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Bridge Simulator Study to Determine the Optimum Safe Ship Speed in Suez Canal

Transit of an Ultra Large Container Vessel in 25 Knot Beam Wind Speed

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***Abstract*—Ship sizes are getting bigger, but the canal is the same size. Economies of scale need balancing. The "Ever Given" was a 22,000 + TEU Suezmax accident which blocked the canal. But the bigger capacity 23,000 + TEU "MSC Gulsun" is also a Suezmax. Where is the size and weather limitation one would ask and where does it stop? The Suez maximum ship length for the canal is under 400 meters, hence, to be precise 399.9 meters. Therefore, the increased container capacity is by way of additional breadth, height, and depth. But the broader, higher windage, and deeper she is, handling the ship becomes more challenging to the Pilots & Ship handlers and more accident prone. Therefore, the weather limitations and optimum speed recommendations for a safe transit must be studied for this maximum size of 399.9 meter length ships for the canal than for smaller ships.**

Keywords—optimum, ultra large ship safe speed, Suez Canal, Ever Given accident.

I. INTRODUCTION

According to the Suez Canal regulations the ship speed in the transit convoy should be 8.64 Knots keeping 1.5 miles in between ships. It is felt that in strong winds, high windage Suezmax ships such as the "Ever Given", "MSC Gulsun" are under better control if a higher speed is maintained. It must be taken into consideration the under-keel clearance. Squat and interaction including bank effects increase with the ship's speed. This simulator-based research study determines the optimum speed for this ship model "MSC Gulsun".

II. METHODOLOGY

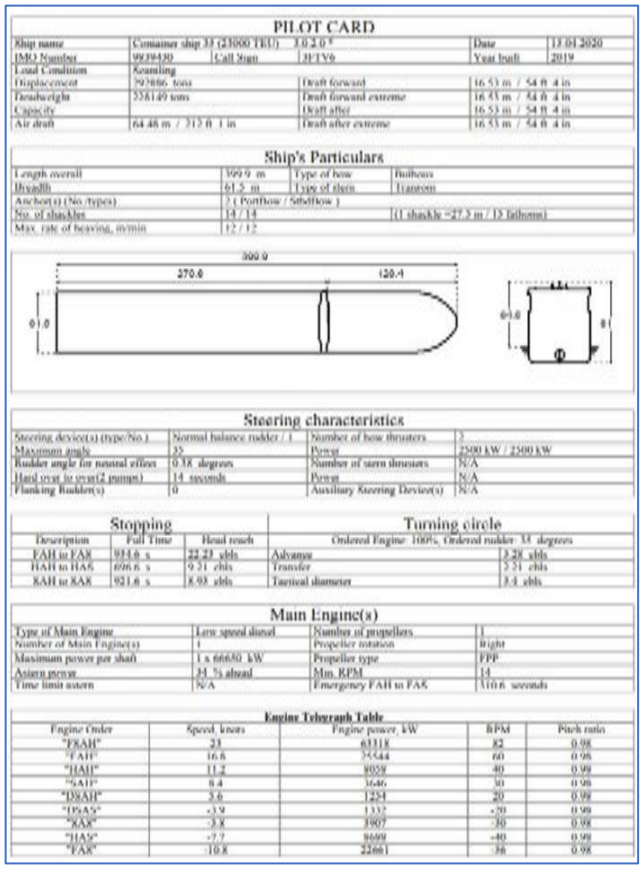
The selected ship model 35, a Suezmax ultra large container carrier (MSC Gulsun) was tested between the 149- and 156-Kilometre posts in the canal. in the CINEC Wartsila Transas NT Pro 5000 full mission Bridge Simulator. Tests were carried out in 5 different engine speeds of Dead Slow Ahead, Slow Ahead, Half Ahead, Full Ahead, Navigation Full Ahead with wind speeds of 25 Knots in True wind directions of 180, 225, 270, 315, 360 degrees totaling 25 tests. Out of this the 5 exercises displayed below were the 270 degree beam wind tests which were found to have the maximum athwartship drift and most difficult to manoeuvre. . The vessel's navigation was conducted by an experienced Pilot / Ship handler and steered by a competent Helmsman included in the Bridge Team. The challenge was to keep the ship within the dotted line on the ECDIS chart which maintains the deep 25-meter depth as per Figure 3 & 5.

