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Simulator Study to Determine the Wind Speed Limitation in the Suez Canal for an Ultra Large Container Vessel

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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. But the bigger capacity of 24,000 + TEU *Ever Ace* is also a Suezmax. Where is the limitation, one would ask, and where does it stop? The maximum ship length for the canal is 400 meters. Therefore, the increased container capacity is by way of additional breadth, height, and depth. But the broader, higher windage, and deeper she is, the handling becomes more challenging to the pilots & ship handlers and more accident prone. Therefore, the weather limitations and cutoff points must be more stringent for this maximum size of ships than for smaller ships.

In this context, it is noteworthy to mention that in 1977 the 3,043 TEU being the world's largest container vessel *Tokyo Bay* lost control and ran aground during the transit near the 156 km mark in the canal due to steering difficulties in strong winds. After this incident, the ship owner made recommendations to not transit the canal when wind speeds exceed 20-25 knots.

Keywords: *Ever Given*, Suez Canal, Simulator, ULCC wind limit

Introduction

We saw how the world economy slowed down from the "*Ever Given*" canal blockage. But the authorities have allowed larger capacity ships like the "*Ever Ace*" to transit the canal. Hence it is necessary to look at safety aspects and risk assessments, to avoid a repeat of the canal block.

Large ships due to being more accident-prone need restrictions on wind speed and direction, and cut-offs especially in the Suez Canal as seen by the "*Ever Given*" grounding in 2021. This has not been clearly defined in the canal authority rules and is left for the master and the pilots to decide. Many questions have been raised about this grounding in several forums about wind speed & direction, ship speed, windage area, bank effect, squat, interaction, leeway and even the ship's rudder size.

In these three exercises, we look at the wind speed and direction tests on steering an ultra-large 24,000 TEU container (ULCC) ship model to determine safe navigation limits in the Suez Canal utilizing the CINEC Wartsila Transas 5000 Bridge Simulator in the "*Ever Given*" grounding.

Methodology

The selected ship model 35, a Suezmax ultra-large container carrier (*MSC Gulsun*) was tested between the 149 and 156 KM posts in the CINEC Wartsila Transas 5000 full mission Bridge Simulator with true wind speeds of 25, 30, and 35 knots in true wind directions of 315°(T), 270°(T) & 225°(T) totaling 9 tests, as shown in Table 2. Out of this, the 3 exercises displayed below were the 270^0 beam wind tests which were found to have the most athwartship drift. The vessel's navigation was conducted by an experienced pilot/ship handler and steered by a competent helmsman included in the bridge team.

It will be noteworthy to mention that many years ago the Suez Canal was transited where the pilot was accompanied by a helmsman as well as has been done in the Kiel canal transit.

Below the ship model, 35 is larger compared to the ship *Ever Given* which blocked the canal in 2019.

Figure 1: Ship model 35

Table 1 below compares the ship model used by *MSC Gulsun* and the *Ever Given* which blocked the canal in way of dimensions and tonnages. It is noteworthy that both ships were called Suez Max meaning the maximum size for the canal although the *MSC Gulsun* is broader and deeper.

Table 1: Comparison of the ship model and *Ever Given*

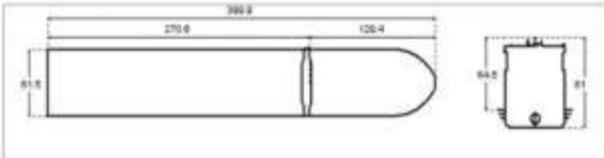
Ship model used	***MSC Gulsun***	***Ever Given***
Length overall (metres)	399.9	399.9
Breadth extreme (metres)	61.5	58.8
Draft (metres)	16.53	16.00
Capacity (TEU)	23756	20124
Displacement (metric tonne)	292886	265876
Engine output (kilo watt)	66650	59300
Rudder type	Balanced	Balanced
Approximate windage area (400x60-20%) (square metres)	19,200	19,200

