

**FULL MISSION SHIPHANDLING SIMULATION (FMSS) STUDY
FOR WESTPORTS 2 EXPANSION AT WESTPORTS MALAYSIA
SDN BHD, PULAU INDAH, PORT KLANG,
SELANGOR DARUL EHSAN**

FINAL FMSS REPORT

KASI Document Ref. No.: FMSS – 36.MC04.19.WSB – Final

Date: 3rd October 2019

Project Proponent



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Full Mission Shiphandling Simulation (FMSS) Study for Westports 2 Expansion at Westports Malaysia Sdn Bhd, Pulau Indah, Port Klang, Selangor Darul Ehsan

Final FMSS Report

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DOCUMENT CONTROL SHEET

Project Title	Full Mission Shiphandling Simulation (FMSS) Study for Westports 2 Expansion at Westports Malaysia Sdn Bhd, Pulau Indah, Port Klang, Selangor Darul Ehsan
Client	Westports Malaysia Sdn Bhd P.O. Box 266, Pulau Indah, 42009 Port Klang, Malaysia.
Job Type	Full Mission Shiphandling Simulation (FMSS) Session

Document Type	Full Mission Shiphandling Simulation (FMSS) Report - Final
Document No.	FMSS – 36.MC04.19.WSB – Final
Revision No.	00
Date	3 rd October 2019

Distribution	Format of Submission	No. of Copies
Westports Malaysia Sdn Bhd	Softcopy	-

Record of Issue

STATUS	REV	PREPARED	REVIEWED	APPROVED	DATE	REMARKS
Draft Final	00	TSL	ZZ	BN	27.09.19	First Issue
Final	00	TSL	ZZ	BN	03.10.19	Amended as per comments from Client dated 1 st October 2019

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ABBREVIATIONS

3D	Three Dimensional
KASI	KASI (Malaysia) Sdn Bhd
km	Kilometres
LOA	Length Overall
LPK	Lembaga Pelabuhan Klang
m	Metre
SOP	Standard Operating Procedure

EXECUTIVE SUMMARY

KASI (Malaysia) Sdn Bhd (hereinafter referred to as “KASI”) has been appointed by Westports Malaysia Sdn Bhd (hereinafter referred to as “Westports”) to conduct a Full Mission Shiphandling Simulation (FMSS) study for the Westports 2 expansion.

The Westports 2 Expansion consists of an additional 4,800m of wharf length, creating a total of eight (8) new berths. It starts from the final berth on the south-western end, CT9. There are four (4) berths in the same berth line (030° / 210°) as the previous berths and thereafter four (4) more berths on a southerly alignment (178° / 358°). The Westports 2 Expansion will create 4,800m of additional berth length and will cater for container vessels of up to 400m LOA.

The FMSS session was held between 17th – 20th September 2019 at KASI’s Centre for Maritime Simulation and Innovation, Kota Kinabalu, Sabah. The FMSS Committee, chaired by Captain Mazhazli Jamaludin of Westports Malaysia Sdn Bhd, consisted of members from Lembaga Pelabuhan Klang, local pilots and KASI.

The FMSS found that:

- The 2nd green buoy at the approach channel entrance should be repositioned to allow more sea room for arriving and departing vessels, as indicated in **Section 4.1**;
- The new dredged basin is considered sufficient for berthing / unberthing operations of the design vessels at the new berths and will not encroach into the existing navigation channel;
- The following tugboat configurations were found to be sufficient:

Vessel Size	Tugboat Configuration
400m LOA	4 x 70T BP ASD Tugboats (All Berths)
300m LOA	3 x 60T BP ASD Tugboats (All Berths)
260m LOA	3 x 50T BP ASD Tugboats (CT13 and CT14) 2 x 50T BP ASD Tugboats (Other Berths)

- There is a need to install lit beacons at the kink (knuckle) and wharf end (CT17);
- Extra caution must be exercised when manoeuvring close to the kink (knuckle) due to the shift in current direction. It is recommended that pilotage simulation familiarisation training be carried out for the new berths;
- It is critical to maintain good communication with port control, especially on the movements (inbound / outbound) of other vessels;

- For departure operations from CT17, recommend tugboats to escort the vessel until it clears the channel due to strong cross currents within the channel, in case of an emergency situation such as a vessel engine failure or tugboat failure.

The findings and conclusions from the FMSS Study validates the layout of the Westports 2 Expansion with regards to safe ship transit, approach, manoeuvring, berthing, unberthing and departure operations for the design vessels. Additionally, the marine operations to the berths will not have significant navigational impact on the existing navigation channel, subject to compliance with the recommendations listed in this study.

1.0

INTRODUCTION

Westports Malaysia Sdn Bhd (hereinafter referred to as “Westports”) intends to expand their existing container wharf by adding an additional eight (8) berths, namely CT10 to CT17. The project will be referred to as the Westports 2 Expansion.

The additional berths will start from the final berth on the south-western end, CT9. There are four (4) berths in the same berth line (030° / 210°) as the previous berths and thereafter four (4) more berths on a southerly alignment (178° / 358°). The Westports 2 Expansion will create 4,800m of additional berth length and will cater for container vessels of up to 400m LOA.

Additionally, Westports will dredge a new approach channel and manoeuvring basin for the new berths. The channel and basin will be dredged to -18m CD, matching the existing navigation channel.

KASI (Malaysia) Sdn Bhd (hereinafter referred to as “KASI”) has been appointed by Westports to conduct a Full Mission Shiphandling Simulation (FMSS) study for the Westports 2 expansion.

1.1

Study Objectives

The objectives of the FMSS were agreed upon during a kick-off meeting held between Westports and KASI on 4th September 2019 as follows:

- Assess the suitability of the dredged channel for use by the design vessels;
- Assess the suitability of the manoeuvring areas (ie. turning circles) for use by the design vessels;
- Assess towage requirements;
- Assess requirements for safety enhancement measures such as the placement of aids to navigation;
- Assess extent of time spent / level of encroachment within the existing navigation channel during berthing / unberthing operations (especially while turning);
- Identify potential navigational concerns during approach, berthing, unberthing and departure operations at the proposed new berths.

2.0 FMSS STUDY OVERVIEW

2.1 Work Activities Flowchart

KASI's execution of the FMSS study is illustrated in **Figure 1**.

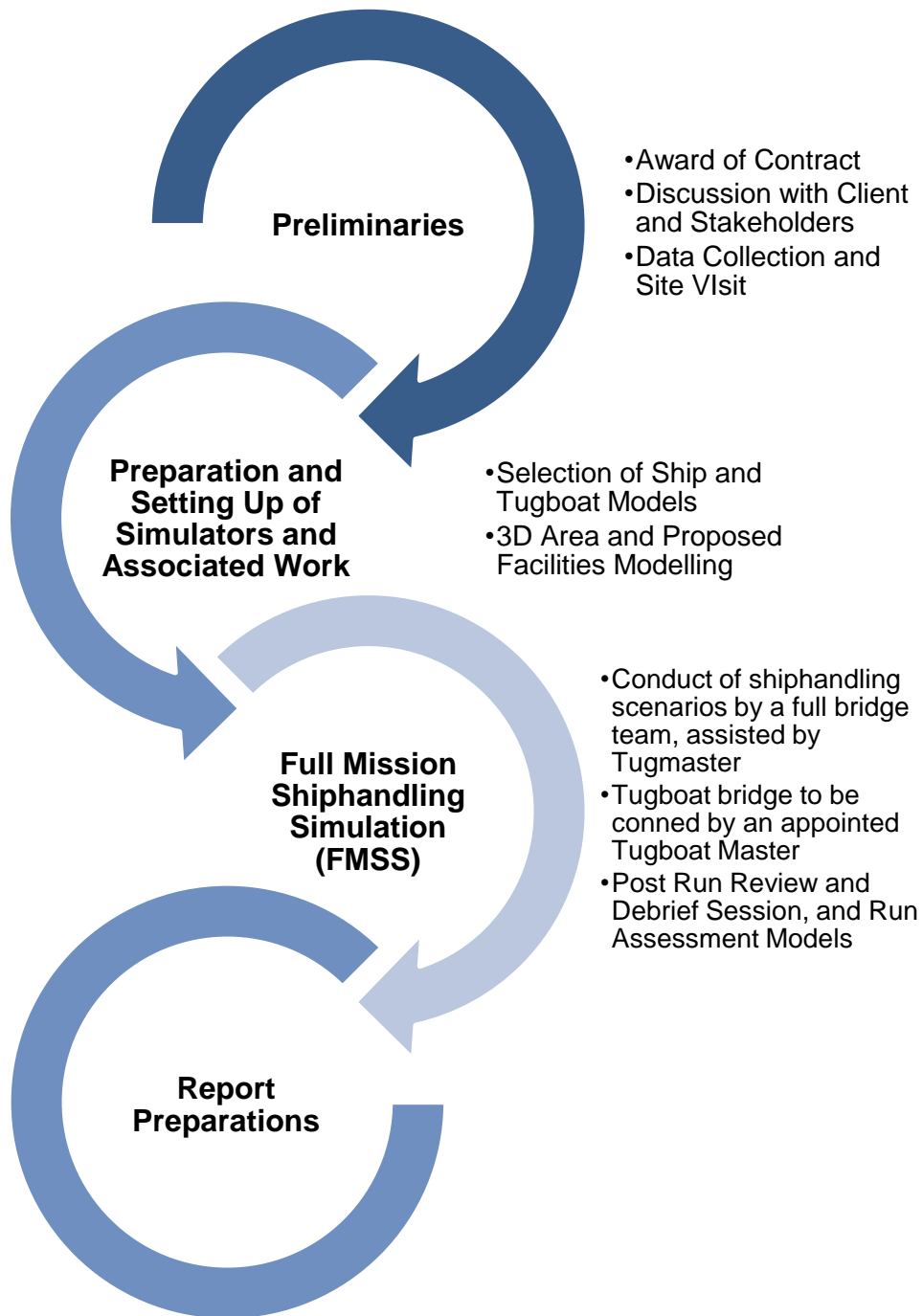


Figure 1: Work Activities Flow Chart

2.2

Data Collection

Data collated includes the following:

- Environmental and bathymetric data;
- Port layout and jetty plan (also elevation) in CAD format from the Client;
- Admiralty, up-to-date geographic and local scene data and ECDIS chart for the area.

Specific data such as geographical location, existing environmental data prevalent such as wind speed and direction, current and tidal information and port layout design details was provided to KASI by Westports.

Details focusing on the area of interest were also collated including specific data such as geographical location (e.g. visual landscape, aids to navigation, the state of coastal lines as per the latest BA chart) and existing environmental data prevalent, covering wind speed and direction, current (format Mike 21 at various levels) and local tidal information, for input into the ship handling simulator.

2.3

Requisition of Ship and Tug Models

Particulars of the design vessels were provided by Client and once the required information was established, KASI selected the ship computer mathematical models available in its library that closely approximate the design vessels and these were utilised for the navigation simulation exercises.

KASI's ship models respond realistically to the following external forces:

- a) Hydrodynamic forces due to:
 - Hull Hydrodynamics
 - Propellers with Fixed or Variable Pitch
 - Rudders of Conventional or High Lift Type
 - Lateral Bow or Stern Thrusters
 - Rotatory Thrusters
 - Squat Effect
 - Hydrostatic Restoring Forces
 - Shallow Water Effects
- b) Forces due to environment or site:
 - Dynamic Currents or Shear Currents
 - Dynamic Winds and Waves
 - Windage Effects
 - Channel Effects
 - Bank Proximity
 - Ship-to-Ship and Ship-to-Tug Interaction
- c) Mechanical Control Forces:
 - Tugs
 - Anchors
 - Hawsers and Winches
 - Deliberate Heel and Trim

2.4 **3D Area Modelling of the Westports 2 Expansion and Surrounding Facilities**

The collected data formed the basis for the creation of detailed hydrodynamic three dimensional (3D) simulation computer mathematical model of the Westports 2 Expansion, including the berths layout, approach channel, manoeuvring basin and area bathymetry using Model Wizard.

Model Wizard is software specifically designed for the marine industry to create the scenario of a project site on the 3D Database. This includes the components of seabed and landscape, Electronic Navigation Chart, radar database, 3D visual models and current profiles.

2.5 **Navigation Simulation Runs on Approach, Berthing, Unberthing and Departure**

After the area model was set up, a series of real-time ship handling simulation runs were carried out using model ships. Run designs were based on agreed scenarios best suited to give the desired result stated in the scope of work. KASI's in-house NTPRO 5.40 full mission shiphandling simulators would be used for the simulation study.

Shiphandling simulation runs were conducted under accurate and realistic environments to model the behaviour of design ships under baseline and given met-ocean conditions. The runs covered the following:

- Approach Runs
- Berthing Runs
- Unberthing Runs
- Night Operations
- Emergency Runs

A number of simulation runs of various scenarios were carried out in the program. These were discussed in detail with the client and a run "matrix" was produced. The runs started either from the pilot boarding station or at a point closer to the berth (for arrival runs) or from a berth of the jetty (for departure runs). Passing traffic, adverse weather and visibility restrictions were also incorporated to some of the runs to simulate realistic conditions at Westports.

The numbers, sequence and scenarios for each of the simulation runs were jointly decided by the client and KASI. Some of the runs ended when the vessel was tied safely to the berth. Other simulation runs ended when the ship was positioned parallel to the berth, within 50 meters from the berths, under the tugs control.

The simulation program included scenarios when a distressed vessel is under emergency situation, including vessel engine or tug failures.

2.6 Assessment of Simulation Outcomes

Runs were reviewed by a panel comprising of ship handling and navigation experts from KASI, Westports and Lembaga Pelabuhan Klang based on level of piloting difficulty and ship controllability. Ship controllability was assessed based on the evenness of ship tracks, as shown in the run plots, extent of main engine orders and tug capacities and the pilot's assessment of the level of control of the ship experienced during the runs.

- Post-run evaluation and overall debrief was conducted after each run;
- A number of post-run reviews were conducted using the simulator's replay facility;
- Written records of the post-run outcomes, evaluations and reviews and recommended potential changes to the port / jetty layout / infrastructure were prepared and incorporated in this report.

2.7 FMSS Committee

The FMSS Committee, chaired by Captain Mazhazli Jamaludin of Westports Malaysia Sdn Bhd, consisted of members from Lembaga Pelabuhan Klang, local pilots and KASI.

A full list of the members is attached as **Appendix A**.

2.8

Simulation Program

The study focused on two general objectives, to determine the feasibility of operations and define the operational parameters of said operations.

Two (2) simulation instructors assisted the pilots during the simulation runs. Tug support and passing traffic were also simulated and controlled by the simulation instructors.

The agreed run scenarios (port layout, model ships / tugs, passing traffic and metocean conditions) were set up prior to the commencement of the runs. The bridge resources and instrumentation switched on, included twin ARPA radars, echo sounder, ECDIS, GPS, rudder angle and engine revolution indicators.

Each run started and ended from pre-determined start and end positions. During the run, conning of the ship was conducted by the pilot and the level of tug usage decided by him. If tugboat model had to change from pull to push or vice versa or if the tug had to move position in relation to the model ship, realistic time allowance was made.

During each run, simulation data was continuously recorded and included the following:-

- Elapsed time
- Ship position and heading
- Speed over ground
- Speed and rate of turn
- Rudder and engine settings
- Under keel clearance
- Tug and thrust activity
- Current and wave conditions;
- Position and heading of any target ships.

3.0 DESCRIPTION OF THE SIMULATOR, CONFIGURATION AND SET UP

3.1 Description of the Simulator

The FMSS session was conducted in KASI's dedicated Centre for Maritime Simulation (CMS) in Kota Kinabalu, Sabah. CMS is equipped with one (1) full mission shiphandling simulator and one (1) full mission tug simulator. In addition, the centre is also equipped with a desktop shiphandling simulator. KASI's simulators are ClassNK certified as fully compliant with STCW 2010 Manila Amendments (Certificate No: 16-039).

The latest version of NTPRO v5.35 simulates the effects of environmental conditions and interaction effects such as wind/wave shading, bank, squat and ship-ship interaction on a vast library of vessel types. KASI's system allows for direct integration of hydraulic data into the simulation process, giving it the added accuracy of replicating the actual fluid dynamics for the study area.

The "Seagull 6000" visualisation system, used in KASI's simulators, generates an out-of-window view that is stunningly realistic, and each bridge is equipped with controls and instrumentation to fully simulate real ship handling. Hence the behaviour of the vessel can be studied in more realistic conditions. The simulator system is certified by DNV-GL as a Class A simulator with class notation "Integrated simulator system, NAUT AW (SIM) DYNPOS-AUT (SIM), HSC, Tug, Ice' as per the new edition of the DNV-GL standard of Certification of Maritime Simulators.



Figure 2: KASI's Centre for Maritime Simulation (Left) and Main Bridge Simulator (Right)

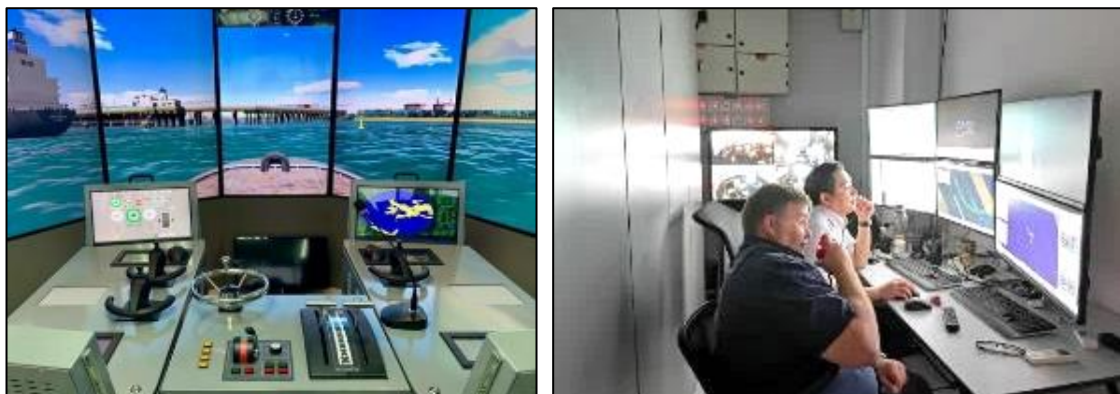


Figure 3: Tug Bridge Simulator (Left) and Instructor Station (Right)

3.2

Simulation Area Model Database of Westport 2 Expansion

The 3D simulation exercise area model for the Westports 2 Expansion includes the Westports 2 Expansion berths (CT10 to CT17), new dredged approach channel / basin as well as the existing Westports berths. A screenshot of the area model is shown in **Figure 5** below.

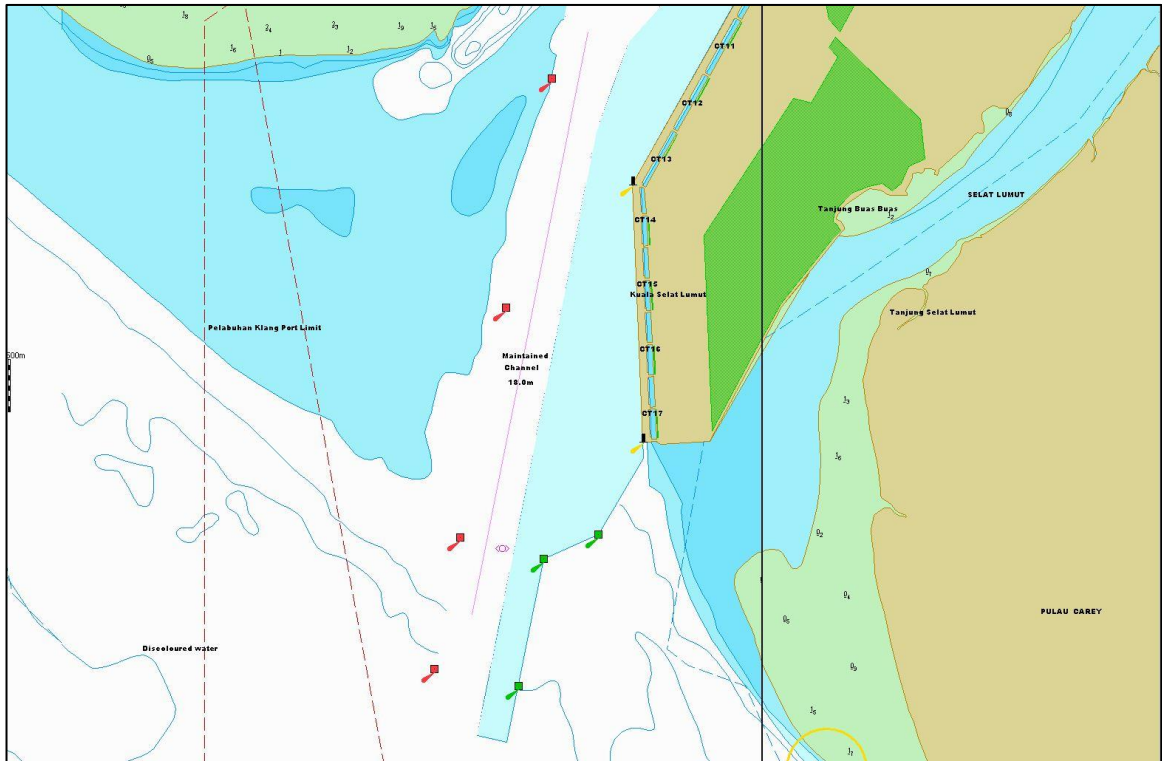


Figure 4: Screenshot of 2D Simulation Exercise Area Model of Westports 2 Expansion



Figure 5: Screenshot of 3D Simulation Exercise Area Model of Westports 2 Expansion



Figure 6: Screenshot of 3D Simulation Exercise Area Model of Berth CT17

3.3 Westports 2 Expansion Configuration

For the purpose of the FMSS study, berths CT10, CT13, CT14 and CT17 were assessed. The naming / numbering of the berths are shown in **Figure 7** below.



Figure 7: 3D Simulation Model of the Proposed Expansion

3.4 Selection of Ship Model

3.4.1 Design Vessels

KASI selected ship models for the FMSS that closely approximate the design vessels from the particulars issued by the Client. The ship models have been selected as having sizes close to the design limit for each berth, and therefore represent the worst-case scenario in respect of navigation.

The details of the ship models selected and agreed by the Client for the FMSS are detailed in **Table 2**. The tugboat models selected are as detailed in **Table 3**.

The design vessel for each of the assessed berths are shown below:

Berth Number	Design Vessel	Tugboat Sizes
CT10	Up to 400m LOA container ships	70T BP ASD Tugs
CT13	260m and 300m LOA container ships	Mixture of 50 and 60T BP ASD Tugs
CT14	260m and 300m LOA container ships	Mixture of 50 and 60T BP ASD Tugs
CT17	Up to 400m LOA container ships	70T BP ASD Tugs

Table 1: Design Vessels

Based on the specifications provided by Westports (shown in **Table 1**), the following ship models were selected from KASI's ship model library for use in simulation:



Container Ship 24



Container Ship 29



Container Ship 14

Model	Container Ship 24	Container Ship 29	Container Ship 14
Conditions	Loaded	Loaded	Loaded
LOA (m)	396	300	261.4
Beam (m)	53.6	48.2	32.25
Draft (m)	16	10.9	12.6
Propulsion	FPP	FPP	FPP
Berth No.	CT10, CT17	CT13, CT14	CT13, CT14

Table 2: Ship Models Used for Simulation Runs



50T BP ASD Tugboat



60T BP ASD Tugboat



70T BP ASD Tugboat

Model	50T BP ASD Tugboat	60T BP ASD Tugboat	70T BP ASD Tugboat
Bollard Pull	50	60	70
LOA (m)	26.1	25.3	33.1
Beam (m)	8.9	10.4	12.0
Draft (m)	3.89	4.0	4.9
Propulsion	Z-Drive	Z-Drive	Z-Drive
No. of Thruster	None	None	None

Table 3: Tug Model Used for Simulation Runs

3.5

Run Assessment Criteria

The assessment of the simulation outcomes are discussed in **Section 4.0**. A run is awarded one of three classifications: Pass, Marginal or Fail. **Table 4** below lists the criteria for the classifications.

PASS	<ul style="list-style-type: none"> • The ship remains under full control at all times • The ship stays within the dredged basin with acceptable clearances or closest point of approach (CPA) from other objects, facilities or obstacles. • For berthing manoeuvres, the ship ends the run alongside, or in such a position that lines would be ashore without appreciable difficulty, at acceptable speed, with an acceptable sway velocity (less than 0.4 knots / 0.2 ms⁻¹) and no appreciable yaw rate. • For departure manoeuvres, the ship exits smoothly, without risk of drifting onto the jetty or other ships or grounding.
MARGINAL	<ul style="list-style-type: none"> • The master considers the ship is at the limit of control. • The ship stays within the navigable part of the dredged basin and swing area, but with unacceptable clearances from other objects, facilities or obstacles. • For approach manoeuvres, the ship ends up alongside, but may have an unacceptably high approach velocity (greater than 0.4 knots / 0.2 ms⁻¹). The manoeuvres can be concluded, but minor damage or grounding may occur. • For departure manoeuvres, the ship experiences some difficulty while coming off the berth. The manoeuvre is completed with potential for minor damage only.
FAIL	<ul style="list-style-type: none"> • The master loses control of the ship. • The ship strays outside the navigable part of the dredged basin and / or grounds. • For approach manoeuvres, the ship cannot get alongside at all, or it has struck the berth or another ship with sufficient force that severe damage may have occurred, or has grounded. • For departure manoeuvres, the ship either cannot come off the berth or encounters significant difficulty in manoeuvring, such that severe damage may have occurred, or the ship grounds.

Table 4: Run Assessment Criteria

4.0

Findings and Recommendations

In line with the FMSS objectives, the FMSS findings have been categorised into the following sections:

- Dredged Channel (Approach Channel)
- Suitability of Manoeuvring Areas
- Towage Requirements
- Aids to Navigation (AtoNs)
- Potential Navigational Concerns

4.1

Dredged Channel (Approach Channel)

It is recommended that the 2nd green buoy at the approach channel entrance be repositioned to create more sea room to allow for a more gradual angle of approach (arriving vessels) and more room for vessels to pick up speed from the final berth, CT17 (departing vessels) – as shown in yellow below:

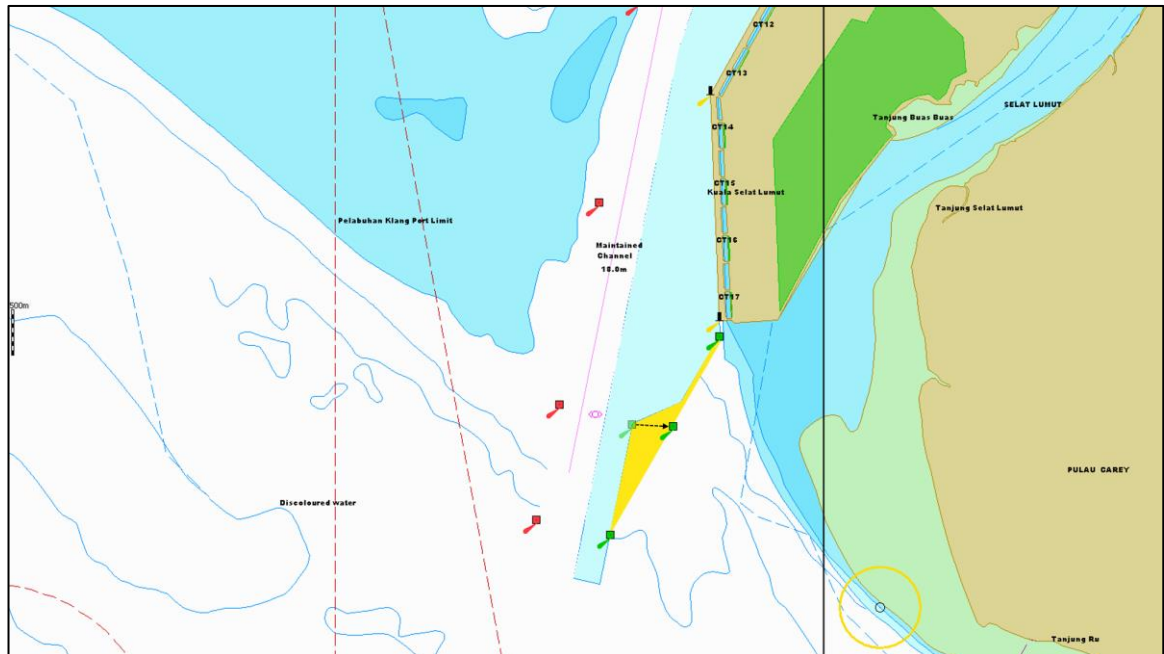
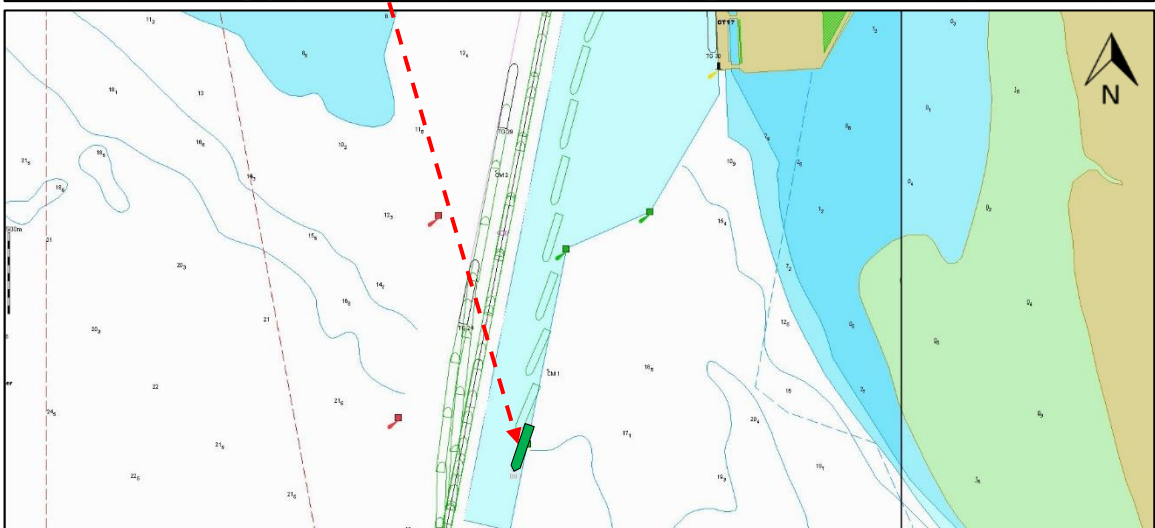
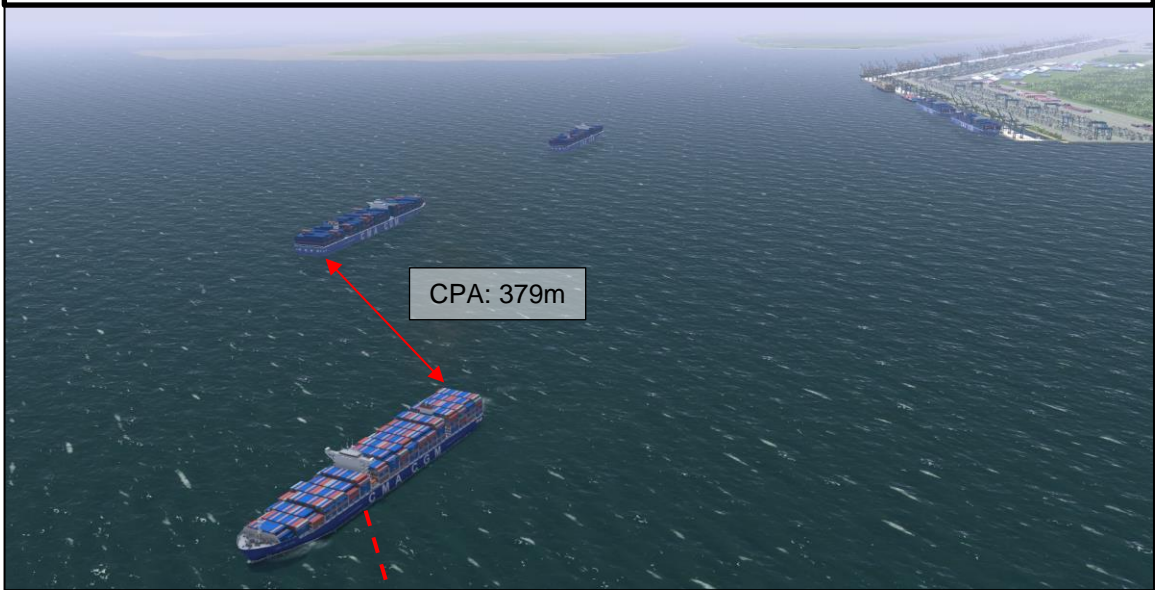


Figure 8: Shifting of 2nd Green Buoy at Approach Channel Entrance (additional sea room for manoeuvring created is highlighted in yellow)

Selected simulation runs relating to this recommendation are shown below.

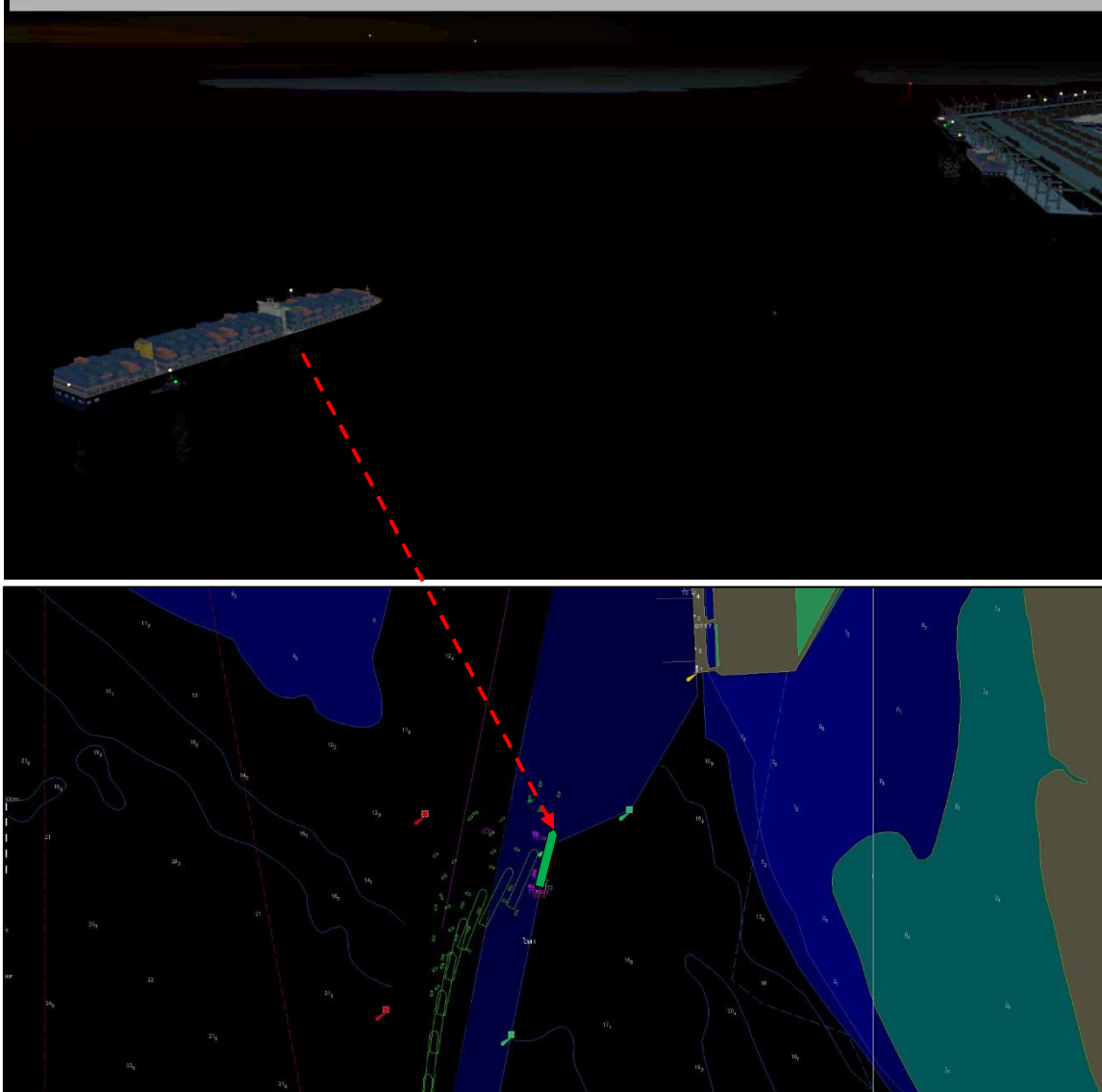
Run No.: 21	Departure from CT14 simultaneously with two (2) inbound vessels
Ship Model	Container Ship <ul style="list-style-type: none"> • LOA : 300m • Beam : 48.2m • Draft : 15.27m
Environmental Condition	Wind: 20 - 25 knots / SW, Current: Flood
Run Outcome	Vessel drifted and allided with the green buoy at the channel entrance as vessel did not manage to gain enough speed to counteract the strong cross current within the approach channel. Run rated FAIL
Recommendation	Shifting the 2 nd green buoy at the channel entrance would create more room for the departing container ship to pick up speed to counteract the cross current at the channel entrance.