It will be noteworthy to mention that many years ago the Suez Canal was transited where the Egyptian Pilot was accompanied by a helmsman as well, like has been done in the Kiel canal transit. Below the ship model 35 the "MSC Gulsun" is even larger in capacity and dimensions compared with the ship Ever Given which blocked the canal in 2019.

Figure 1: shows the simulator tested vessel proceeding in the Suez Canal.

Tested Ship model 35 “MSC Gulsun”

Length overall	399.9 meters
Breadth extreme	61.5 metres
Draft	16.53 metres even keel
Capacity:	23,756 TEU
Displacement	292,886 tonnes
Engine output	66,650 Kilowatts
Rudder	Normal balanced rudder
windage area	400 x60x 80% = 19,200 m2 estimated



PILOT CARD

Ship name	Container ship 35 (23000 TEU)	3 0 2 0 9		Date	13.01.2020
IMO Number	9939430	Call Sign	3FEY6	Year built	2019
Load Condition	Seaming				
Displacement	292886 tons		Draft forward	16.53 m / 54 ft 4 in	
Deadweight	228149 tons		Draft forward extreme	16.53 m / 54 ft 4 in	
Capacity			Draft after	16.53 m / 54 ft 4 in	
Air draft	64.46 m / 212 ft 1 in		Draft after extreme	16.53 m / 54 ft 4 in	

Ship's Particulars

Length overall	399.9 m	Type of bow	Bulbous
Breadth	61.5 m	Type of stern	Transom
Anchor(s) (No./types)	3 (Portflow / Stbdflow)		
No. of shackles	14 / 14		(1 shackle =27.5 m / 15 fathoms)
Max. rate of heaving, m/min	12 / 12		

Steering characteristics

Steering device(s) (type/No.)	Normal balance rudder / 1	Number of bow thrusters	3
Maximum angle	35	Power	2500 kW / 2500 kW
Rudder angle for neutral effect	0.38 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	14 seconds	Power	N/A
Flanking Rudder(s)	0	Auxiliary Steering Device(s)	N/A

Stopping

Description	Full Time	Head reach
FAH to FAS	934.6 s	22.23 x/lls
HAH to HAS	696.6 s	9.51 x/lls
SAH to SAS	921.8 s	8.93 x/lls

Turning circle

Ordered Engine: 100%, Ordered rudder: 35 degrees

Advance	3.28 x/lls
Transfer	2.51 x/lls
Tactical diameter	3.4 x/lls

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 66650 kW	Propeller type	FPP
Astern power	34 % ahead	Min. RPM	14
Time limit astern	N/A	Emergency FAH to FAS	310.6 seconds

Engine Telegraph Table

Engine Order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"FSAH"	23	63318	82	0.98
"FAH"	16.6	25544	60	0.98
"HAH"	11.2	8059	40	0.99
"SAH"	8.4	3646	30	0.98
"DSAH"	3.6	1254	20	0.99
"DSAS"	-3.9	1337	-20	0.99
"SAS"	-3.8	1907	-30	0.99
"HAS"	-7.7	9669	-40	0.99
"FAS"	-10.8	22661	-58	0.98

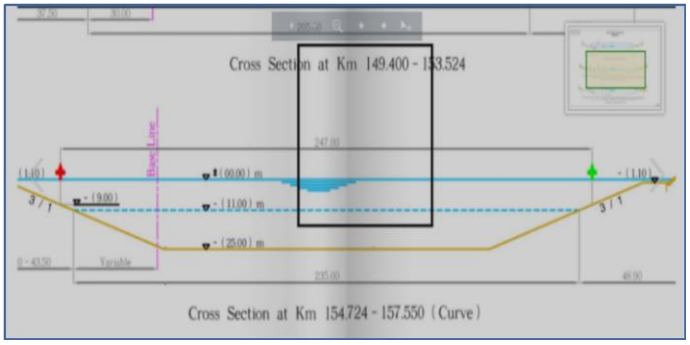


Figure 2: In the above figure the Pilot card gives all details of the vessel required to be presented to the Pilot upon his arrival onboard at the Master Pilot information exchange stage for the onward passage for information and familiarization.

Figure 3: The above figure shows the canal cross section from “SCA (Suez Canal authority) rules of navigation” with a tapering bank with the ship cross section superimposed in black. This is not to scale. The vessel had an under-keel clearance of 8.4 metres.