PILOT CARD

Ship name	Container ship 35 (23000 TEU) 1.6.2.0 *			Date	15.04.2020
IMO Number	9839430	Call Sign	3FTV6	Year built	2019
Load Condition	Scantling				
Displacement	292866 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	64.48 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)	2 (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	2
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			Turning circle	
Description	Full Time	Head reach	Ordered Engine: 100%, Ordered rudder: 35 degrees	
FAH to FAS	934.6 s	22.23 cbls	Advance	3.28 cbls
HAH to HAS	696.6 s	9.21 cbls	Transfer	2.21 cbls
SAH to SAS	923.6 s	8.95 cbls	Tactical diameter	3.4 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 66650 kW	Propeller type	FPP
Astern power	34 % ahead	Min. RPM	16
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"	16.8	25344	60	0.98
"HAH"	11.2	8058	40	0.98
"SAH"	8.4	3646	30	0.98
"DSAH"	5.6	1254	20	0.98
"DSAS"	-3.9	1352	-20	0.98
"SAS"	-5.8	3907	-30	0.98
"HAS"	-7.7	8608	-40	0.98
"FAS"	-10.8	22661	-56	0.98

Figure 2: The ship's pilot card

This 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 of information and familiarization. This vessel had two pilots employed by the Suez Canal authority for the transit.

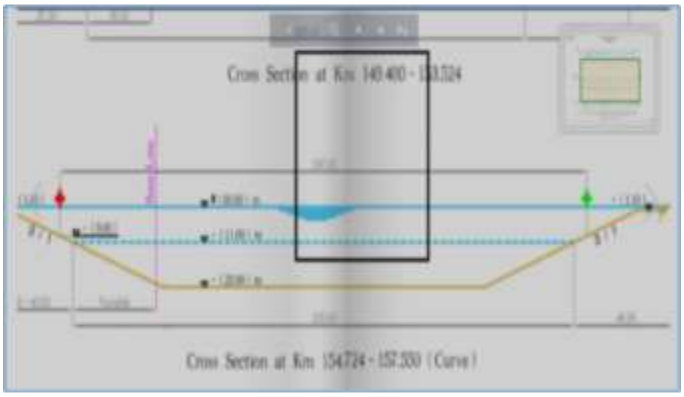


Figure 3: Cross-section of the canal with the vessel superimposed (Not to scale)

Exercise 1. The objective was to keep the ship within the dotted line in the chart which is the 25-meter baseline as per Figure 4. True wind direction is 270 T x 25 knots. The ship's heading is 350 degrees, engine half ahead (HAH) draft is 16.53 meters even keel. To maintain this course, engines and rudder were used. The bow thruster was not used. The ship maintained an average speed of 9 knots as required by the canal authority.

