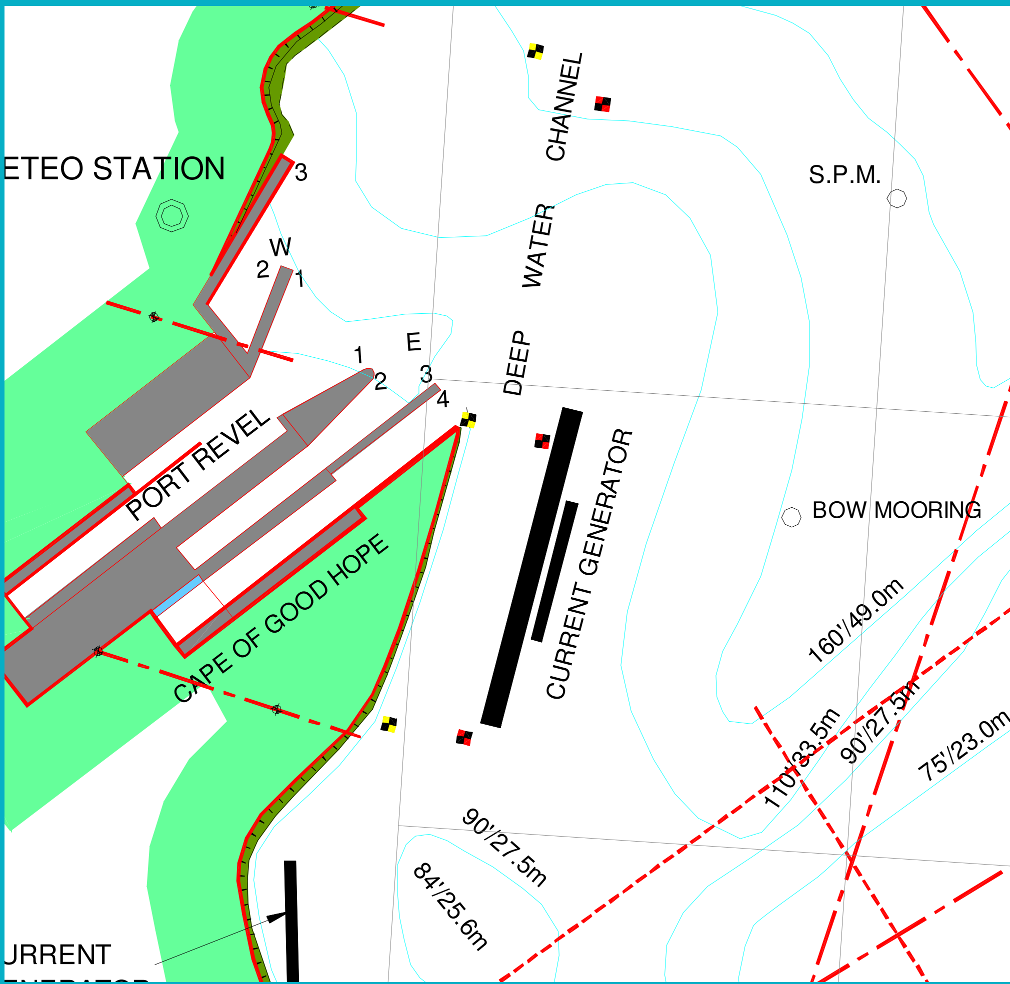
Pier H

Sogreah © Unit 1 Page 33

PORT REVEL Shiphandling

PORT REVEL - Port



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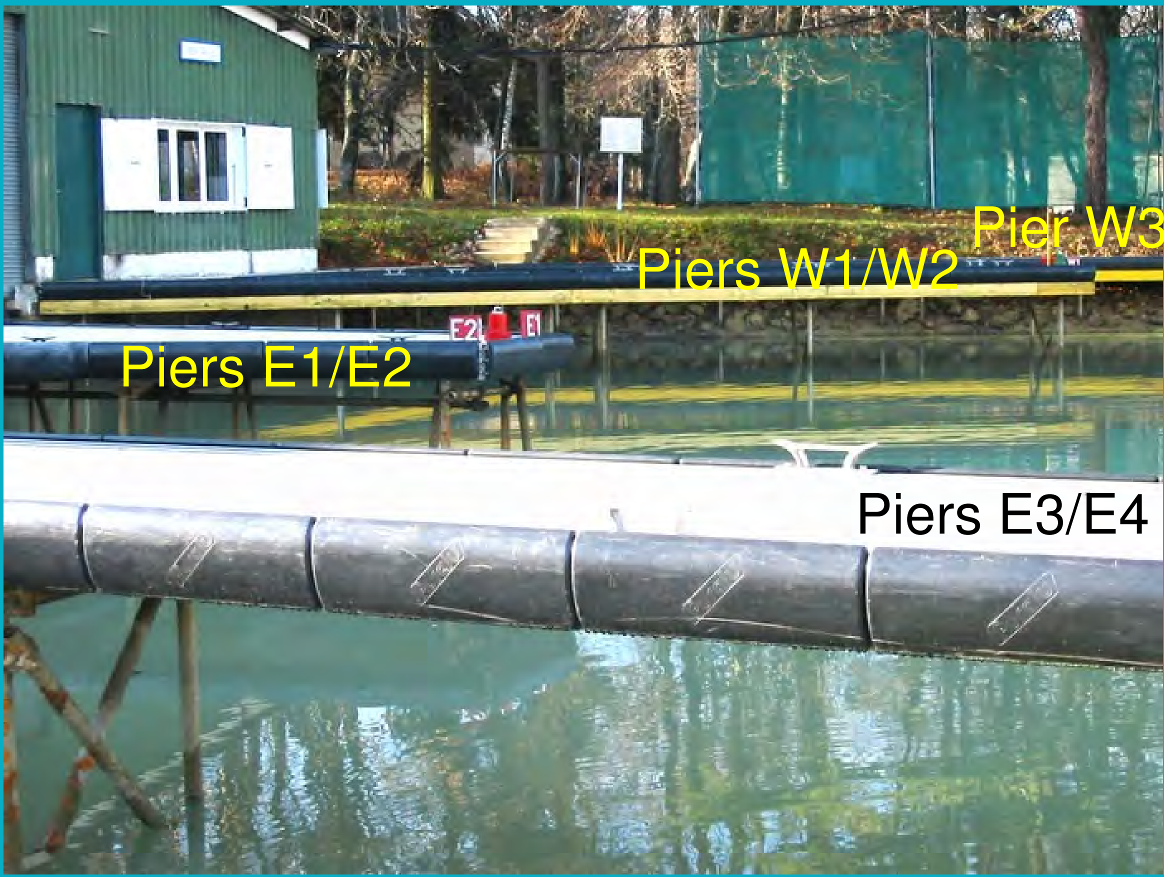
Piers E & W



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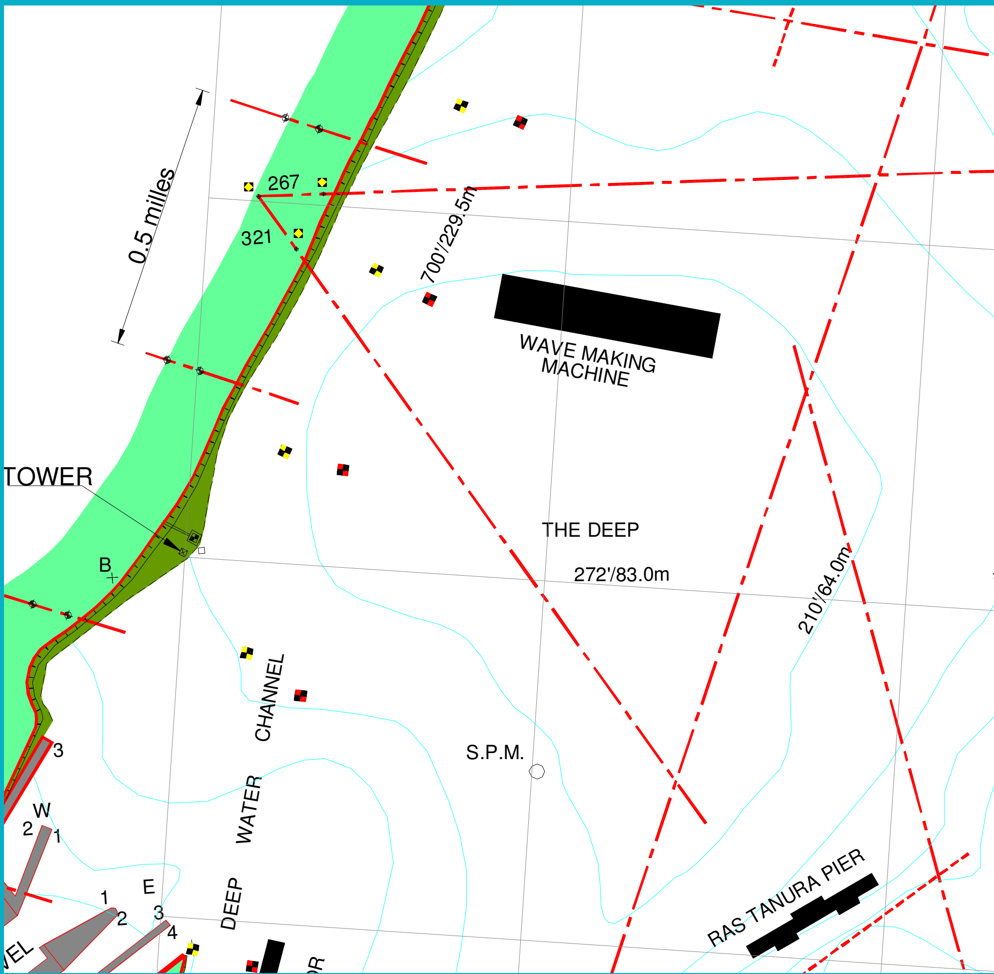
PORT REVEL - West



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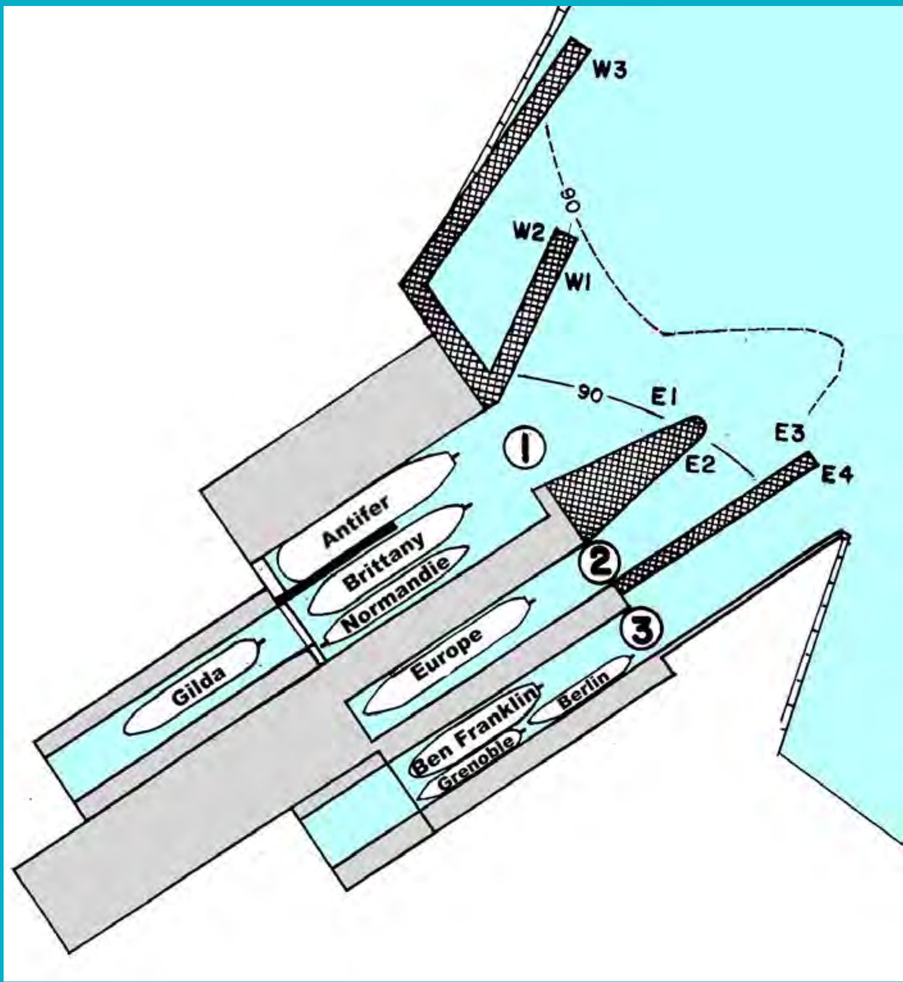
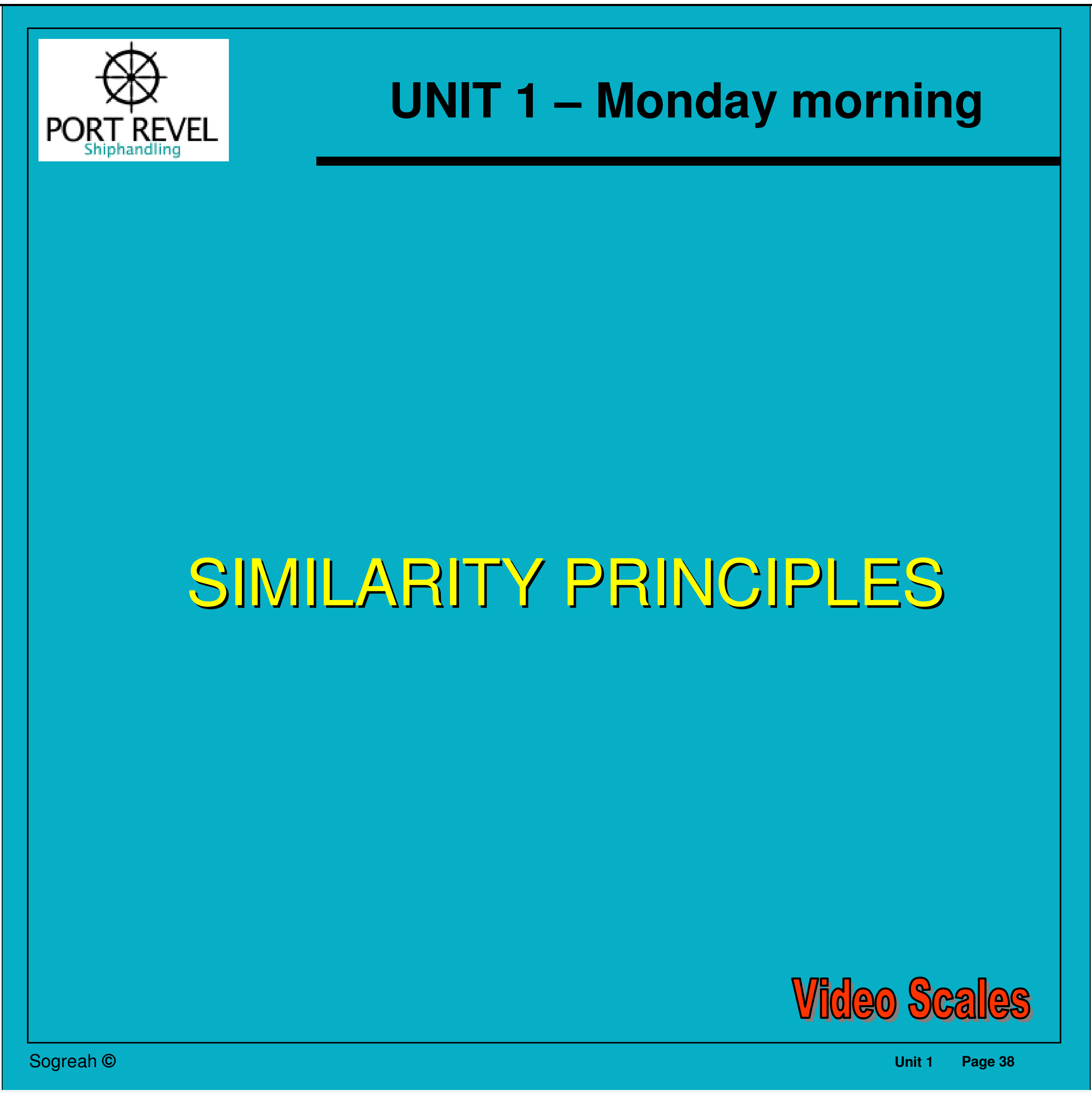
PORT REVEL Shiphandling

PORT REVEL HARBOUR



Sogreah © Unit 1 Page 37



Many famous scientists, hydraulics engineers and naval architects have been relying on scale model tests for decades, and especially towing tank tests. These concerned the ships, however, not the men handling them, and the idea of training pilots and ships' masters on scale models was initiated in the sixties.

Similitude is not a vague approximate likeness, but has a very definite, precise meaning.

Although the similitude conditions discussed here may seem complicated, they are in fact quite simple and **intuitive**, being based on natural physical laws.

35 years of experience have shown that students quickly get the feel of their models in the same way as the real ships they are accustomed to handling; this is really the way to get fully effective results from the Course at Port Revel.

There are several aspects of similitude, which we shall now consider in turn.

SCALES
Length

$$LENGTH = S_L = \frac{1}{25}$$

$$AREA = S_A = \left(\frac{1}{25}\right)^2 = \frac{1}{625}$$

$$VOLUME = S_V = \left(\frac{1}{25}\right)^3 = \frac{1}{15.625}$$

N.B.: The block coefficient is not affected by the scale factor

Prototype / EUROPE	**Model ship / EUROPE**
Lpp = 1075' (330 m)	**l = 43' (13 m)**
B = 170' (52 m)	**b = 7' (2 m)**
D = 66 ' (20 m)	**d = 2.6' (0.80 m)**

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A model has exactly the same shape as the real ship. In other words, all the dimensions of the latter, e.g. its length, breadth, draught, etc. are divided by the same factor to give the model dimensions. This factor is called the "scale factor" $S_{(L)}$, the value of which is 25 in the case considered here, i.e. **the scale is 1/25**.

A point to note here is that ratios, such as L/B, L/d, or the block coefficient, are the same on both the model and ship. And, as angles are length ratios, they are the same as well.

SCALES
Mass

MASS (Volume × Density) : $S_M = S_V \times 1$

N.B. : density is the same for the prototype and the model

$$S_d = 1$$

Prototype/EUROPE	Model ship
Displt : 290 000 t	**Displt : 18.6 t**

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A model ship to be used for training not only has to look like the real ship, but it must move like her as well (if subject to similar forces).

The scale factor for mass and displacement is the same as for volumes, as sea water and the water in our lake have very nearly the same specific gravity.

Hence : $S_{(M)} = S_{(L)}{}^3 = 25^3 = 15{,}625$

SCALES
Time

According to FROUDE Law :

$$S_{time} = \sqrt{S_L} = \sqrt{\frac{1}{25}} = 1/5$$

Everything happens five times faster

Prototype	Model ship
60 min	12 min
30 sec (rudder)	6 sec

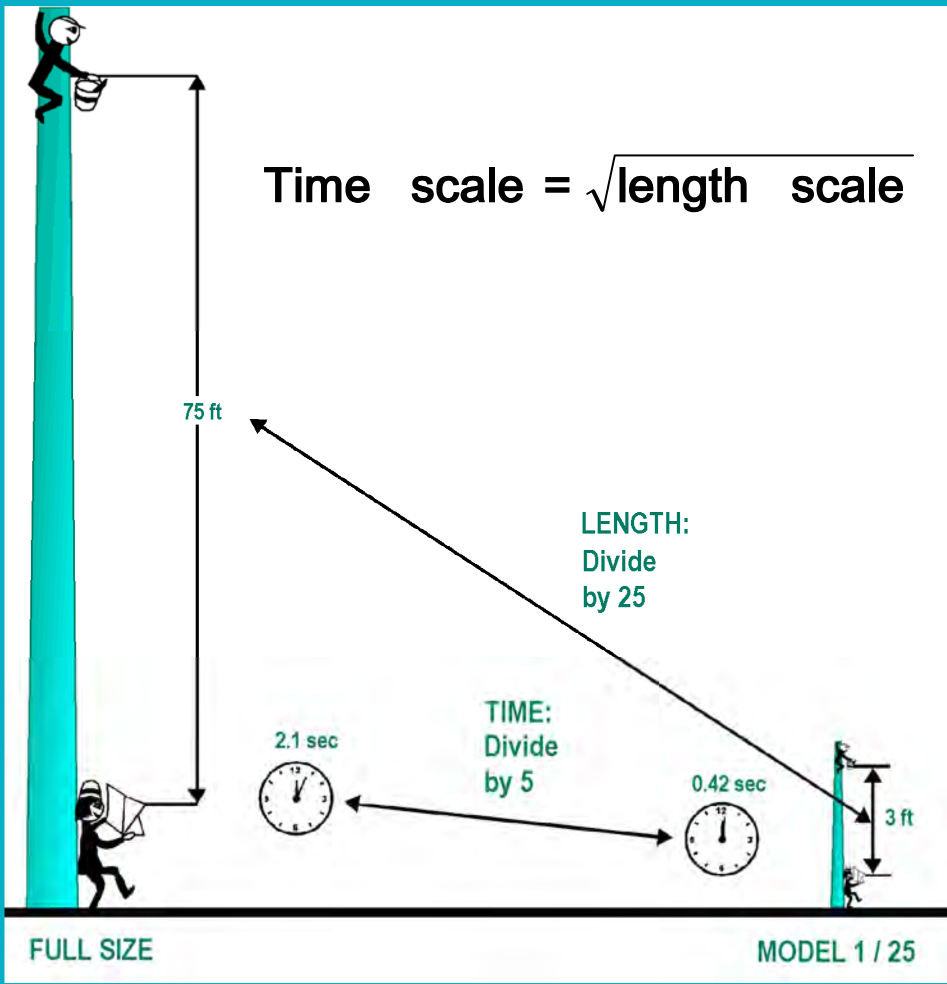
Sogreah © Unit 1 Page 41

As the velocity scale is the square root of the length scale (according to Froude's law) the **model motions are five times slower** than the real thing, and, consequently, time is five times shorter than in nature.

Because of the time reduction on the model, the Master has to react about five times as fast as in real life, for the model equipment is adjusted to respond that much faster. Experience has shown, however, that students, by and large, very soon get used to this, one reason being that the time reduction is partly offset by a corresponding increase in the ship's angular velocity; the student feels angular motion and senses a change in heading much sooner on the model than on a real ship.

To sum up, therefore, **students will be expected to react faster on the models, but they will also be informed of what is happening sooner than on a real ship**.

TIME SCALE



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If a man painting up the 75 foot topmast of the real ship drops his can of paint, the fellow reading his paper on deck underneath will get the paint all over him exactly 2.1 seconds later.

On a model with a mast 25 times shorter, i.e. 3 feet tall, we know both from elementary physics and experience that the "model man" at the foot of the man will get the can on his head 0.42 seconds after it was let go, i.e. in 1/5th of the full-scale time, not 1/25th.

TIME SCALE CALCULATOR

Prototype

$D = 0.5 \times g \times T^2$

Model ship

$d = 0.5 \times g \times t^2$

$$
\begin{aligned}
D &= 25\,d \\
0.5 \times g \times T^2 &= 25 \times 0.5 \times g \times t^2 \\
T^2 &= 25\,t^2 \\
T &= 5\,t \\
\frac{T}{5} &= t \\
1^{\text{hour}} &\rightarrow 12\ \text{min}
\end{aligned}
$$

~6 days x 6^{hours} x 5 = 180^{hours} manoeuvring in real life

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PORT REVEL
Shiphandling

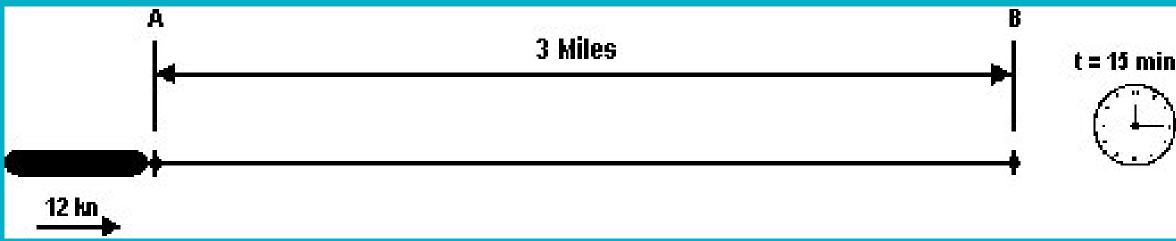
SCALES
Speed

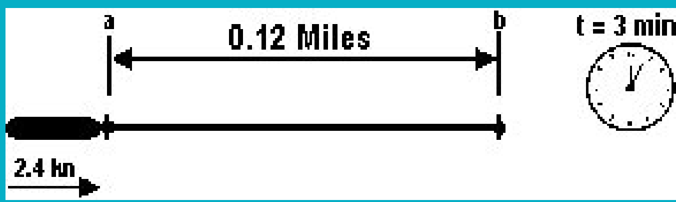
$$S_{speed} = \frac{S_L}{S_t} = \frac{\frac{1}{25}}{\frac{1}{5}} = \frac{1}{5}$$

The behaviour of the model at 2 kn is the same as that of the prototype at 10 kn

PORT REVEL Shiphandling

SHIP UNDER WAY





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To illustrate the application of these various scales, we shall consider a 190,000 DWT **ship under way** maintaining a constant full speed of 12 knots at 65 r.p.m. (Fig. 2). It will thus cover 3 miles (about 18 ship's lengths) in 15 minutes.

The corresponding distance equivalent to 18 ship's lengths for the "BRITTANY" model is only of 0.12 mile (= 3/25), (i.e. roughly the length of the lake), which the model covers in about 3 minutes (15/5) at a speed of 12/5 = 2.4 knots at 65 x 5 = 325 r.p.m.

SCALES
Acceleration

$$S_{acceleration} = \frac{S_{speed}}{S_{time}} = \frac{1/5}{1/5} = 1$$

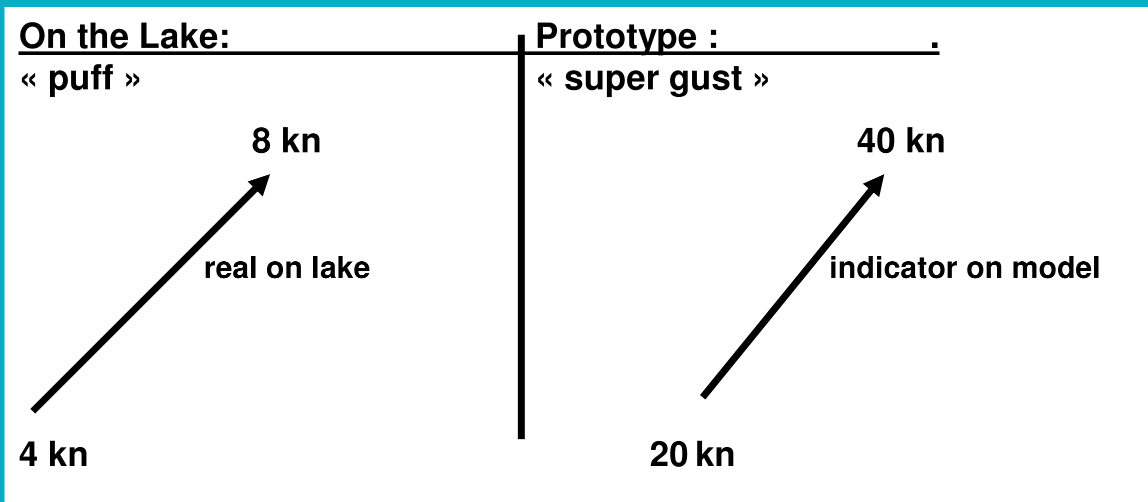
Acceleration is unchanged.

N.B. : Also valid for "acceleration of gravity"

PORT REVEL Shiphandling

SCALES
Wind speed (Natural wind)

The model ship subjected to a 4 kn wind on the lake has the same behaviour as the prototype subjected to a 20 kn wind.



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Regarding wind, it should be borne in mind that owing to the speed factor of 5 a given wind speed on the lake is equivalent to one five times greater at sea. For example, a 10-knot wind on the lake will have the same effect on the model as a 50-knot wind on the real ship. Consequently, ripples on the water or leaves moving in the trees are not a reliable indication of wind strength.

It must be noted also that similarity of gusts is not perfect: a puff on the lake reproduces a « super gust » as the increase from 20 kn to 40 kn of the example above will take place in a somewhat unrealistic short time. This is a so-called « scale effect ».

SCALES
Angle

$$S_{angle} = \frac{S_{bow}}{S_{radius}} = \frac{1/25}{1/25} = 1$$

The angular view is unchanged

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PORT REVEL
Shiphandling

SCALES
Angular velocity

$$S_{\substack{\text{angular velocity}\\ \text{or rate of turn}}} = \frac{s_{\text{angle}}}{s_{\text{time}}} = \frac{1}{1/5} = 5$$

The rate of turn is five times larger

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Angular motion is five times faster on the model, e.g. the following:

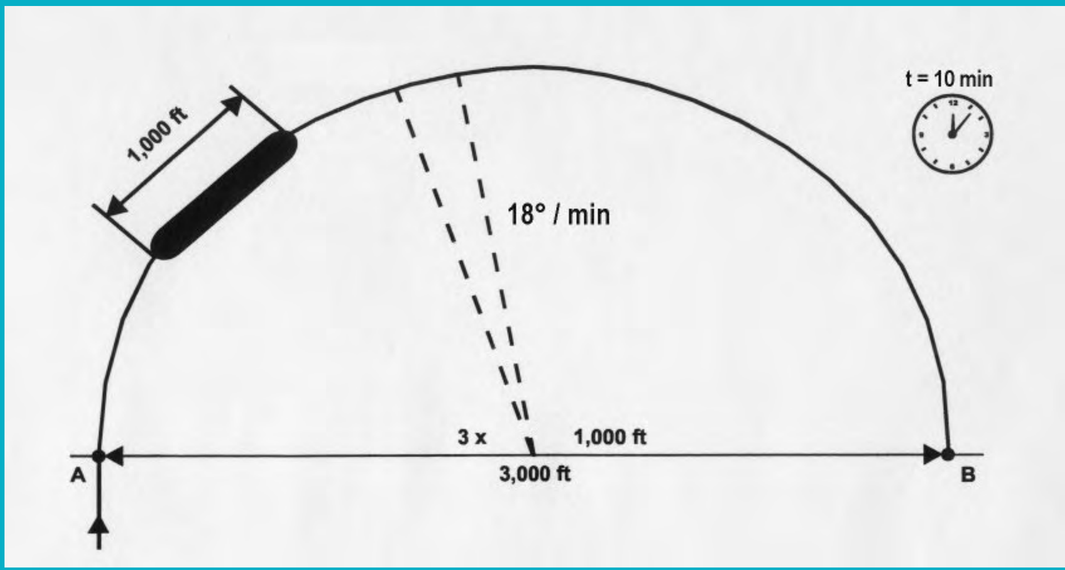
– angular rudder rate,

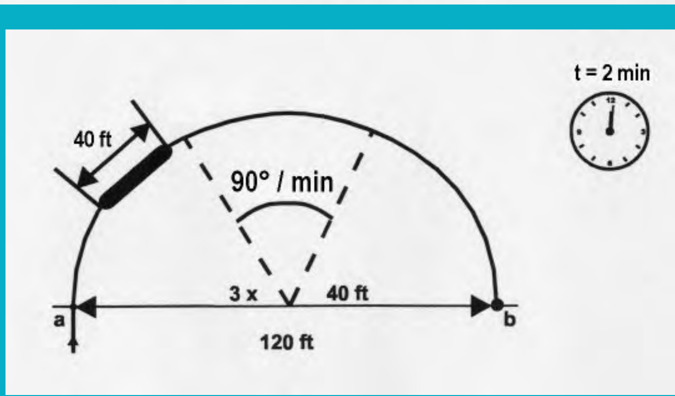
– ship's turning rate for a given rudder angle,

– yaw,

- r.p.m. (but the dials on the model give readings in real life).

RATE OF TURN





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Turning is another example. Supposing the same rudder angles (40°) are set simultaneously on the 190,000 ton tanker and the model travelling at 12 kn and 2.4 kn respectively; after 10 minutes, the real ship will have turned through 180 degrees, with a tactical diameter of about 3 ship lengths, i.e. 3,000 feet, whereas the model will only take 2 minutes (10/5) to turn through the same angle, with the same 3 ship length tactical diameter, but equivalent to 120 feet (3,000/25). The real ship's angular turning rate works out at 18 degrees/min, compared to 90 degrees/min (18°/min x 5) for the model.

Note that the Rate of Turn indicator on the Europe is at full scale, like all other instruments onboard.

SCALES
Force

$$\text{FORCE (Mass} \times \text{Gravity)} : S_F = S_M \times 1$$

N.B. : Gravity is the same everywhere : $S_g = 1$

$$\text{Hence} : S_F = S_V = \frac{1}{15.625}$$

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If in addition to shape, mass and inertia, the forces causing ship motion are "similar", the motion will also be "similar".

Such forces are caused by sea or weather conditions, e.g. wind, current and waves or are generated by the ship herself, e.g. propeller thrust, rudder moment, or else they may be due to hydraulic effects caused by the sea bed or a canal bank. They will be correctly reproduced if they are to the same scale as mass.

SCALES
Power

$$S_{power} = \frac{S_{force} \times S_{length}}{S_{time}}$$

$$S_{power} = S_{force} \times S_{speed} = \left(\frac{1}{25}\right)^3 \times \left(\frac{1}{25}\right)^{0.5}$$

$$S_{power} = \frac{1}{25}^{3.5} = \frac{1}{78.125}$$

Prototype/EUROPE	Model Ship
F.S.S. = 32.000^{HP}	F.S.S. = 0.41^{HP}
F.M.S.= 16.000^{HP}	F.M.S. = 0.20^{HP}
F.Ast = 7 800^{HP}	F.Ast = 0.10^{HP}

CALCULATION OF THE SCALE FACTOR OF POWER

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$ a work is a Force x length

$$\text{Power} = \frac{F \times L}{T}$$ a Force is a Mass x accelerati on (δ)

$$\text{Power} = \frac{M \times \delta \times L}{T}$$ a Mass is a Volume x density

$$\text{Power} = V \times d \times \frac{S}{T} \times \frac{L}{T}$$ an Accelerat ion is a Speed divided by Time

$$P = V \times d \times S \times L \times \frac{1}{T^2}$$ P = Master

$$p = v \times d \times s \times l \times \frac{1}{t^2}$$ p = model

$$p = \frac{V}{25^3} \times 1 \times \frac{S}{5} \times \frac{L}{25} \times \frac{1}{\left(\frac{T}{5}\right)^2} = V \times S \times L \times \frac{1}{T^2} \times \frac{1}{25^3} \times \frac{1}{5} \times \frac{1}{25} \times 25$$

$$p = P \times \frac{1}{25^3} \times \frac{1}{5} = \frac{P}{5 \times 15625} \times \frac{P}{78125}$$

CALCULATION OF THE SCALE FACTOR OF FORCE

$$F = M \times acceleration = M \times \frac{S}{T}$$

$$f = m \times \frac{s}{t} = \frac{M}{25^3} \times \frac{S}{5} \times \frac{5}{T}$$

$$f = M \times \frac{S}{T} \times \frac{1}{25^3} = \frac{F}{15625}$$

$$1\,Kg = 15.6\,Tons$$

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PORT REVEL
Shiphandling

CHANGE THE SCALE …

SHIP	LENGTH (m)			POWER (SHP)		
	1/25	1/36	1/16	1/25	1/36	1/16
Pembroke	159	229	102	6 400	22 932	1 342
Berlin	201	289	129	17 500	62 706	3 670
Grenoble	191	275	122	17 500	62 706	3 670
Gilda	269	387	172	24 000	85 996	5 033
Brittany	305	439	195	32 000	114 662	6 711
Europe	329	474	211	32 000	114 662	6 711
Antifer	337	485	216	45 000	161 243	9 437
Ben Franklin	256	369	164	32 000	114 662	6 711
Normandie	261	376	167	52 000	186 325	10 905

Most ships of the fleet are quite realistic at other scales.

However, Antifer and Normandie have too much power at scale 1/36, as is not considered realistic to have much more than 100 000 HP on a single screw ship.

Do not forget about the time scale: 1/6 at length scale 1/36, and 1/4 at scale 1/16.

CAUTIONS

Forget everything about scale and similarity,

and believe you are on a ship :

- **compare the distance with the length or width of the ship**
- **have a look abeam and check the log**
- **keep the cover (cockpit) closed (wind)**
- **do not stand up to see better**
- **do not argue with your partner**
- **do not use steady as she goes**
- **do not use the stern thruster (barring emergency)**
- **use the bow thruster only for docking and undocking**
- **do not use the Y bow thruster (Gilda) after a grounding**

- **in case of trouble (rudder or engine failure) blow 3 long blasts**

- **in case of danger for the propeller or rudder (buoy, pier, stones, etc) :**
  1. **put the telegraph on stop**
  2. **put the wheel amidships**
  3. **then switch off the main engine**

UNIT 2 – SHIPHANDLING FUNDAMENTALS

1. SUMMARY OF FUNDAMENTALS

Shiphandling is an art. It involves combinations of variables so numerous and complex that no amount of detailed predetermined instruction can bring a ship through a canal or dock it. Each time a ship moves, the precise influences acting on her are different from at any other time; and the ship responds to every one of them.

A great many procedures and processes in the industrial world lend themselves to the kind of training in which definitive actions at specific times can be taught in advance, and anyone with a good memory and a little practice can perform as instructed and obtain minimum results. Shiphandling is not one of them. Consider a ship a thousand yards away from a berth under normal conditions for docking. If the correct instructions, taking all factors into account, are known in advance with precise times stated for their execution, a surprisingly few *bells* and rudder orders would be necessary to dock the ship. But what goes into the making of these few commands? How far in advance must each decision be made before the vessel can be expected to respond? What does the shiphandler have to see about him and what does he have to *see* **in his mind's eye**?

Try to list in detail all the things that you must be aware of that allow you to *feel* the ship; its mass, its power, (or lack of it), its reactions to currents, turbulence, winds, pressures, submarine shapes and forms, interactions, speeds, response times, magnitudes, distances, and above all, resolve these, though ever changing, into definite rudder or engine orders.

In many respects a large ship is the most difficult of all vehicles in the world, or in space for that matter, with which to perform precise manoeuvres. On land, vehicles have a vast range of positive traction under which to manoeuvre. In the air, due to the speeds of flight, an aircraft is most always in an undisturbed medium. Its movement can be easily instrumented and its forces can be physically felt by the pilot. It leaves turbulence far behind. For many years it has been feasible to programme flight *instructions* into electronic devices and either make unmanned flight manoeuvres or use these *instructions* to create flight simulators that are realistic enough for training and research.

In recent years we have all seen how successfully space manoeuvring can be accomplished by instructions electronically memorized in advance and self adjusting in flight.

In all the foregoing examples there is a minimum of turbulence, or a complete absence of it, for the following reasons:

- Positive traction
- High velocity
- Absence of atmosphere

SHIPS HAVE NONE OF THESE ADVANTAGES.

In the cases of vehicles operating with positive traction, negligible turbulence, or absence of atmosphere, units of measure can successfully be assigned to the forces influencing the movement of the vehicle and they can be made accurate enough to **represent** all the things that must be known to control and manoeuvre the vehicle by an electronic device which *understands* these measured observations. The design of such computers is based on a **mathematical model** which represents the real vehicle and the real influences affecting its motion. The controlling device can *observe* the forces represented and respond by driving the controls according to the instructions built into it.

It has not been feasible, or perhaps not even possible to do this for large ship manoeuvres in confined waters. As ships grow larger, and their masses increase, their manoeuvres must be done at ever decreasing speeds. It is becoming harder and harder to **see** the ship responding and to observe critical differences in a ship's speed. The proportion between the ship's safe handling speeds and all the other factors affecting her becomes much greater as ships get larger. The influences that one **cannot see** are becoming more and more important, and are greater in magnitude than those one can see.

How then does the pilot get his job done? He can't *see* inertia. He can't *see* bank cushion. He can't *see* the side pressure on the rudder, or feel the ship turn or decelerate. He can't *see* the turbulence or feel its effect on the ship.

A control computer *knows* how to control a space vehicle because its *thinking* is based upon **mathematical models**; the pilot relies on a *mental model* to substitute for the things he can't actually see or feel physically. This requires knowledge and experience and the use of one's imagination. An effective *mind's-eye-view* comes from a thorough knowledge of ship, surroundings and fundamentals. The skilful application of these comes only through a great deal of practice, a clear concept of the influencing forces, and continuous and careful observation of the ship's movement.

It is therefore important to make a serious review of shiphandling fundamentals. In order to re-examine the fundamentals of shiphandling thoroughly, full use will be made of the following:

- Visual aids and instructor presentations.
- Exchange of ideas and experiences.
- An examination of existing fundamental concepts in the light of the characteristics of modern large displacement vessels.
- Development of new handling concepts specifically applicable to larger modern ships.
- Application, observation and reporting of theoretical effects experienced during *Lake Practice*.
- Discussion on tracks recorded during *Lake Practice*.

2. JUDGEMENT OF FORCES AND MOTION

Shiphandling judgement, as stated before, is based almost entirely on memory (knowledge) and vision. There is less and less that a pilot can see and more and more that a pilot must know as ships get larger. The only **direct** visual observation we can make is that of **distance**. Speed is more or less determined indirectly by telltale signs that indicate speed, or by instruments. Forces, furthermore, are the most remote from visual observation. **Physical** *feel* on ships of any size is non-existent. *Feel* is a conceptual appreciation of the ship's characteristics and is extremely important. How is it developed? Knowledge is the predominant factor. Practical experience is most important. Yet, with ship's cargoes, port facilities and lives at stake, trial and error is inconceivable. Study and observation come first until accurate foresight is developed. Good foresight is judgement when you select decisions and timing from it.

- Know your ship.
- Know your surroundings.
- Know what you are going to do.
- Know when to do it.
- Know the alternatives.
- Know what is happening and what is going to happen.

3. HOW TO REACH A GIVEN DESTINATION

3.1. JUDGEMENT OF DISTANCE AND SPEED

A thorough knowledge of charted information is essential for accurate judgement of distances. An experienced pilot should be able to stand quietly on the bridge and take bearings and plot them more accurately in his head than most people not familiar with the waters can plot them using instruments. He keeps a continual plot and he knows all the significant distances from the ships. In confined waters, judgement of speed need not be made in terms of knots. How one should think of speed is a personal preference, but it must be based on distance, stopping power, ship's manoeuvrability, current, wind, traffic and visibility. In very confined waters if there is any doubt whatsoever just go as slowly as is safe. Remember one has more control over a ship when increasing speed than when decreasing speed.

Whenever it is considered prudent to have someone standing by the anchors, then it is also prudent to keep the speed down to that at which the anchors can be used.

When large loaded ships are berthing, approach speeds to fixed structures must be so low that they are hardly discernable.

3.2. JUDGEMENT OF HEADING

Once in narrow approaches as in a canal, approaching a bridge, another ship or a confined berth, headings must be discerned within small fractions of a degree. Sighting over the jack staff from the exact centre line of the bridge is best but, when it becomes necessary to leave that position, be sure to use some part of the ship's structure forward that gives you a sight parallel to the centre line.

3.3. JUDGEMENT OF MOTION - RATE OF TURN RELATIVE BEARING VARIATIONS

Discernment of leeway and drift is obtained by finding ranges using any two fixed objects within sight ahead. If there is any angle of drift, it will be necessary to have the quartermaster steer by the gyro, because the fixed objects in line with the keel will be changing bearing. While reducing speed in cross wind and current, concentrate on the point toward which you wish to travel and use whatever headings are necessary.

When the surroundings become too confined to use gyro headings any more, then give rudder angle orders directly. When the ship is carrying a drift angle due to wind and/or current, bearings of all objects forward of the beam will be spreading open to the left and right of the point toward which you are moving. Only when the ship's head is in line with that point is there no longer any drift or lee occurring.

When turning in confine surrounding, variation in relative bearing should be adopted instead of the amount of rate of turn.

When winds and currents are within safe working limits, the foregoing observations are all that are necessary to determine their effects on the ship. If the question arises whether it is safe to attempt a manoeuvre because of strong winds and currents, their speeds in figures should be considered based on standard observations and tabulated predictions such as Beaufort Scale, current tables, and judgement of current as observed when passing buoys and fixed objects obstructing the current.

3.4. JUDGEMENT OF SHIP'S BEHAVIOUR

Judgement of bank effects, inertia, etc. must be gained through experience with a specific ship in specific waters. When in doubt, keep the ship at minimum possible speed. If that may be too fast or too slow, it is best not to try the manoeuvre without special assistance. Skill and judgement are further aided by good pre-planning of the manoeuvre. This is not based on guesswork but past practices in the waters. One must know ahead of time where to check speed, what initial rudder angle to use and just when to use it. These pre-planned actions become routine with harbour pilots with appropriate estimated variations for conditions. The advance plans *get* things moving in the right direction. The more accurate they become (through practice and concentration), the less adjusting is necessary during the manoeuvre.

However, one should **never** hesitate to make necessary adjustments. When in doubt make adjustments with enough margin of safety to make up for any doubts. At all times have in mind a clear idea what your speed is and what it should be. Continually evaluate your direction of movement, heading and pertinent distances. Know what these should be at every point in your approach. Know before you get to significant points in your approach how you want the ship to be. Make the necessary adjustments ahead of time, on the side of safety. At all times keep aware of hazards and keep aware of ways out of trouble in case you need them. This means simultaneous, continuous awareness of the vessel's limitations; take them all into account. Make all decisions early, take into account lags and response times and take action as nearly as possible at precisely the best times. Some people tend to be impatient after deciding what to do and take action too early. Others, for some reason, do worse and take actions too late.

These tendencies often have emotional causes from a lack of knowledge of the ships and the surroundings. Too often, errors in timing are simply written off against *judgement* when the proper judgement would have been so easy, had the pilot known his ship and the locale better. The larger the ship, the longer she takes to answer the helm and engines; the more judgements must be based on **advance knowledge** and not on observation alone.

3.5. INERTIA AND MOMENTUM

At Port Revel we normally use the word *inertia* to describe a ship's tendency to remain at rest when at rest, and the word *momentum* to describe a ship's tendency to remain in motion when in motion.

The greater a vessel's displacement the greater her inertia and momentum, and in large bulk carriers engine power is not usually increased proportionately. In most cases engine power is based on the amount required to overcome underwater resistance at a desired speed. Unfortunately, inertia and momentum increase on a higher ratio than underwater resistance for larger vessels.

Displacement	Speed
10,000 T	10 ft/sec=100,000 ft tons/sec.
100,000 T	1 ft/sec=100,000 ft tons/sec.

From the foregoing it is evident that if both vessels are to be stopped in a given distance, the larger one will need either 10 times the amount of power or to be moving initially at one third the speed (sqrt10). As larger displacement ships are built, their sea speeds can be kept approximately the same without making proportional increases in their power. However, their acceleration and deceleration capabilities are reduced, necessitating their being handled at lesser speeds to keep within manoeuvring capabilities.

In effect, everything the shiphandler does with his vessel takes more time, but once a force has been imposed, the vessel stores this energy and later expresses it through her momentum. This *saving bank* of imposed forces must be kept in mind by the shiphandler for every subsequent action. The larger the ship, the lower the speed is for a given amount of momentum. Momentum is discerned by the shiphandler in terms of his judgement of speed. Where, in a 10,000-ton vessel, the pilot must judge speeds between one and ten knots, the pilot of a 100,000-ton vessel must be capable of judging differences of speed between one tenth of a knot and one knot for the management of only the same amount of momentum!

3.6. CONCLUSION

Shiphandling is neither an exact science nor a mysterious art.

Skill and judgement come from good old-fashioned knowledge.

Timely application of knowledge comes through practice and analysis of what you have done and what you might have done.

Speed (headway) is your worst enemy unless you actually **need** it, but power in reserve can be a good friend.

You have anchors on a ship to be used. Choose speed accordingly.

4. FORCES NOT UNDER CONTROL

The slides hereafter clarify the following aspects:

4.1. WIND

4.2. CURRENT

Some effects of currents, particularly those applying to very large displacement vessels, should be kept in mind:

4.2.1. MOMENTUM

4.2.2. LENGTH AND SPEED

4.2.3. BOTTOM CLEARANCE

4.3. SWELL

4.4. SEICHES

4.5. ICE

4.6. SHALLOW WATERS AND CANAL EFFECTS (PM: SEE UNIT 4)

PORT REVEL
Shiphandling

THE ART OF SHIPHANDLING

THE ART OF SHIPHANDLING

INVOLVES THE EFFECTIVE USE

OF FORCES UNDER CONTROL

TO OVERCOME THE EFFECT OF

FORCES NOT UNDER CONTROL

Charles H. COTTER, 1962

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Shiphandling is an **art** more than a science.

We believe generally that:

- some forces are under control: man made ships, …
- other forces are not under control: Mother Nature.

PORT REVEL
Shiphandling

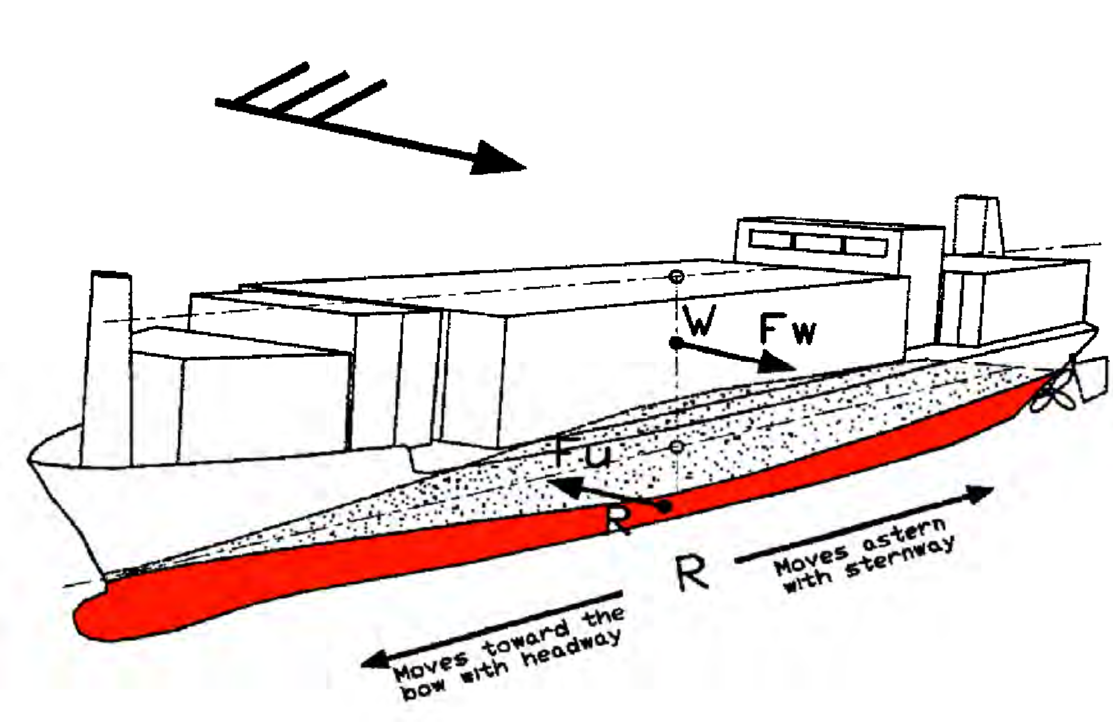
Why training ...?!

Human error costs the maritime industry $541m a year, according to the UK P&I Club. From their own analysis of 6091 major claims (over $100,000) spanning a period of 15 years, the Club has established that these claims have cost their members $2.6bn, 62% of which is attributable to human error.

UNIT 2 – Monday afternoon

http://www.cargolaw.com/2003nightmare_t-bone.html

WIND EFFECTS

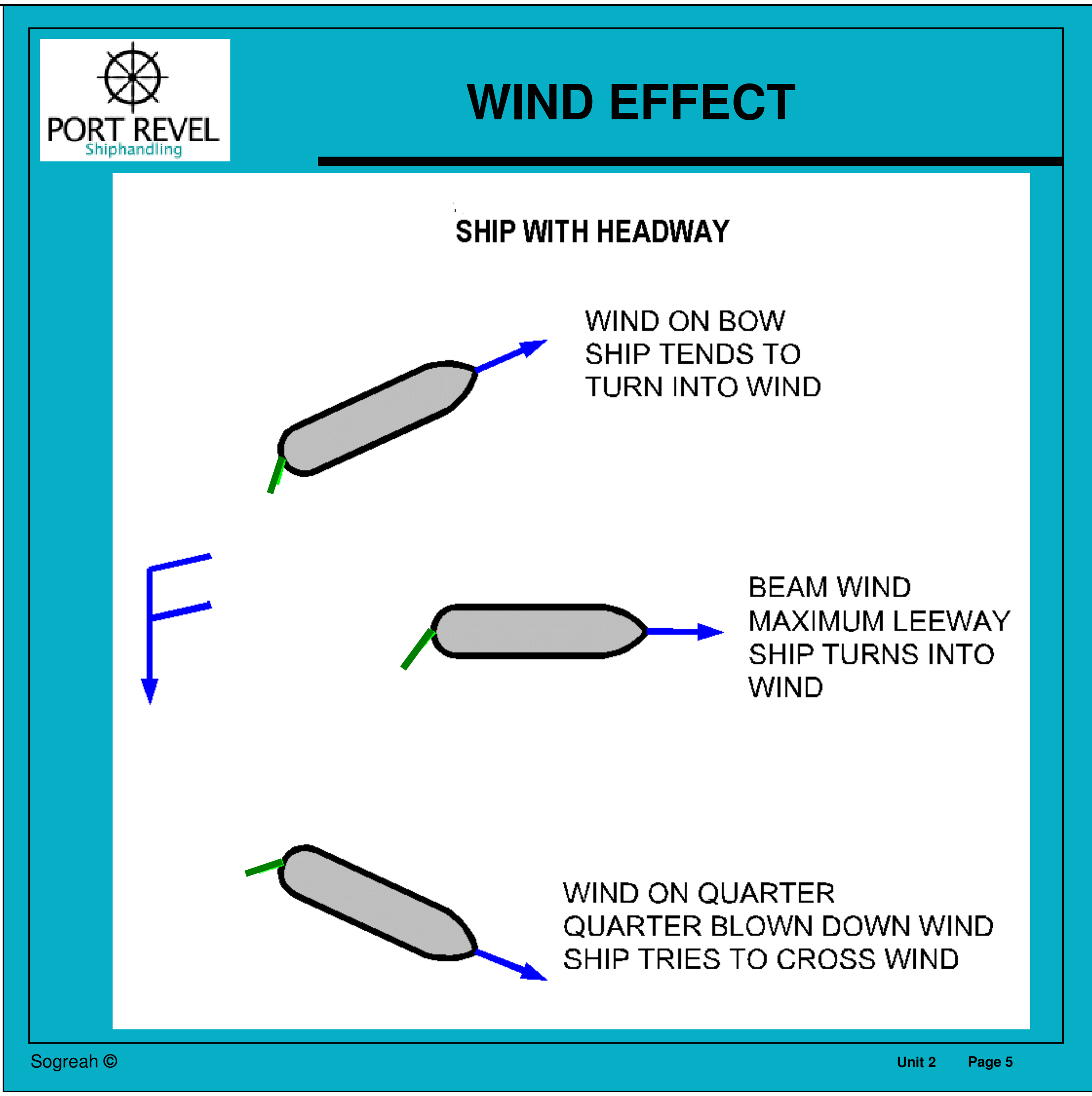


Fw - Wind induced forces make the ship drift
Fu - Under water resistance forces due to the drift
W - Centre of area of dead works
R - Centre of application of under water resistances forces which moves with the ship's motion.

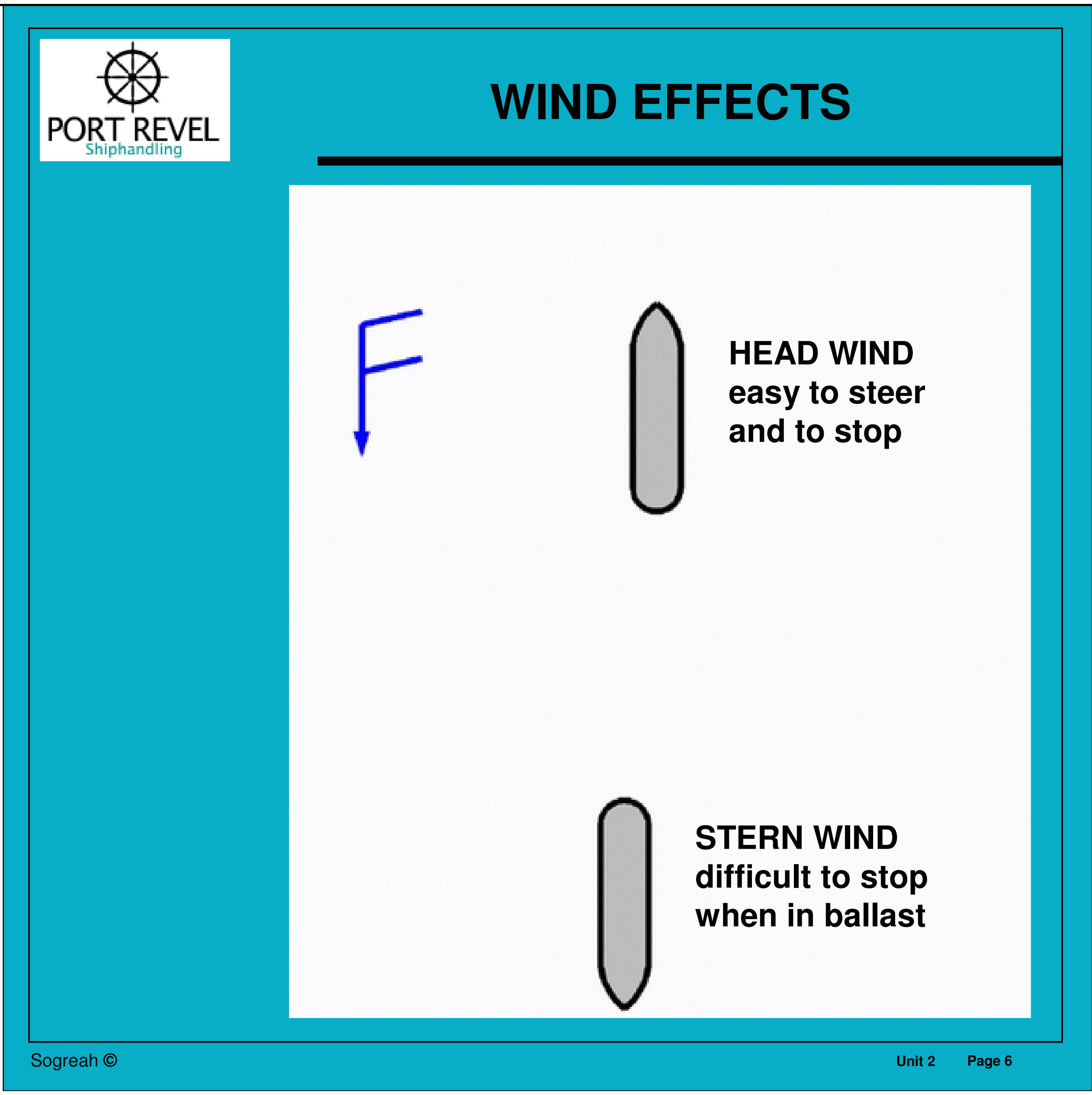
The wind-induced forces applied at the centre of area of the ship's dead-works make her drift and generate, on the opposite side, underwater resistance forces applied at the centre of area of her quick-works when she is at rest.

With headway, the underwater resistance R moves as indicated.

These forces, opposed to each other, form a couple, which tends to turn the ship towards a balance position, close to beam wind.



When the vessel is underway, the application point of the underwater resistance forces moves towards the leading edge, i.e. the bow with headway or the stern with sternway, which makes the ship haul up, with headway, or back into the wind with sternway, at the same time as she is drifting.



Points to consider when manoeuvring a ship in wind conditions:

a) What heading relative to wind will the vessel tend to adopt when steerage-way is lost?

b) How slowly can the vessel be going in the wind before losing steerage-way?

c) How fast will the vessel drift to leeward?

d) At what point off the wind will the vessel tend to head while she still has steerage-way?