Run 21 – Departure from CT14 simultaneously with two (2) incoming vessels



Run No.: 24	Approaching CT17 and berthing SST
Ship Model	Container Ship <ul style="list-style-type: none"> • LOA : 396m • Beam : 53.6m • Draft : 16m
Environmental Condition	Wind: 20 - 25 knots / SW, Current: Flood
Run Outcome	After slowing down to berth at CT17, vessel drifted and allided with the green buoy at the channel entrance. Run rated FAIL
Recommendation	Shifting the 2 nd green buoy at the channel entrance would create more room for the approaching container ship.

Run 24 – Approaching CT17



4.2

Suitability of Manoeuvring Areas

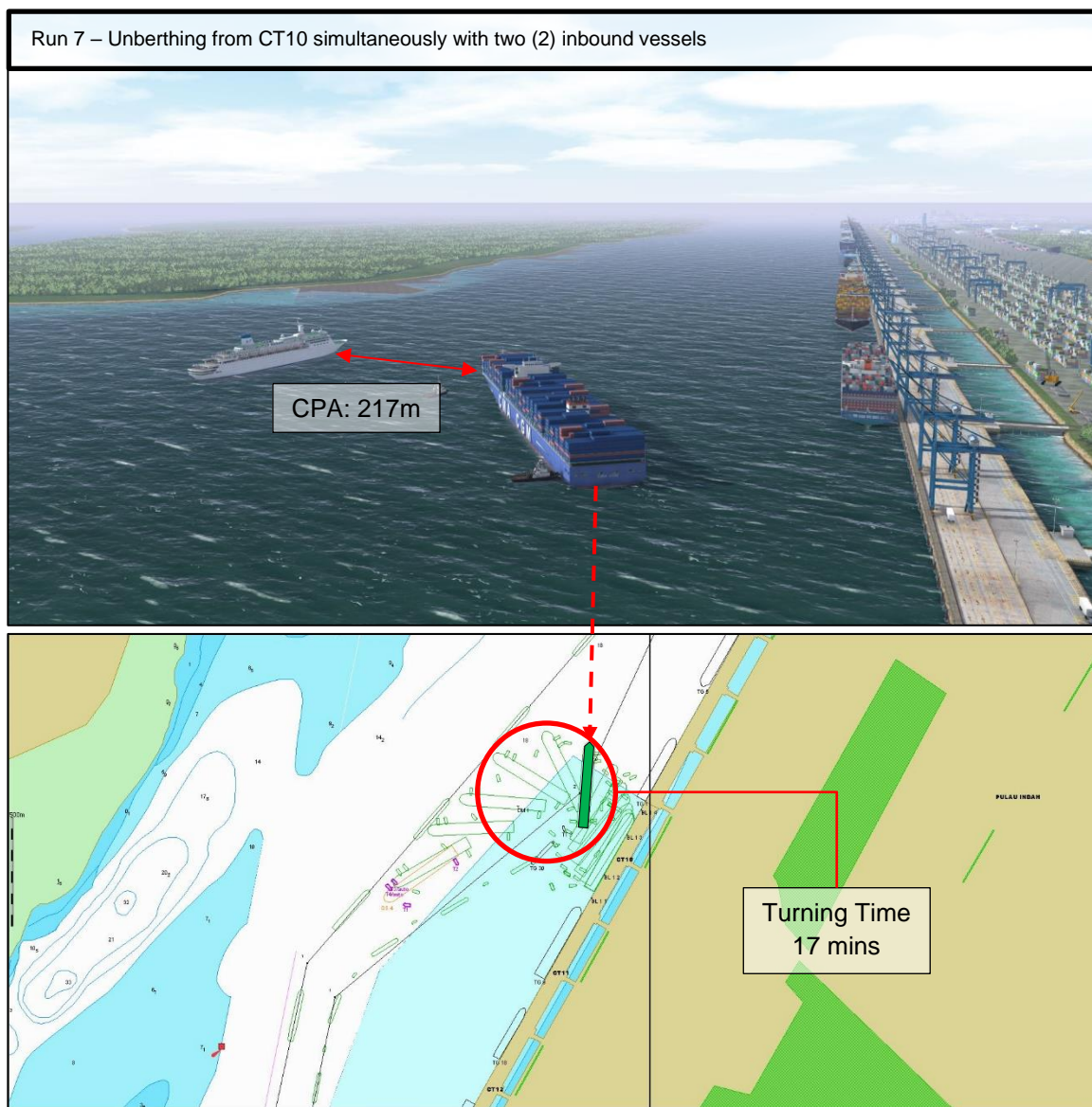
The new dredged basin is considered sufficient for berthing / unberthing operations of the design vessels. The simulation runs indicated that the approach, berthing, unberthing and departure operations of the design vessels to the new berths (CT10 – CT17) will not encroach into the existing navigation channel.

Selected simulation runs demonstrating this finding are shown below.

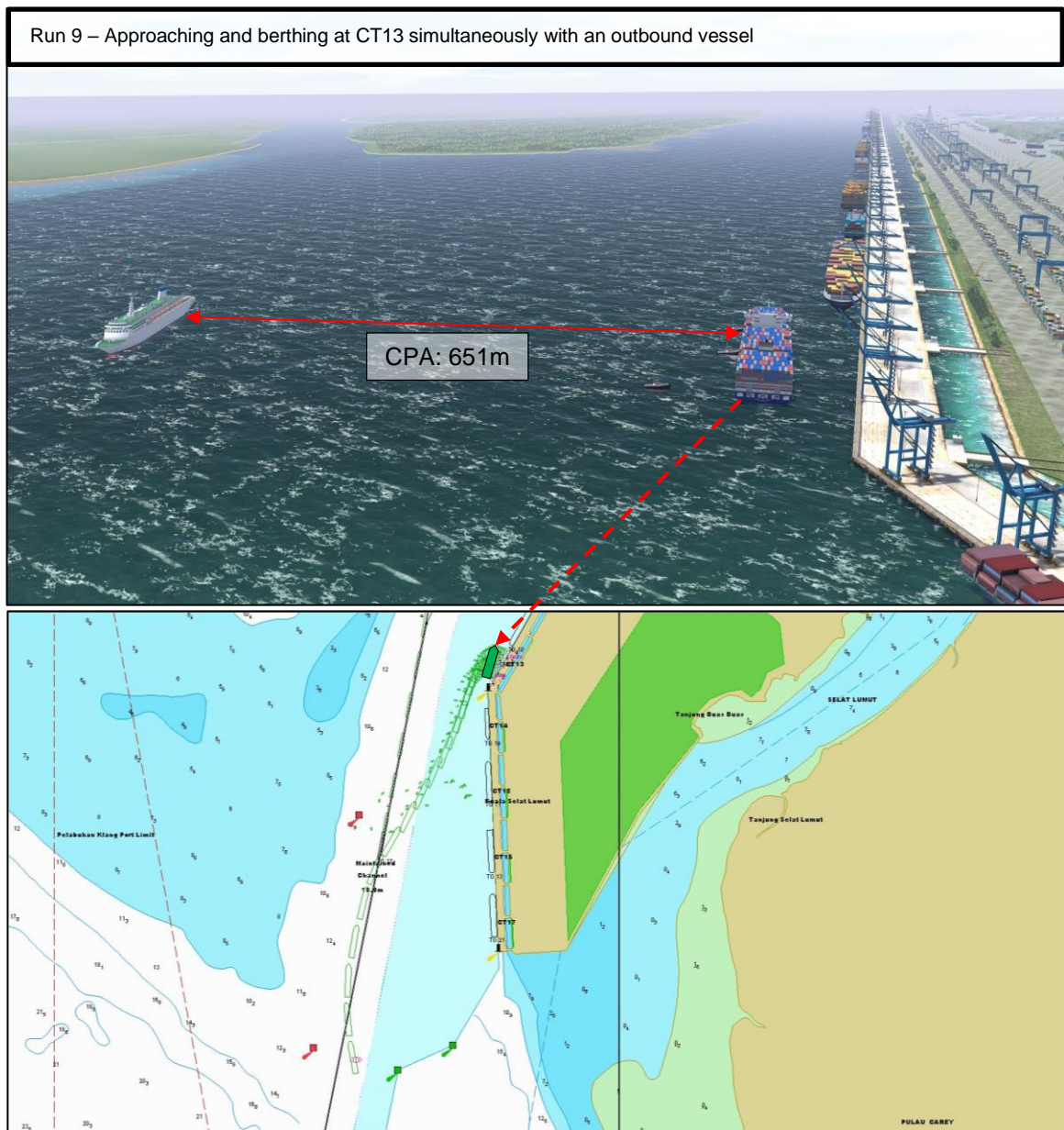
Run No.: 2	Approaching and berthing at CT10 simultaneously with an outbound vessel
Ship Model	Container Ship <ul style="list-style-type: none"> • LOA : 396m • Beam : 53.6m • Draft : 16m
Environmental Condition	Wind: 20 - 25 knots / SW, Current: Ebb
Run Outcome	Vessel successfully approached and turned toward berth CT10 whilst maintaining sufficient clearances from the outbound vessel. However, berthing speed exceeded 1 knot due to strong current. Run rated Marginal
Recommendation	Pilotage simulation familiarisation training should be conducted to familiarise pilots with the manoeuvres to the new berths and the new current profiles.



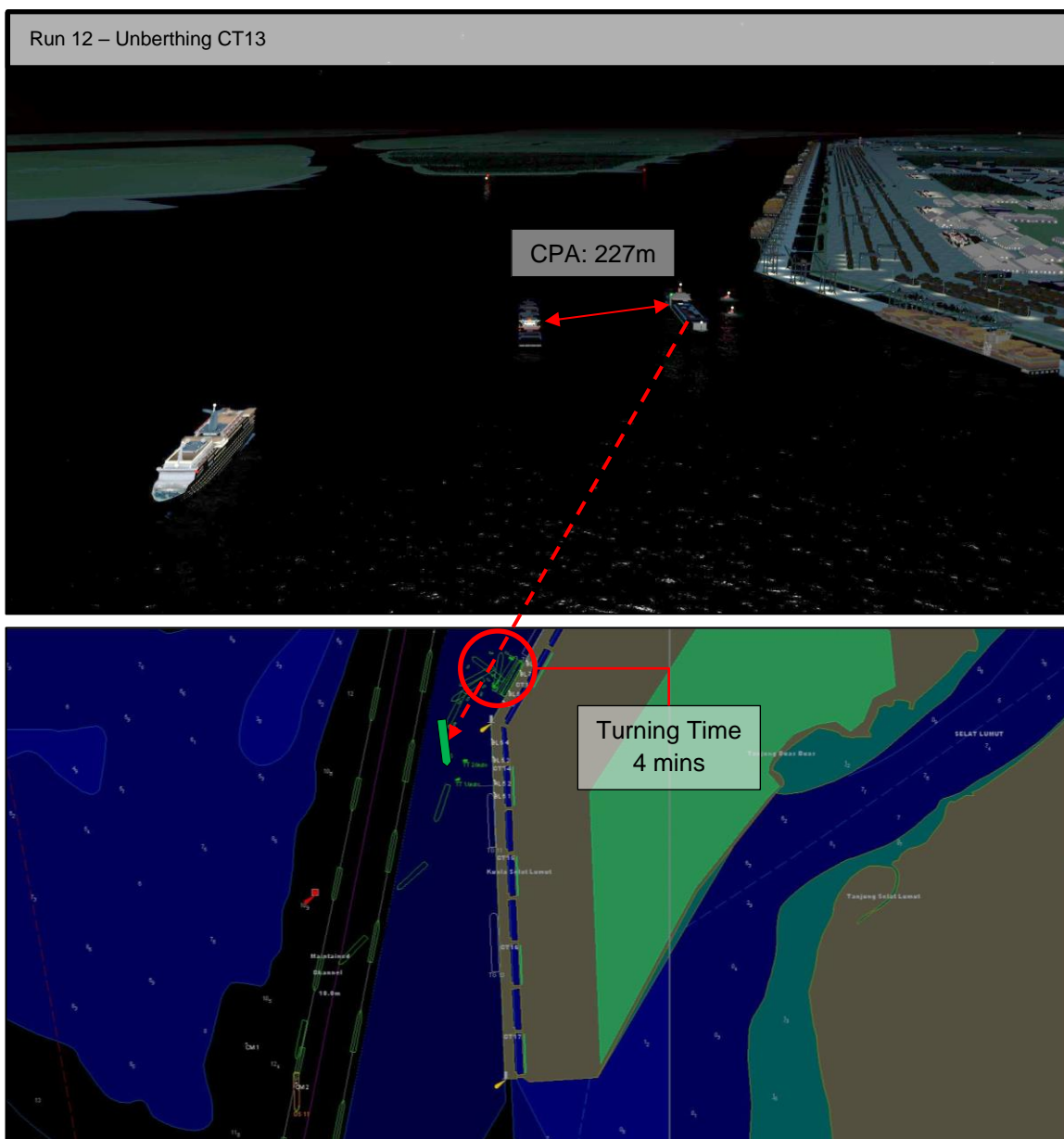
Run No.: 7	Unberthing from CT10 simultaneously with two (2) inbound vessels
Ship Model	Container Ship <ul style="list-style-type: none"> • LOA : 396m • Beam : 53.6m • Draft : 16m
Environmental Condition	Wind: 20 - 25 knots / SW, Current: Flood
Run Outcome	Ship successfully unberthed, turned and departed whilst maintaining sufficient clearances from the inbound vessels. Run rated Pass .



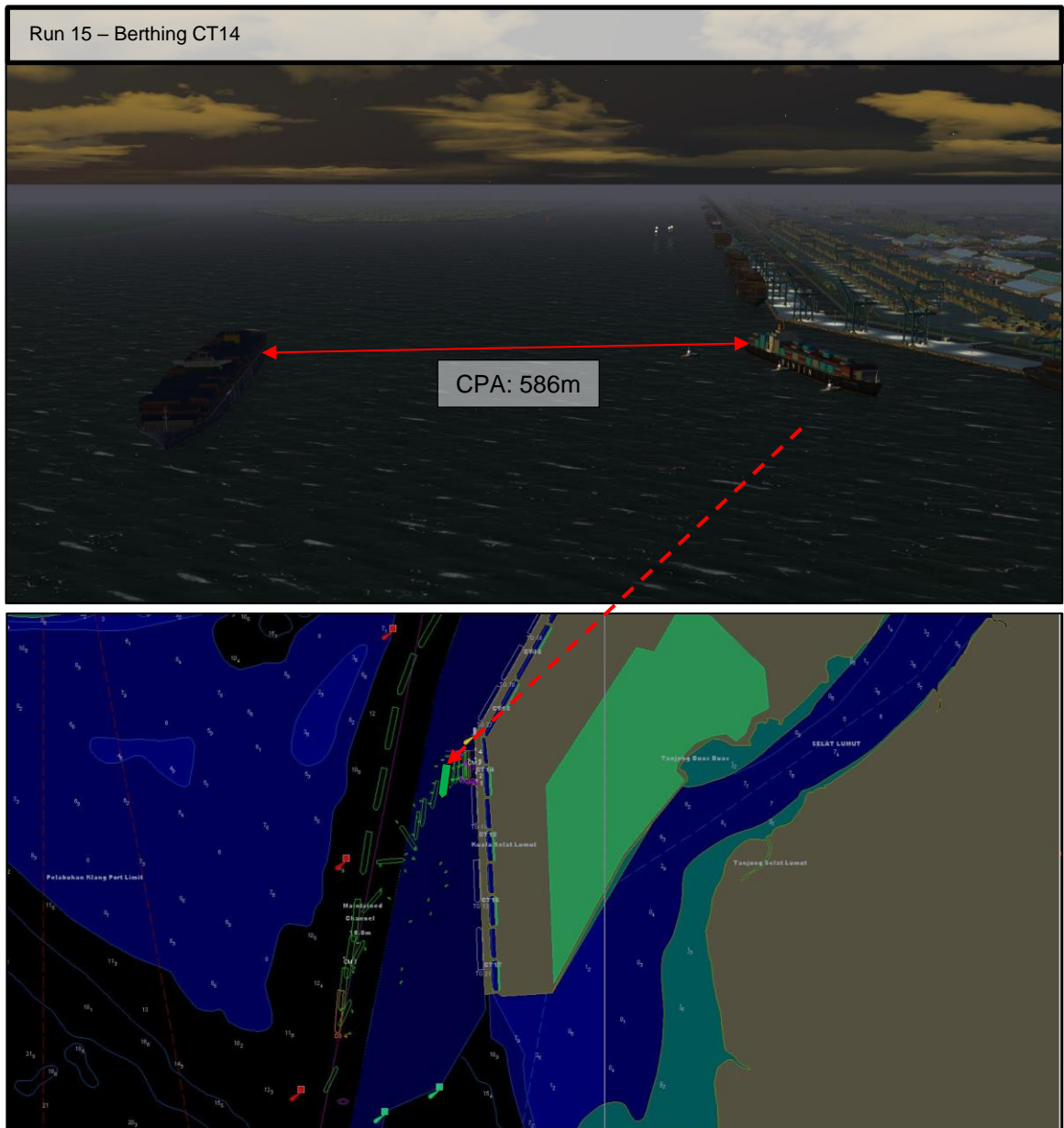
Run No.: 9	Approaching and berthing at CT13 simultaneously with an outbound vessel
Ship Model	Container Ship <ul style="list-style-type: none"> • LOA : 300m • Beam : 48.2m • Draft : 10.9m
Environmental Condition	Wind: 20 - 25 knots / SW, Current: Flood
Run Outcome	Vessel successfully approached and turned toward berth CT13 whilst maintaining sufficient clearances from the outbound vessel. Run rated Pass



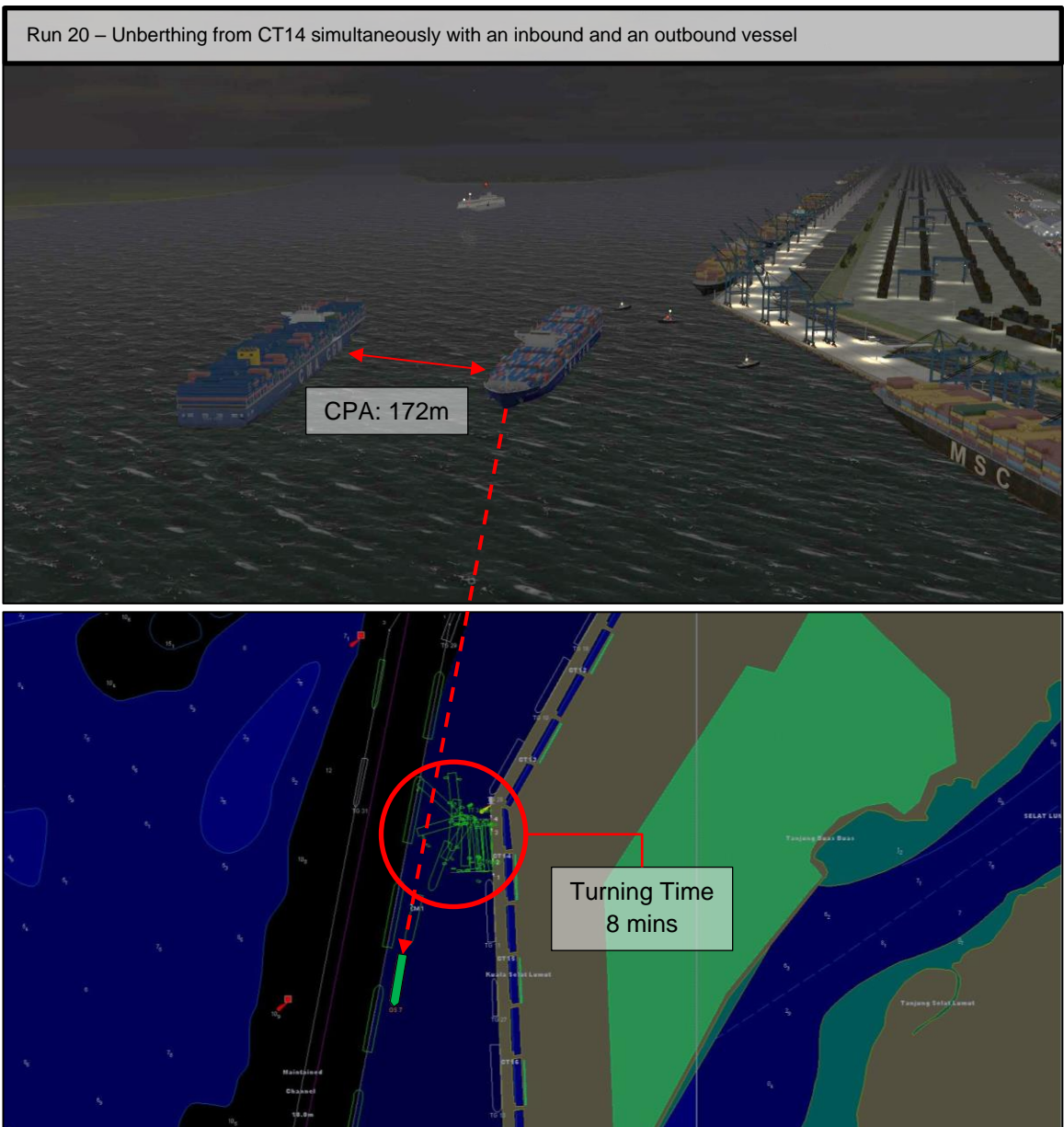
Run No.: 12	Unberthing from CT13 simultaneously with an inbound and an outbound vessel
Ship Model	Container Ship <ul style="list-style-type: none"> • LOA : 261.4m • Beam : 32.25m • Draft : 12.6m
Environmental Condition	Wind: 20 - 25 knots / SW, Current: Flood
Run Outcome	Ship successfully unberthed, turned and departed whilst maintaining sufficient clearances from the other transiting vessels. Run rated Pass



Run No.: 15	Approaching and berthing at CT14 simultaneously with an outbound vessel
Ship Model	Container Ship <ul style="list-style-type: none"> • LOA : 261.4m • Beam : 32.25m • Draft : 12.6m
Environmental Condition	Wind: 20 - 25 knots / SW, Current: Ebb
Run Outcome	Vessel successfully approached and turned toward berth CT14 whilst maintaining sufficient clearances from the outbound vessel. Run rated Pass

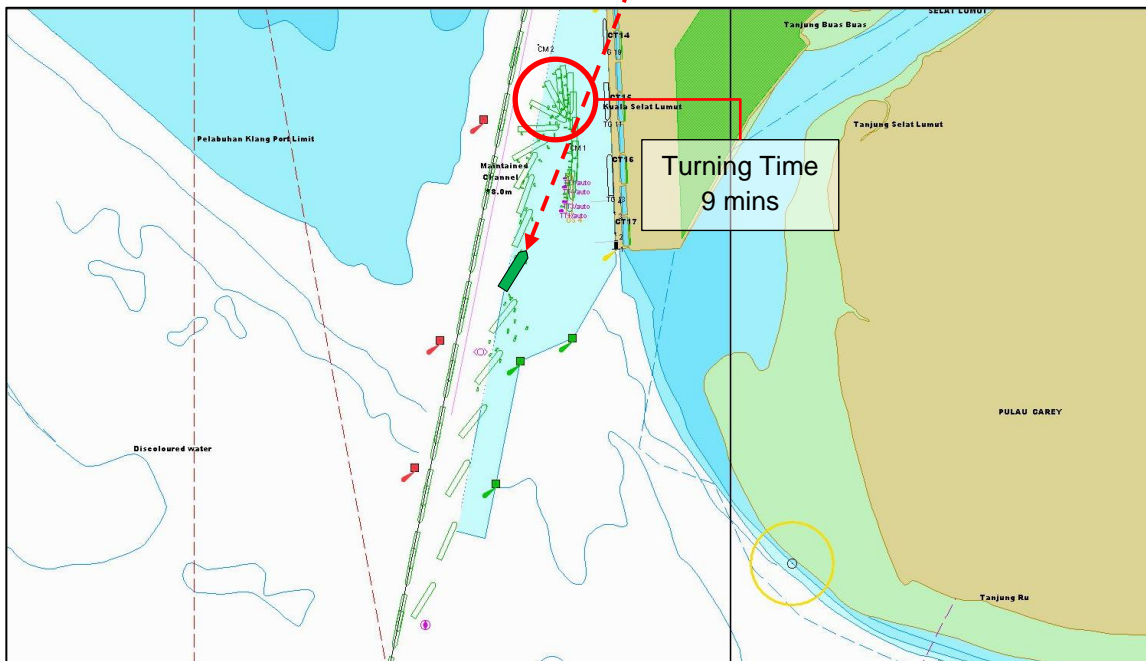
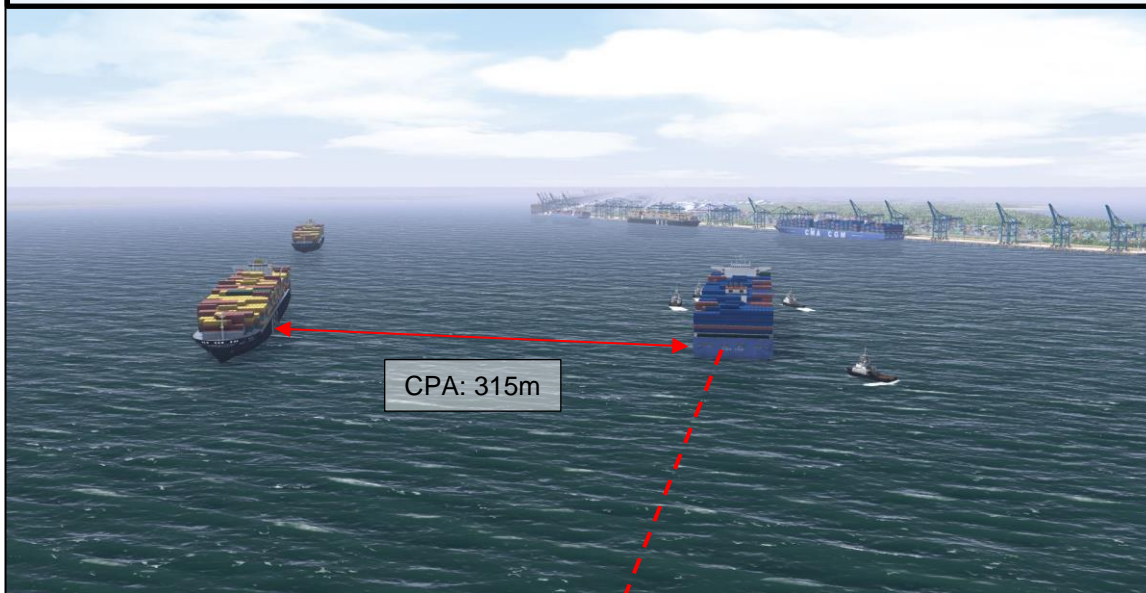


Run No.: 20	Unberthing from CT14 simultaneously with an inbound and an outbound vessel
Ship Model	Container Ship <ul style="list-style-type: none"> • LOA : 300m • Beam : 48.2m • Draft : 10.9m
Environmental Condition	Wind: 20 - 25 knots / NE, Current: Ebb
Run Outcome	Ship successfully unberthed, turned and departed whilst maintaining sufficient clearances from the other transiting vessels. Run rated Pass



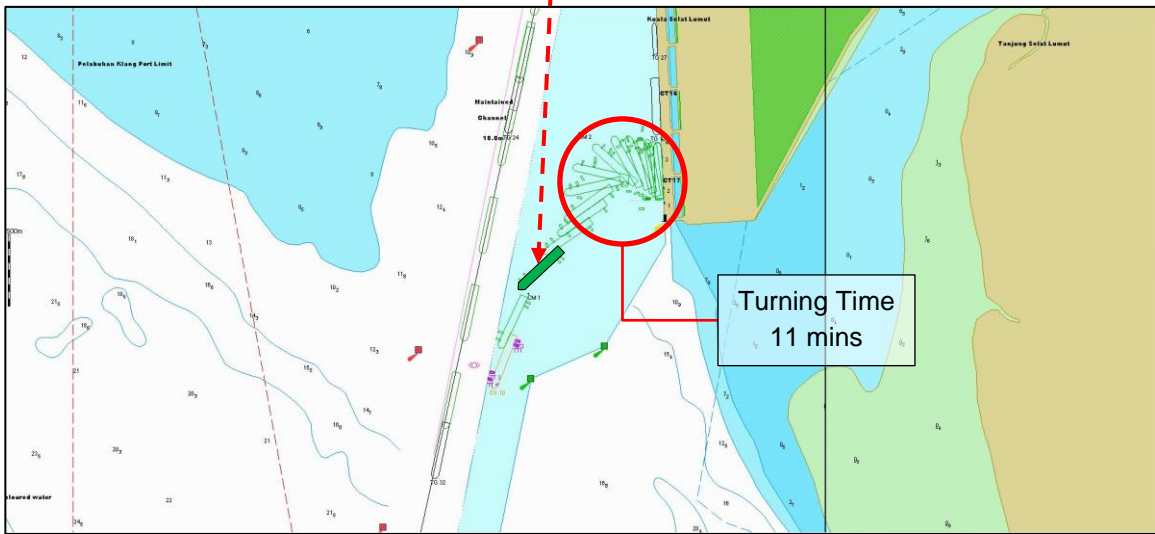
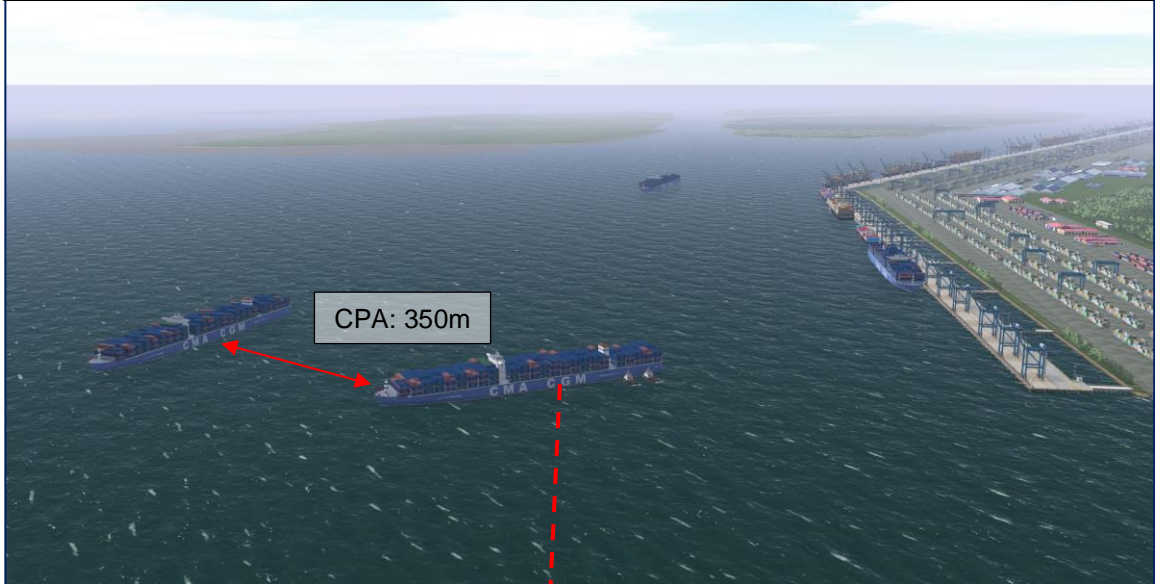
Run No.: 23	Approaching and berthing at CT17 simultaneously with two (2) outbound vessels
Ship Model	Container Ship <ul style="list-style-type: none"> • LOA : 396m • Beam : 53.6m • Draft : 16m
Environmental Condition	Wind: 20 - 25 knots / SW, Current: Ebb
Run Outcome	Ship successfully approached and turned to come parallel to Berth CT17 whilst maintaining sufficient clearances from the inbound vessels. Run rated Pass

Run 23 – Approaching and berthing at CT17 simultaneously with two (2) outbound vessels



Run No.: 28	Unberthing from CT17 simultaneously with two (2) outbound vessels
Ship Model	Container Ship <ul style="list-style-type: none"> • LOA : 396m • Beam : 53.6m • Draft : 16m
Environmental Condition	Wind: 20 - 25 knots / SW, Current: Flood
Run Outcome	Ship successfully unberthed, turned and departed whilst maintaining sufficient clearances from the other transiting vessels. Run rated Pass

Run 28 – Unberthing from CT17 simultaneously with two (2) outbound vessels



4.3 Towage Requirements

The following tugboat configurations were found to be sufficient:

Vessel Size	Tugboat Configuration
400m LOA	4 x 70T BP ASD Tugboats (All Berths)
300m LOA	3 x 60T BP ASD Tugboats (All Berths)
260m LOA	3 x 50T BP ASD Tugboats (CT13 and CT14) 2 x 50T BP ASD Tugboats (Other Berths)

Table 5: Tugboat configuration

4.4 Aids to Navigation

It is recommended to install lit beacons at the kink (knuckle) and wharf end (CT17). The parameters of the lights installed are as follows:

Height above Pier : 20m

Light Colour : To be finalised by LPK

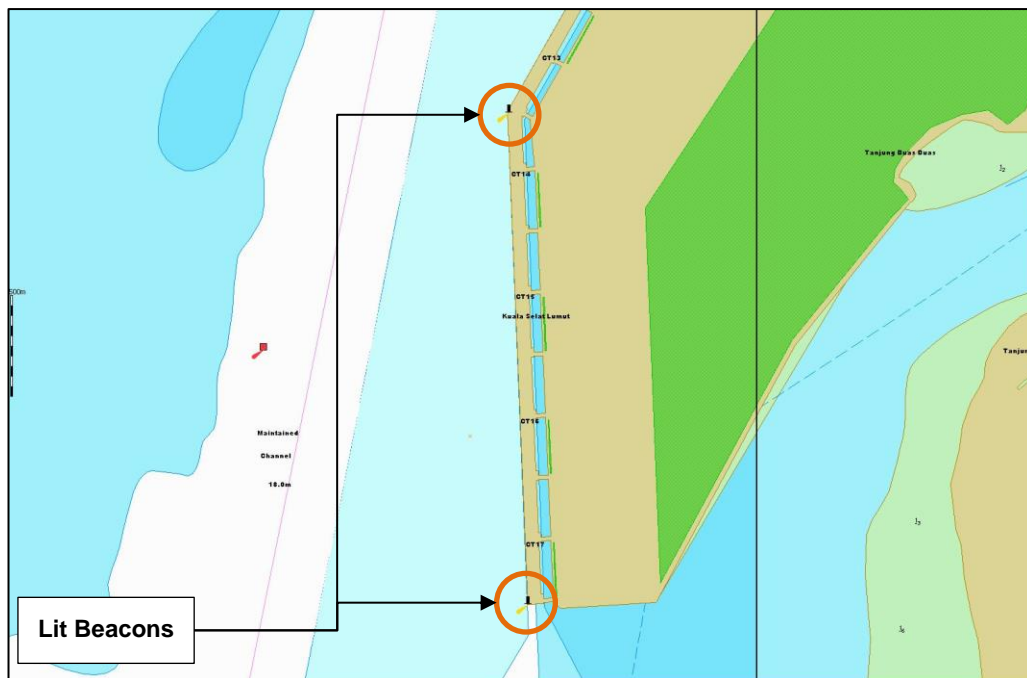


Figure 9: Screenshot showing Location of Proposed Lit Beacons



Figure 10: Screenshots showing Location of Proposed Lit Beacons

4.5 Potential Navigational Concerns

The following potential navigational concerns were identified:

- Extra caution must be exercised when manoeuvring close to the kink (knuckle) due to the shift in current direction (see Run 2);
- It is critical to maintain good communication with port control, especially on the movements (inbound / outbound) of other vessels;
- For departure operations from CT17, recommend tugboats to escort the vessel until it clears the channel due to strong cross currents within the channel, in case of an emergency situation such as a vessel engine failure or tugboat failure.