- Number of Exercises: - 05

III. EXERCISE 1 :

DEAD SLOW AHEAD ENGINE SPEED OF 5.6 KNOTS

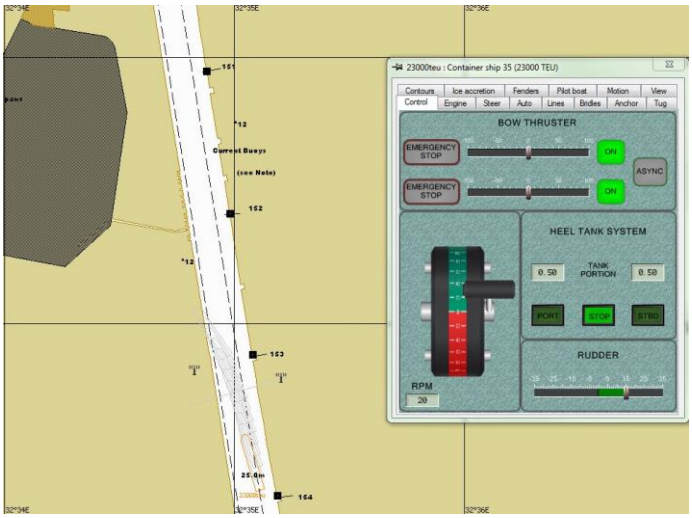


Figure 4: The above figure shows the ship moving in the canal to the east of the dredged channel close to grounding, marked by the dotted lines passing the 154 Km post northbound trending to turn to swing to port. The control panel is also shown with starboard rudder.

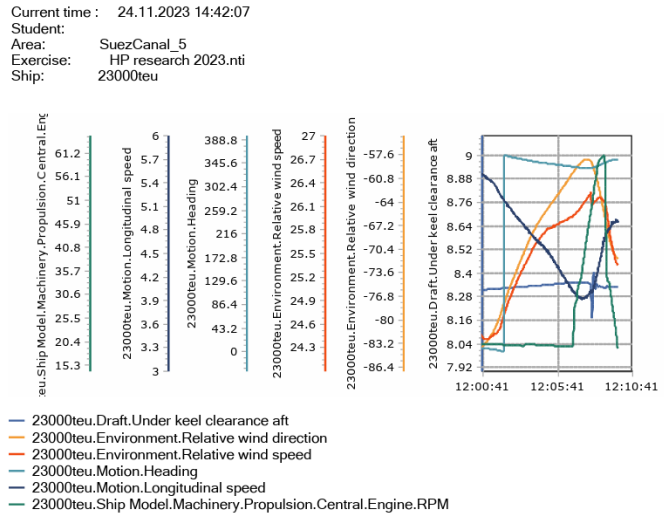


Figure 5: The above figure shows the above data in graphic description during the canal transit in exercise.

IV. Exercise 2 : Slow Ahead Engine Speed of 8.4 Knots

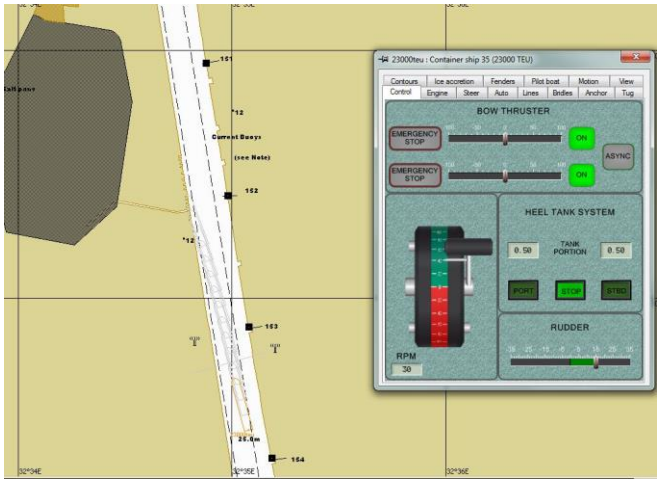


Figure 6: The above figure shows the vessel to the east of the dotted dredged line with more starboard helm needed to counteract the Port ROT. (Rate of Turn)