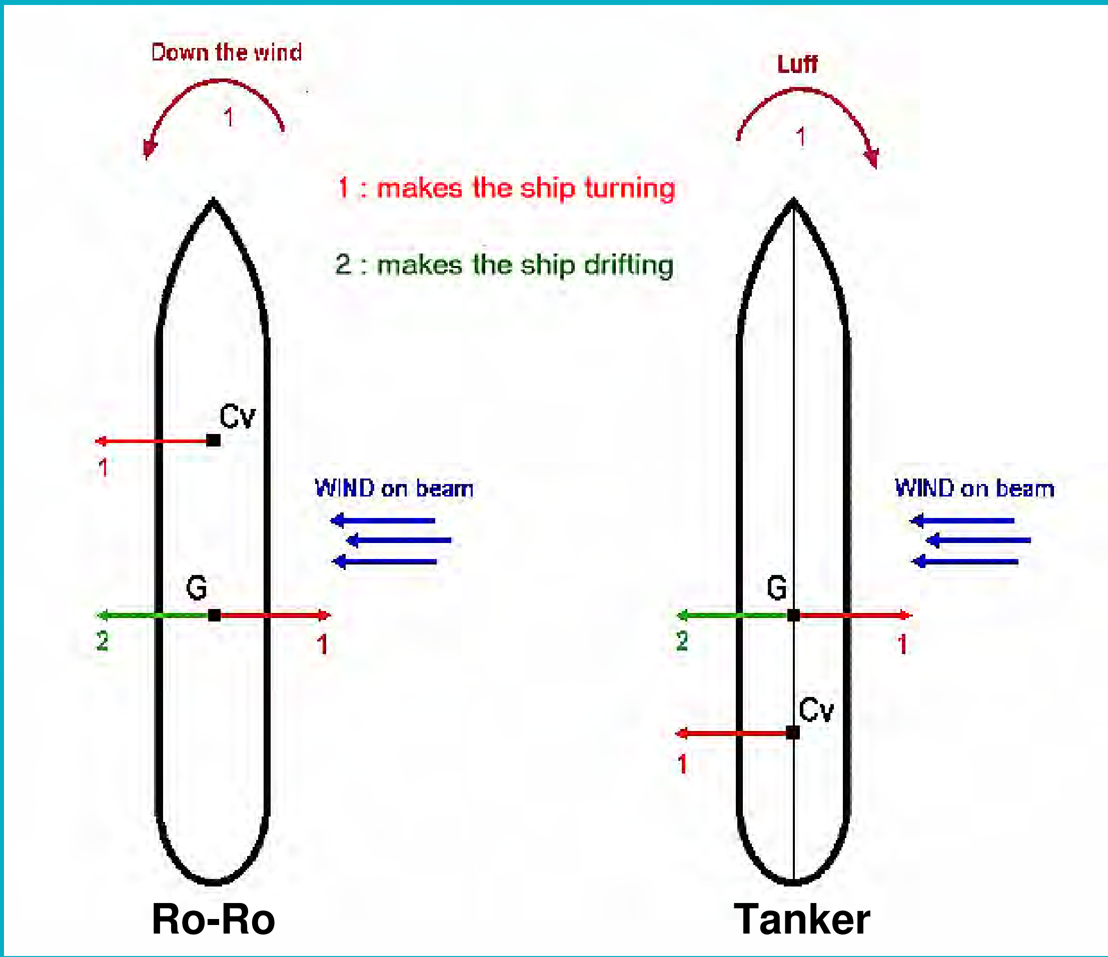
e) How can the wind be of help in the intended manoeuvre?

f) Can the manoeuvre be done safely in the existing conditions?

About storms …

Photo Columbia River Bar Pilots

WIND EFFECT ON BEAM



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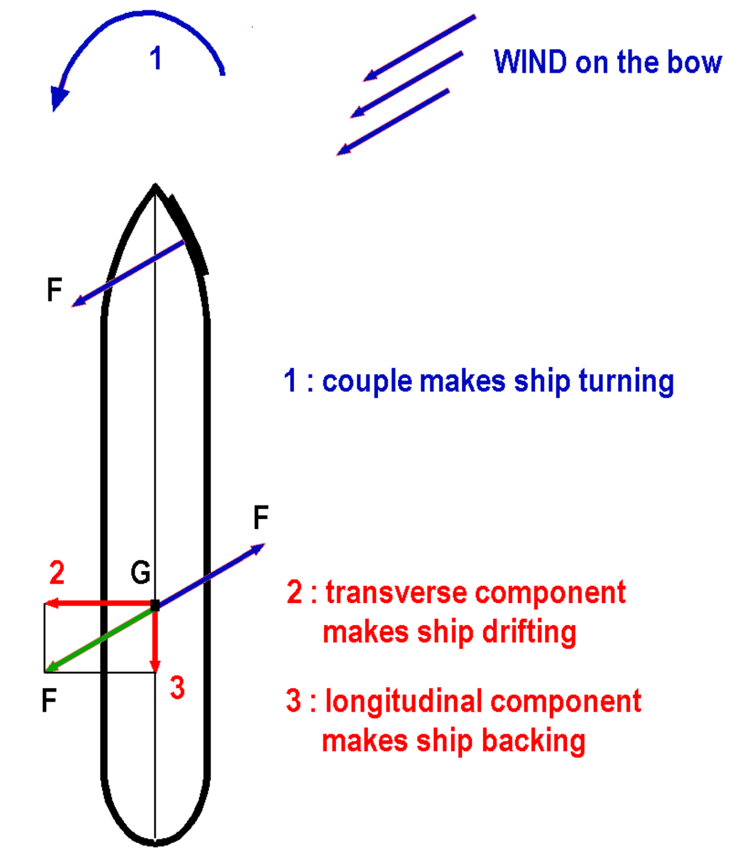
Due to the shape of superstructures, a tanker will luff to the wind, and a Ro-Ro ship will move down the wind

WIND EFFECT ON BOW



Ship stopped over the ground

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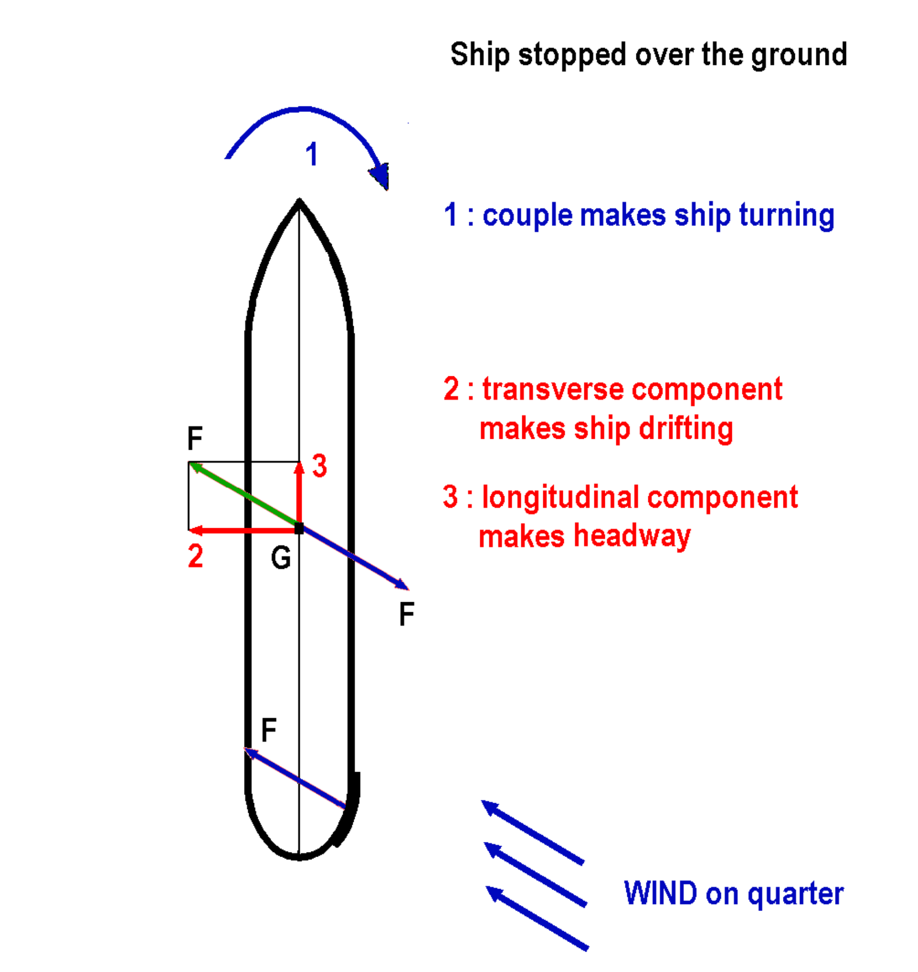
PORT REVEL Shiphandling

WIND EFFECT ON STERN



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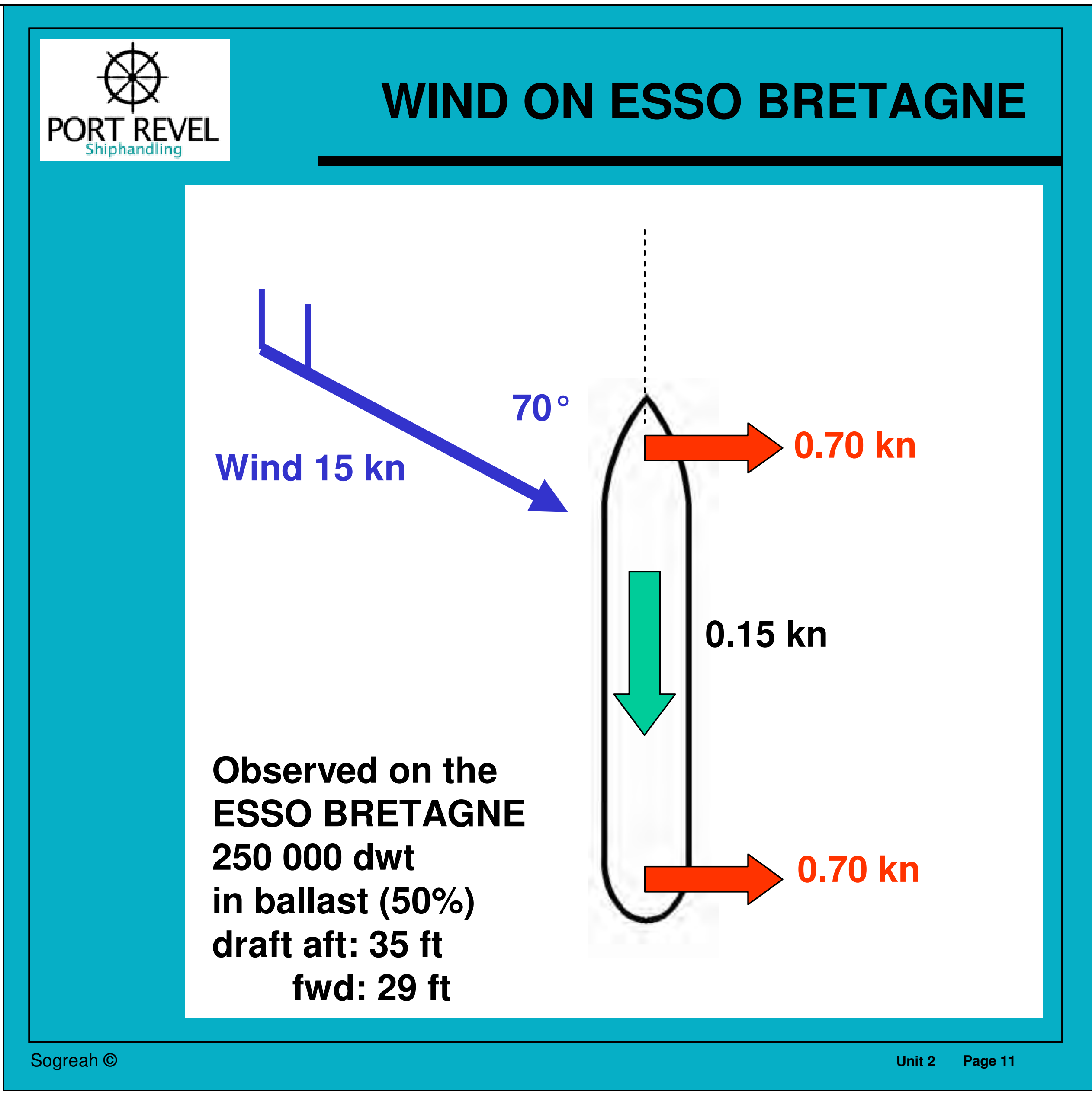
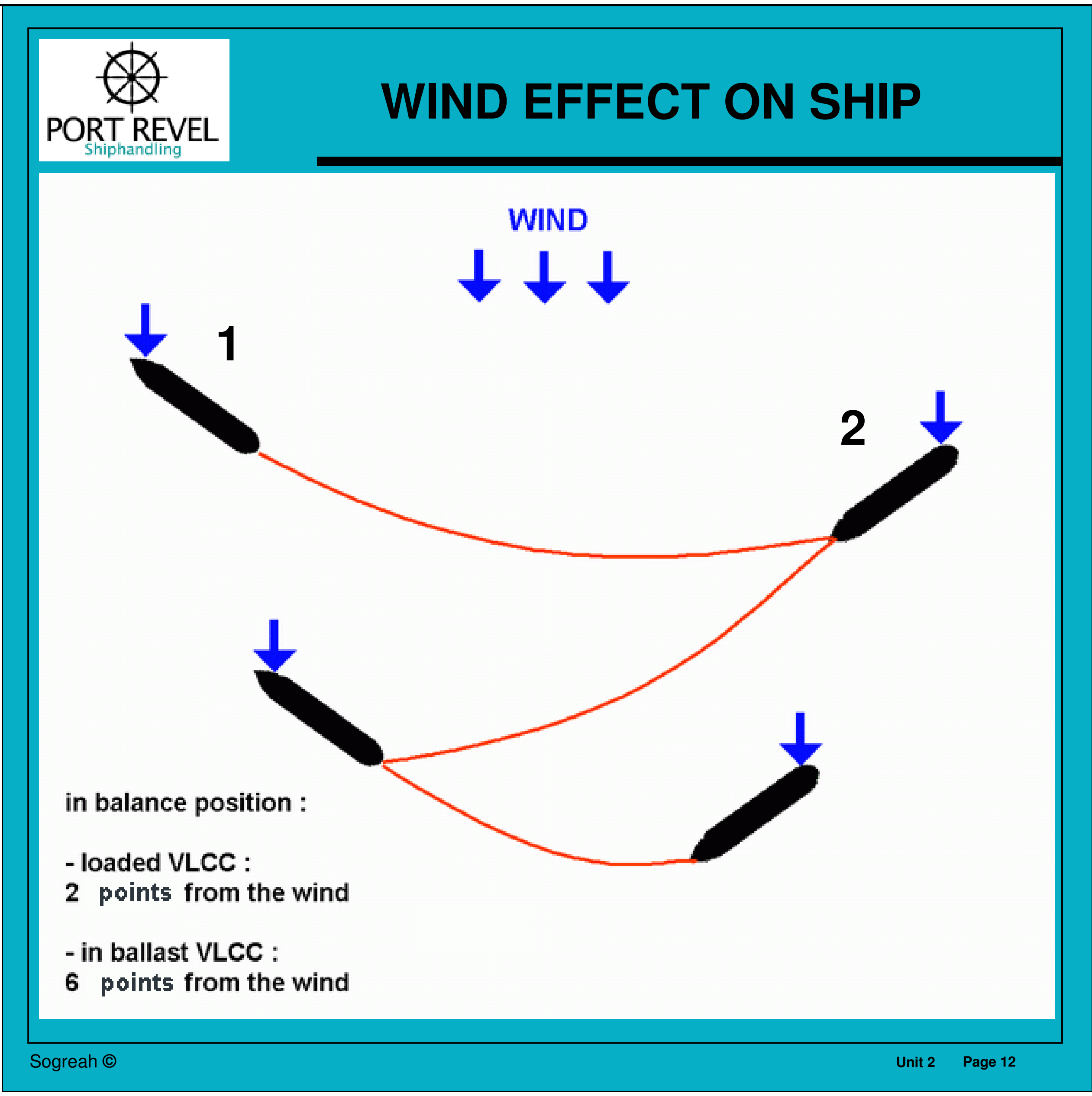


With 15 kn of wind on the bow, she is drifting at 0.7 kn and backing at 0.15 kn



Position 1: ship dead in water with wind on shoulder: drifting ship gets sternway

>> Pivot Point moves aft

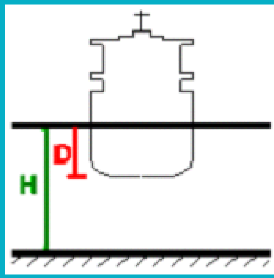
Position 2: ship dead in water with wind on quarter: drifting ship gets headway

>> Pivot Point moves forward

DRIFTING SPEED

For 30 kn wind :

FULLY LOADED VLCC :



H/D = 1.2 >> Drift = 0.36 kn

H/D = 3 >> Drift = 0.66 kn

IN BALLAST VLCC :

H/D = 2 >> Drift = 0.96 kn

H/D = 3 >> Drift = 1.20 kn

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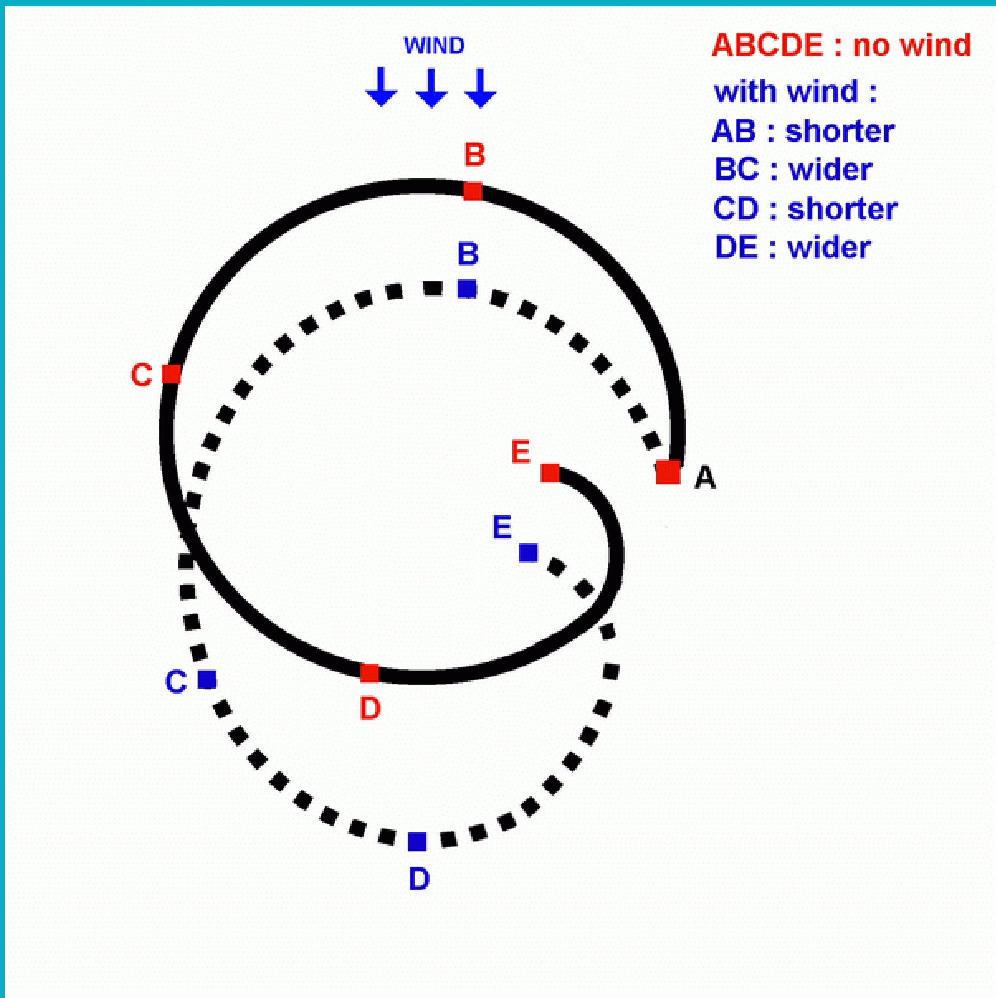
More drift on deep water than on shallow water.

TURNING CIRCLE WITH WIND



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Section BC may become too wide with wind, so that you may have to turn her into the wind first: turn clockwise to starboard instead of port

FORCES DUE TO THE WIND (1)

BEAM WIND (Transverse Force)

$$Fy_{[tons]} = 0.52x \ 10^{-4} \ x Area[Sqm] \ x \ W^{2} [m/s]$$

with W = wind speed in metres/second (1 m/s = 2 kn)

HEAD WIND (Longitudinal Force)

$$Fx_{[tons]} = 0.39 \ x \ 10^{-4} \ x \ Area \ [Sqm] \ x \ W^{2} \ [m/s]$$

WIND SPEED	BEAM WIND		HEAD WIND	
	Kg/m^2	Lb/Sqft	Kg/m^2	Lb/Sqft
10 kn	1.3	0.27	1.0	0.20
20 kn	5.2	1.06	3.9	0.80
30 kn	12.0	2.40	9.0	1.80
40 kn	21.0	4.24	15.6	3.20
50 kn	33.0	6.66	24.8	5.60

Care for the squared wind speed !

FORCES DUE TO THE WIND (2)

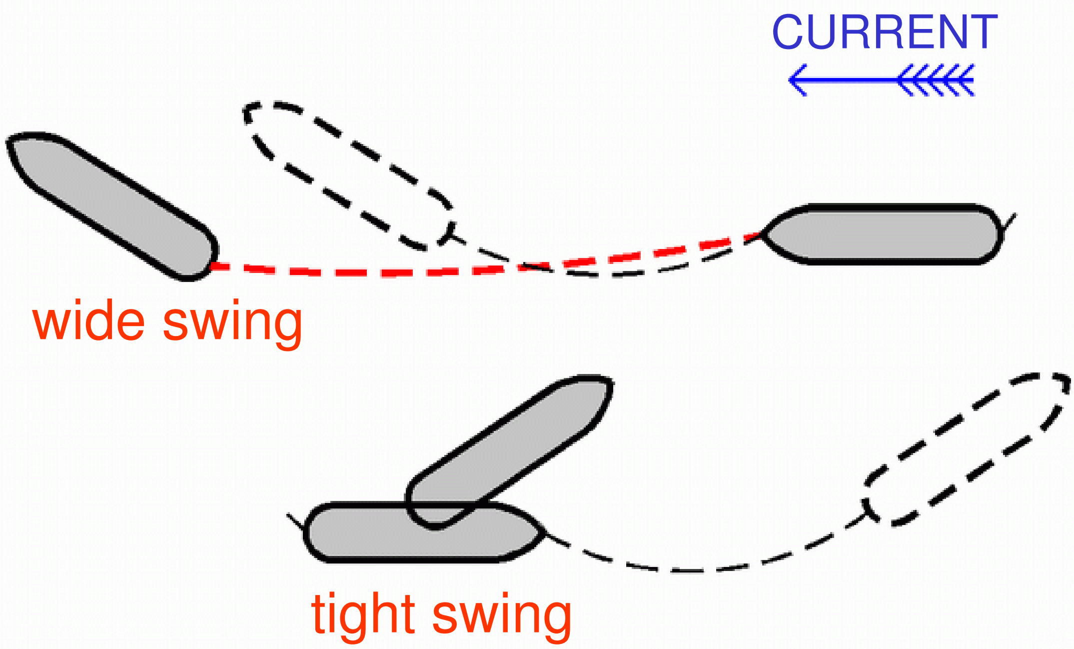
■ EXAMPLES (FORCES IN TONS)

Ship	Exposed area (m^2)			10 kn	20 kn	30 kn	50 kn
Brittany (ballast)	Head	1,019	Fx	1.0	4.0	9.0	25.0
Draft = 11.10m	Beam	4,696	Fy	6.0	24.0	55.0	153.0
Gilda (70% loaded)	Head	1,017	Fx	1.0	4.0	9.0	25.0
Draft = 10.70m	Beam	3,438	Fy	4.5	18.0	40.0	112.0
Ben Franklin (LNG)	Head	1,480	Fx	1.5	6.0	13.0	36.0
Draft = 11.10m	Beam	6,587	Fy	8.6	34.0	77.0	214.0

Tens of tons … many tugs: be careful when wind is expected to be over 25 kn …

Note that forces on the LNG carrier are twice those on the partly loaded oil tankers

CURRENT EFFECTS



After G.L. Danton

Sogreah © Unit 2 Page 17

Consider the current in the vicinity of confined waters. The current at different points across and along a river, or in and about port facilities inside a harbour and across the ends of jetties, varies in strength tremendously and frequently eddies in the opposite direction. The current may be nearly uniform against a short, small vessel over its entire length. But a 1,000-foot long tanker may have an entirely different force or direction acting on one end than on the other end during a stretch of river or harbour steaming. Furthermore, the large ship's speed in terms of **ship lengths per hour** is a very small fraction of the speed of the small vessel in terms of **her ship lengths per hour** whilst crossing a variable current even though their actual speeds are the same. The current affects all ships equally until they begin to cross lines of changing current. Then the large long vessel has much greater difficulty than the smaller vessel.

PORT REVEL Shiphandling

FORCES DUE TO CURRENT (1)

BEAM CURRENT

$$Fy_{[tons]} = C \times \frac{104.4}{7{,}600} \times Area_{[m^2]} \times V^2_{[knots]}$$

"C" depends on the bottom clearance

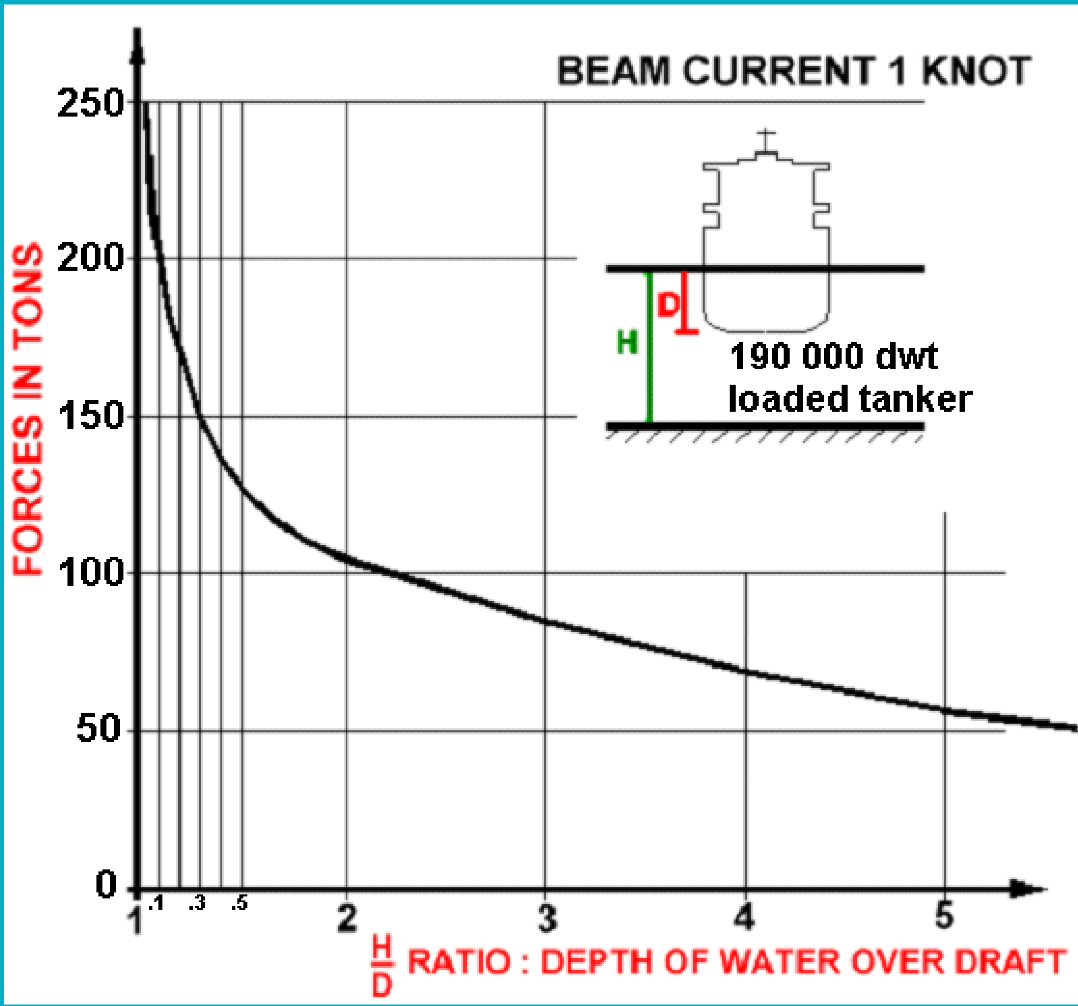
$\frac{Depth}{Draft} = \frac{H}{D}$	1.05	1.10	1.20	1.50	3.00	6.00
C	3.30	2.90	2.35	1.70	1.00	0.60

Video Tow Boat

Sogreah © Unit 2 Page 18

C increases dramatically when clearance decreases.

FORCES DUE TO CURRENT (2)



The effect of the current increases **drastically** when the under-keel clearance reduces.

With H/D = 2, the transverse force with a beam current of only 1 kn is around 100 tons: the bollard pull of 2 big tugs …

With H/D = 1.1, the transverse force increases to over 200 tons.

When a long ship is steaming or turning in restricted and confined waters, the under-keel clearance can be quite different at different points of the keel, and thus, in spite of a uniform current, the induced current forces will be different on each part of the vessel, resulting in rotation of the ship.

FORCES DUE TO CURRENT (3)

FOR 1 KNOT BEAM CURRENT

Current forces in tons

$\frac{\text{Depth}}{\text{Draft}} = \frac{H}{D}$	1.05	1.10	1.20	1.50	3.00	6.00
C	3.30	2.90	2.35	1.70	1.00	0.60
Antifer 400,000 dwt A = 7,414 m²	336	295	239	173	102	61
Brittany 190,000 dwt A = 5,642 m²	256	225	182	132	78	46
Gilda 125,000 dwt A = 4,185 m²	190	167	135	98	57	34
Berlin 38,000 dwt A = 2,320 m²	105	92	75	54	32	19

If the current speed is different from one knot, multiply these figures by the square of actual current.

Hundreds of tons: **do not try to move a ship against the current !**

A one-knot uniform current will have exactly the same effect on the speed of a 10,000-ton vessel as on a 100,000-ton vessel, but the momentum of the first will be changed by the amount of 10,000 tons-knot while the change in the momentum of the other will be 100,000 tons-knot because of the difference in inertia between the two vessels.

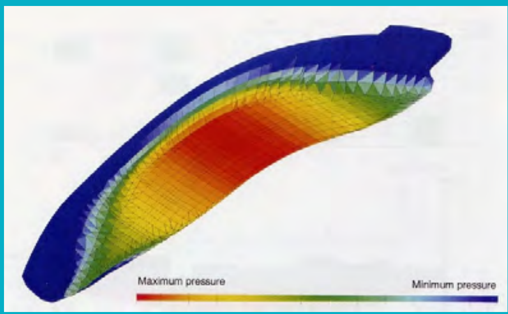
SWELL IN ASTORIA

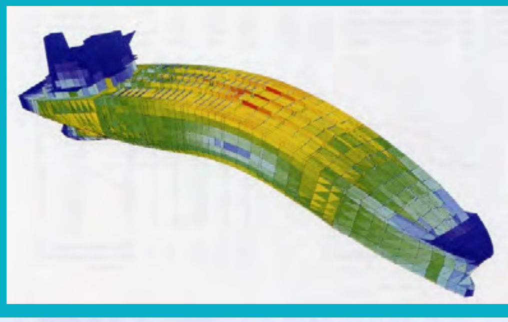
Photo Columbia River Bar Pilots

Sogreah © Unit 2 Page 21

According to the ratio of the ship's rolling or pitching period to the wave period, the ship will pitch and roll over the waves, or just break the waves and absorb kinetic energy.

STRESSES ON SHIP





From K. van Dokkum

Sogreah ©   Unit 2   Page 22

Ships are (fortunately) more flexible than one might think …

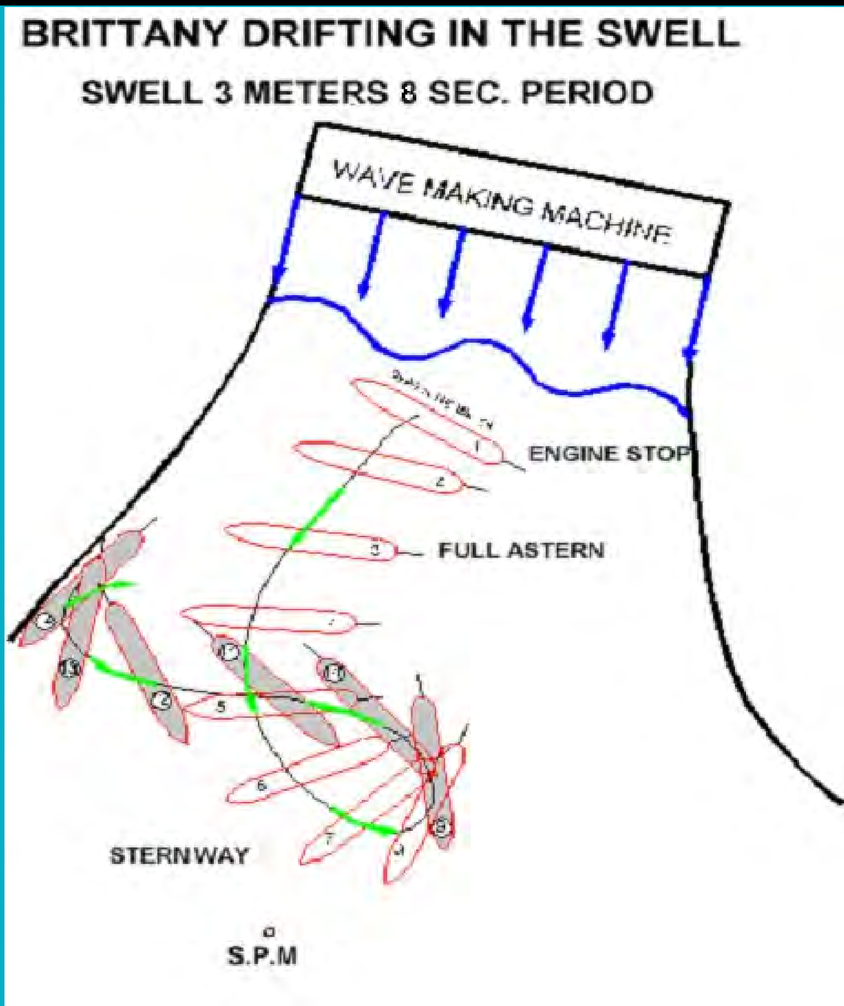
BRITTANY IN SWELL

Drifting at 2.5 kn with engine stopped

Sogreah © Unit 2 Page 23

The wave-induced forces will make the ship drift and the behaviour of the ship will be the same as if affected by wind-induced forces.

SWELL EFFECT



Sogreah ©

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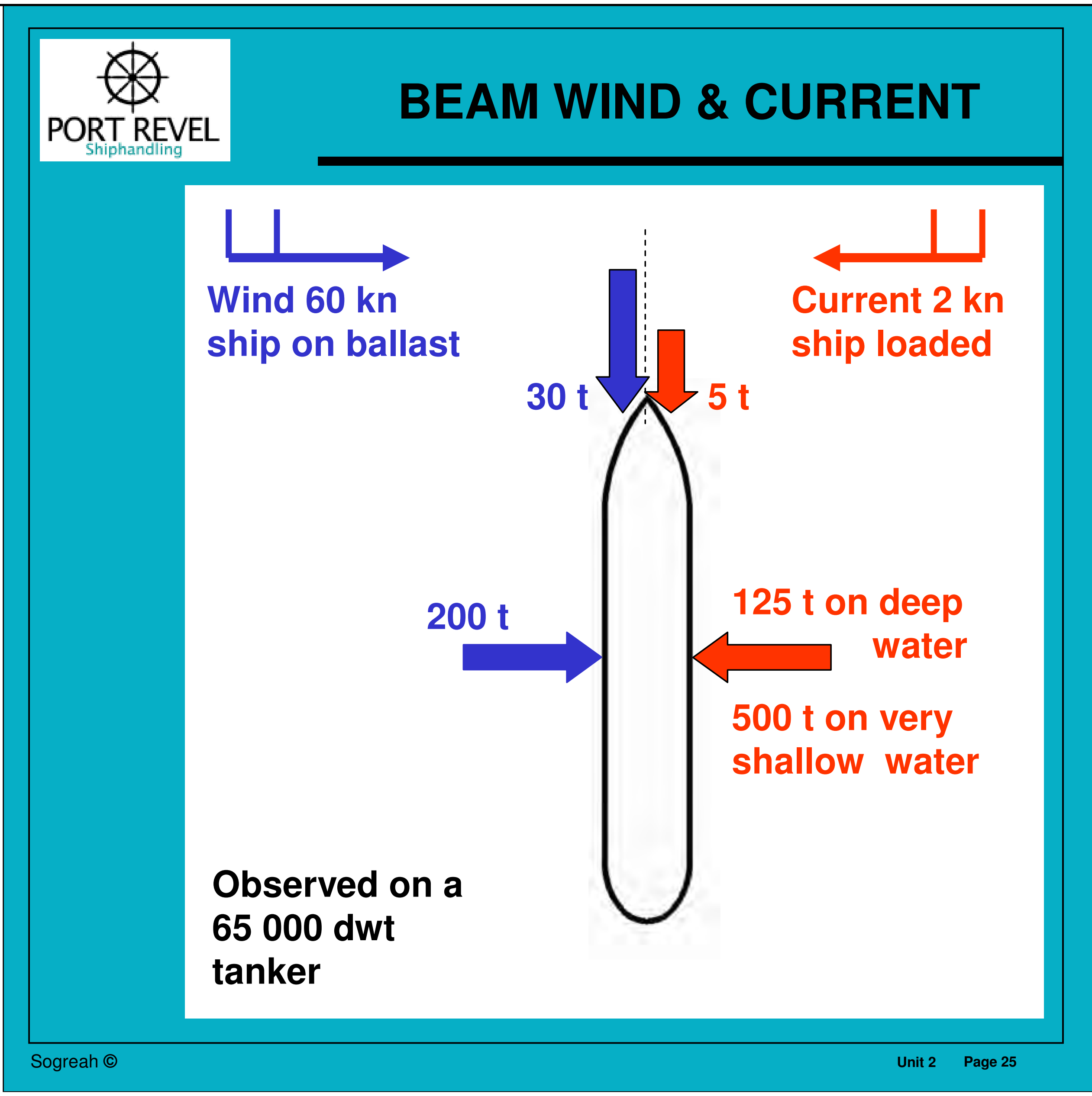
When full astern in a wave field, the Pivot Point moves astern: the ship is drifting the stern into the swell.



Force due to beam current on very shallow water (H/D < 1.20) is **4 times** the force on deep water.

PORT REVEL Shiphandling

BEAM WIND & CURRENT & SWELL

Tanker 500 000 DWT

Loaded draft = 29 m
Depth = 34 m

		Ship in ballast	Ship loaded
WIND	20 m/s (40 kn)	230 T	82 T
CURRENT	0.5 m/s (1 kn)		360 T
SWELL	8 sec/2 m		147.5 T
	8 sec/3 m		325 T
	8 sec/4 m		575 T

Hundreds of tons …

ICE

under control … if ice-breaker available

Sogreah ©

Unit 2 Page 27

SEICHES

Seiches are more real than Nessie …

Probably the most famous picture of the Loch Ness monster was the "surgeon's photo" supposedly taken by Colonel Robert Wilson.
This photo was acknowledged as a fake, though, by Christain Spurling, who helped build the model monster that was photographed.
He admitted the hoax shortly before he died in1993, at age 90.

http://unmuseum.mus.pa.us/lochness.htm

Sogreah © Unit 2 Page 28

Seiche is the term referring to a standing wave, i.e. oscillations of the water from side to side or end to end, in an enclosed body of water.

Seiche may be caused by meteorological events such as moving low pressure front, by seismic vibrations or, as in the case of ocean harbours, by oscillations in the adjacent sea.

Although the initial oscillation may be hardly discernable, it can develop into a violent surging if the oscillations causing the movement are in harmony with the harbour's own natural frequency. At certain stages of the tide, the harmonics of a harbour may synchronize with the adjacent sea motions and result in back and forth surging of the water in the harbour.

It may not be evident to the eye nor evident on smaller vessels, but a very small amount of surging can put enough movement on a large-displacement vessel for her **to part all her mooring lines**. This has been known to happen in calm, flat harbours and for no apparent reason. Adverse surging is particularly evident in Pacific Ocean ports. It usually does not endanger smaller ships because their surging does not carry as much **momentum** as the surging, even if very slight, of a large-displacement tanker.

SHALLOW WATERS

Pelican in Nauw van Bath (2003)

Sogreah © Unit 2 Page 29

1,930 TEU container Pelican 1 suffered severe hull damage in collision with Maersk Bahrain on the River Scheldt near Antwerp on July 20, 2003.

Tugs from Multraship and URS pushed Pelican 1 onto a sand bank immediately after the collision to remove her from the narrow and busy Nauw van Bath shipping lane … and to avoid the risk of Pelican 1 sinking.

UNIT 3 – FORCES UNDER CONTROL

The slides hereafter clarify the following aspects:

1. FORCES ACTING ON A SHIP

1.1. ENGINE TYPES

1.2. PROPELLERS

1.3. RUDDERS

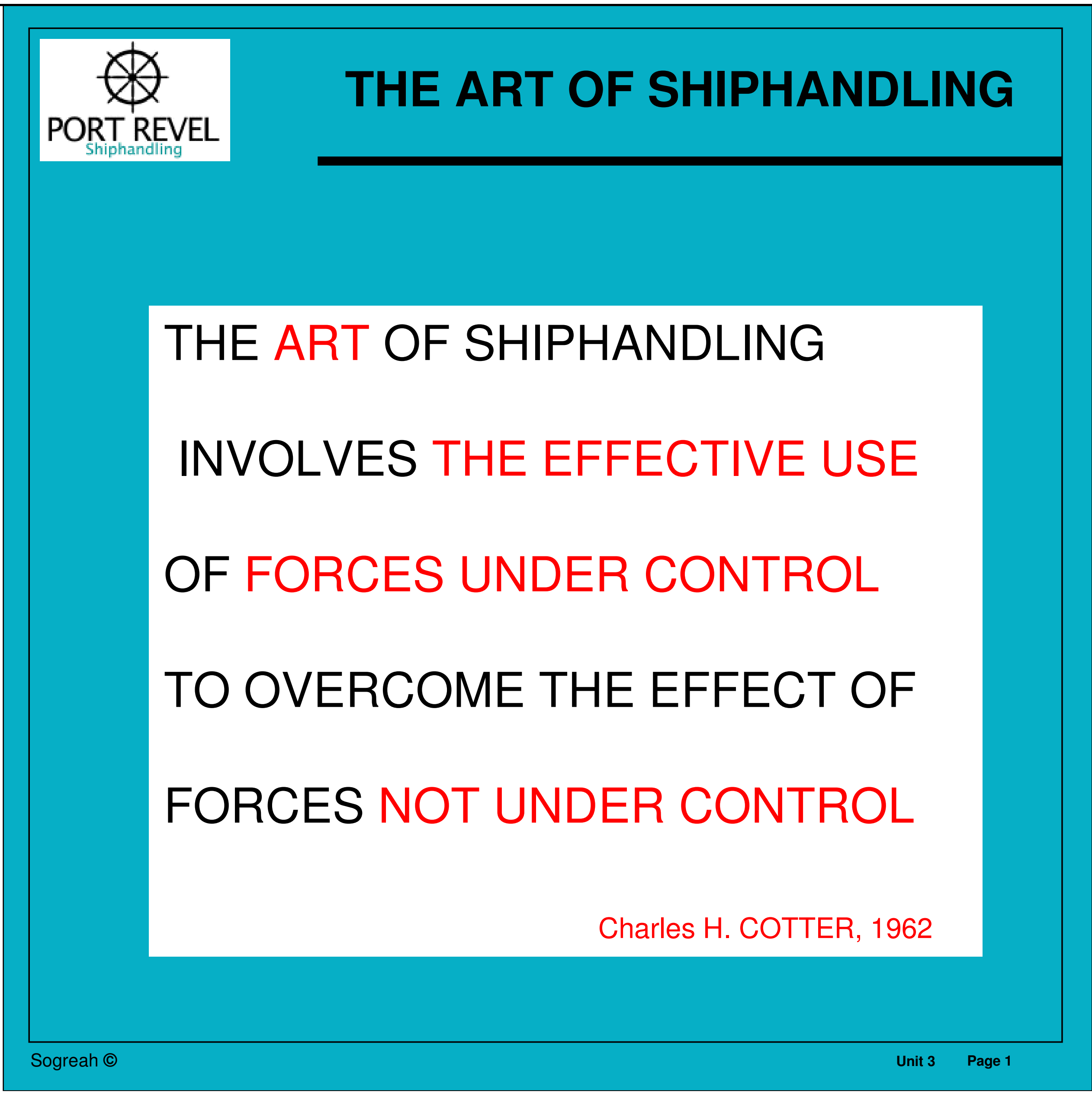
1.4. THRUSTERS

1.5. TUGS

1.6. MOORING LINES

1.7. ANCHORS (PM: SEE UNIT 5)

2. PIVOTING POINT



Shiphandling is an **art** more than a science.

We believe generally that:

- some forces are under control: man made ships, …
- other forces are not under control: Mother Nature.

UNIT 3 – Tuesday

FORCES ACTING ON THE SHIP

Engine types
Propellers
Rudders
Thrusters

Tugs
Mooring lines
Anchors (pm: see unit 5)

Photo: Trireme Trust

Sogreah © Unit 3 Page 2

Reconstruction of an ancient **trireme** used by Greeks and Romans between 6th century BC until 4th century AD. By John Morrison, John Coates and Frank Welsch in 1987.

The ship was named Olympias. Her length is 37 m, the beam is just under 6 m.

There were usually 200 men on board, including 170 rowers.

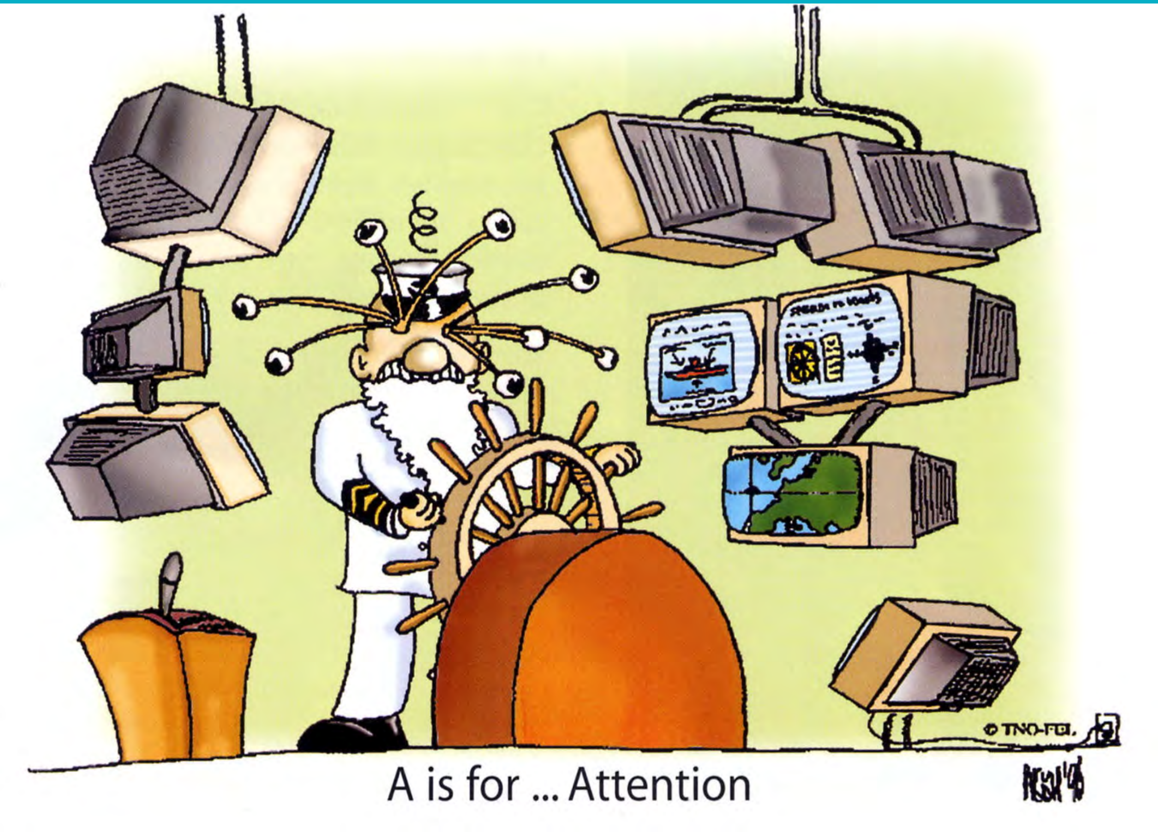
The cruising speed may have been 6 kn, with a sprint speed of 9 kn under oar.

For further information, see:

•http://home-3.tiscali.nl/~meester7/engtrireme.html

•http://www.atm.ox.ac.uk/rowing/trireme/

AN ERGONOMIC NIGHTMARE



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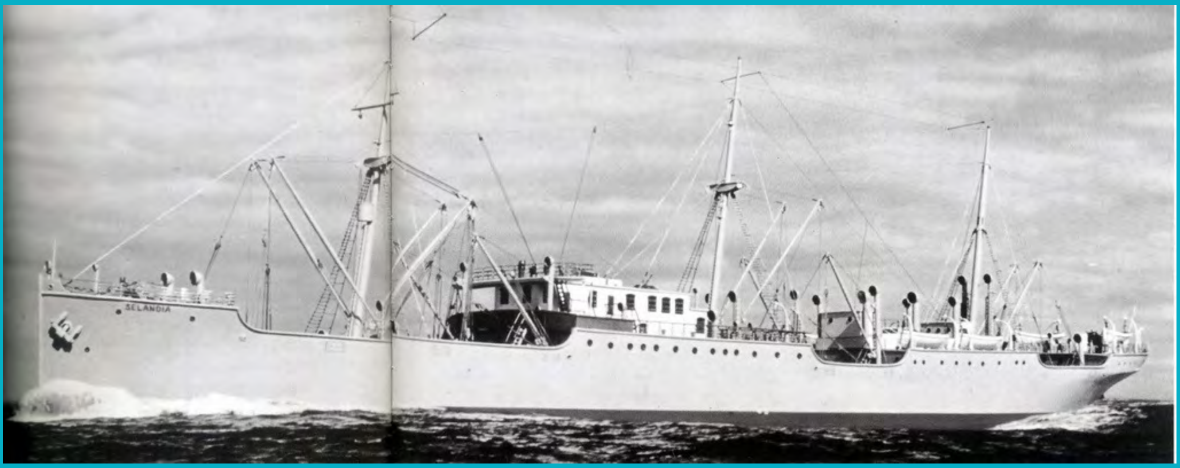
Unit 3 Page 3

The SELANDIA
6 800 dwt - 1912

First oceangoing diesel engine powered ship, launched in Denmark.



L = 115 m   B = 16 m
Twin-screw with two 8-cylinder 1250 HP diesel engines

Sogreah ©   Unit 3   Page 4

ENGINE TYPES:

Diesel

- This is the most common type of propulsion for almost all the ships today.
- Quick starts and stops of propeller while manoeuvring at slow speed.
- "Dead slow ahead" R.P.M., sometimes as much as 30% of maximum R.P.M.
- Difficult to start in reverse when making good headway.
- Older types are limited with regard to the number of starts that can be made in a given period of time.

PORT REVEL
Shiphandling

T-2 tanker PETERSBURG
17 000 dwt

481 T-2 tankers were built in the USA during WW2

L = 160 m B = 21 m D = 9 m V = 14.5 to 16 kn
6 000 HP turbo-electric propulsion

Sogreah © Unit 3 Page 5

ENGINE TYPES:

Steam Turbine

- Takes time to build up or reduce R.P.M.

- Backing power is limited. Most astern turbines give less than 2/3 the R.P.M. of the ahead turbine.

- When using a "touch ahead" to regain steering, the gradual build-up sometimes increases headway before the propeller race is strong enough to re-establish steering.

- Turbines are capable of very low R.P.M. ahead or astern. This affords greater facility when working engines against a mooring line or anchor.

Turbo-electric or diesel electric

- Are very handy.

- Full power is quickly available ahead or astern.

- Low R.P.M. are possible.

- Unfortunately, fuel oil consumption is too high.

J. O'BRIEN Liberty Ship
10 600 dwt - 2 500 HP

2751 ships built
from 1941 to 1945:

L = 135 m
B = 17 m

V = 11 kn

2 500 HP
3-cylinder
reciprocating
steam engine

Sogreah © Unit 3 Page 6

Out of the 2751 ships built during WW2, only two survived: the SS Jeremiah O'Brien (above) in San Francisco, and the SS John W. Brown in Baltimore.

Steam reciprocating engines are not in use any more.

PORT REVEL Shiphandling

QUEEN MARY 2 in 2003

L = 345 m (1132 ft)
B = 41 m (135 ft)
D = 10 m (33 ft)
H = 72 m (236 ft)
V = 30 kn
4 x 21.5 MW pods
Cost: US$ 800 M
Passengers: 2620
Crew: 1253

 Unit 3 Page 7

ENGINE TYPES:

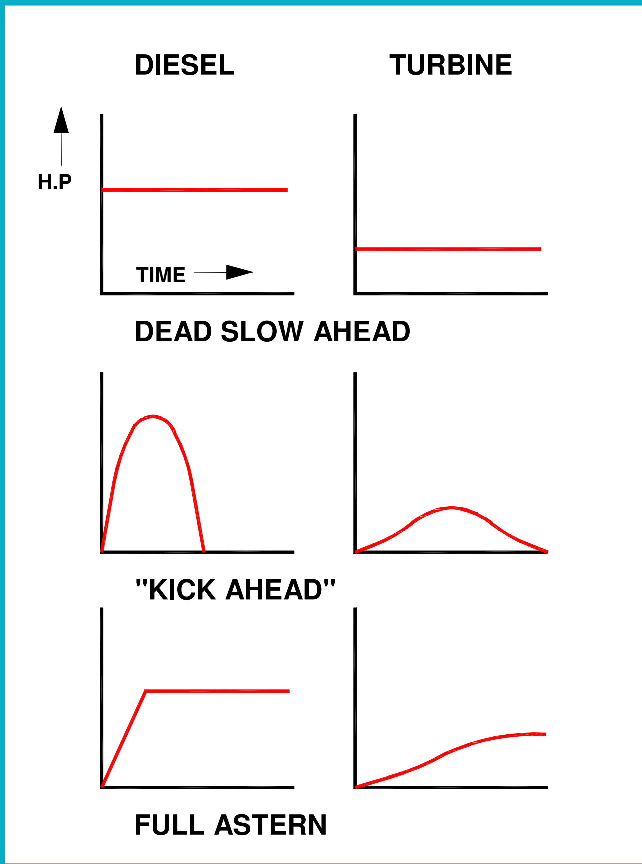
Pods:

Jointly developed by ALSTOM and ROLLS-ROYCE, the Mermaid™ design uses a minimum of mechanical parts to optimise available vessel space, ensure greater reliability, and reduce mounting time. Removal of the shaft line, propeller brackets and rudder, decreases the total resistance to motion by 5-10%. In addition, optimisation of the shape, positioning, and angle of Mermaid™ in relation to the ship allows an increase in efficiency of up to 15%, in comparison with conventional solutions.

Mermaid™ azimuthing through 360°, with controllable torque available in all directions, allows a faster and safer manoeuvrability. It also decreases vessel vibration and noise levels; and helps to provide an environmentally friendly vessel with reduced exhaust gas emissions.

Mermaid™ significantly increases ship capabilities, and enables vessels to reach high speeds of up to 30 knots as on the Queen Mary 2.

ENGINE TYPES



Sogreah © Unit 3 Page 8

Most ships have diesel engines by now, but still some turbines are found:

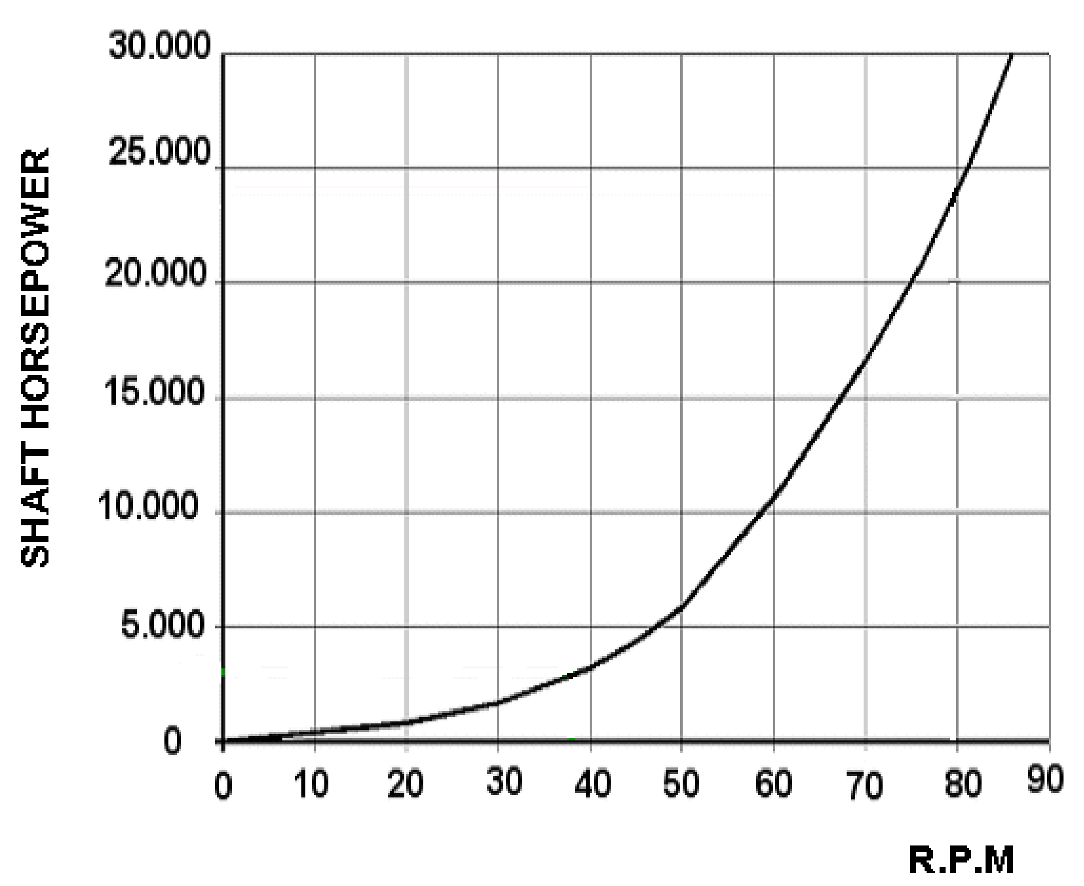
-Dead slow ahead is slower with a turbine than with a motor: you can run a minimum of 15 rpm instead of 35 or 40 with a motor.

- Turbine is similar in that to a Controllable Pitch Propeller.
- With cpp or turbine, you can manoeuvre without speeding up the ship.
- With a motor you will have to stop from time to time (and even to back the engine) and give a kick ahead to keep control.

The main drawback of turbine engines is their slow acceleration which requires more anticipation from the pilot. For this reason the Port Revel ships are set quite often with their turbine option.