4.6 Additional Recommendations for Navigation Safety

In addition to the above recommendations, the following additional measures are proposed to improve navigation safety:

- Deployment of a Portable Pilotage Unit (PPU)
- Conduct of Pilotage Shiphandling / Advanced Tug Master Simulation Training
- Installation of a “Smart Port” Traffic Management System

4.6.1 Deployment of a Portable Pilotage Unit (PPU)

All Westports pilots should be provided with a Portable Pilotage Unit (PPU) to enable them to access real-time metocean and navigational information such as separation distances in real-time, thereby increasing the level of safety in pilotage operations.

An example of a PPU is an iPad Pro installed with suitable software such as Wärtsilä Pilot PRO.

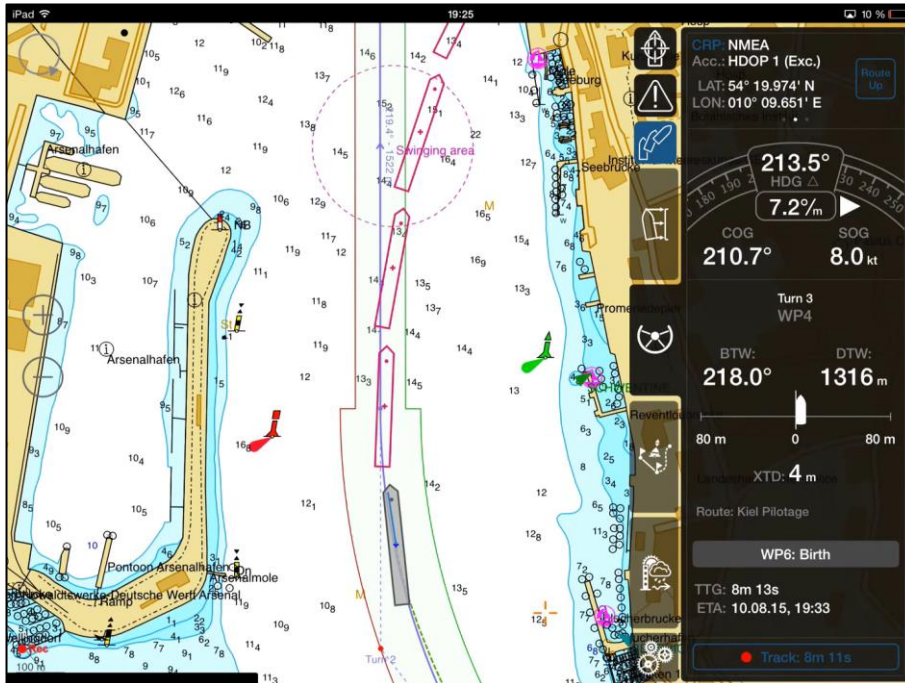


Figure 11: Sample Screenshot from Pilot PRO Software

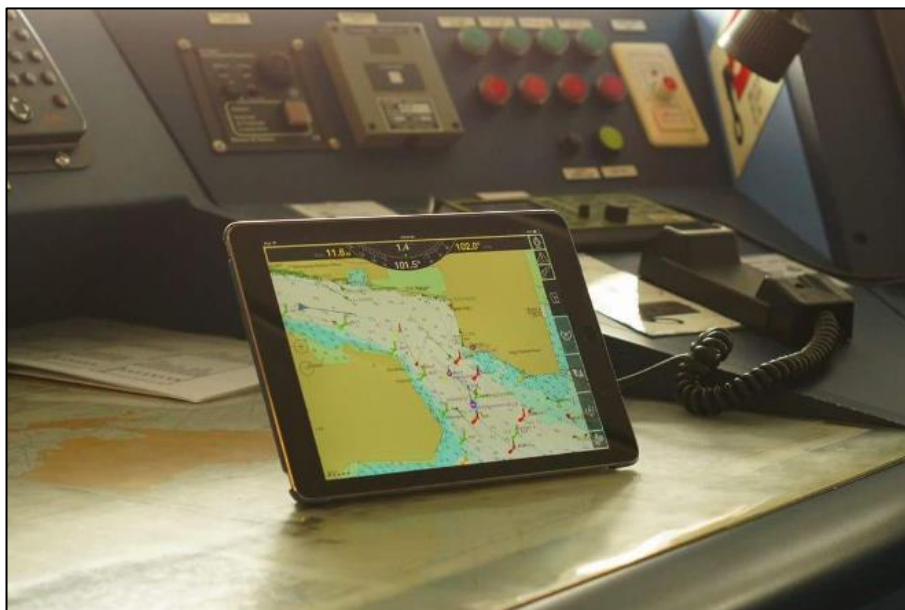


Figure 12: Example of iPad Running Pilot PRO Software onboard Ship

4.6.2 **Conduct of Pilotage Shiphandling / Advanced Tug Master Simulation Training**

The new expansion will create a series of new navigational manoeuvres for the Westports pilots. The results of the shiphandling simulation runs indicated that these manoeuvres can be challenging if the pilots are unprepared. For example, in Run 2, the container vessel's berthing speed exceeded acceptable limits due to a change in current direction during the final approaches to the berth.

Therefore, it is recommended that all Westports pilots undergo yearly pilotage shiphandling simulation familiarisation training for the new berths. Additionally, all tug masters providing towage services at Westports should undergo Advanced Tug Master Training covering standard as well as emergency operations.

4.6.3 **Installation of a "Smart Port" Traffic Management System**

As the new berths are in close proximity to the navigation channel leading to the existing Westports berths and Northport, it is recommended to upgrade the existing VTMS with an intelligent traffic management system, incorporating elements of Internet-of-Things (IoT) sensors.

Currently, 'traditional' VTMS rely on sensors such as radar and AIS to obtain the position of vessels within their monitoring area. This information is then relayed to pilots, ship masters and tug masters via VHF. This becomes less effective in busier waterways, as VTMS operators will have to monitor and 'estimate' the routes for multiple simultaneous manoeuvres (approaching within the navigation channel, berthing operations, unberthing operations and departing within the navigation channel). This makes it difficult for the operators to visualise the operations within the waterway and provide useful information in advance.

An intelligent traffic management system such as Portify or Sea Traffic Management (STM) will allow the passage plans, routes and estimated arrival times for all operations to be overlaid on the operator's dashboard. This will allow the operators to easily identify potential areas of concern ahead of time and provide relevant advice / information for the prevention of accidents.

The implementation of IoT sensors will allow for a wider range of data to become available, such as tidal height, tidal stream, salinity, wind speed, wind direction and visibility data. New developments have allowed such data to not only be viewable by the VTMS operators but also by pilots, vessel crew members and shore support teams such as mooring gangs.

The potential benefits of installing an intelligent traffic management system are safer and more efficient port operations.

5.0**CONCLUSION**

The findings and conclusions from the FMSS Study validates the layout of the Westports 2 Expansion with regards to safe ship transit, approach, manoeuvring, berthing, unberthing and departure operations for the design vessels. Additionally, the marine operations to the berths will not have significant navigational impact on the existing navigation channel, subject to compliance with the recommendations listed in this study.

- END OF DOCUMENT -

Appendix A

FMSS Attendees List

Appendix B

Simulation Run Matrix

Run No.	Ship Model				Scenarios	Tug Configuration	PST / SST	Day / Night	Met-ocean Conditions			Results
	Simulation Model Name	LOA (m)	Draft (m)	Condition					Wind	Wave	Current	
									Speed (knot) / Direction (From)	Height (m) / Direction (From)	Speed (knot) / Direction (To)	
CT10												
1	Container Ship 24	396	16	Loaded	Approach and berthing	4 x 70T ASD	PST	Day	20 - 25 / NE	1 – 1.5m	Ebb	PASS
2	Container Ship 24	396	16	Loaded		4 x 70T ASD	PST	Night	20 - 25 / SW	1 – 1.5m	Ebb	MARGINAL
3	Container Ship 24	396	16	Loaded		4 x 70T ASD	SST	Night	20 - 25 / NE	1 – 1.5m	Flood	PASS
4	Container Ship 24	396	16	Loaded	Unberthing and departure	4 x 70T ASD	SST	Night	20 - 25 / NE	1 – 1.5m	Ebb	PASS
5	Container Ship 24	396	16	Loaded		4 x 70T ASD	PST	Night	20 - 25 / SW	1 – 1.5m	Flood - 1.75x	PASS
6	Container Ship 24	396	16	Loaded		4 x 70T ASD	PST	Dusk	20 - 25 / SW	1 – 1.5m	Ebb - 1.75x	PASS
7	Container Ship 24	396	16	Loaded		4 x 70T ASD	SST	Day	20 - 25 / SW	1 – 1.5m	Flood - 1.75x	PASS
CT13												
8	Container Ship 14	261.4	12.62	Loaded	Approach and Berthing	2 x 50T ASD	PST	Day	20 – 25, NE	1 – 1.5m	Ebb	MARGINAL
9	Container Ship 29	300	15.27	Loaded		3 x 60T ASD	SST	Day	20 – 25, SW	1 – 1.5m	Flood - 1.75x	PASS
10	Container Ship 14	261.4	12.62	Loaded		2 x 50T ASD	PST	Night	20 – 25, NE	1 – 1.5m	Ebb	PASS
11	Container Ship 14	261.4	12.62	Loaded	Unberthing and Departure	3 x 60T ASD	SST	Dusk & Rain	20 - 25, SW	1 - 1.5m	Ebb - 1.75x	PASS
12	Container Ship 14	261.4	12.62	Loaded		2 x 50T ASD	SST	Night	20 – 25, SW	1 – 1.5m	Flood - 1.75x	PASS
13	Container Ship 29	300	15.27	Loaded		3 x 60T ASD	SST	Night	20 – 25, SW	1 – 1.5m	Ebb	PASS
14	Container Ship 29	300	15.27	Loaded		3 x 60T ASD	PST	Night	20 – 25, NE	1 – 1.5m	Flood	PASS
CT14												
15	Container Ship 14	261.4	12.62	Loaded	Approach and Berthing	3 x 50T ASD	PST	Dusk	20 – 25, SW	1 – 1.5m	Ebb - 1.75x	PASS
16	Container Ship 14	261.4	12.62	Loaded		2 x 50T ASD	SST	Night	20 – 25, SW	1 – 1.5m	Flood	PASS
17	Container Ship 29	300	15.27	Loaded	Unberthing and Departure	3 x 60T ASD	PST	Dusk	20 – 25, SW	1 – 1.5m	Ebb - 1.75x	PASS
18	Container Ship 14	261.4	12.62	Loaded		2 x 50T ASD	SST	Night	20 – 25, SW	1 – 1.5m	Flood	PASS
19	Container Ship 14	261.4	12.62	Loaded		3 x 50T ASD	PST	Night	20 – 25, NE	1 – 1.5m	Flood - 1.75x	PASS
20	Container Ship 29	300	15.27	Loaded		3 x 50T ASD	SST	Night	20 – 25, NE	1 – 1.5m	Ebb - 1.75x	PASS
21	Container Ship 29	300	15.27	Loaded		3 x 60T ASD	PST	Day	20 – 25, SW	1 – 1.5m	Flood - 1.75x	FAIL

Run No.	Ship Model				Scenarios	Tug Configuration	PST / SST	Day / Night	Met-ocean Conditions			Results
	Simulation Model Name	LOA (m)	Draft (m)	Condition					Wind	Wave	Current	
									Speed (knot) / Direction (From)	Height (m) / Direction (From)	Speed (knot) / Direction (To)	
CT17												
22	Container Ship 24	396	16	Loaded	Approach and Berthing	4 x 70T ASD	SST	Day	20 – 25, NE	1 – 1.5m	Flood	PASS
23	Container Ship 24	396	16	Loaded		4 x 70T ASD	PST	Day	20 – 25, SW	1 – 1.5m	Ebb - 1.75x	PASS
24	Container Ship 24	396	16	Loaded		4 x 70T ASD	SST	Night	10 – 15, SW	0.5 – 1.0m	Flood - 2.25x	FAIL
25	Container Ship 24	396	16	Loaded	Unberthing and Departure	4 x 70T ASD	SST	Day	20 – 25, SW	1 – 1.5m	Ebb	PASS
26	Container Ship 24	396	16	Loaded		4 x 70T ASD	PST	Night	20 – 25, SW	1 – 1.5m	Flood - 1.75x	PASS
27	Container Ship 24	396	16	Loaded		4 x 70T ASD	SST	Night	20 – 25, NE	1 – 1.5m	Ebb - 1.75x	PASS
28	Container Ship 24	396	16	Loaded		4 x 70T ASD	SST	Day	20 – 25, SW	1 – 1.5m	Flood - 1.75x	PASS
Emergency												
29	Container Ship 24	396	16	Loaded	Steering Failure (CT10 - Departure)	4 x 70T ASD	PST	Night	20 – 25, SW	1 – 1.5m	Flood	PASS
30	Container Ship 14	261.4	12.62	Loaded	Engine Failure (CT14 - Departure)	2 x 50T ASD	SST	Day	20 – 25, SW	1 – 1.5m	Flood	PASS
31	Container Ship 14	261.4	12.62	Loaded	Engine Failure (CT14 - Arrival)	3 x 50T ASD	PST	Dusk	20 – 25, SW	1 – 1.5m	Ebb - 1.75x	PASS
32	Container Ship 24	396	16	Loaded	Engine Failure (CT17 - Departure)	4 x 70T ASD	PST	Day	10 – 15, NE	0.5 – 1.0m	Flood - 2.25x	MARGINAL

Appendix C

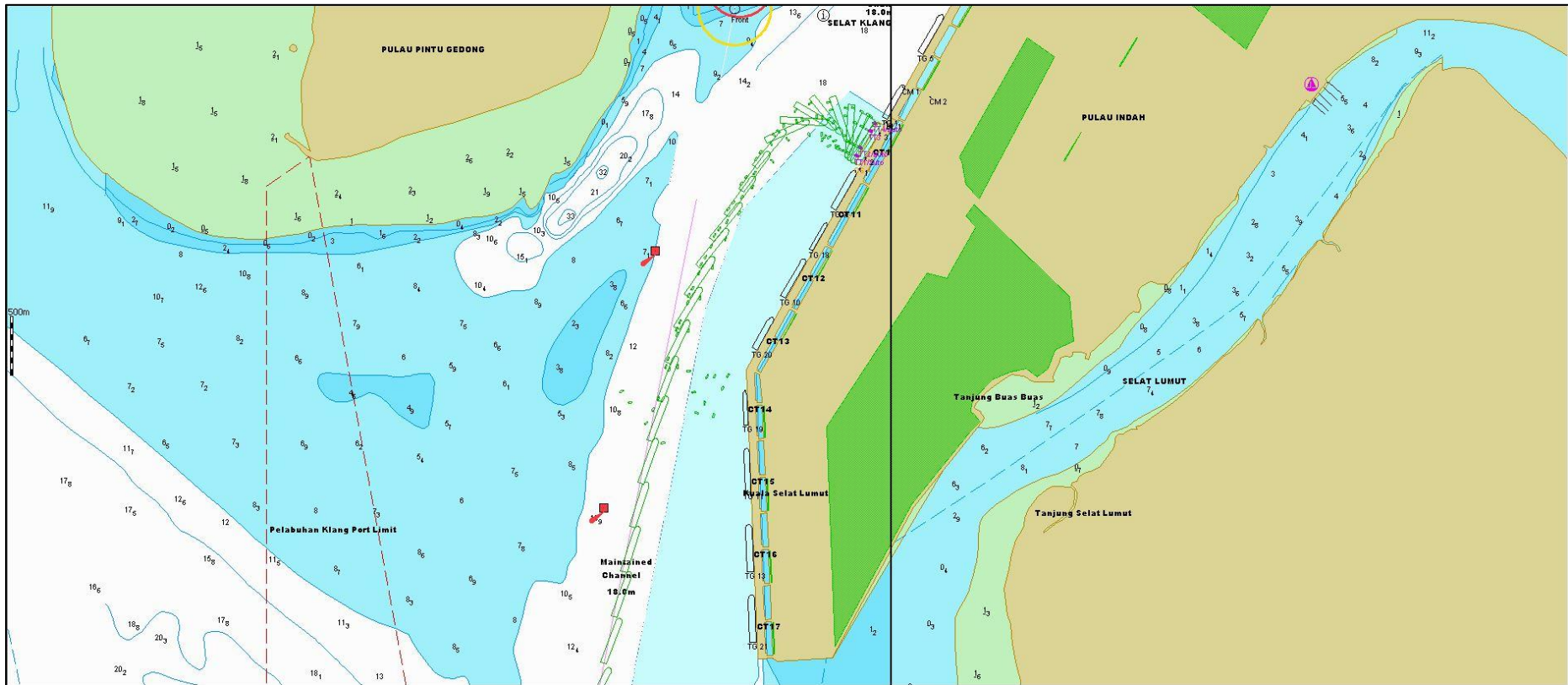
Simulation Run Plots and Time History Plots

Appendix C – Run Plots and Time History Plots

Simulation Runs (32 Total)

Run 1 – Container Ship Approaching and Berthing at CT10

Ship Model	Container Ship, 396m LOA, Loaded	Tugboats, 4 x 70t ASD Tugboats	
Environmental Conditions	Current: Ebb	Wind: 20 – 25 knots / NE	Wave: 1 – 1.5m / NE
Run Outcome	Ship successfully berth alongside. Run rated Pass		Duration: 1hour 5minutes



Engine RPM



Rudder Angle



Speed Over Ground (Knots)



Tugboat 1 Force (t)



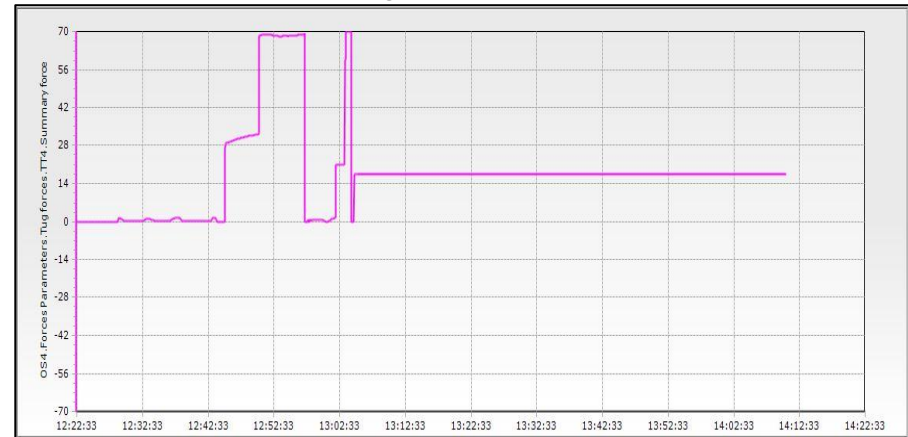
Tugboat 2 Force (t)



Tugboat 3 Force (t)

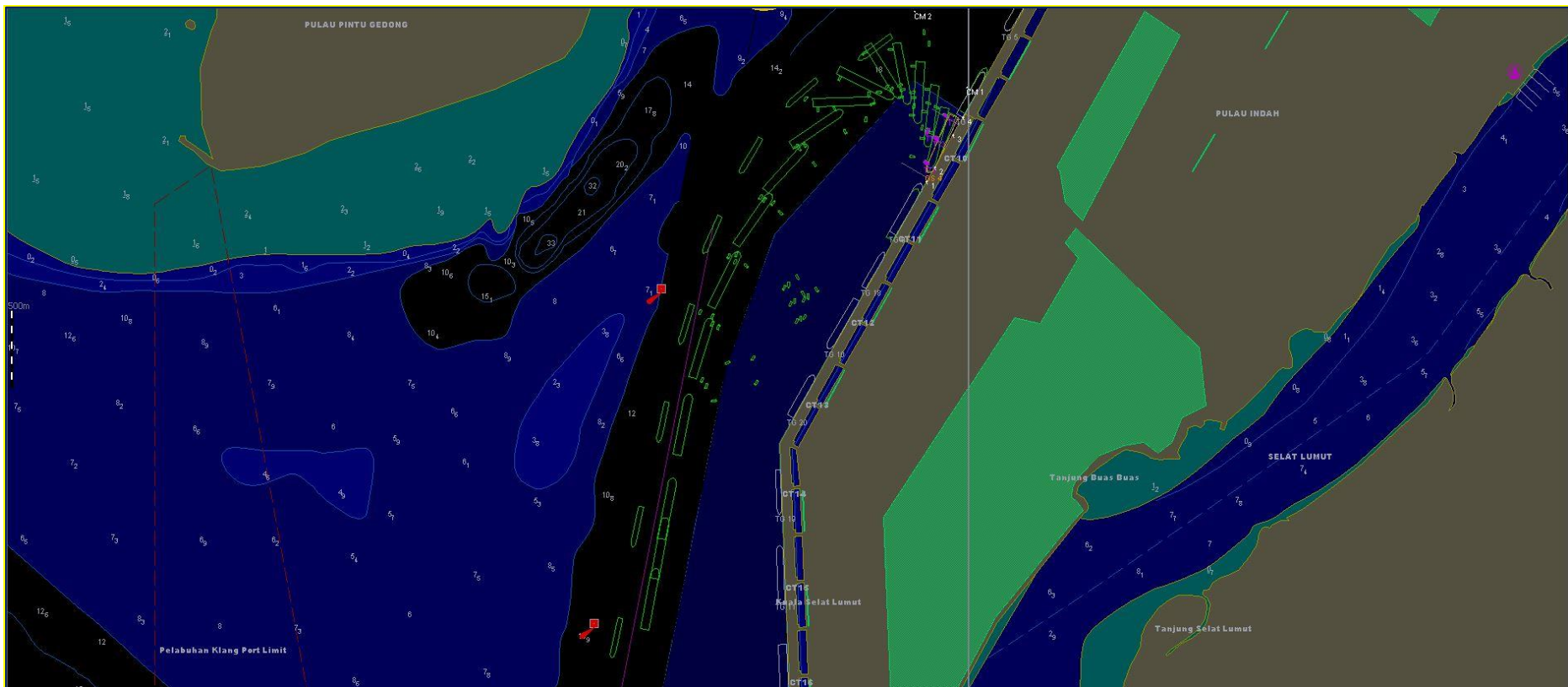


Tugboat 4 Force (t)

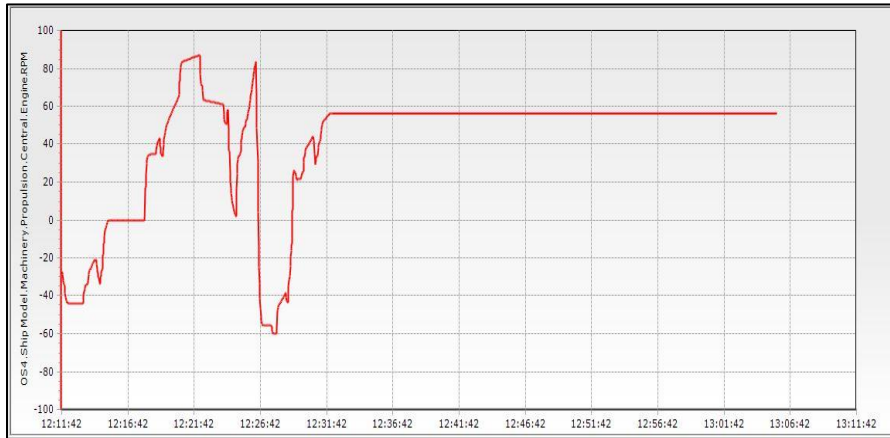


Run 2 – Container Ship Approaching and Berthing at CT10 Simultaneously with An Outbound Vessel

Ship Model	Container Ship, 396m LOA, Loaded	Tugboats, 4 x 70t ASD Tugboats	
Environmental Conditions	Current: Ebb	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SE
Run Outcome	Vessel successfully approached and turned toward berth CT10 whilst maintaining sufficient clearances from the outbound vessel. However, berthing speed exceeded 1 knot due to strong current. Run rated Marginal		Duration: 32 minutes
Recommendation	Pilotage simulation familiarisation training should be conducted to familiarise pilots with the manoeuvres to the new berths and the new current profiles.		



Engine RPM



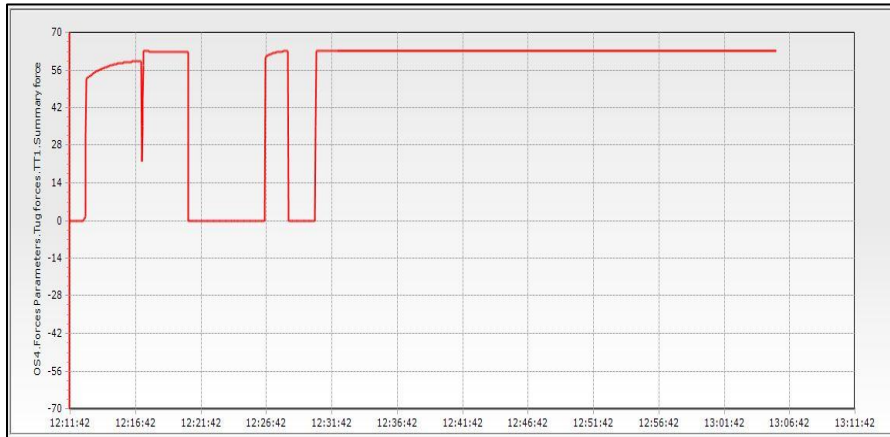
Rudder Angle



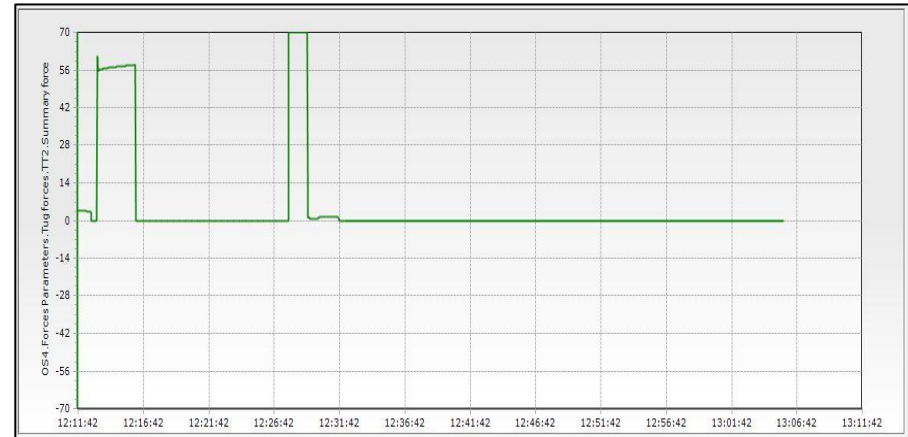
Speed Over Ground (Knots)



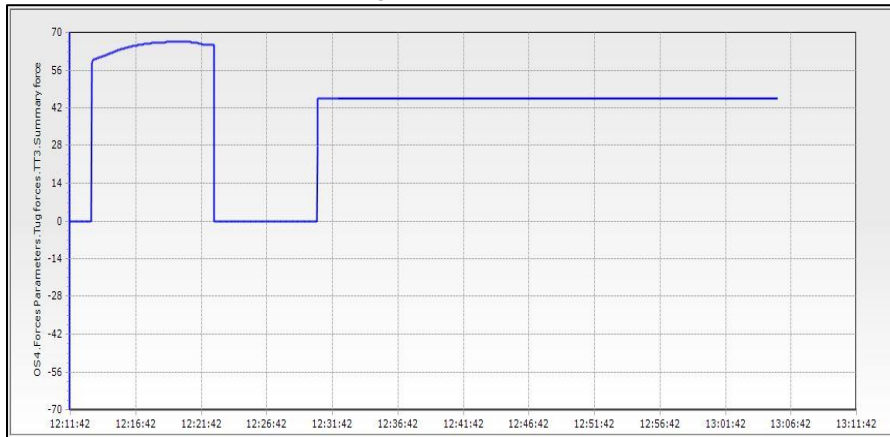
Tugboat 1 Force (t)



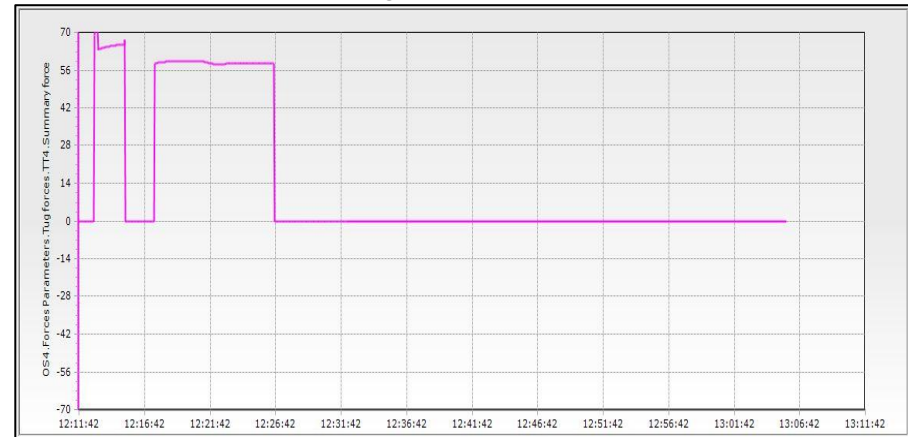
Tugboat 2 Force (t)



Tugboat 3 Force (t)



Tugboat 4 Force (t)



Run 3 – Container Ship Approaching and Berthing at CT10

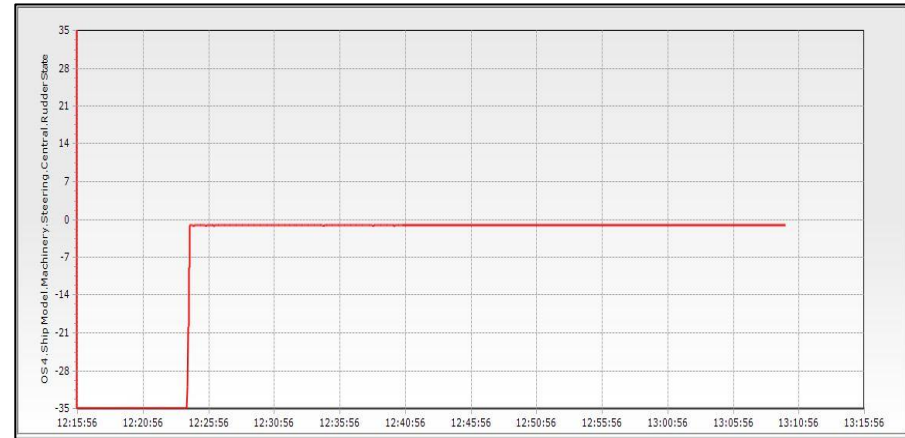
Ship Model	Container Ship, 396m LOA, Loaded	Tugboats, 4 x 70t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / NE	Wave: 1 – 1.5m / NE
Run Outcome	Ship successfully berth alongside. Run rated Pass		Duration: 40 minutes



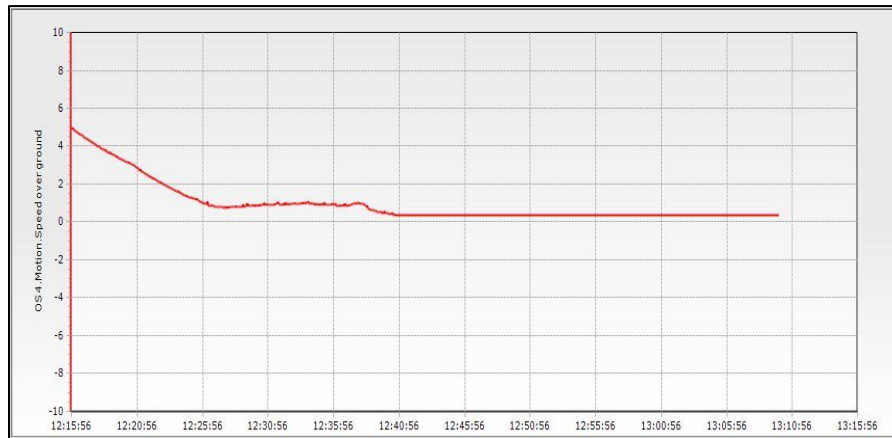
Engine RPM



Rudder Angle



Speed Over Ground (Knots)



Tugboat 1 Force (t)



