DALI COLLISION

Comparison study
to investigate effectiveness of CRT type tugboat

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Preface

On March 26, 2024, about 0129 eastern daylight time, the 947-foot-long Singapore-flagged cargo vessel (containership) Dali was transiting out of Baltimore Harbor in Baltimore, Maryland, when it experienced a loss of electrical power and propulsion and struck the southern pier supporting the central truss spans of the Francis Scott Key Bridge [1].

The Dali was not guided by tugboats at the moment of approaching the bridge.
An investigation has been carried out by Novatug to see how a CRT type of tugboat could have impacted the event when connected.

The investigation is carried out using a maritime simulator that is built for navigation simulations.

Summary of incident Dali

According to the published preliminary NTSB report the Dali lost power and for some time also rudder control. The Dali collided with the bridge leading to loss of lives, extreme damage to the bridge and temporary blockage of port exit and entrance, which on its turn lead to loss of revenue, and additional cost for the logistic companies involved.

Purpose of this study is to investigate what a CRT type of tugboat could have done to prevent the collision.

The CRT type of tugboat is an abbreviation of Carrousel Rave Tug. It is a tugboat having a unique towing winch system that can rotate 360 degrees around the deckhouse. Combining it with 2 Voith Schneider Propellers suited on bow resp. stern end of the tugboat, it leads to a highly effective tugboat which is in particular suited for supplying high towline forces using the hull resistance of the tugboat, rather than using propulsion power. Particular with seagoing vessels at speed, the effectiveness is guaranteed because it is based on the use of hull resistance which gets higher with increasing speed. It can thus generate higher towline forces with increasing speed.

Simulations background

The maritime simulator used is supplied by FORCE (Denmark) and is certified according the DNV Standards for Certification No. 2.14 for Maritime Simulator Systems.
Simulations have been performed by a licensed tug captain having 20+ years of experience as tug master and 5+ years as senior training captain.

The available database of geographical areas and seagoing ships does not contain the Baltimore port, neither an exact version of the Dali.
Therefore conservative alternatives have been used (see below).

Area:
Baltimore bridge: channel is 165 metres wide for ships having draft of 12 metres or above, with bridge opening 220 metres wide.
Investigated area is the approach channel of the Botlek bridge, Rotterdam port (The Netherlands) having a bridge opening of 55 metres wide.

Vessel:
The Dali, a 947-foot-long, steel-hulled general cargo vessel (containership), was built by HD Hyundai Heavy Industries Co., Ltd. in 2015.

Dali is a Neopanamax container ship with the following dimensions:
Loa: 299.92 metres
Beam: 48.2 metres
The vessel's draft on departure was 12.15m
Displacement = 112,383 metric tons as loaded at departure.

Investigated vessel is the virtual container vessel "3726 Bronze Star" with the following characteristics:
LPP: 349.3 [m]
Breadth: 51.0 [m]
Max speed: 24.6 [kn]
Draught: 13.0 [m]
Draught, Fore: 13.00 [m]
Draught, Aft: 13.00 [m]
Displacement: 155,800 [t]

Summarized: the investigated area is more restrictive and the investigated vessel is longer, wider and heavier, making the simulation conservative.

The CRT tugboat is the "Multratug 32" with characteristics:
L.O.A.: 31.90 m
B.O.A.: 13.20 m
Max. bollard pull: 70 tons
Total power: 5300 kW
Propulsion: 2x Voith Schneider propeller (VSP) 32R5EC/250-2

Simulation

Simulation started with 1 CRT connected on the stern of the container vessel.
Vessel speed 8.7 knots and 100% propulsion power loss is simulated with rudder hard to starboard (35 degrees) to simulate the container vessel is going off course, to starboard. Once this has effect, the rudder is put back to midships.
Then after approx. 1:25 minute (85 seconds) the tugboat is starting to apply steering and braking force on the towline to steer the container vessel back on a safe course.

The result is a safe passage through the Botlek bridge, with speed decreased to 3 knots with the CRT tugboat used within its safe limits, using very little tug engine power and acceptable towline forces (max. 78.6 metric tonnes).