VLCC POWER CURVE

For a loaded 200,000 dwt turbine vessel



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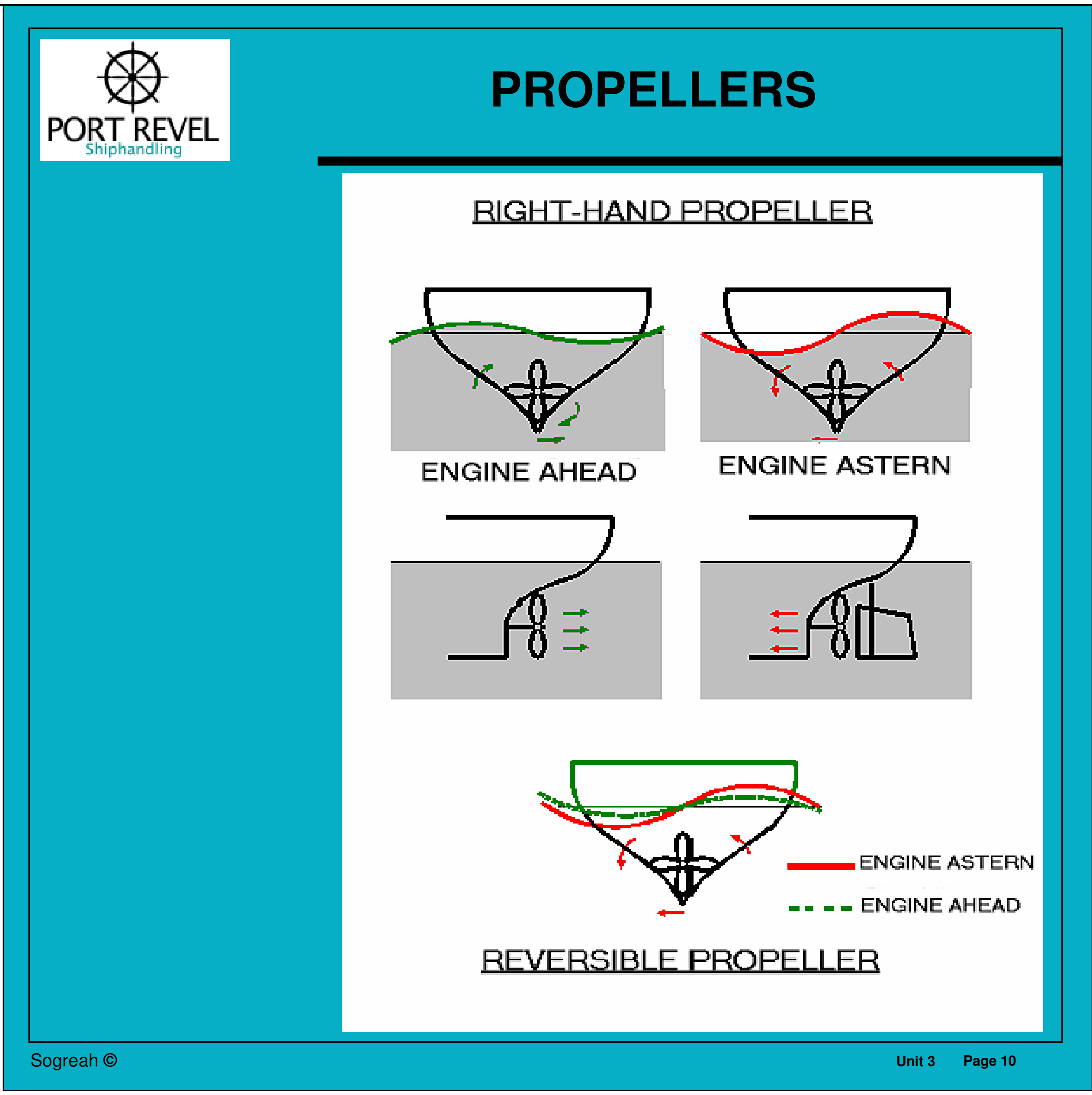


Single screw right-turning and twin screw out-turning are by far the most prevalent.

Single screw propellers (right-turning):

- When going ahead, the bow tends to cant to port most strongly at first, and, as headway increases, the effect lessens.

- When going astern, the stern tends to cant to port. This results in a pronounced swing to starboard.

ASTERN TRANSVERSE THRUST

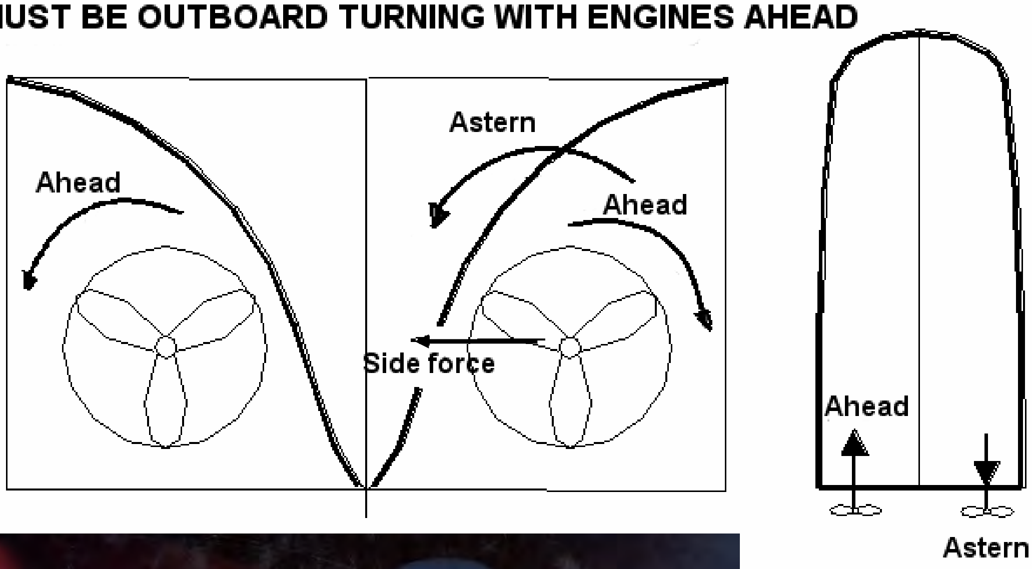
Mesured on the Brittany model

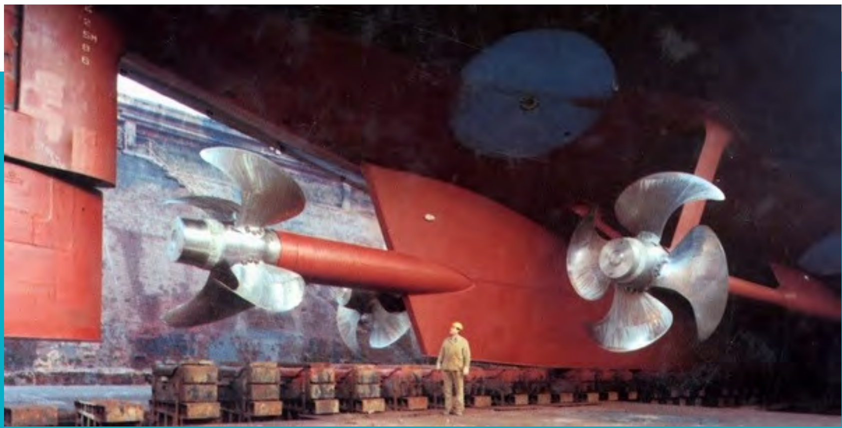
Engine order	RPM	Bollard Pull (t)	Transverse thrust (t)	% of B.P.
Ahead				
D.S	30	43		
Slow	45	105		
Half	65	234		
Full	85	371		
Astern				
Slow	30	31	5.4	17%
Half	55	85	11.8	14%
Full	80	176	26.5	15%

PORT REVEL
Shiphandling

TWIN SCREWS AND FIXED BLADE PROPELLERS

THEY MUST BE OUTBOARD TURNING WITH ENGINES AHEAD





Sogreah ©

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Twin screw propellers (outward-turning):

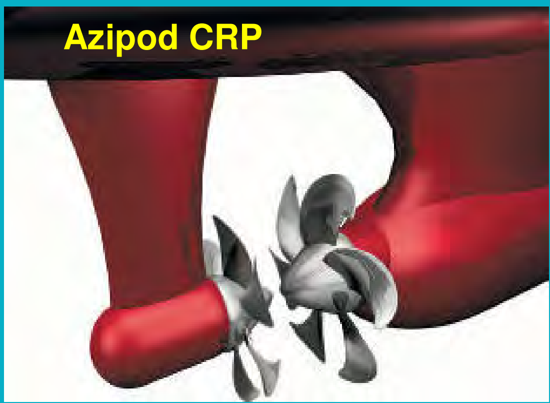
- **Rudder amidships:** Both propellers turning ahead or astern (same R.P.M.), “side forces" are cancelled out. Only fore-and-aft thrust remains.

- **Turn to port:** Both propellers turning clockwise, the “side force" pushing the bow to port helps to turn the ship.

- **Turn to starboard:** Both propellers turning counter clockwise, the “side force" helps to turn the ship similarly.

SPECIAL PROPELLERS

Schottel variable pitch



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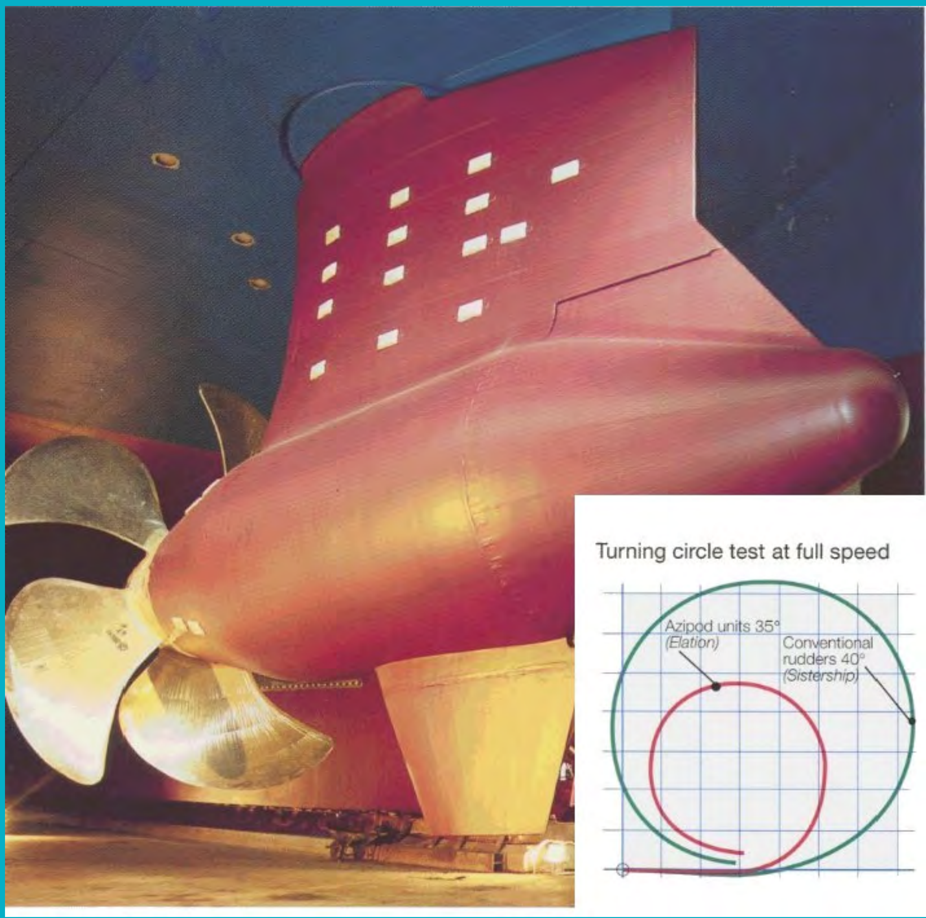
AZIPOD®



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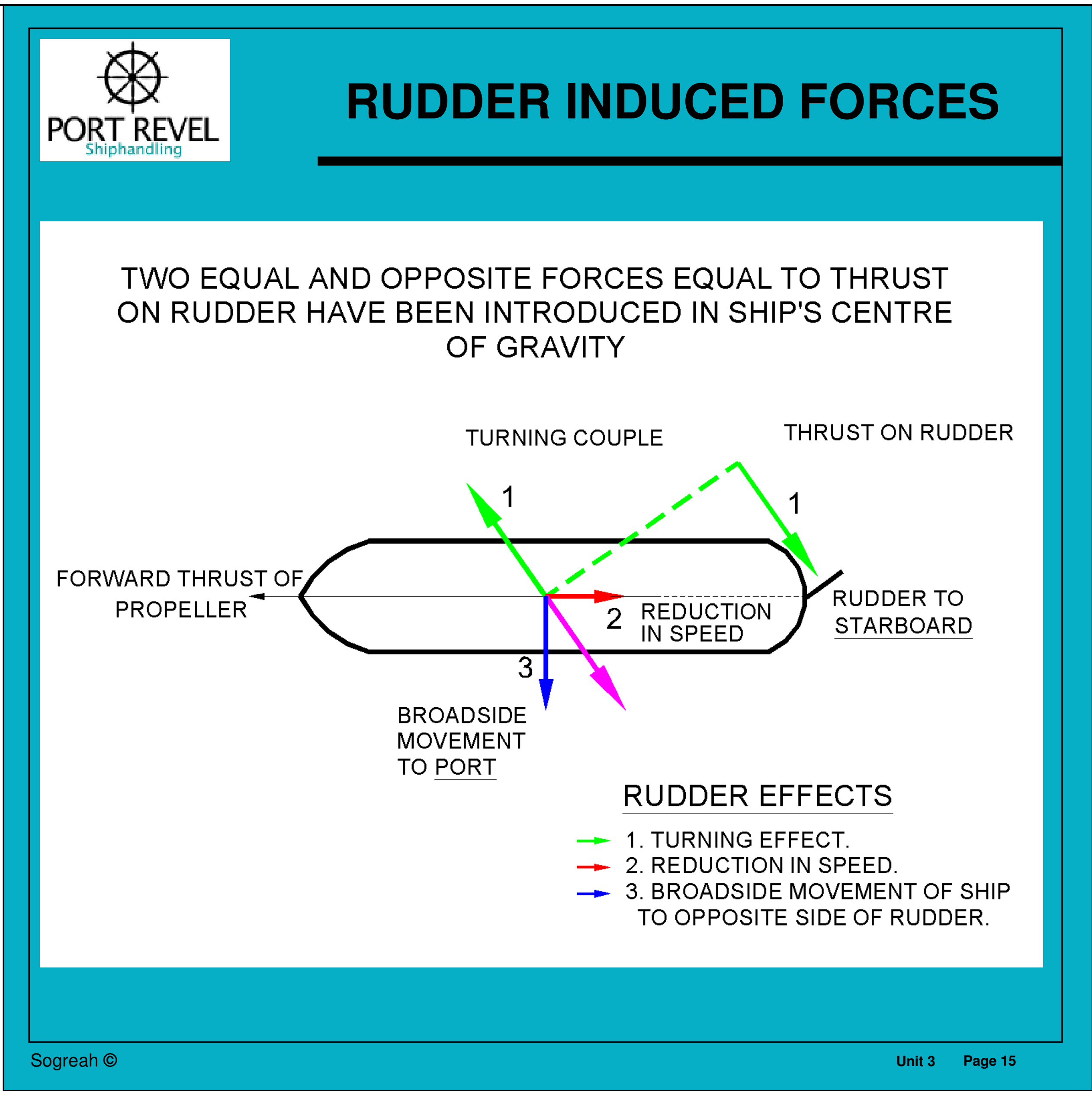


Rudders are most effective when located abaft the propeller. A great many twin screw vessels do not have this advantage. Transverse propeller thrust plays an important role and its effect varies with the size and area distribution of the rudder and stern form.

As the single screw race spirals astern of the propeller, part of the race is thrown against the port side of the upper half of the rudder. The other part is thrown downward against the lower starboard side of the rudder.

Theoretically, if the rudder area above the propeller axis is equal to the rudder area below it, the forces from the race acting on each side of the rudder will offset each other. Otherwise, transverse thrust can be increased or decreased depending on the distribution of the rudder area above or below the propeller axis.

RUDDER BLADE AREA

SHIP	DWT (t)	Lpp (m)	Draft (m)	Wet Ship Area (m^2)	Rudder Area (m^2)	Ratio %
BERLIN	38 000	201	10.92	2 195	33.23	**1.5%**
GILDA	125 000	269	15.52	4 175	65.30	**1.6%**
BRITTANY	190 000	305	18.45	5 627	93.00	**1.7%**
EUROPE	255 000	329	20.00	6 580	110.00	**1.7%**
ANTIFER	400 000	337	22.00	7 414	140.00	**1.9%**
BEN FRANKLIN	89 000	256	11.10	2 842	51.00	**1.8%**

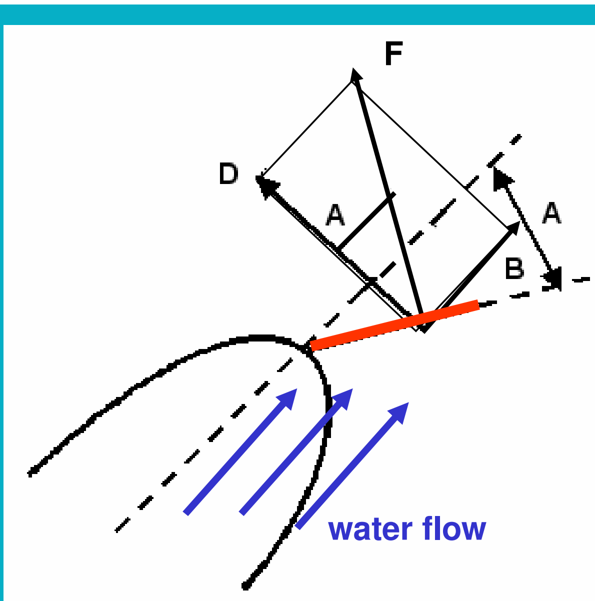
NB: Wet Ship Area = Lpp x Draft as a first aprox.

The rudder blade area is about 1.5 to 2% of the wet area of the ship.

A rudder is efficient in steering a ship only due to the fact that a strong water flow from the propeller hits it.

MAXIMUM RUDDER EFFECT

THE MAXIMUM STEERING EFFECT WITH CONVENTIONAL RUDDER IS 45°



$F = k \times Area \times (speed)^2 \times sine\ A$

$D = F\ cosine\ A$

$B = F\ sine\ A$

Area is the area of the rudder

Speed is the speed of the water

k is a coefficient

D : component generating steering effect

B : component generating braking effect

According to the trigonometric formula: $sine\ 2A = 2\ sine\ A \times cosine\ A$

Thus: $D = k \times Area \times S^2 \times sine\ A \times cosine\ A$

$D = k' \times Area \times S^2 \times sine\ 2A$

The maximum for sin 2A is 1 when A = 45°

Sogreah ©

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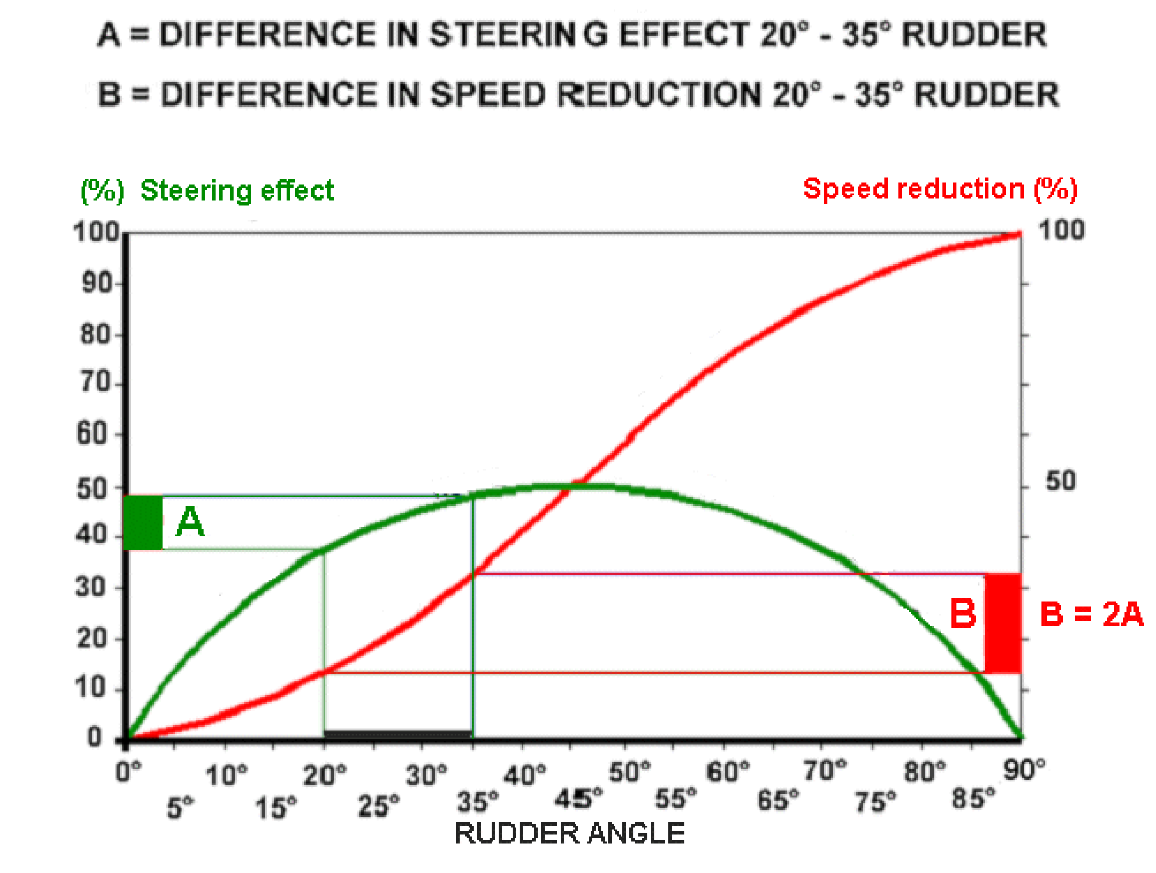
RUDDER EFFECT



Sogreah © Unit 3 Page 18

The maximum steering effect is obtained with 45° rudder angle.

The maximum braking effect is (theoretically) obtained with 90° rudder angle.

If you wish to limit the speed reduction, do not exceed 10° rudder angle.

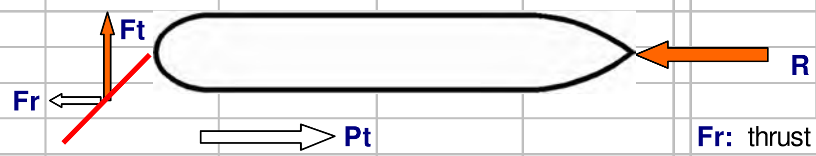
When increasing the rudder angle from 20° to 35°:

- the steering force is increased by 25% (from 40 to 50 in the example above)
- but the speed reduction is also increased (by over 100%, from 15 to 35 in the example above)

PORT REVEL
Shiphandling

TURNING & BRAKING EFFECT

NB: measured <u>static</u> forces on Normandie model with rudder at 40° to starboard



Fr: thrust on the rudder
Ft: measured steering force
R: measured thrust of ship
Pt: thrust of propeller

	Ft (t) (measured)	R (t) (measured)	Fr (t) = Ft * Tg 40°	Thrust (t) Pt = R + Fr
DS ahead	**15**	30	13	43
Slow	**45**	60	38	98
Half	**75**	85	63	148
Full	**165**	165	138	303

Steering force Ft is about half the total propeller thrust.

Steering force is 75 t at Half Ahead …

WHAT IS A KICK AHEAD ?

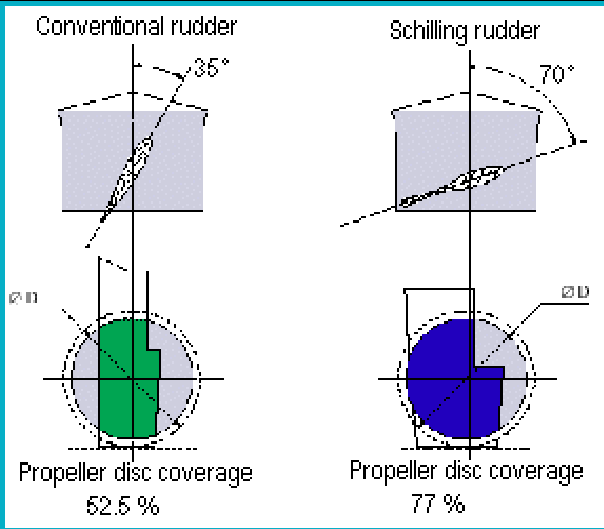
It is a good thrust on the rudder for a short time without gathering too much headway.

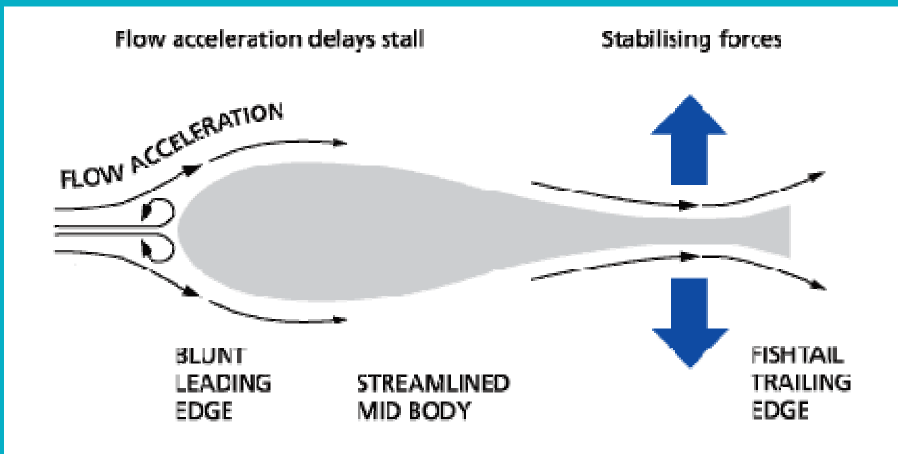
The greatest benefit of that is when you start from the ship dead in the water, first you put the wheel hard over, and only after that, put the engine half or full ahead: as soon as the forward movement is initiated the pp goes well forward, you have a great turning lever and the maximum rudder turning force (in fact it will never be better).

take care on the lake: 5s = 1s !

Maximum steering effect is obtained due to high flow velocity on the rudder blade.
Due to inertia effects, the ship will start to turn before she will start to move ahead.

SCHILLING RUDDER





http://www.becker-marine-systems.com

Sogreah ©

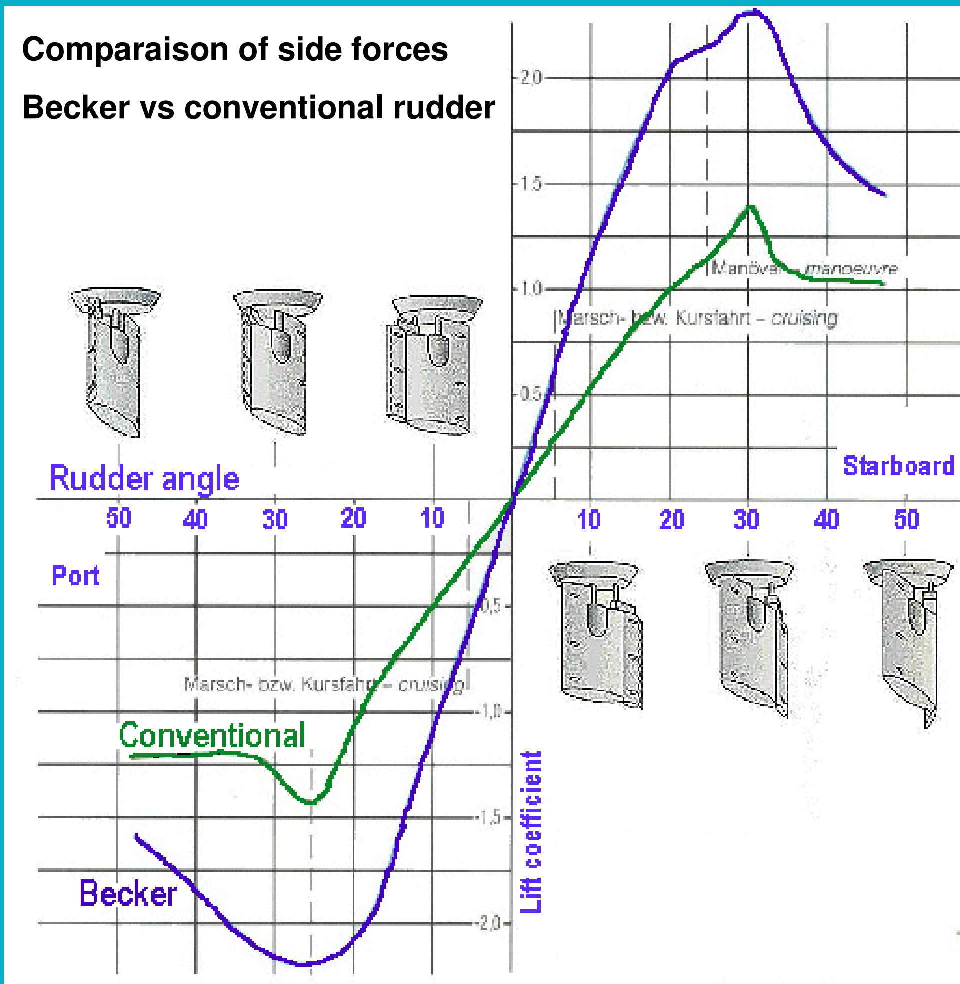
Unit 3 Page 21

With 70° max rudder angle, the Schilling rudder has a 77% propeller disk coverage instead of 52.5% for a conventional rudder with 35° max rudder angle.

The unique profile of the Schilling rudder incorporates a rounded leading edge promoting good flow properties at all rudder angles and a fishtail trailing edge that accelerates the flow and recovers lift over the aft section of the rudder.
This induces:

- Significantly reduced overshoot angles.
- Exceptional full speed course keeping ability.
- Improved crabbing and zero speed control.
- Enhanced turning capability with significantly reduced turning circles at speed.
- Reduced head reach and lateral deviation.

BECKER RUDDER



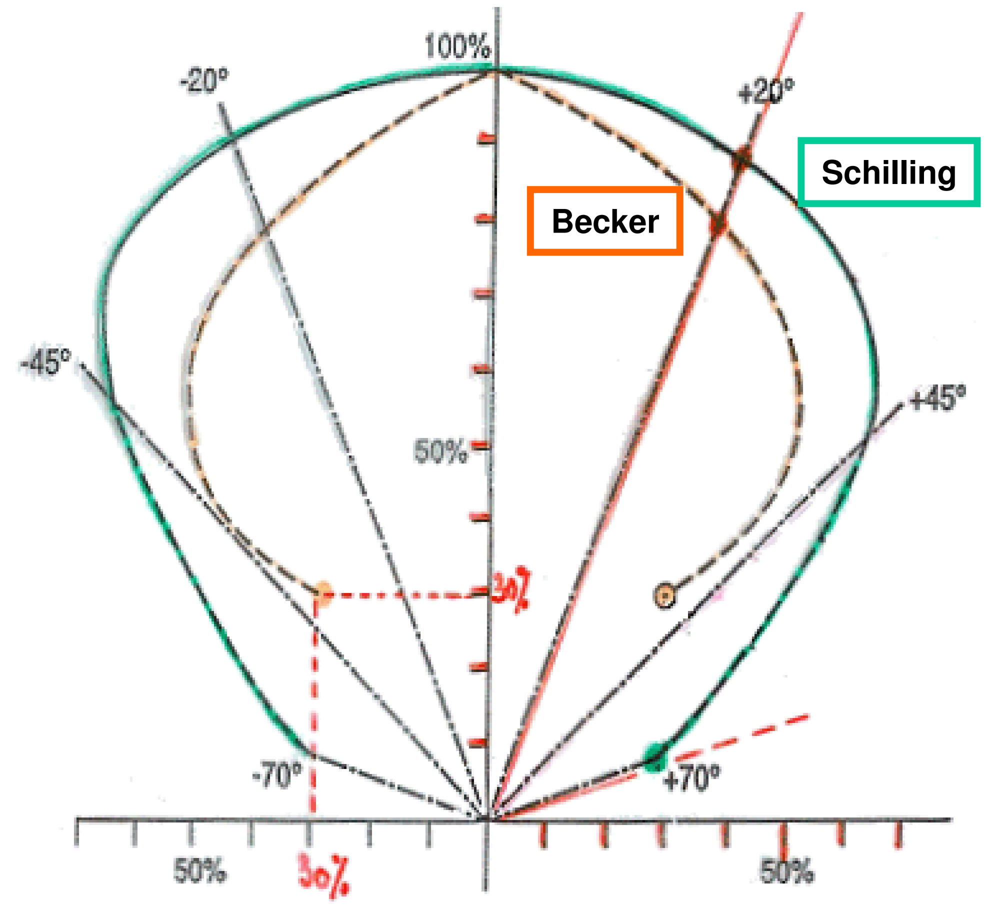
http://www.becker-marine-systems.com

This type of rudder is articulated with a simple mechanical arrangement which moves the hinged tip of the rudder at a higher ratio than the main spade. This is normally double, so that a rudder angle of 35° will result in the tip moving at 70° from the fore and aft line.

This explains the higher side forces shown above.

PORT REVEL Shiphandling

SCHILLING vs BECKER RUDDER



Side thrust as % of bollard pull (at zero ahead speed)

Sogreah ©

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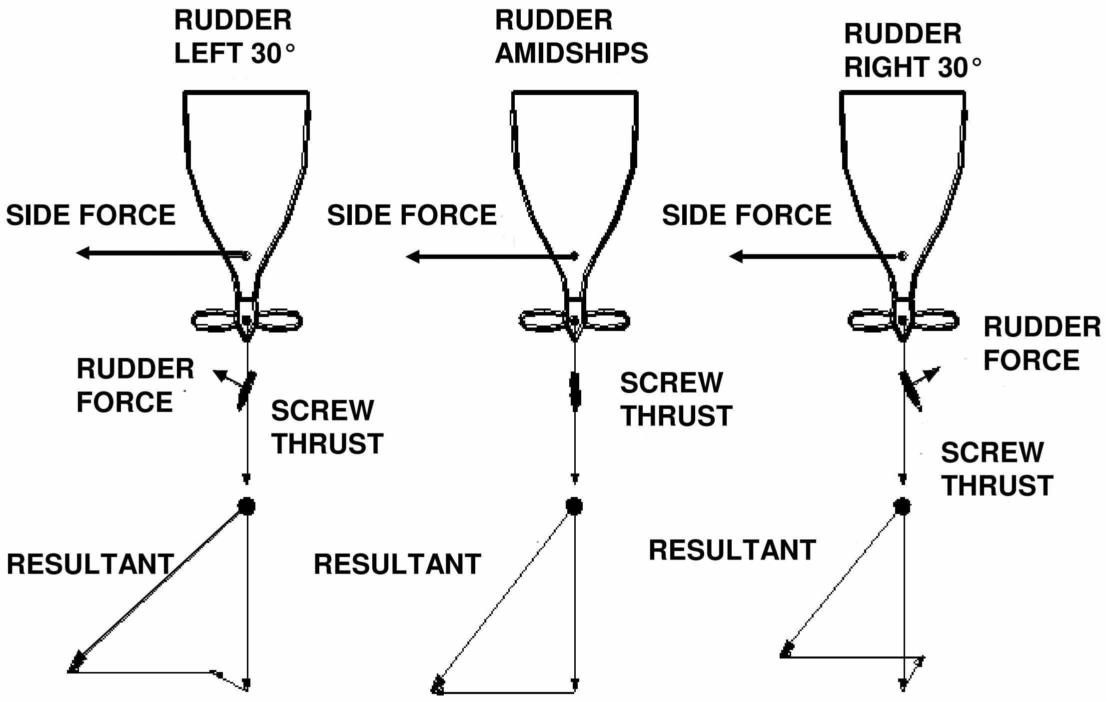
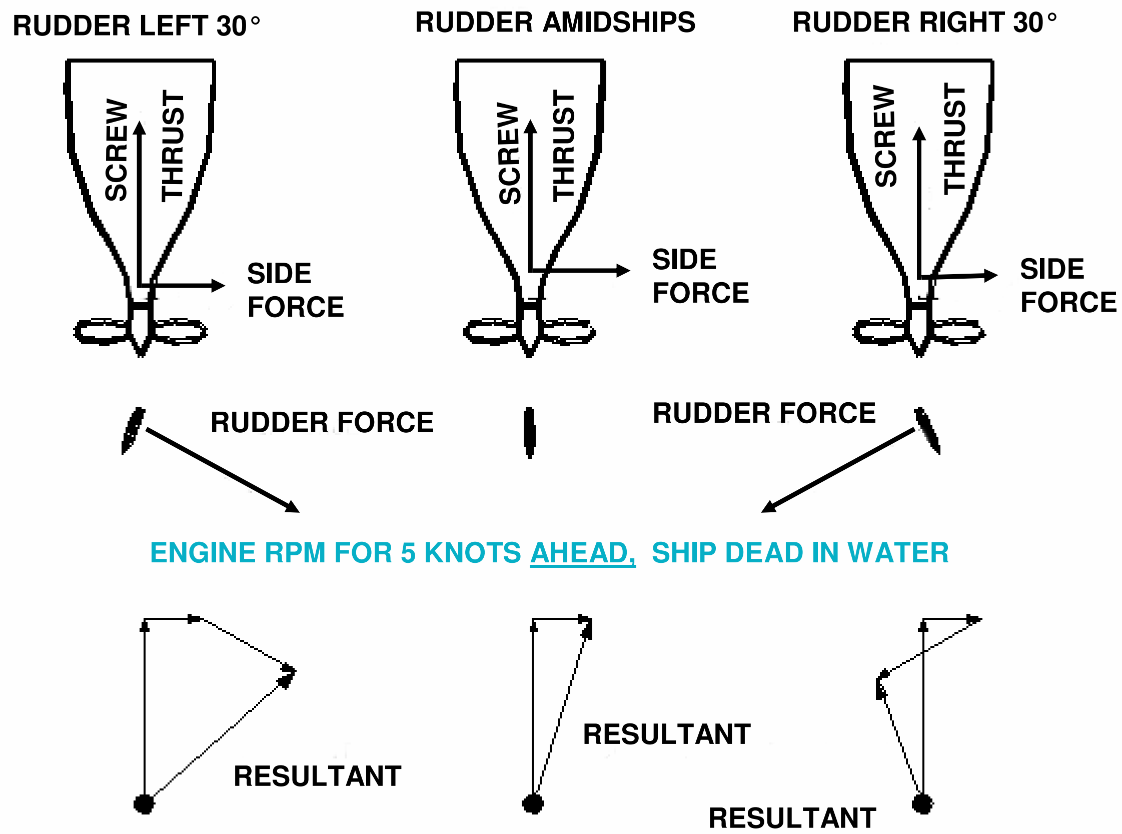
RUDDER FORCES ASTERN



ENGINE RPM FOR 5 KNOTS ASTERN, SHIP DEAD IN WATER

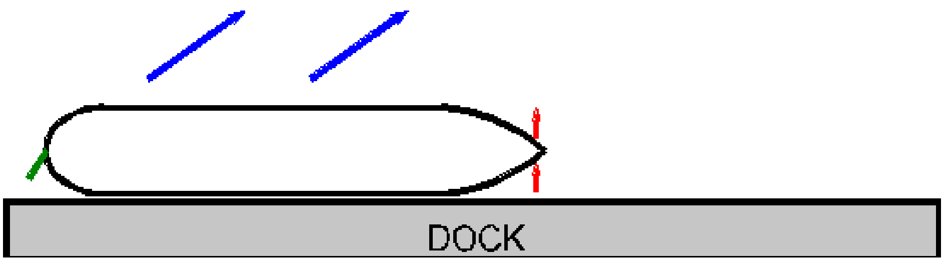
After R.S. Crenshew – US Naval Inst.

RUDDER FORCES AHEAD



After R.S. Crenshew – US Naval Inst.

LEAVING DOCK USING BOW THRUSTER



- RUDDER HARD OVER TOWARD DOCK
- KICK AHEAD WITH ENGINES TO LIFT STERN OFF
- BOW THRUSTER TO LIFT BOW OFF

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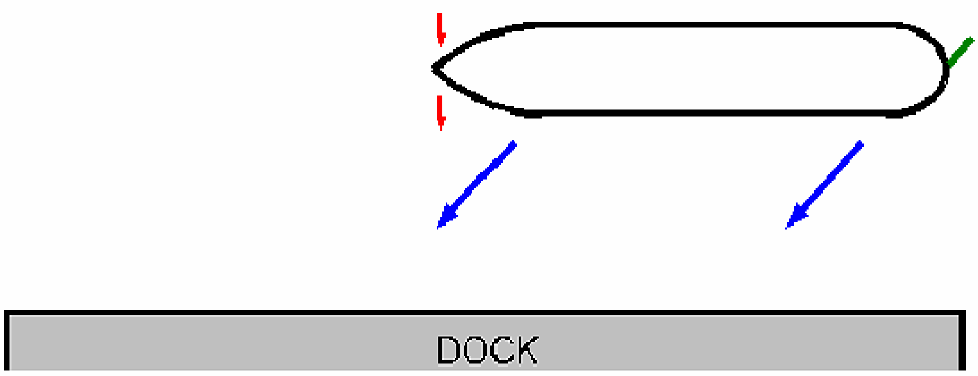
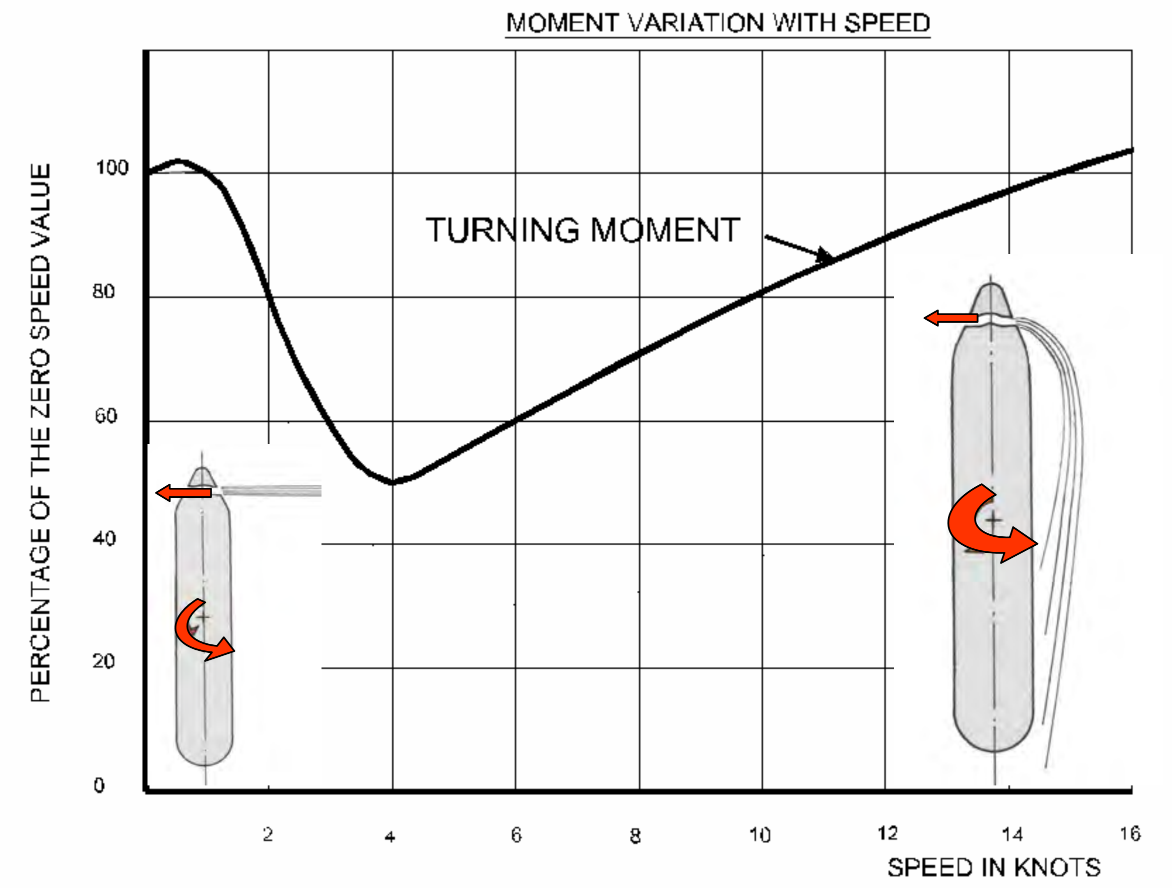
DOCK APPROACH USING BOW THRUSTER

PORT SIDE TO DOCK



- HAVE SHIP IN POSITION NEARLY PARALLEL TO DOCK-FACE WITH LITTLE OR NO HEADWAY
- RUDDER HARD TO STARBOAD
- KEEP ENGINE TO "KICK" STERN IN
- KEEP PARALLEL TO DOCK BY USING BOW THRUSTER TO PORT
- AVOID TO MUCH HEADWAY

BOW THRUSTER



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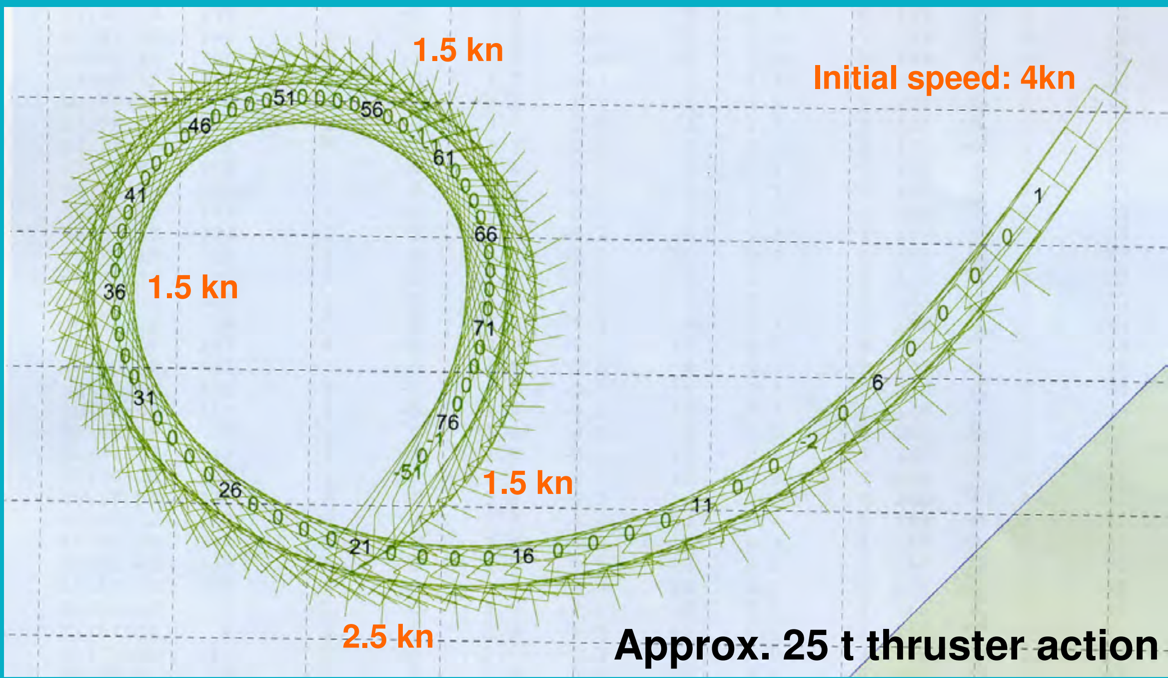
The turning moment due to the bow thruster reduces with increasing ship speed up to about 4 kn. At higher speeds the hydrodynamic flow provides an additional turning component which increases the total turning moment back to the zero speed value.

PORT REVEL Shiphandling

ACTION OF BOW THRUSTER

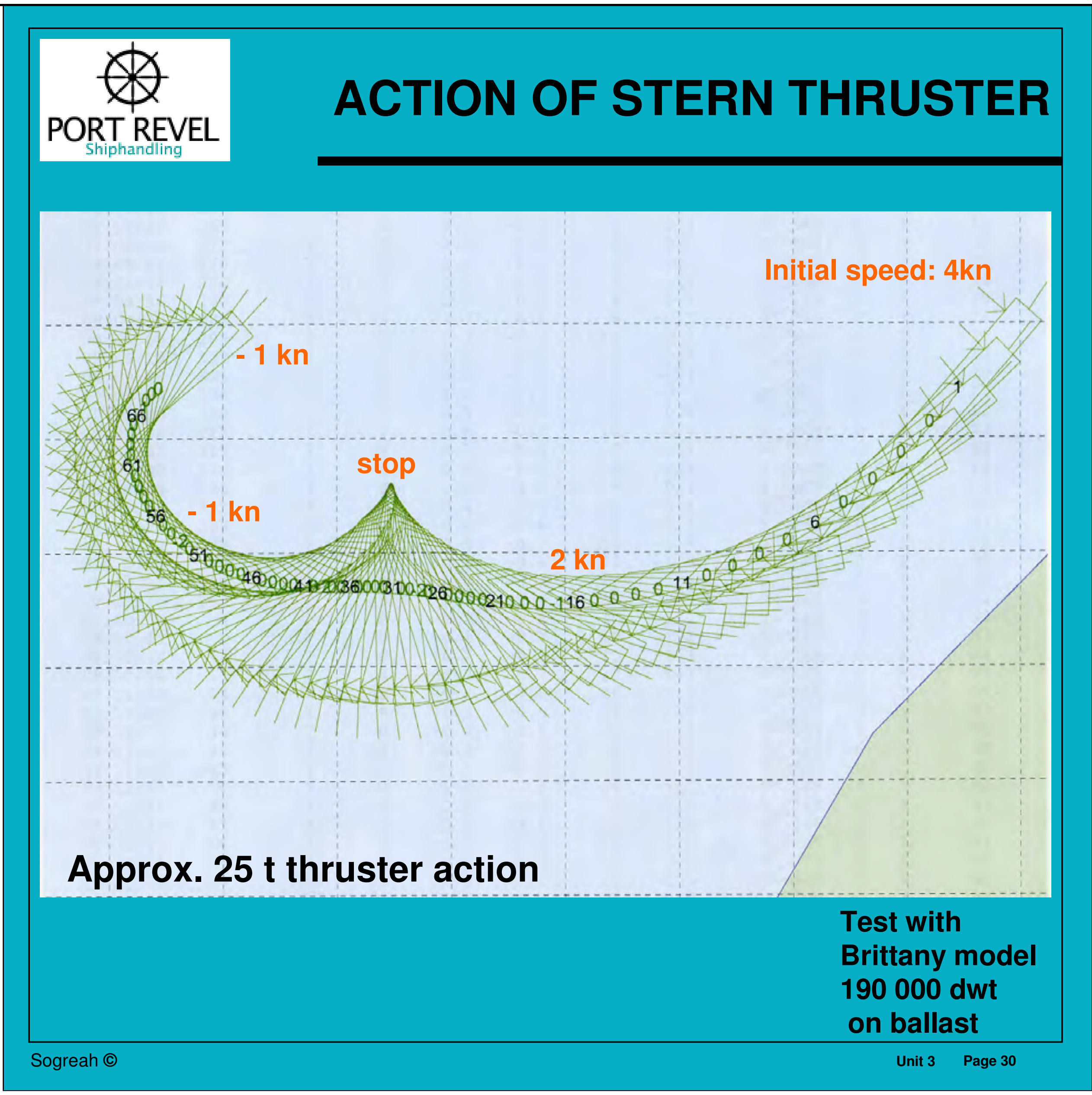


Test with
Brittany model
190 000 dwt
on ballast

Sogreah ©

Unit 3 Page 29

With long term bow thruster action she keeps 1.5 kn headway.



With long term stern thruster action she gets 1 kn sternway after she has stopped and turned around.

TUGS

Tugs with new 442 000 dwt double hull tanker of V-PLUS (Euronav/OSG)

Sogreah © Unit 3 Page 31

Tow boats are used in a variety of ways throughout the world. Whether breasting a ship bodily, turning a ship or towing, the less way a ship is carrying, the more effectively the tug's power can be applied.

When using tugs, their speeds, turning capabilities and control response times must be taken into account just as much as those of the ship.

Before having a tug let go a stern line, the vessel should carry a very small amount of headway, or have the tug veer to the quarter from which the stern is swinging to help keep the line out of the propeller.

Be sure safeguards are taken to avoid crowding a tug between other vessels, piers, etc. Be sure to safeguard against the dangers presented by a ship's anchors when working with tugs.

Ship Docking Module (SDM) at Tampa

With headway on the vessel, a proportion of the tug's power will be dissipated in "trailing", resulting in less power being available in the direction required. To hold a ship stopped in a broadside current or broadside wind, the tug force must equal the lateral forces of current and wind on the vessel. To increase or decrease a vessel's movement, the tugs must also overcome the vessel's inertia. To turn a vessel when stopped, the tugs must overcome lateral resistance and rotational inertia. Whenever a tug is used to tow a ship on a line from the tug's towing bits, extreme care should be exercised not to override the tug with too much speed. For instance, a tug towing a ship astern on a stern line will do perfectly well while the ship is moving at a speed well below the normal speed of the tug, and the towing force is kept in line with the direction of movement. However, should it be necessary to have the tug cant the stern in one direction or the other, the tug will have to move to a position off the quarter. Due to relative motion, the tow line will make an angle between the centre line of the tug and the direction in which the tow line is tending. This off-centre strain will list the tug and, if not checked in time, can result in the tug becoming swamped or capsized. It is the tug's duty not to lead too broadly from the ship and it is the ship's duty **not to carry too much stern-way** at times such as this.

MOORING LINES

The AMSTERDAM in Victoria (BC)

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When entering or leaving a berth, particularly a berth alongside a pier or wharf, mooring lines can be used in conjunction with engines, particularly steam turbine engines, but cannot be expected to stand the strain of the vessel in motion.

With very little motion, a large displacement vessel will break any number of lines of the very best material. However, by using the engine to control the momentum of the vessel until she is stopped over the ground without putting a heavy strain on a line, the engine can be kept in balance against a line so that its force can be utilised. For example, barring adverse wind or current, even the largest ship in the world can be "breasted off" the face of a pier on a good spring line with careful use of the engine. The trick is, of course, to have the ship's momentum arrive at nearly zero at the time the line becomes tight.

With extremely large displacement vessels, it is common practice to get all movement off the vessel by means of tugs, engines, anchor, etc. if possible, before relying on mooring lines to arrest the last discernable motion remaining on the ship.

UNIT 3 – Tuesday

PIVOTING POINT

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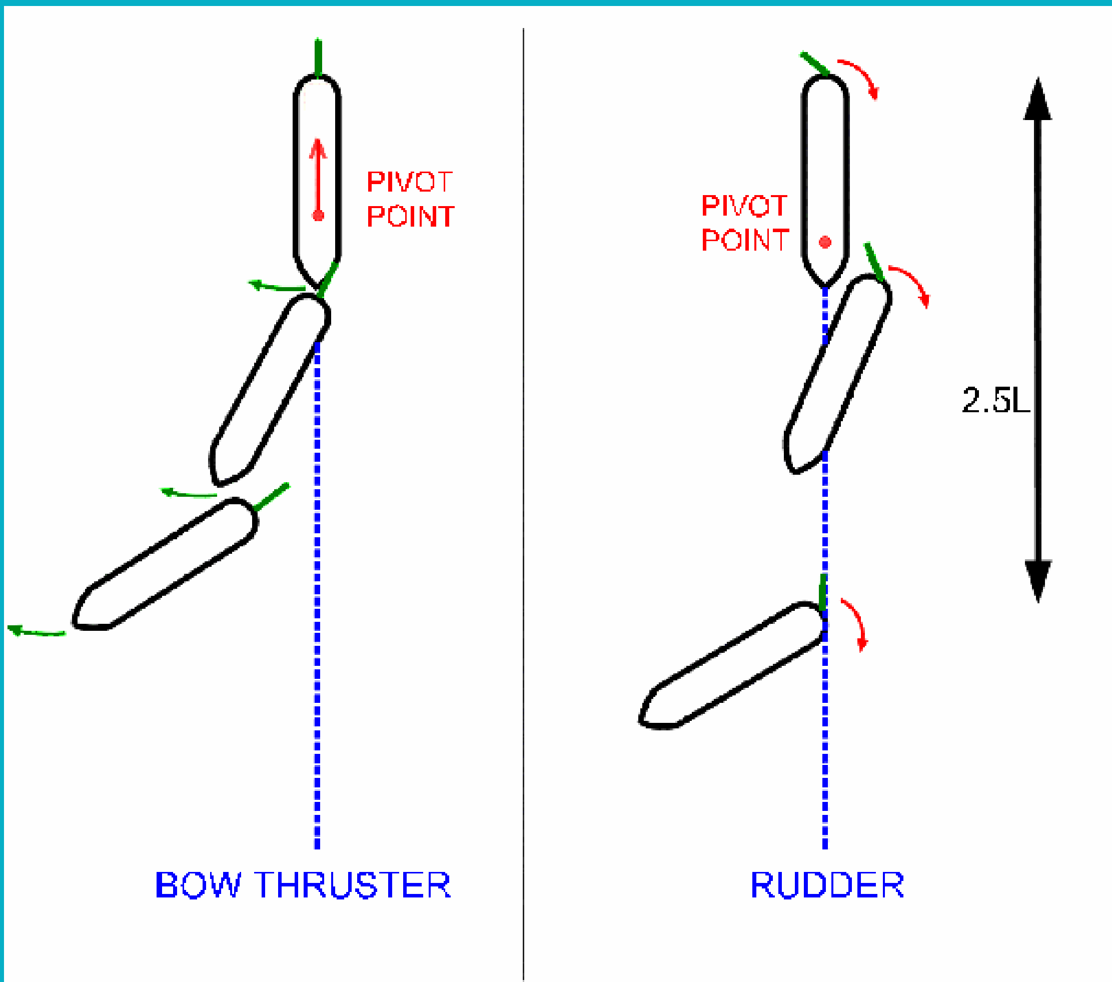
A good example of a **fixed** Pivoting Point.

Ships have a **mobile** Pivoting Point.

According to Capt Benny Petterson & Capt Sven Glydén:

- when the ship is stopped in the water, PP coincides with the Centre of Gravity of the ship,
- when the ship is gaining speed, PP moves alongships in the same direction as the movement.

RUDDER & BOW THRUSTER EFFECT (1)



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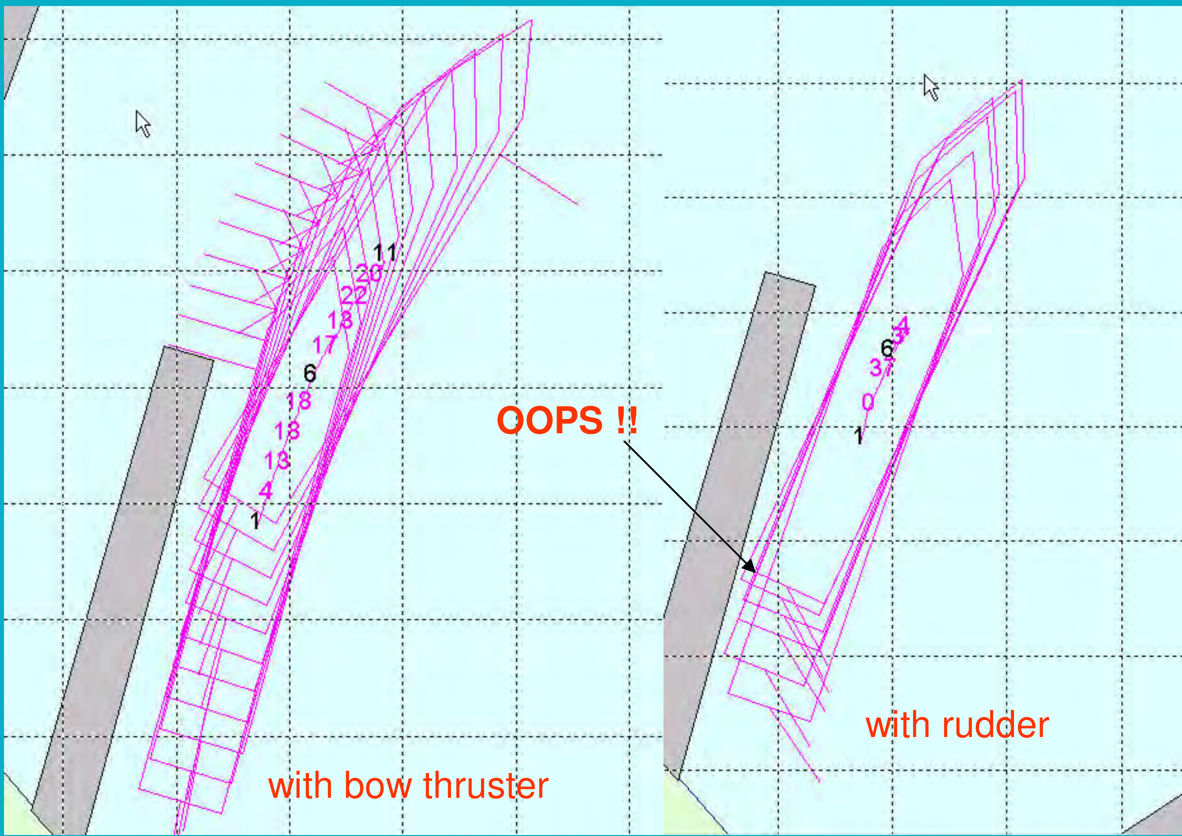
With normal rudder action, the Pivot Point is located somewhere in the fore half of the ship. With bow thruster activated, the Pivot Point moves aft.