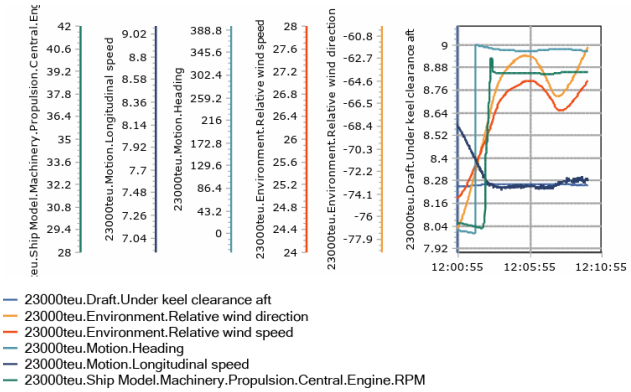


Figure 7: The above figure shows in graphic form the data in during transit in exercise 2.

V. Exercise 3 : - Half Ahead Engine Speed of 11.2 Knots

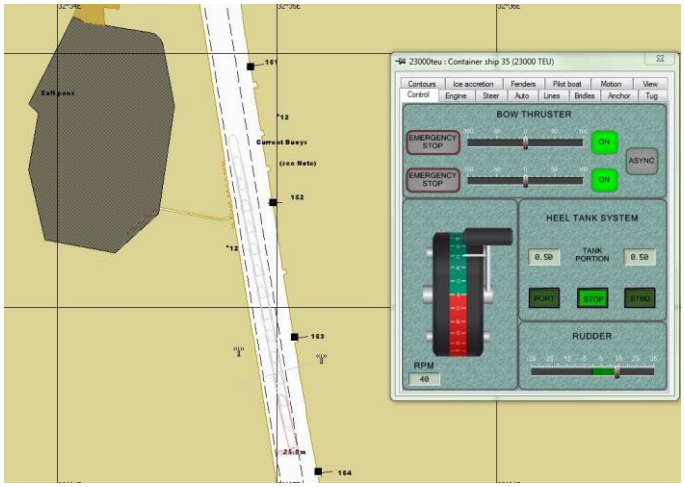


Figure 8: The above figure shows the vessel more steadier trending in the dredged area in dotted line again with Starboard rudder.

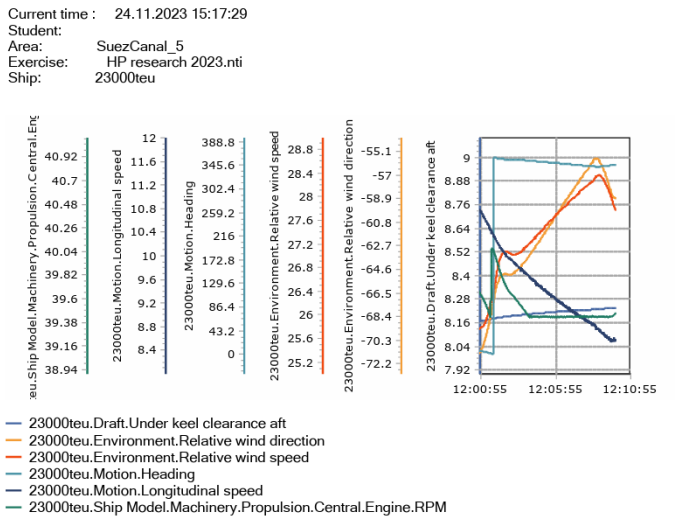


Figure 9: The above figure shows in graphic form the data in during transit in exercise 3.

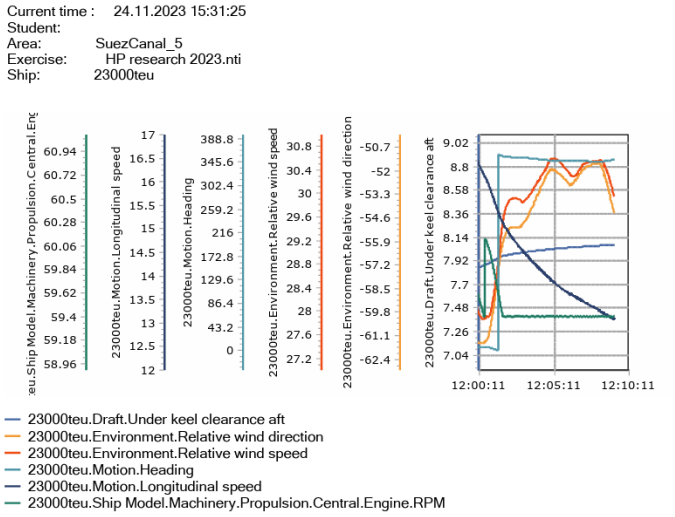


Figure 11: shows in graphic form the data in during transit in exercise 4.