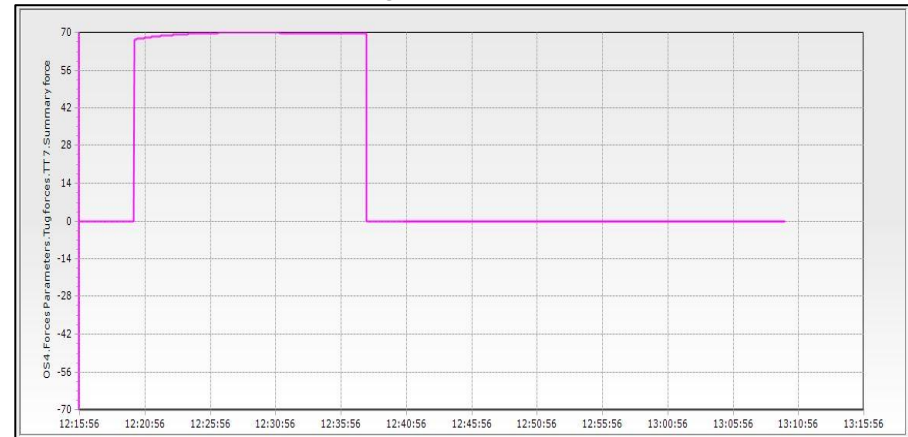
Tugboat 2 Force (t)



Tugboat 3 Force (t)

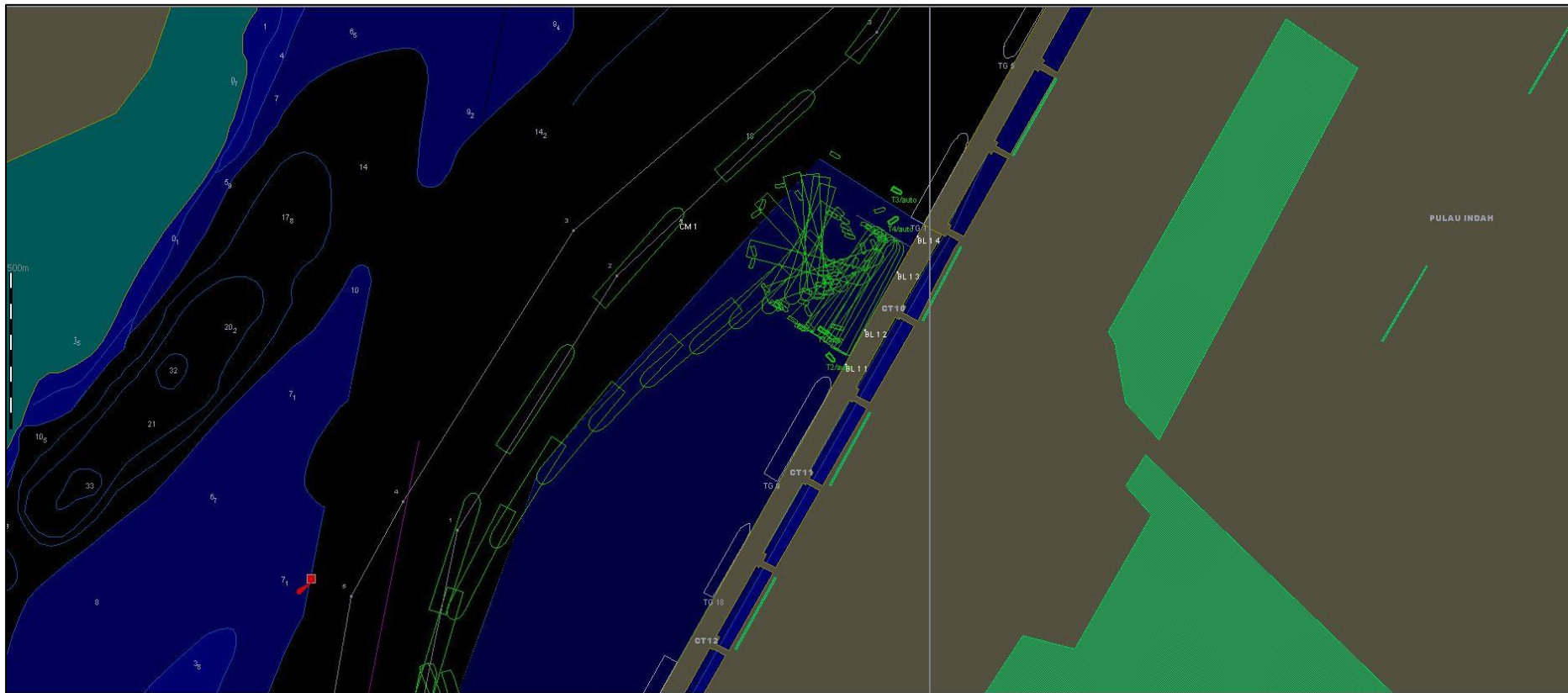


Tugboat 4 Force (t)



Run 4 – Container Ship Unberthing and Departing from CT10

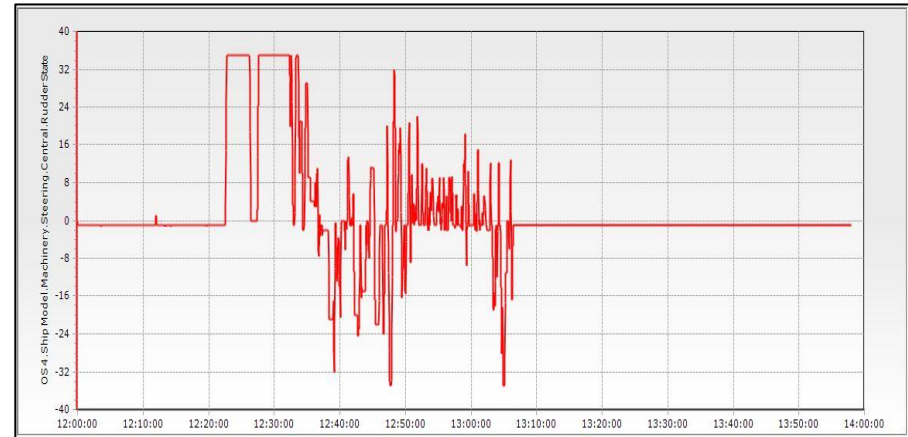
Ship Model	Container Ship, 396m LOA, Loaded	Tugboats, 4 x 70t ASD Tugboats	
Environmental Conditions	Current: Ebb	Wind: 20 – 25 knots / NE	Wave: 1 – 1.5m / NE
Run Outcome	Ship successfully unberths. Run rated Pass		Duration: 1hour 6minutes



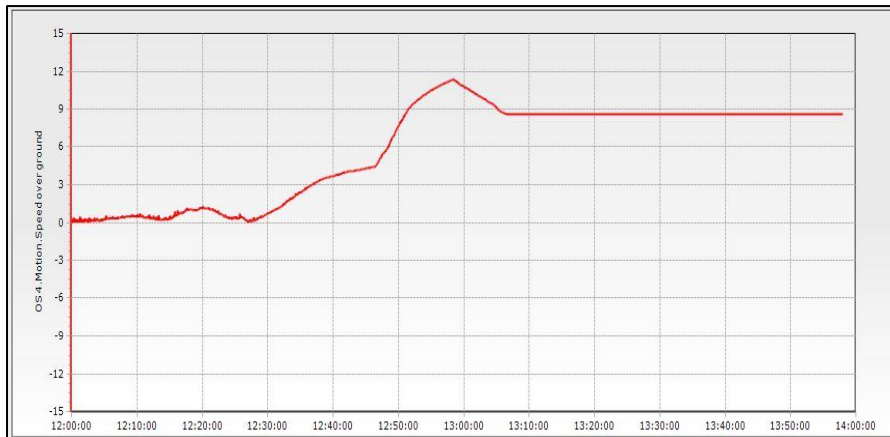
Engine RPM



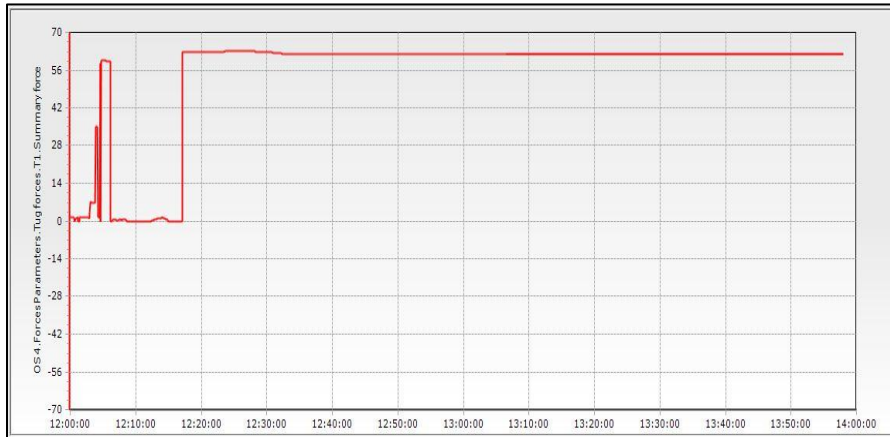
Rudder Angle



Speed Over Ground (Knots)



Tugboat 1 Force (t)



Tugboat 2 Force (t)



Tugboat 3 Force (t)



Tugboat 4 Force (t)

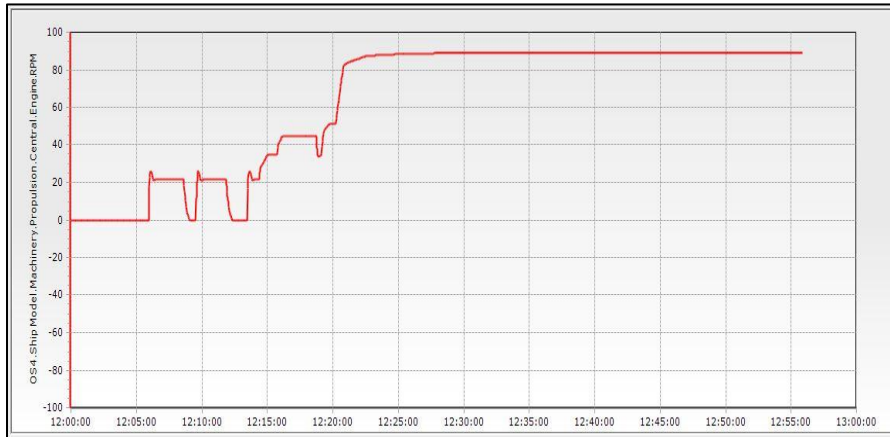


Run 5 – Container Ship Unberthing and Departing from CT10

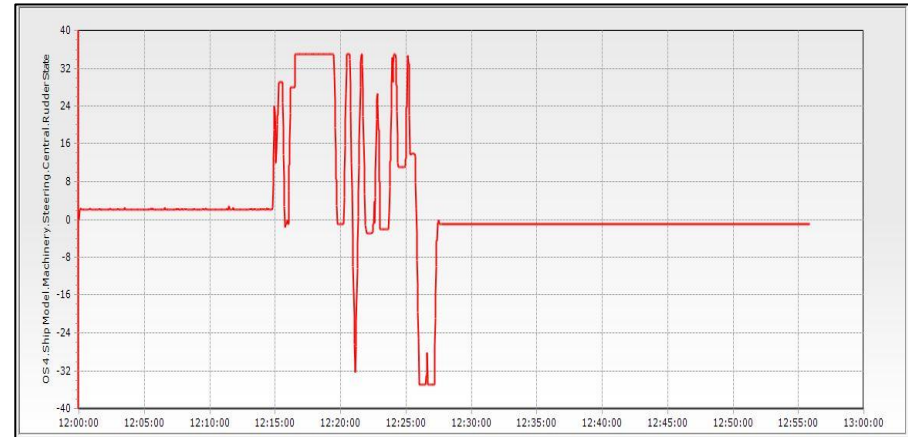
Ship Model	Container Ship, 396m LOA, Loaded	Tugboats, 4 x 70t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship successfully unberths. Run rated Pass		Duration: 27minutes



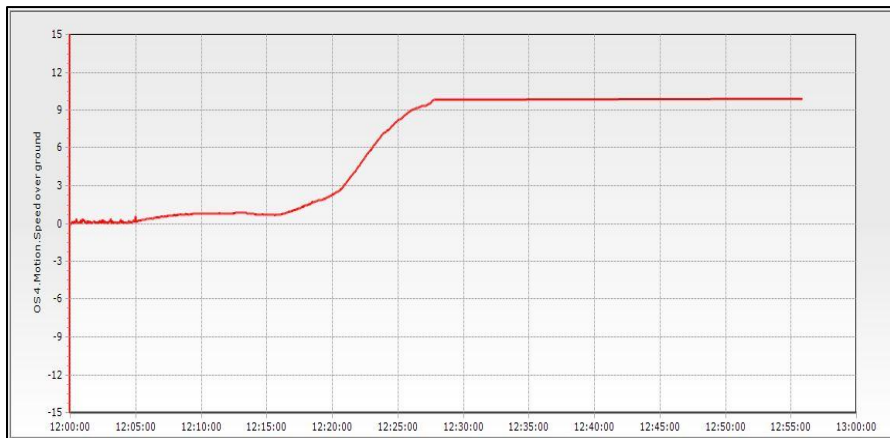
Engine RPM



Rudder Angle



Speed Over Ground (Knots)



Tugboat 1 Force (t)



Tugboat 2 Force (t)



Tugboat 3 Force (t)



Tugboat 4 Force (t)

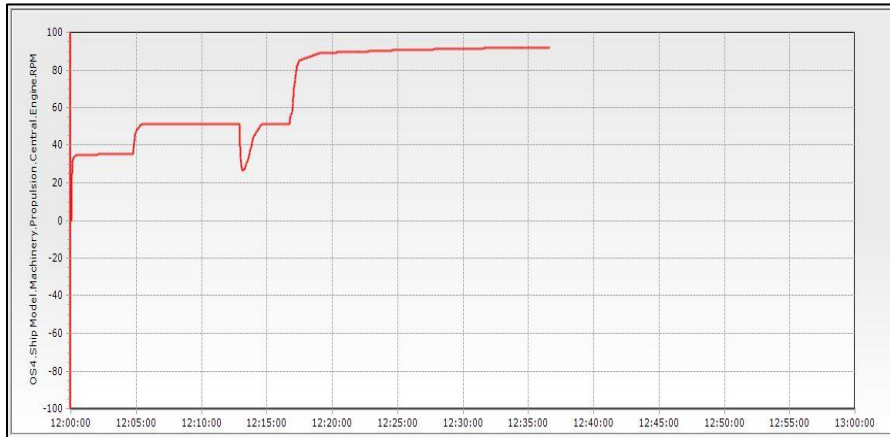


Run 6 – Container Ship Unberthing and Departing from CT10

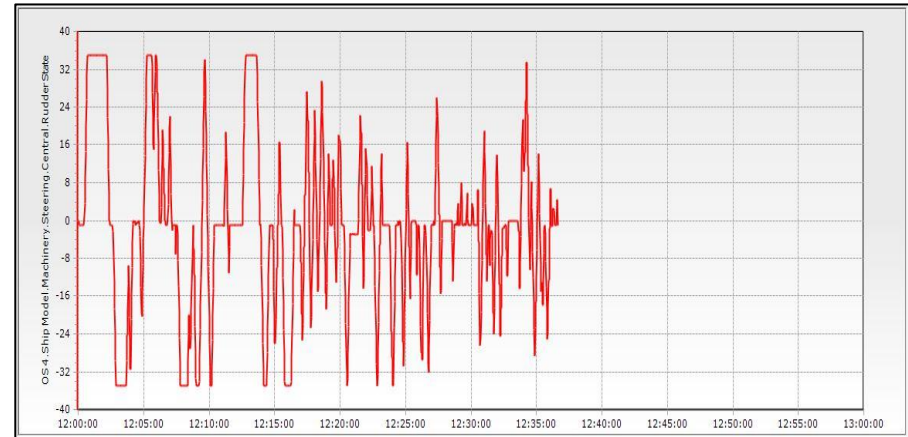
Ship Model	Container Ship, 396m LOA, Loaded	Tugboats, 4 x 70t ASD Tugboats	
Environmental Conditions	Current: Ebb	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SE
Run Outcome	Ship successfully unberths. Run rated Pass		Duration: 35minutes



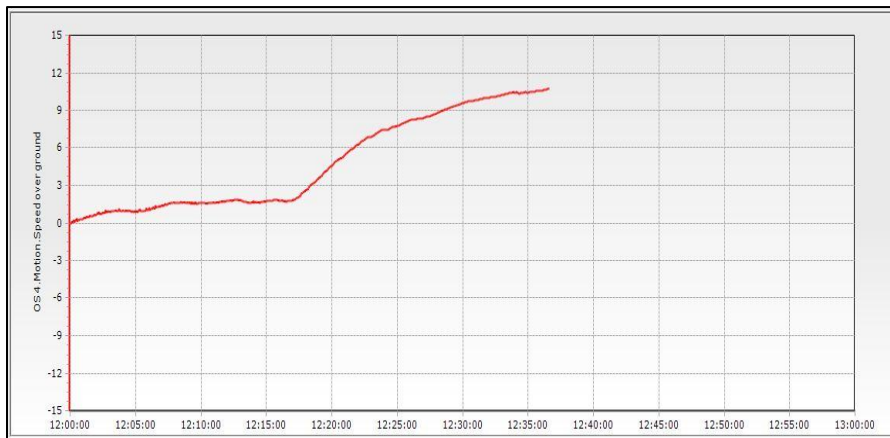
Engine RPM



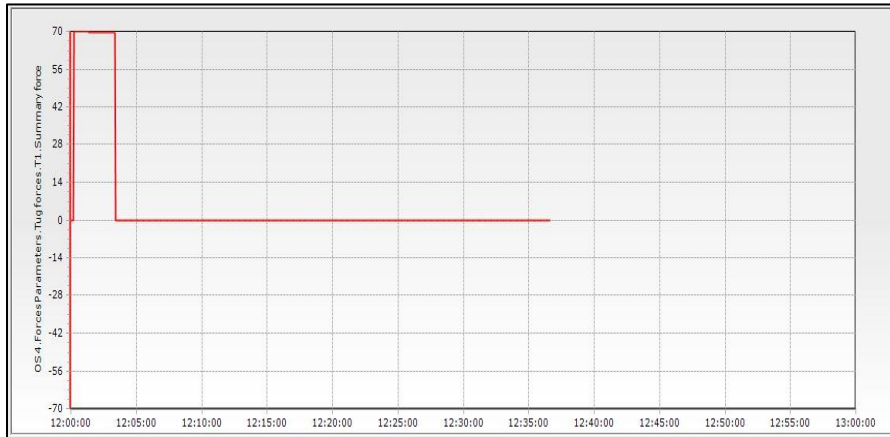
Rudder Angle



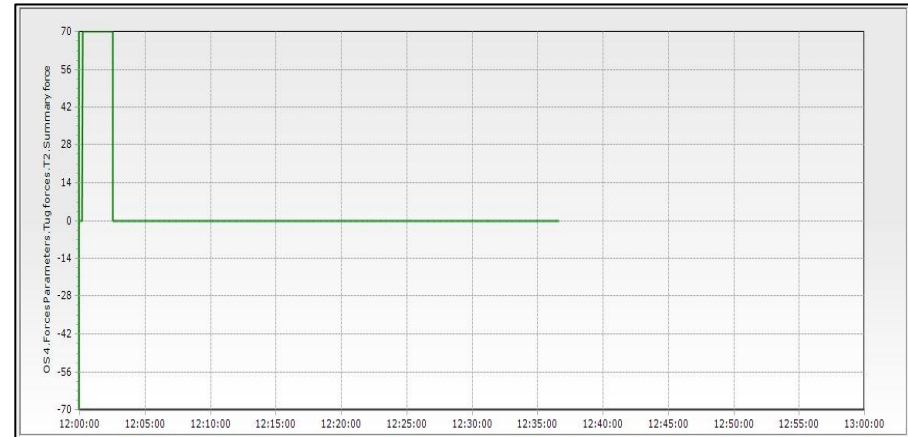
Speed Over Ground (Knots)



Tugboat 1 Force (t)



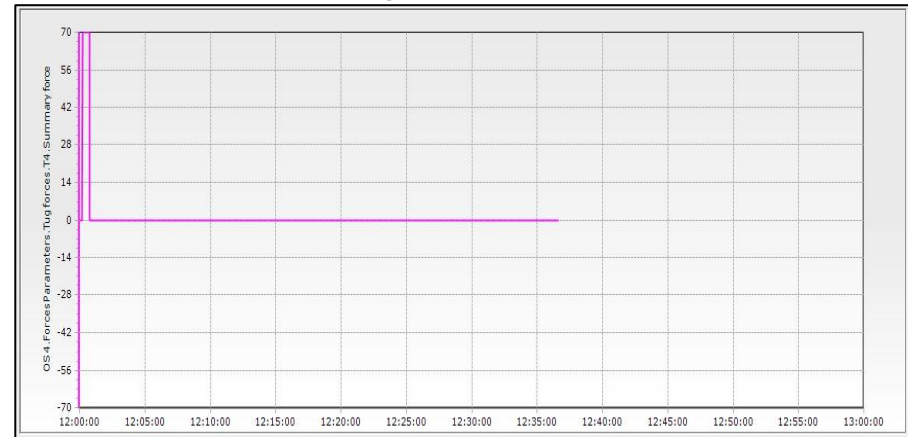
Tugboat 2 Force (t)



Tugboat 3 Force (t)

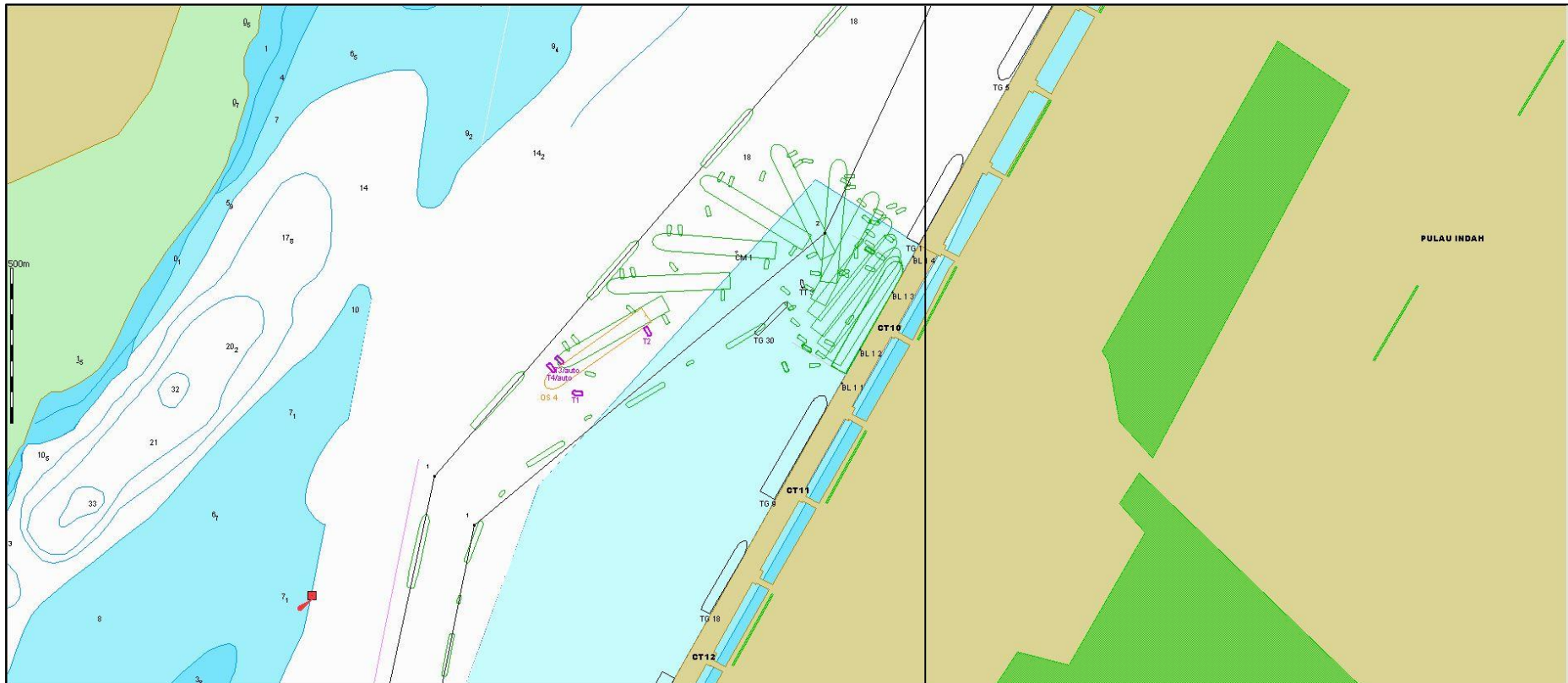


Tugboat 4 Force (t)



Run 7 – Container Ship Unberthing from CT10 Simultaneously with Two (2) Inbound Vessels

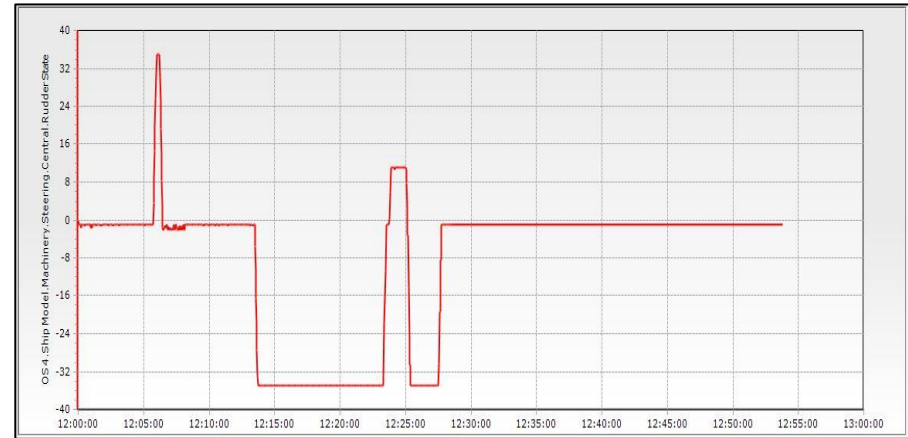
Ship Model	Container Ship, 396m LOA, Loaded	Tugboat, 4 x 70t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship successfully unberthed, turned and departed whilst maintaining sufficient clearances from the inbound vessels. Run rated Pass		Duration: 54minutes



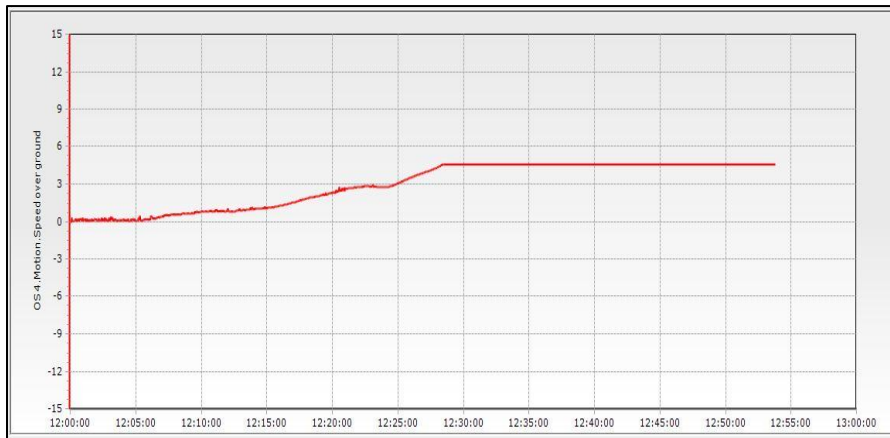
Engine RPM



Rudder Angle



Speed Over Ground (Knots)



Tugboat 1 Force (t)



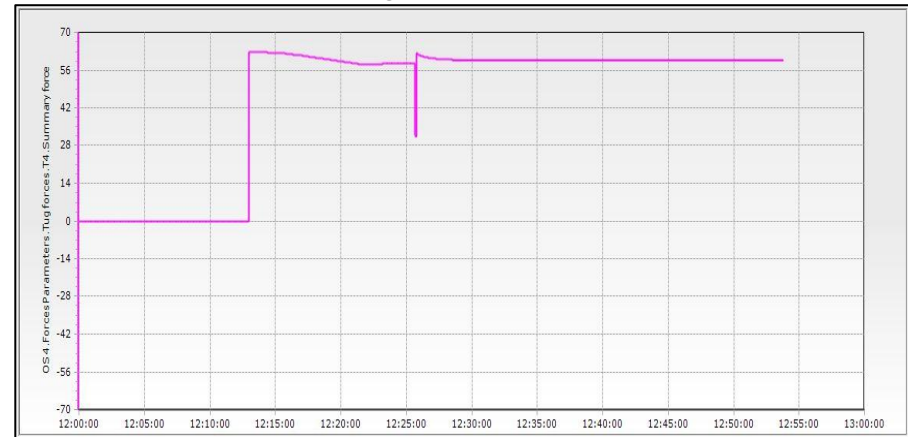
Tugboat 2 Force (t)



Tugboat 3 Force (t)

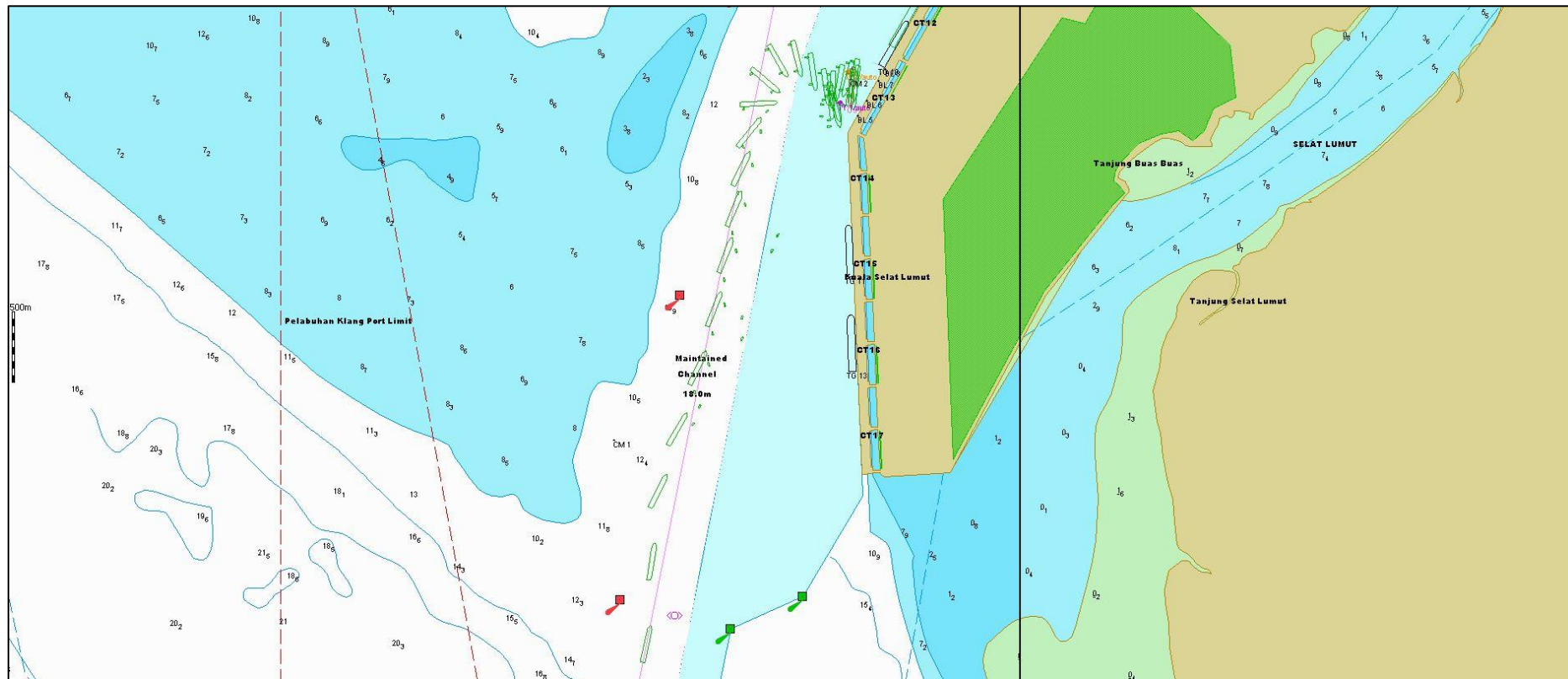


Tugboat 4 Force (t)



Run 8 – Container Ship Approaching and Berthing at CT13

Ship Model	Container Ship, 261.4m LOA, Loaded	Tugboats, 2 x 50t ASD Tugboats	
Environmental Conditions	Current: Ebb	Wind: 20 – 25 knots / NE	Wave: 1 – 1.5m / NE
Run Outcome	Ship unable to berth alongside due to strong current effect. Run rated Marginal		Duration: 51minutes
Comment	Committee agreed that vessels approaching Berth CT13 should attempt to swing toward the berth after clearing the red buoy after the knuckle (kink). This will allow the vessel to adopt a more gradual approach angle.		
Recommendation	Pilotage simulation familiarisation training should be conducted to familiarise pilots with the manoeuvres to the new berths and the new current profiles.		