A video capture is available of the entire simulation which gives clear understanding of what has been done, see screenshot in figure 1 and 2.

Figure 1 Screenshot of simulation

Figure 2 Screenshot of simulation

The underlying data has been recorded and exported for further analysis for a better understanding.

In figure 3 the tracks of both the container vessel and tugboat are displayed in resp. red and blue color.

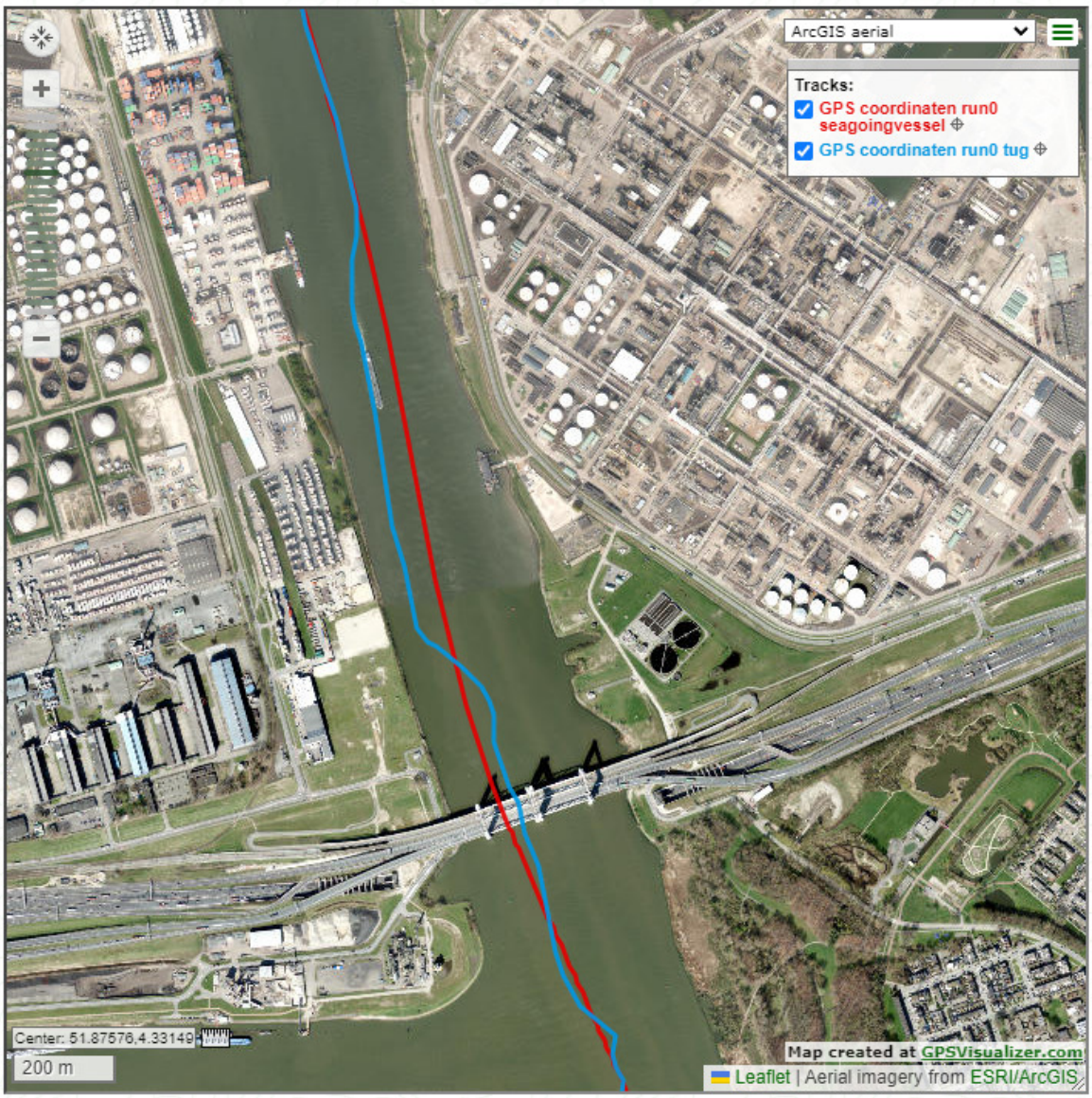

Figure 3 GPS trajectory plotted in Google Earth, starting on the north

Data analysis

The data has been exported and analyzed in MS Excel. Figure 4 shows graphical displays of the most relevant data. The container vessel data is stored under code 3726001 where the tug data is stored under code 3777001.