RUDDER & BOW THRUSTER EFFECT (2)



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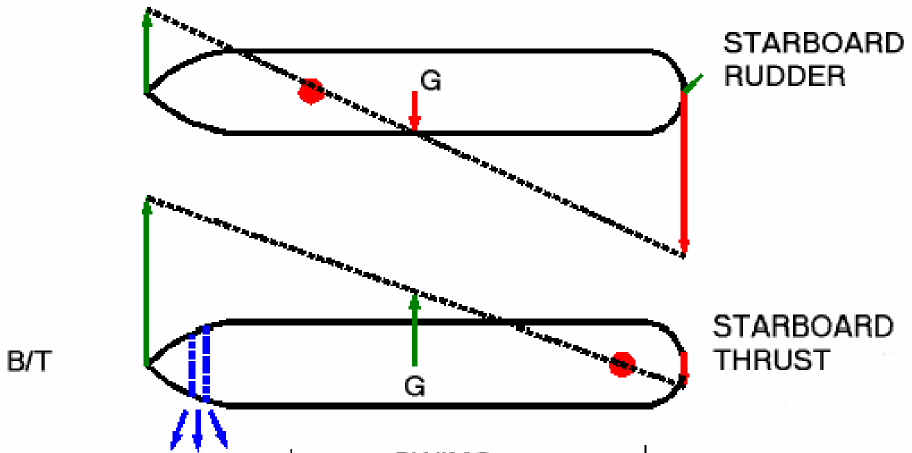
Beware when leaving a berth …

BOW THRUSTER ACTING WITH RUDDER



	SWING	DRIFT
RUDDER ACTION	TO STARBOARD	TO PORT
B/T ACTION	TO STARBOARD	TO STARBOARD
IN COMBINATION	INCREASED	REDUCED

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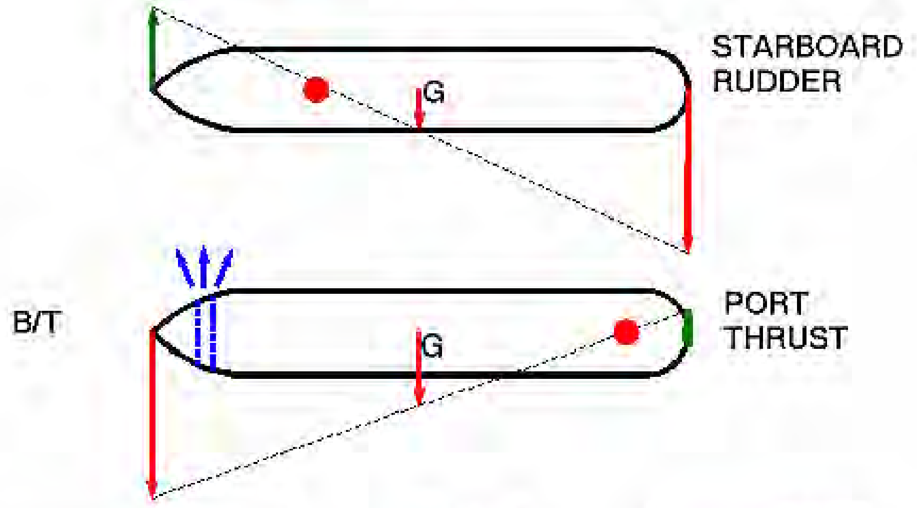
The bow thruster can be used in combination with the rudder to simultaneously:

- increase the swing, and
- reduce the drift.

BOW THRUSTER vs RUDDER



	SWING	DRIFT
RUDDER ACTION	TO STARB.	TO PORT
B/T ACTION	TO PORT	TO PORT
IN COMBINATION	ZERO	INCREASED

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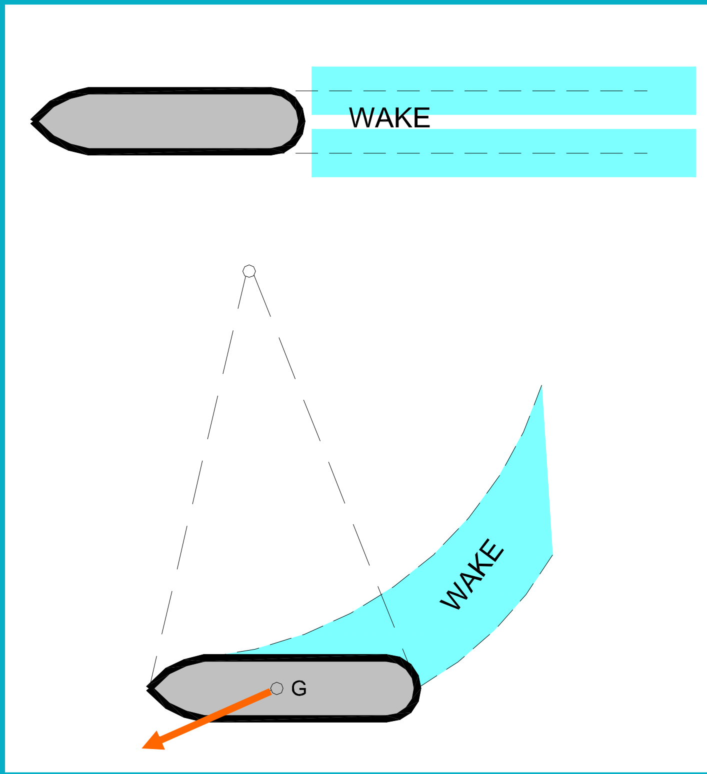
In counter-action, the combined effect of rudder and bow thruster is a pure drift with no swing.

SKIDDING

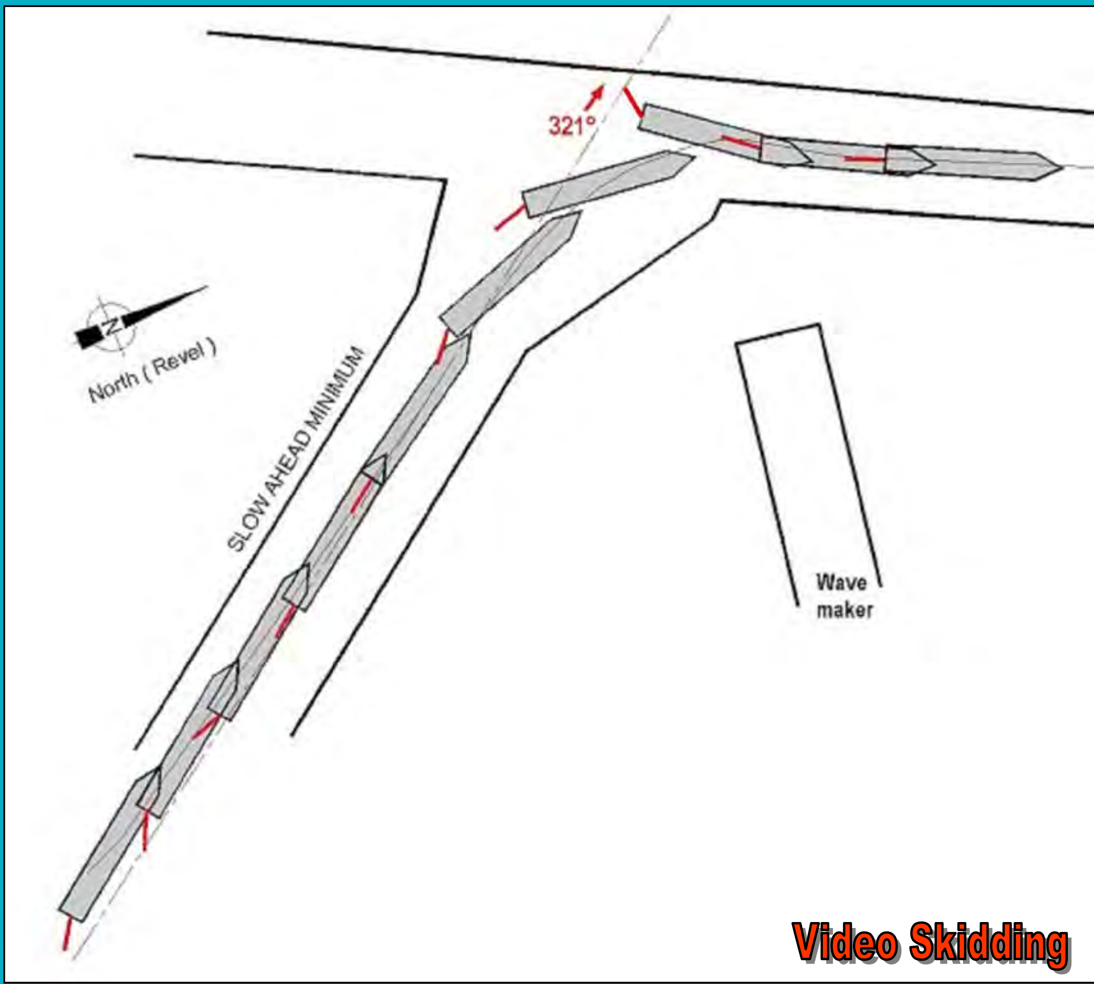


SKIDDING DEPENDS ON:

- SHIP SPEED
- RUDDER ANGLE
- RUDDER AREA
- DISPLACEMENT
- UNDERWATER RESISTANCE
- DEEP OR SHALLOW WATER

PORT REVEL Shiphandling

SKIDDING INTO THE NORTH CHANNEL



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- Stand on the port side of your ship when you turn to starboard, in order to use « landmarks » on your own ship.
- follow a collision route with the starboard buoy in the curve, and
- perform an overswing.
- if you feel you are skidding out of the curve, give a kick ahead with hard port rudder.

SKIDDING
Resistance of water body

Wallenius' AIDA turning with a SCHILLING MONOVEC rudder

Photo: Wallenius & Schilling

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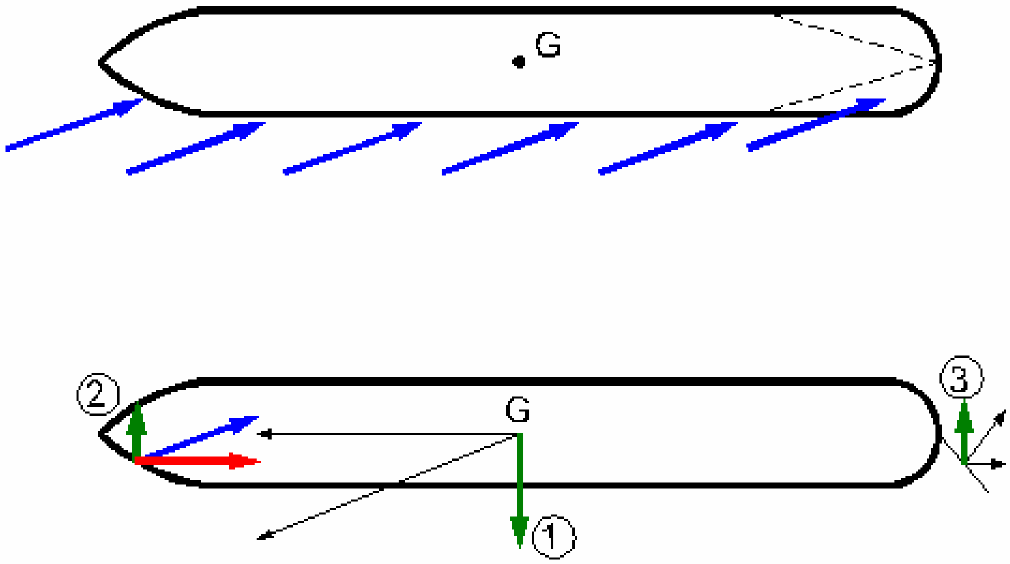
UNDER WATER RESISTANCE



When ship steadies up under correcting helm, there is a balance of forces

1 SIDE MOTION OF SHIP
2 TRANSVERSE COMPONENT OF UNDER WATER RESISTANCE
3 TRANSVERSE COMPONENT OF RUDDERTHRUST

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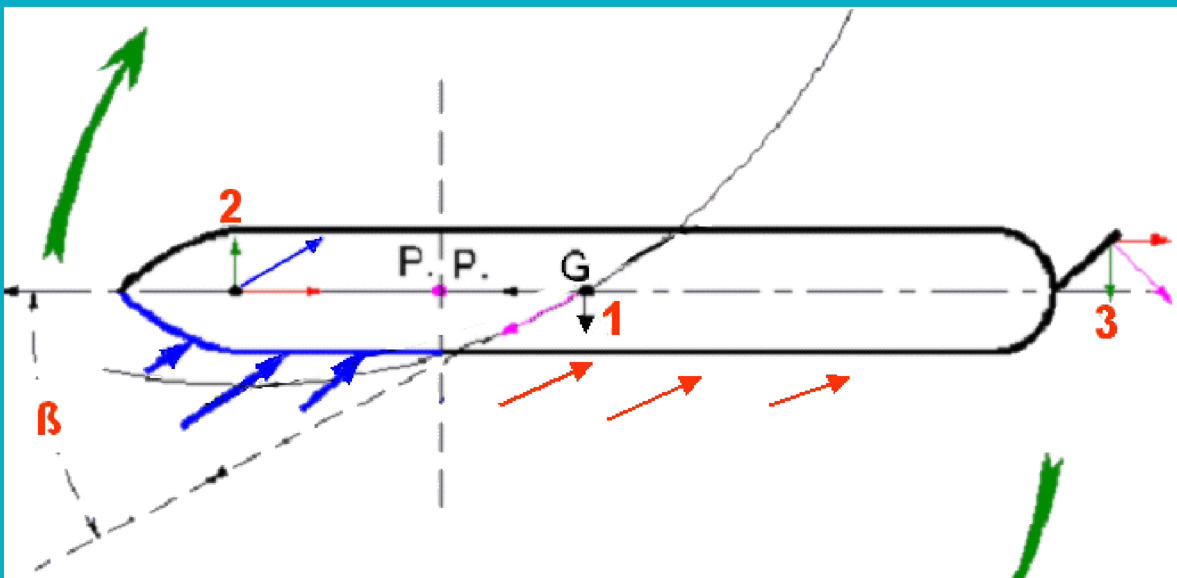
PORT REVEL
Shiphandling

TURNING CIRCLE
ON DEEP WATER



The ship turns under 3 forces :

1- Side motion of centre of gravity

2- Transverse component of underwater resistance located ahead of the Pivot Point

3-Transverse component of the rudder force

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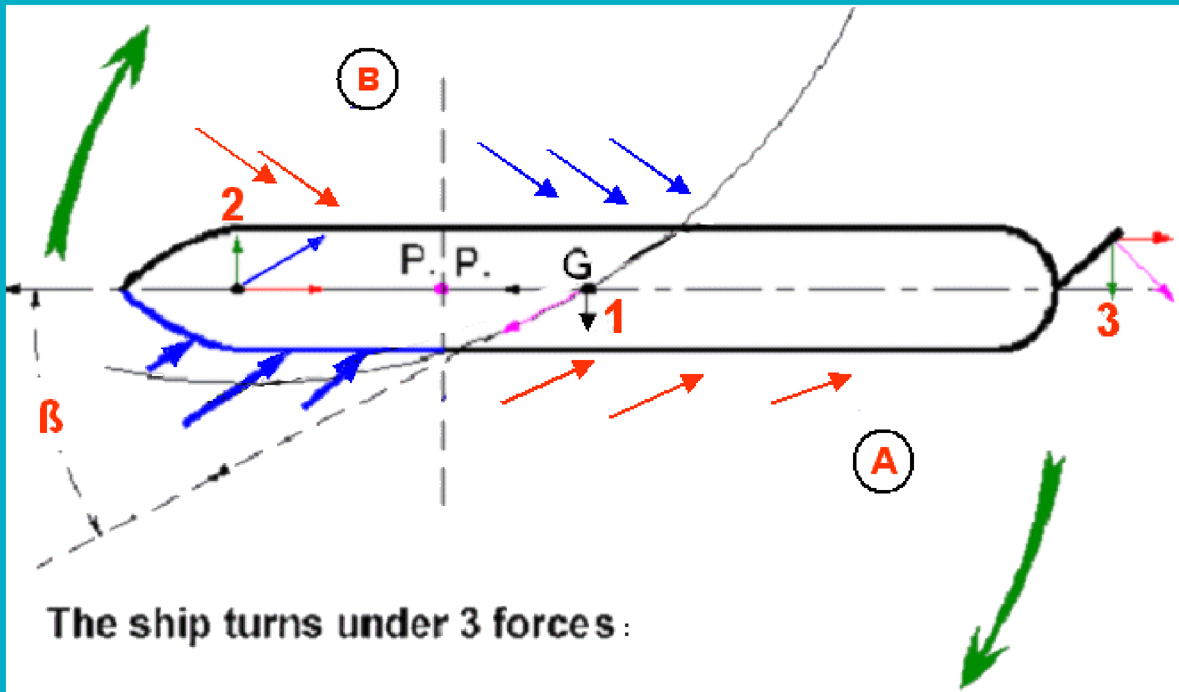
Underwater resistance ahead of the Pivot Point could be called « a low cost bow thruster » !

The more the ship's bow is rounded the more efficient is this effect: a big and wide tanker will turn easier than a thinner ship …

PORT REVEL Shiphandling

TURNING CIRCLE
ON VERY SHALLOW WATER



The ship turns under 3 forces :

1- Side motion of centre of gravity

2- Transverse component of underwater resistance located ahead of the Pivot Point

3-Transverse component of the rudder force

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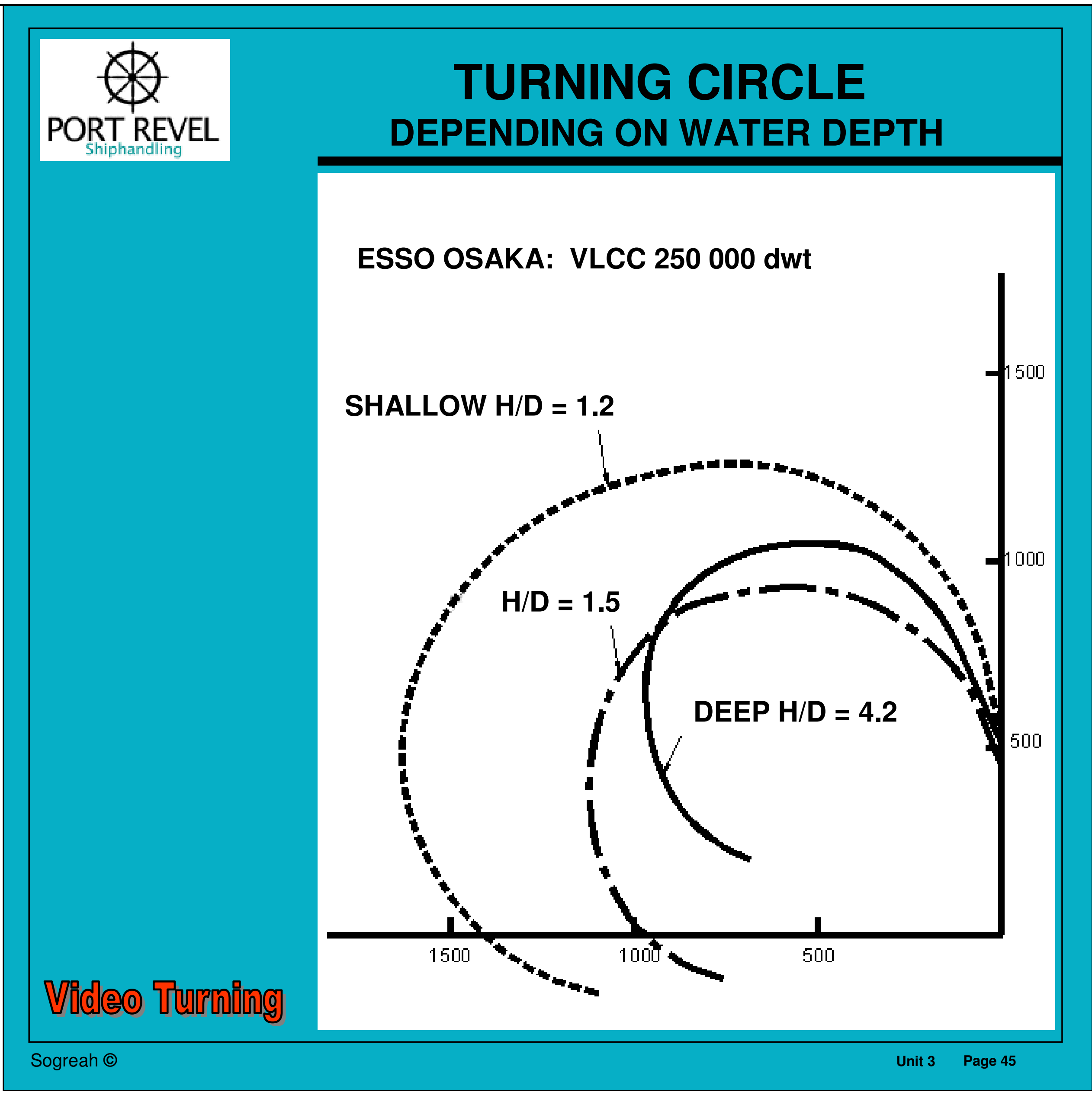
On very shallow waters:

- the underwater resistance is increasing: water flow is restricted underneath the ship near **A** & **B**,

- the drift **ß** is decreasing: the underwater resistance comes in line with the fore and aft line.

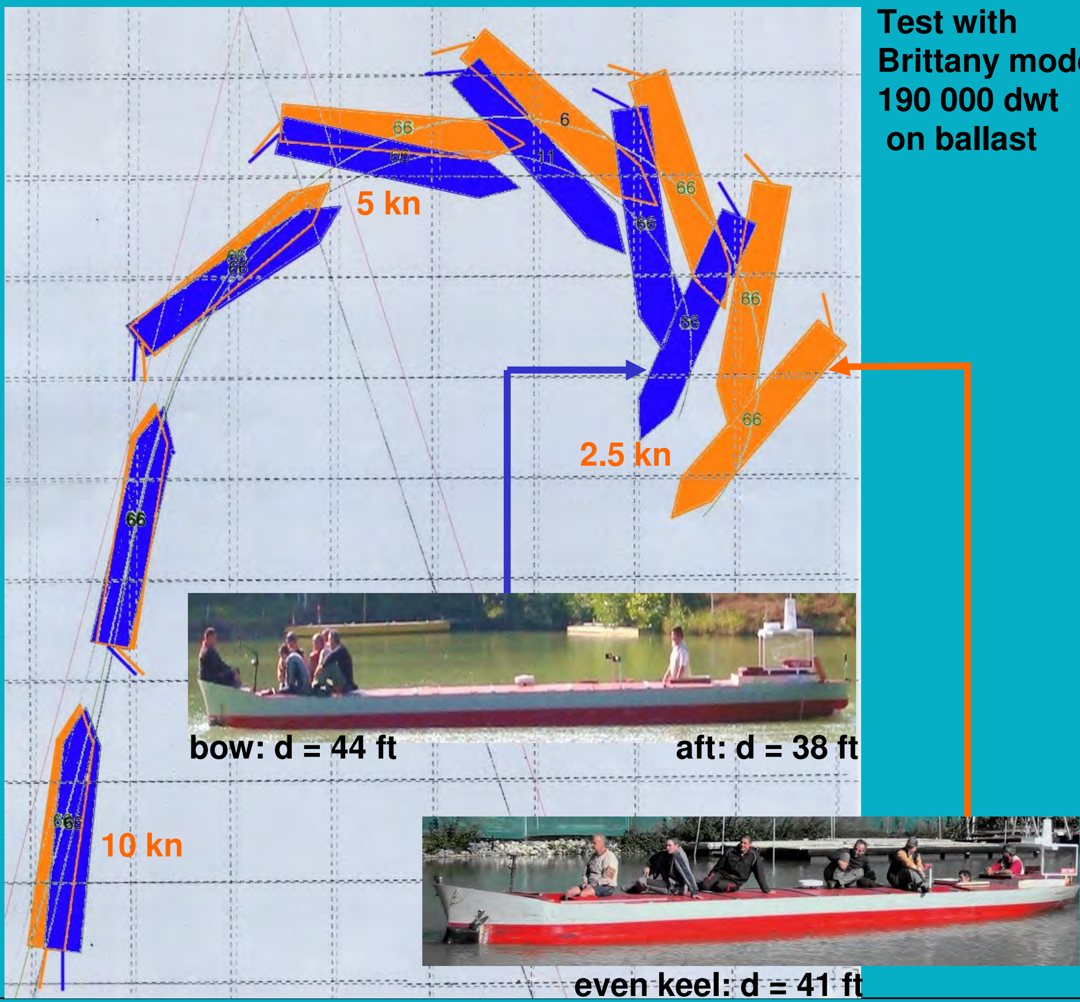


The shallower, the wider the turning circle.

PORT REVEL
Shiphandling

TURNING CIRCLE
DEPENDING ON TRIM

Test with Brittany model 190 000 dwt on ballast



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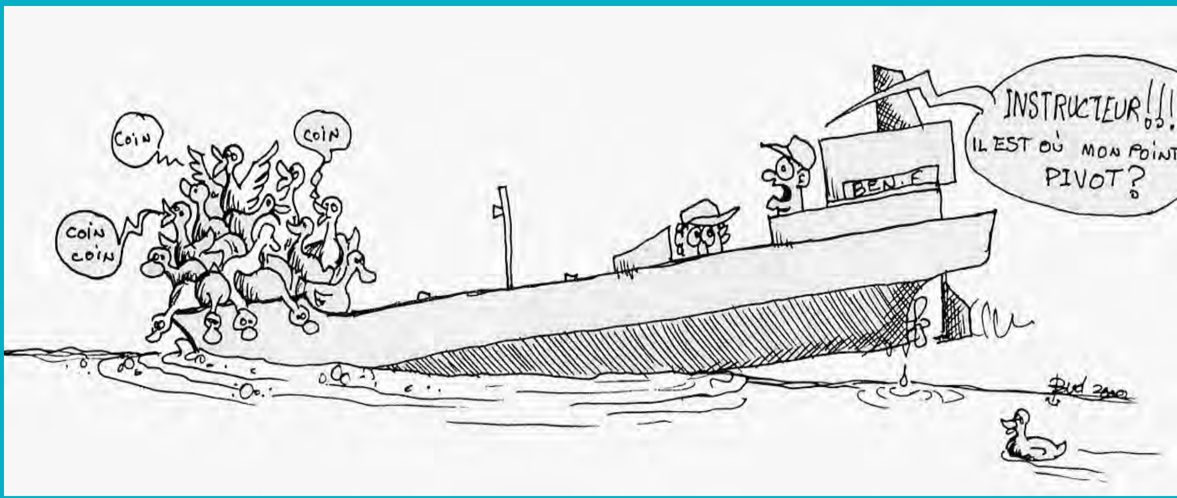
WHERE IS MY PIVOT POINT ?!



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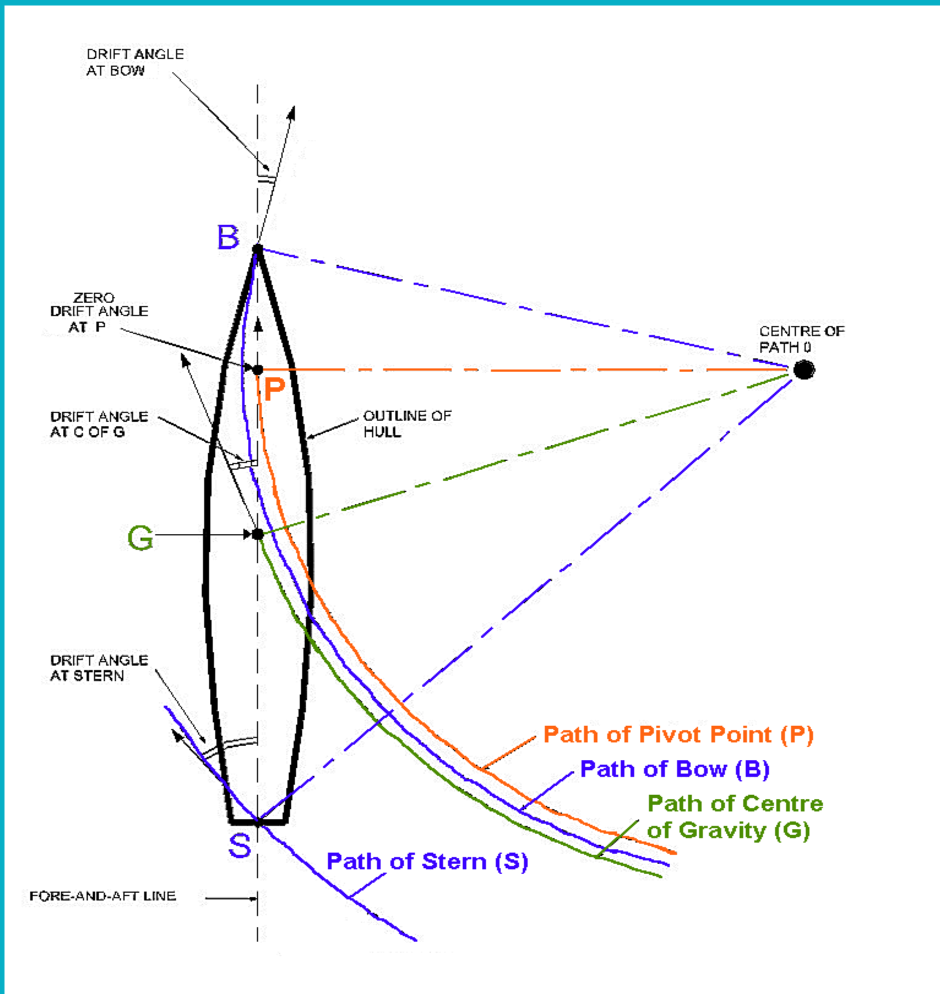
TURNING CIRCLE
PATHS



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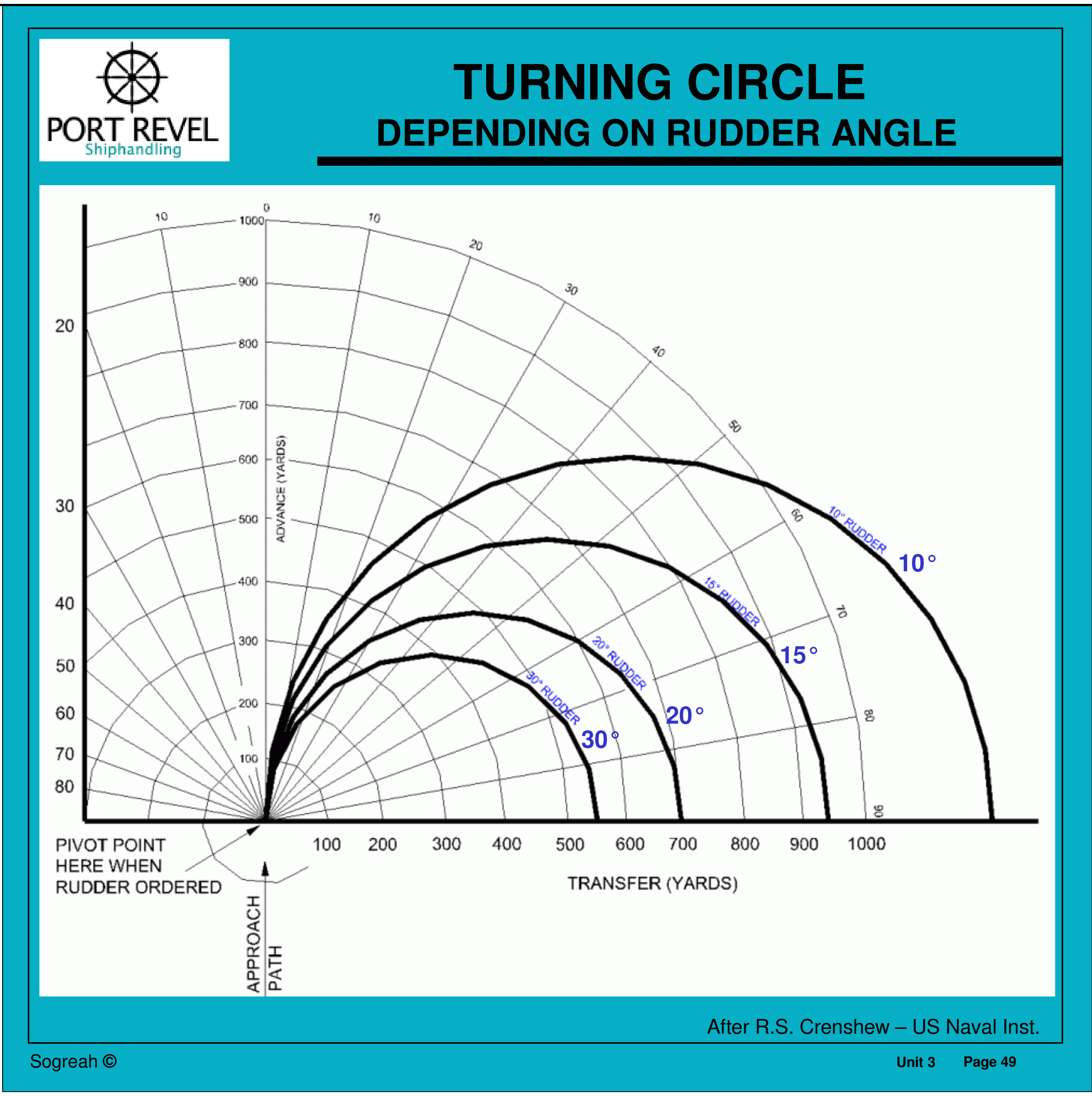
The drift angle varies alongships.

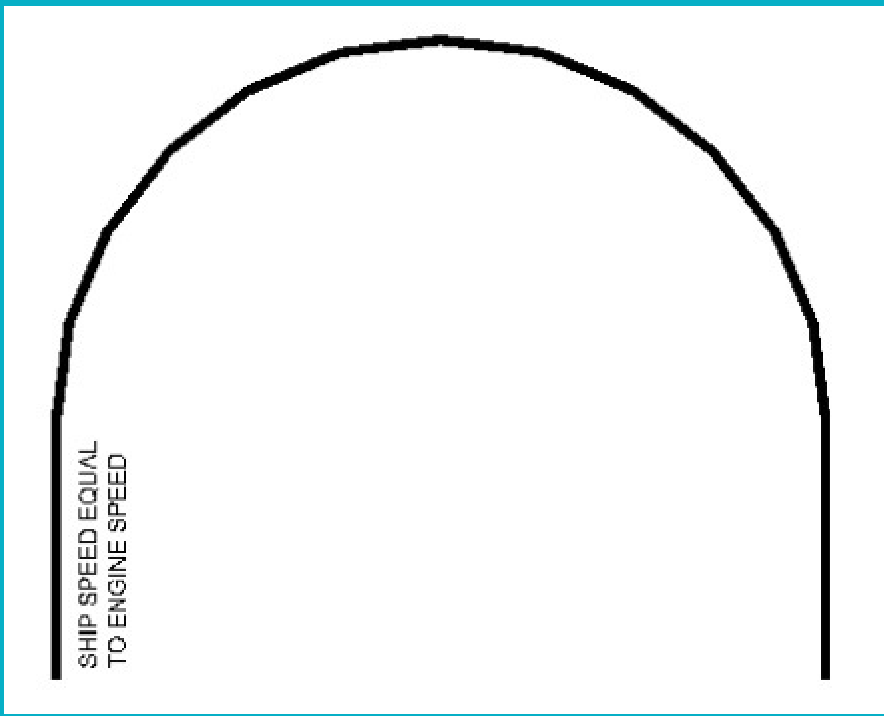
The larger the drift angle, the greater the hull resistance will be and consequently, the loss of speed.



Increasing from 10° to 20° rudder, yields 40% less transfer,

Increasing from 20° to 30° rudder, yields 20% less transfer.

EFFECT OF ENGINE SPEED ON TURNING CIRCLES (1)

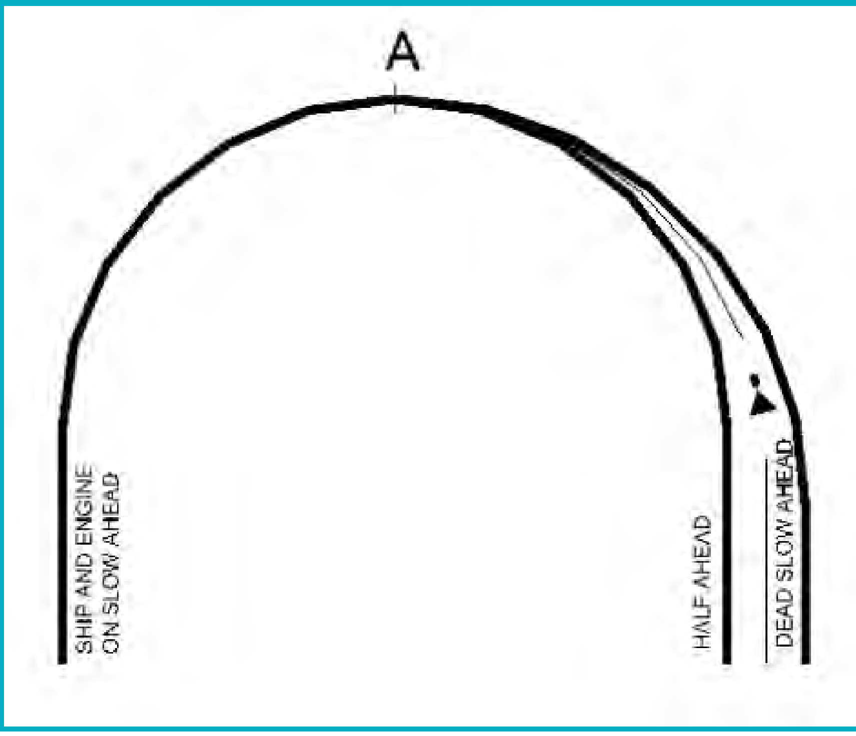


As long as the engine speed is equal to the ship speed the diameters of the turning circles are the same

Surprisingly, this is valid at almost any ship speed.

PORT REVEL
Shiphandling

EFFECT OF ENGINE SPEED ON TURNING CIRCLES (2)



To alter the diameter of the turning circle, you can use your engine.

From position A:

-to keep the buoy to port, you increase to half ahead

-to keep the buoy to starboard, you reduce to dead slow ahead

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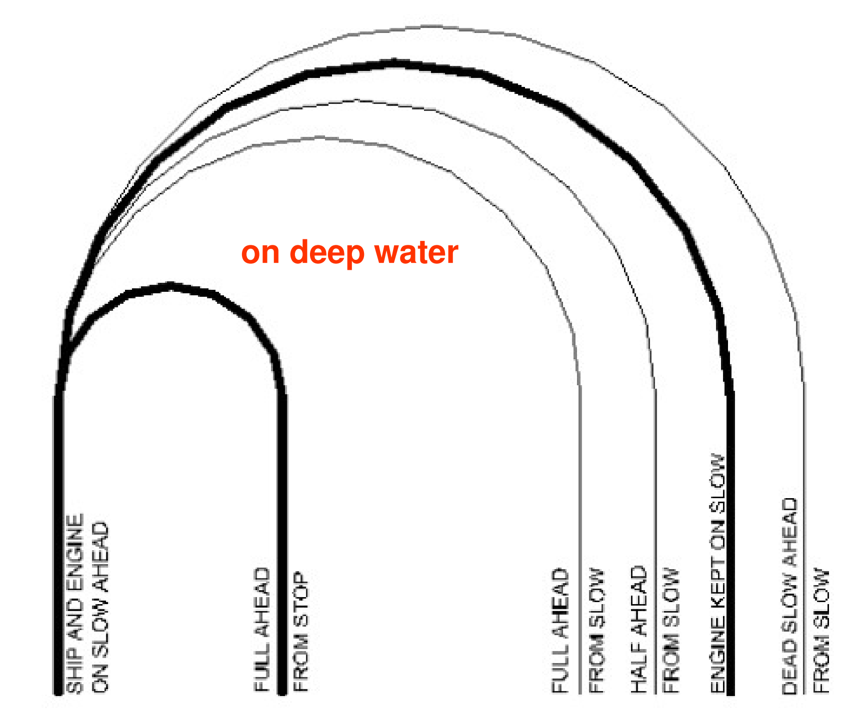
You can steer with the engine:

- in an accelerating turn, the turning circle is reduced,
- in a decelerating turn, the turning circle is increased.

EFFECT OF ENGINE SPEED ON TURNING CIRCLES (3)



- When you increase engine speed over ship speed you reduce the diameter of the turning circle

-When you reduce the engine speed under the ship speed you increase the diameter of the turning circle

-If you start to turn with the ship dead in the water you have the shortest turning circle

Sogreah © Unit 3 Page 52

The main question is:

what is the engine speed compared to the ship's speed ?

These effects are much reduced on shallow waters.

UNIT 4 – SHALLOW WATERS & CONFINED WATERS

The slides hereafter clarify the following aspects:

1. SHALLOW WATERS

1.1. SHALLOW WATER EFFECTS

1.2. WAVE FORM

1.3. SINKAGE AND SQUAT

1.4. DEPTH AND WIDTH OF INFLUENCE

2. CANAL EFFECTS

2.1. BANK EFFECTS

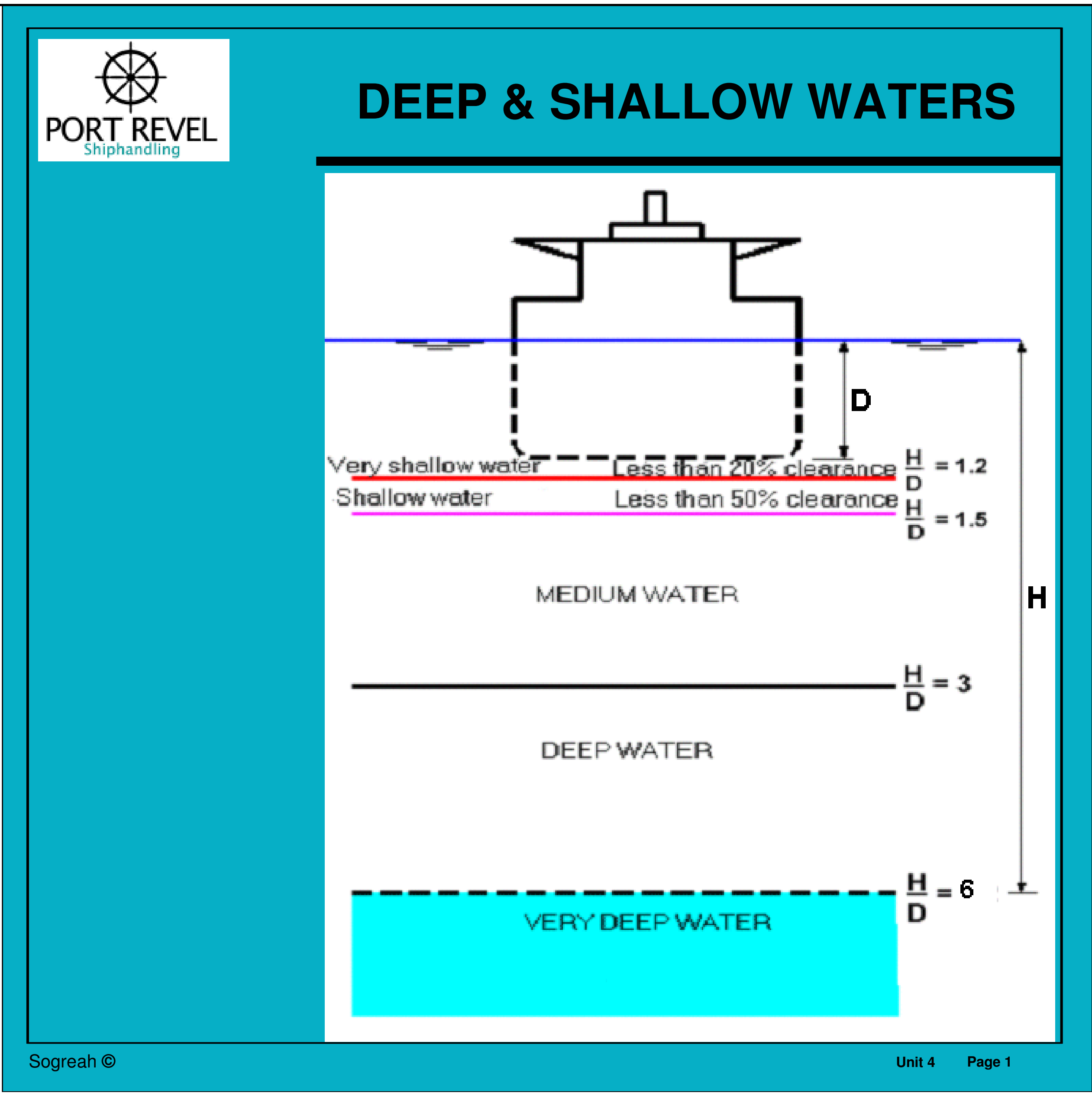
2.2. SATURATION SPEED OR SCHIJF LIMITING SPEED

2.3. TRANSIT THROUGH CANALS

2.3.1. STRAIGHT SECTION OF CHANNEL OR CANAL

2.3.2. CHANNEL BENDS

2.3.3. CHANNEL OR RIVER BENDS WITH A CURRENT



When the keel clearance is less than 50% of the draft, the ship is in shallow water. When a ship enters shallow waters, the movement of water is restricted by the barrier of the sea-bed. The same volume is needed to replace the space left by the passage of the hull at a constant speed, but because of the now restricted place in which to act, the water particles must move with a correspondingly greater velocity. Friction and turbulence are increased and the wave form changes, resulting in reduction in speed, increased sinkage and squat and reduced propeller and rudder efficiency.

PORT REVEL
Shiphandling

ENTERING SHALLOW WATER

Under water resistance increases

<u>Signs:</u>

- water flow velocity increases underneath the ship, more load on propeller: <u>less RPM</u>

- vibrations

- speed reduction

- higher bow wave

- PP moves more aft : steering becomes more sluggish

- draft and trim change

- stern wave or wash overtaking the ship

<u>ultimate stage</u>: grounding by the head

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The effects of shallow water on the ship are:

- More ship's power is absorbed by the water due to increased friction.
- Ship's speed, therefore, decreases.
- Larger waves and troughs are formed and the ship "*sinks*" closer to the bottom than she would do at the same speed over the ground in deep water.
- At the same time the ship's trim changes: sinkage is greater forward than aft for ships having a high block coefficient. This effect is called « *squat* ».
- Turbulence interferes with rudder and propeller effectiveness.
- Diameter of turning circle increases.

PORT REVEL Shiphandling

SHALLOW WATER EFFECTS

SHELL MAGDALA

TANKER 210,000 DWT
Length: 310 m
Draft: 19 m

EFFECT OF BOTTOM CLEARANCE ON SPEED			
Bottom Clearance	Depth	R.P.M.	Speed
100 %	38 m	85.0	15.2
58 %	30 m	83.5	15.2
42 %	27 m	81.5	13.8
23 %	23.3 m	77.0	11.0

EFFECT OF BOTTOM CLEARANCE ON TURNING CIRCLE		
Bottom Clearance	Depth	Diameter
100 %	38 m	920 m # 3 S.L.
58 %	30 m	1,070 # 3.5 S.L.
25 %	25 m	1,300 # 4 S.L.

As the keel clearance reduces:

- speed is reduced,
- turning circle is increased.

UNIT 4 – Wednesday

SHALLOW WATER EFFECTS

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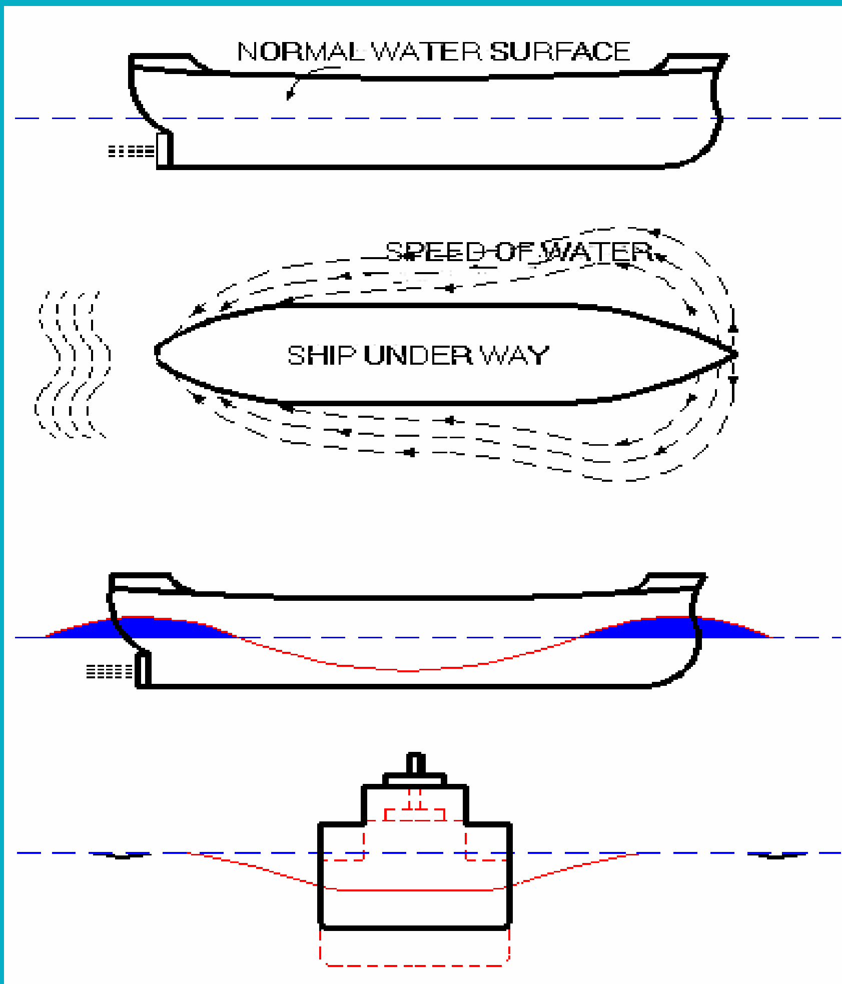
WAVE FORM



Video Wave Form

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As a hull moves, it pushes water away in all directions. Since water is fluid, but not compressible, it flows around and under the ship to fill the space left behind, and generate what we call the "*wave form*".

The wave form consists of:

- a bow wave: water rising around the bow,

- a trough along the main body of the ship with speed-up of water,

- a stern wave due to the water rushing behind the ship,

- a following wave.

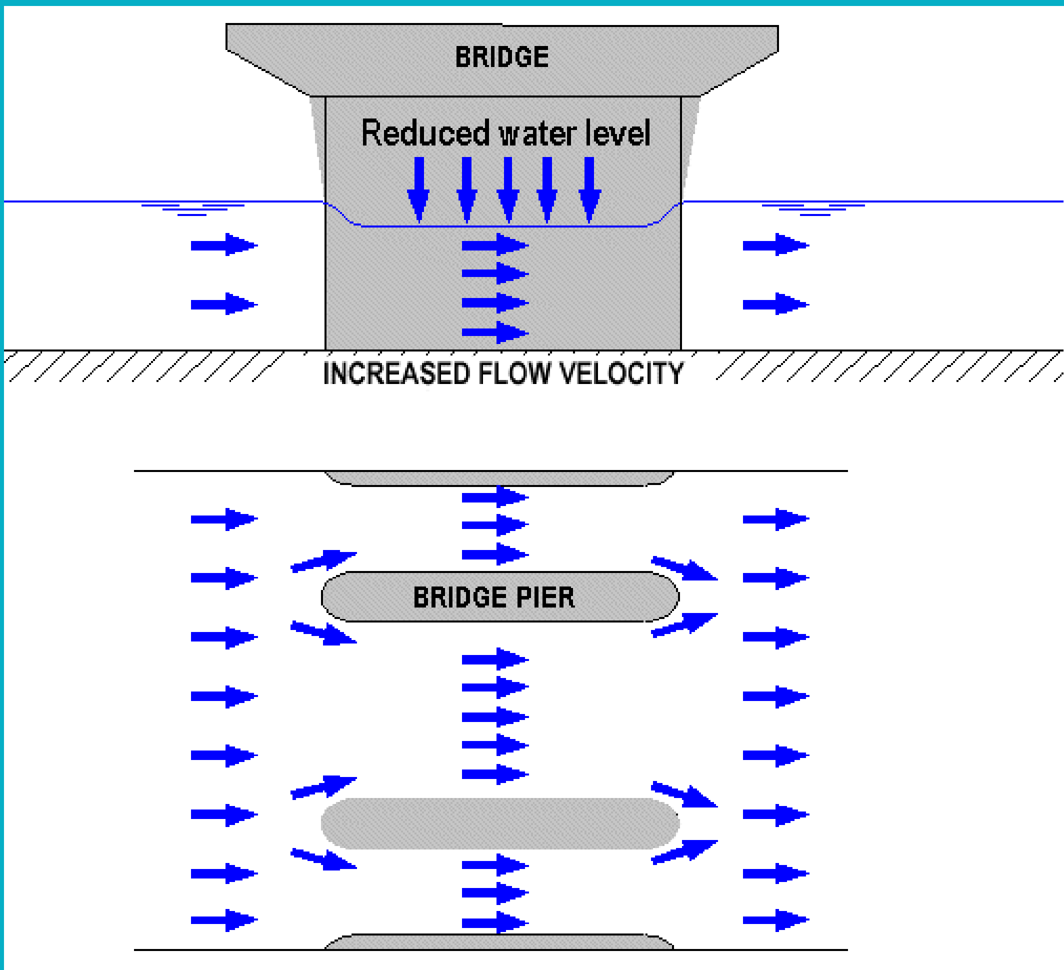
The shape of the wave form depends on the shape of the hull and the speed of the ship through the water.

FLOW AT BRIDGE PIER

Sogreah © Unit 4 Page 6

Increased flow velocity induces lowered water level, according to the law of Bernouilli.

SINKAGE



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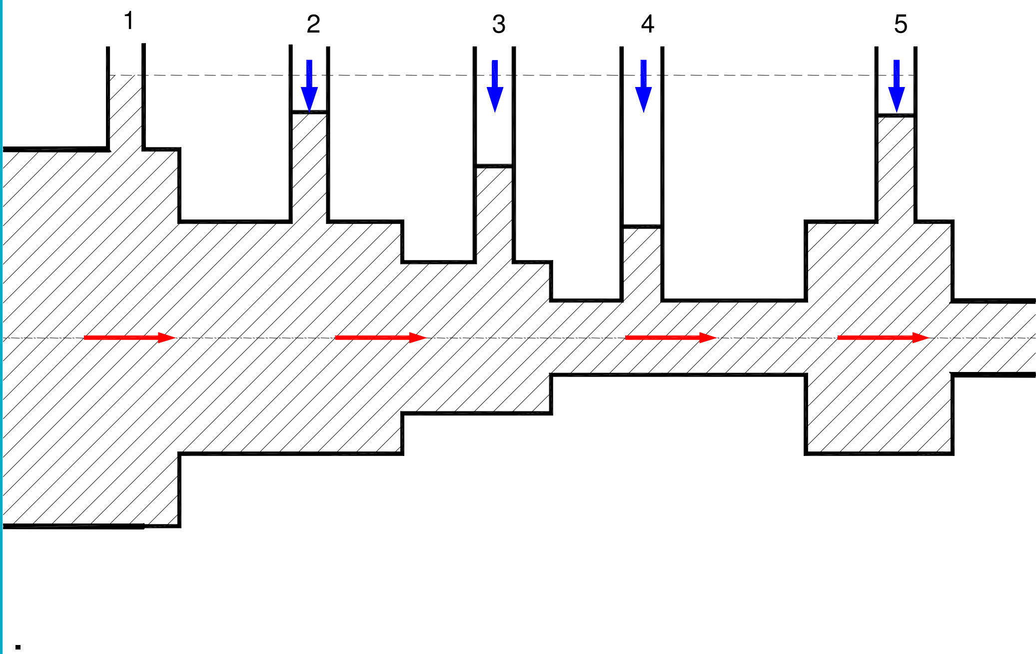
The bridge pier in the flow has the same effect as a ship steaming ahead.

BERNOUILLI 'S & VENTURI 'S RELATION



Pressure in tube test drops when diameter of the pipe decreases: when the liquid speeds up.

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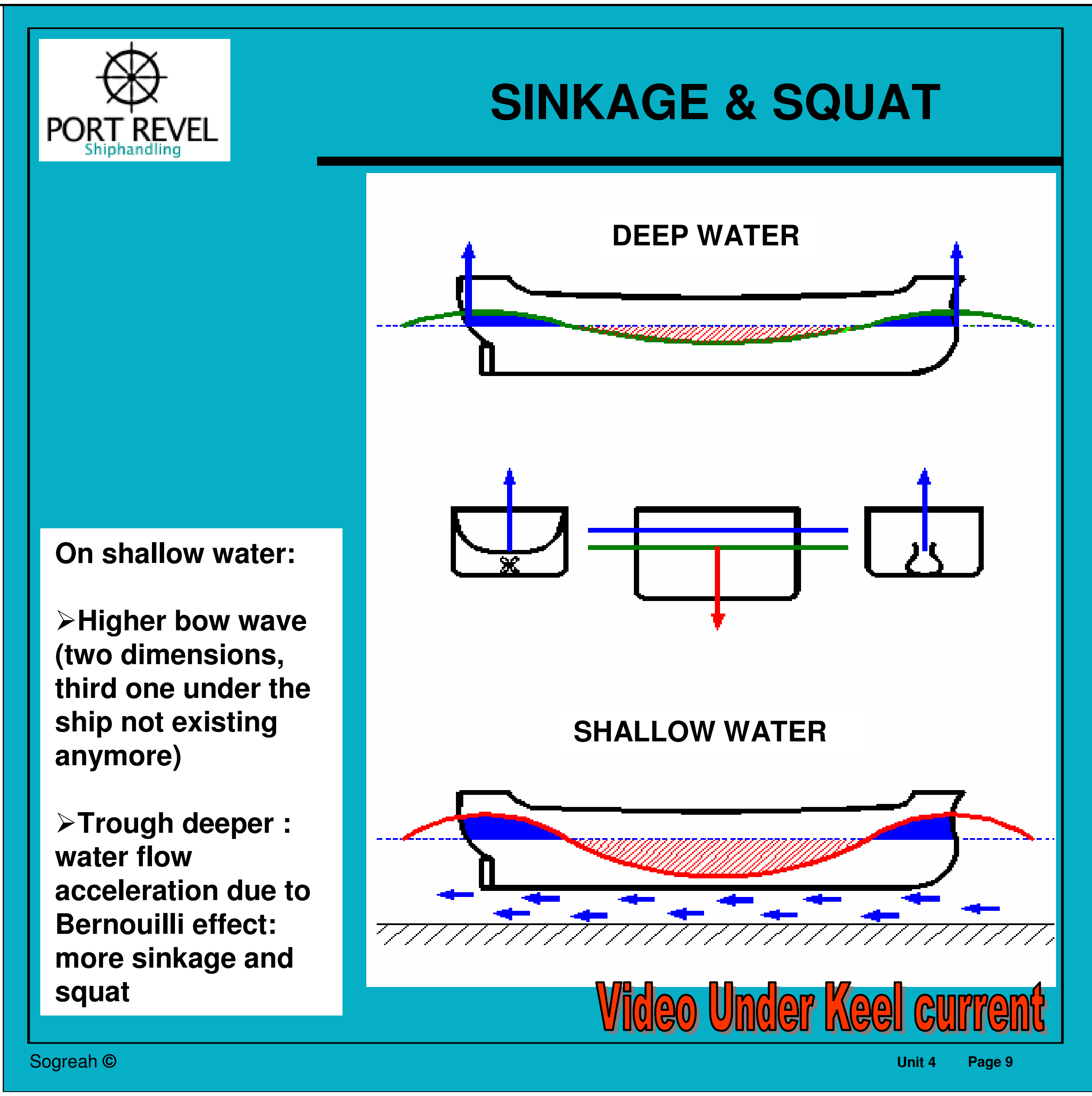
Unit 4 Page 8



a) **A fall in water level around the entire ship**, which drops towards the sea-bed, we say that she "*sinks*".

b) Secondly, a lost of buoyancy in the main body of the hull, buoyancy which is recovered by the bow and the stern waves. Since the shape of the two ends of the ship is different and according the position of the wave form relative to the ship, the ship sinks with **a change of trim**, called "*squat*".