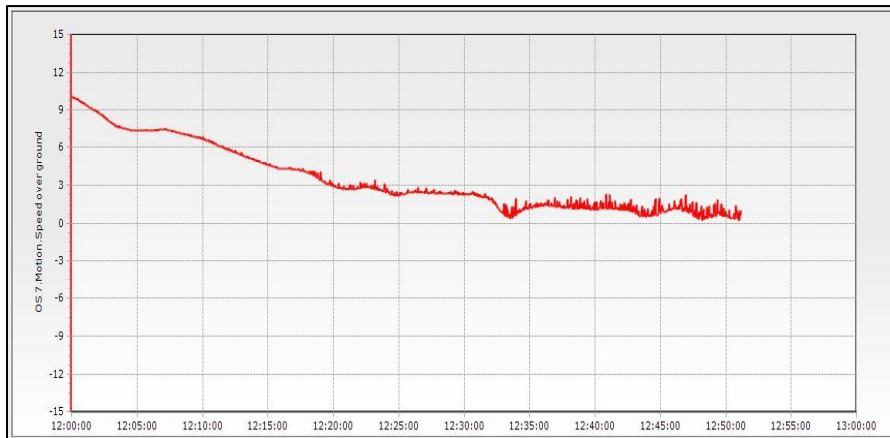
Engine RPM



Rudder Angle



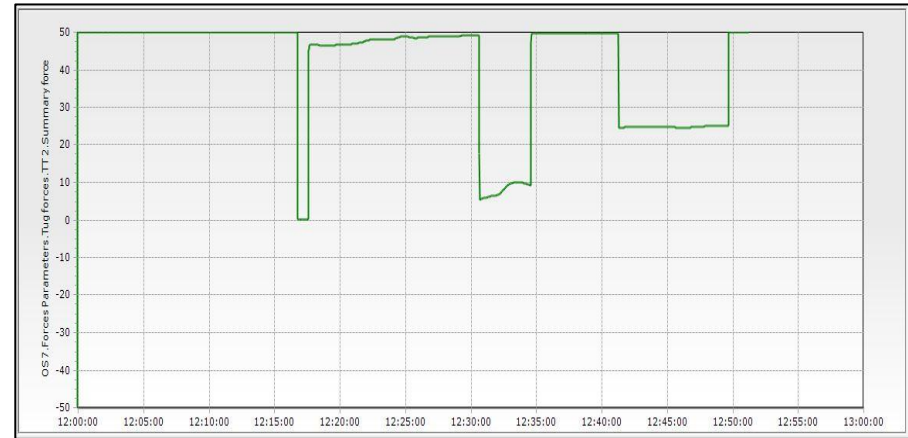
Speed Over Ground (Knots)



Tugboat 1 Force (t)

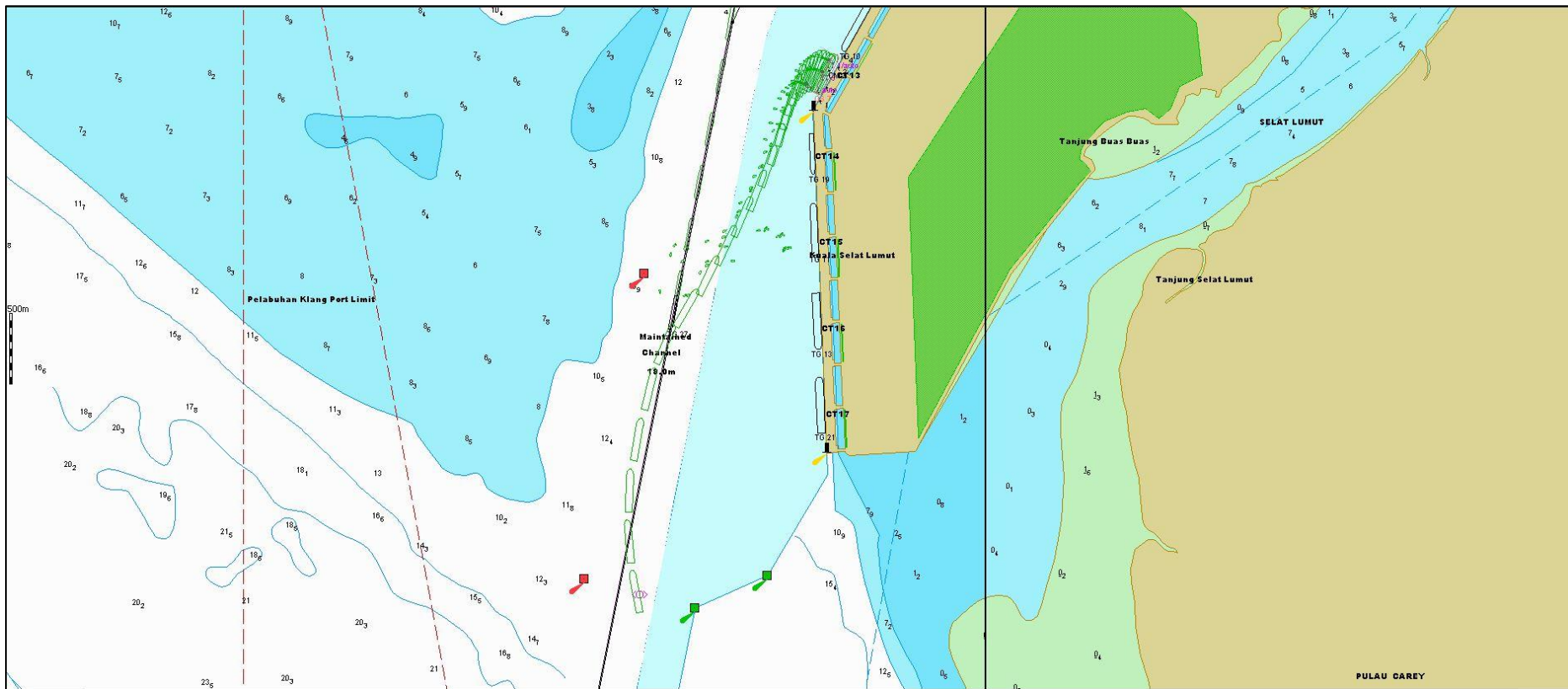


Tugboat 2 Force (t)



Run 9 – Container Ship Approaching and Berthing at CT13 Simultaneously with An Outbound Vessel

Ship Model	Container Ship, 300m LOA, Loaded	Tugboats, 3 x 60t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Vessel successfully approached and turned toward berth CT13 whilst maintaining sufficient clearances from the outbound vessel. Run rated Pass		Duration: 27minutes



Engine RPM



Rudder Angle



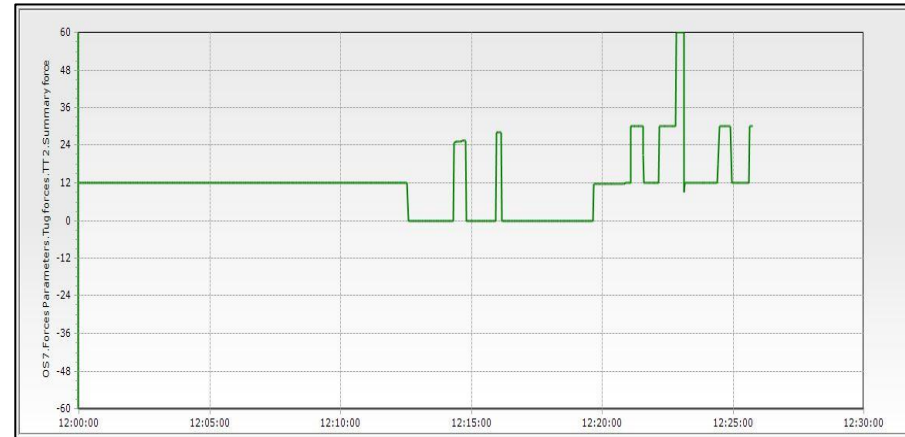
Speed Over Ground (Knots)



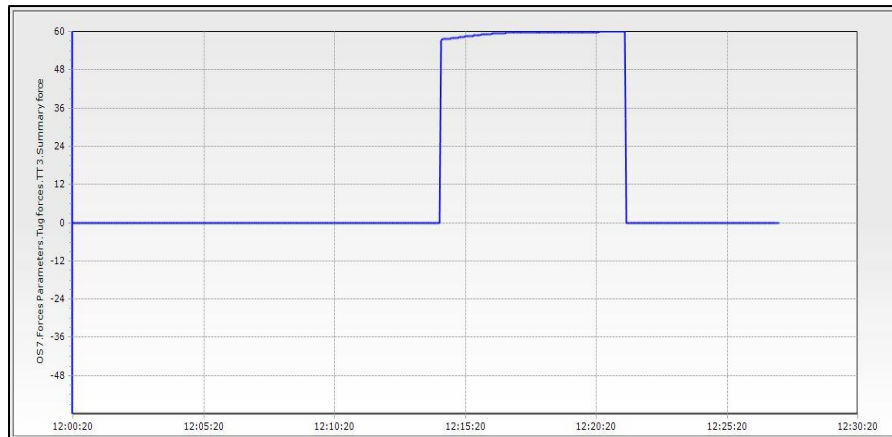
Tugboat 1 Force (t)



Tugboat 2 Force (t)

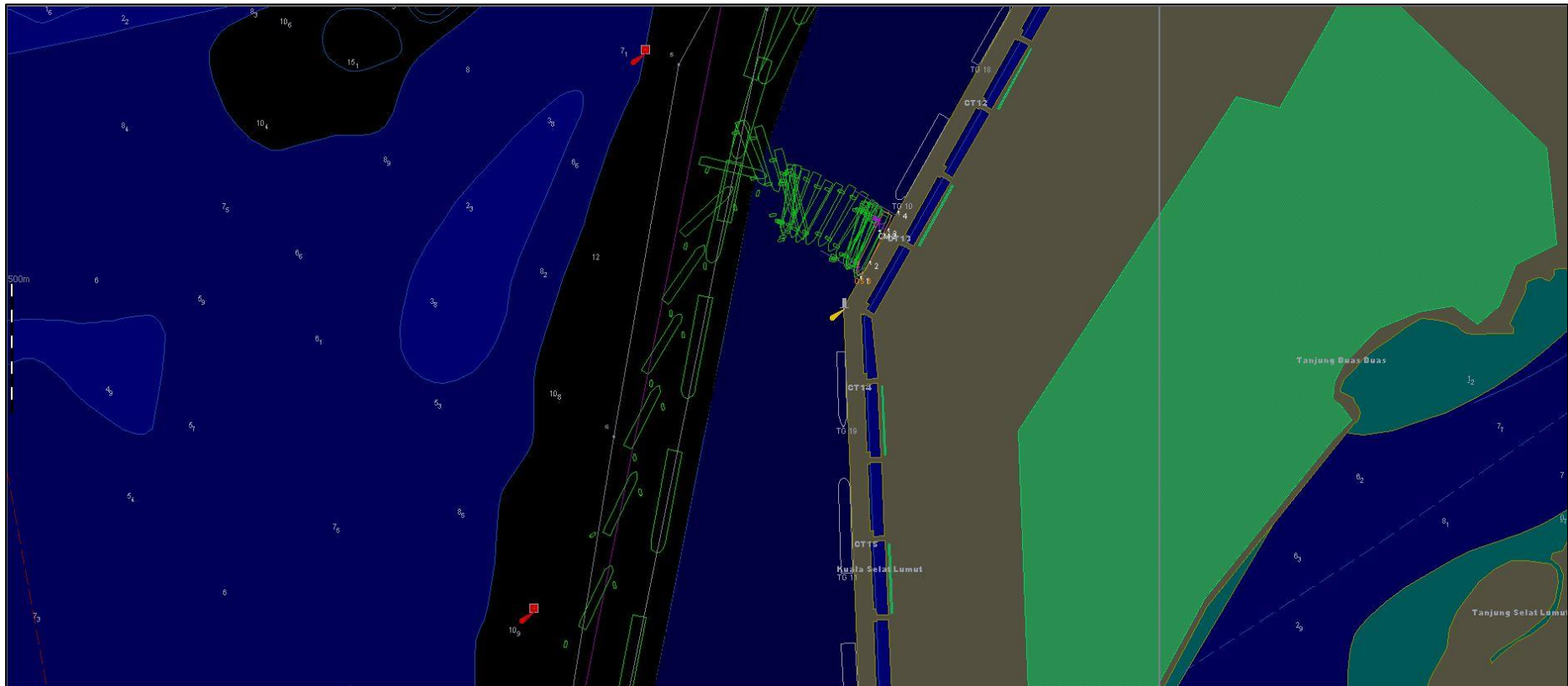


Tugboat 3 Force (t)

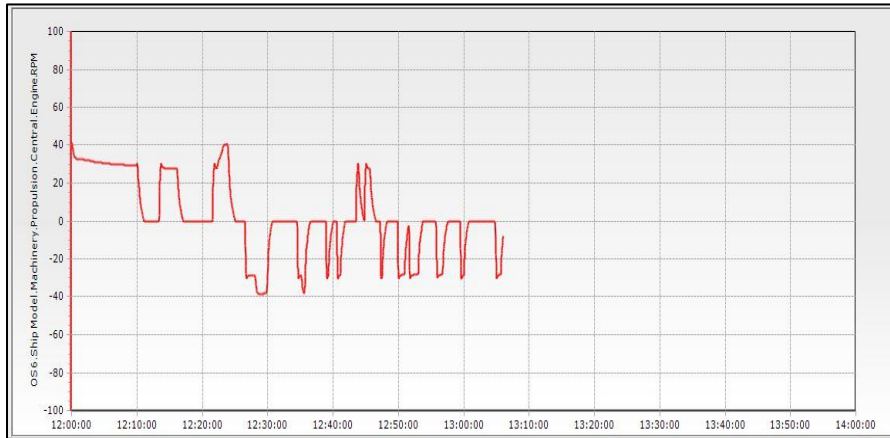


Run 10 – Container Ship Approaching and Berthing at CT13 Simultaneously with An Outbound Vessel

Ship Model	Container Ship, 261.4m LOA, Loaded	Tugboats, 2 x 50t ASD Tugboats	
Environmental Conditions	Current: Ebb	Wind: 20 – 25 knots / NE	Wave: 1 – 1.5m / NE
Run Outcome	Ship successfully berth alongside at CT13 whilst maintaining sufficient clearances from the outbound vessel. Run rated Pass		Duration: 1 hour 6minutes



Engine RPM



Rudder Angle

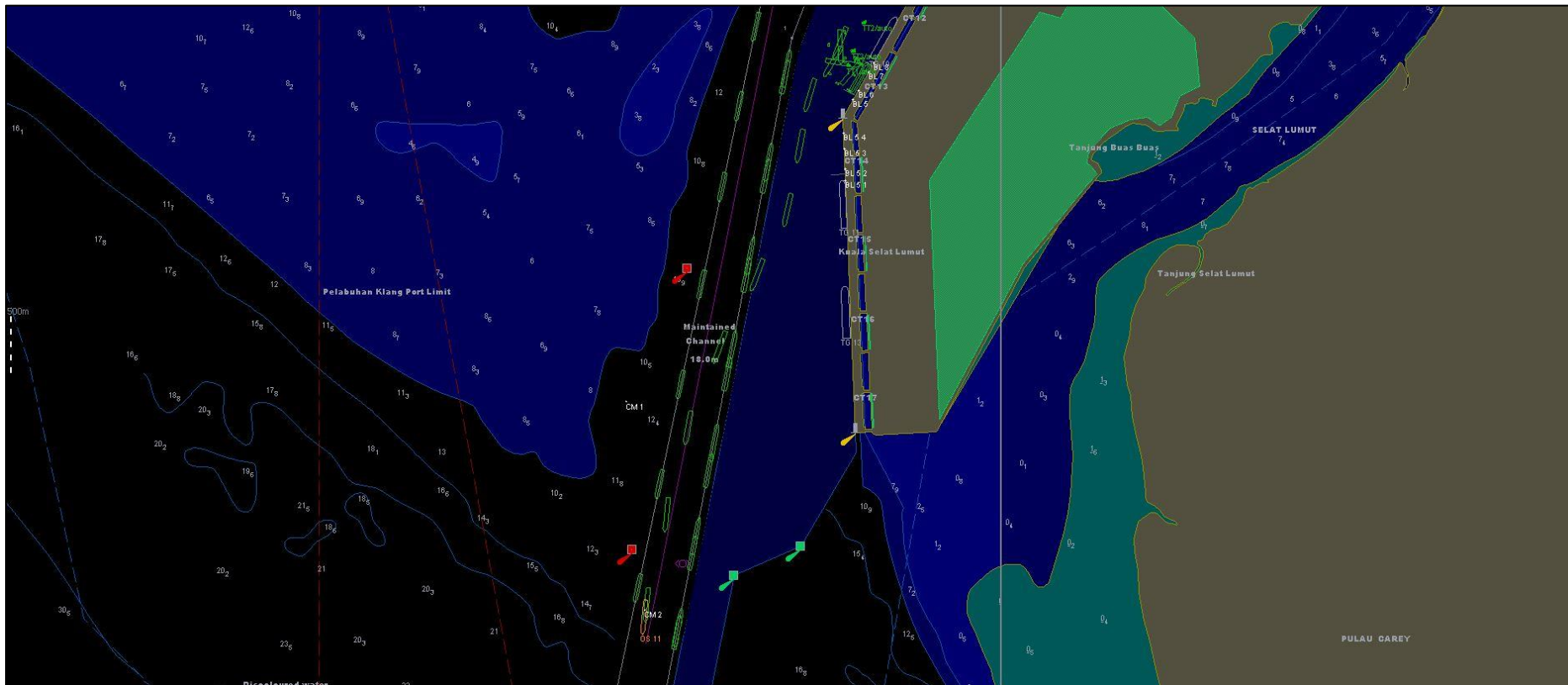


Speed Over Ground (Knots)

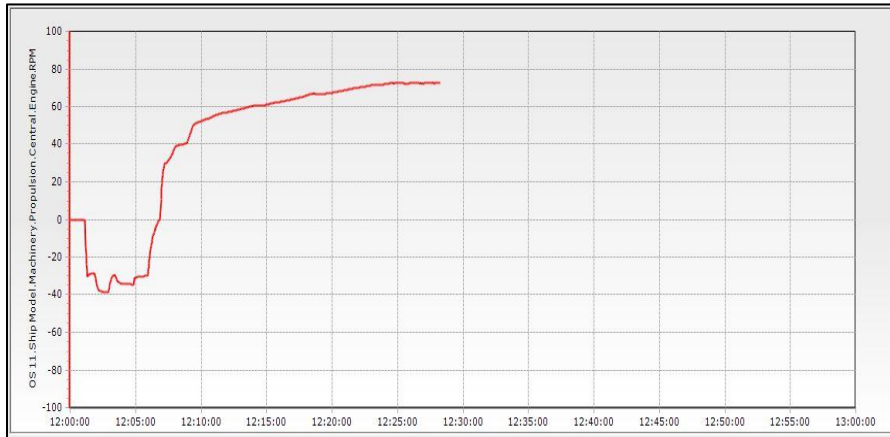


Run 11 – Container Ship Unberthing and Departing from CT13 Simultaneously with An Inbound and An Outbound Vessel

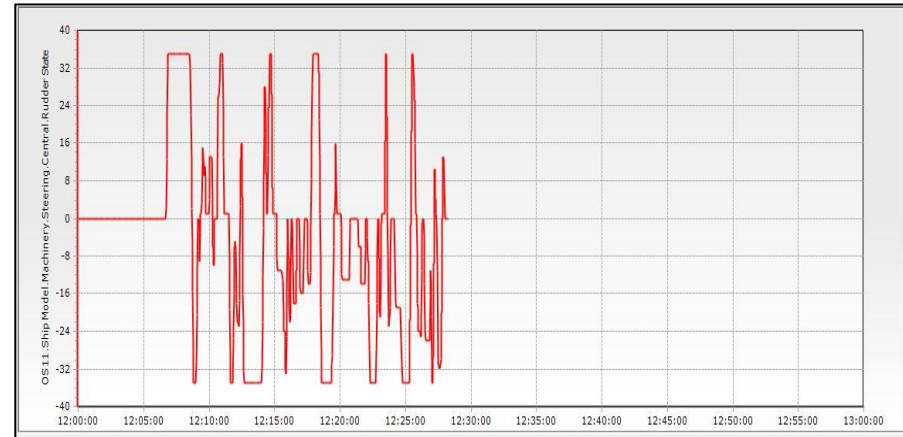
Ship Model	Container Ship, 261.4m LOA, Loaded	Tugboats, 3 x 60t ASD Tugboats	
Environmental Conditions	Current: Ebb	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship successfully unberthed, turned and departed whilst maintaining sufficient clearances from the other transiting vessels. Run rated Pass		Duration: 28minutes



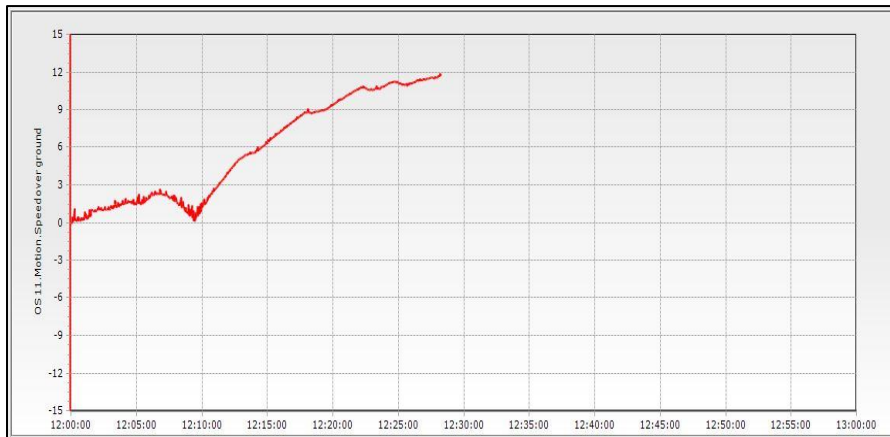
Engine RPM



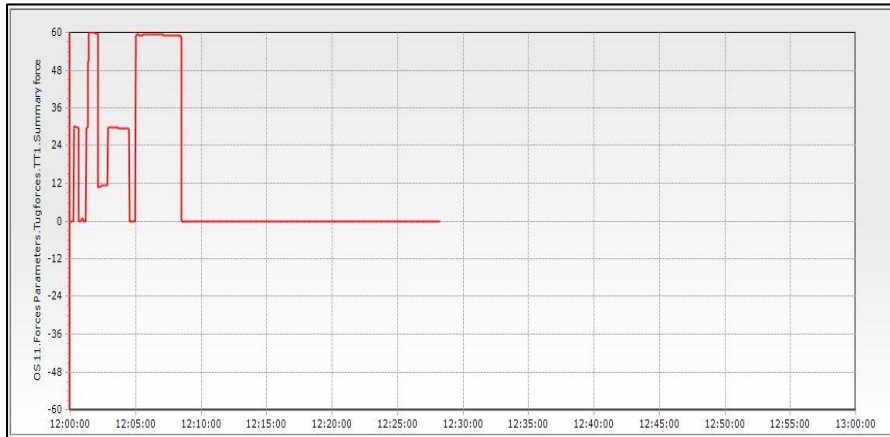
Rudder Angle



Speed Over Ground (Knots)



Tugboat 1 Force (t)



Tugboat 2 Force (t)

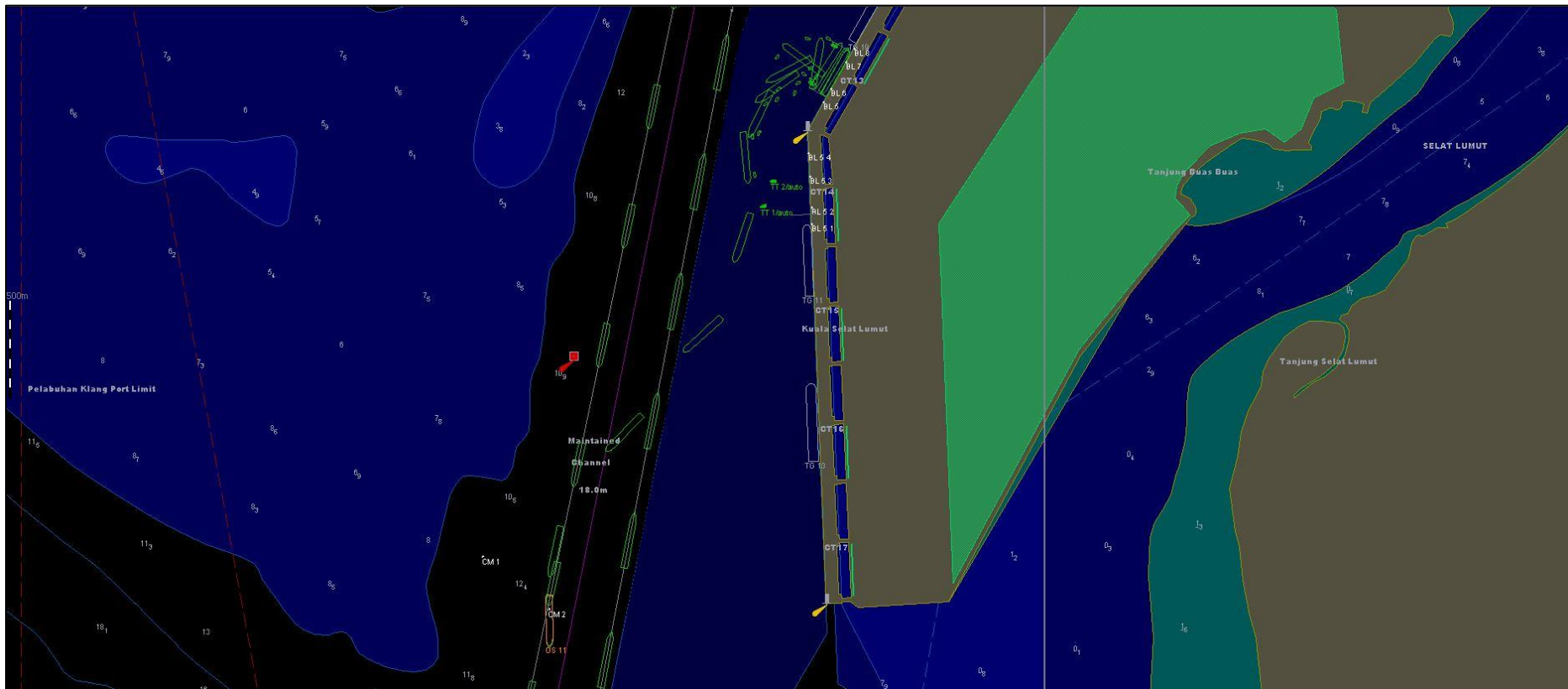


Tugboat 3 Force (t)

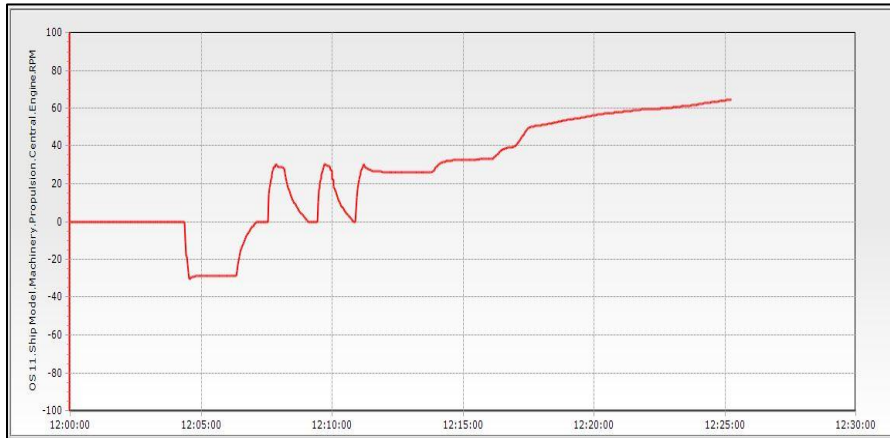


Run 12 – Container Ship Unberthing and Departing from CT13 Simultaneously with An Inbound and An Outbound Vessel

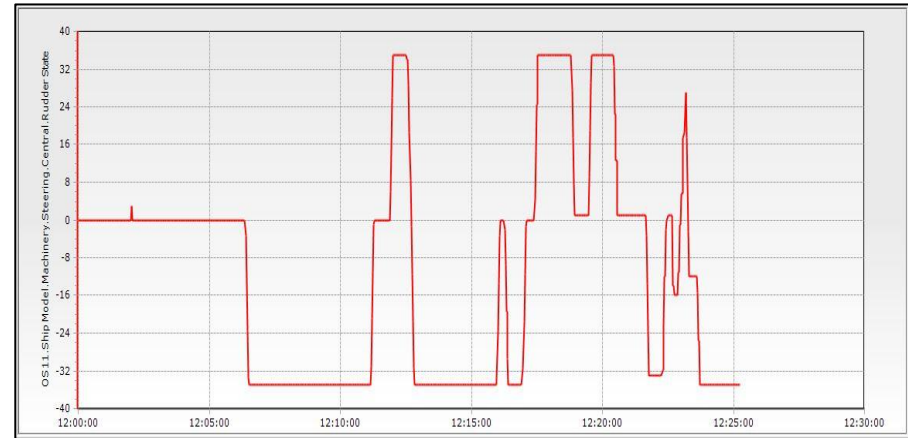
Ship Model	Container Ship, 261.4m LOA, Loaded	Tugboats, 2 x 50t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship successfully unberthed, turned and departed whilst maintaining sufficient clearances from the other transiting vessels. Run rated Pass		Duration: 27minutes



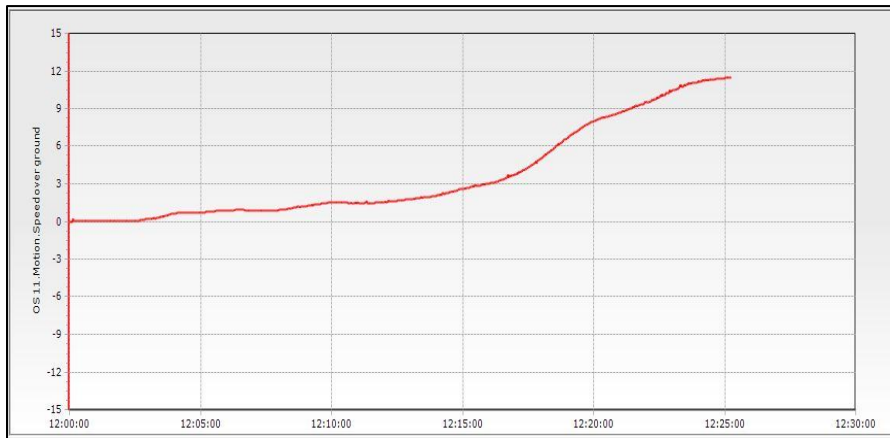
Engine RPM



Rudder Angle



Speed Over Ground (Knots)



Tugboat 1 Force (t)

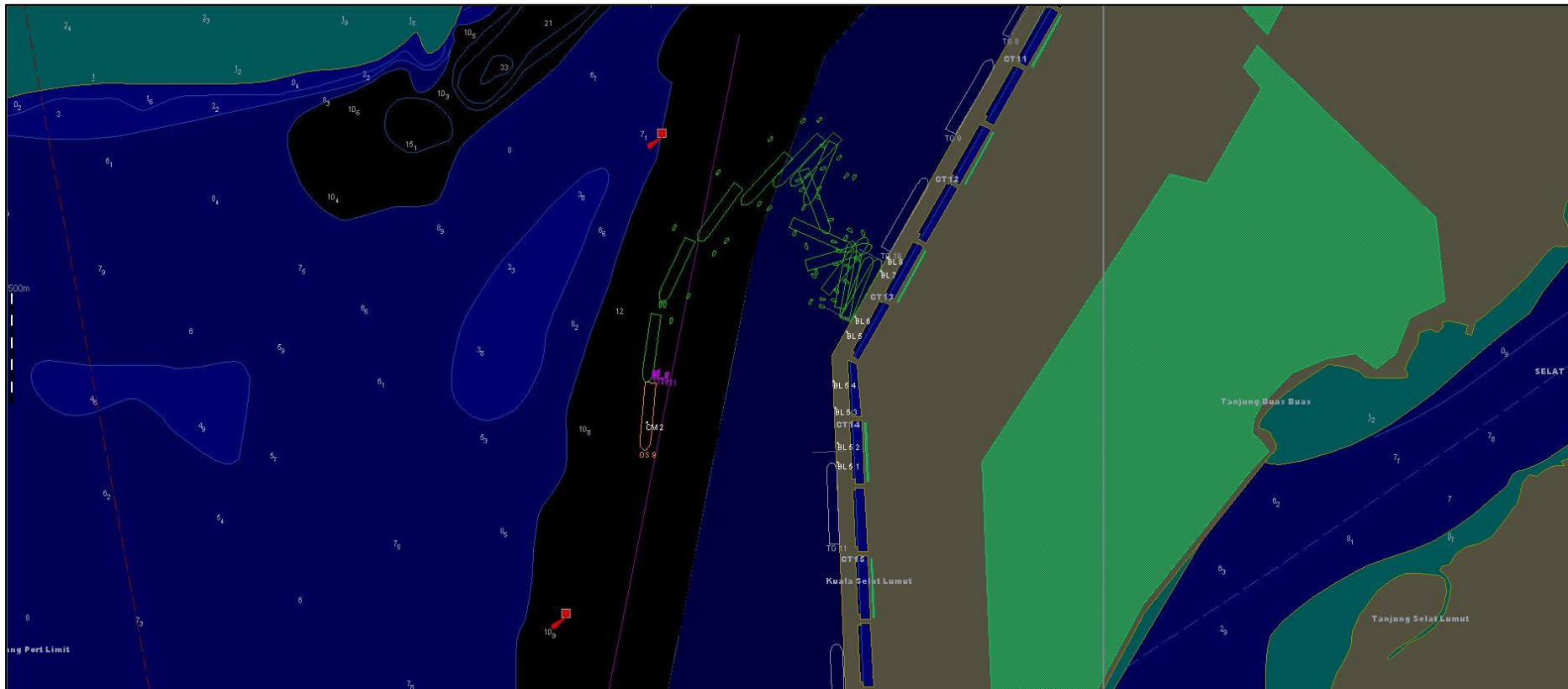


Tugboat 2 Force (t)

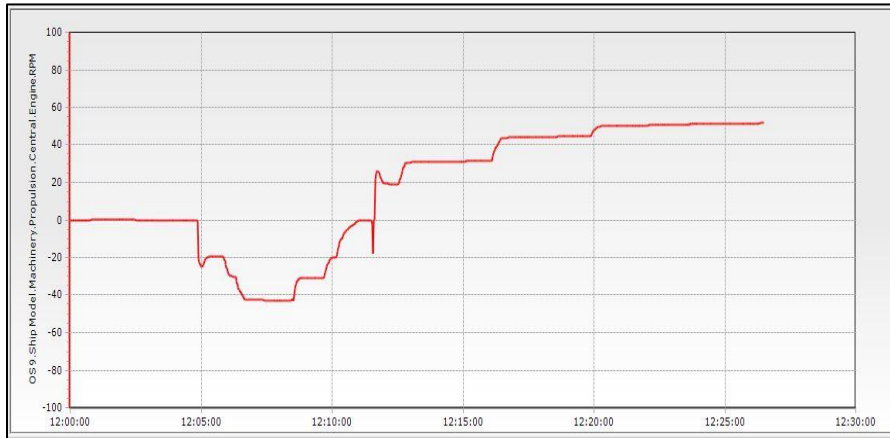


Run 13 – Container Ship Unberthing and Departing from CT13

Ship Model	Container Ship, 300m LOA, Loaded	Tugboats, 3 x 60t ASD Tugboats	
Environmental Conditions	Current: Ebb	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship successfully unberthed, turned and departed. Run rated Pass		Duration: 27minutes



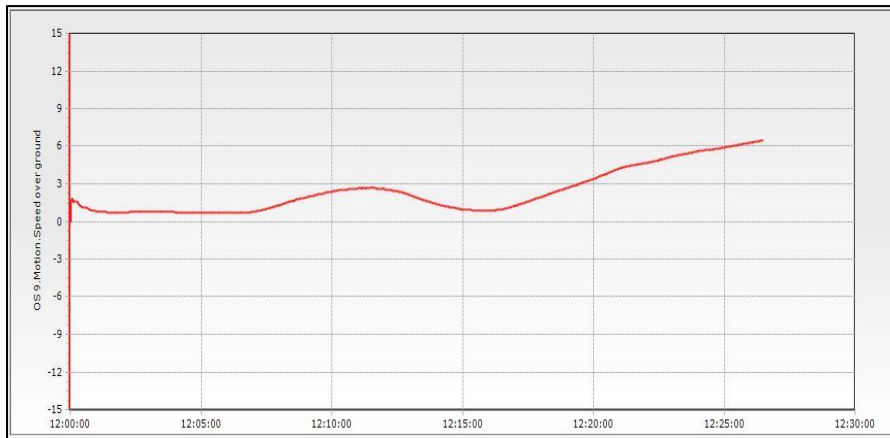
Engine RPM



Rudder Angle



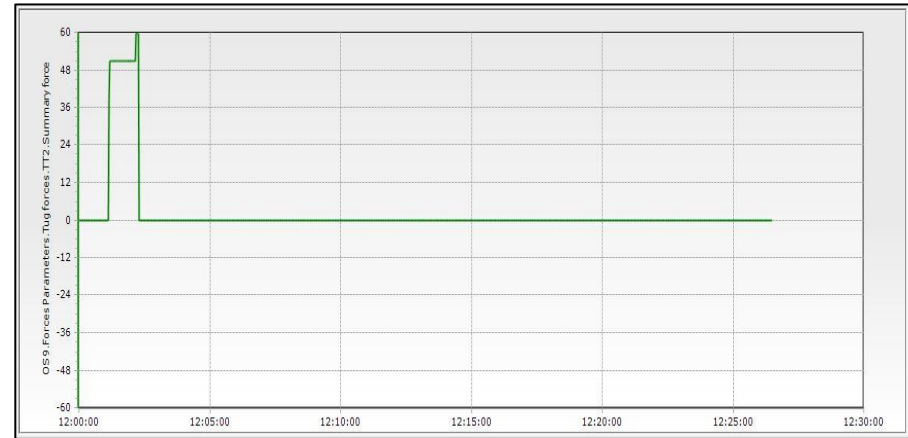
Speed Over Ground (Knots)