The first graph shows the propulsion power of the container vessel where power is lost and drops to 0.

The second graphs shows the speed of the container vessel (approx.. 8.7 knots when power was lost).

The red vertical line indicates the moment where the propulsion power of the container vessel was lost (~115 seconds) after start of simulation.
The green vertical line indicates the moment where the CRT started to apply steering force to correct the course of the container vessel (~200 seconds).
Some time gap of 1:25 minutes has been modelled between black-out and tug action to simulate delay in communication.

The third graph shows the relative angle between the container vessel and CRT. First the tug follows inline (relative angle ~0) but once action is started the tug starts to change her heading to the starboard side which increases their relative angle.
This steering is required to create a) towline force and b)required towline angle

The fourth graph shows the towline force following from the tug's action. From the green line on the tug generates towline forces with maximum value 78.6 metric tonnes.

More underlying data is available, however this reports limits itself to showing the basic information.

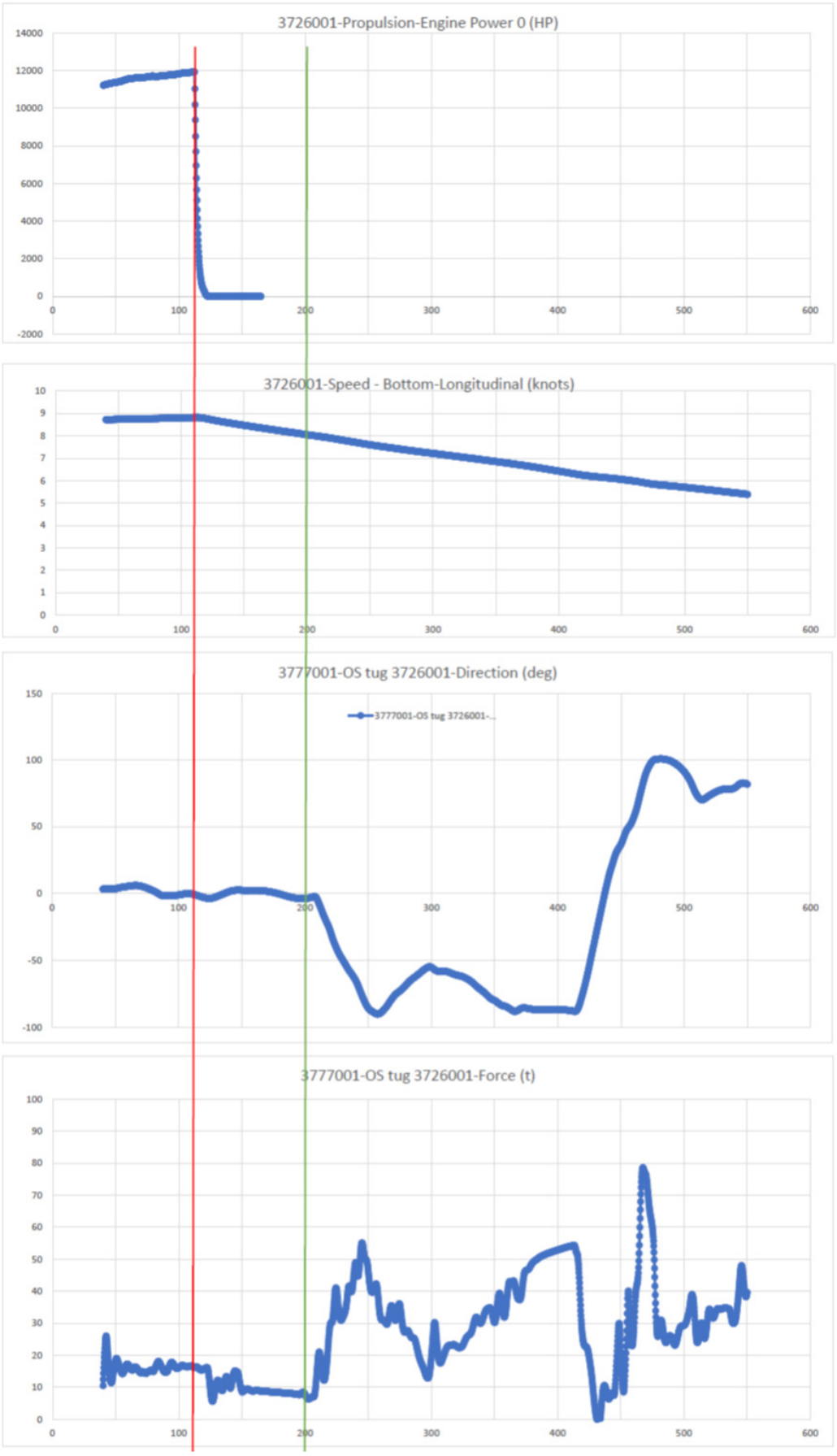

Figure 4 Graphs made from exported simulator run

It is imported to evaluate the required tug power as the CRT is able to perform the assistance with very little engine power. This shows below graph (figure 5). The tug power is limited to max 300 HP per engine, 600 HP in total.

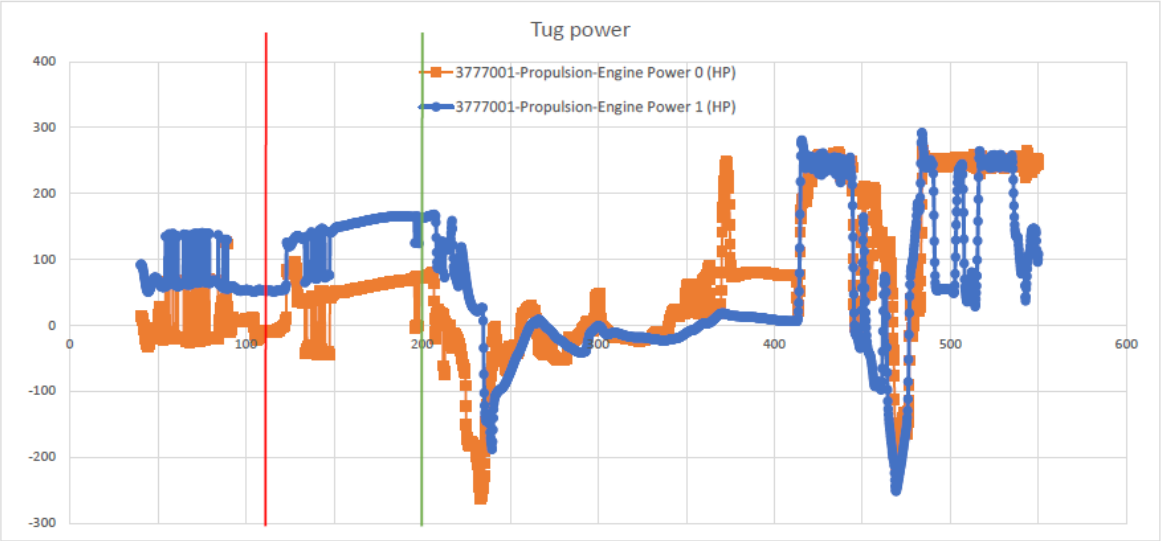

Figure 5 Graphical display of simulation

Conclusion

Simulation of the bridge passage of a bigger container vessel than Dali, in a more confined space, simulating propulsion power loss and initial rudder action to starboard, showed that the assistance of the CRT tugboat would have helped the container vessel to pass the bridge safely.

It is very likely that the CRT could have prevented the collision once it would have been connected to the stern of the Dali.

References

[1] NTSB preliminary report DCA24MM031 “Contact of Containership Dali with the Francis Scott Key Bridge and Subsequent Bridge Collapse”