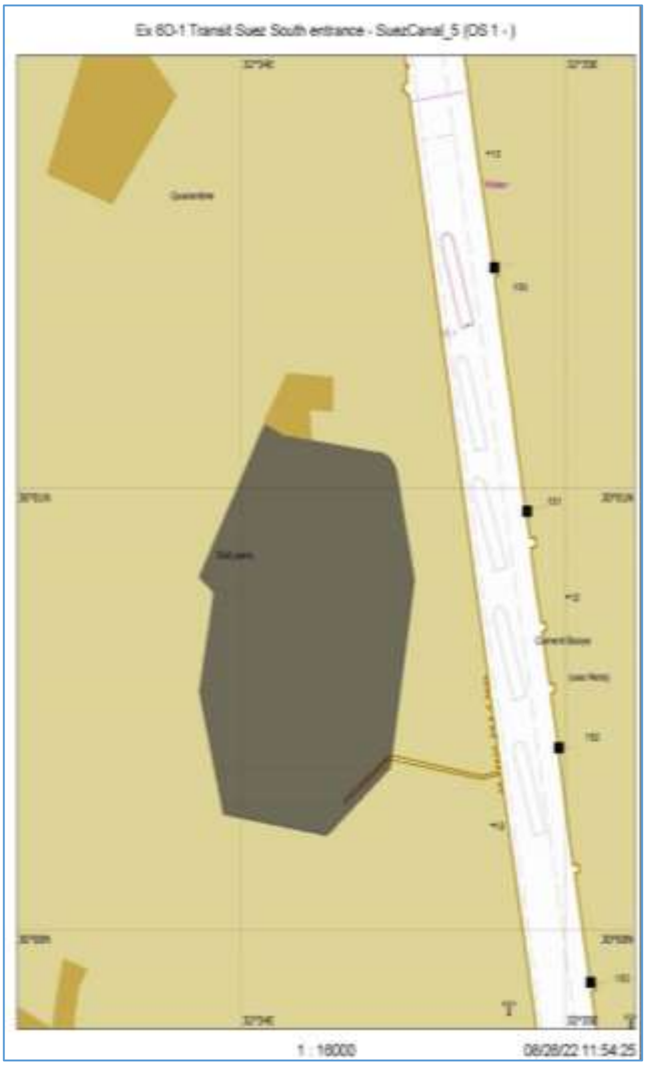


Figure 4: The vessel's track shown at 2-minute intervals at 25 knots wind in exercise 1

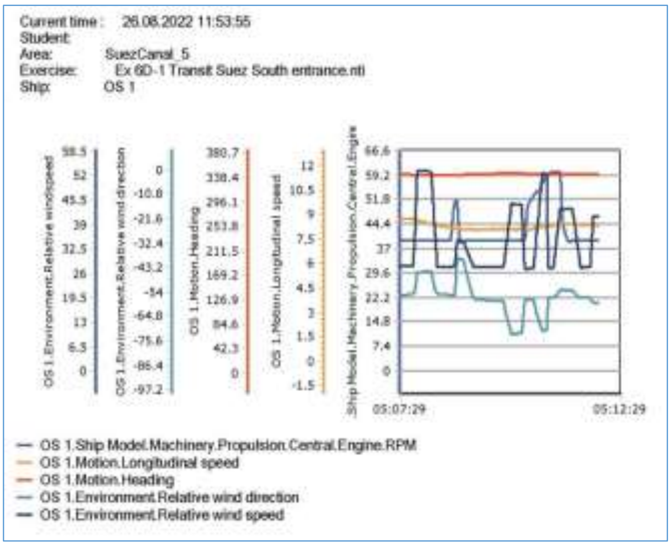


Figure 5: The graphic display of engine RPM, ship speed, ship heading, relative wind direction & speed in exercise 1

Exercise 1 Result

The ship handler managed to keep the vessel within the 25-meter baseline within the dotted lines. Increased rudder and engine movements had to be used for this purpose which also increased the relative wind speed to around 28 knots to counteract the wind drift the vessel had to be steered to the port of the course line.

Exercise 2. The objective was to keep the ship within the dotted line in the chart which is the 25-meter baseline. True wind direction is 270 T x 30 knots. The ship's heading is 351 degrees, draft is 16.53 meters even keel. To maintain this course, engines and rudder were used. The bow thruster was not used. Maintained an average speed of 9 knots.