Tugboat 1 Force (t)



Tugboat 2 Force (t)

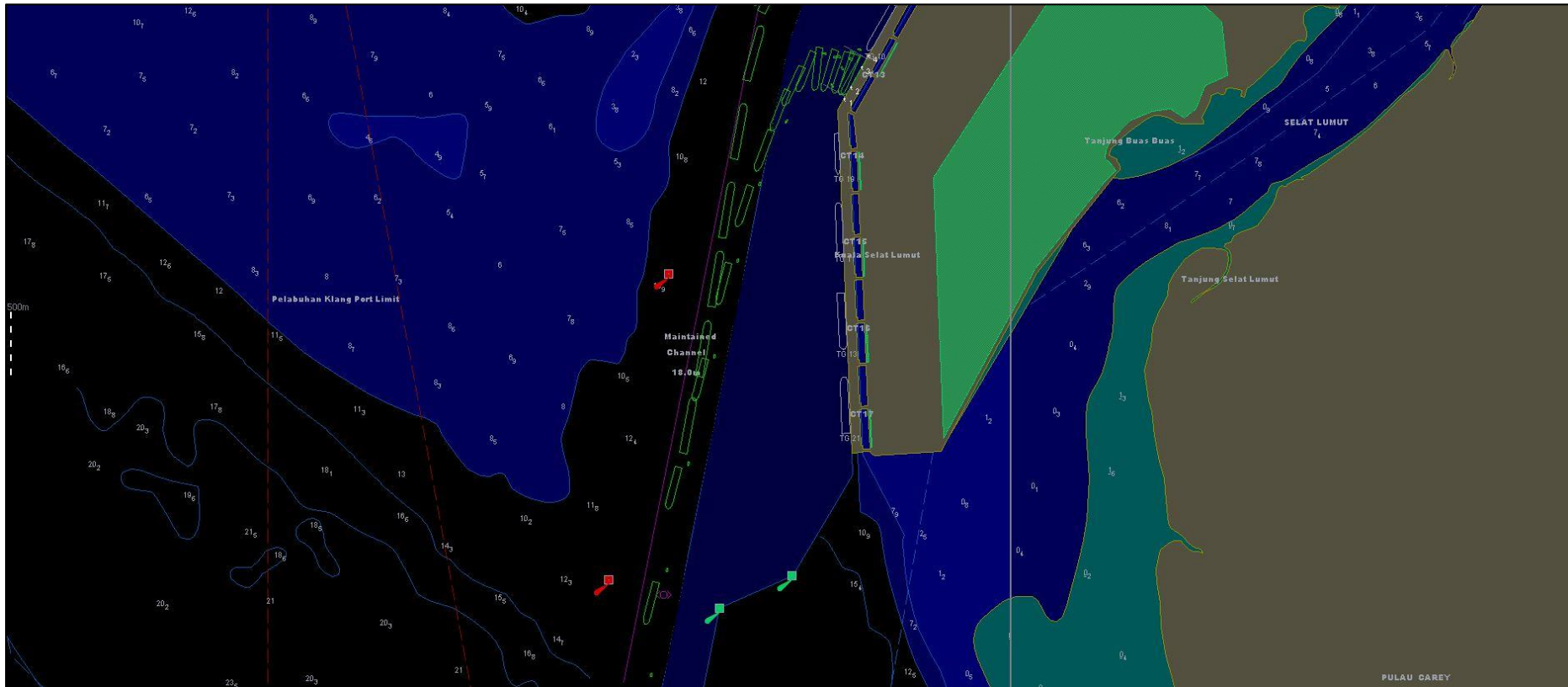


Tugboat 3 Force (t)



Run 14 – Container Ship Unberthing and Departing from CT13

Ship Model	Container Ship, 300m LOA, Loaded	Tugboats, 3 x 60t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / NE	Wave: 1 – 1.5m / NE
Run Outcome	Ship successfully unberthed, turned and departed whilst maintaining sufficient clearances from the inbound vessels. Run rated Pass		Duration: 40minutes



Engine RPM



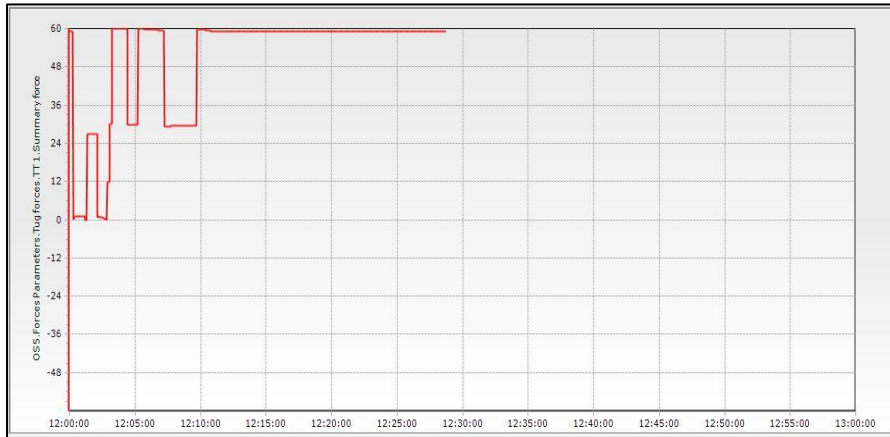
Rudder Angle



Speed Over Ground (Knots)



Tugboat 1 Force (t)



Tugboat 2 Force (t)

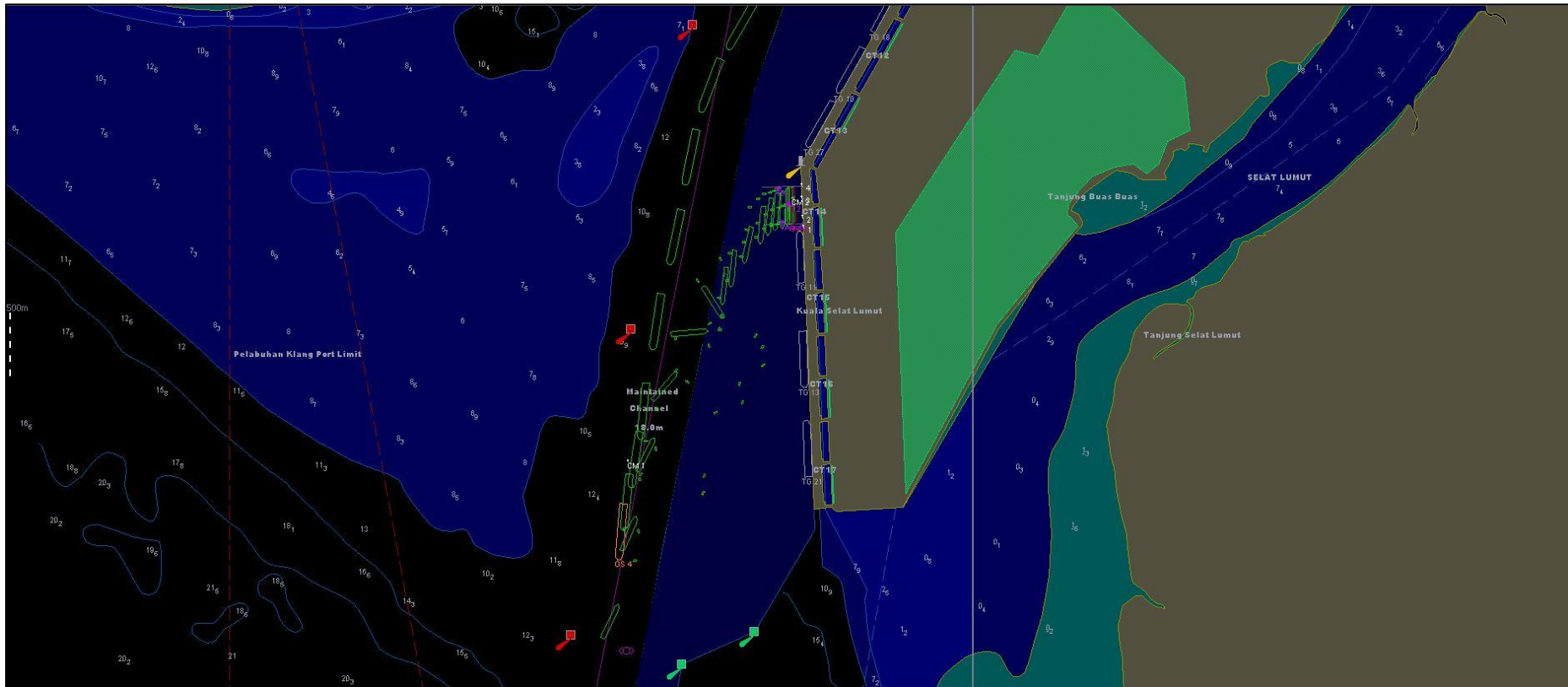


Tugboat 3 Force (t)



Run 15 – Container Ship Approaching and Berthing at CT14 Simultaneously with An Outbound Vessel

Ship Model	Container Ship, 261.4m LOA, Loaded	Tugboats; 3 x 50t ASD Tugboats	
Environmental Conditions	Current: Ebb	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship successfully berth alongside at CT14 whilst maintaining sufficient clearances from the outbound vessel. Run rated Pass		Duration: 35minutes



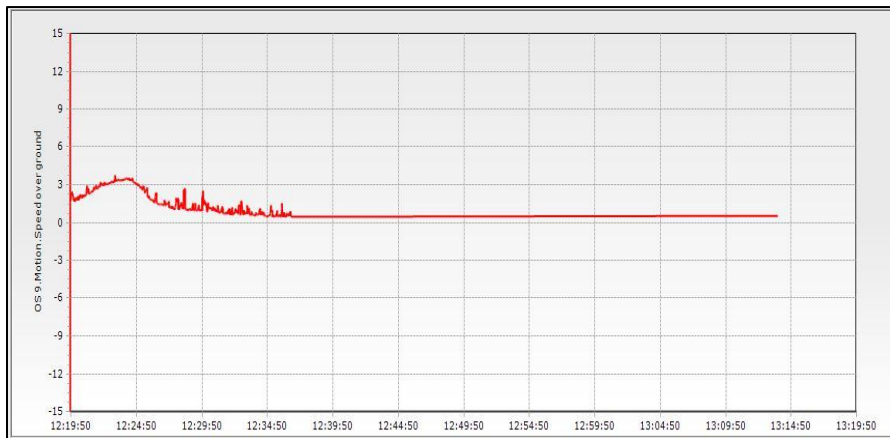
Engine RPM



Rudder Angle



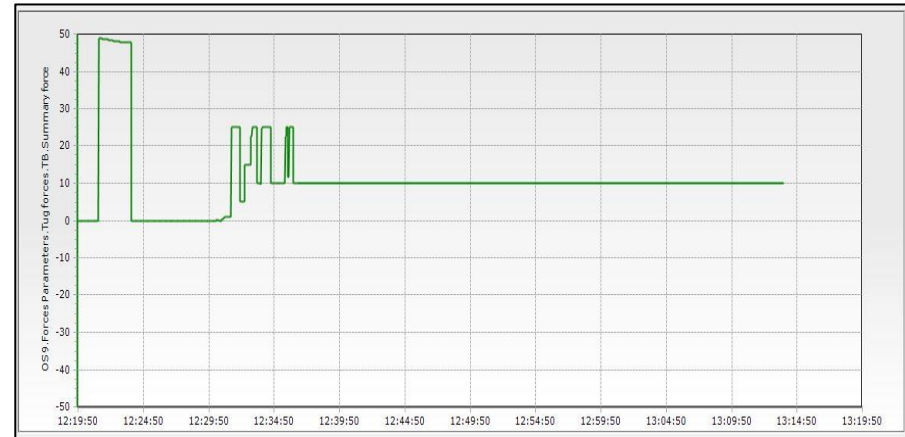
Speed Over Ground (Knots)



Tugboat 1 Force (t)



Tugboat 2 Force (t)

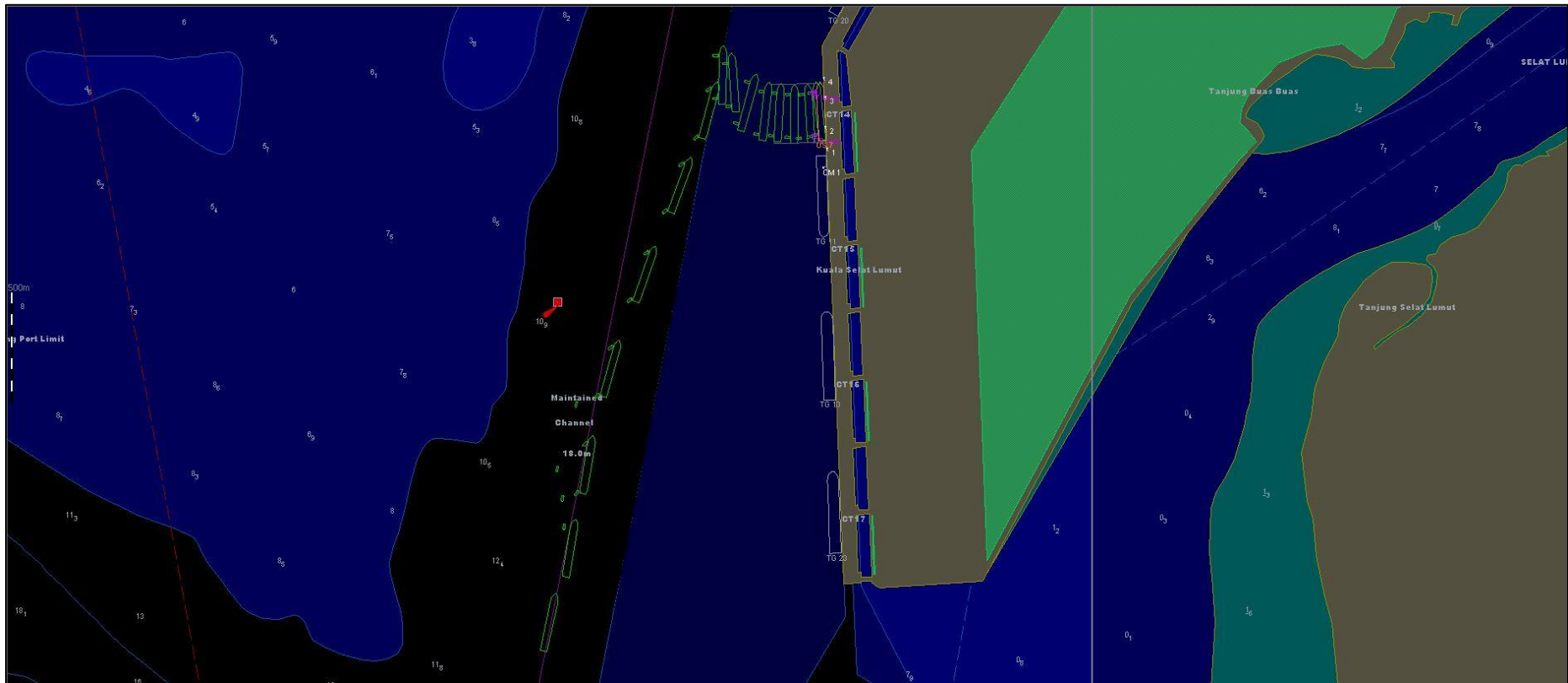


Tugboat 3 Force (t)

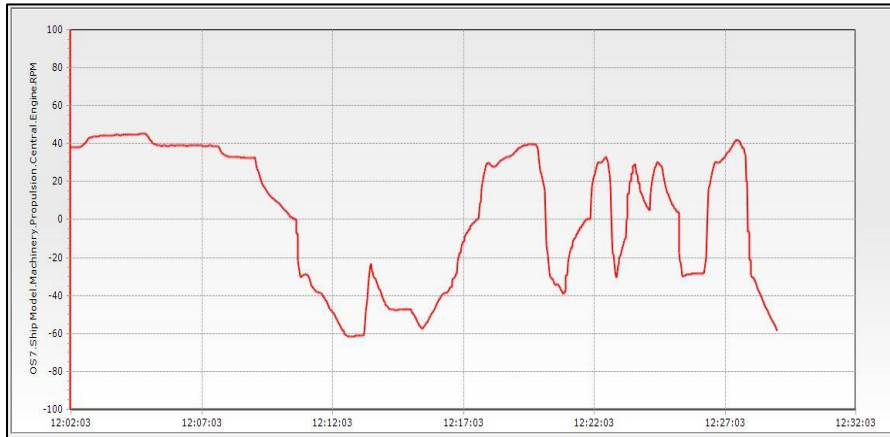


Run 16 – Container Ship Approaching and Berthing at CT14

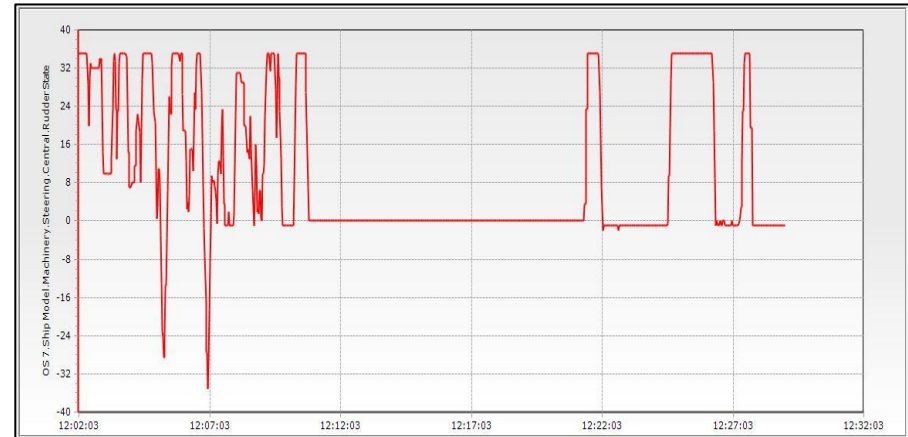
Ship Model	Container Ship, 261.4m LOA, Loaded	Tugboats, 2 x 50t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship successfully berth alongside. Run rated Pass		Duration: 29minutes



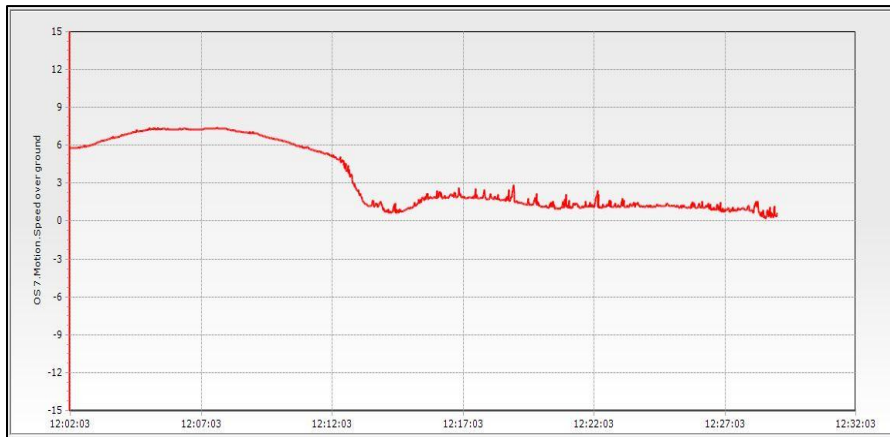
Engine RPM



Rudder Angle



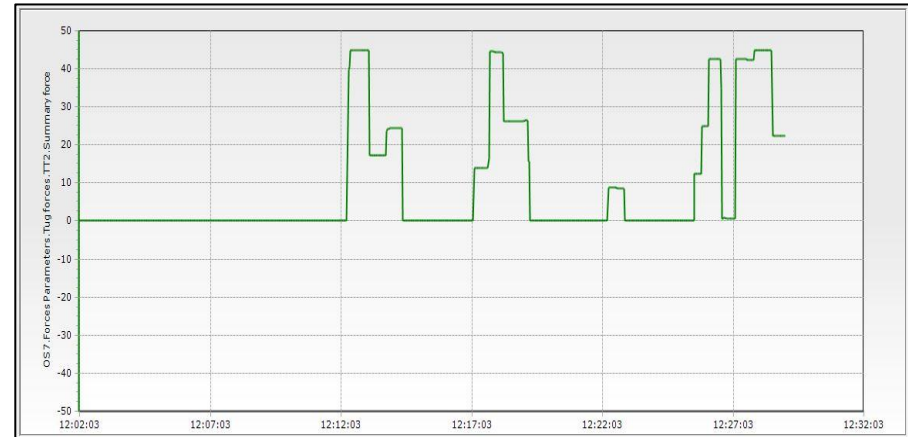
Speed Over Ground (Knots)



Tugboat 1 Force (t)

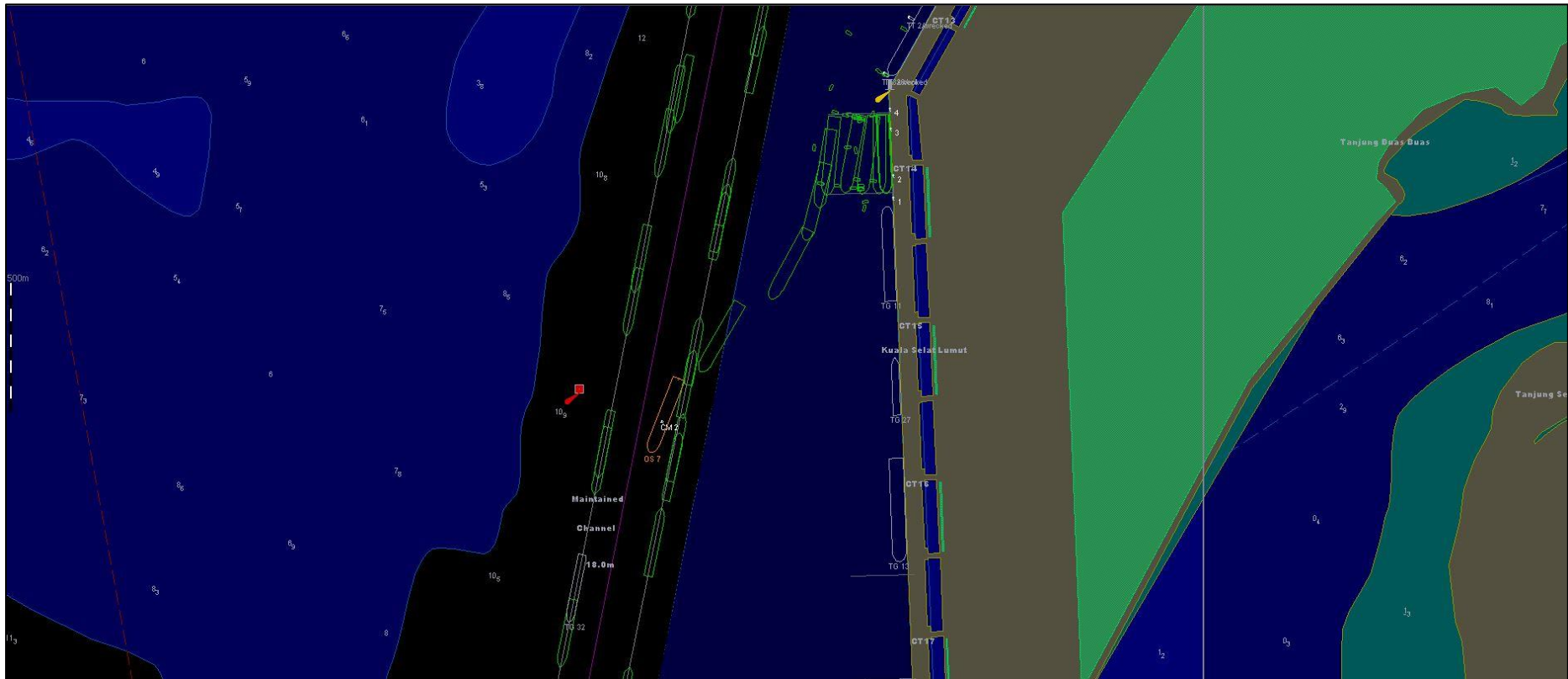


Tugboat 2 Force (t)

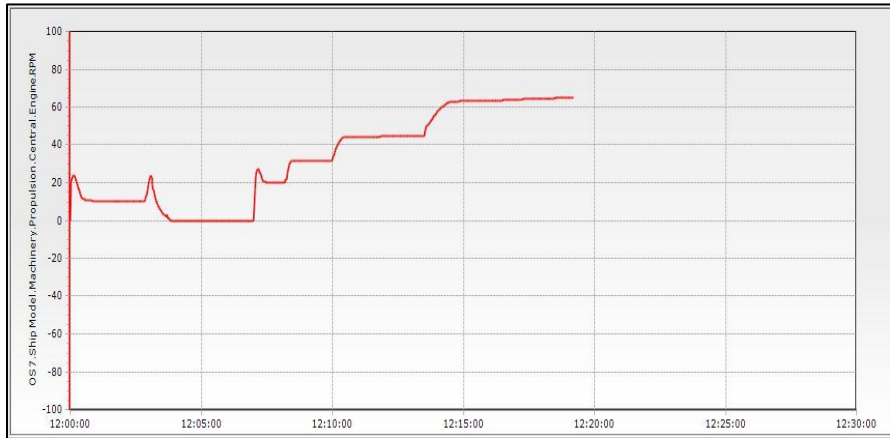


Run 17 – Container Ship Unberthing And Departing from CT14 with An Inbound Vessel and An Outbound Vessel

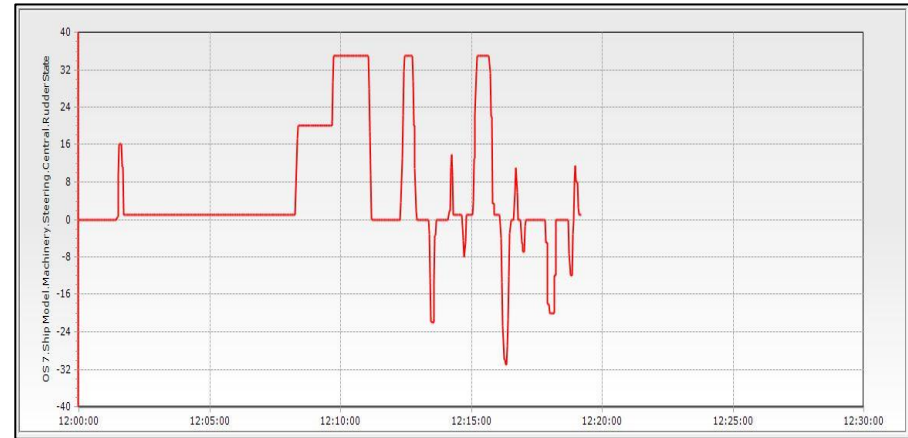
Ship Model	Container Ship, 300m LOA, Loaded	Tugboats, 3 x 60t ASD Tugboats	
Environmental Conditions	Current: Ebb	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship successfully unberths and departed whilst maintaining sufficient clearances from the other transiting vessels. Run rated Pass		Duration: 19minutes



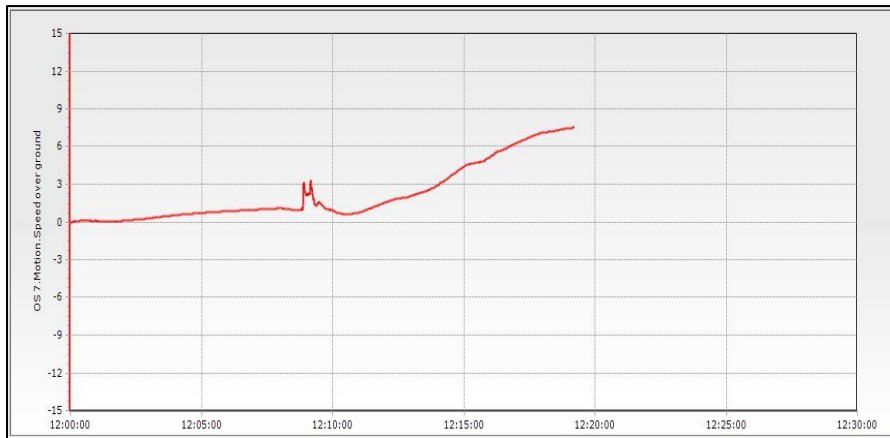
Engine RPM



Rudder Angle



Speed Over Ground (Knots)



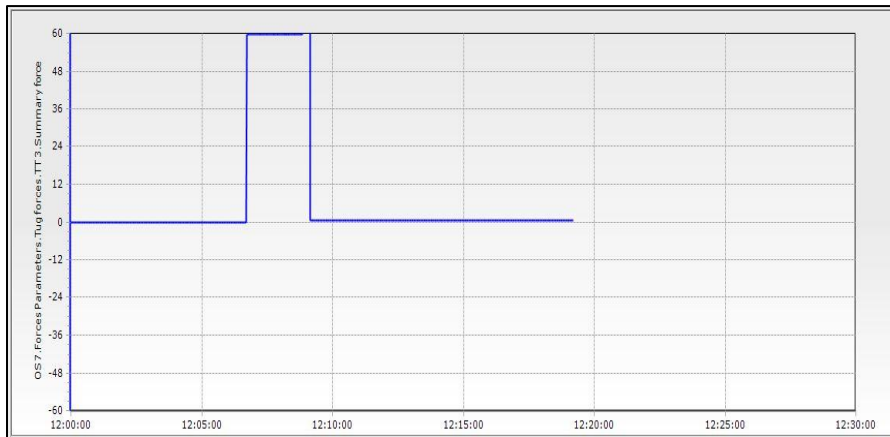
Tugboat 1 Force (t)



Tugboat 2 Force (t)



Tugboat 3 Force (t)

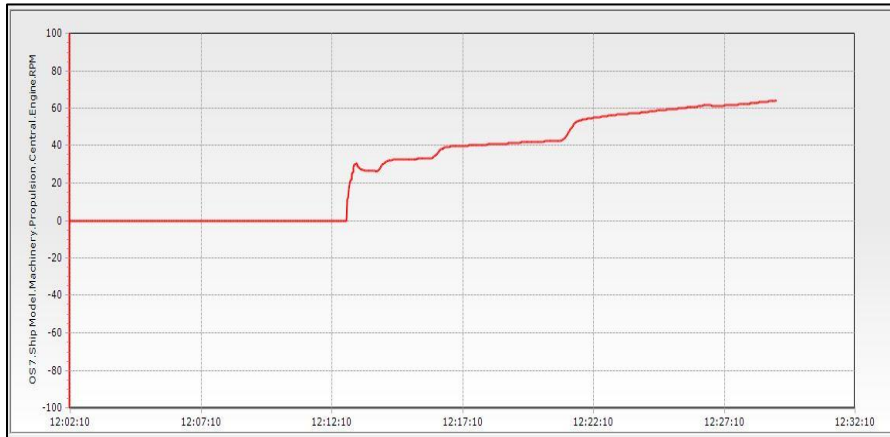


Run 18 – Container Ship Unberthing and Departing from CT14 with An Inbound Vessel

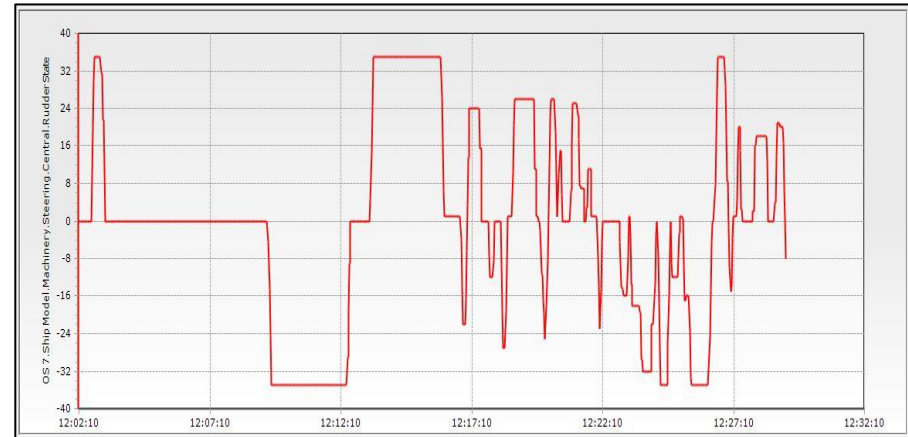
Ship Model	Container Ship, 261.4m LOA, Loaded	Tugboats, 2 x 50t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship successfully unberths whilst maintaining sufficient clearances from the inbound vessels. Run rated Pass		Duration: 30minutes



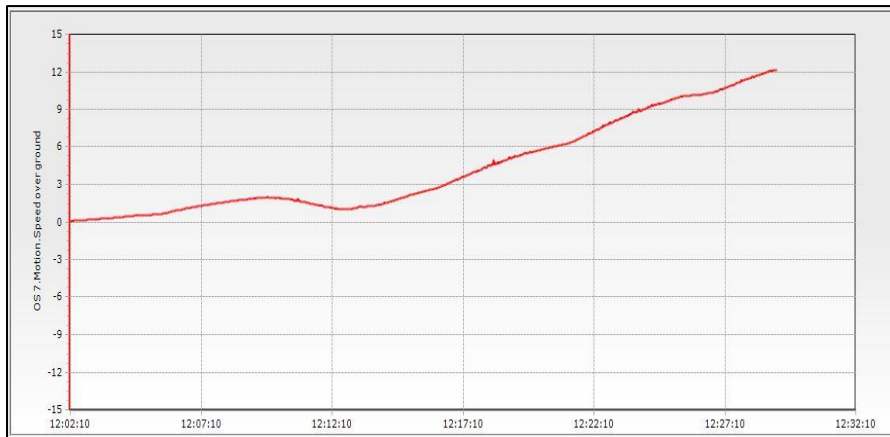
Engine RPM



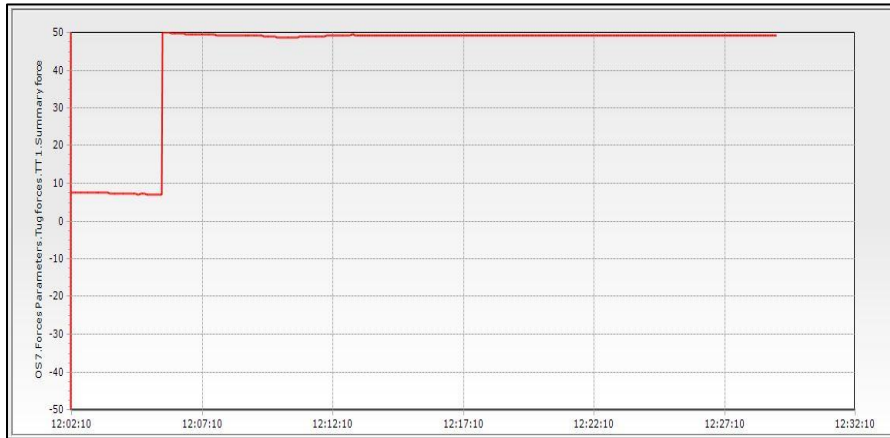
Rudder Angle



Speed Over Ground (Knots)



