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SIMULATED PROPELLER WALK ON A 13.300 TEU CONTAINER SHIP

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Abstract: *Maritime transport continues to be the main pillar of the global economy as the largest amount of all raw and processed products is made through it. The increasing number of vessels led to the increase on maritime traffic thus increasing the risk of naval accidents. The main factor of all naval accidents remains the human factor, being present in about 80-90% of the cases.*
The movement of a ship is made under the influence of the propeller unit and steering system. Knowing the characteristics, of the ship, of steering and propulsion, represent one the main responsibilities for the officer in charge with the navigational watch. The aim of this paper is to present the influence of the propeller upon the ship maneuverability by simulation techniques.

INTRODUCTION

The main purpose of the crew is to navigate safetly and to ensure that the onboard personnel, the ship and the load will reach its destination safely.From navigation safety regulations point of view the persons responsible for this act are the master and the bridge team. In order to fulfill their duties all those involved shall be first of all properly familiar with the operation of the engine controls on the bridge, with manual and automatic steering as well as with the characteristics of the vessel's maneuvrabilityand also comply to all maritime regulations.
Under STCW Code, Colreg, SOLAS the master bears the ultimate responsibility for the safety of the vessel. He shall ensure that the officer of the watch is familiar with all navigation equipment prior to his watch. He should also provide standing orders for the watch in order to ensure ship safety. Whenever he is on the bridge and wants to take over the command of the ship he should specifically inform the officer of the watch in charge that he is taking over the watch.
According to the STCW Code, the Officer of the watch is the master's representative and is responsible for the safe navigation of the ship at all times and for complying with COLREG rules, until the master specifically announces he is taking over.Therefore all the OOW must be familiar to the ship's characteristics regarding her maneuvrability.
Information of the vessel's stopping distanceand turning ability shall be found in the guides"Wheelhouse Poster" and "Vessel OperatingManual" on the bridge.

SHIP'S CHARACTERISTICS

Shiphandling and maneuvring can be defined as the art of controlling a ship underway in open sea or harbours. The most important thing one needs to understand in shiphandling is to anticipate how the ship will behave under different circumstances and what order to give in order to have the ship behave and move the way he wants.
Of course, the way a ship behaves in water depends on a series of internal and external factors. Such internal factors can be: the engine power, speed, effect of the type of propeller, rudder movement and type, thrusters, anchors and mooring lines etc. Each and every vessel is different, thus the internal factors vary from one to another. Thus being on the bridge of different vessels, the OOW must have accurate information off the vessel. IMO adopted Resolution A.601(15) in 1987 regarding provision and display of manoevring information on boards ships. Line 1.2 states:
The manoevring information should be presented as follows:

1. Pilot card
2. Wheelhouse poster
3. Manoevring booklet.

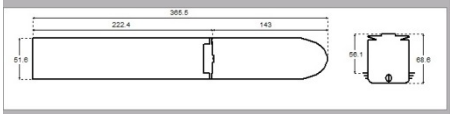
The pilot card should be filled in by the master and it describes the current condition of the ship such as it's loading, propulsion, manoevring equipment and other relevant information. The pilot card is intended to offer information to a pilot boarding a vessel.

PILOT CARD

Ship name	Container ship 13 (13300 TEU) 3.0.11.0 *			Date	19.12.2012
IMO Number	N/A	Call Sign	N/A	Year built	2009
Load Condition	Ballast				
Displacement	134000 tones		Draft forward	10 m / 32 ft 10 in	
Deadweight	156800 tonnes		Draft forward extreme	10 m / 32 ft 10 in	
Capacity			Draft after	12.5 m / 41 ft 1 in	
Air draft	56.15 m / 184 ft 8 in		Draft after extreme	12.5 m / 41 ft 1 in	

Ship's Particulars

Length overall	365.5 m	Type of bow	Bulbous
Breadth	51.65 m	Type of stern	Transom
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	13 / 15		(1 shackle =27.5 m / 15 fathoms)
Max. rate of heaving, m/min	9 / 9		