SQUAT: FROUDE RELATION

$$(1)\quad q = \frac{\text{Ship Speed in Deep Water (Knots)}}{\sqrt{\text{Ship Length (Feet)}}}$$

Ship underway sea speed in deep water

q < 1:ship is down by the head (tankers)

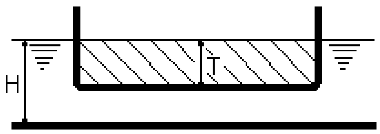
q = 1.2: ship is even keel (containers)

q > 1.3: ship is down by the stern (war ship)

(1) Froude Relation gives how the ship sinks but not how much

PREDICTING SHIP SINKAGE
(Simplified Barrass formula)

1- In very shallow open water.
for 1.10 < H/T <1.20

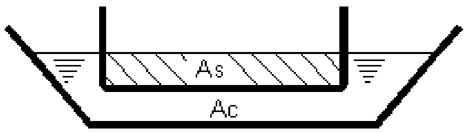


$$S_{[m]} = C_B \frac{V^2_{[knots]}}{100}$$

2- In confined canal.

n = Blockage factor = Ac/As

for 3.5 < n <10



$$S_{[m]} = 2\ C_B \frac{V^2_{[knots]}}{100}$$

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Confined water sinkage is **twice** that of open water sinkage.

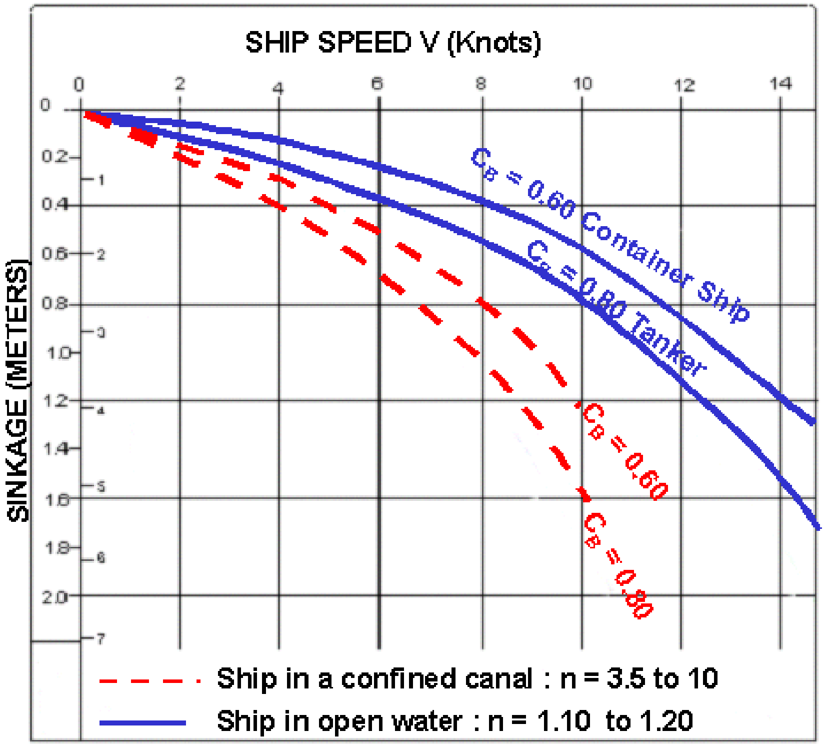
PORT REVEL
Shiphandling

PREDICTING SHIP SINKAGE (Simplified Barrass formula)

For C_B = 0.80 on open water :

at speed 10 Kn => sinkage=0.8m

at speed 12 Kn => sinkage=1.2m



$$C_B = \text{Block coefficient} = \frac{\text{Displ}/1.026}{L \times B \times D}$$

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Up to 2 m (7 ft) sinkage on shallow open waters is a realistic possibility …

The amount of squat and sinkage depends on:

- ship's speed
- hull shape (mainly the block coefficient "C_B" which may depend on the ship's draft)
- restriction of water:
   . under the keel: in shallow waters
   . and on the sides: in confined waters, channel & canal

SHALLOW WATERS - SUMMARY

-higher bow wave increases the underwater resistance:
- speed reduced
- rpm reduced

- lack of buoyancy: sinkage and trim change

- pivot point pushed more aft, steering lever is reduced

- larger turning circle: diameter is up to 50 % larger

- stopping distance is increased

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Due to the passage of a ship, the water is affected under the keel and off the sides until a certain distance, which varies with the shape of the hull and the speed of the ship over the ground. These distances are called the depth and the width of influence.

When the bottom clearance is less than the depth of influence, the ship is said to be navigating in **restricted waters**.

When the side clearance is limited by a slope or a bank at a distance less than the width of influence, the ship is said navigating in **confined waters**.

UNIT 4 – Wednesday

CANAL EFFECTS

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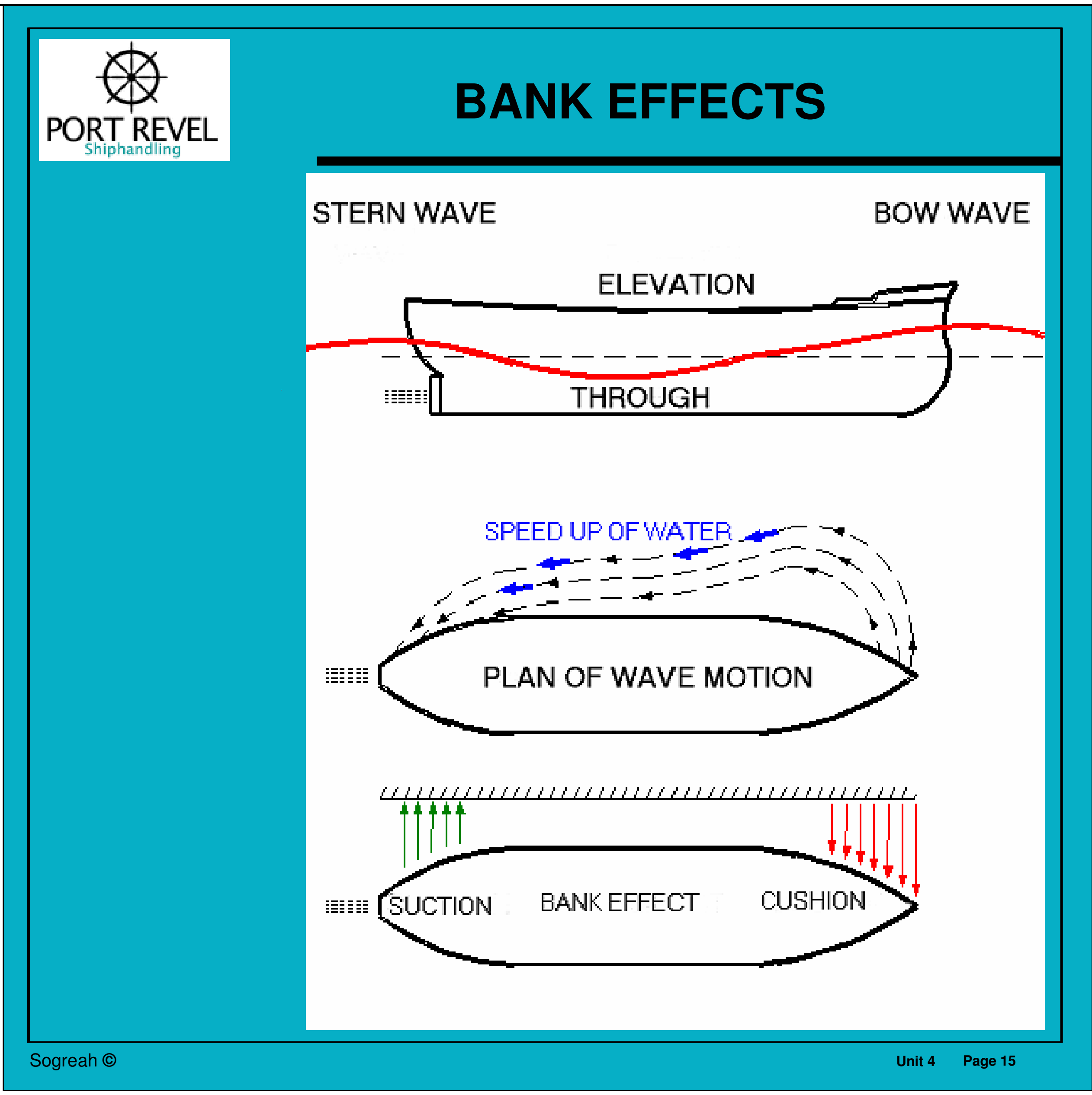


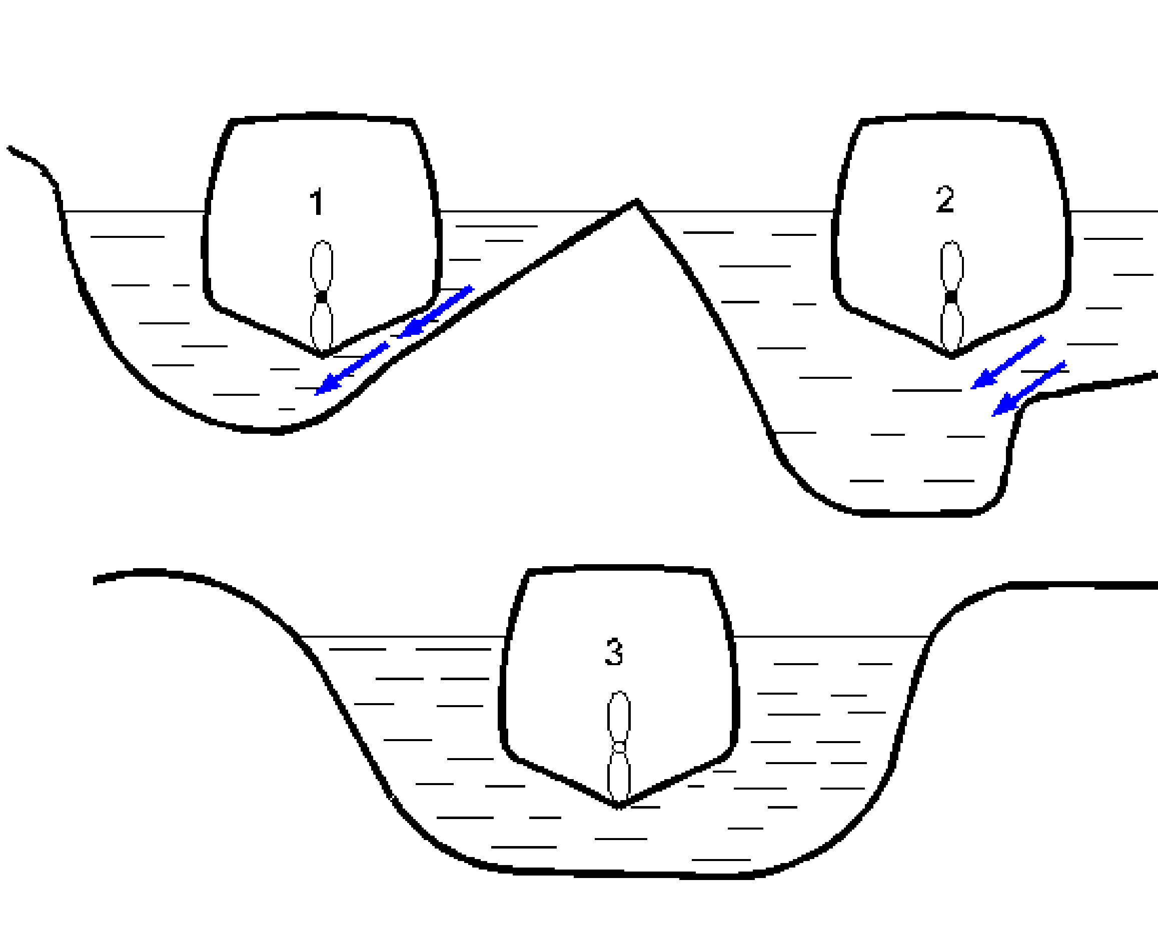
Bow cushion

As the bow pushes water away, opening way for the passage of the hull, confined water on one side will restrict the flow of that water. The result is a "cushion" effect between the bow and the bank. The direction of this force is not only horizontally outwards from the bow, but in all directions between the bow and the bank. The bow wave becomes higher on the side toward the bank and the increase in pressure, forces **the bow away from the bank**.

Propeller suction

"Suction" in shallow water exists at the stern. This is particularly noticeable in the supply flow to the propeller which drives the water away a little faster than the water can flow in. As a result, the difference is made up by a greater inflow from the sides. This depresses the surface at the sides just forward of the propeller. When the sea bed is regular, this "suction" is equal on both sides of the stern. However, if there is a bank or the water is shallower on one side, the source of flow is restricted and the water surface between the obstruction and the propeller is depressed. The increased suction on the shallow side begins to act and **the stern is drawn toward the bank**.

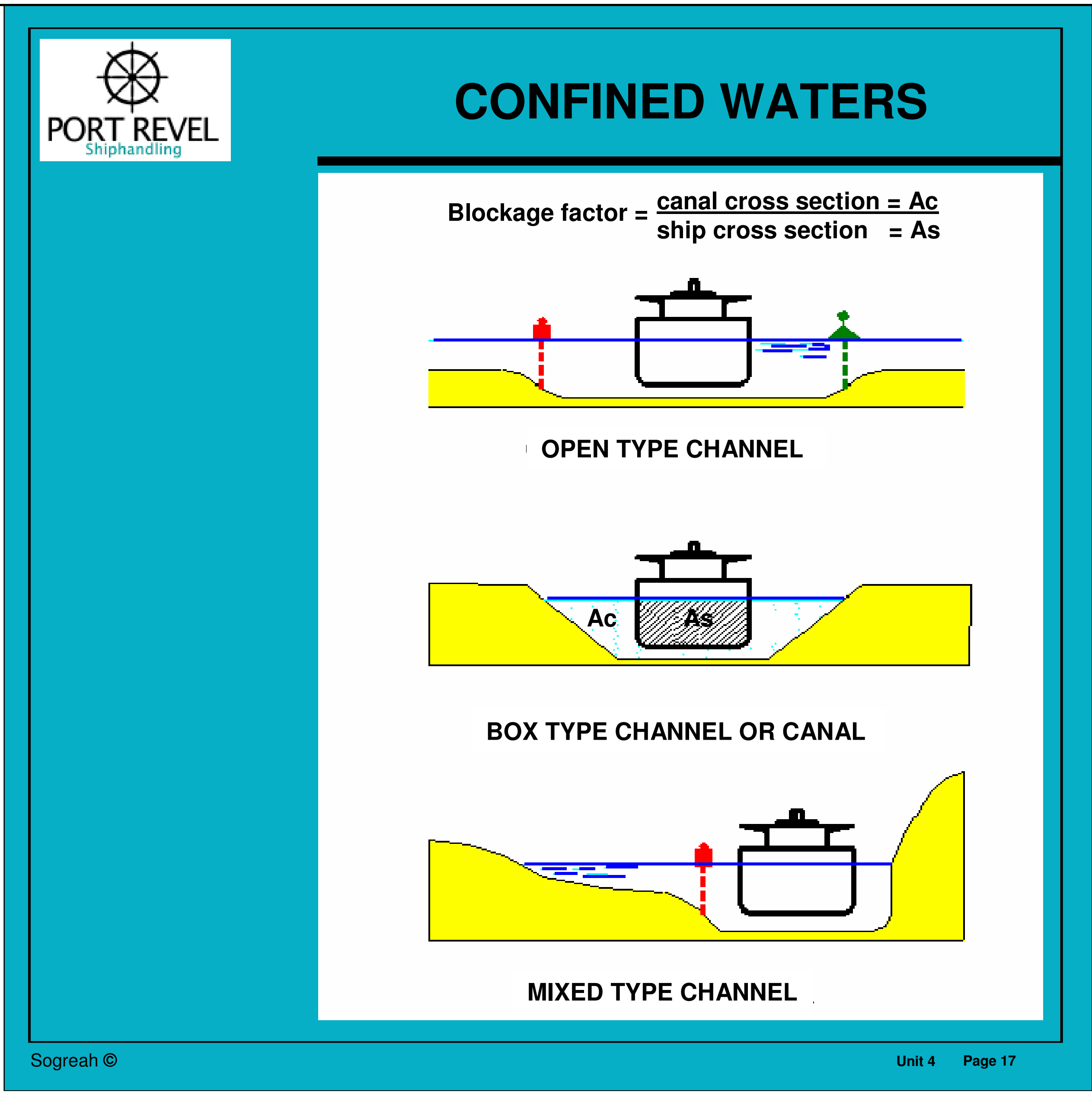
INEQUALITIES OF THE BOTTOM



From G.L. Danton

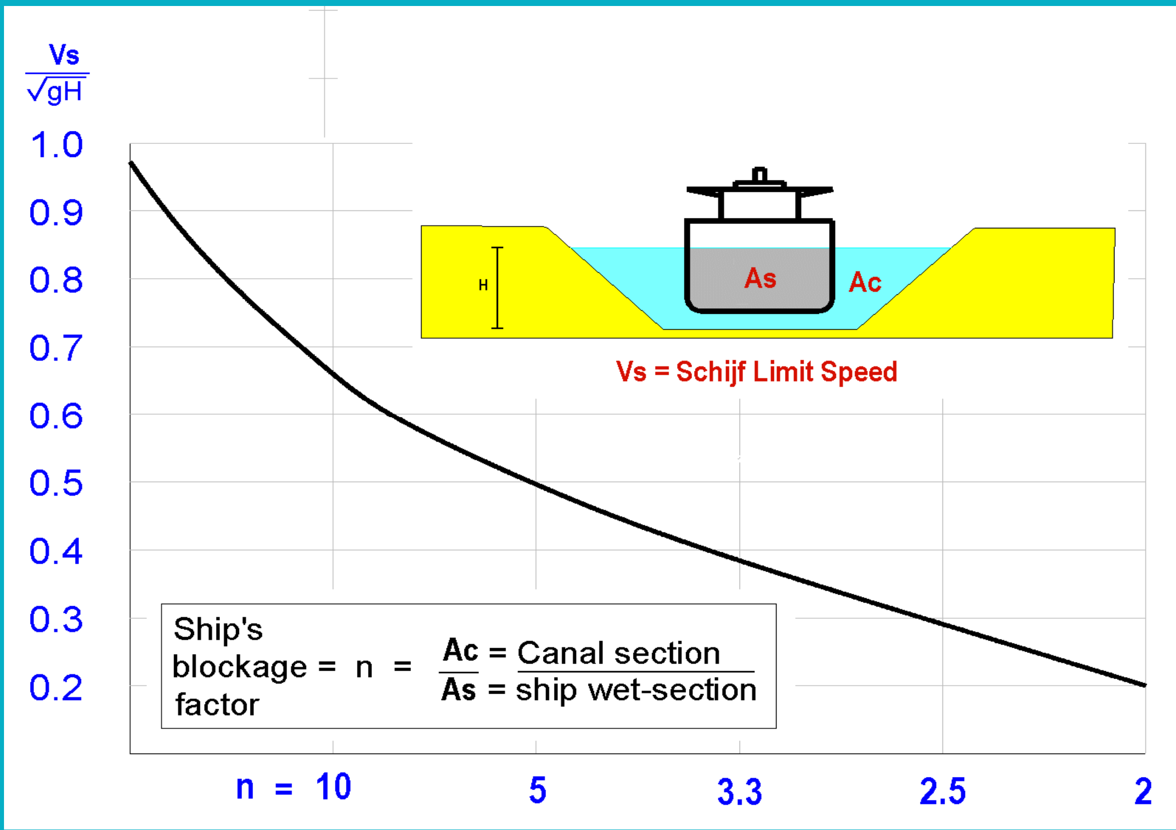
Sogreah © Unit 4 Page 16

In 1) and 2) the ship is taking a sheer to port because of the canal's asymmetry.



The "*blockage factor*" which is the ratio of the ship's underwater section to that of the channel.

SCHIJF LIMIT SPEED (1)

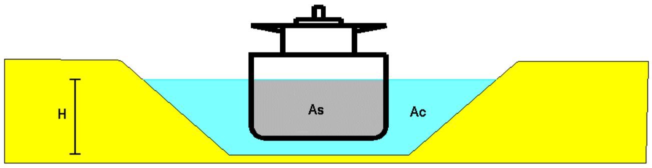


Depending on n, the factor on Y axis has to be multiplied by the square root of gH to find the saturation speed Vs

Sogreah © Unit 4 Page 18

In a canal or narrow channel, shallow water effects become very pronounced. Not only is there a restriction on the flow of water under the ship, but there are banks restricting the water on either side. There is a "*saturation speed*" when the ship becomes very difficult to control due to restriction of water flow. The saturation speed depends mainly on the blockage factor. The waves and troughs about the hull are steeper and larger than before. The banks act as a cushion on both sides of the bow and cause suction on both sides of the stern. The ship is in a balance between these forces only when she is in the centre of the canal section. As soon as the ship gets slightly away from the centre (due either to her steering or an irregularity in the canal), the bow cushion and stern suction between the ship and the nearer bank both increase.

SCHIJF LIMIT SPEED (2)



Ship's blockage factor = n = $\frac{Ac = \text{Canal section}}{As = \text{ship wet-section}}$

Example

Suez Canal

Brittany n=4 → Vs = 11 kts

Gilda n=6 → Vs = 13 kts

Berlin n=8 → Vs = 15 kts

TRIAL WITH BRITTANY

RPM	Bell	theor. speed deep water	Duration	Steering ability
35	slow	7 kts	7 m 37 s	Very good
50	half	10 kts	5 m 25 s	Still good
65	full	13 kts	5 m 29 s	VERY BAD

Brittany in Suez Canal: Max speed: 9 kts !

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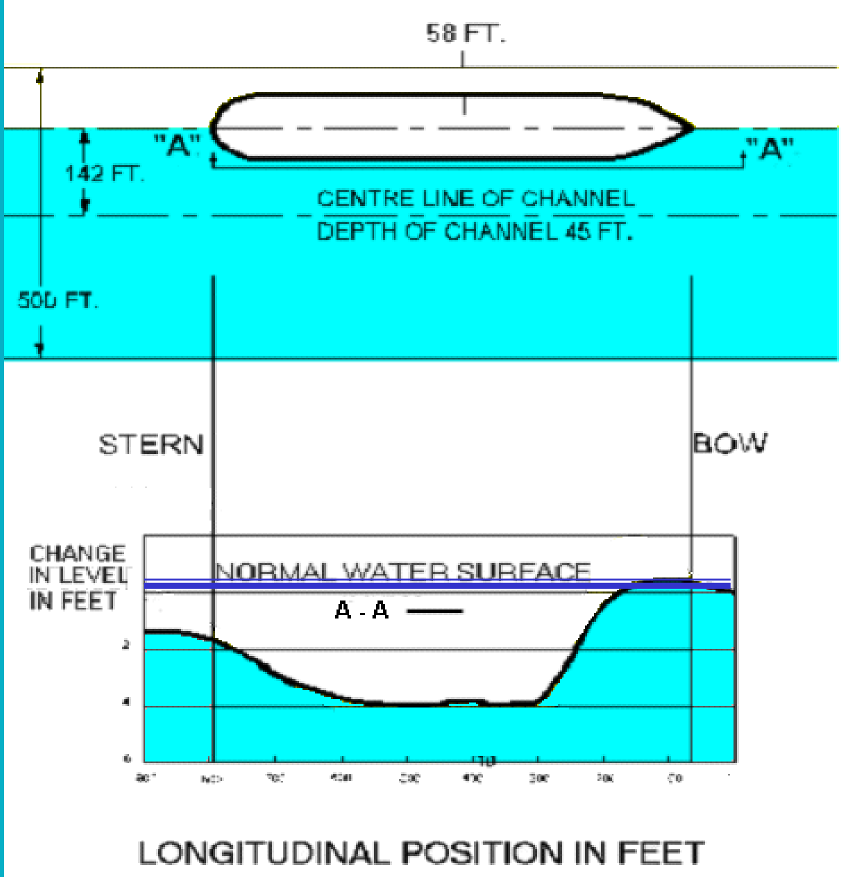
Steaming in a canal at near saturation speed is an unsafe practice : one should exceed 75% of the saturation speed.

BANK EFFECT (1)



After R.S. Crenshew – US Naval Inst.

Sogreah ©

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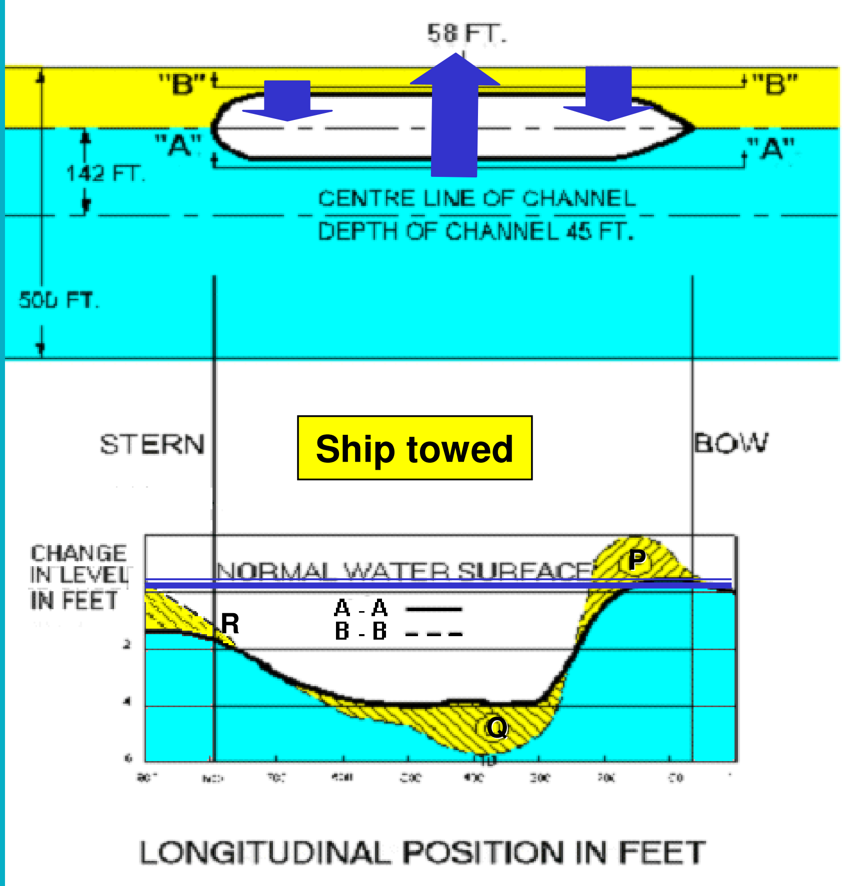
BANK EFFECT (2)



After R.S. Crenshew – US Naval Inst.

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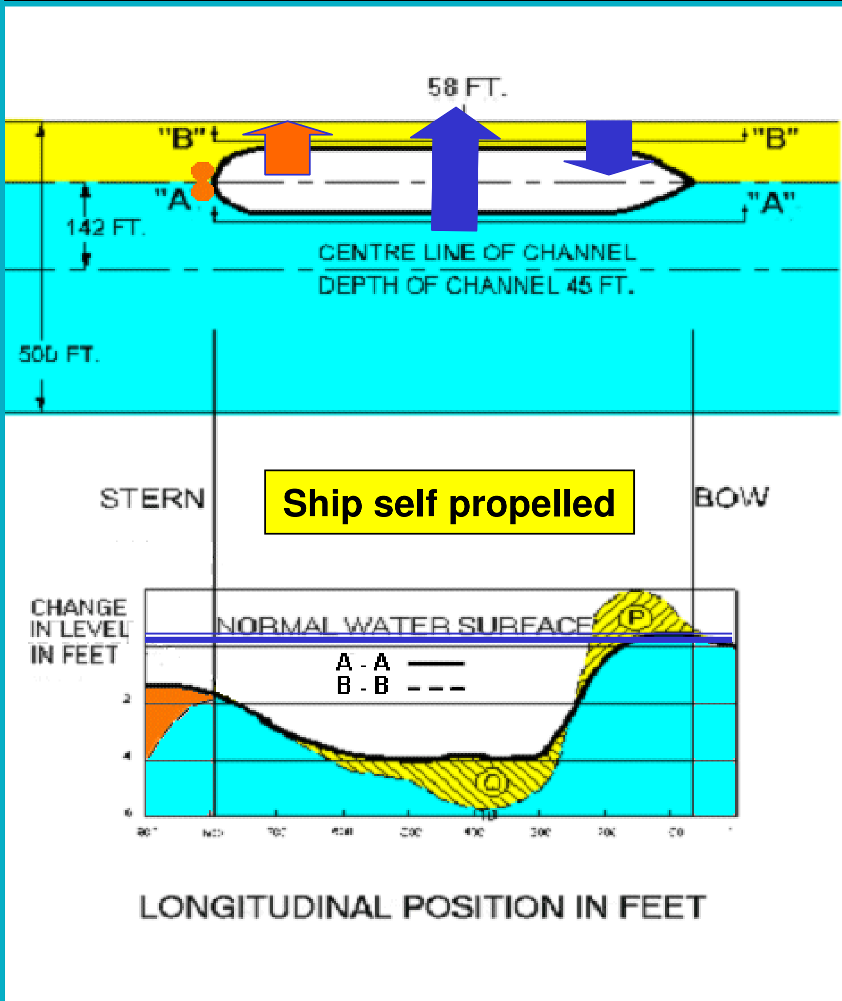
On line B – B: a higher water level between the ship and the bank is seen at the bow (P) and the stern (R). A lower water level is seen in the middle of the ship (Q).

- as area Q is larger than area P + area R, the ship is sucked to the bank.
- as area P is larger than area R, the bow is pushed away from the bank.

BANK EFFECT (3)



Sogreah ©

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With a self propelled ship, water is taken away from the bank to the centre of the canal by the propeller. This induces suction of the stern to the bank.

TRANSIT THROUGH CANALS

The Normandie (4400 TEU) in the Suez Canal

Video Bank Effects

Sogreah © Unit 4 Page 23

1. Straight section of channel or canal

- Stay in the middle of the canal or just off the centre line.

- In case of yaw:

  . overestimate the amount of rudder at the very beginning;

  . when hard over on the rudder is not enough, give a kick ahead, as short as possible, on the engine.

2. Channel bends

The bank cushion can be used to advantage in safely making bends in a narrow channel or canal by favouring the right side when the canal bend is to the left and by favouring the left side when the bend turns to the right. The ideal track round a bend is the one that lets the ship follow the canal with the least amount of rudder.

3. Channel or river bends with a current

- When heading downstream, stay close to the middle of a channel bend.

- When heading upstream, stay wide, keep in the bend.

Two sound basic principles, but in rivers or channels with current and irregular banks, extreme caution is necessary when good local knowledge is not available.

UNIT 5 – STOPPING THE SHIP

The slides hereafter clarify the following aspects:

1. USE OF ANCHORS

2. EMERGENGY STOPS

2.1. HARD TURNING

2.2. RUDDER CYCLING

2.3. CRASH STOP

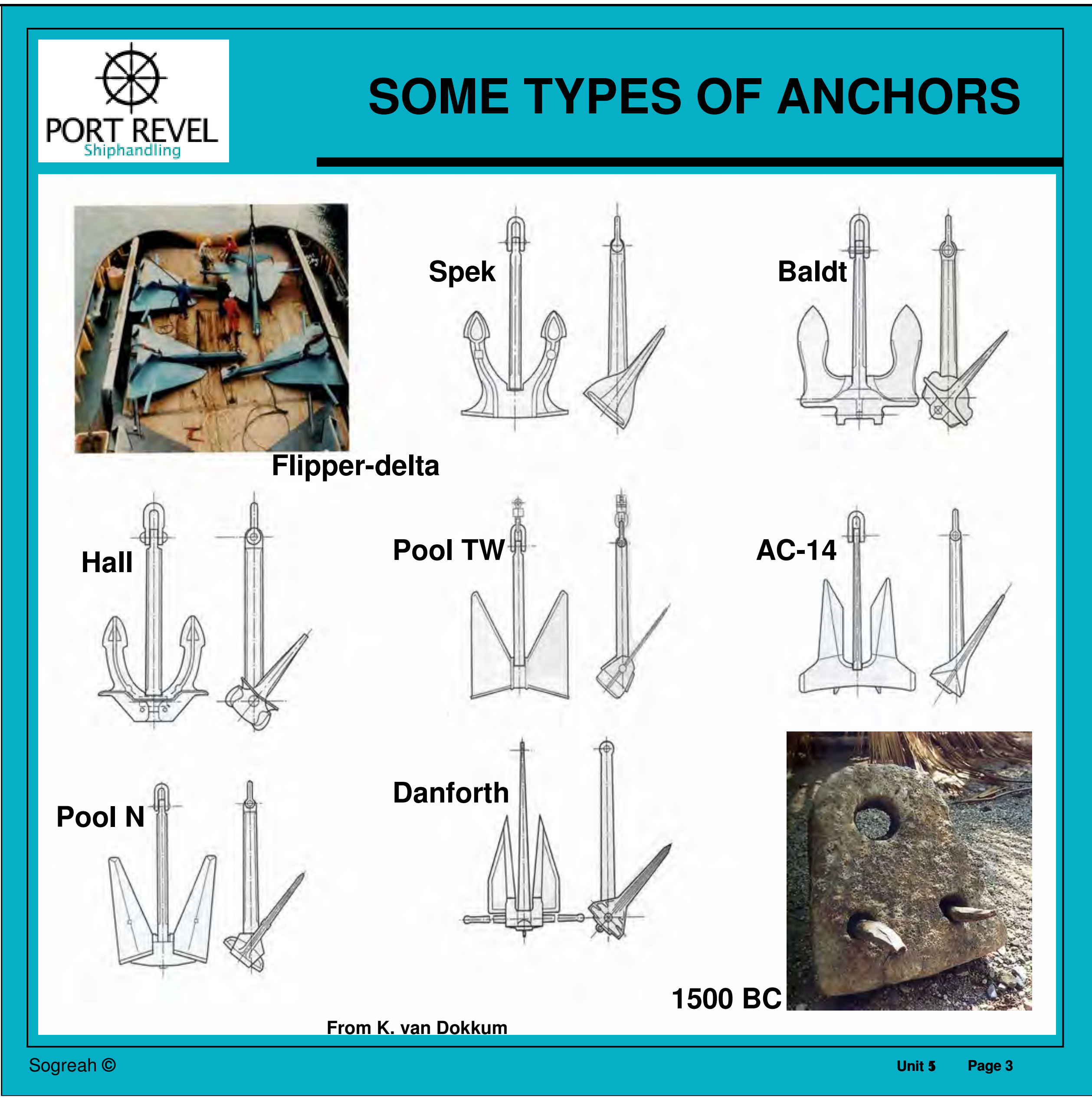
UNIT 5 – Thursday

USE OF ANCHORS

Sogreah © Unit 5 Page 1

Let go the anchor … !

Sogreah ©



The **holding power**, beyond which the anchor starts to drag, depends on:

- weight and shape of the anchor,
- length of chain,
- bottom quality.

HOLDING POWER

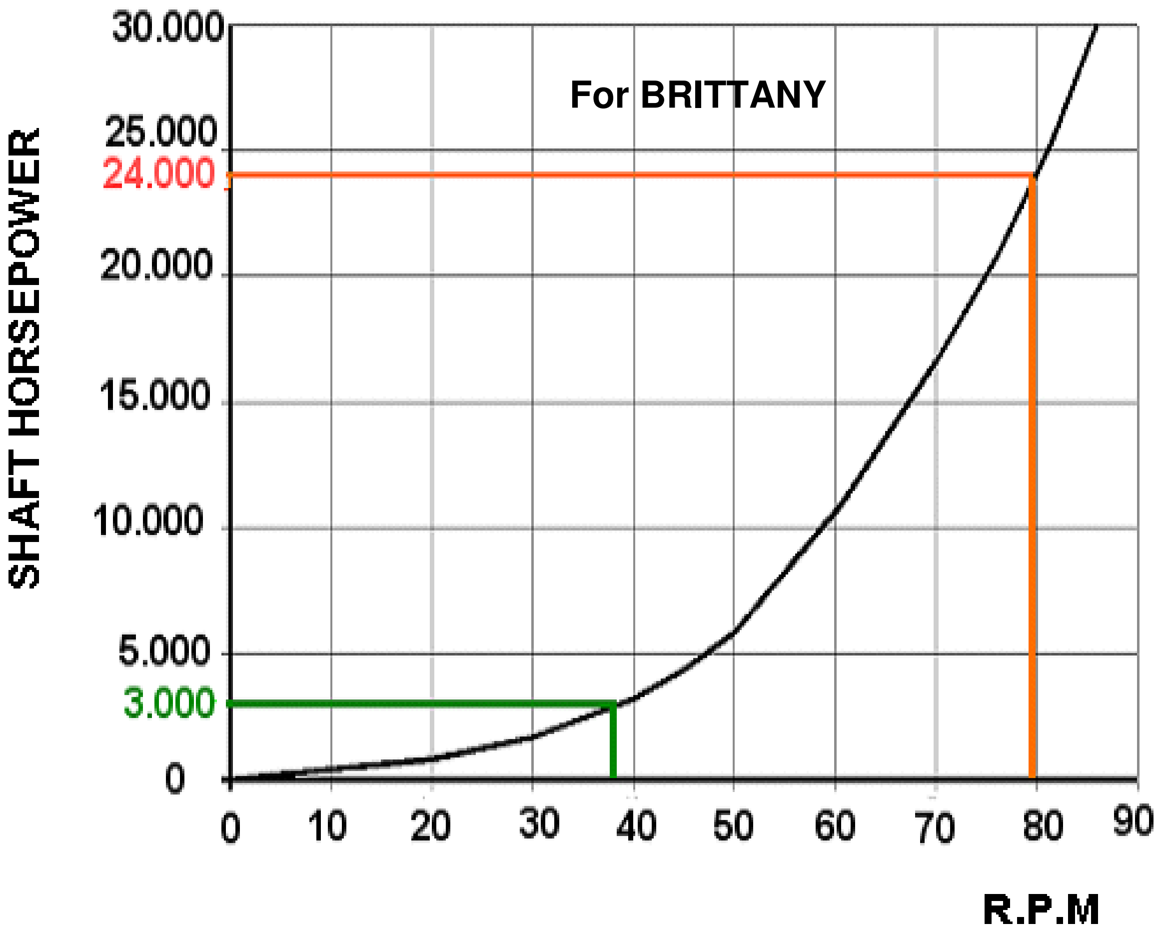
SHIP	SIZE (dwt)	ANCHOR WEIGHT (t)	COEFF.	HOLDING POWER (t)	CHAIN BREAKING (t)
GRENOBLE	43 000	5	8	40	150
GILDA	125 000	14	8	112	400
BRITTANY	190 000	20	8	160	580
EUROPE	255 000	23	8	184	700
ANTIFER	400 000	27.5	8	220	1000

The holding power of traditional anchors is around 7 to 8 times their weight (8 used in table above) on a sound clay bottom … it is nil on a flat rocky bottom !

Special anchors can have a holding power in excess of 10, and even 20 times their weight.

The nominal chain breaking load is normally around 4 times higher than the holding power.

CARE FOR PROP THRUST ...



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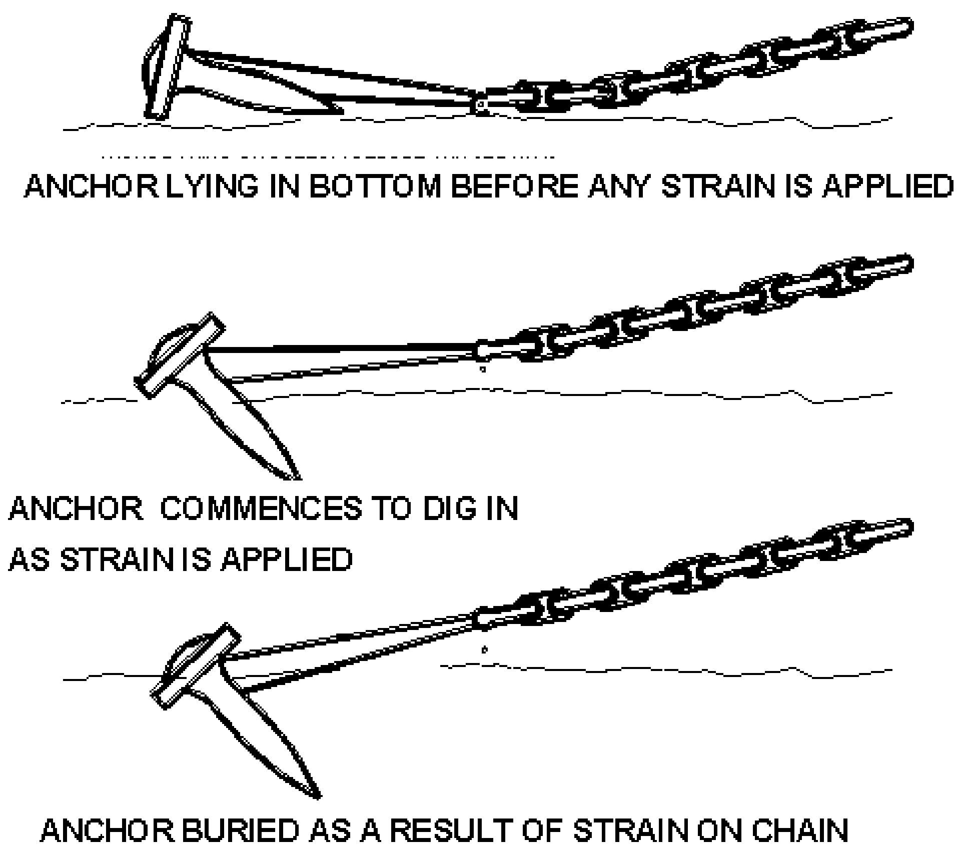
Keep in mind that when increasing rpm from Dead Slow to Slow (20 to 40 rpm) on the Brittany (190 000 dwt tanker), the propeller thrust will increase from around 15 to 50 tons. This must be compared to the holding power of the anchor on the bottom.

STAYING AT ANCHOR



After R.S. Crenshew – US Naval Inst.

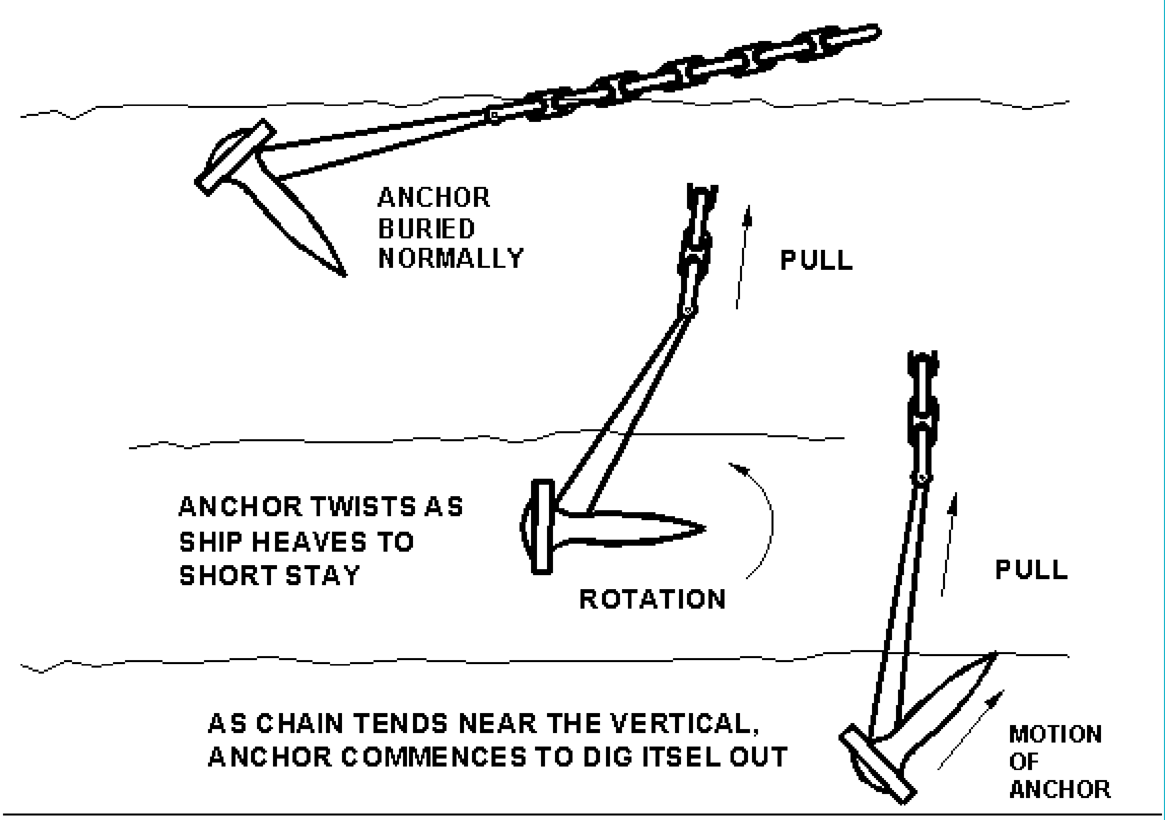
Sogreah © Unit 5 Page 6

When used for anchoring, sufficient length of chain must be used to allow for a near horizontal pull on the anchor so that the flukes will dig in:

- if angle of chain to ground = 5° >> holding power is reduced by 25%,
- if angle of chain to ground = 15° >> holding power is reduced by 50%.

As anchoring is meant to resist drift due to wind and/or current, beware for correct orientation of the flukes with respect to wind and/or current direction.

HEAVING ANCHOR



After R.S. Crenshew – US Naval Inst.

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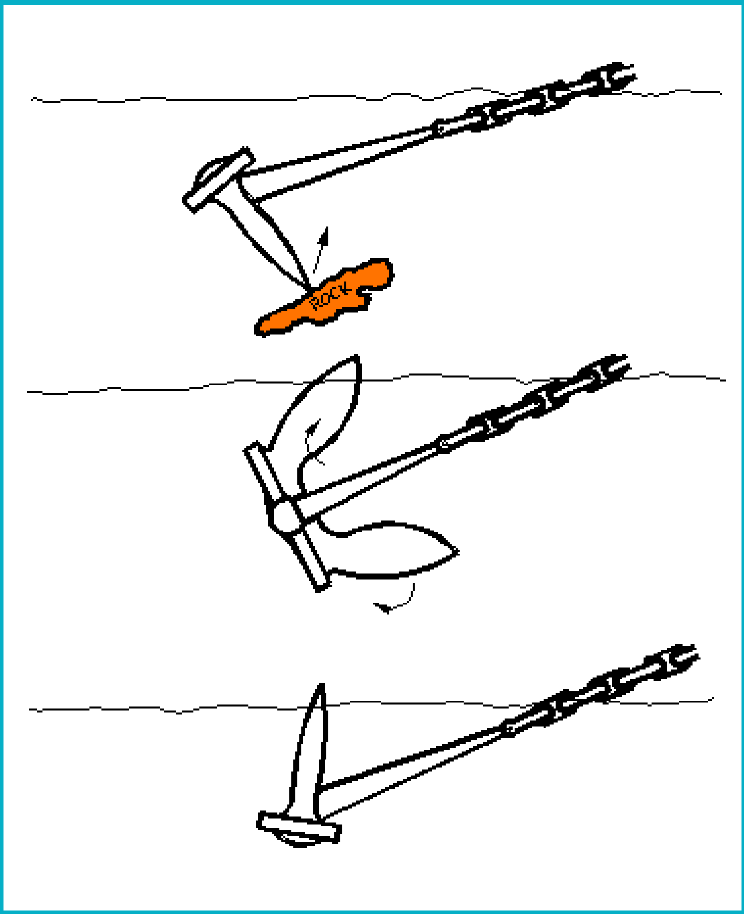
Unit 5 Page 7

DRAGGING ANCHOR

One fluke strikes rock and anchor starts to turn.

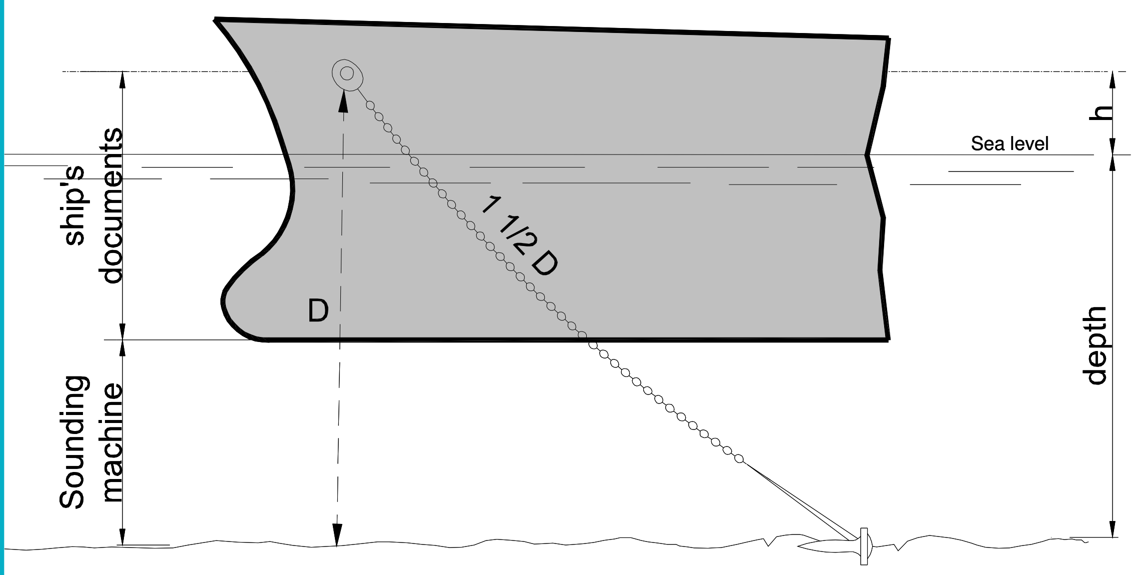
Roll continue and anchor begins to come out.

Anchor upside down. Ready to dig out completely.



After R.S. Crenshew – US Naval Inst.

DREDGING ANCHOR (1)



Length of chain paid out < 1.5 to 2 D

Sogreah © Unit 5 Page 9

Basically a means of making vessels fast to the ground, the anchor is also an important device to be used for manoeuvres in confined waters and in emergencies:

- to stay at anchor: L = around 5 D,

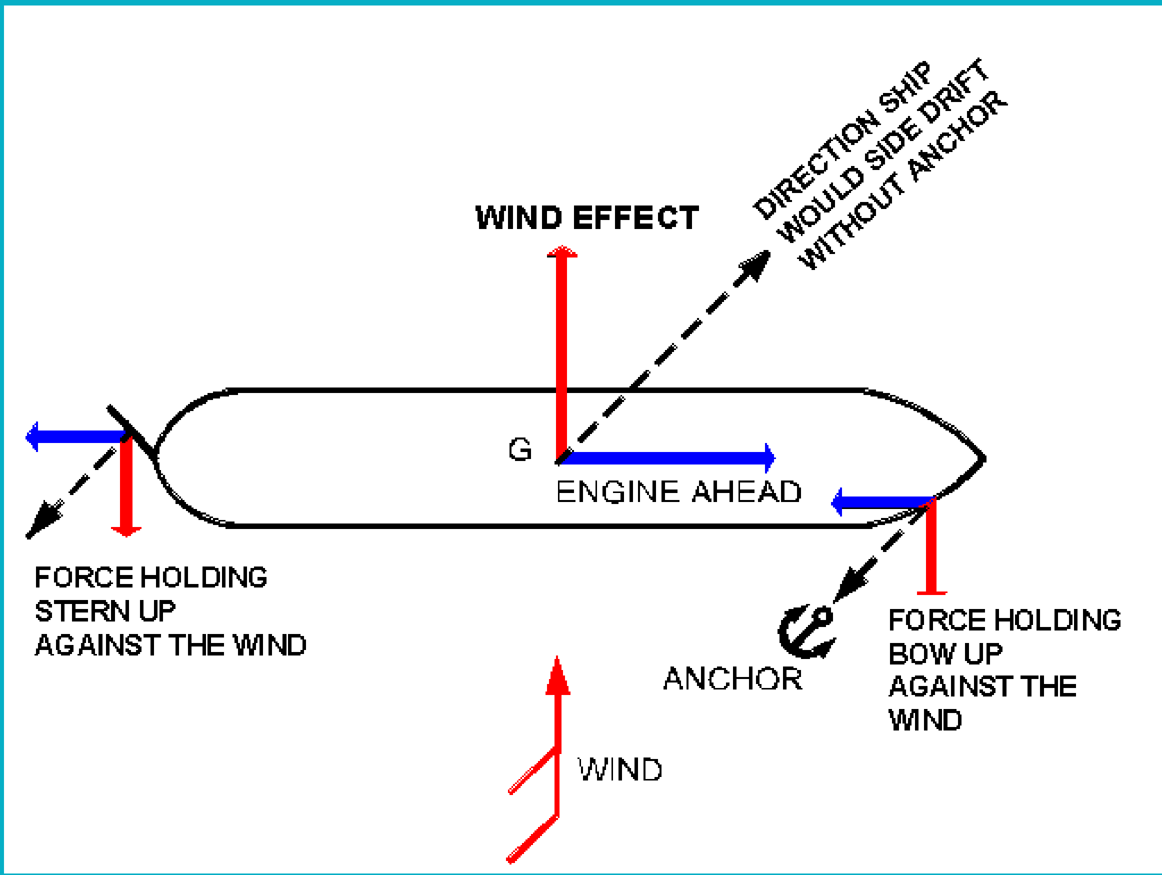
- to turn the ship on one anchor: L = around 3 D (pivot point is then moved forward close to hawse pipe),

- to dredge an anchor: L = around 1.5 to 2 D.

Dredging an anchor is dragging an anchor **on purpose**.

When used for dredging, the length of chain must be based on the amount of drag desired. This in turn depends on the vessel's speed, the depth of the water, nature of the soil, condition of loading of ship, wind and current. The drag of the anchor varies inversely with the speed of the ship and, if too much chain is used, the anchor may "hang up" as the ship slows down. On the other hand, too little chain may not provide an effective drag at all. Ship's speed when dredging should be as low as is necessary for manoeuvrability, and sudden changes in propeller R.P.M. should be avoided. Increases in speed may cause the anchor to jump under a strain which has straightened the catenary. The movement of the chain in resuming its larger catenary will impart a velocity to the anchor over the velocity of the ship and cause it to skip along the bottom.

DREDGING ANCHOR (2)



Sogreah © Unit 5 Page 10

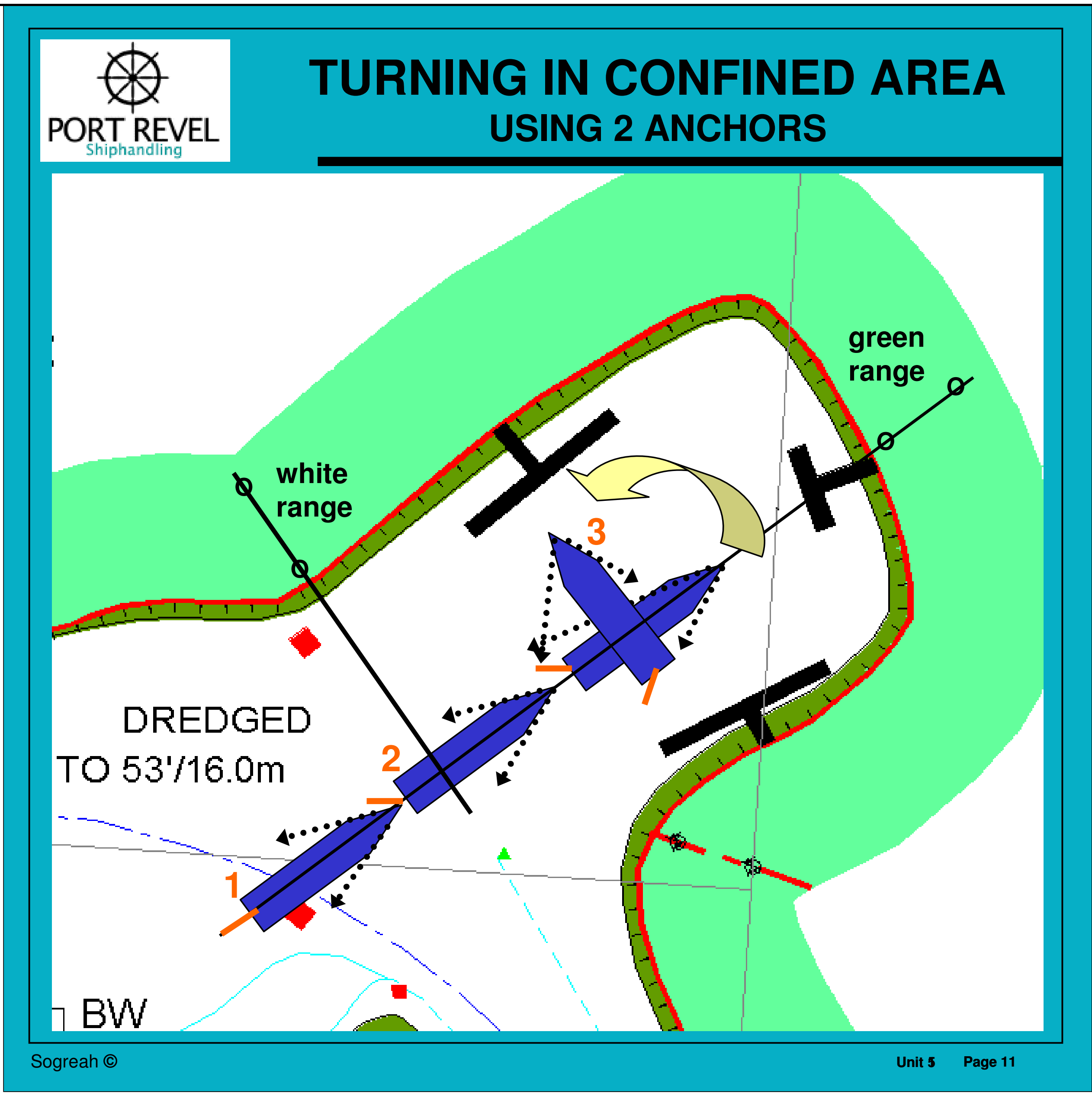
In confined waters, an anchor properly used allows a vessel to be steered on propeller thrust alone with little or no headway.

The holding power of a dredging anchor is around 20 – 30% of the regular holding power: if you need more, let go a second anchor …

In shallow waters, at low speeds on a ship with deep chain lockers, the weight of the chain standing in the locker may stop the chain from running out once the anchor has landed on the bottom.

On large deadweight vessels, if an anchor holds or gets "hung up" while dredging, the brake alone may not be able to absorb all the vessel's momentum, so great care must be taken to ensure that chain is held at a short enough scope.

The lead of the chain from the hawse-pipe is not always a true indication of the lead to the anchor. A leeward anchor may even lead under the ship to windward enough to cause a swing in the opposite direction. Using a lee anchor can be very effective in holding a ship to windward because it allows a very flat catenary from the ships bottom toward the anchor.