VI. Exercise 4 : Full Ahead Engine Speed of 16.8 Knots

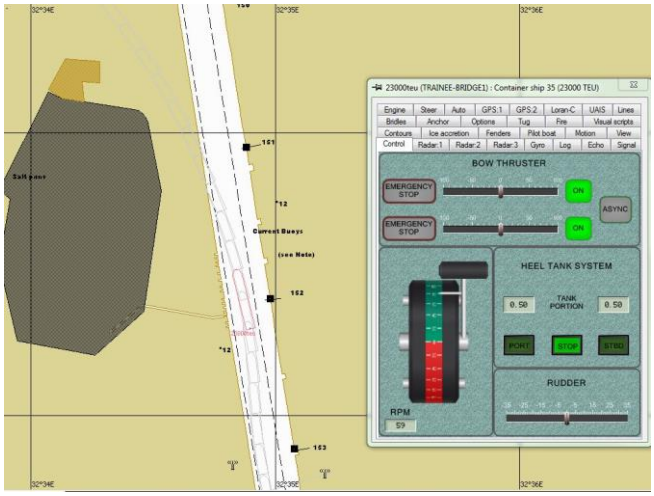


Figure10: The above figure shows the vessel proceeding within the dredged area shown by the dotted line with better steering.

VII. Exercise 5 : Navigation Full Ahead Engine Speed of 23.0 Knots

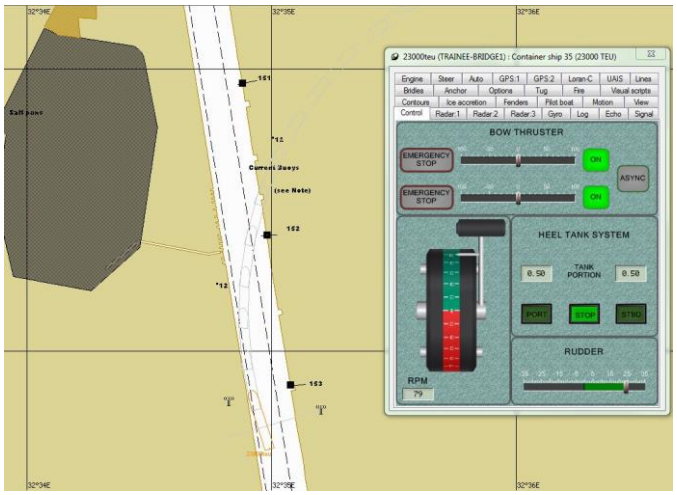


Figure 12: The above figure shows the vessel moving at Navigation Full ahead. More rudder had to be used to manoeuvre the course keeping of the vessel with Bank interaction effects more prominent.

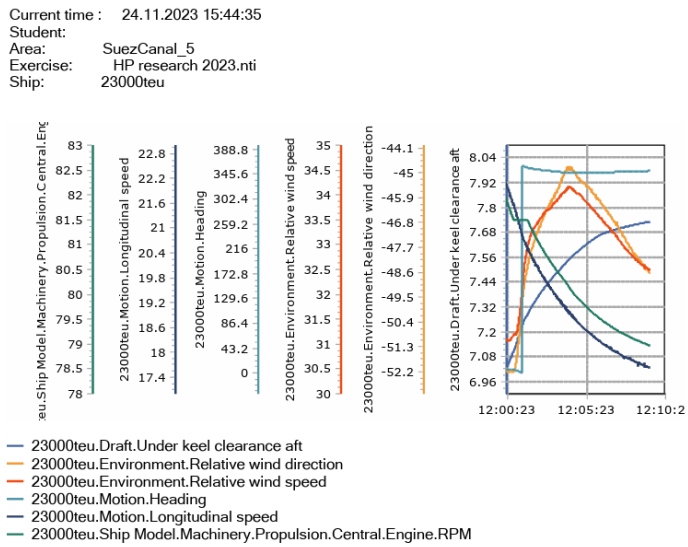


Figure 13: shows in graphic form the data in during transit in exercise 5.