Steering characteristics

Steering device(s) (type/No.)	Normal balance rudder / 1	Number of bow thrusters	2
Maximum angle	35	Power	1795 kW / 1795 kW
Rudder angle for neutral effect	-0.05 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	22 seconds	Power	N/A
Flanking Rudder(s)	0	Auxiliary Steering Device(s)	Auxiliary Steering Device(s): N/A

Stopping			Turning circle	
Description	Full Time	Head reach	Ordered Engine: 100%, Ordered rudder: 35 degrees	
FAH to FAS	346.6 s	8.74 cbls	Advance	5.73 cbls
HAH to HAS	398.6 s	7.04 cbls	Transfer	2.81 cbls
SAH to SAS	531.6 s	6.29 cbls	Tactical diameter	6.42 cbls

Main Engine(s)

Type of Main Engine	Low speed diesel	Number of propellers	1
Number of Main Engine(s)	1	Propeller rotation	Right
Maximum power per shaft	1 x 80080 kW	Propeller type	FPP
Astern power	68.4 % ahead	Min. RPM	20
Time limit astern	N/A	Emergency FAH to FAS	32.2 seconds

Engine Telegraph Table

Engine order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"FSAH"	27.2	71293	94.5	0.93
"FAH"	17.8	24592	65.1	0.93
"HAH"	13.4	11646	50	0.93
"SAH"	9.2	4380	35	0.93
"DSAH"	6.5	1913	25.4	0.93
"DSAS"	-3.2	2560	-25	0.93
"SAS"	-4.6	6361	-34.9	0.93
"HAS"	-6.8	17104	-49.8	0.93
"FAS"	-8.6	37388	-64.8	0.93

Fig. 1 Pilot card

The wheelhouse poster should contain general particulars and detailed information that describe the manoeuvring characteristics of the vessel. It should be permanently displayed in the wheelhouse and have such a size to ensure ease of use.

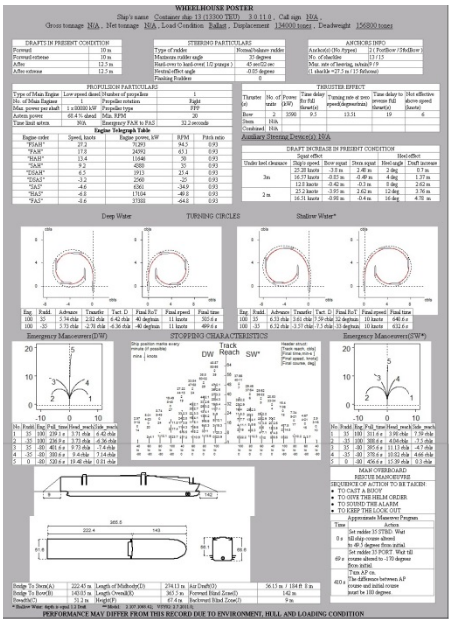


Fig. 2 Wheelhouse poster

The document containing the most detailed information about the vessel's manoeuvrability is the manoevring booklet. The data presented here should include the ones presented in the wheelhouse poster toghether with other relevant information. Most of it cand be estimated but some should be obtained by sea trials. One of the most important information that can be obtained from theses documents regard the propeller.

TRANSVERSE THRUST EFFECT / PROPELLER WALK

The motion of a vessel is given by it's propulsion system, namely engine and propeller. Propulsion of vessels has come a long way since it's begining. It all started with the use of sails, paddle wheels and it somehow ended with the invention of the propeller of different types. The aim of this paper is not to discuss about different types of existing propellers, but to present the way that it influences the ship's motion. A right-hand fixed propeller will be taken into cosideration that can be considered like a paddle wheel. According to the rotation on the propeller a basic and a reaction force will affect the surface of the propeller blades. (Fig. 3)