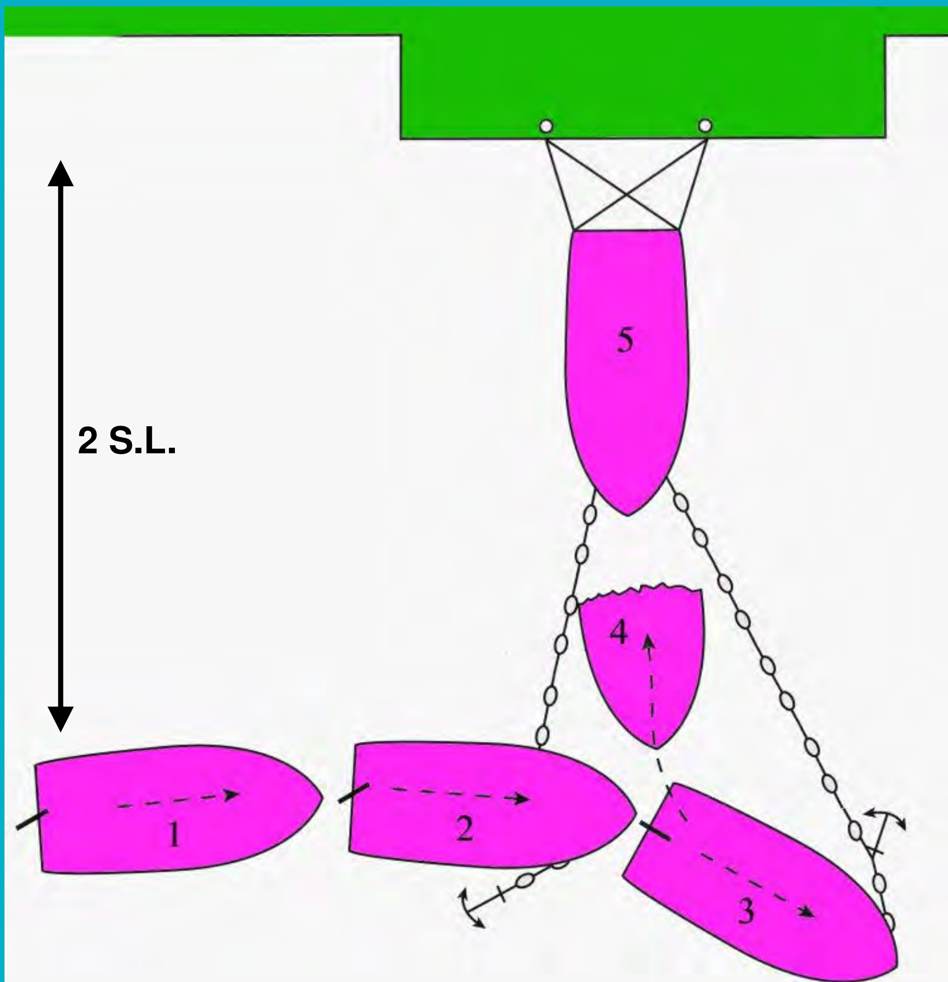


Position 1: Approach on the green range, slow down in due time, drop 3 shackles on each side,

Position 2: when bridge by the beam on the white range, walk out port anchor up to 8 shackles, then hard a port,

Position 3: when turned 90°, heave the stb chain and pick up the anchor, continue to turn while heaving easy-easy the port anchor.

MEDITERRANEAN MOORING



From K. van Dokkum

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Unit 5 Page 12

Position 1: Dead slow, stb helm

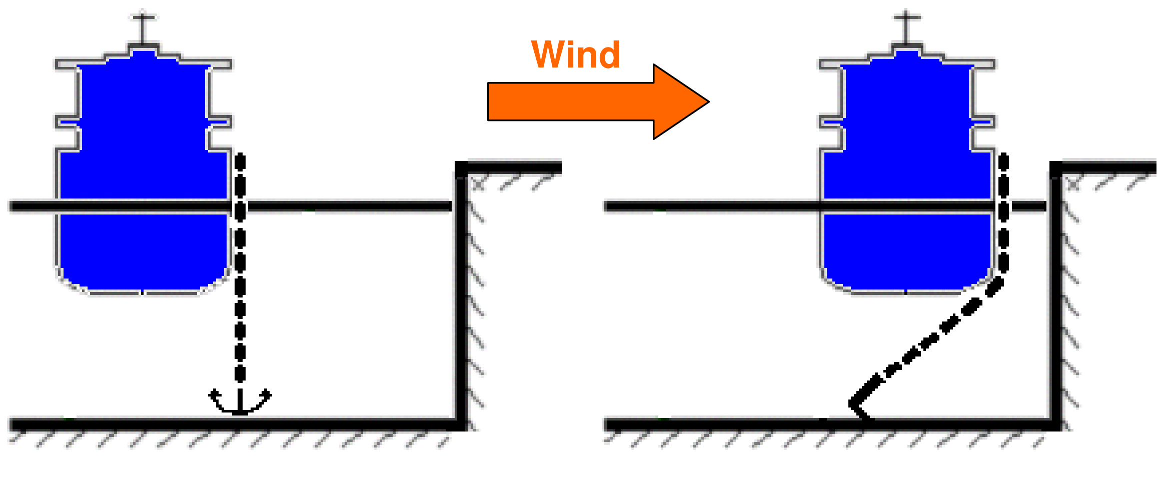
Position 2: Stop engine, stb helm, let go stb anchor (offshore side)

Position 3: Let go port anchor, rudder midships, full astern

Position 4: Reduce to dead slow astern, pay out both anchor chains, stop engine

Position 5: Quarter stern ropes and crossed inboard springs

EMERGENCY DOCKING



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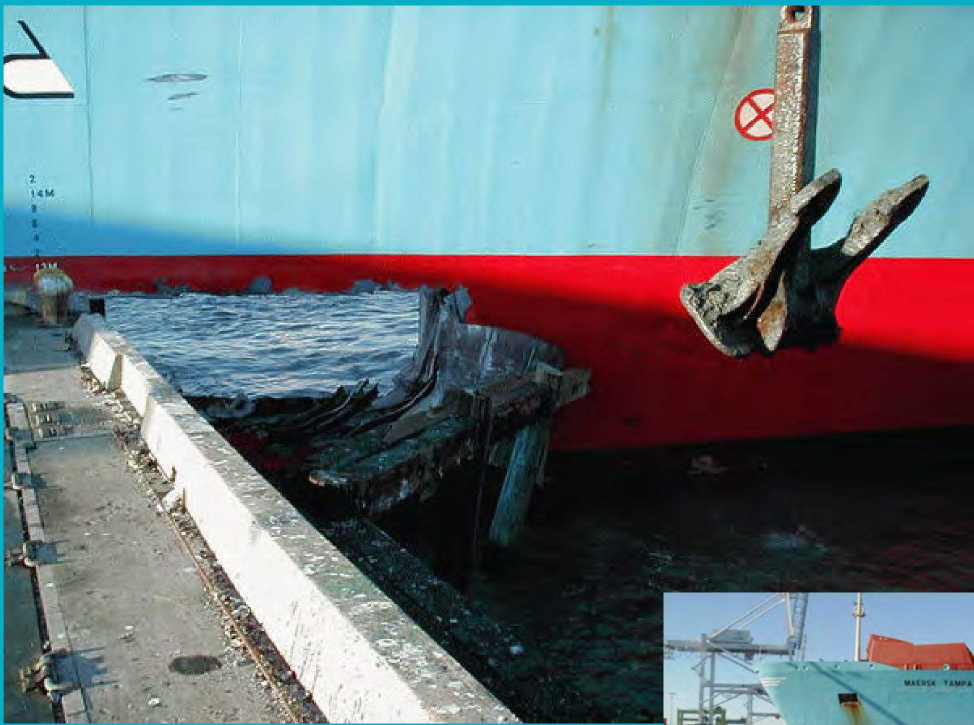
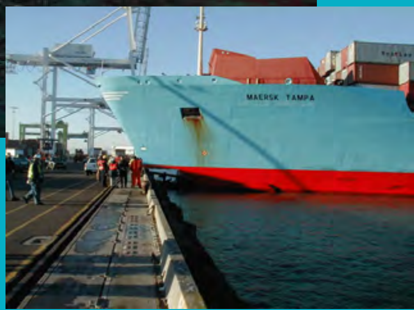
UNIT 5 – Thursday

EMERGENCY STOPS





OUPS …
wish I had let go the anchors before …

http://www.cargolaw.com/2000nightmare_tampa_maersk.htm

Sogreah ©

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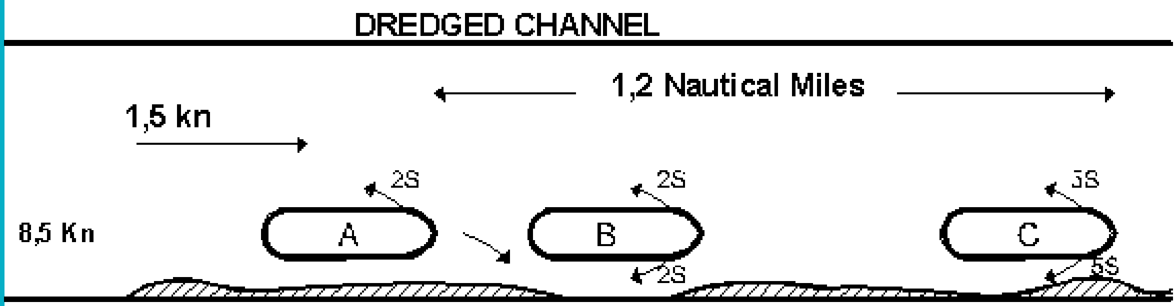
EMERGENCY USE OF ANCHOR

Capt. HOFSTEE's (Rotterdam pilot) experience in a dredged channel with a 30 000 GRT ship (36 ft draft) with engine black out at 8.5 kn with 1.5 kn current astern

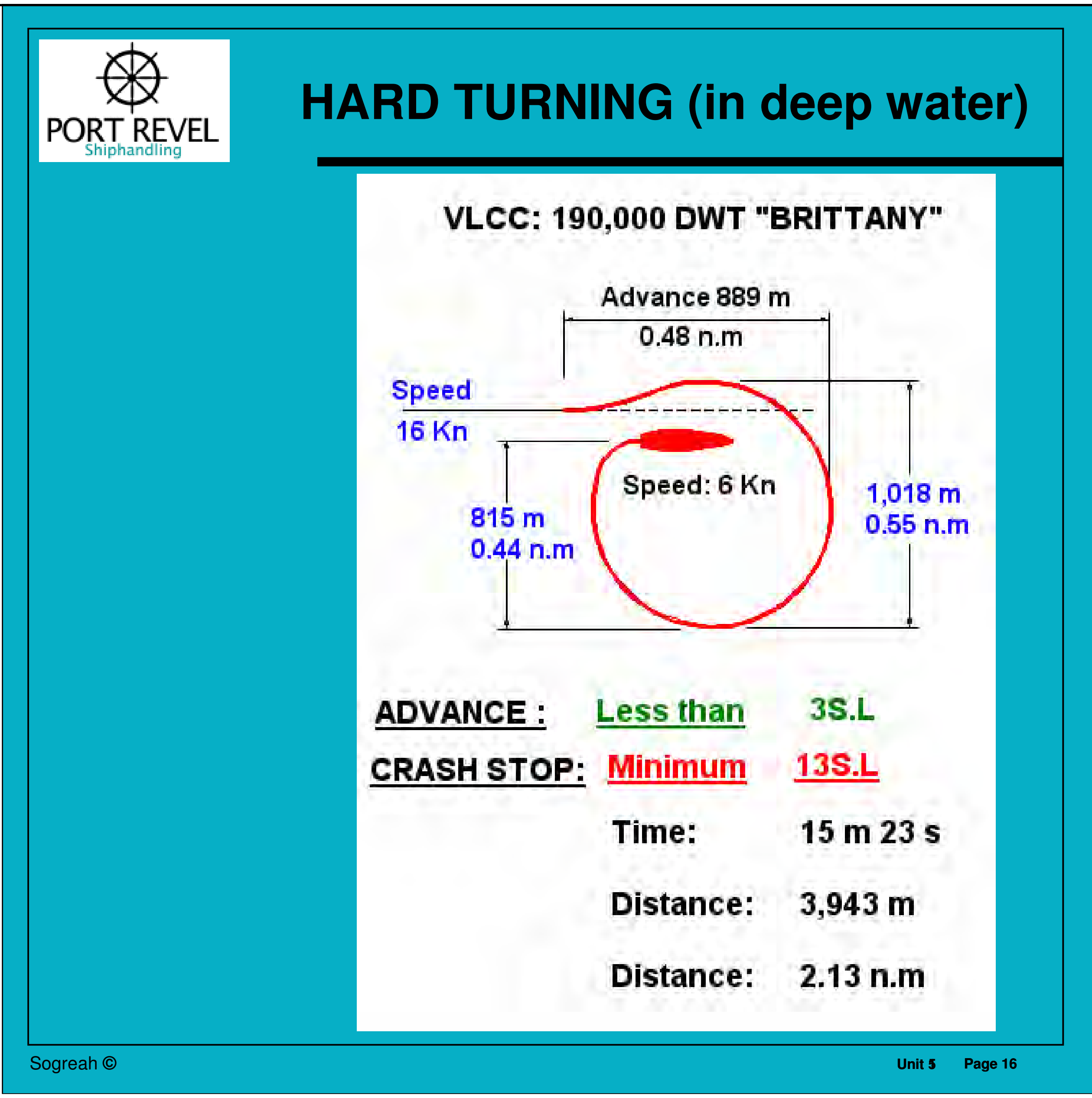


A – Engines black-out, ship sheering slightly to starboard
At first dropped port anchor: 2 shackles

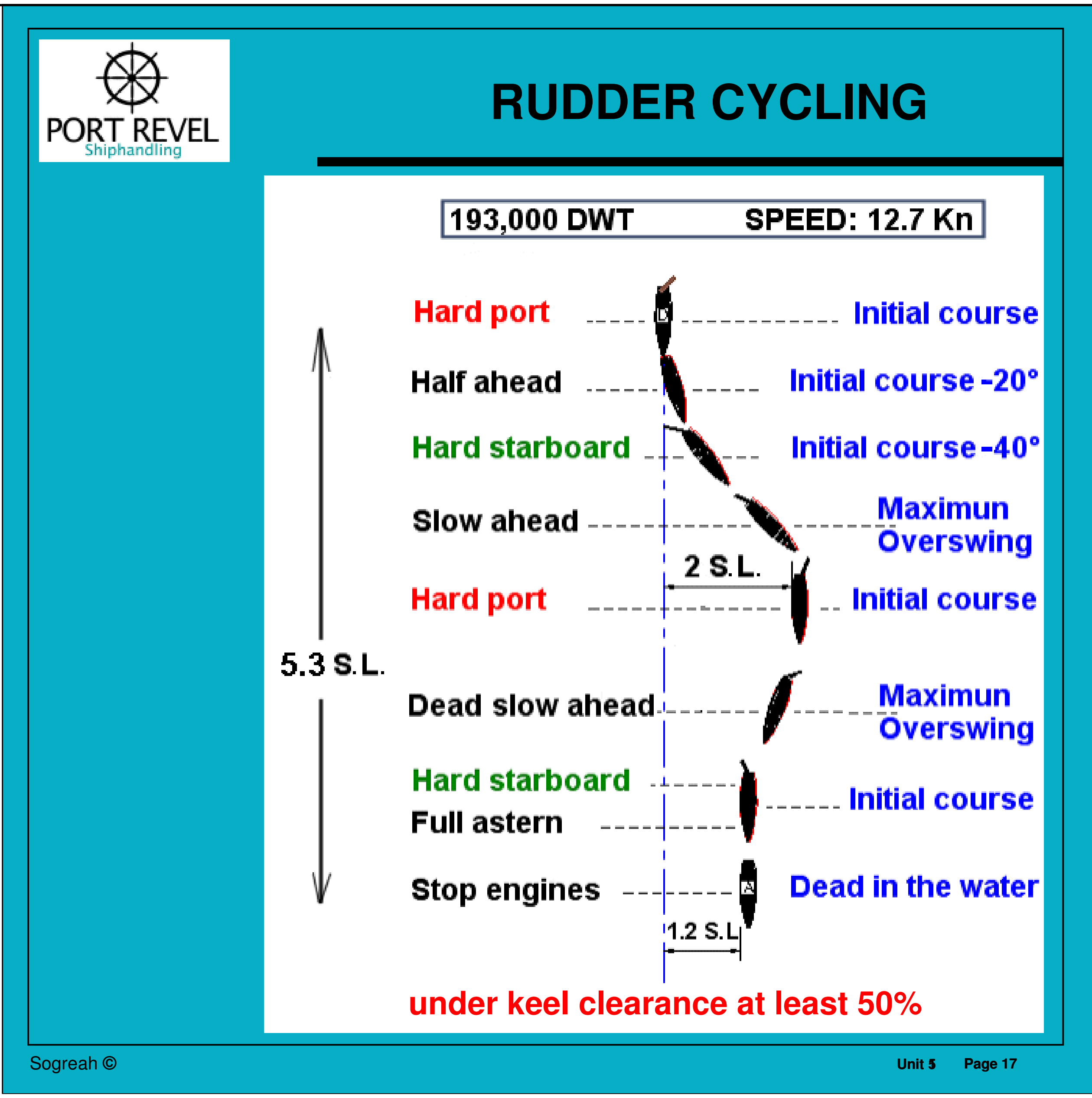
B – Ship steady
dropped starboard anchor: 2 shackles
and then slaked step by step, up to 5 shackles both sides

C – Ship stopped over the ground within 1,2 Nautical Miles

Video Stop in canal



The hard turn is an efficient way of stopping a ship, but sometimes there may not be enough room on the side (usual tactical diameter is around 3 ship lengths).



This manoeuvre was developed by B.S.R.A. with ESSO on the Esso Bernicia in 1972.

The advantage of "**Rudder Cycling**" is that it is possible to keep control of the steerage up to the last moment. However, it is efficient only **if the under keel clearance is at least 50%.**

The speed is reduced by introducing under water resistance:

– by **fish tailing** - Rudder is always hard over on either side,

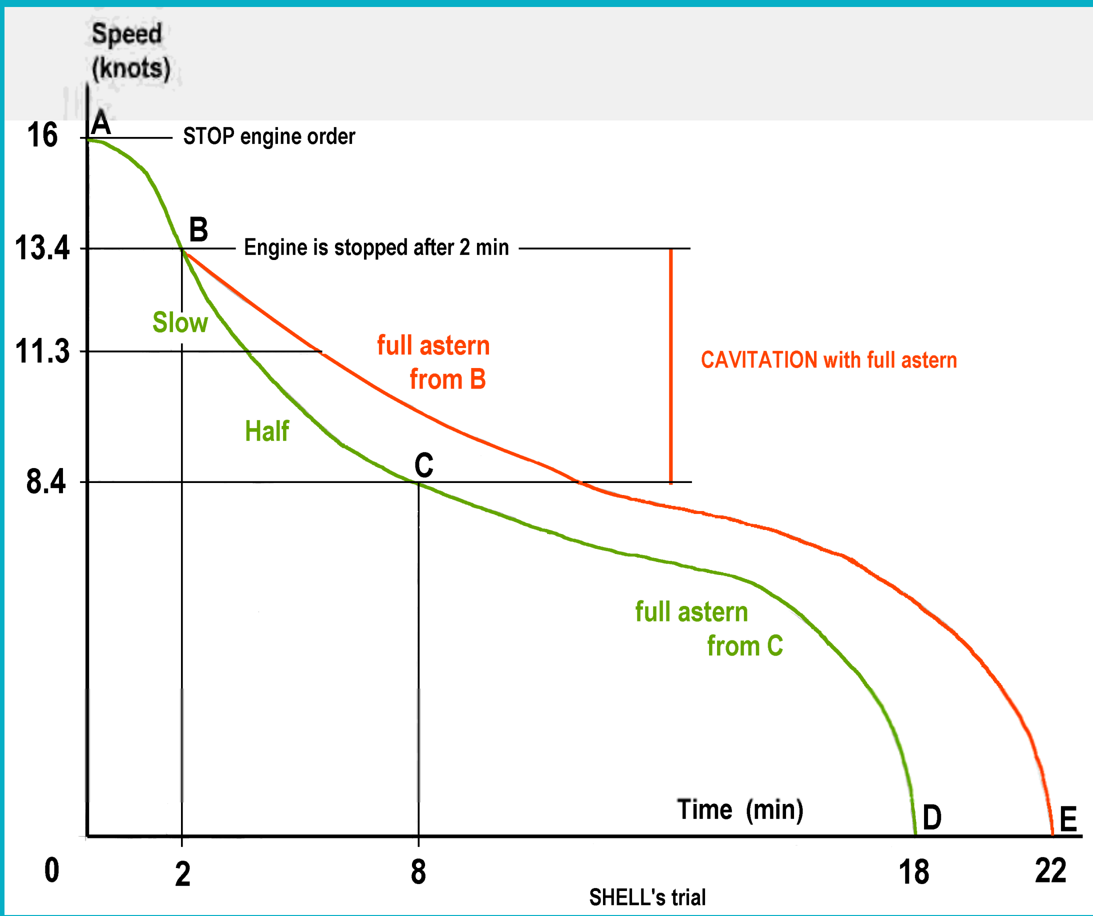
– by **yaws** with a great rate of turn (skidding).

In order to keep a good rudder force capable of giving a good rate of turn, the engine speed is reduced step by step and kept close to the ship's speed.

The procedure presented in this manual should be considered only as a guide and not as a strict procedure and this must be clearly indicated if posted on the bridge.

In practice, local conditions (space) and the traffic situation must first be considered and then rudder cycling started on either side, keeping in mind not to confuse and not to hinder the vessels in the vicinity.

CRASH ASTERN



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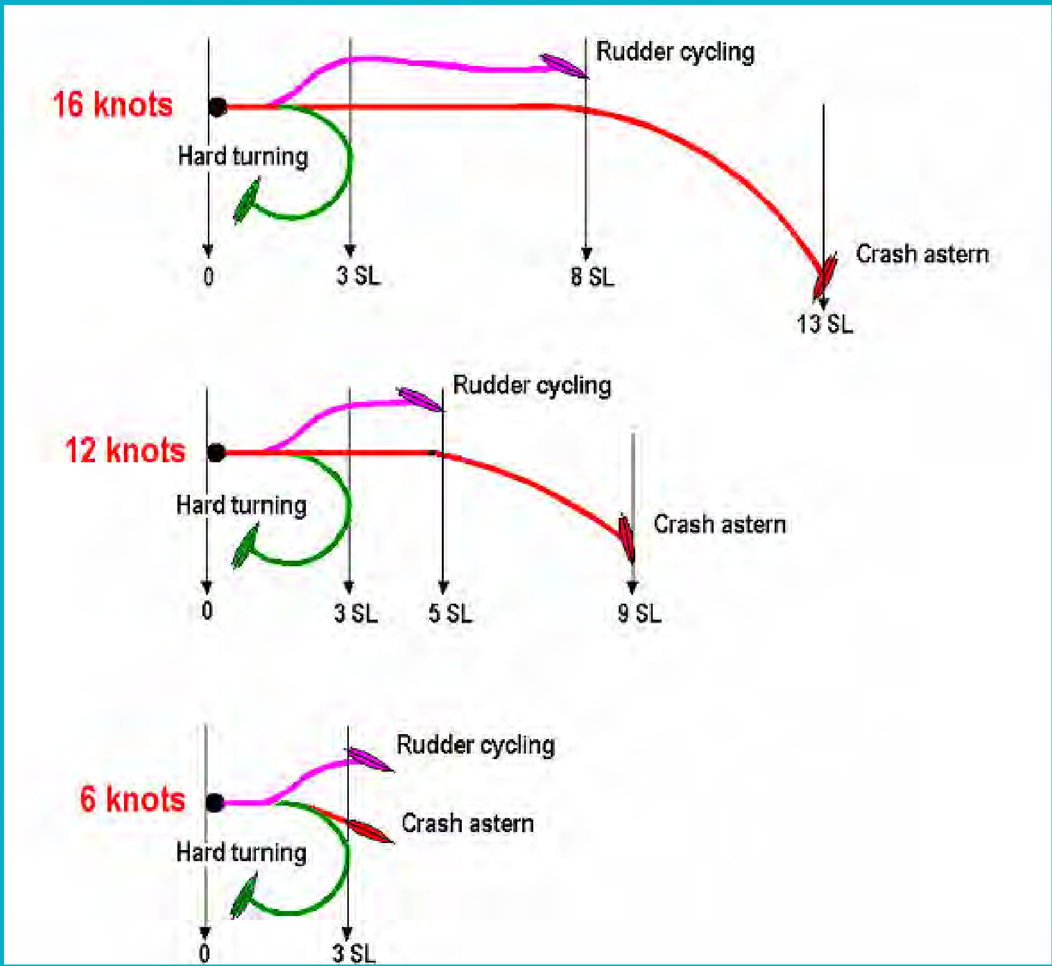
The **crash astern stop** manoeuvre, particularly when the speed is over 6 knots, needs too much room and, more especially, the ship becomes rapidly out of control and you never know where the course will end.

Increasing astern rpm gradually is more efficient as it avoids cavitation.

It is even better to gradually reduce rpm ahead **before** stopping the engine and going astern: the earlier stage of slowing down is procedure the most delicate as the wave system which moves at the same speed as the ship, will reach the stern and alter her course stability. It is therefore advised never to handle abruptly if the course must be controlled (e.g. in a canal).

STOPPING DISTANCES



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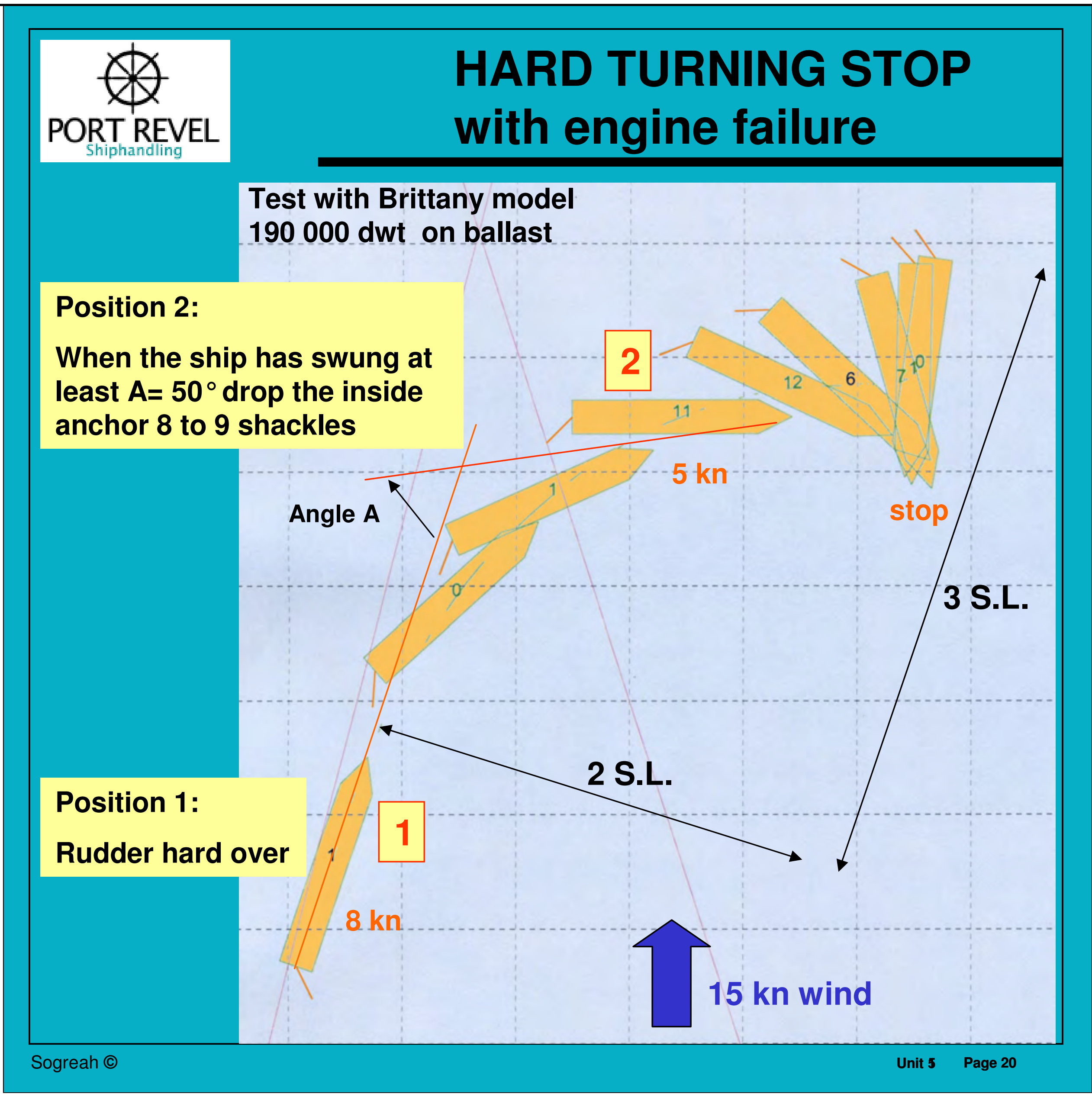
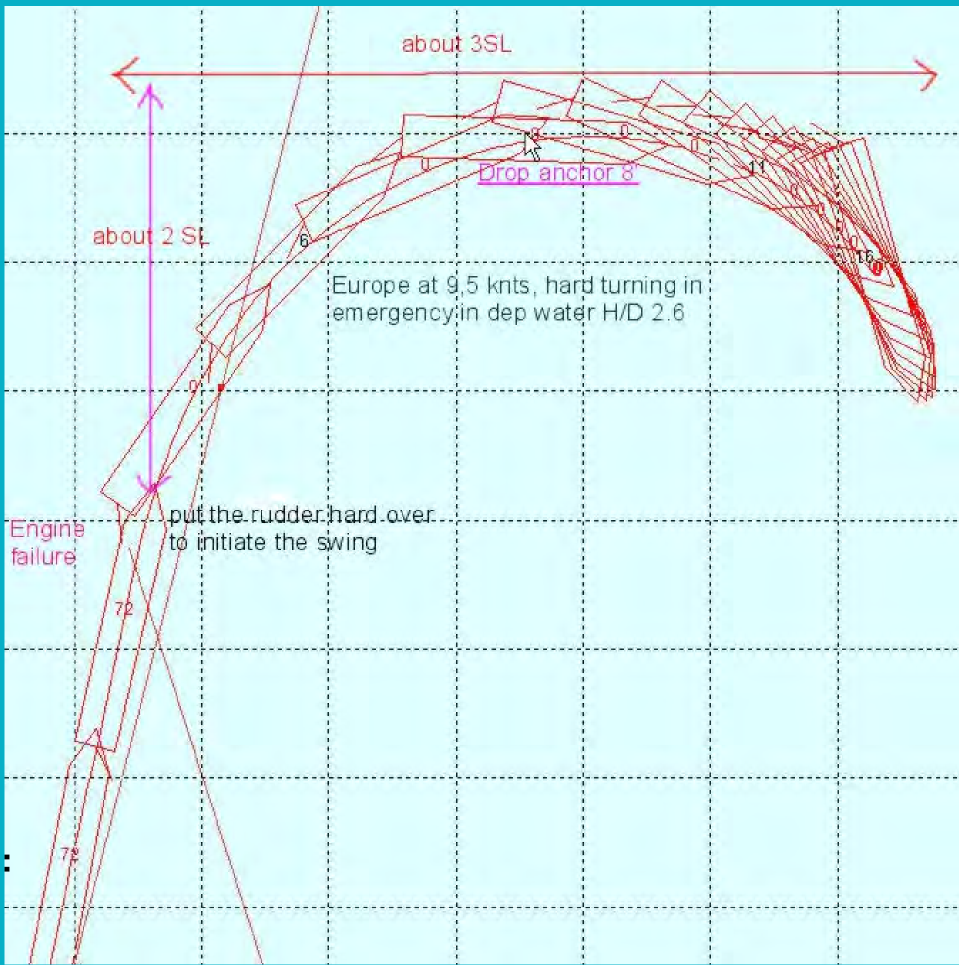
– Over 12 kn: if enough space side ways, the hard turning procedure is the best.
– Under 12 kn: if space is limited on both sides, use rudder cycling.
– Under 6 kn: the crash astern stop can be used.



Emergency Stop with engine failure and stern wind by heading into the wind using the underwater resistance of the ship.

TRIAL: HARD TURNING STOP with engine failure

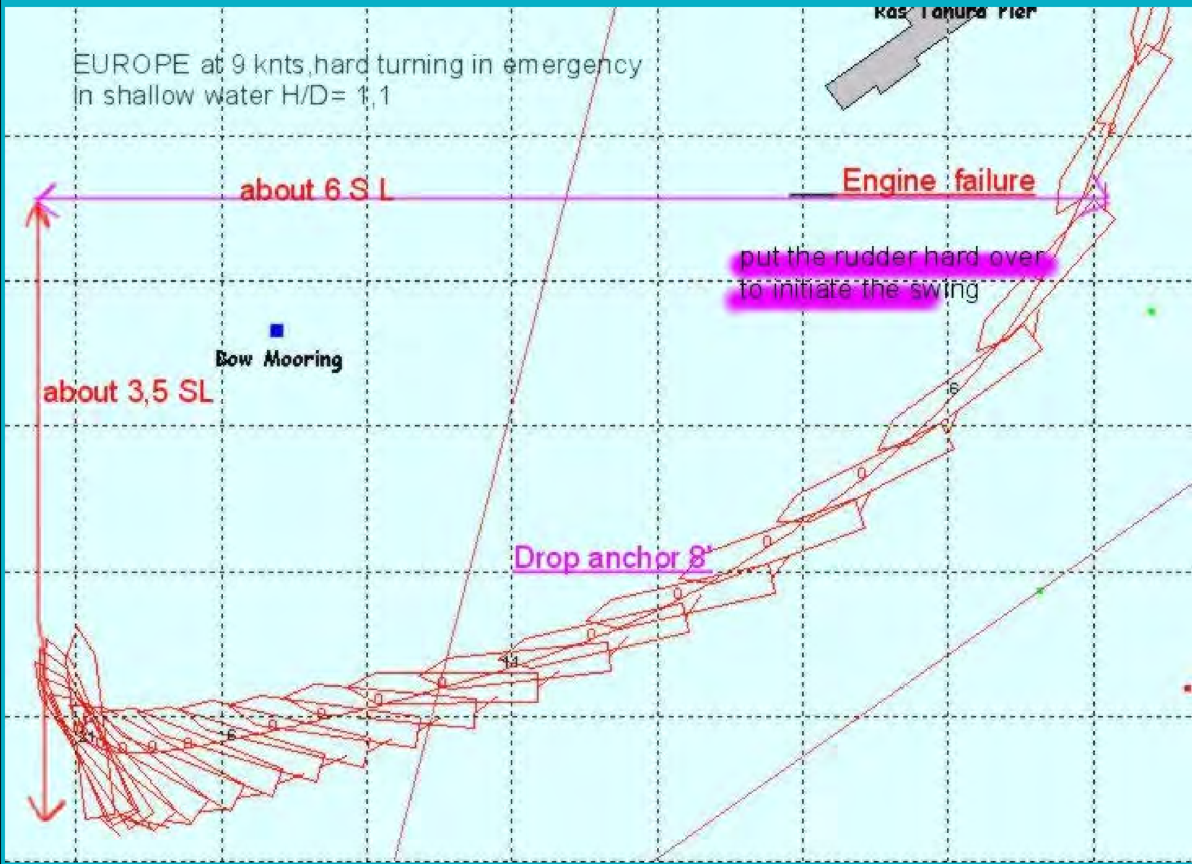


Test with Europe model: 255 000 dwt loaded

Sogreah © Unit 5 Page 21

Emergency Stop with engine failure and stern wind by heading into the wind using the underwater resistance of the ship.

TRIAL: HARD TURNING STOP with engine failure

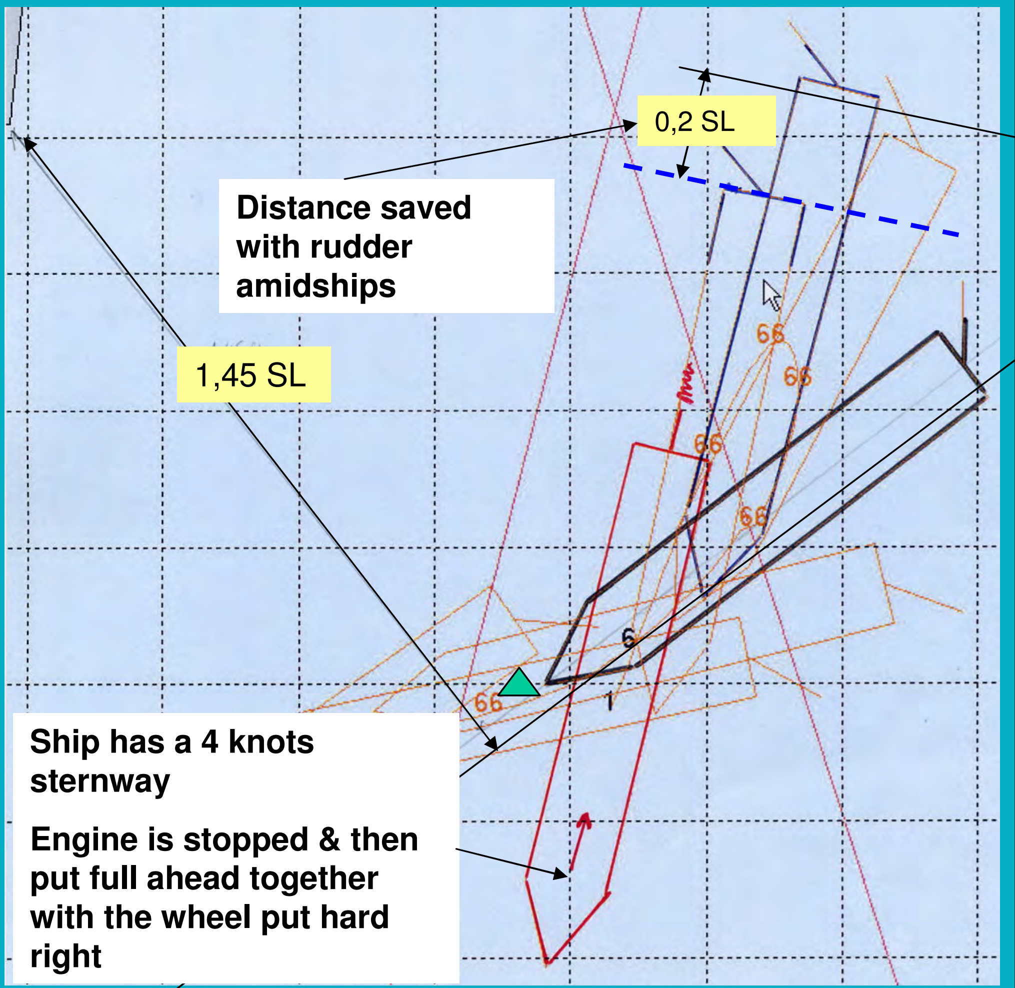


Test with Europe model: 255 000 dwt loaded

Sogreah © Unit 5 Page 22

Emergency Stop with engine failure and stern wind by heading into the wind using the underwater resistance of the ship.

STOP AND TURN THE SHIP



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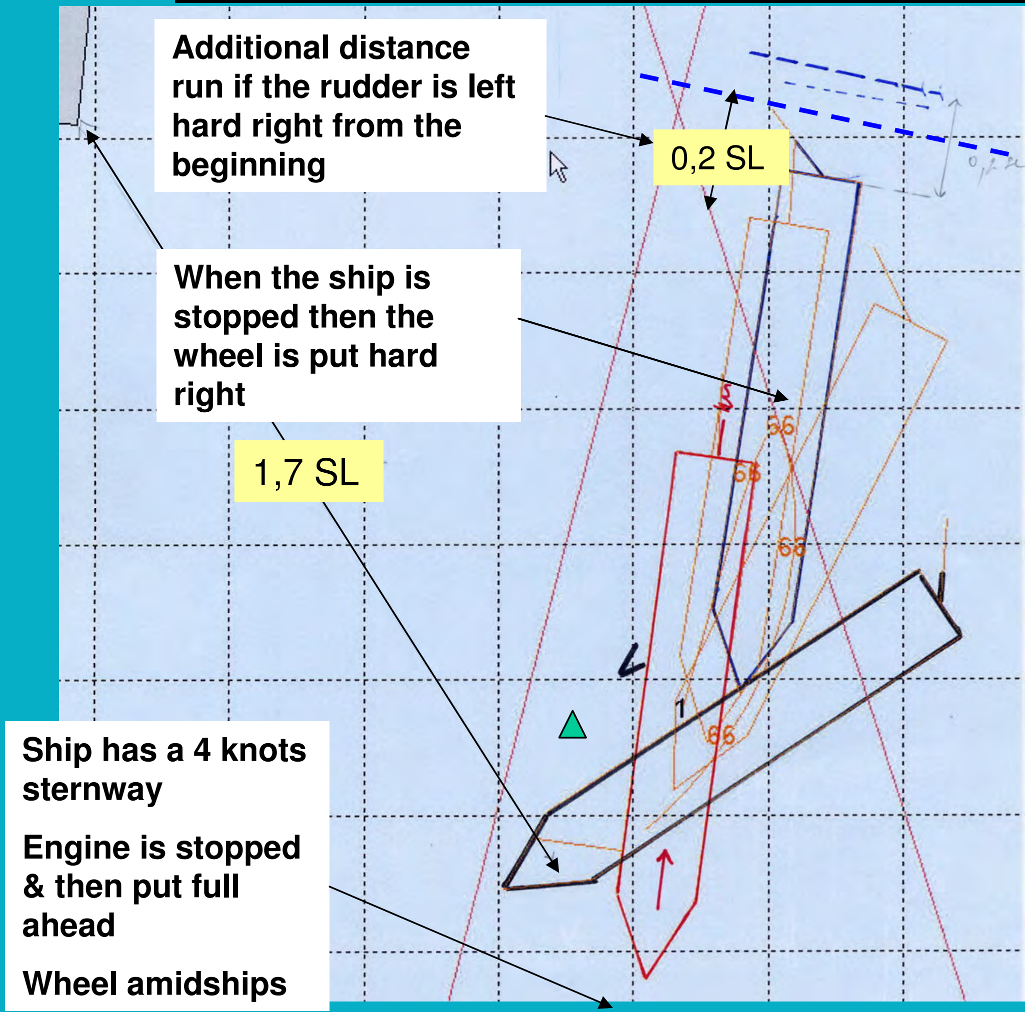
STOP THE SHIP, THEN TURN



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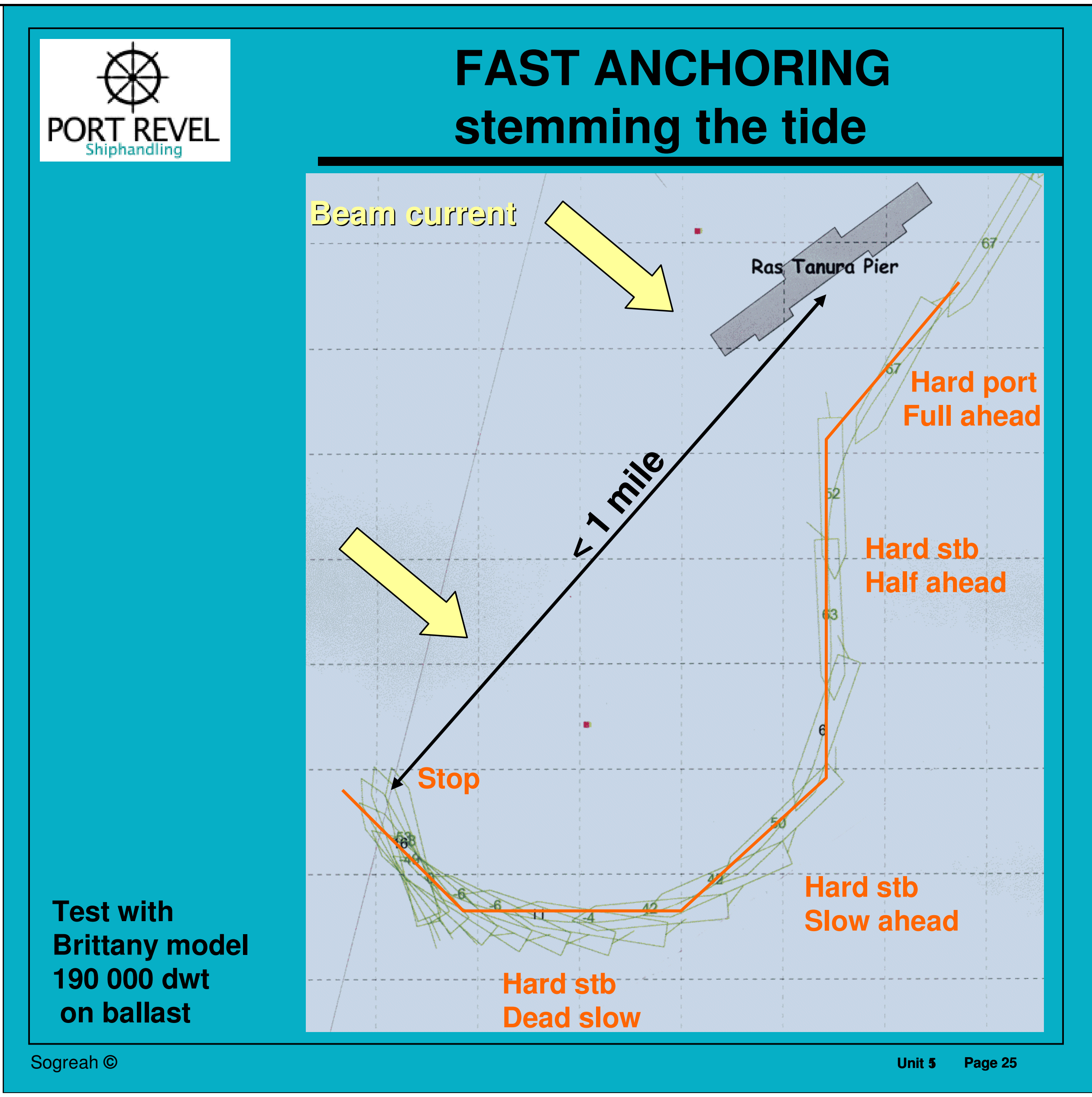


Stopping for anchoring with a beam current by heading into the current.

BATILLUS – 1976
551 000 dwt

Initial cost: 130 M$
sold for 8 M$ in 1985

Sogreah ©

Unit 5 Page 26

BELLAMYA

Sogreah ©

Unit 5 Page 27

UNIT 6 – SHIP INTERACTIONS IN CANALS

The slides hereafter clarify the following aspects:

1. MEETING

2. OVERTAKING

2.1. OVERTAKING A MOORED SHIP

2.2. OVERTAKING A SAILING SHIP

PORT REVEL Shiphandling

The OLYMPIAN HIGHWAY in the PANAMA CANAL

Panamax vessel:

L < 274.3 m (900 ft)

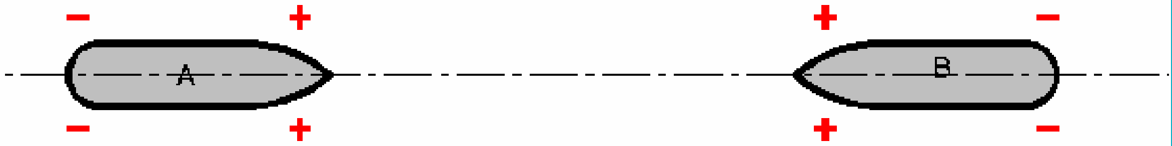
B < 32.3 m (106 ft)

Video Bank Effects

http://www.dgolds.com/oldsite/Panama/ThroughTheLocksWithAPanamaxShip.htm

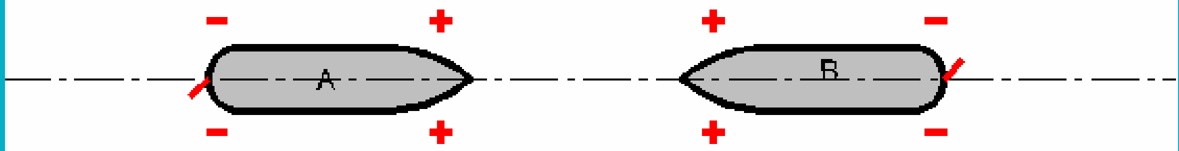
MEETING IN CHANNELS (1)

SLOW AHEAD



SPEED SHOULD BE REDUCED TO JUST SUFFICIENT FOR GOOD CONTROL

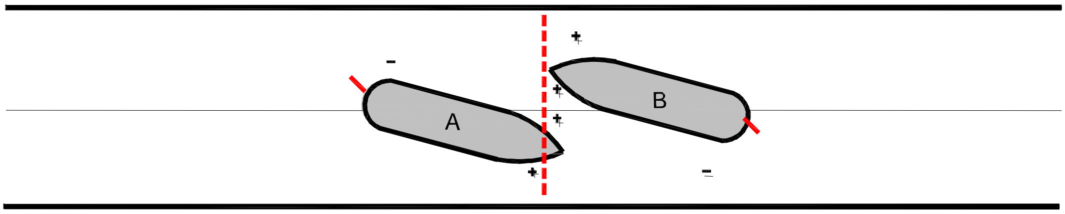
HALF AHEAD



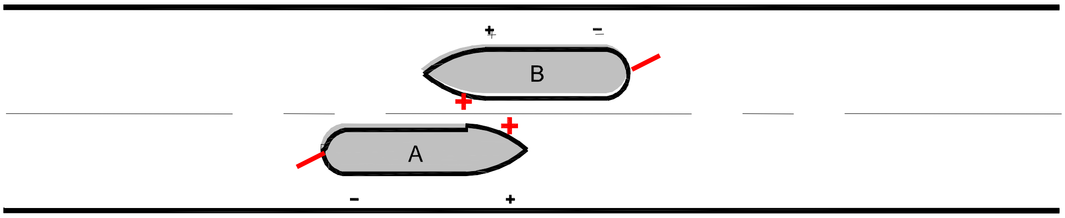
1,5 TO 2 SHIPLENGTH

BOTH SHIP: STARB. HELM

MEETING IN CHANNELS (2)



PORT HELM TO CLEAR STERN - INCREASE ENGINE SPEED
PRESSURE AT BOWS NEARLY BALANCED



STARBOARD HELM TO NEUTRALIZE STERN SUCTION IF ANY
PRESSURE AT BOWS BALANCED

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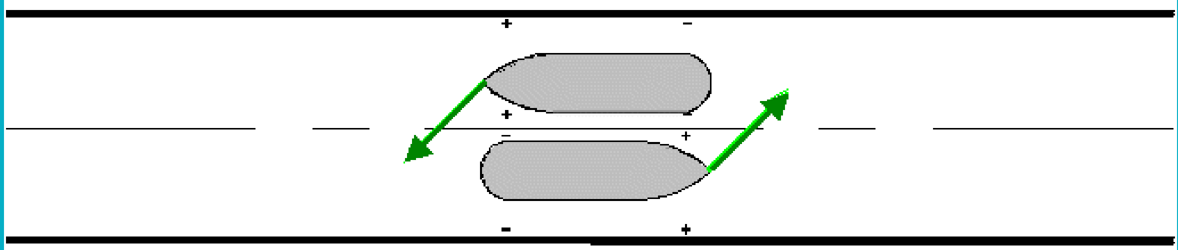
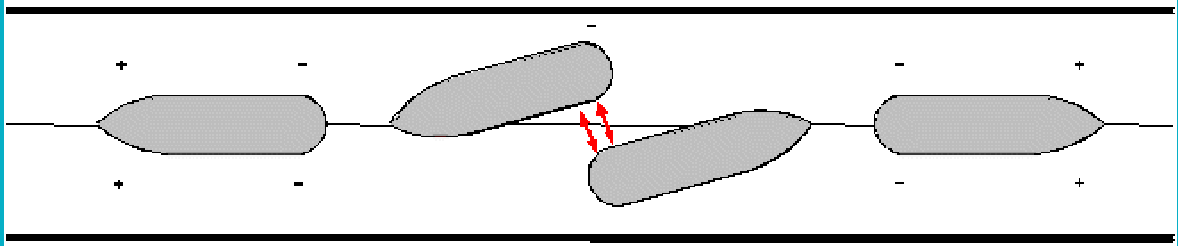
Unit 6 Page 3

MEETING IN CHANNELS (3)



SHIPS DRAWN TOGETHER BY INTERACTION
BANK EFFECTS TURN BOTH SHIPS TO PORT.

CONTROL - BUT DO NOT STOP SWING TO PORT.



AS SHIPS CLEAR EACH OTHER , STERNS WILL BE DRAWN TOGETHER
AND BOTH SHIPS FINISH UP NEAR MID-CHANNEL AGAIN .
USE RUDDER ONLY TO CONTROL SWING.

PORT REVEL
Shiphandling

Meeting in Houston Channel: Texas chicken

Sogreah ©

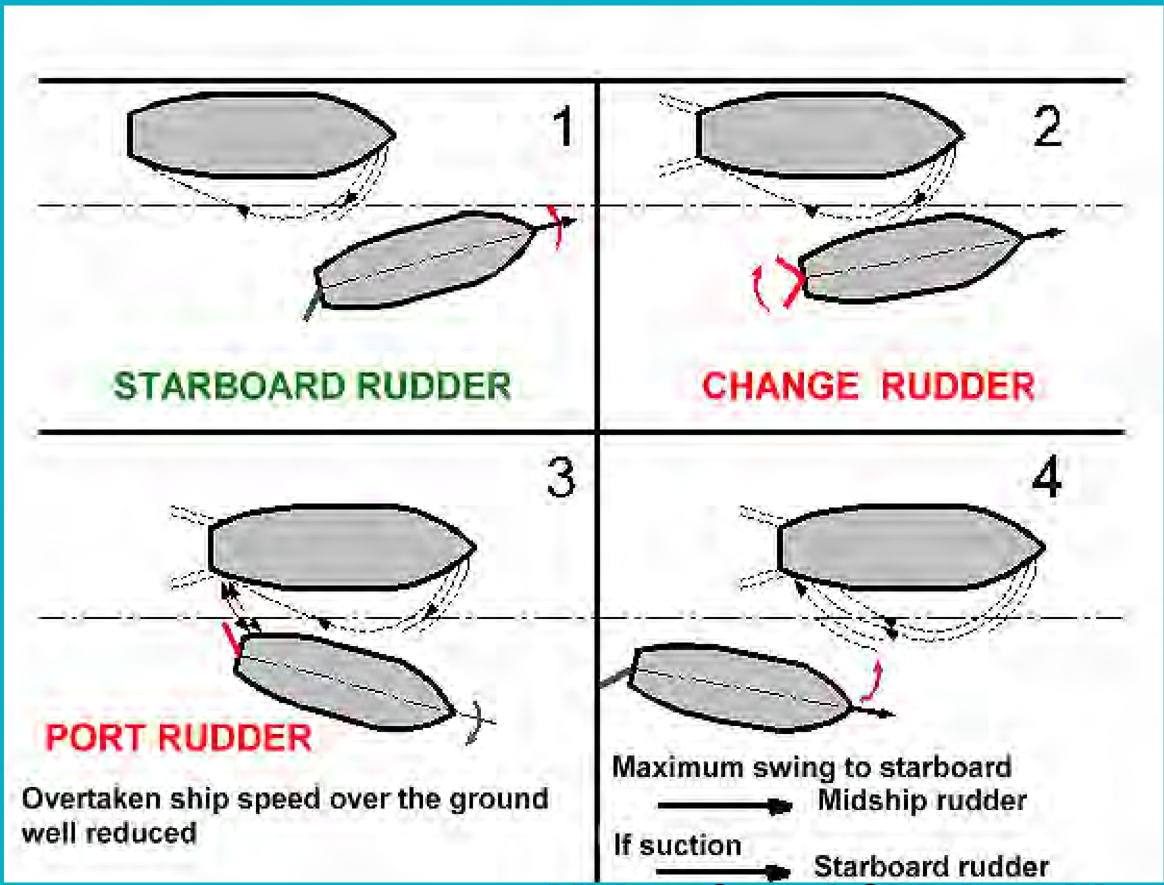
Unit 6 Page 5

NICE MEETING YOU …

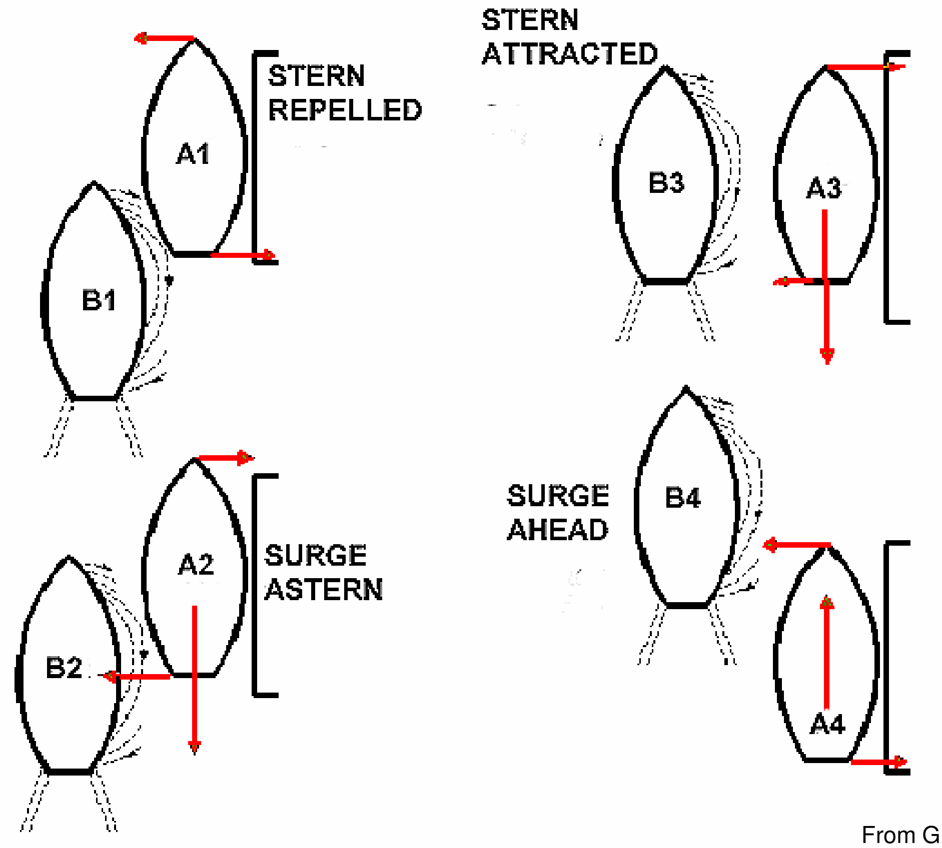
Sogreah © Unit 6 Page 6

CLOSE OVERTAKING

what to be done on overtaken ship



OVERTAKING A MOORED VESSEL



From G.L. Danton

SHIP INTERACTION

When it goes wrong ...

Sogreah ©

Unit 6 Page 9

WATCH YOUR AIR DRAFT …

Windoc hits Welland Canal Bridge - August 11th, 2001

http://www.wellandcanal.ca/transit/2001/august/windocstory.htm

UNIT 7 – ESCORT TUGS

The slides hereafter clarify the following aspects:

1. OBJECTIVES

2. ASD TUGS

3. VSP TUGS

4. FORCES

5. COMMANDS FOR ASD TUGS

6. COMMANDS FOR VSP TUGS

7. MORE COMMANDS

ESCORT TOWING

Tanker escort towing was born on the US West Coast in the wake of the EXXON VALDEZ oil spill in 1989.

Both the states of Washington and of Alaska mandated the use of safe, powerful and high speed tugs in restricted waters.

The following definition of « escorting » is becoming generally accepted:

> ***Deployment of a tug in a position from which it can rapidly and safely effect steering or braking control over a ship which has lost its propulsion and/or steering system in a confined waterway, and (most critically) at speeds in excess of 6 knots.***

After Robert G. Allen

OBJECTIVES

1 - Assess the absolute necessity of tethering the tug.

2 - Assess the need to react very rapidly in the event of a casualty. Students need to be shown the effects of a short time delay in implementing corrective action upon the increase in off-track error.

3 - Instruct the students to have a predetermined course of action planned that can be initiated immediately in the event of casualty.

4 - Show the impact of speed through the water on the effectiveness of manoeuvres.

5 - Assess the limitation of escort tugs utilised at this time. Specifically, the maximum speed to use « Powered indirect » with the reverse tractors and VSP tractors.

6 - Show the effectiveness of the « Transverse Arrest » manoeuvre utilised with reverse tractors.

7 - Show the emergency use of anchors at a short stay to help brake the ship.