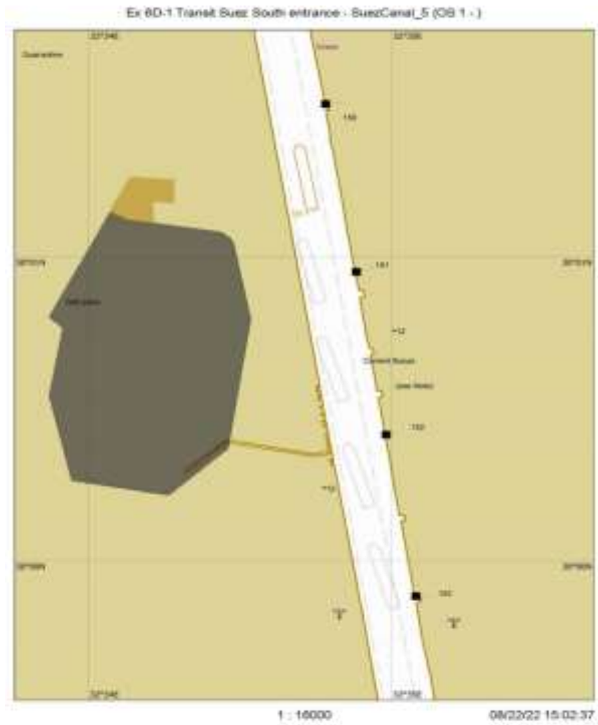


Figure 6: The vessel's track shown at 2-minute intervals at 30 knots wind in exercise 2

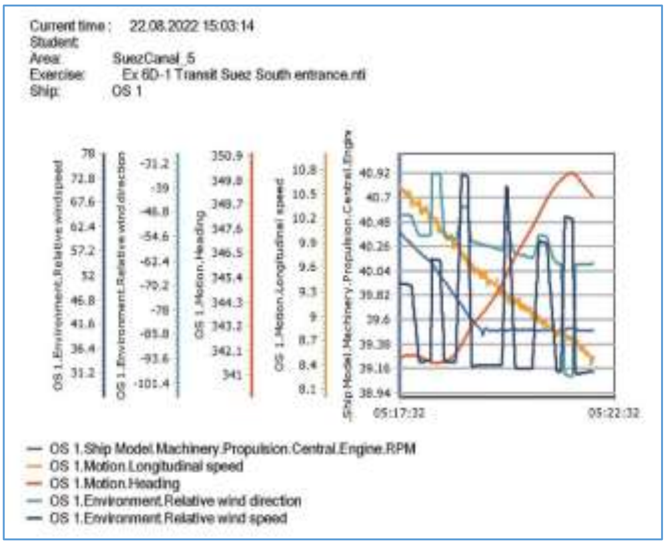


Figure 7: The graphic display of engine RPM, ship speed, ship heading, relative wind direction & speed in exercise 2

Exercise 2 Result

The vessel needed to be steered to keep very close to the dotted line on the port bow. The ship handler managed to keep the vessel within the 25-meter baseline within the dotted lines. Increased rudder and engine movements had to be used for this purpose which also increased the relative wind speed to around 28 knots.

Exercise 3. The objective was to keep the ship within the dotted line in the chart which is the 25-meter baseline. True wind direction is 270 T x 35 knots. Draft is 16.53 meters even keel. To maintain this course, engines and rudder were used. The bow thruster was not used. Maintained an average speed of 9 knots.

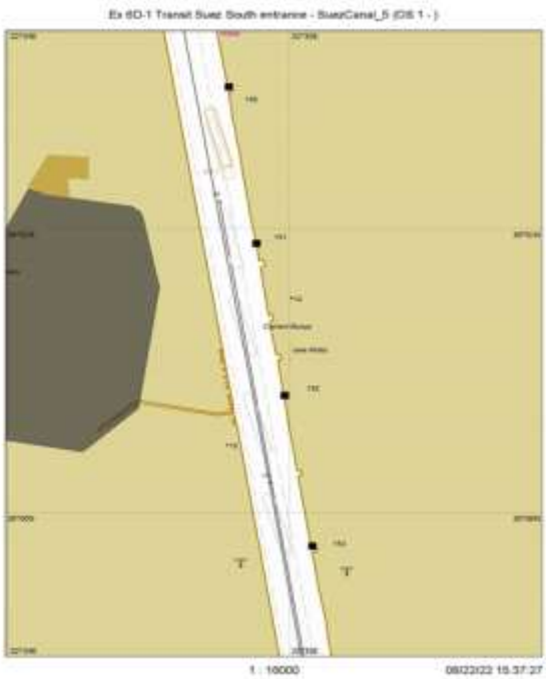


Figure 8: The vessel's track shown at 2-minute intervals at 35 knots wind in exercise 3