Tugboat 1 Force (t)

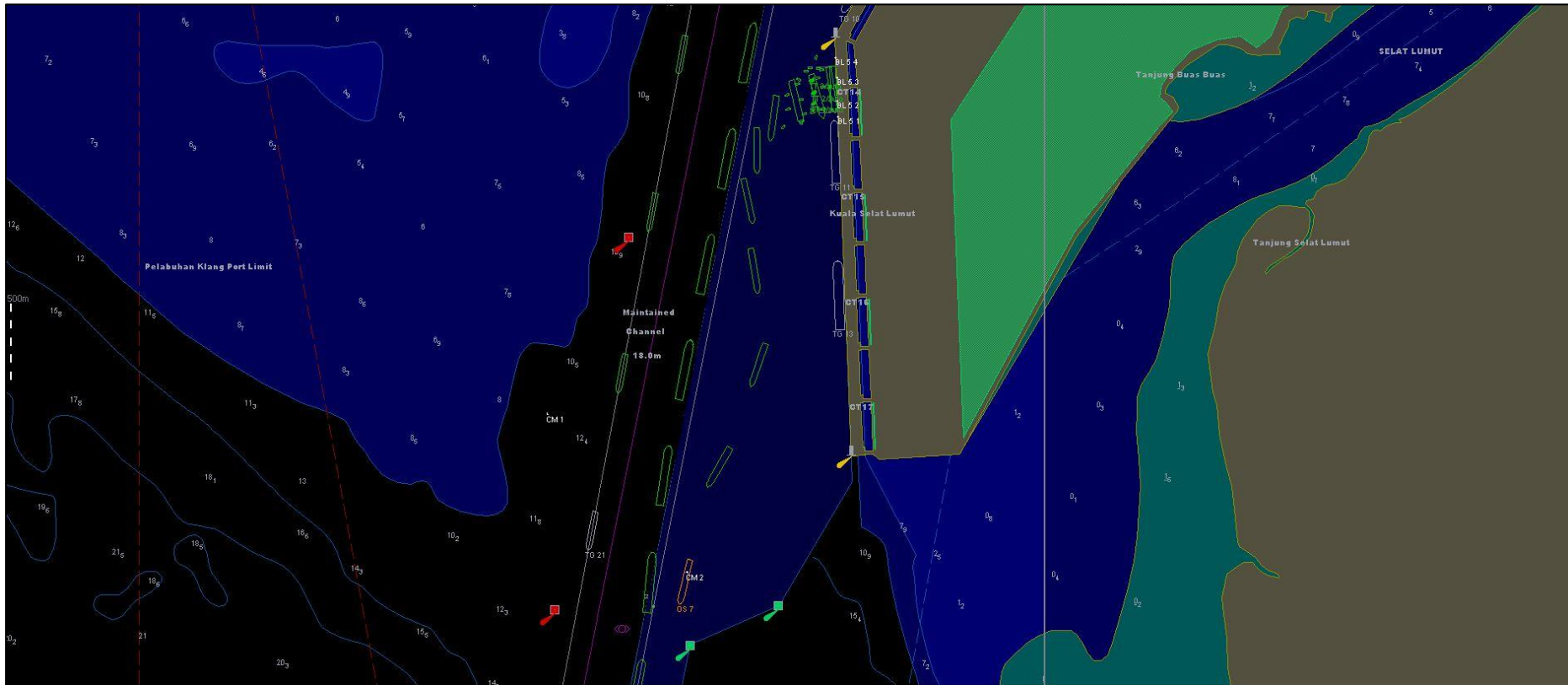


Tugboat 2 Force (t)



Run 19 – Container Ship Unberthing and Departing from CT14 with An Inbound Vessel and An Outbound Vessel

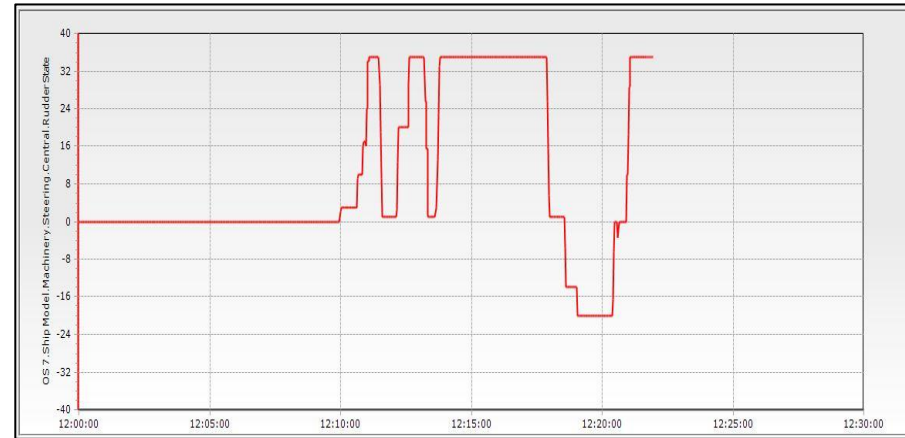
Ship Model	Container Ship, 261.4m LOA, Loaded	Tugboats, 3 x 50t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / NE	Wave: 1 – 1.5m / NE
Run Outcome	Ship successfully unberths and departed from CT14 maintaining sufficient clearances from the inbound vessels.		Duration: 20minutes
	Run rated Pass		



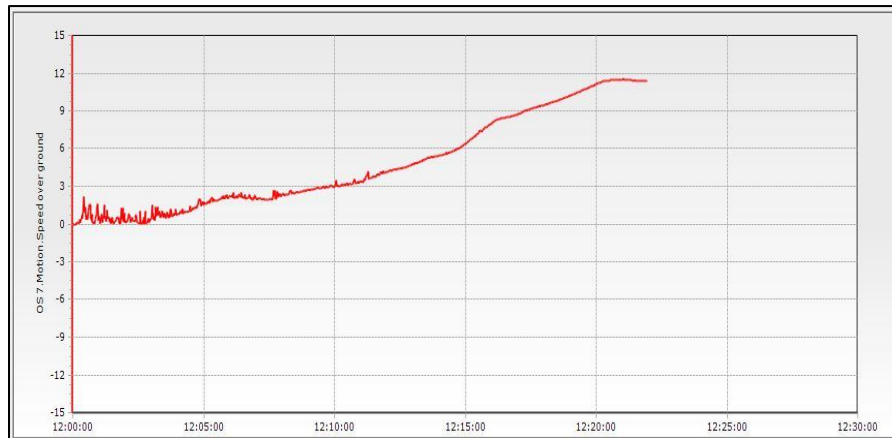
Engine RPM



Rudder Angle



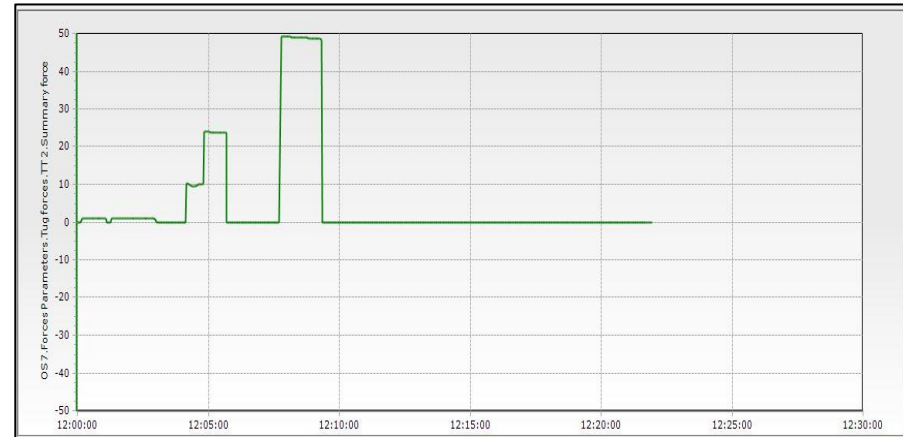
Speed Over Ground (Knots)



Tugboat 1 Force (t)



Tugboat 2 Force (t)

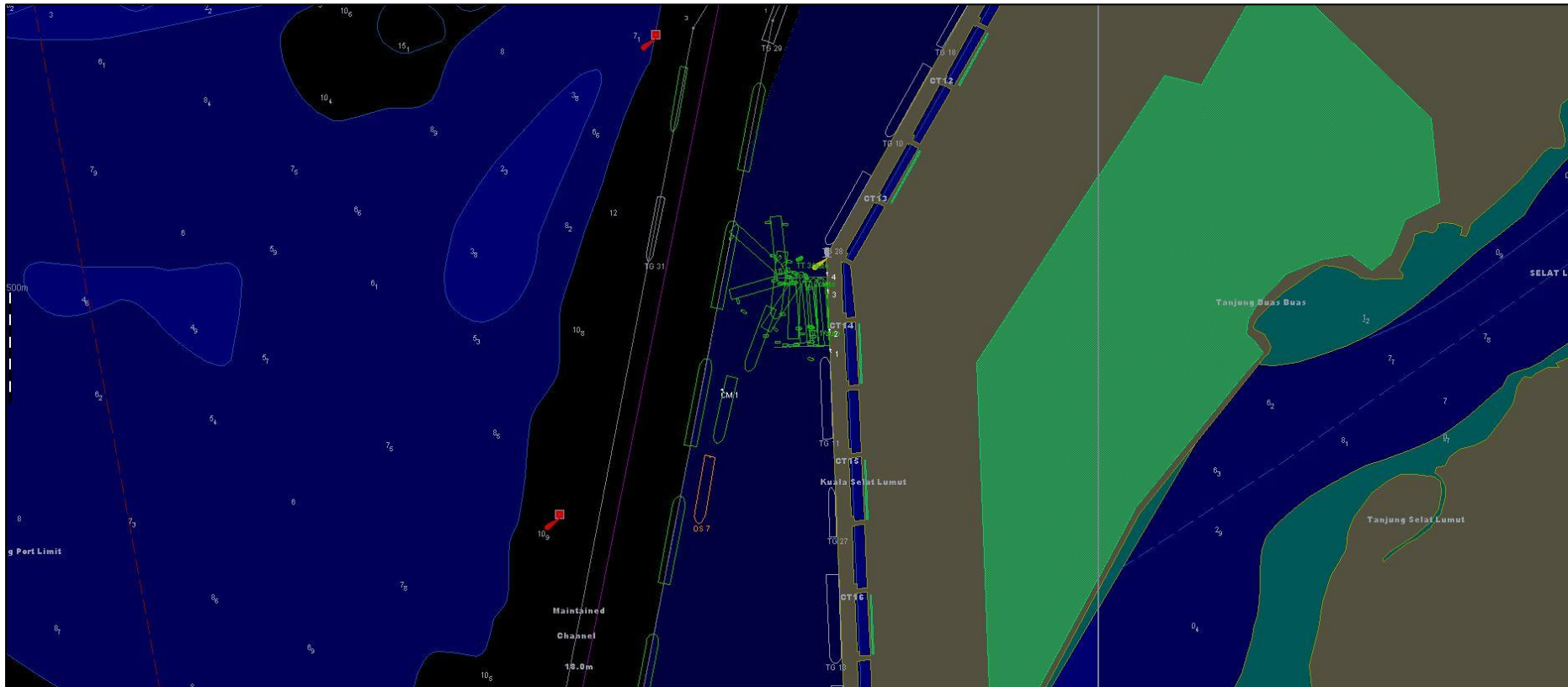


Tugboat 3 Force (t)

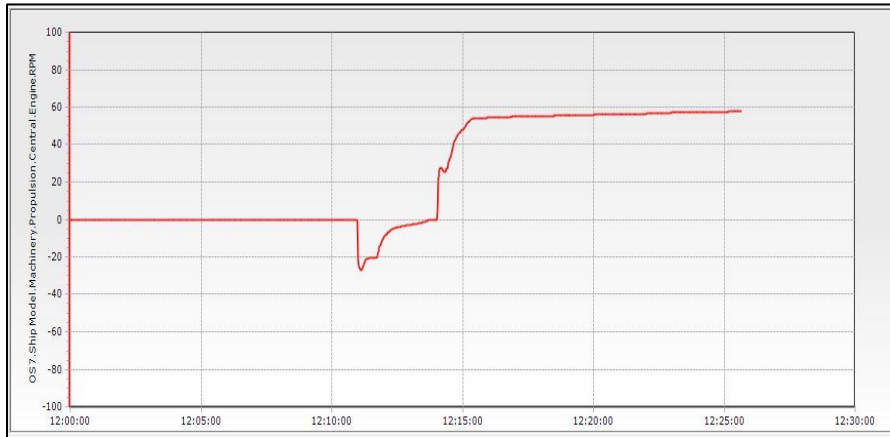


Run 20 – Container Ship Unberthing and Departing from CT14

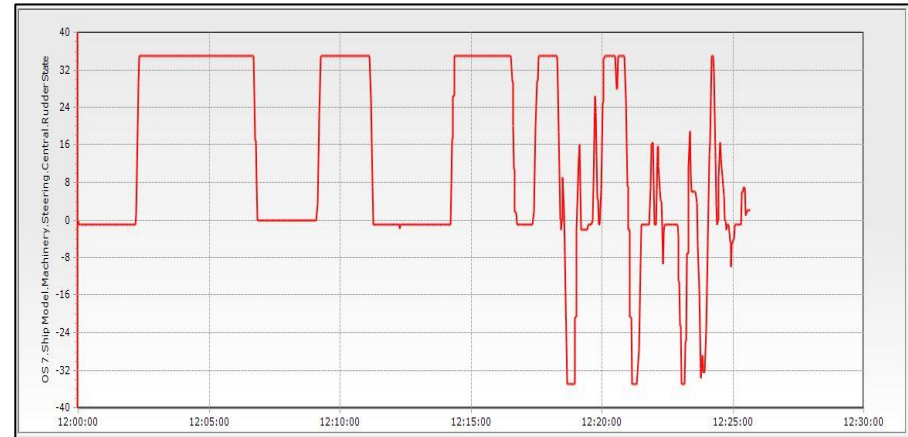
Ship Model	Container Ship, 300m LOA, Loaded	Tugboats, 3 x 50t ASD Tugboats	
Environmental Conditions	Current: Ebb	Wind: 20 – 25 knots / NE	Wave: 1 – 1.5m / NE
Run Outcome	Ship successfully unberths, turned and departed from CT14 whilst maintaining sufficient clearances from the other transiting vessels. Run rated Pass		Duration: 26minutes



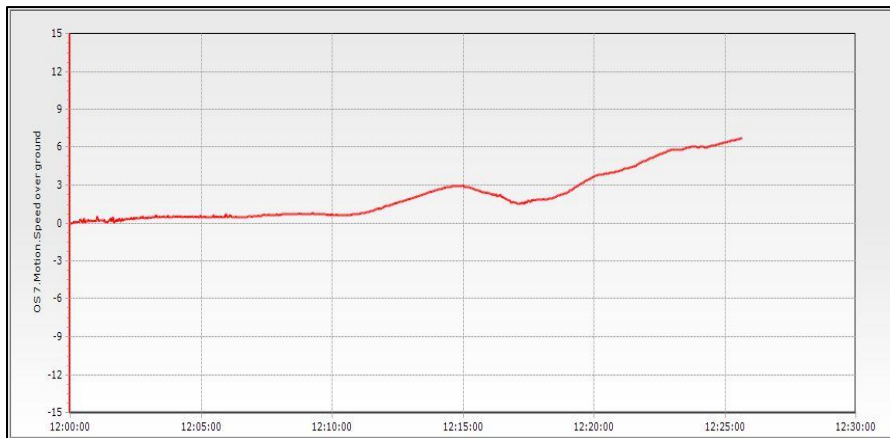
Engine RPM



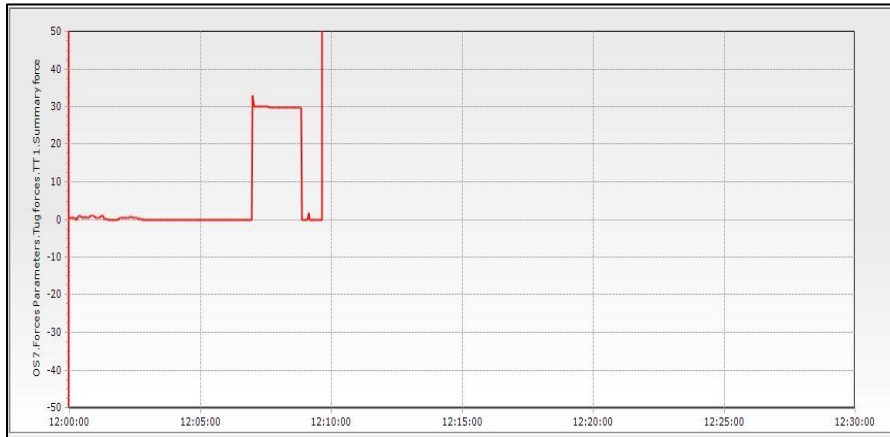
Rudder Angle



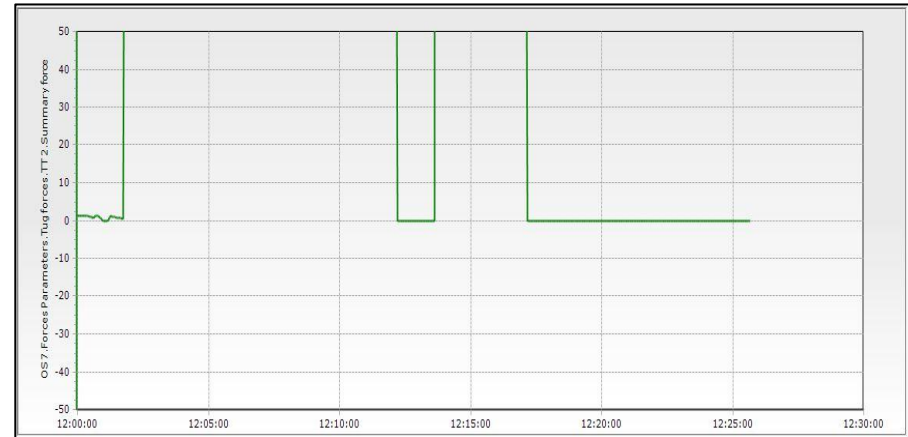
Speed Over Ground (Knots)



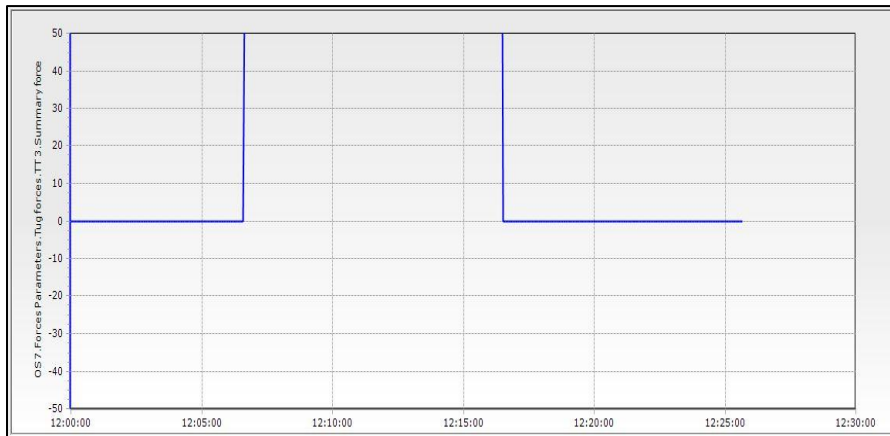
Tugboat 1 Force (t)



Tugboat 2 Force (t)

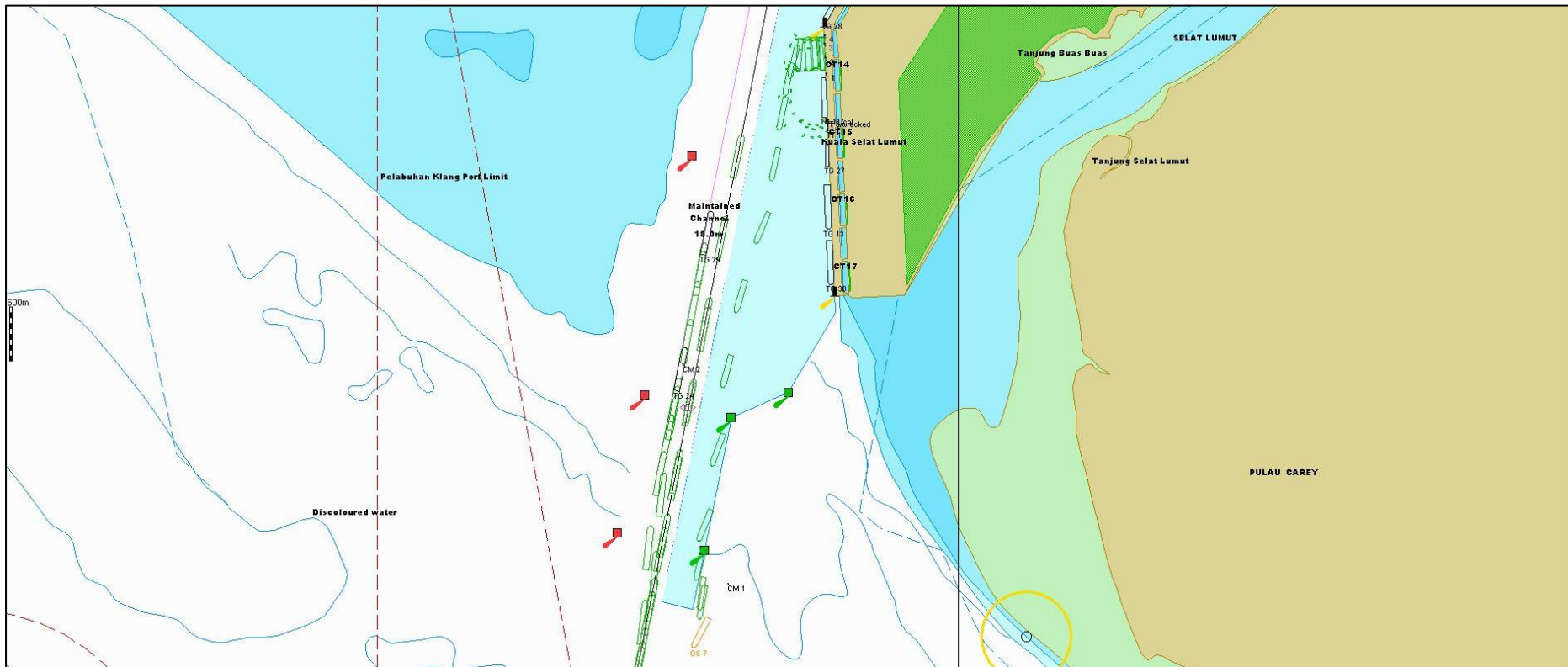


Tugboat 3 Force (t)

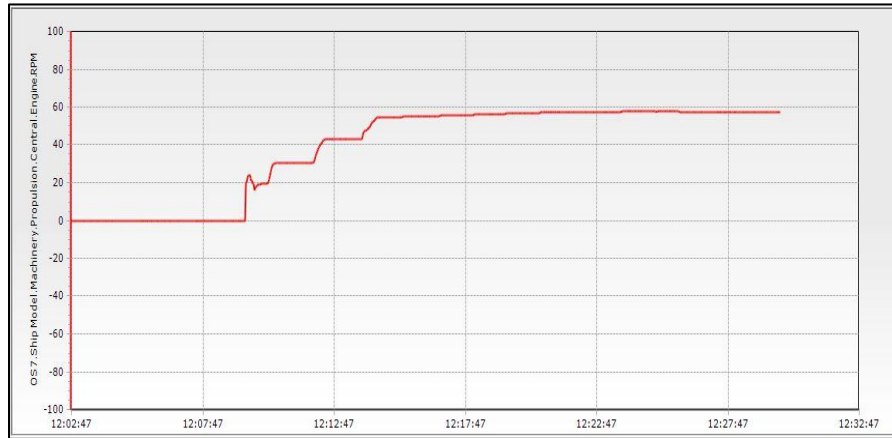


Run 21 – Container Ship Unberthing and Departing from CT14 Simultaneously with An Inbound Vessel and Outbound Vessel

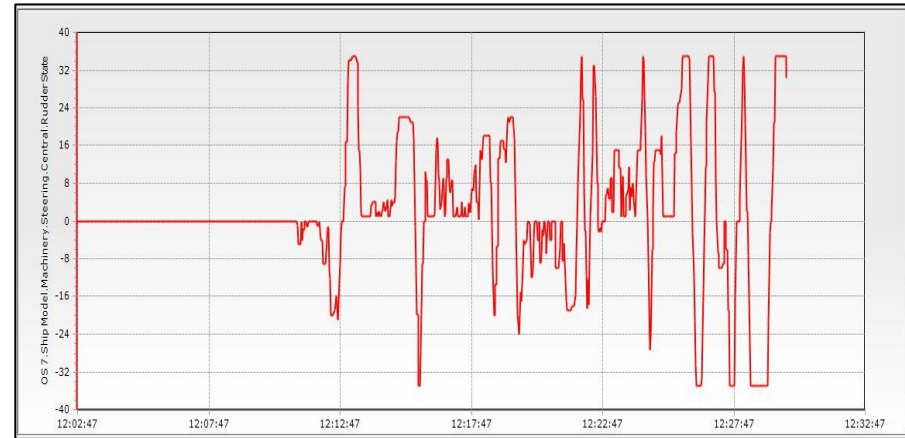
Ship Model	Container Ship, 300m LOA, Loaded	Tugboats, 3 x 60t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Vessel drifted and allided with the green buoy at the channel entrance as vessel did not manage to gain enough speed to counteract the strong cross current within the approach channel. Run rated Fail		Duration: 25 minutes
Recommendation	Shifting the 2nd green buoy at the channel entrance would create more room for the departing container ship to pick up speed to counteract the cross current at the channel entrance.		



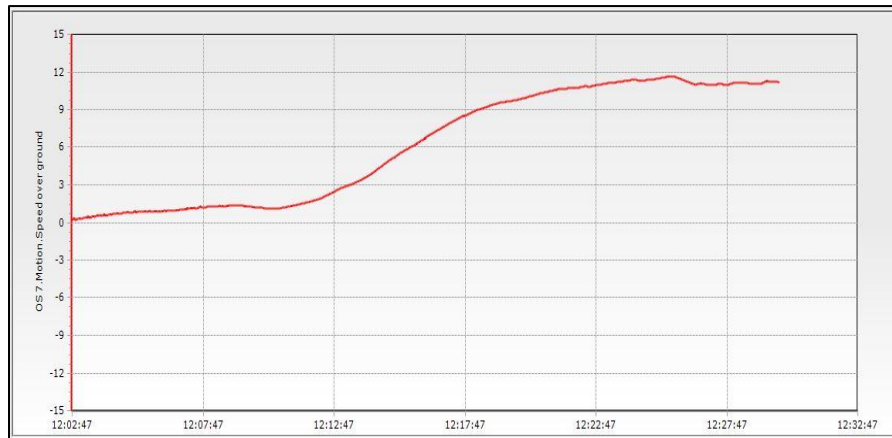
Engine RPM



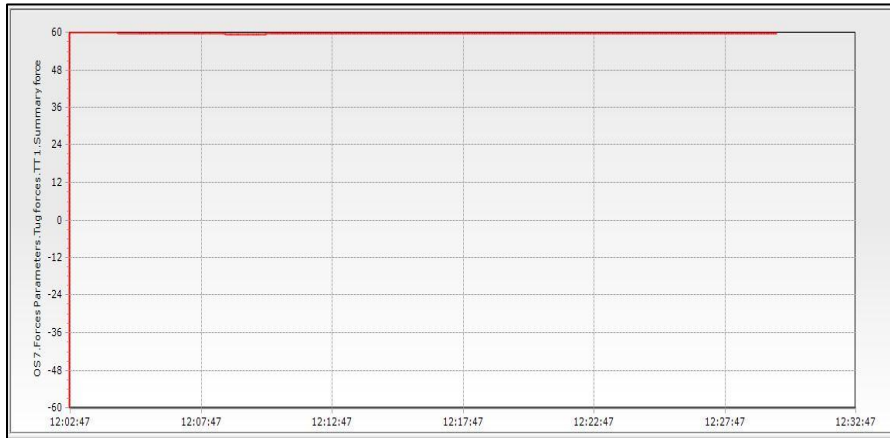
Rudder Angle



Speed Over Ground (Knots)



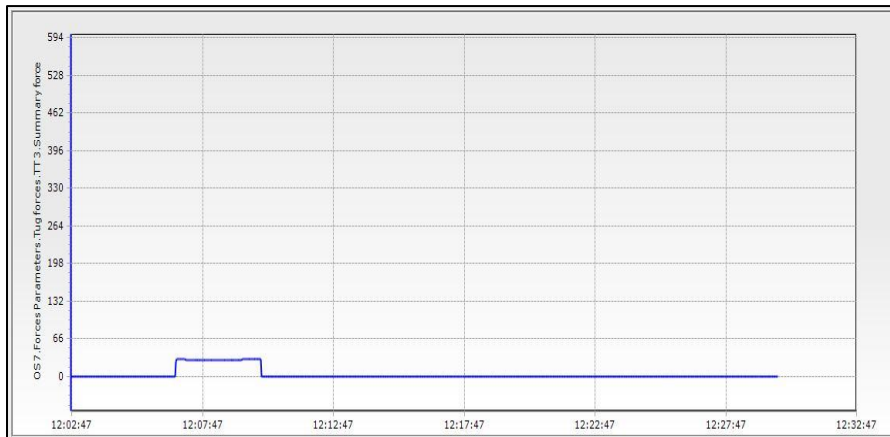
Tugboat 1 Force (t)



Tugboat 2 Force (t)

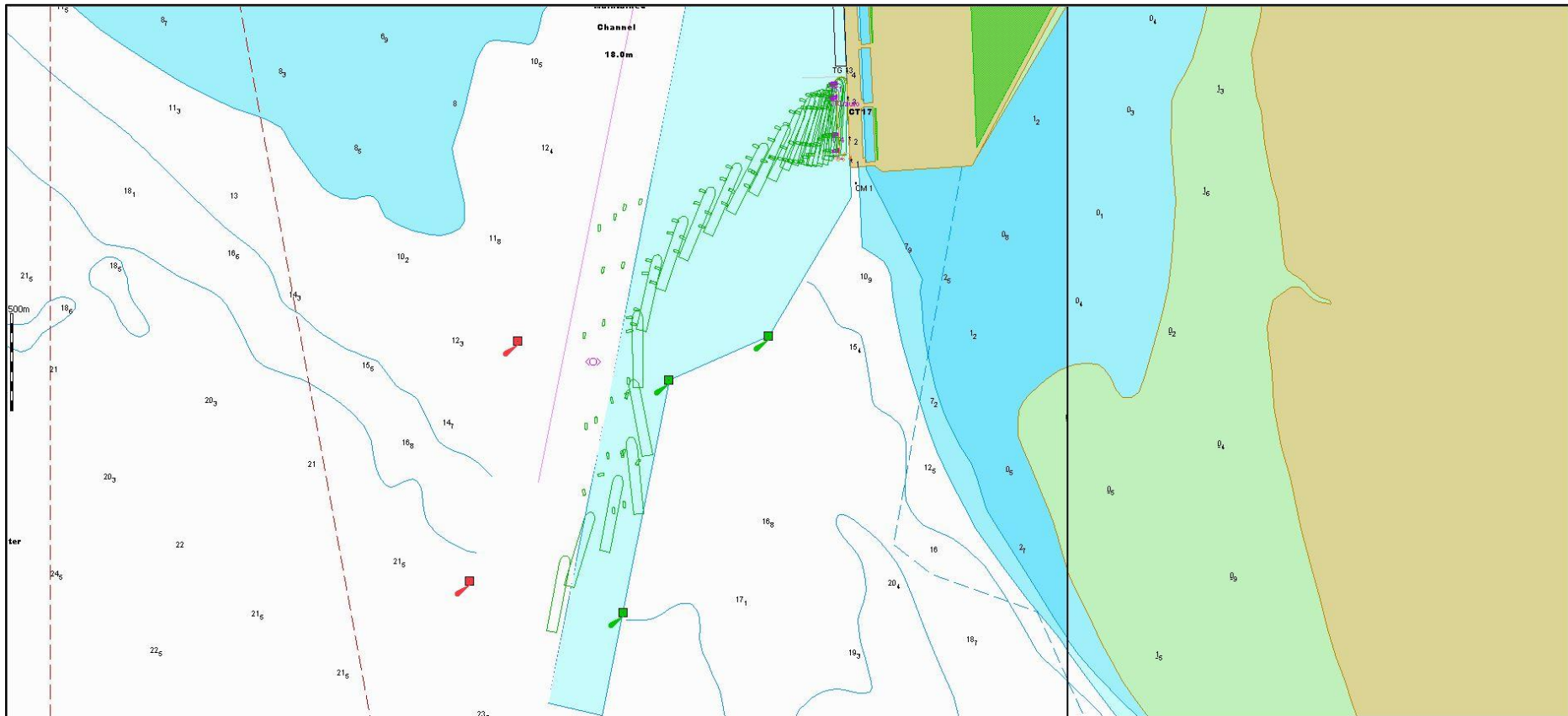


Tugboat 3 Force (t)



Run 22 – Container Ship Approaching and Berthing at CT17

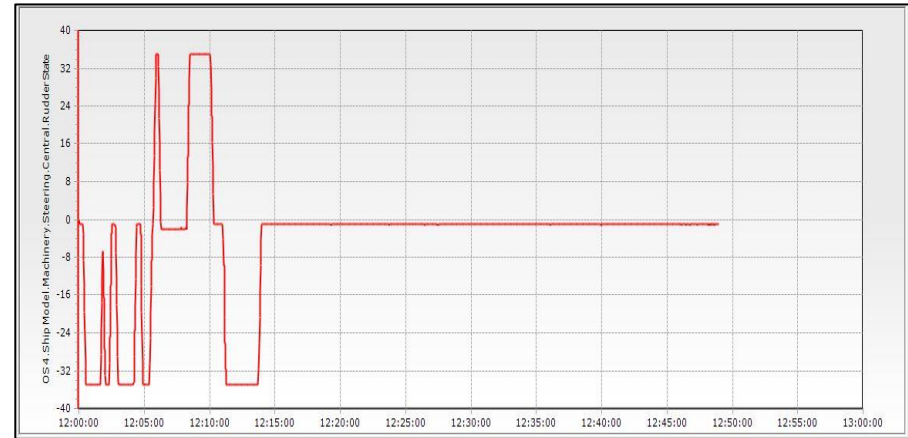
Ship Model	Container Ship, 396m LOA, Loaded	Tugboats, 4 x 70t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / NE	Wave: 1 – 1.5m / NE
Run Outcome	Ship successfully berth alongside. Run rated Pass		Duration: 50minutes