 Unit 7 Page 2

OPA 1990

Oil Pollution Act 1990 in Washington State:

« … by November 17, 1994, all laden single hull, self-propelled tank vessels of 5 000 gross tons and over, operating in defined areas of Puget Sound and Pr William Sound, must be accompanied by two escort vessels with specific performance capabilities. »

MINIMUM REQUIREMENTS FOR ESCORT TUGS

Turning: turn the tanker 90° with free swinging rudder at initial speed of 6 kn

Holding: hold the tanker on steady course against 35° locked rudder

Stopping: stop the tanker from 6 kn

Towing: tow the tanker at 4 kn in calm seas and hold it steady in 45 kn headwind

According to OPA 90 (from Scalzo & Hogue, ITS 1996)

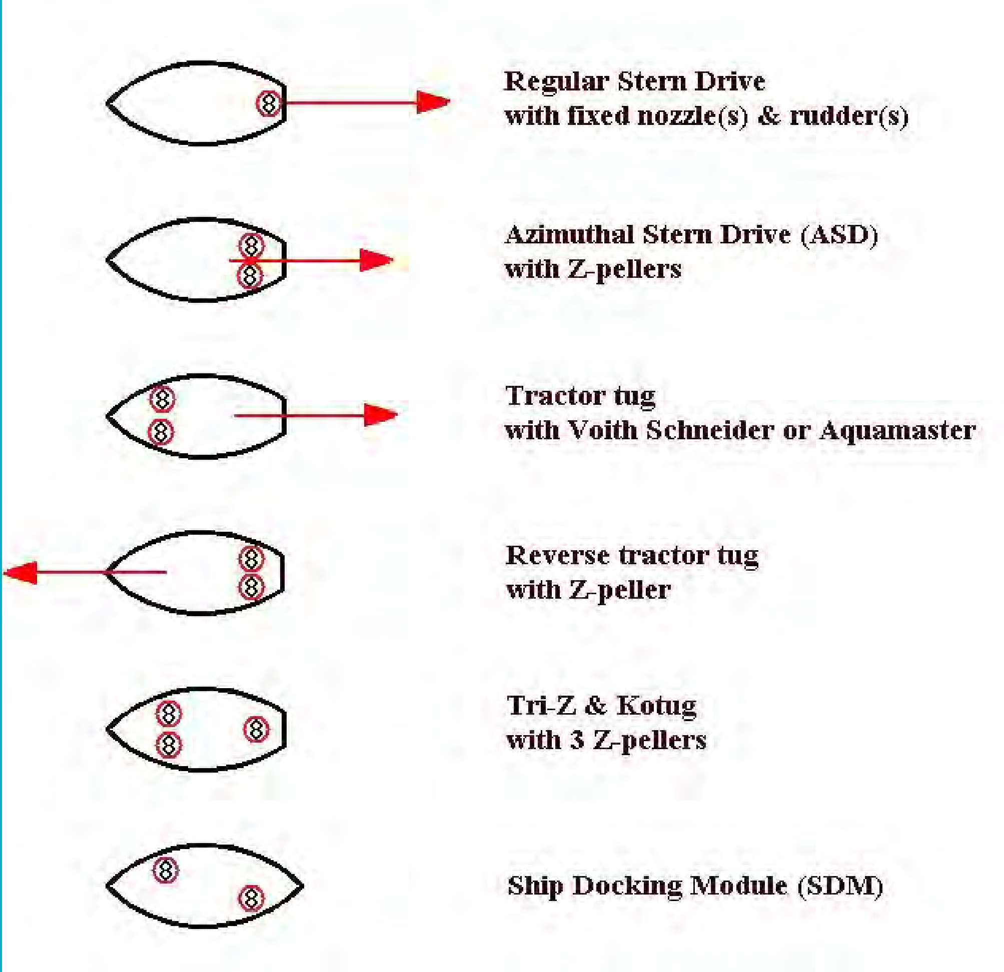
ARCO ESCORT PLAN IN PUGET SOUND

for 120 000 dwt tanker
with 8 000 HP Tractor Tug:

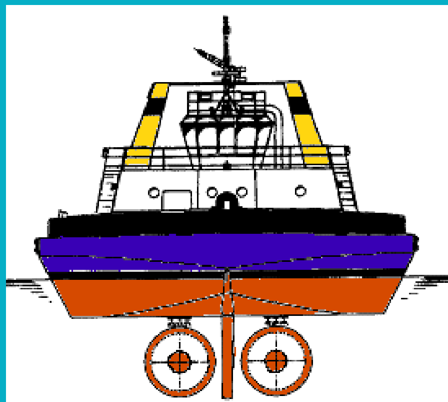
Zone	Speed	Running Mode	Escort
1	max	Bow first	Untethered
2	11 kn	Stern first	Untethered
3	8 kn	Stern first	Tethered

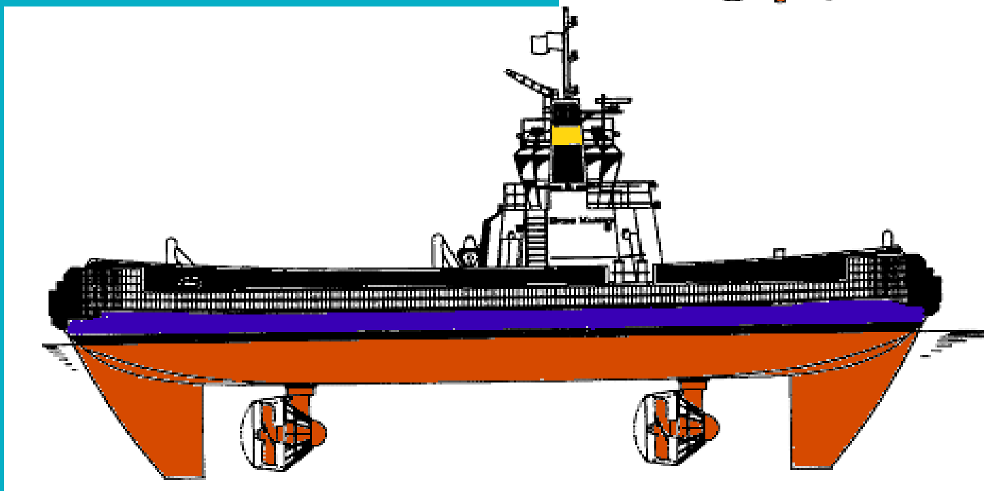
(from Scalzo & Hogue, ITS 1996)

TYPES OF TUG


Regular Stern Drive
with fixed nozzle(s) & rudder(s)
Azimuthal Stern Drive (ASD)
with Z-pellers
Tractor tug
with Voith Schneider or Aquamaster
Reverse tractor tug
with Z-peller
Tri-Z & Kotug
with 3 Z-pellers
Ship Docking Module (SDM)

SDM : Ship Docking Module





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Unit 7 Page 7

PORT REVEL
Shiphandling

KORT NOZZLE

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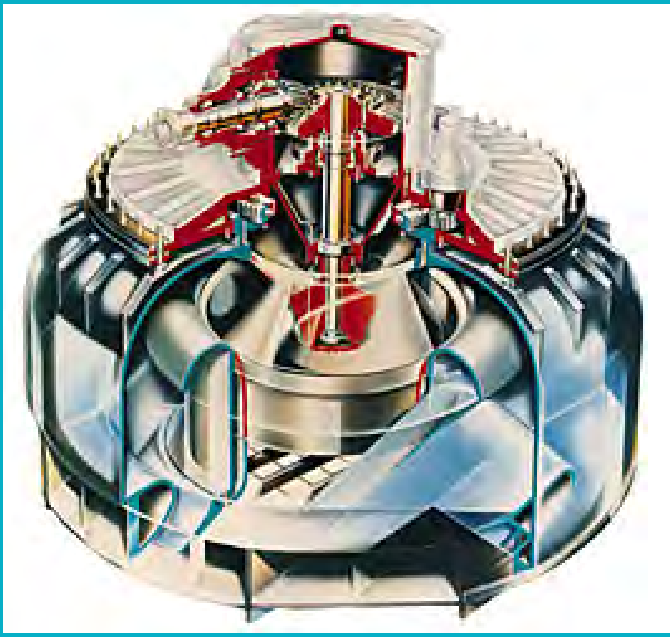
Unit 7 Page 8

SCHOTTEL PUMP JET



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Unit 7 Page 9

TUG COMMANDS

ASD TUGS

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Unit 7 Page 10

PORT REVEL
Shiphandling

Z-PELLER

Sogreah ©

Unit 7 Page 11

ASD “RASTAR”

	True dimensions (meter)	True dimensions (feet)	Dimensions at scale (meter)
L.O.A.	45.6	150,0	1.9
Ext Breadth	15.1	50,0	0.63
Draft	3.84	12.6	0.16
Skeg Length	24.5	80.3	1.02
Skeg Heigth	1.7	5.5	0.07
Skeg Area	41.5	447,0	0.07
Kort Diameter	2.9	9.5	0.12
Kort unit area	6.6	71	0.013

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ESCORT TUG : RASTAR 5000

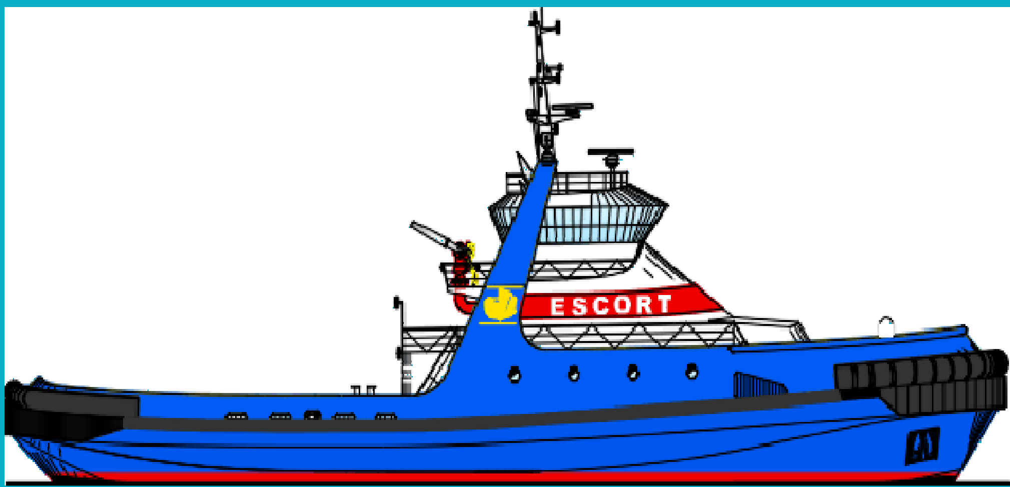
Rastar 5000

Length: 148 ft (45 m)

Breadth: 50 ft (15 m)

Draft: 20 ft (6.25 m)

Propulsion: 10 100 HP Z-Peller



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ASD LEVERS

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Unit 7 Page 14

PORT REVEL Shiphandling

TUG COMMANDS

VSP TUGS

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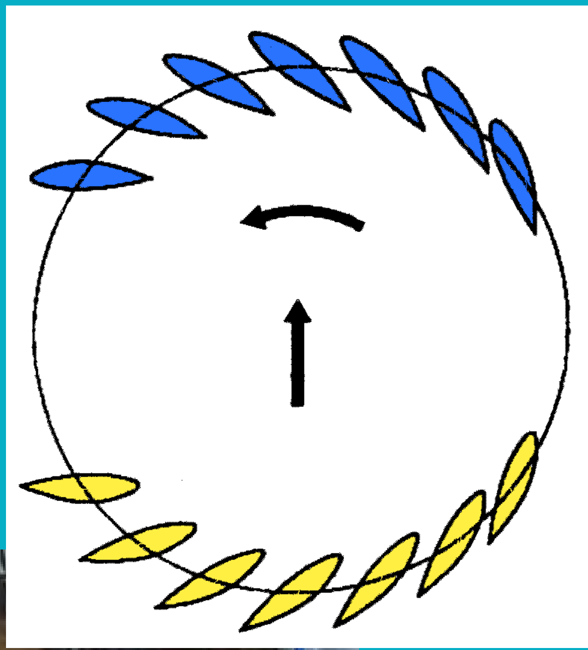
VOITH SCHNEIDER PROPULSION



Video Transmission

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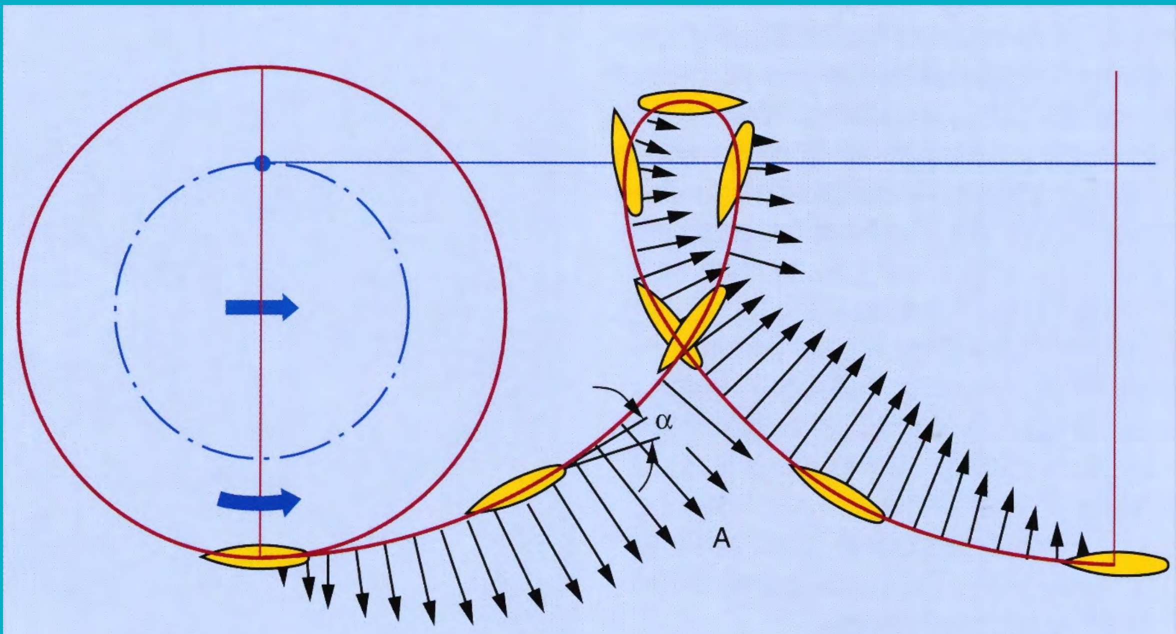
VOITH SCHNEIDER CYCLOÏD



Distribution of lift forces along the blade path. *A hydrodynamic lift*
α angle of attack

Video

Cycloïd

Sogreah ©

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PORT REVEL
Shiphandling

VOITH SCHNEIDER TUG

Sogreah ©

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VSP "PORT REVEL"

	True dimensions (meter)	True dimensions (feet)	Dimensions at scale (meter)
L.O.A.	48,0	157,0	2,0
Ext Breadth	14.9	49,0	.62
Draft	3.6	12,0	.15
Skeg Length	9.6	31.5	.40
Skeg Heigth	3.6	11.8	.15
Skeg Area	34.6	372,0	.055
Thruster unit area	19.1	205	.030

FOSS's escort tugs

Lindsey Foss & Garth Foss

Length: 155 ft (47 m)
Breadth: 46 ft (14 m)
Draft: 20 ft 6 in (6.25 m)
Propulsion: 7700 HP Voith Schneider
Running speed: 14.5 kn

Video Foss Escort test

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CROWLEY's escort tugs

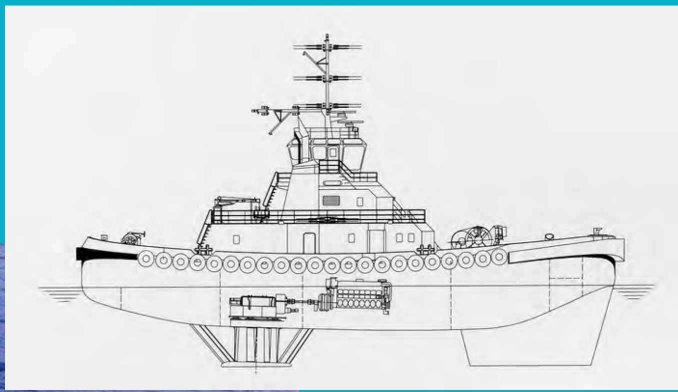
Nanuq & Tan'erliq

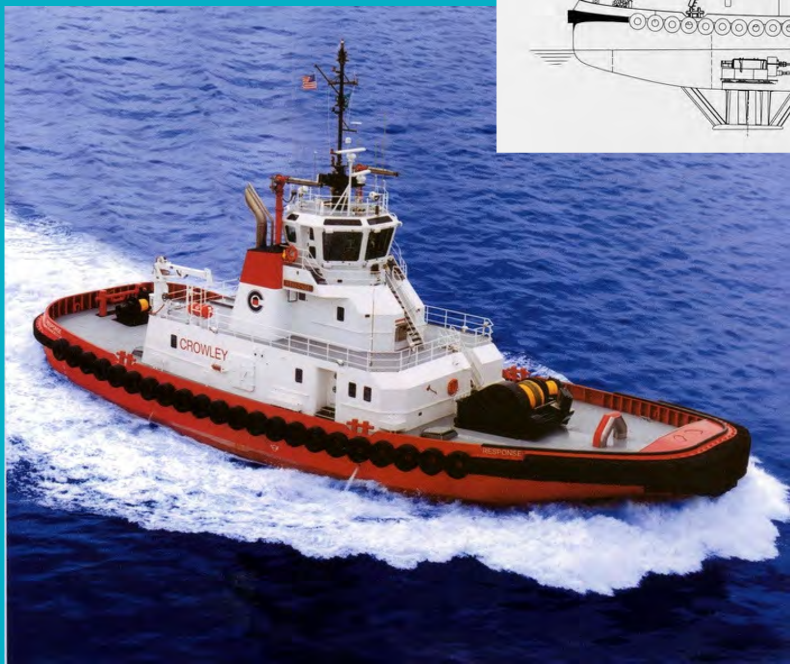
Length: 153 ft (47 m)
Breadth: 48 ft (15 m)
Draft: 24 ft (7.30 m)
Propulsion: 9400 HP Voith Schneider
Running speed: 15.7 kn

CROWLEY's escort tugs

Response

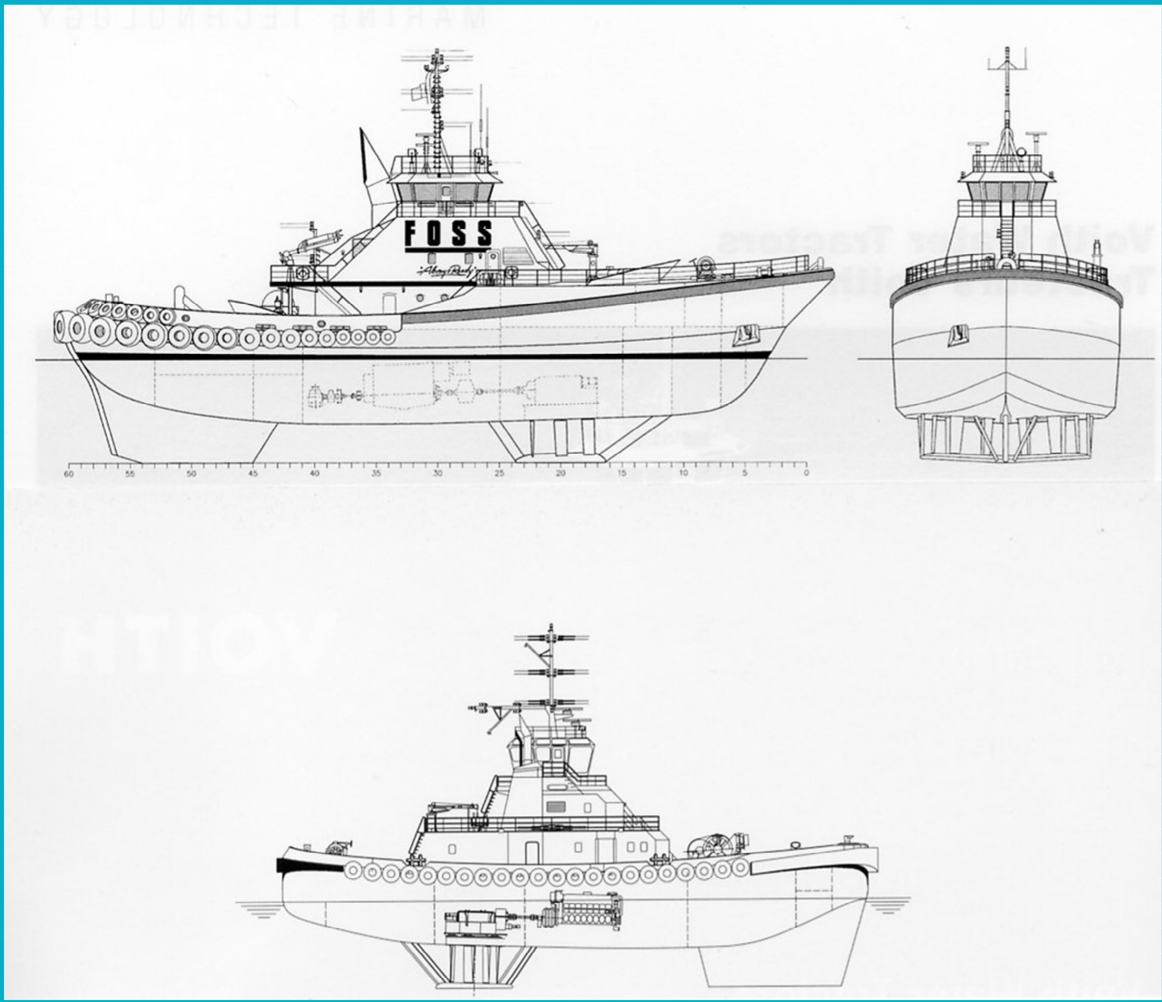
Length: 131 ft (40 m)
Breadth: 46 ft (14 m)
Draft: 19 ft (5.75 m)
Propulsion: 6600 HP Voith
Running speed: 15 kn





Where is the stern ?!

DIFFERENT VSP TUGS



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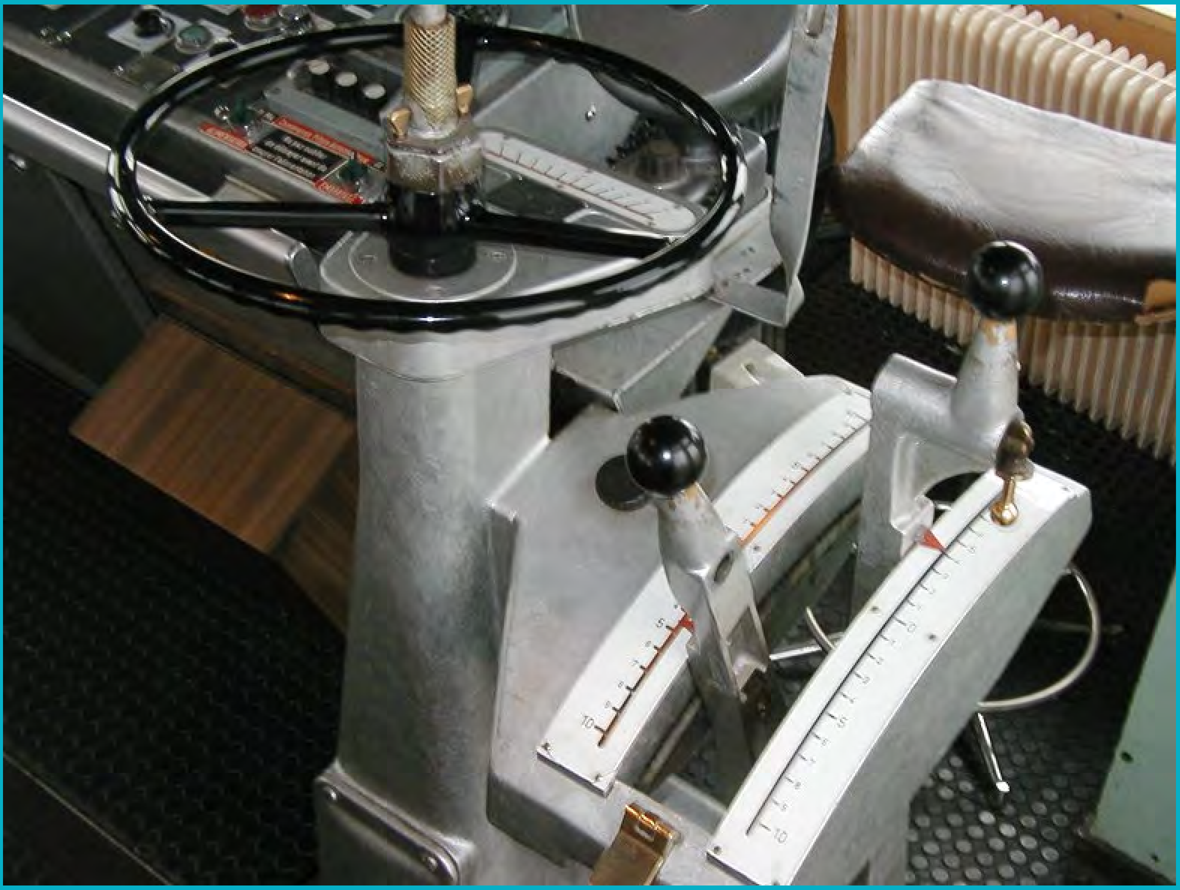
VSP LEVERS and WHEEL



Video Levers & wheel

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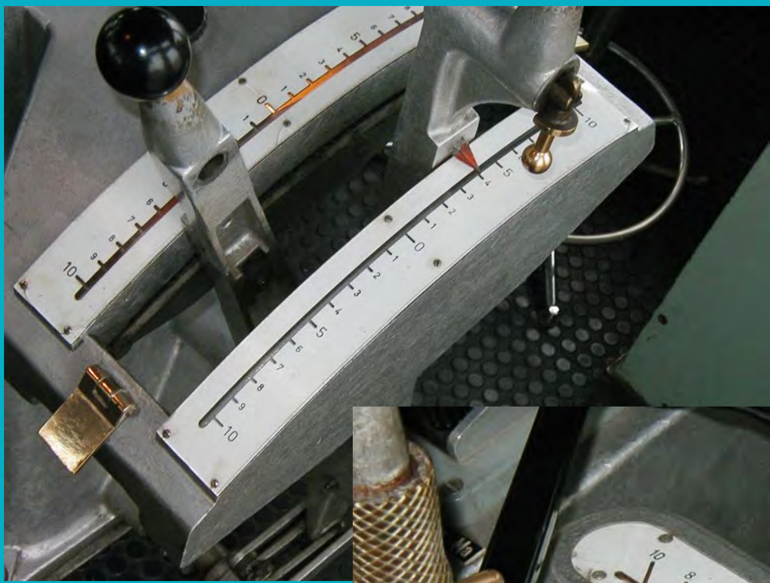
VSP LEVERS and WHEEL (2)



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Unit 7 Page 25

VSP Forward Thrust

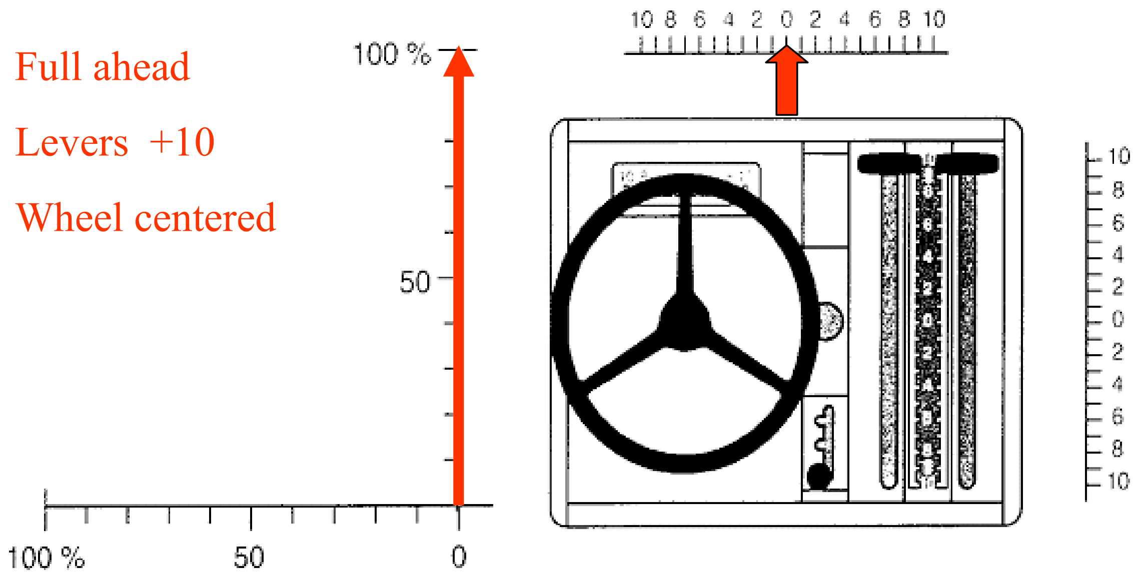
The levers control the pitch of the VSP blades and direct the pitch so as to produce the fore and aft thrust.

The wheel controls the phase of the VSP blades so as to control the lateral thrust component.

Full ahead

Levers +10

Wheel centered



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VSP Oblique Thrust

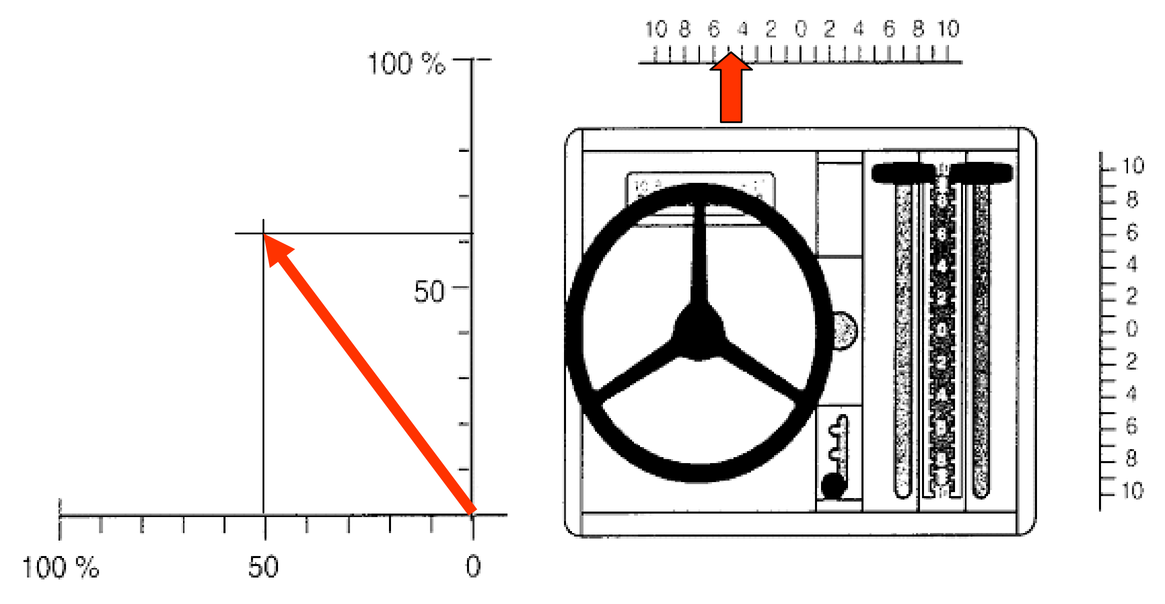
Levers +10

Wheel 5 to port

Fore thrust 60%

Transverse thrust 50%

Sideways motion to port



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VSP Lateral Thrust

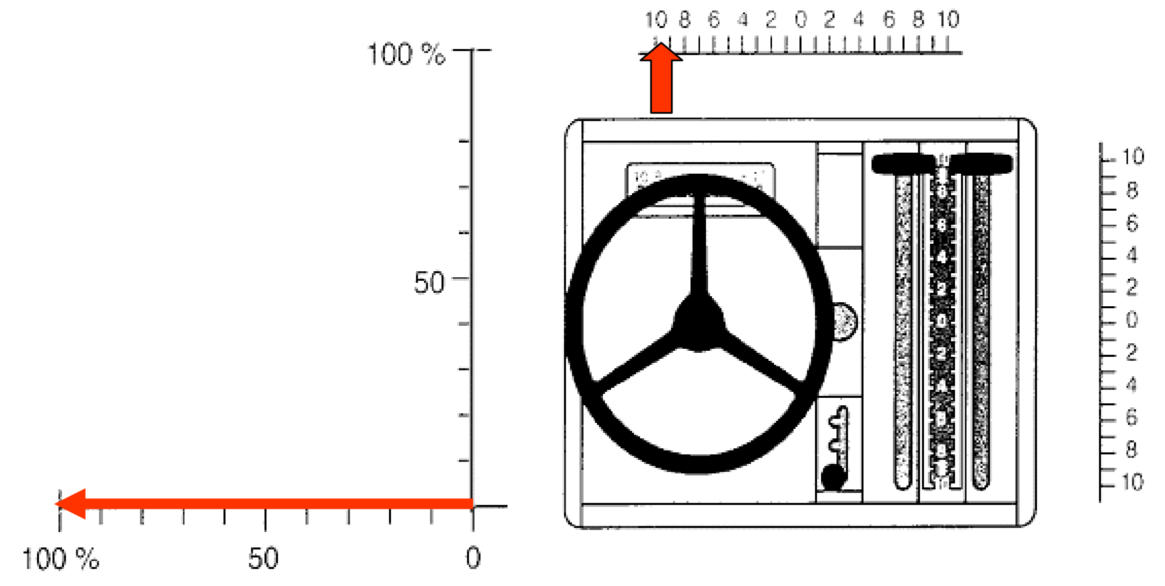
Levers +10

Wheel 10 to port

Fore thrust 0

Transverse thrust 100%

Lateral motion to port



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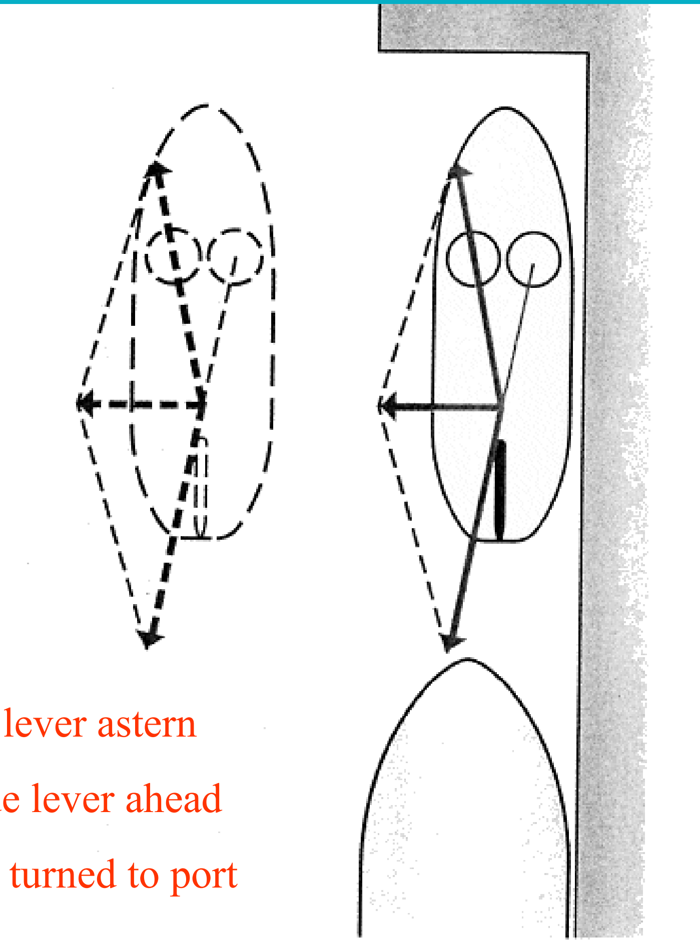
VSP leaving berth



Inside lever astern

Outside lever ahead

Wheel turned to port

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TUG COMMANDS

A few words on

FORCES

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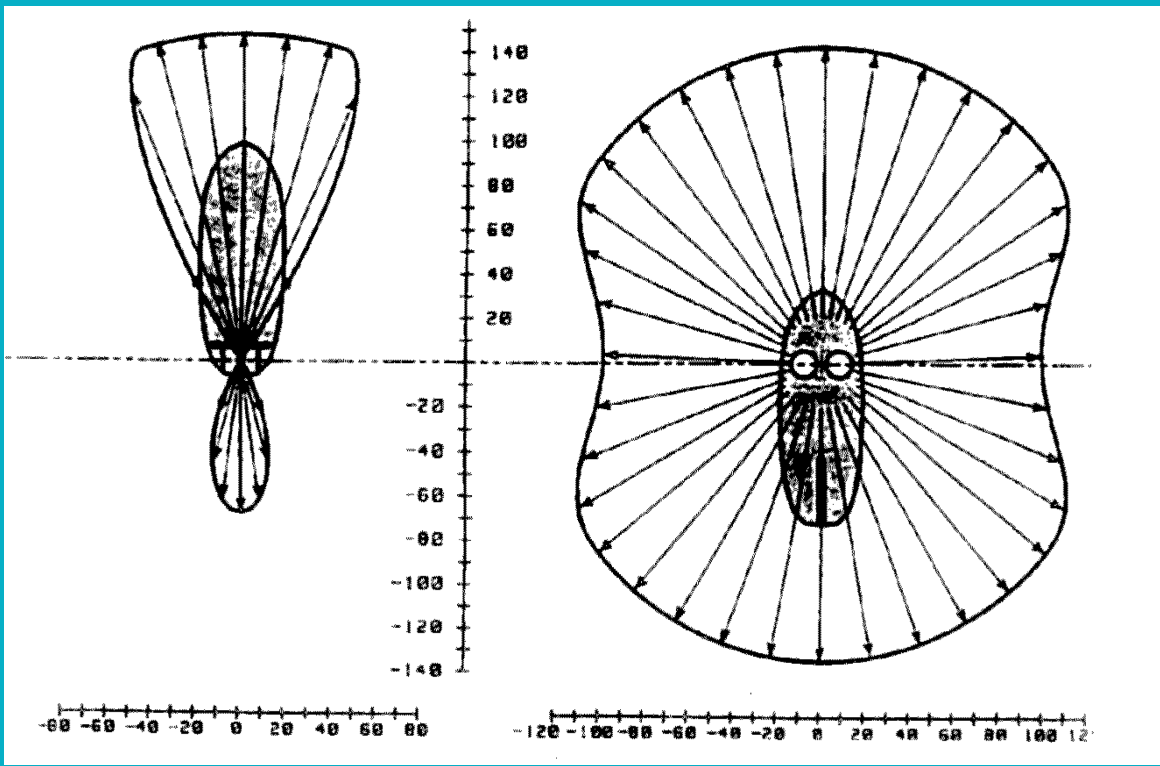
THRUST COMPARISON



Conventional

Voith tractor

Video Compare tugs

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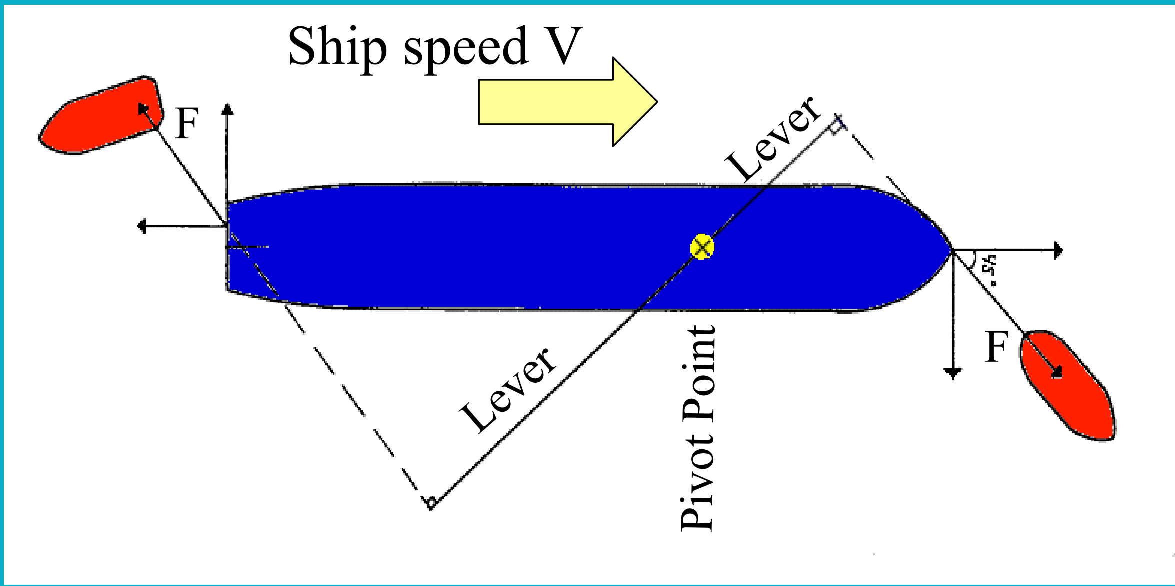
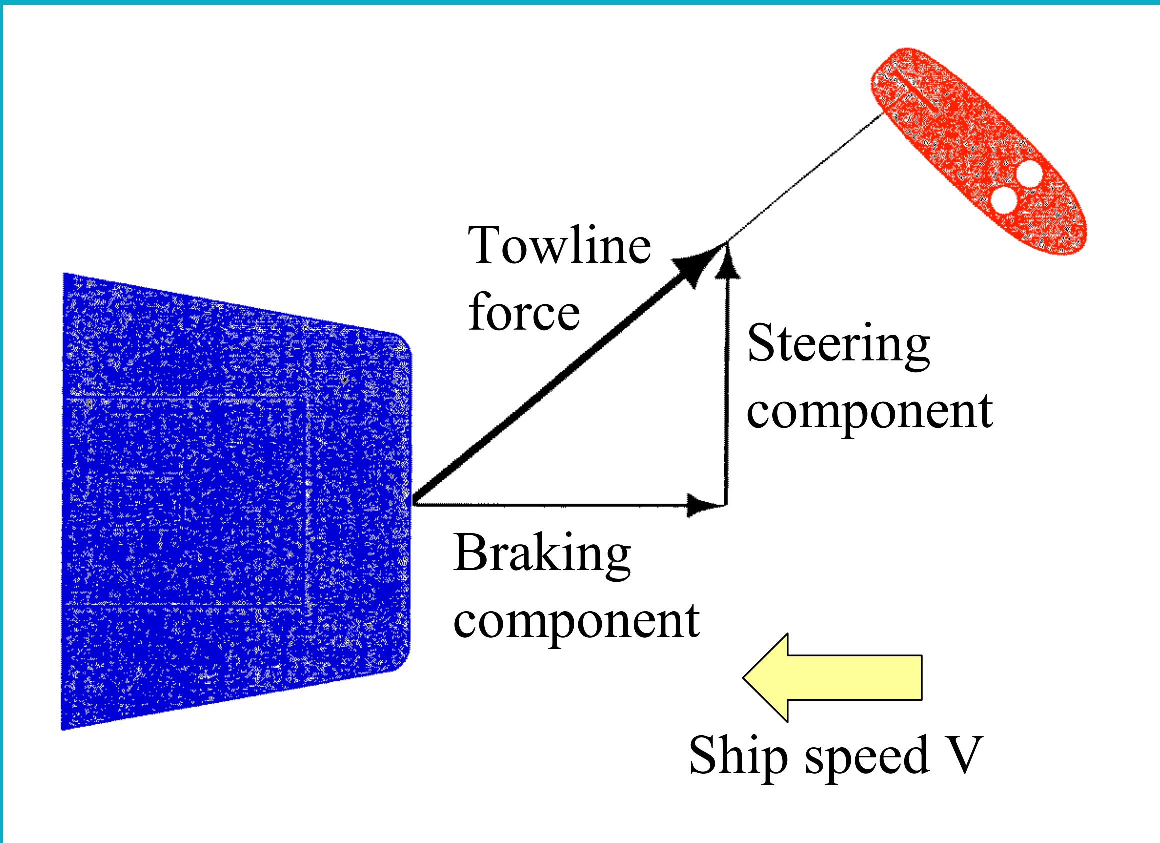
TUG and PIVOT POINT



Aft tug much more efficient for turning the vessel, with headway

TOWLINE FORCE



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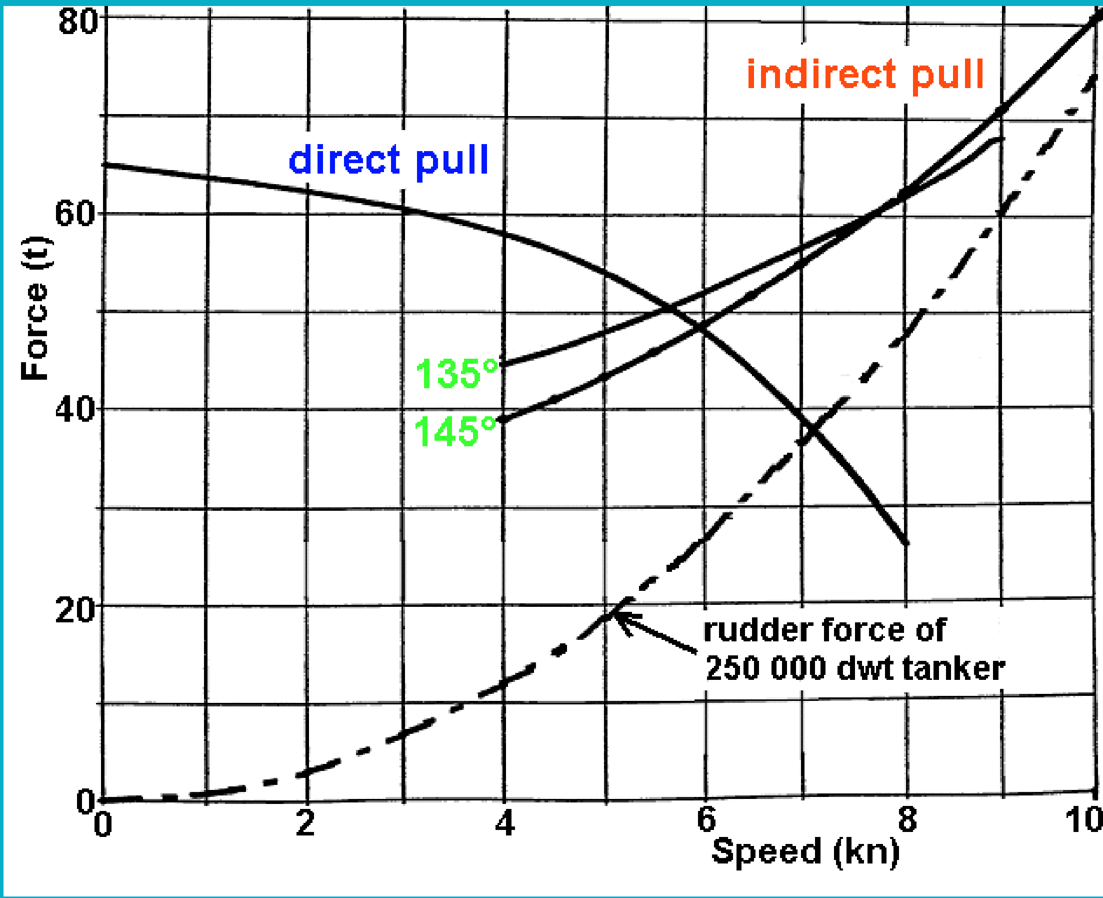
REQUIRED STEERING PULL

Type of Escorted Vessel	Required Tons Steering pull at 10 knots
30,000 M^3 gas carrier	32
40,000 DWT bulk carrier	40
60,000 M^3 gas carrier	43
70,000 DWT bulk carrier	60
150,000 DWT tanker	88
300,000 DWT VLCC	116

Required steering pull based on 15° rudder angle

STEERING
with 2 x 3400 HP VSP tug



(from VOITH Turbo Marine GmbH)

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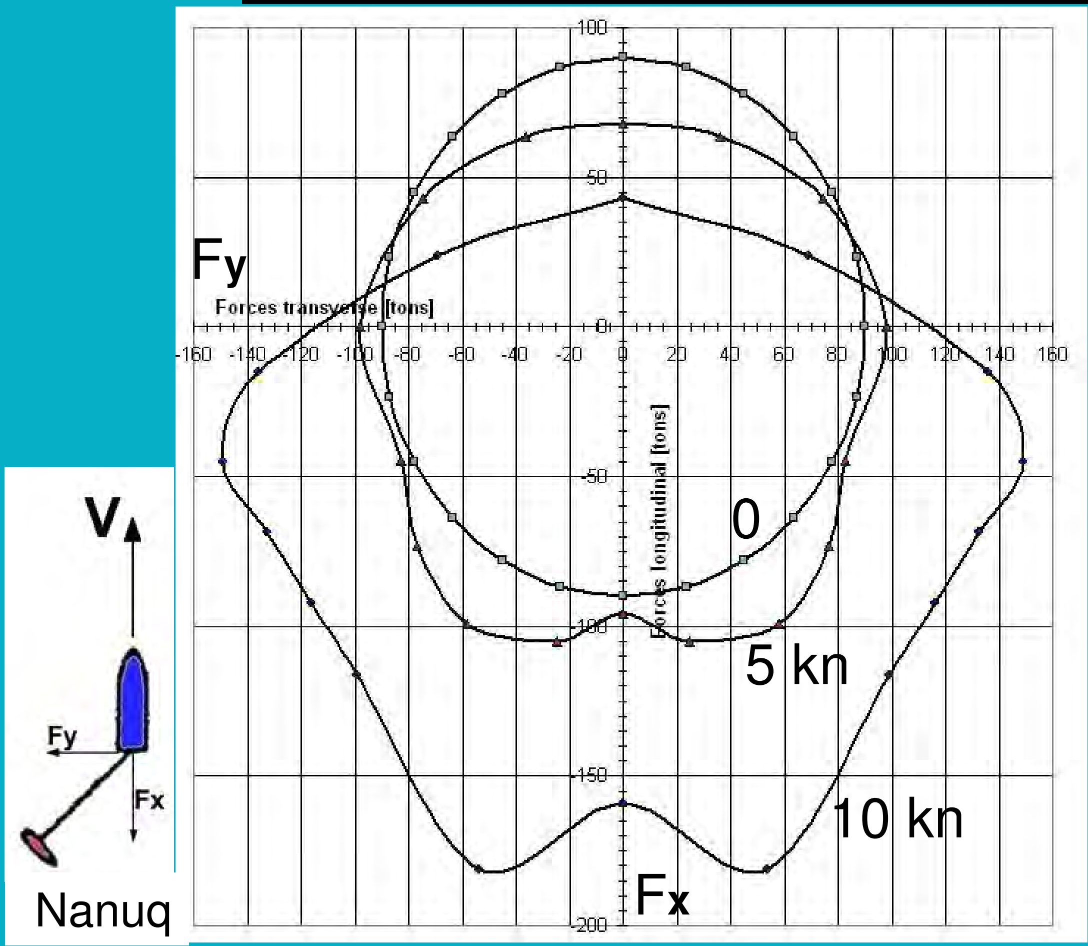
TUG FORCES ON SAILING SHIP



Video Wave effect

(from VOITH Turbo Marine GmbH)

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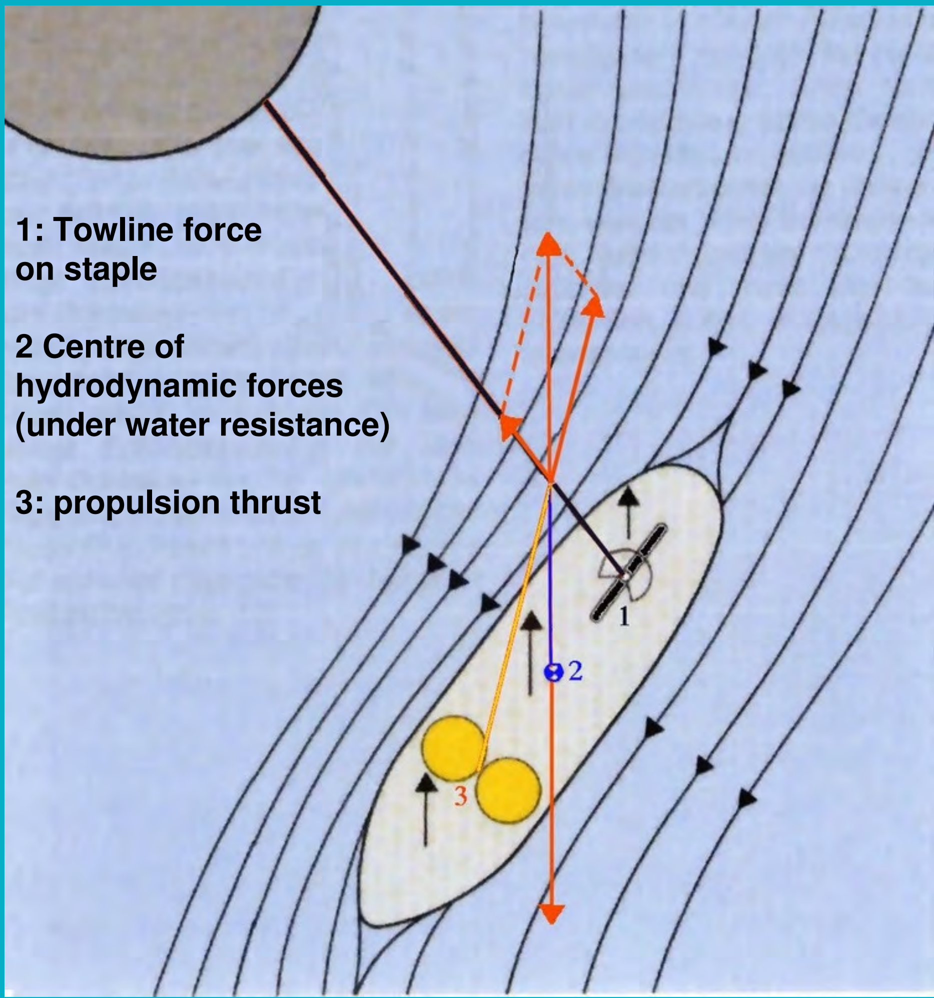
PORT REVEL
Shiphandling

FORCES ON VSP TUG
in indirect mode



(based on a
VOITH
Turbo Marine GmbH
drawing)

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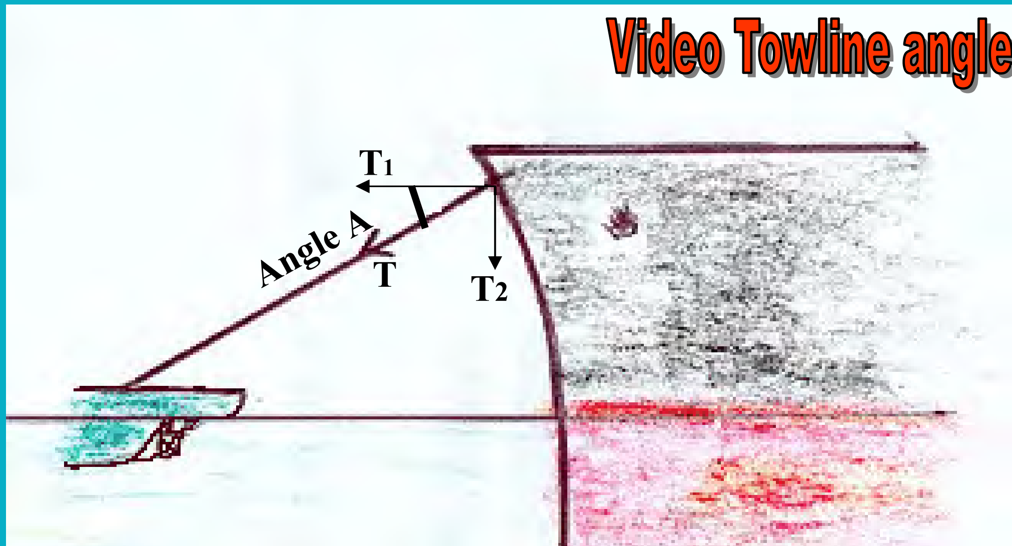
Unit 7 Page 37

This force diagram shows that the under water resistance is balanced by the propulsion thrust and the towline force on the staple.