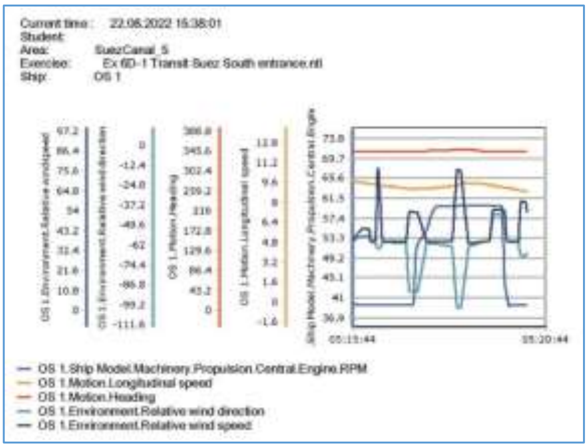


Figure 9: The graphic display of engine RPM, ship speed, ship heading, relative wind direction & speed in exercise 3

Exercise 3 Result

It was necessary to steer 345 degrees to make good 350 degrees. At a speed of 9 knots, there was over 1 knot of sideways athwartship bodily drift.

The vessel's starboard quarter came in touch with the shallows and grounded (Figure 9).

Summary Analysis and Conclusion

Table 2: Results summary

True wind speed in knots	25	25	25	30	30	30	35	35	35
True wind direction in degrees	225	270	315	225	270	315	225	270	315
Current in knots	0	0	0	0	0	0	0	0	0
Av. ship speed in knots	9	9	9	9	9	9	9	9	9
Course over ground to steer in degrees	350	350	350	350	350	350	350	350	350
Max. counteract angle in degrees	2	3	3	4	5	4	6	6	6
Finding: transit manoeuvre	G	G	G	D	VD	D	GR	GR	GR

Note: G = good; D = difficult; VD = Very difficult; GR = grounded

From Table 2, it can be seen that a total of 9 tests were done with the wind in three directions on the port side at wind speeds of 25, 30 & 35 knots. It was found that the most drift and danger of grounding occurred when the wind was abeam to the ship.

The canal had an average minimum dredged breadth (between the shown dotted lines) of approximately 154 meters near 149 km post. This means if the ship was well centred on a straight parallel heading to the canal, she will have 46 meters on either side. If she was off centred for some reason, there will be so much less margin of error. Also, if the ship was taking a bend in the canal or if the speed was slower the margin of error will be much less.

Comparatively, the breadth of the tested ship model 35 ship's breadth was 61.5 meters as against the *Ever Given* breadth of 58.8 meters. Hence, model 35 is a broader and deeper ship.

In this simulation exercise study, it was found that the safe beam true wind speed should be 25 knots at a ship's speed of 9 knots on a straight run. This could be more difficult on a bend and at a slower speed. A heading of 6 degrees was required to be steered to counteract the drift with the given windage area on this straight run. The port bows and starboard quarter distances to the dotted dredged canal were found to be 15 meters if she was well-centred. Hence it was found that this was a difficult ship-handling task given the conning position of the vessel, the starboard quarter was more likely to overshoot the dotted dredged line. A slight error of judgement or off centered will mean running aground which was apparent in exercise 3. In all three exercises, the vessel had to be steered to the port of the course line to counteract the set and drift of the westerly winds. To maintain the heading starboard helm had to be used and at times increased engine RPM as well.

During this study, the interaction effects, squat, under keel clearance, pivot point, and windage area were factors considered. Bottom and bank irregularities which can cause hydrodynamic changes were not considered.

Acknowledgements

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