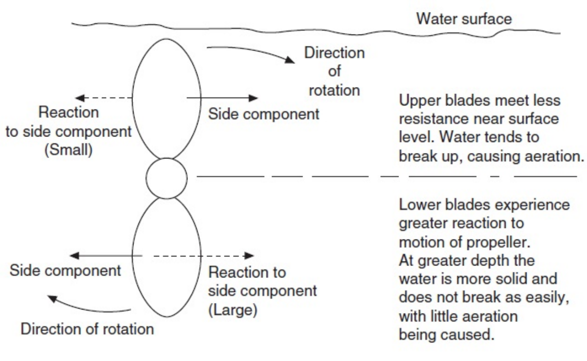


Fig. 3 Forces acting on propeller blades

The resultant forces will give a forward movement (or backwards), depending on the rotation of the blades, and a sideways movement called transverse thrust. If a vessel equipped with a right-hand propeller is moving forward, the stern will be moved to starboard and the bow to port.

When it rotates counter clockwise to propel the vessel astern, theopposite happens. The stern cants to port and the bow to starboardbesides propelling the vessel astern.(Fig. 4,5)

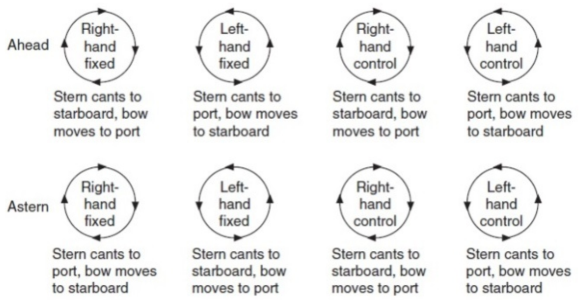


Fig. 4 Transverse thrust effect

Transverse thrust is most significant when the vessel is initiallypropelled ahead or astern from a stationary position. When thevessel has gathered some headway, transverse thrust is lessnoticeable.This force depends on ship geometry, direction of travel, propeller direction, vessel speed and depth of water.

Although the transverse thrust may seem to be a disadvantage, with good practice, it can be put to use when manoeuvring a vessel in cases like berthing or unberthing the vessel.

When in open sea, this force, if left unattained can lead to a different heading that the one desired if the vessel is in manual mode. This force be counteracted by putting the rudder one side or the other according to the rotation of the propeller.

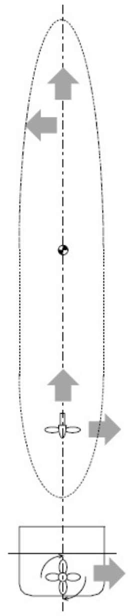


Fig. 5 Transverse thrust effect

SIMULATION OF THE PROPELLER WALK EFFECT

In order to determine how this effect affects a vessel trialsmust be conducted whether at sea or simulated, at different speed and draught.

"Mircea cel Batran" Naval Academy purchased in 2009 a complex of operational maritime simulatorsnamed "Integrated simulator for driving of watercraft" type Navi-Trainer Professional 5000manufactured by TRANSAS Limited Co and certified by DetNorskeVeritas (DNV) as A class (fullmission) for bridge and machinery. This complex of simulators has been updated in December 2013 and meets the Standard Certification No. 2.14 for Maritime Simulator Systems, adopted in January 2011.

One of the biggest vessels simulated is anExplorer class containership, one of the biggest containerships, that can carry 13.300 TEU. The simulated model allows to work with the vesselunder different load conditions.

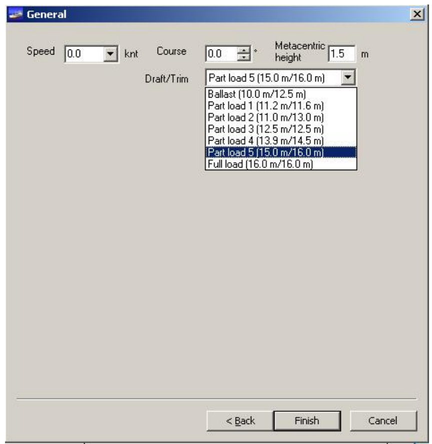


Fig. 5 Various loads of the vessel

General information and the characteristics of this vessel are given in Table 1 and figure 6.