TOWLINE ANGLE



for $T = 25$ t

A = 30°	T_1 =21.6t
A = 45°	T_1 = 17.7t
A = 60°	T_1 = 12.5t

as : $T_1 = T \text{ cosine } A$

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TUG COMMANDS

- Reference tug commands to own ship
- When asking for a push or pull: include direction
- Always give tug name before order
- Don't use given name of tug captain

TUG COMMANDS

Some commands with

ASD

as a reverse tractor tug

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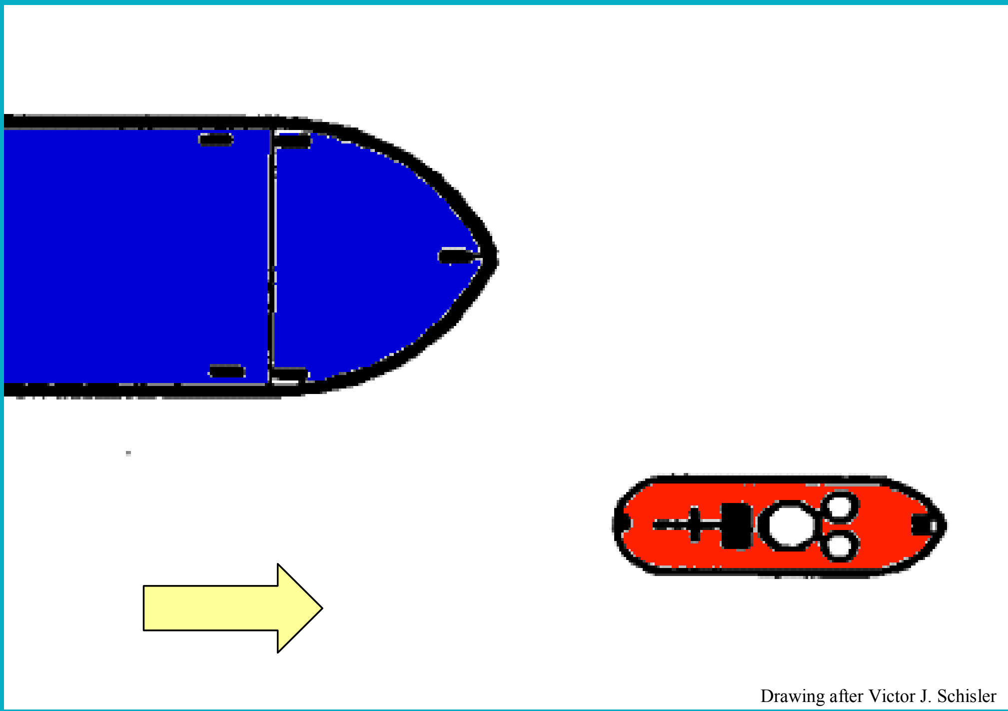
Unit 7 Page 40

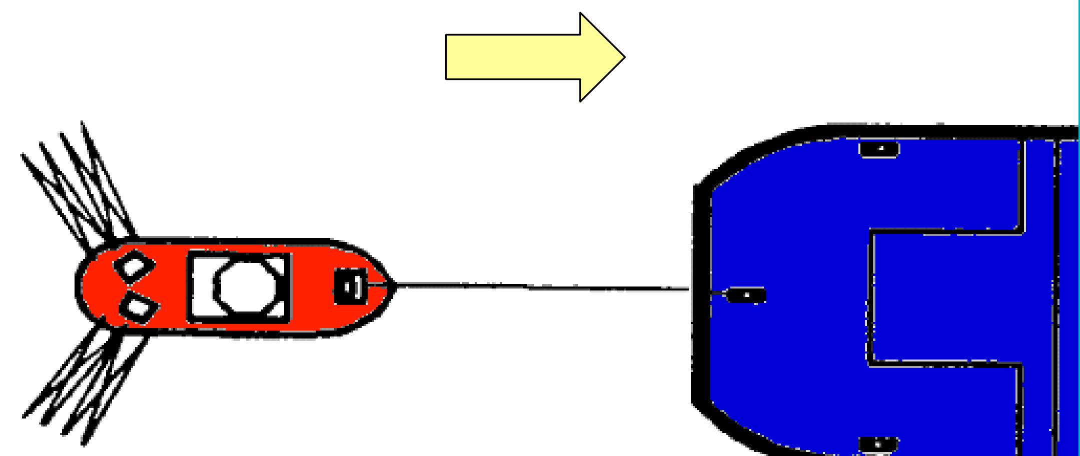
Run (or stand by)



Tug runs free, forward or aft, far enough: no interaction

Sogreah © Unit 7 Page 41

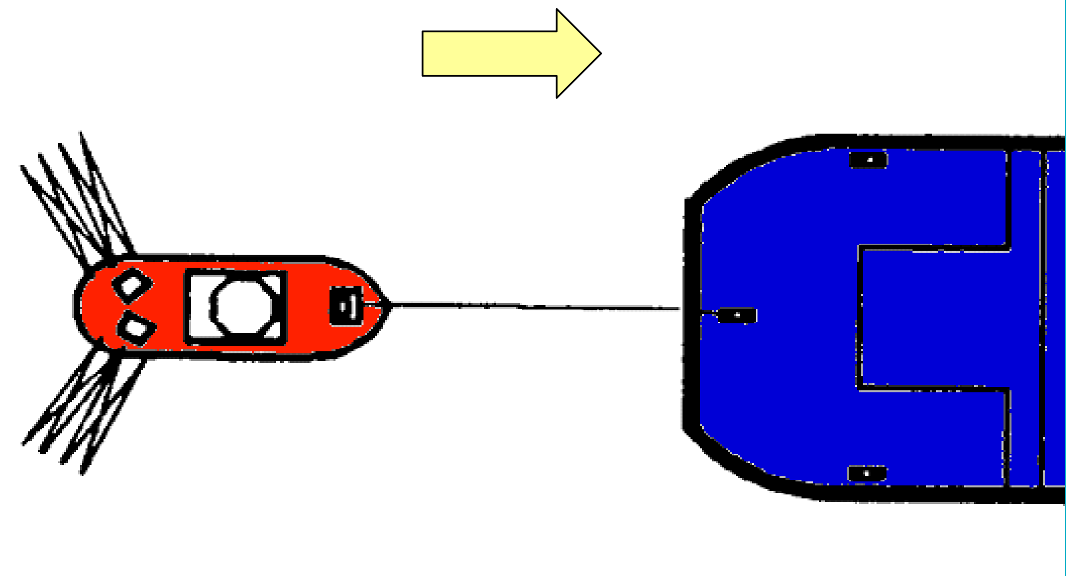
Run astern (or ahead)



Drawing after Victor J. Schisler

Tug is tethered with slack line, ready for immediate assistance

Drag in line

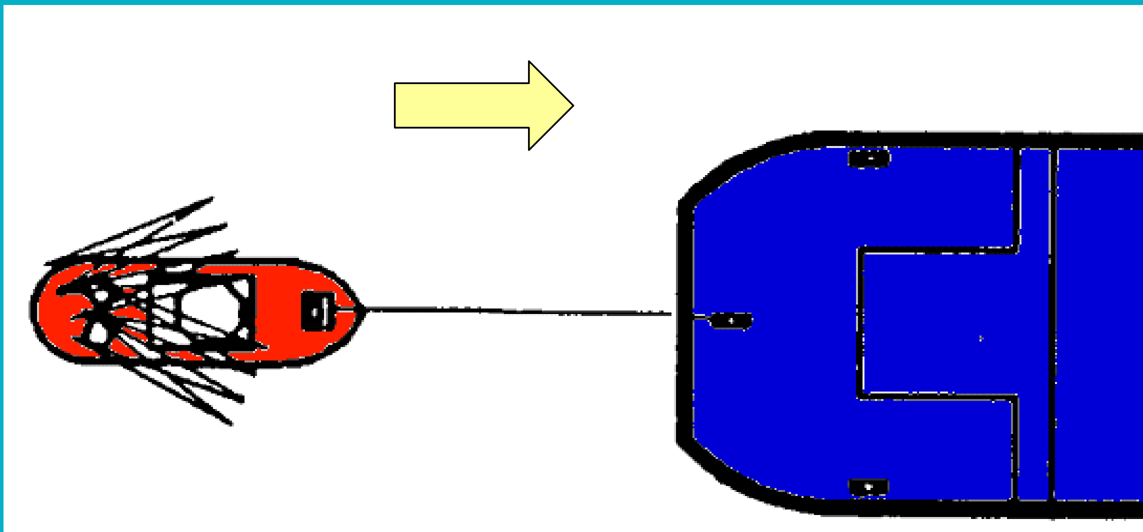


Drawing after Victor J. Schisler

Keep a light strain on the towline
Don't allow tug to shear off to one side

Sogreah © Unit 7 Page 43

Pull in line astern or straight back



Drawing after Victor J. Schisler

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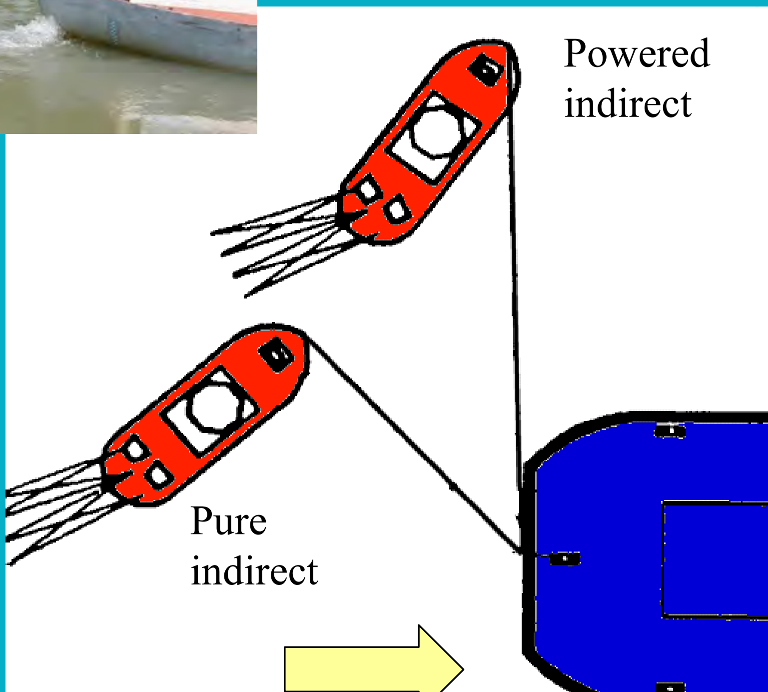
Indirect port (or starboard)

Video Powered indirect



Drawing after Victor J. Schisler

Speed > 6 kn

To reduce speed
and
influence heading

Video Indirect in line

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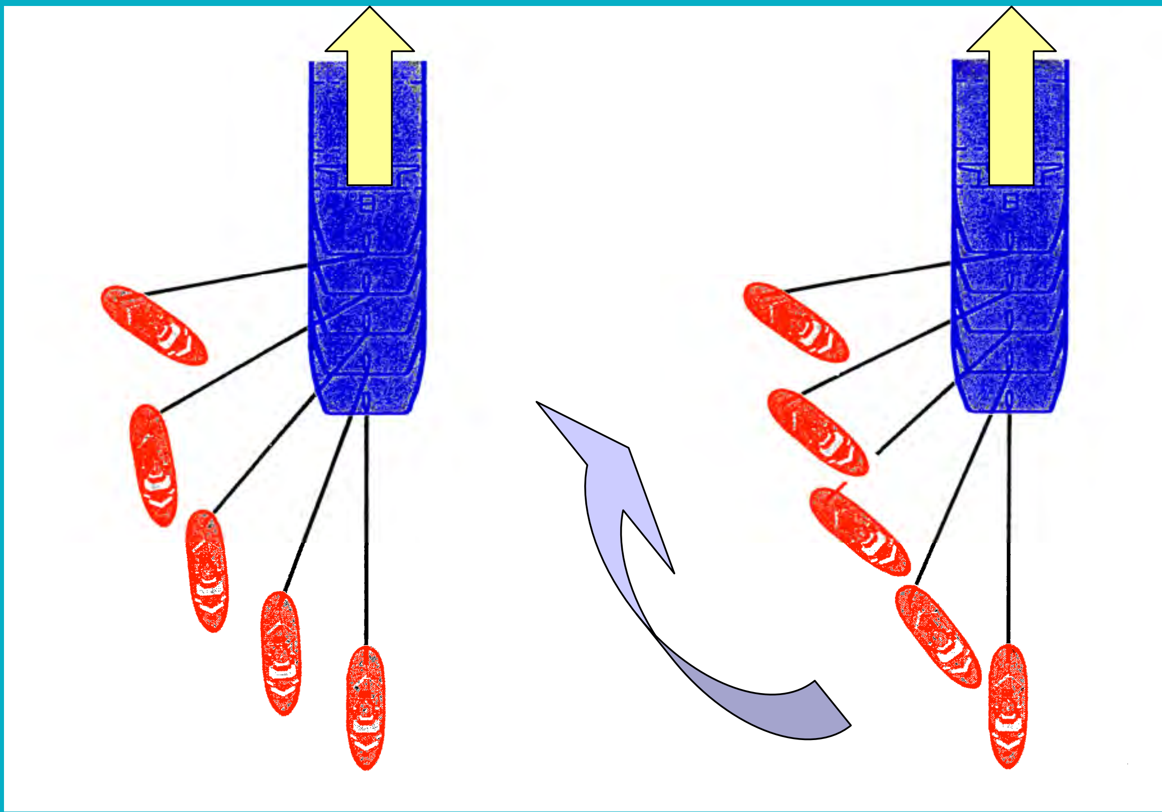
Unit 7 Page 45

DRIVING and FLYING



DRIVING
to steering position

FLYING
to steering position

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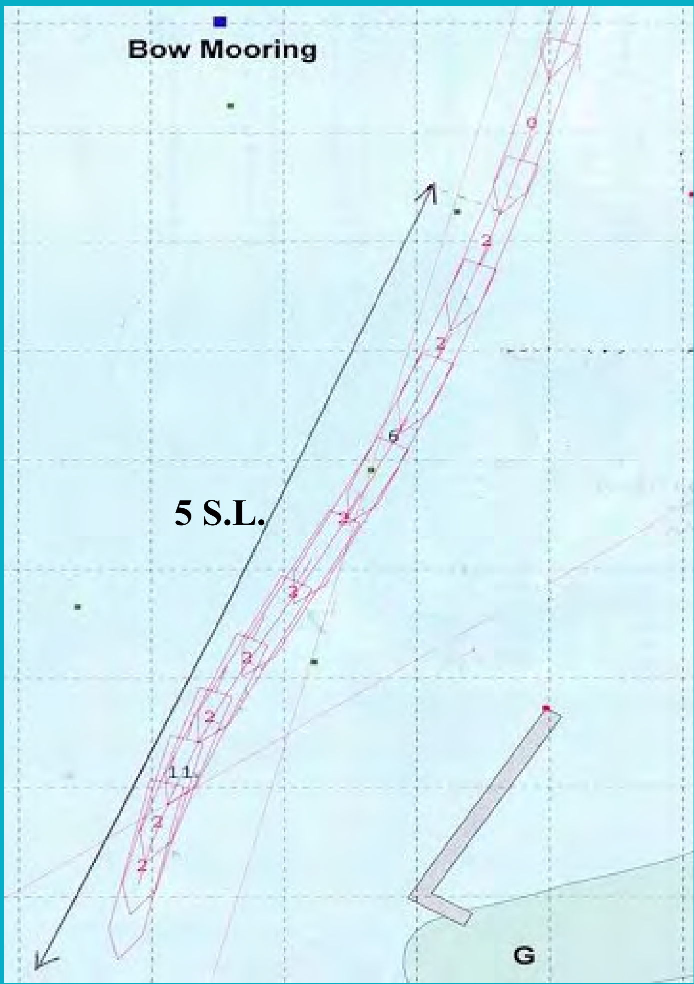
Unit 7 Page 46

EMERGENCY STOP with 60 t ASD



<< Engine failure with rudder amidships
V = 9 kn

<< Start pulling indirect in line

<< V= 6 kn

<< from indirect to direct

<< V = 4.5 kn

Ship stopped

Sogreah © Unit 7 Page 47

PORT REVEL Shiphandling

TUG COMMANDS

Some commands with

VSP

Video Approach bow

Video Approach stern

Video Approach aft chock

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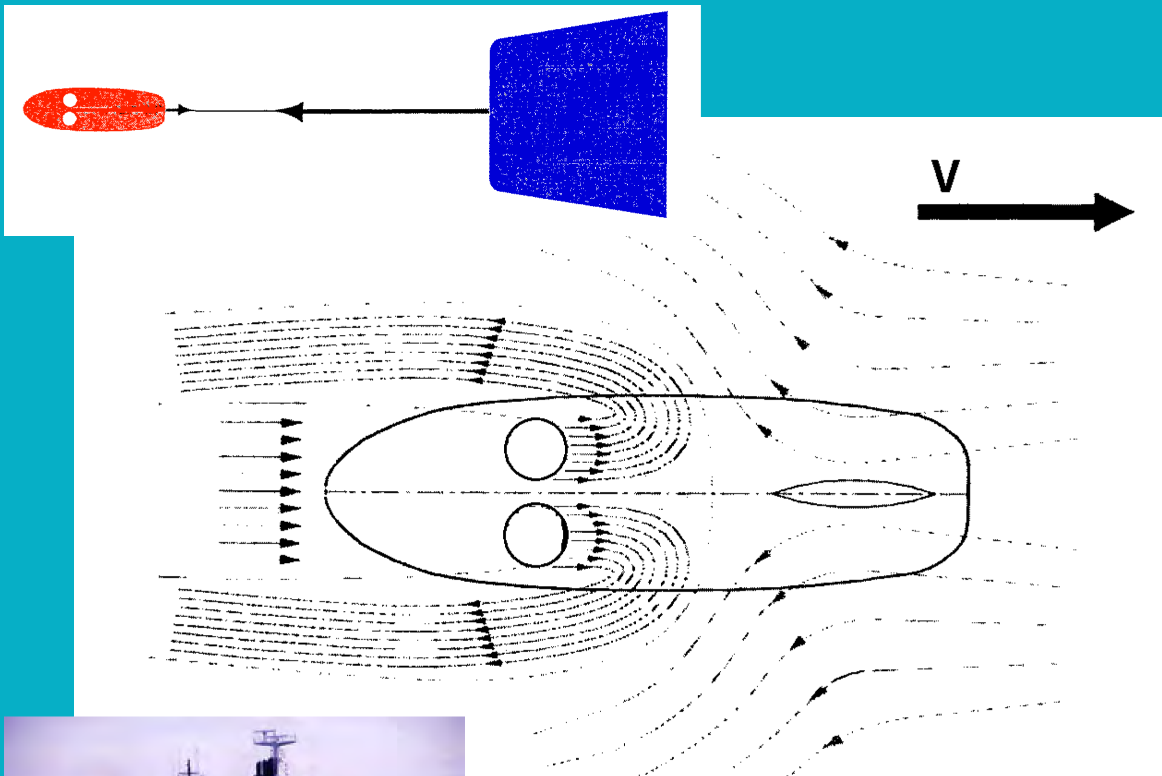
Unit 7 Page 48

Water flow in VOITH



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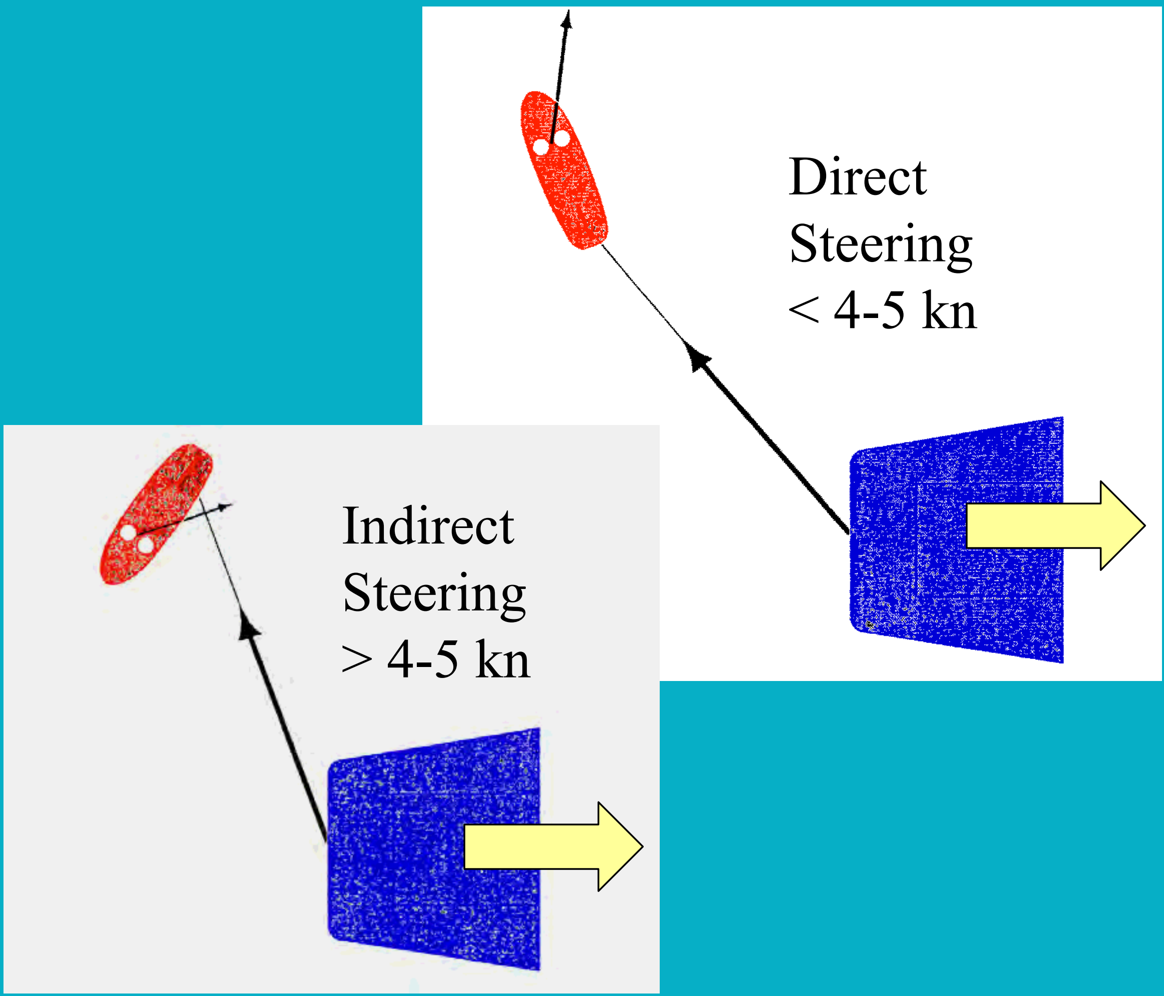
PORT REVEL Shiphandling

STEERING



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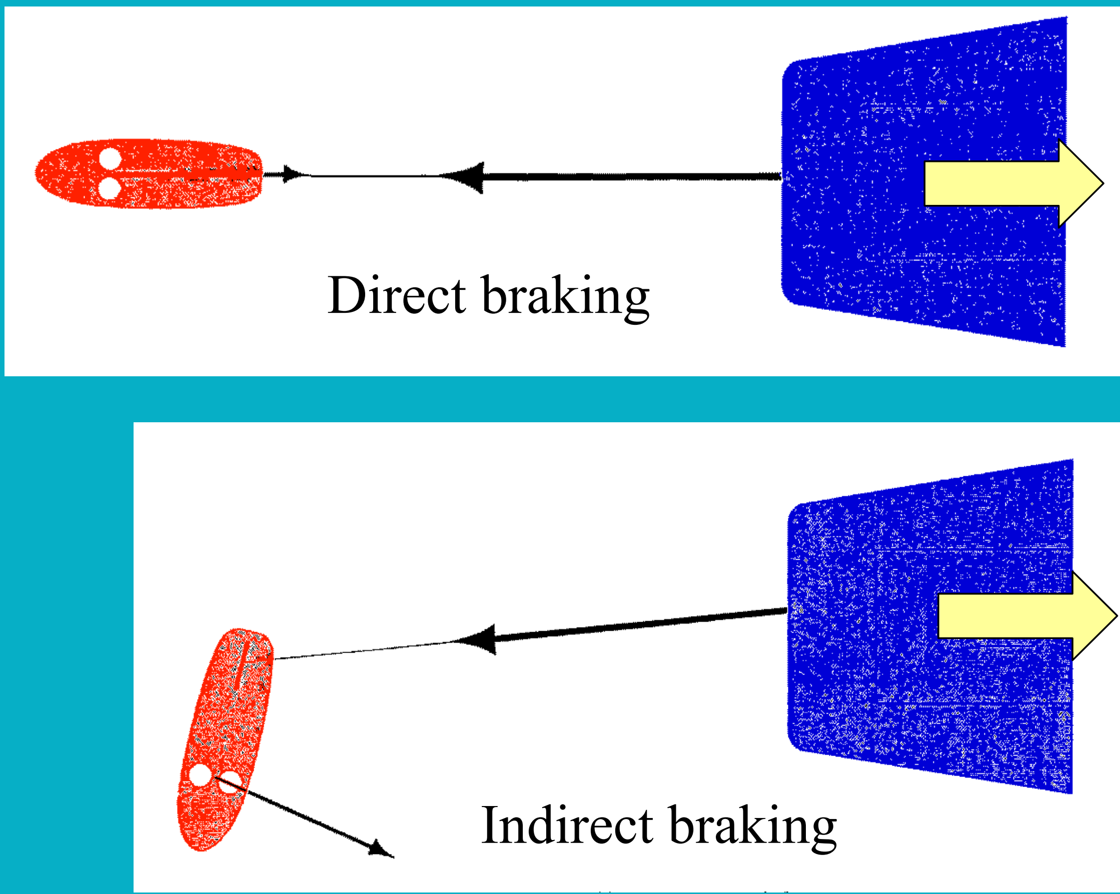
BRAKING



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STEERING IN CANAL with VSP

Sogreah ©

INDIRECT with VSP

Sogreah ©

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INDIRECT with VSP

Sogreah © Unit 7 Page 54

WIDE SLOT STAPLE

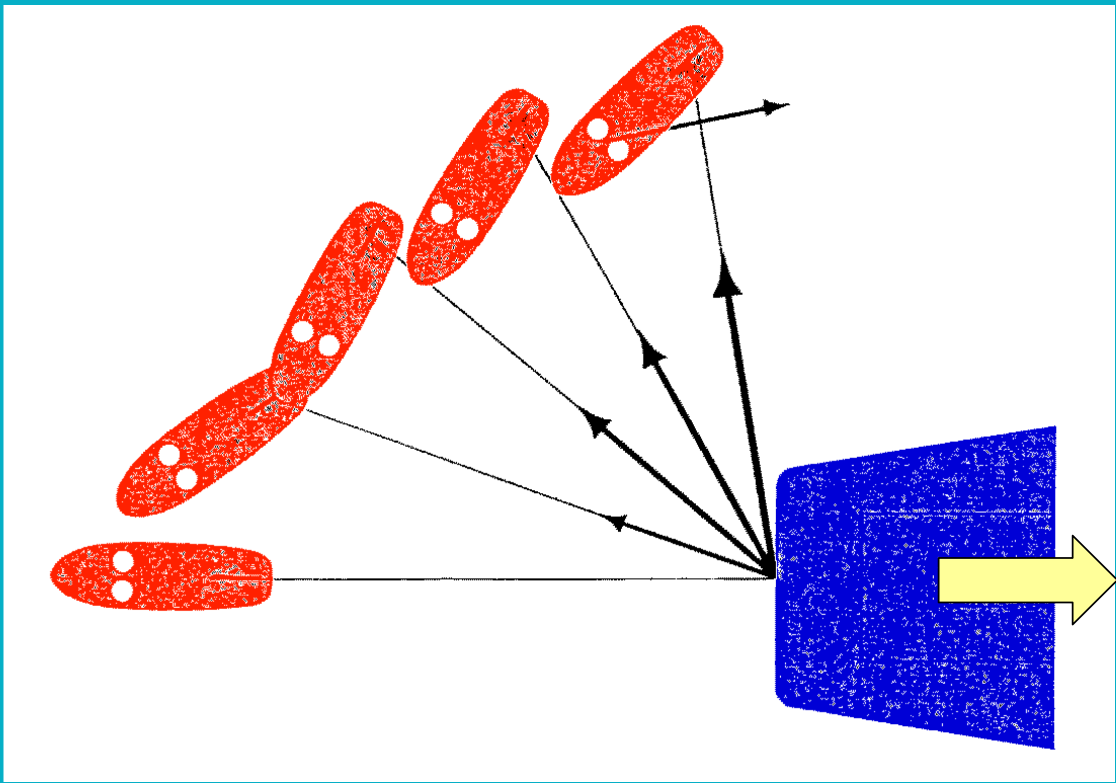
Less list for more safety !

Photo: International Tug & Salvage - Design: Robert Allan Ltd

Sogreah ©   Unit 7   Page 55

INDIRECT with VSP

From BRAKING to STEERING



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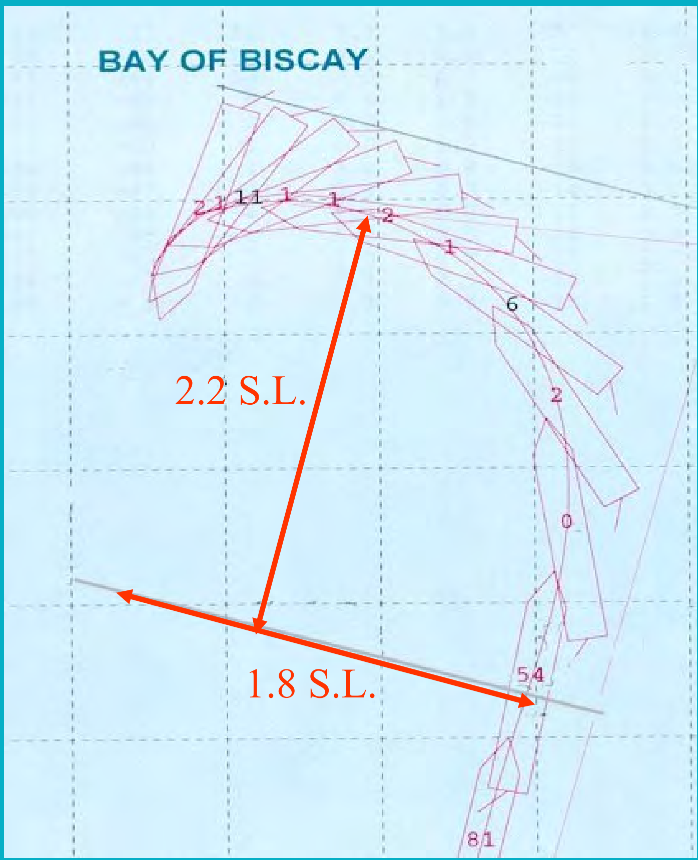
EMERGENCY STOP with 60 t VSP



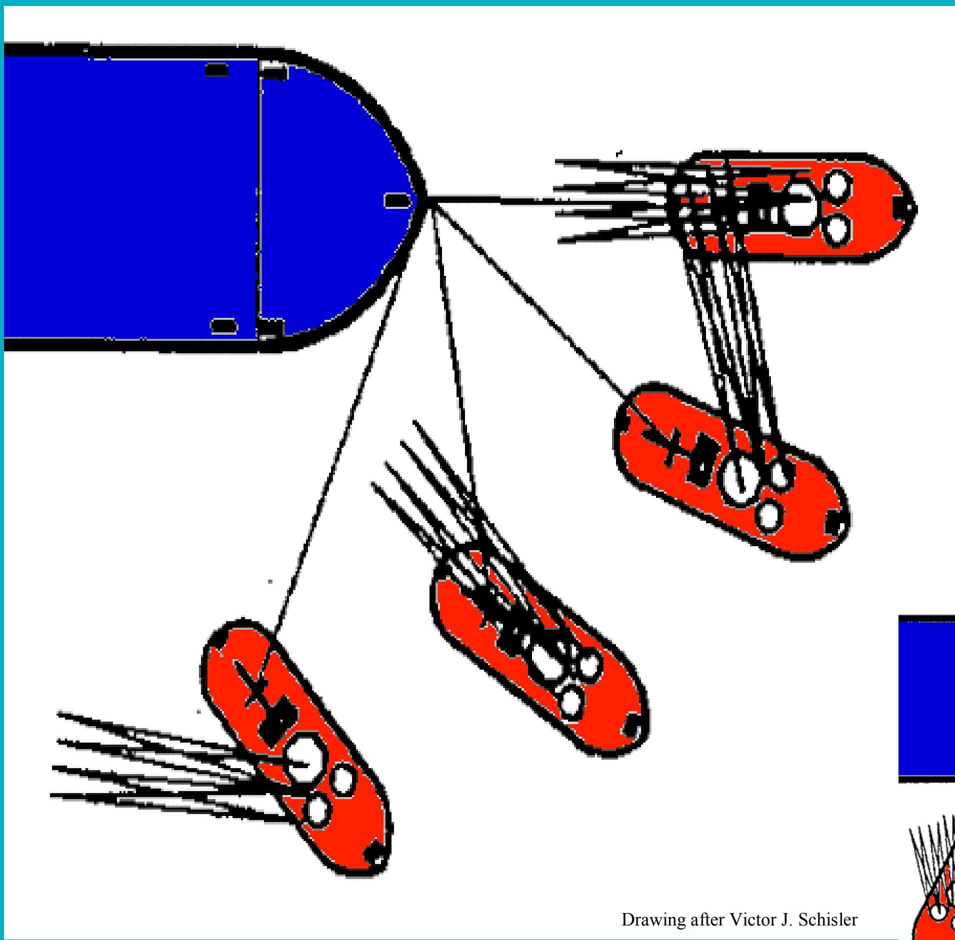
<< Ship stopped

<< from indirect to direct

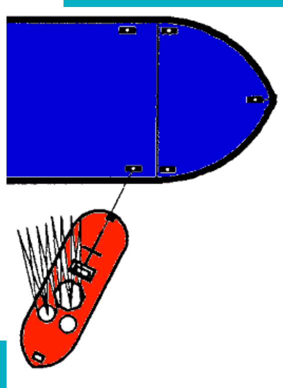
<< Start pulling indirect to starboard

<< Engine failure with rudder hard port
V = 8 kn

Pull bow to starboard (or port) easy, half or full



Mind danger of tripping when V > 5 kn



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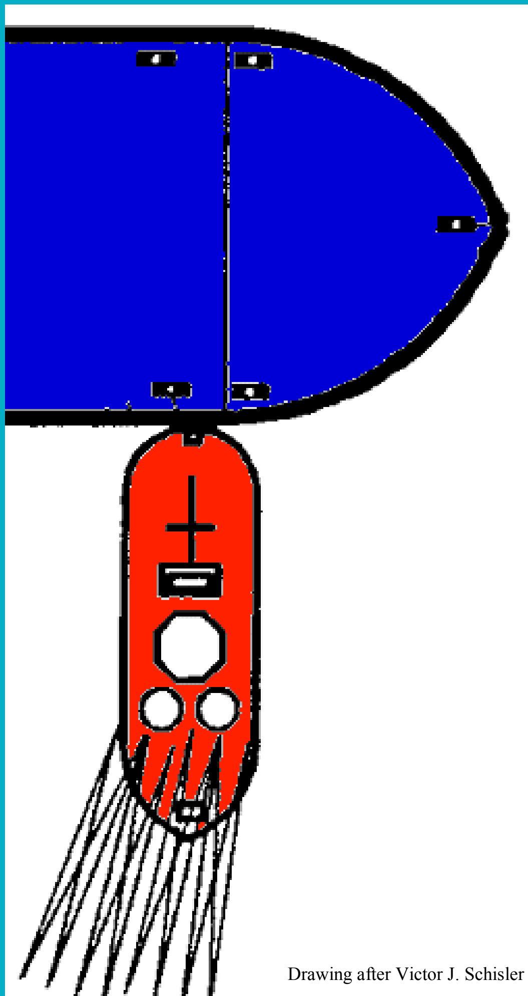
Unit 7 Page 59

Push bow to starboard (or port) easy, half or full



Push 90°
to the keel

with
tug tethered

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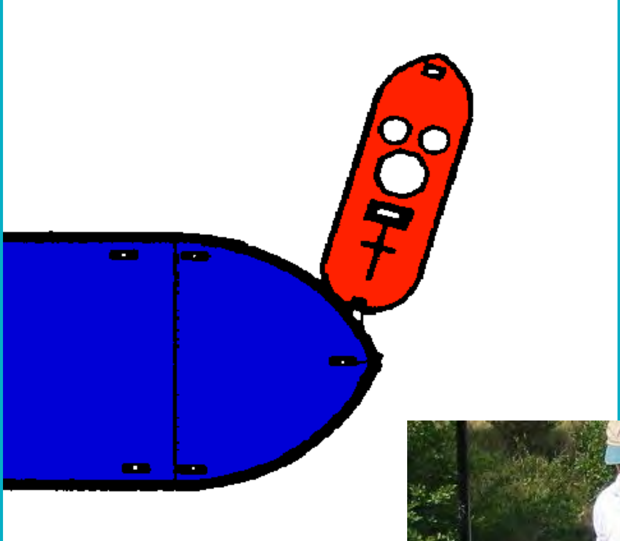
Unit 7 Page 60

PUSH – PULL MODE


Drawing after Victor J. Schisler

Come to push and pull mode, and stop

with tug tethered

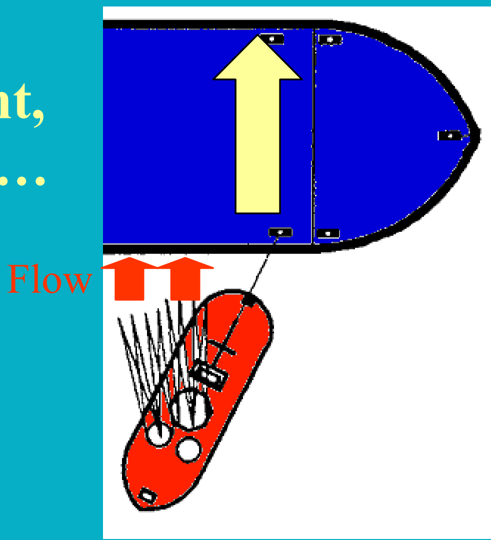
To shorten the reaction time of the tug ready to push or pull

PUSH – PULL MODE

And remember …

if you pull, don't forget to slack the line to have best efficiency,

because the flow generated by the propeller of the tug push the ship, like a current, to the other side you want …



Sogreah ©

TUG COMMANDS

More

COMMANDS

Video Secondary towpoint

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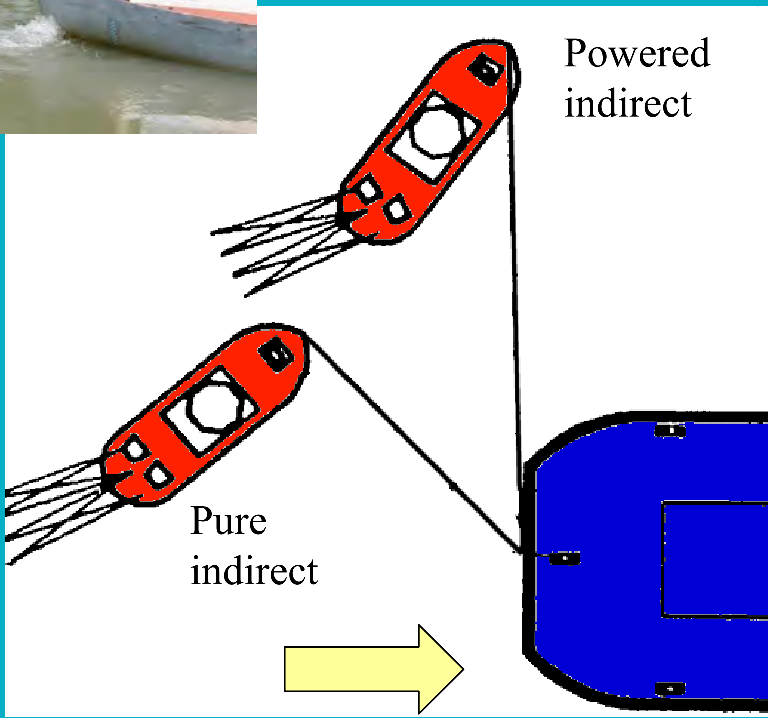
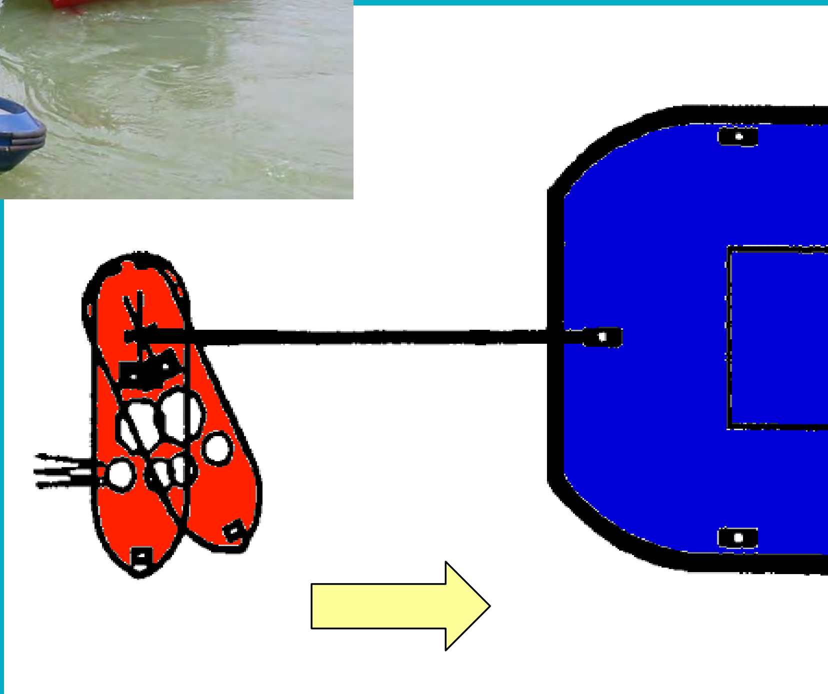
INDIRECT PULL



Speed > 6 kn

To reduce speed
and
influence heading

INDIRECT IN LINE
staple to port



Drawing after Victor J. Schisler

Sogreah ©

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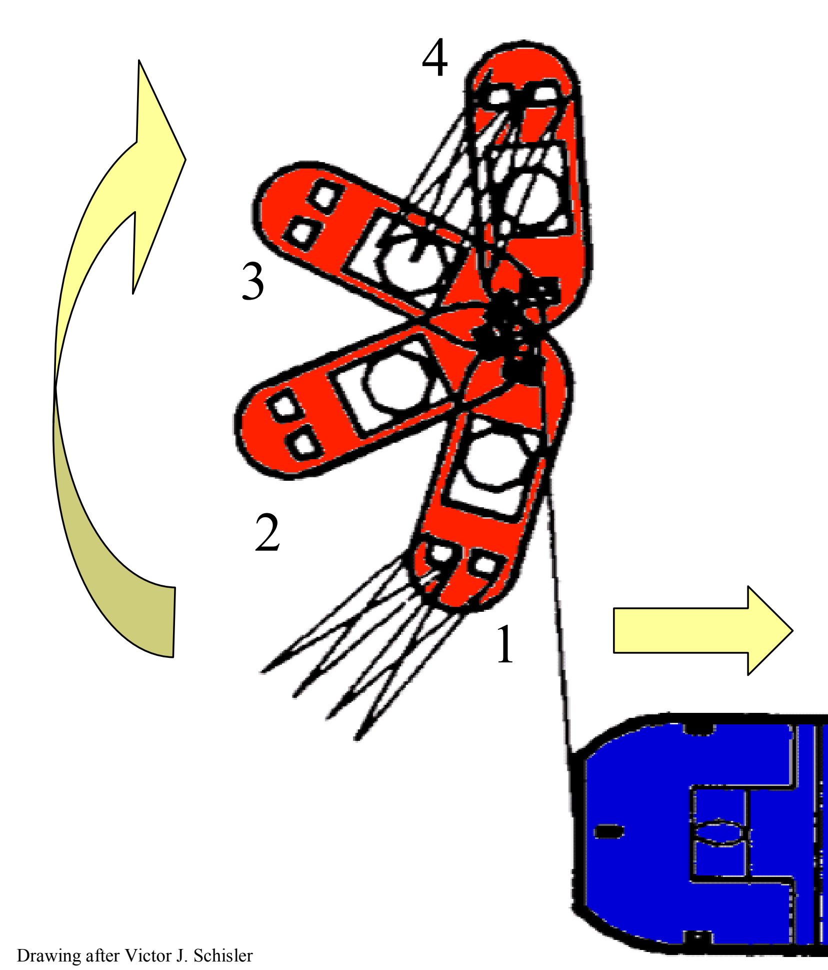
JACKNIFE
and pull to port

From position 1 to 4, in direct pull mode



Drawing after Victor J. Schisler

Video jacknife

Sogreah ©

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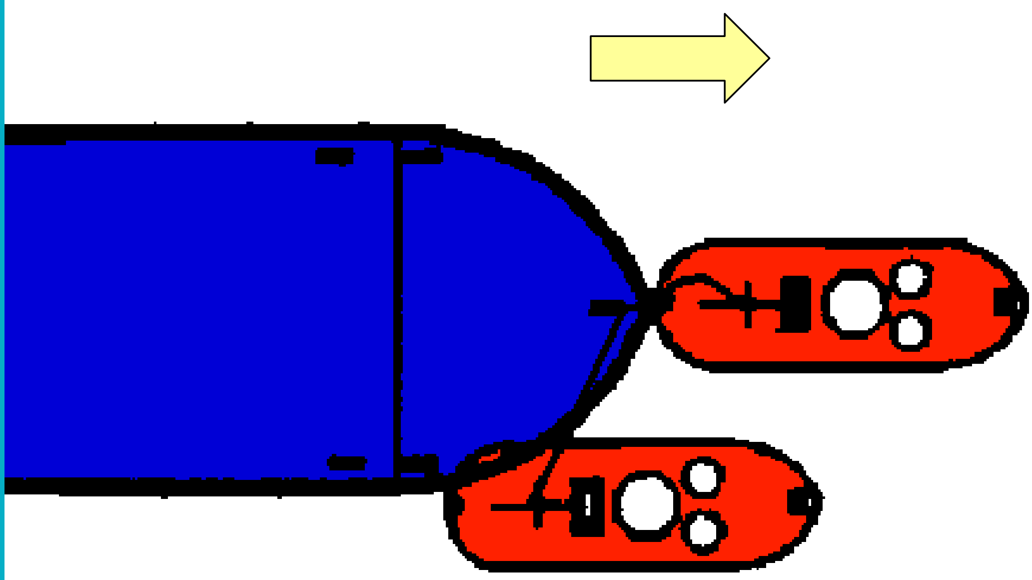
SIT ON THE STEM



Sit (rest) on your line on the starboard side of the stem

Drawing after Victor J. Schisler

Sogreah ©

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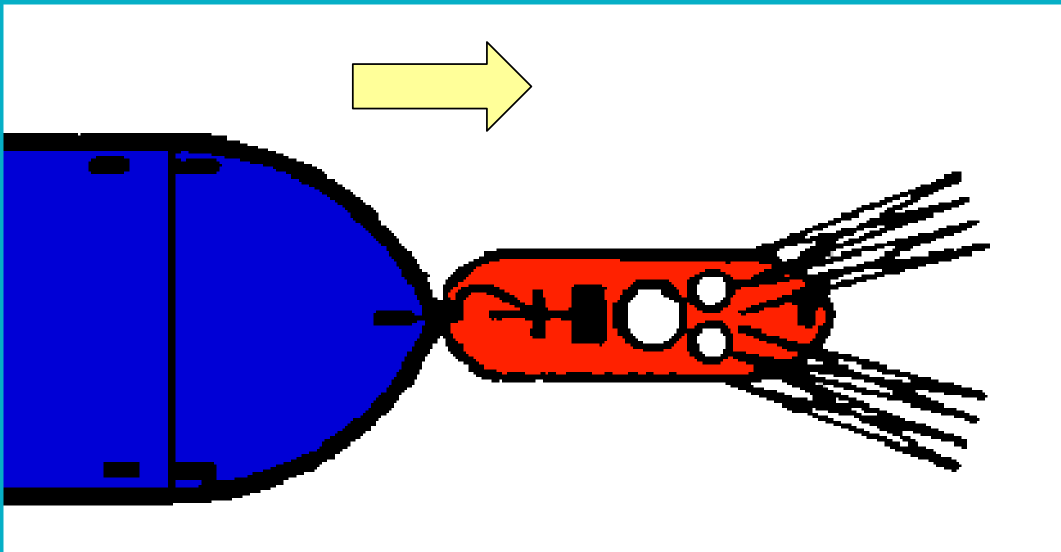
PUSH AGAINST THE STEM


Drawing after Victor J. Schisler

and, push the bow to port (or starboard)

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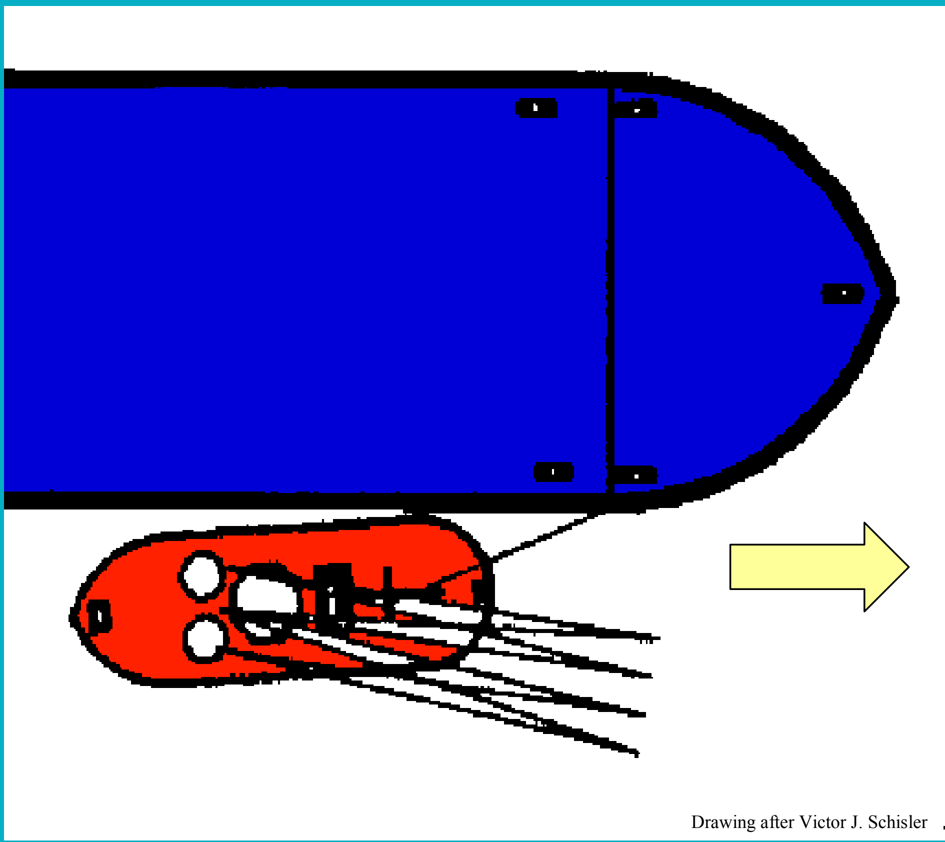
SLACK
to lay alongside



and, pull alongside

Sogreah ©

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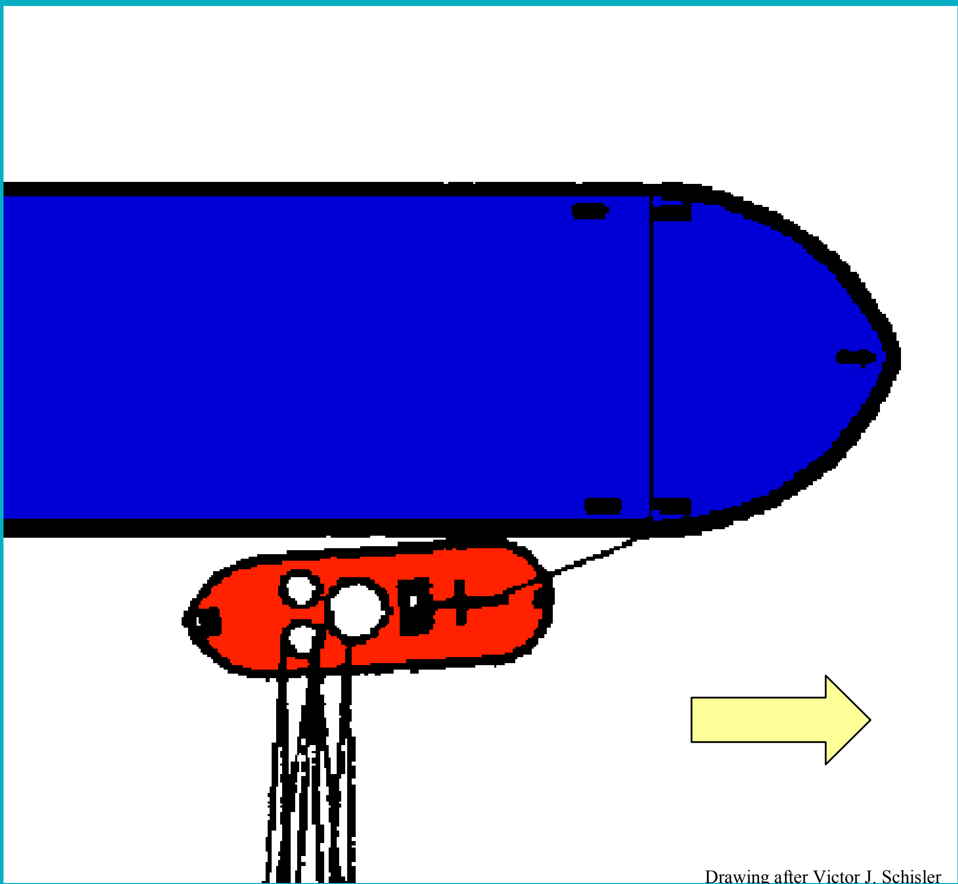
SIDE THRUST INTO SHIP



Drawing after Victor J. Schisler

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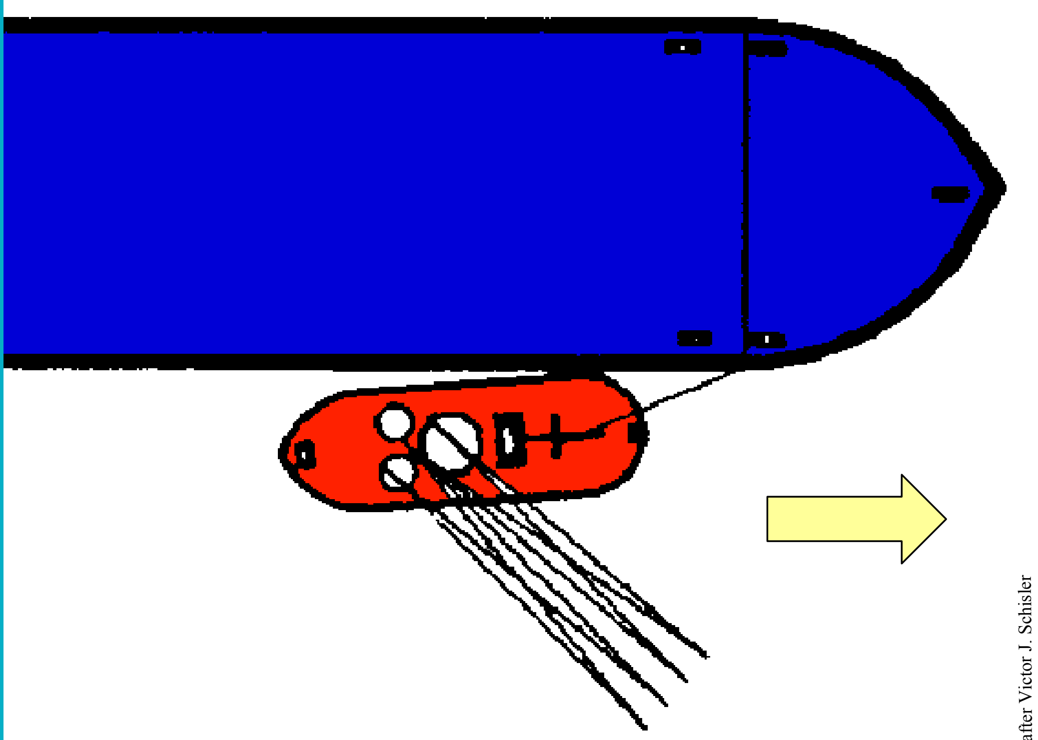
PULL ALONGSIDE



Pull alongside and side thrust into the ship

Sogreah ©

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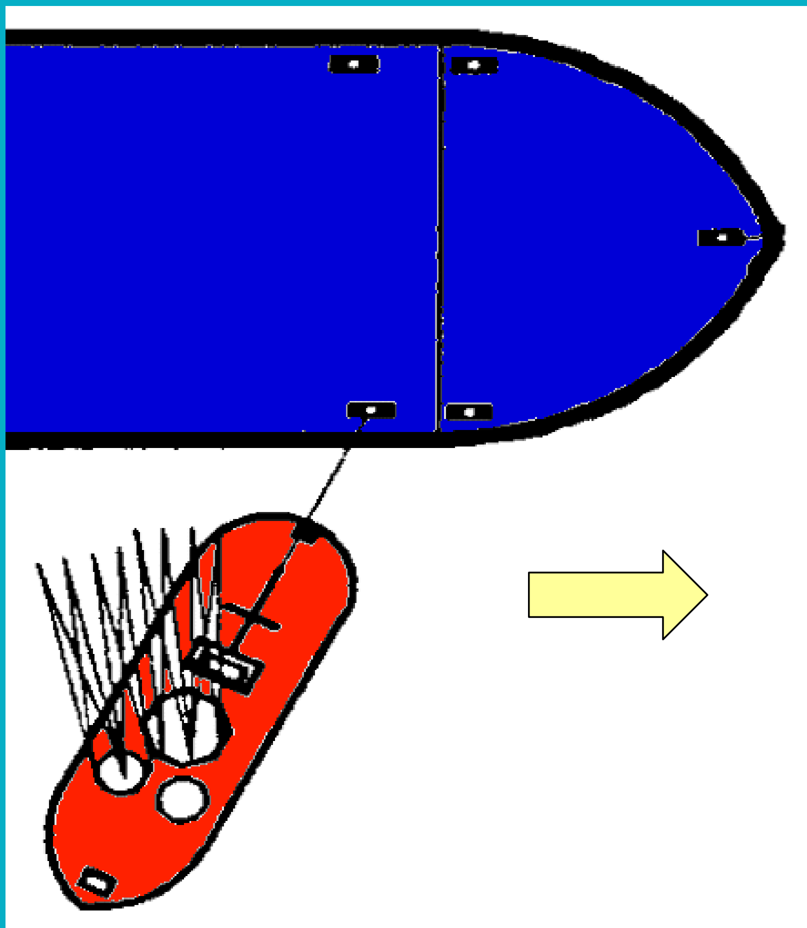
PULL OFF THE SHIP



Drawing after Victor J. Schisler

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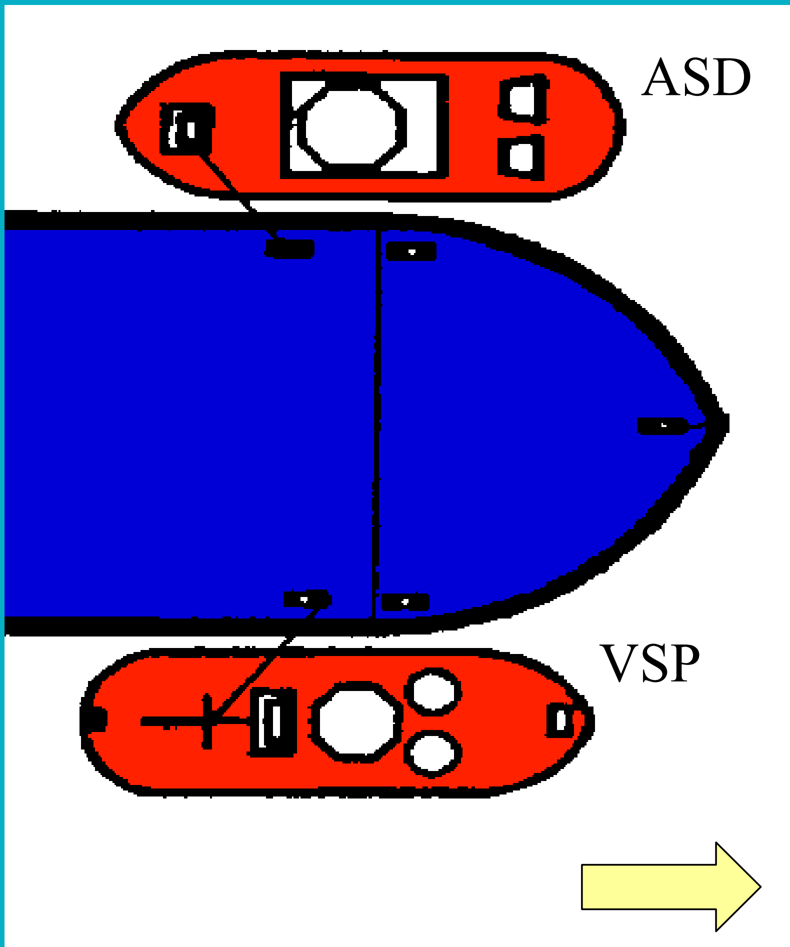
PULL A LINE ON THE BOW
working end aft



Drawing after Victor J. Schisler

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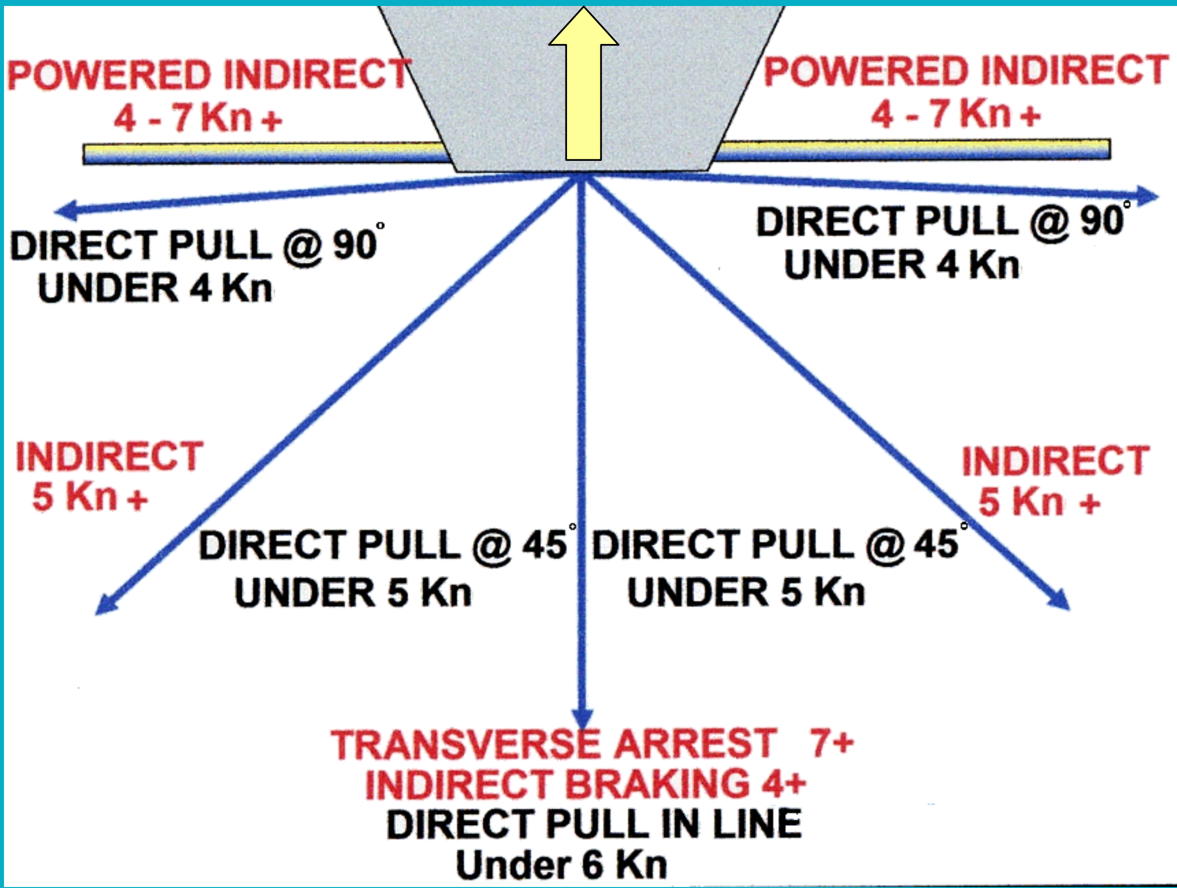
SUMMARY OF COMMANDS



(from Towing Solutions)