VIII. Summary Analysis and Conclusion

True wind speed in knots	25	25	25	25	25
True wind direction in degrees	270	270	270	270	270
Current in Knots	0	0	0	0	0
Ship's engine speed in Knots	Dead Slow Ahead 20rpm 5.6k	Slow Ahead 30rpm 8.4k	Half Ahead 40rpm 11.2k	Full Ahead 60rpm 16.6k	Navigation Full Ahead 82rpm 21k
Average ship Speed over ground in Knots	5.0k	8.0K	9.0k	12.5k	18.0K
Course to make good over ground in degrees	350	350	350	350	350
Max. counteract angle in degrees	2	3	3	4	5
Finding: transit manoeuvre	GR	VD	G	G	D

G = Good D= Difficult VD= Very Difficult

GR= Grounded

Figure 14: shows the concluding test results analysis table

The ship was loaded to the maximum on deck with containers as well, be it loaded or emptied. This made it very difficult to manoeuvre the ship in the center of the canal during the transit always drifting closer to the leeward canal bank. To counteract and make good the course the vessel had to be steered allowing for the set and drift.

The counteract drift angle had to be limited to 5 degrees with a view to keep the 399.9-meter Suez maximum vessel within the deeper dredged dotted line in the chart (figure 5) on a straight run. From the study it is apparent that transiting at DSAH (Dead Slow Ahead) engine speed and settling down to 5 Knots ground speed is not recommended as it is too dangerous to manoeuvre and the vessel grounded. At SAH (Slow Ahead) engine speed and settling down to 8 Knots ground speed was found to be a very difficult maneuver even after increasing RPM.

IX. Optimum Speed:

At FAH (Full Ahead) engine speed, settling down to 12.5 Knots due to resistance was found to be the most appropriate optimum ground speed for the canal manoeuvre in the 25-knot wind speed be from the study. Minimum Engine RPM adjustments were needed.

The SCA rules require all vessels permissible speed. in the Canal to be 16km/Hr. which equates to 8.64 Knots.

From the above research tests, it was found. that the tested vessel found it difficult to maintain maneuverability in the center of the channel in ground speed of 8.5 Knots achievable at Half Ahead Engine RPM of 40 in the wind condition of 270 Deg. x 25 Knots.

From the above research tests, it was found that the tested vessel's optimum longitudinal ground speed was. 12.5 Knots in the given wind conditions. This could be achieved with a Full Ahead Engine speed of 16.6 Knots at 60 RPM. When considering this optimum speed, the wind speed and direction, resistance, interaction, squat, and Bank effects were taken into consideration. The vessel had a static UKC of 8.5 meters. in all exercises.

Note:
The tests were carried out in five different wind directions namely North, Northwest, west, southwest, and south. It was observed that the maximum set & drift and the difficulty in maintaining maneuverability.in the channel was when the wind direction was from the beam direction namely 270 deg., Hence the reasonfor this final research tests to be done at wind condition 270 deg and 25 Knots.

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Abbreviations:

- DSAH: Dead Slow Ahead
- SAH: Slow Ahead
- HAH: Half Ahead
- FAH: Full Ahead
- TEU: Twenty-foot equivalent units
- SCA: Suez Canal Authority
- RPM: Revolutions per minute

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References

[1]
Perera .H, Disanayaka S.M, Sedrick P, Widyalankara R, Dantanarayana N, Karunasena C.
Simulator study to determine the wind speed limitation in the Suez Canal for an Ultra Large Container Vessel.
European Journal of Science, Innovation & Technology 2023 Volume 3.

[2]
Baric M, Mohovic R, Mohovic D. Pavic V.
The simulation of sloped bank effect influence on Containership trajectory.
Journal of Marine Science and Engineering 2021.

[3]
Longden, Alex.
Were bad weather conditions to blame for the grounding of the Ever Given?
Meteorological Technology International

https://www.meteorologicaltechnologyinternational.com/features/were-bad-weather-conditions-to-blame-for-the-grounding-of-the-ever-given.html

[4]
Popov A.N., Zelenkov G.S., Papulov D.S.
Reconstruction of various navigational scenarios of the Ever Given ship including grounding in the Suez canal using the Bridge Simulator with upto Date electronic navigation charts.
Journal of Physics volume 2061.