Deplasament	202650 tone
Deadweight	156800 tone
Max speeed	25.4 knts
Lenght overall	365.5 m
Breadth	51.2 m
Height	68.15 m
Type of engine Slow Speed Diesel	1*80080kW
Type of propeler	FPP
Propeller rotation	Right

Tab 1. 13.300 TEU container ship characteristics

The simulations took place in open sea and all the external factors such as tide, wind and current, depth were set to 0 and as a result did not affect the vessel's movement. Simulation took place for all ahead telegraph orders in various conditions of load for a distance of 5 nautical miles.

RESULTS

The various speed that the ship had during simulations is presented in the Engine Telegraph Table below:

Engine Telegraph Table				
Engine order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"FSAH"	27.2	71293	94.5	0.93
"FAH"	17.8	24592	65.1	0.93
"HAH"	13.4	11646	50	0.93
"SAH"	9.2	4380	35	0.93
"DSAH"	6.5	1913	25.4	0.93

Fig.5 Engine Telegraph Table

The load conditions that the ship had are presented in the following table:

Load condition	Draft forward	Draft after
Ballast	10m	10m
Load 1	11.2m	11.6m
Load 2	11m	13m
Load 3	12.5m	12.5m
Load 4	13.9m	14.5m
Load 5	15m	16m
Full	16m	16m

Tab 2. Load conditions

For dead slow ahead speed the following results were obtained:

	Load condition	Final Course
Dead Slow Ahead	Ballast	348.1
	Load 1	347.8
	Load 2	347.3
	Load 3	346.8
	Load 4	345.4
	Load 5	343.9
	Full	342.7

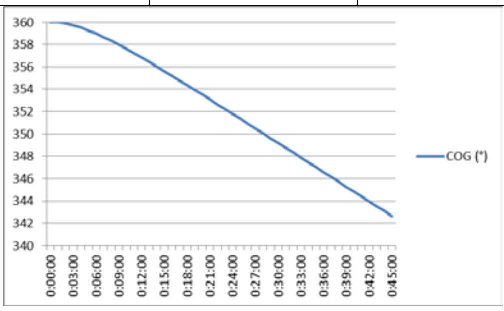


Fig. 6 Propwalk in full load condition –Dead Slow Ahead

For slow ahead speed the following results were obtained:

	Load condition	Final Course
Slow Ahead	Ballast	348.1
	Load 1	347.9
	Load 2	347.6
	Load 3	347.1
	Load 4	345.8
	Load 5	343.7
	Full	342.7

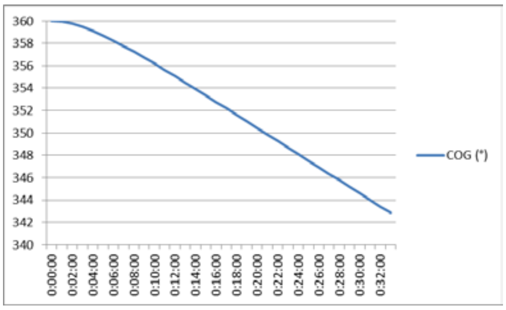


Fig. 7 Propwalk in full load condition –Slow Ahead

For half ahead speed the following results were obtained:

	Load condition	Final Course
Half Ahead	Ballast	348.4
	Load 1	348.2
	Load 2	347.7
	Load 3	347.4
	Load 4	345.7
	Load 5	345
	Full	343.1

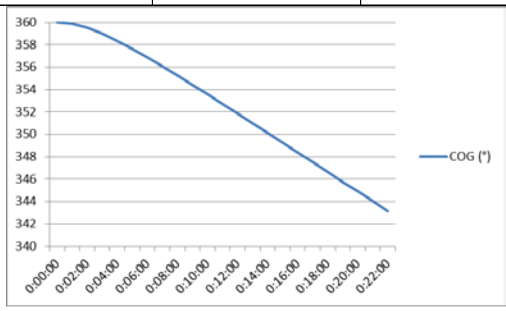


Fig. 8 Propwalk in full load condition –Half Ahead

For full ahead speed the following results were obtained:

	Load condition	Final Course
Full Ahead	Ballast	348.4
	Load 1	348.3
	Load 2	347.9
	Load 3	347.4
	Load 4	345.8
	Load 5	344.2
	Full	343.4

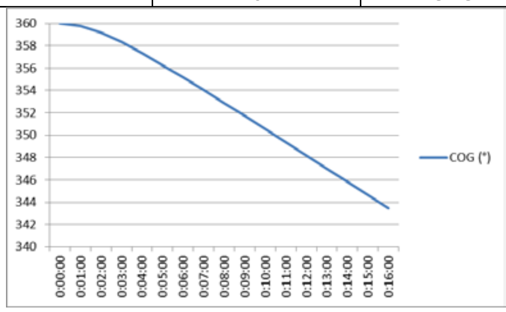


Fig. 8 Propwalk in full load condition –Full Ahead

For full ahead speed the following results were obtained:

	Load condition	Final Course
Full Sea Ahead	Ballast	348.8
	Load 1	348.7
	Load 2	348.3
	Load 3	347.4
	Load 4	346.2
	Load 5	344.8
	Full	343.9

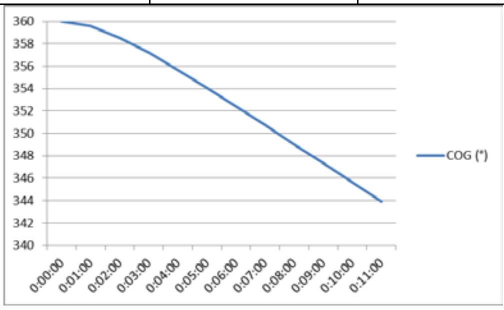


Fig. 9 Propwalk in full load condition –Full Sea Ahead

As expected, when no factor intervenes, the ship will alter her course to port side, depending on her speed and her load conditiond. Another factor to be taken into consideration is the time. The more the ship is left unattained, the more it will alter its course.

One more simulation was performed at full sea ahead in full load condition in order to see the effects.

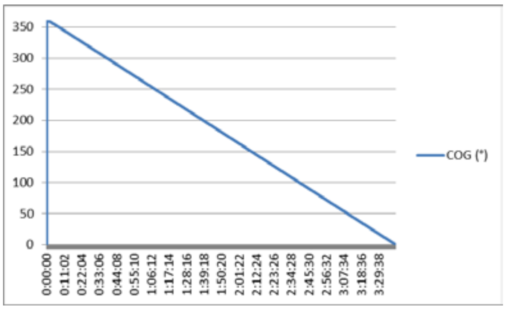


Fig. 10 Propwalk at Full Sea Ahead – full load condition

It takes the ship 3 hours and 40 minutes to make a full turn, without the aid of the helm and other factors. The total distance travelled is 97.8 nautical miles. The starting point was Lat=50° 14' 59.87184" N Long= 11° 46' 59.97364" W and the ending point was Lat =50° 15' 40.99626" N Long= 11° 47' 1.576176"W. The two points are less that 1 nautical mile distance to each other.

CONCLUSIONS

Knowing the characteristics, of the ship, of steering and propulsion, represent one the main responsibilities for the officer in charge with the navigational watch. Having knowledge of these characteristics, one shall know how to act in order to keep a safe navigation.

The propwalk is one of these characteristics that influences the movement of the ship when in port or at open sea. For a distance of 5 nautical miles the alteration of the course varies from 17.3 to 16.1 degrees, depending on the speed and condition load.

Another important factor to be taken into consideration is time. As presented, in less than 4 hours, the shift of a navigation officer, this type of ship will do a full turn to port.

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