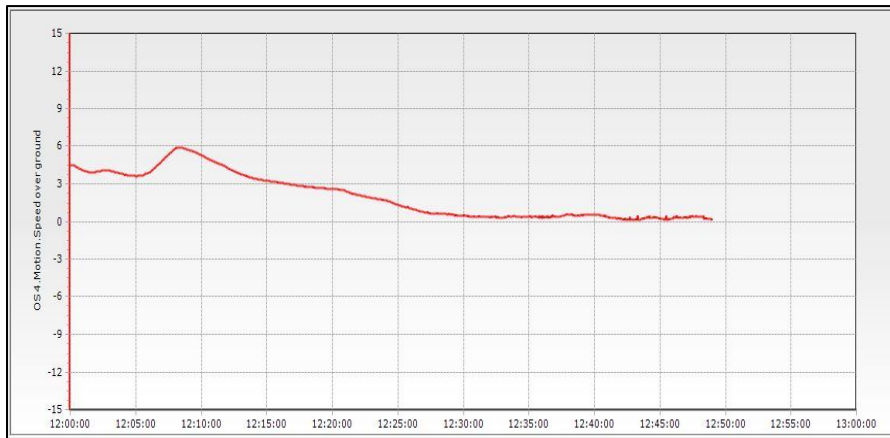
Engine RPM



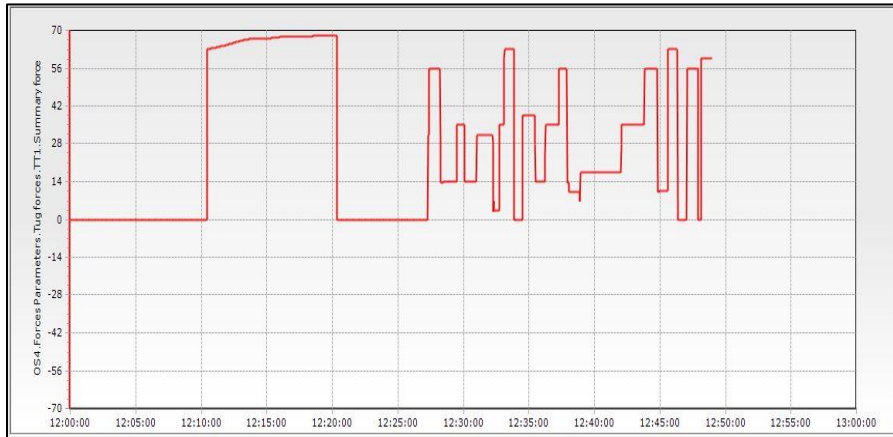
Rudder Angle



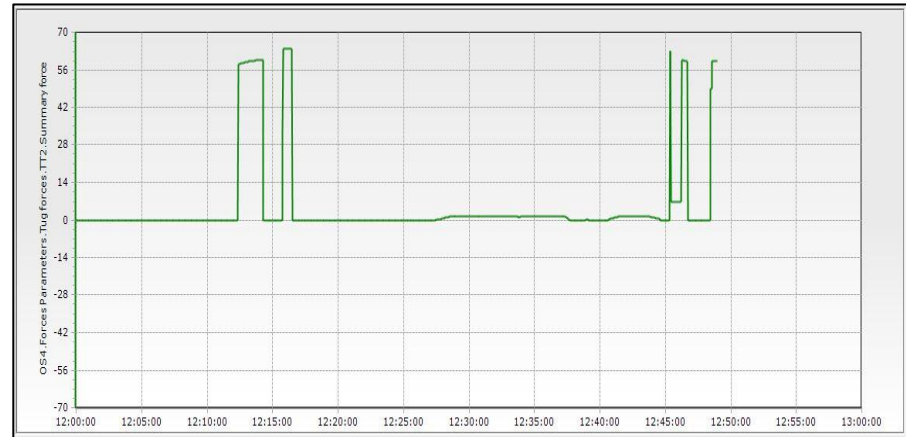
Speed Over Ground (Knots)



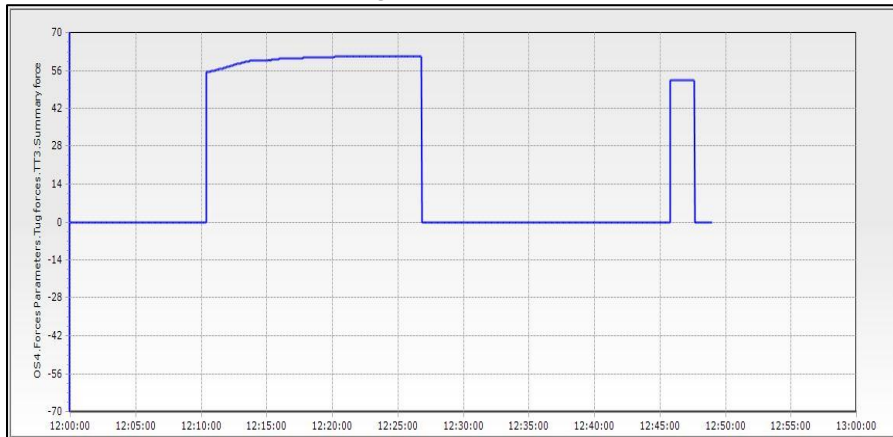
Tugboat 1 Force (t)



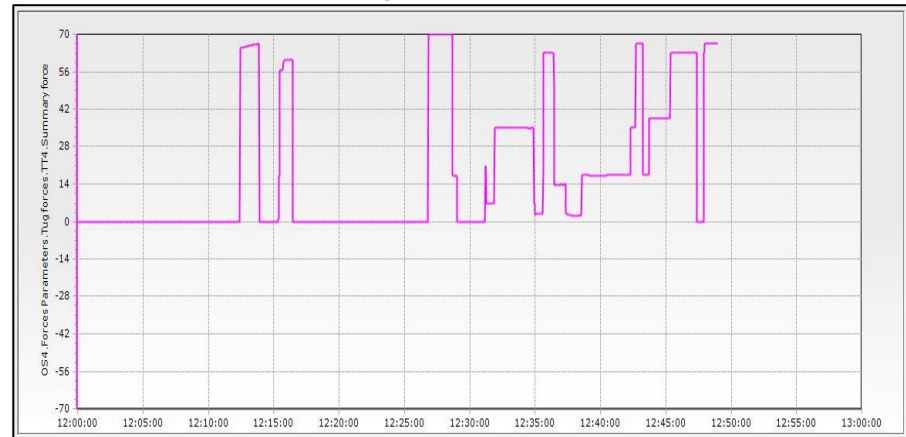
Tugboat 2 Force (t)



Tugboat 3 Force (t)

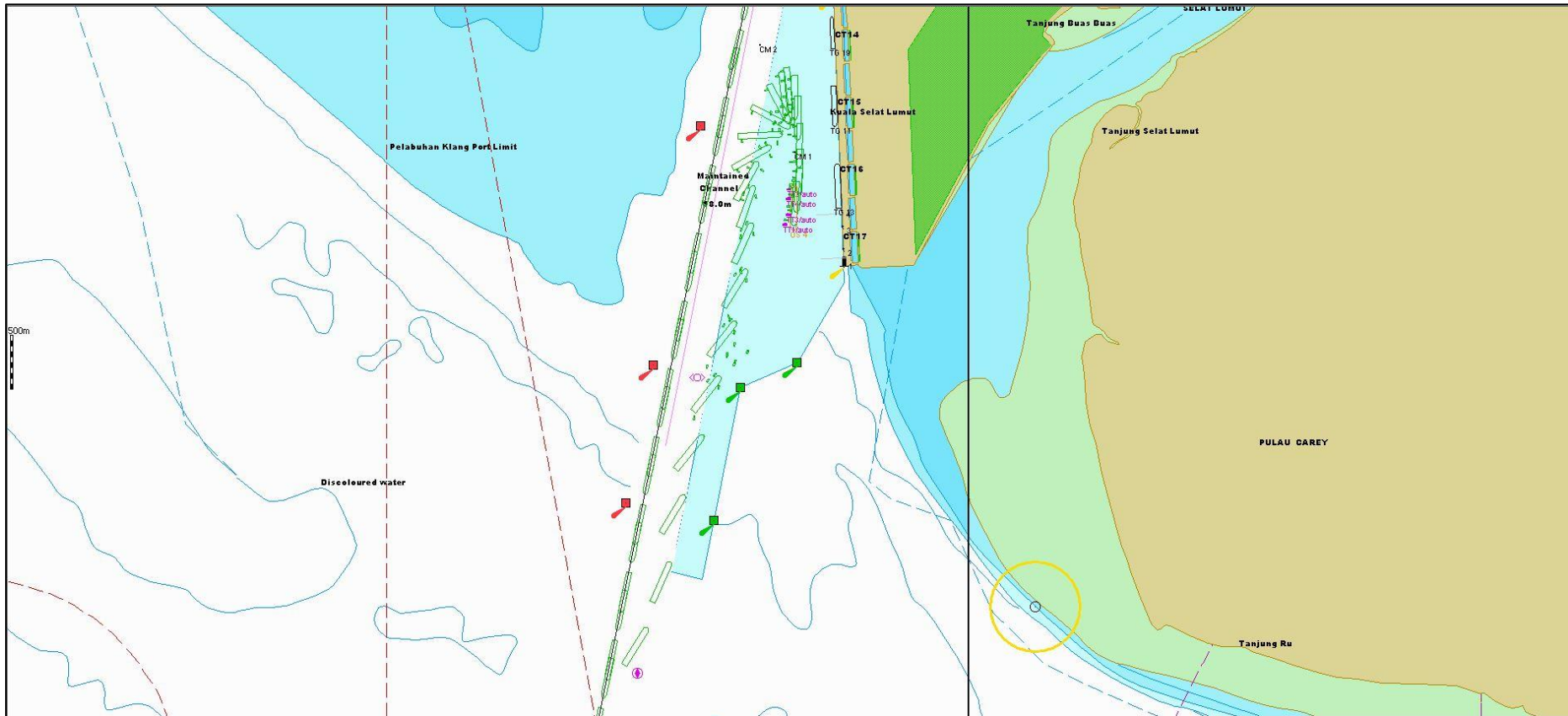


Tugboat 4 Force (t)

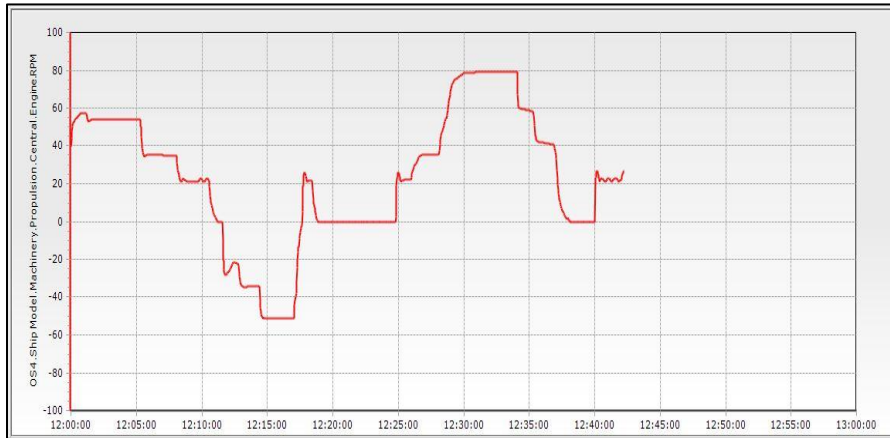


Run 23 – Container Ship Approaching and Berthing at CT17 Simultaneously with An Outbound Vessel

Ship Model	Container Ship, 396m LOA, Loaded	Tugboats, 4 x 70t ASD Tugboats	
Environmental Conditions	Current: Ebb	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship successfully berth alongside at CT17 whilst maintaining sufficient clearances from the outbound vessel. Run rated Pass		Duration: 43minutes



Engine RPM



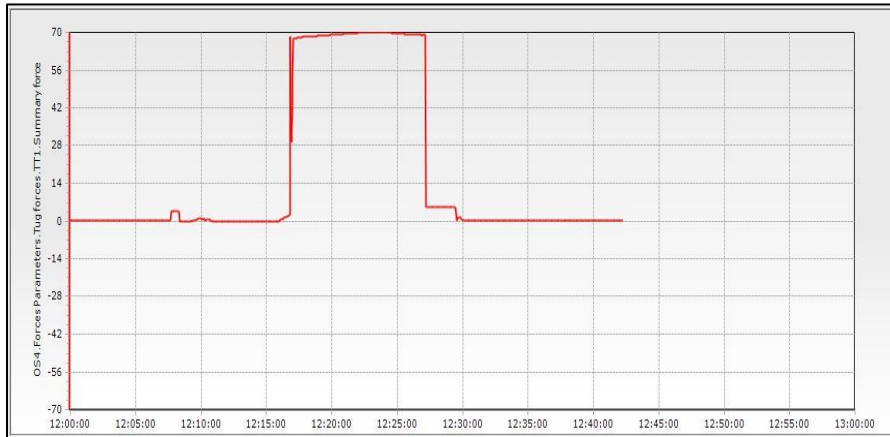
Rudder Angle



Speed Over Ground (Knots)



Tugboat 1 Force (t)



Tugboat 2 Force (t)



Tugboat 3 Force (t)

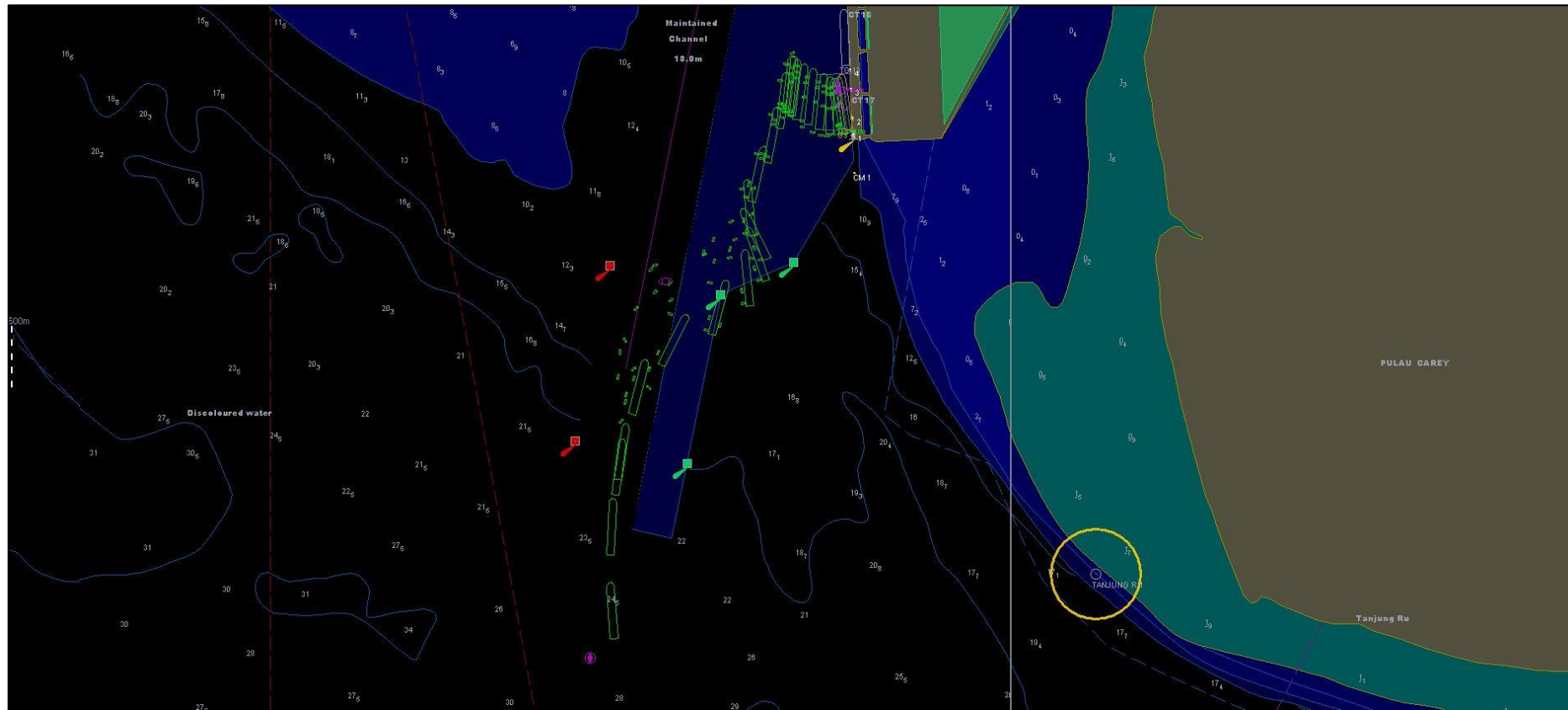


Tugboat 4 Force (t)



Run 24 – Container Ship Approaching and Berthing at CT17

Ship Model	Container Ship, 396m LOA, Loaded	Tugboats, 4 x 70t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SE
Run Outcome	After slowing down to berth at CT17, vessel drifted and allided with the green buoy at the channel entrance. Run rated Fail		Duration: 33 minutes
Recommendation	Shifting the 2nd green buoy at the channel entrance would create more room for the approaching container ship.		



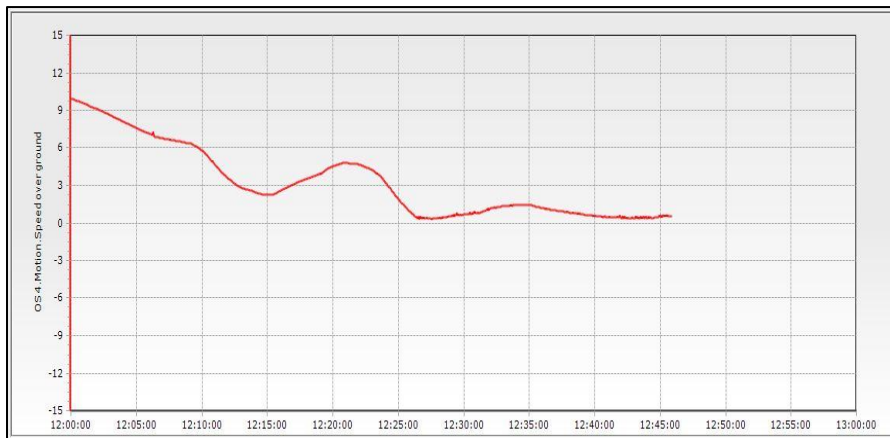
Engine RPM



Rudder Angle



Speed Over Ground (Knots)



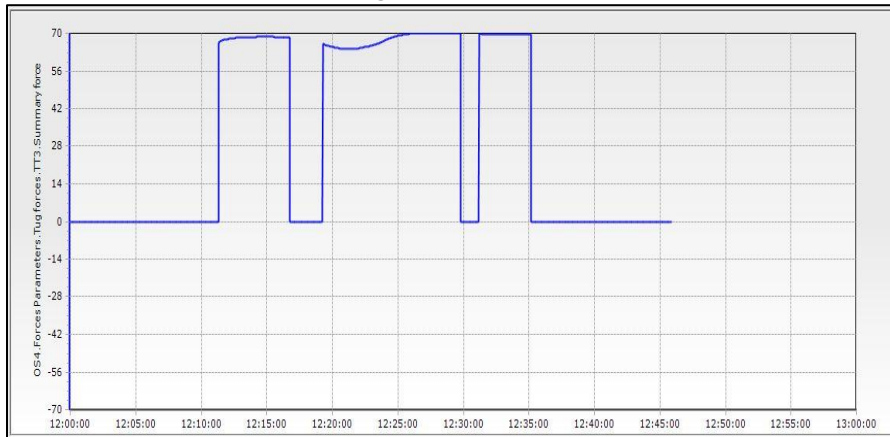
Tugboat 1 Force (t)



Tugboat 2 Force (t)



Tugboat 3 Force (t)

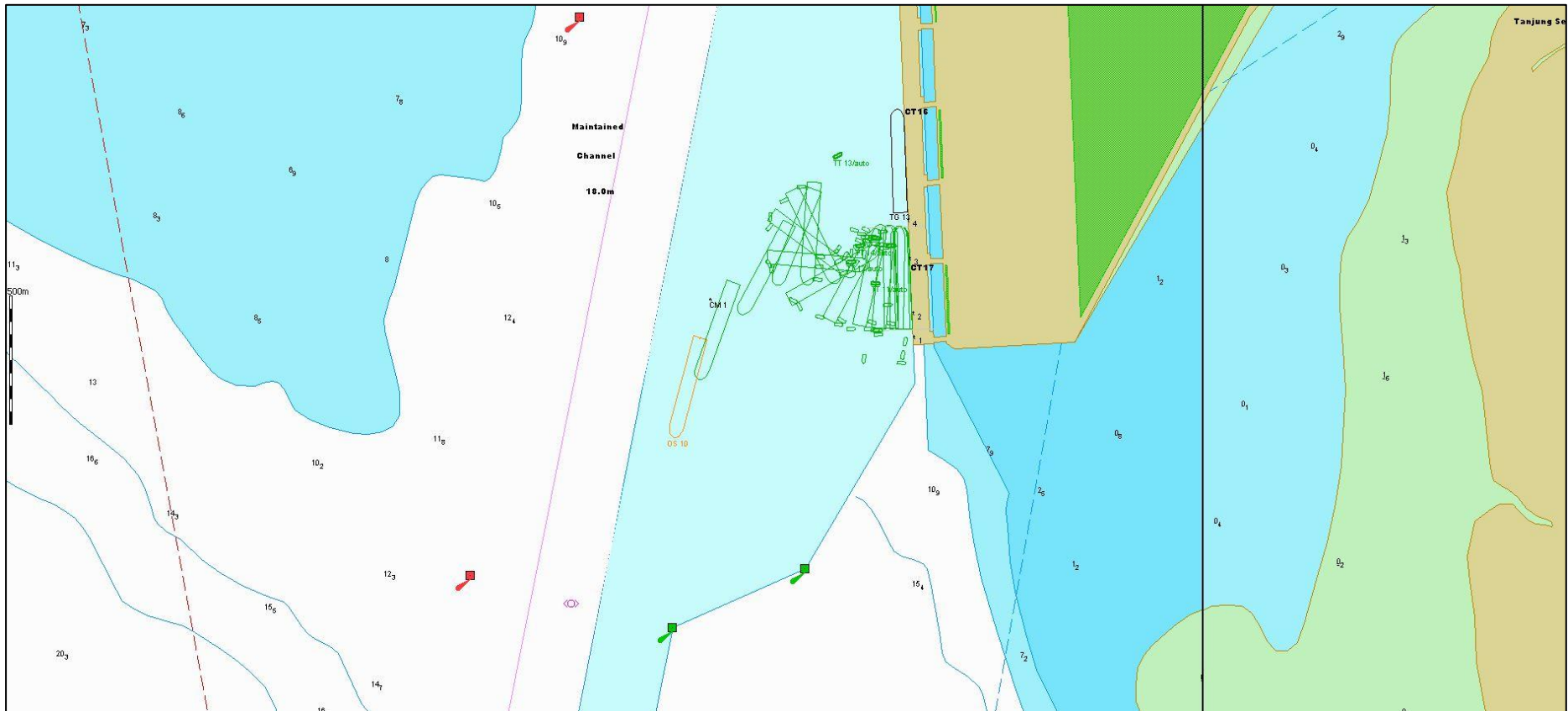


Tugboat 4 Force (t)

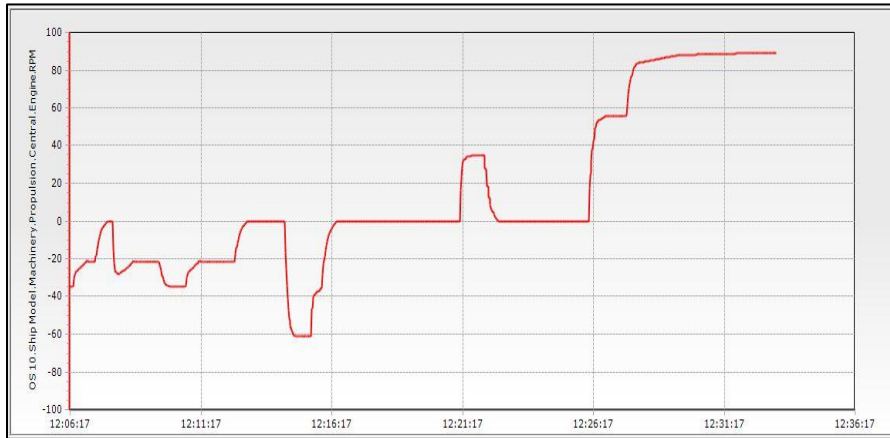


Run 25 – Container Ship Unberthing and Departing from CT17

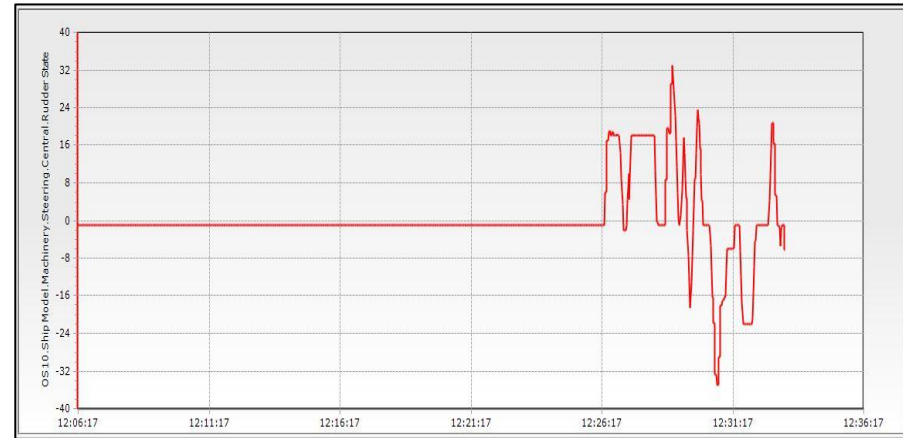
Ship Model	Container Ship, 396m LOA, Loaded	Tugboats, 4 x 70t ASD Tugboats	
Environmental Conditions	Current: Ebb	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship successfully unberths. Run rated Pass		Duration: 33minutes



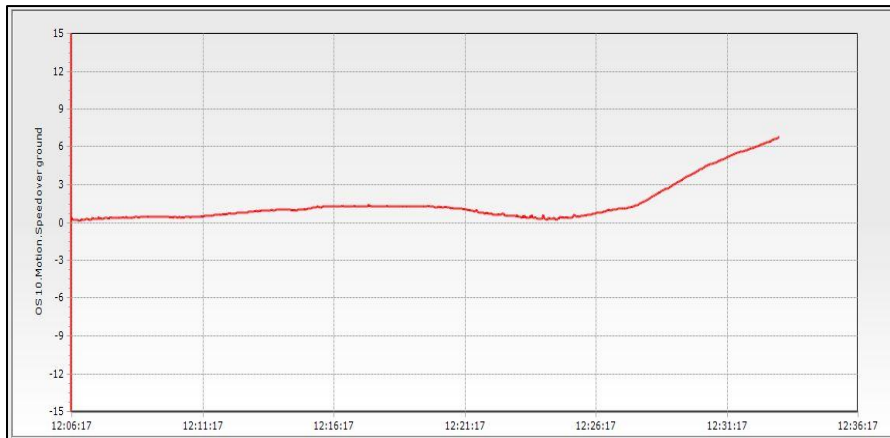
Engine RPM



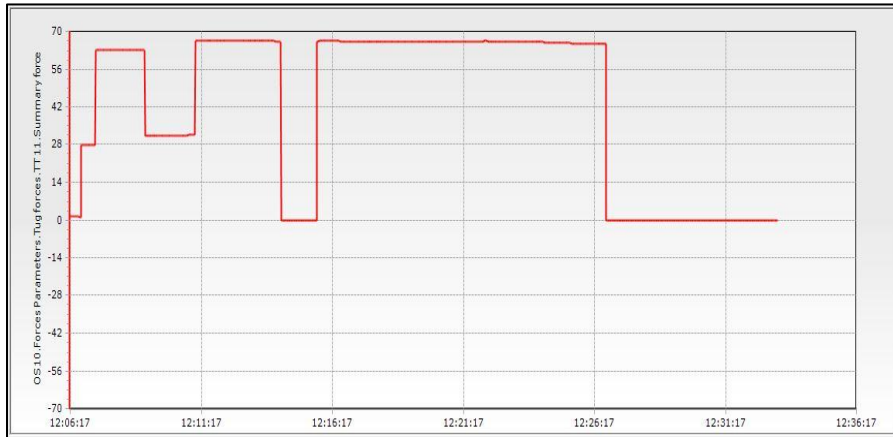
Rudder Angle



Speed Over Ground (Knots)



Tugboat 1 Force (t)



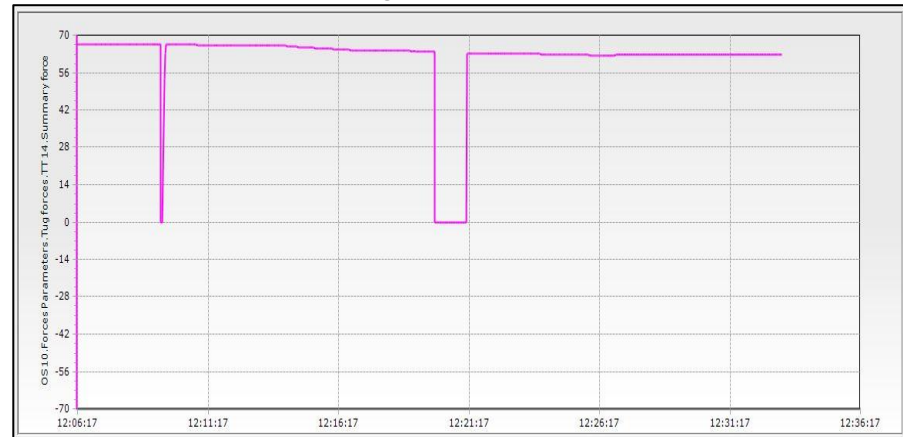
Tugboat 2 Force (t)



Tugboat 3 Force (t)

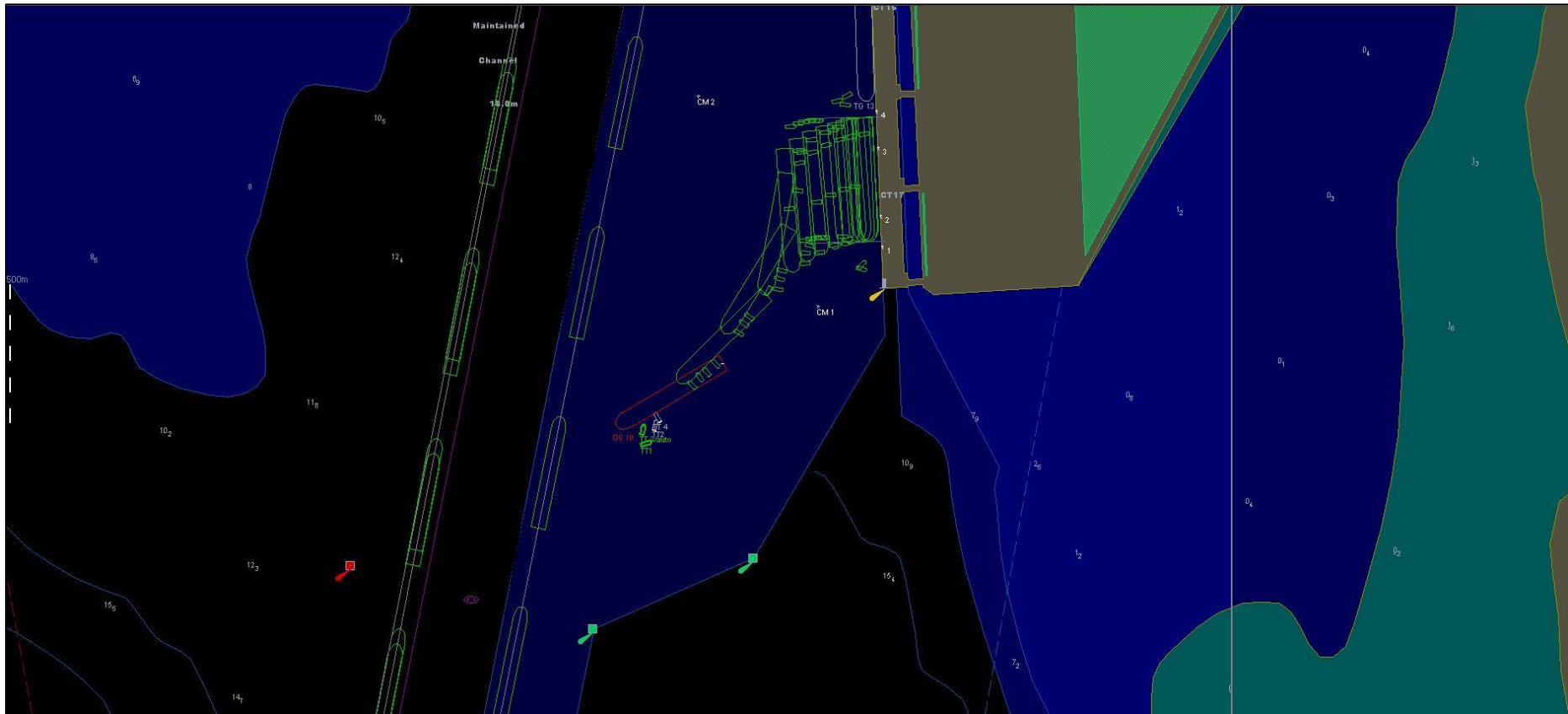


Tugboat 4 Force (t)

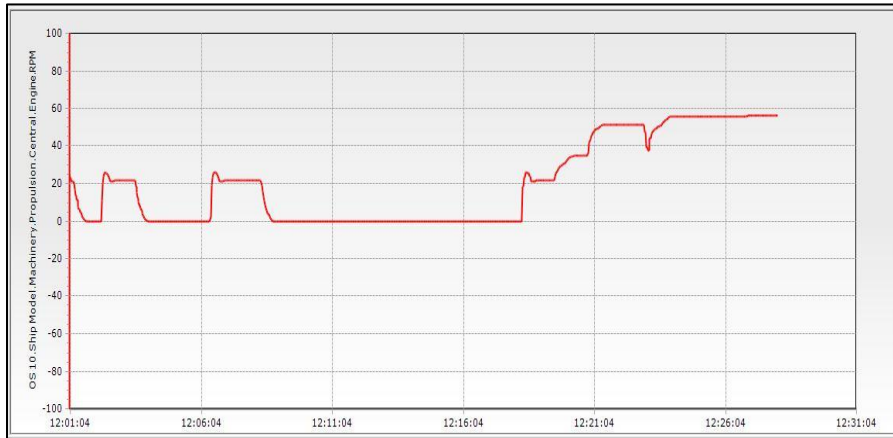


Run 26 – Container Ship Unberthing and Departing from CT17 with Two (2) Inbound Vessels

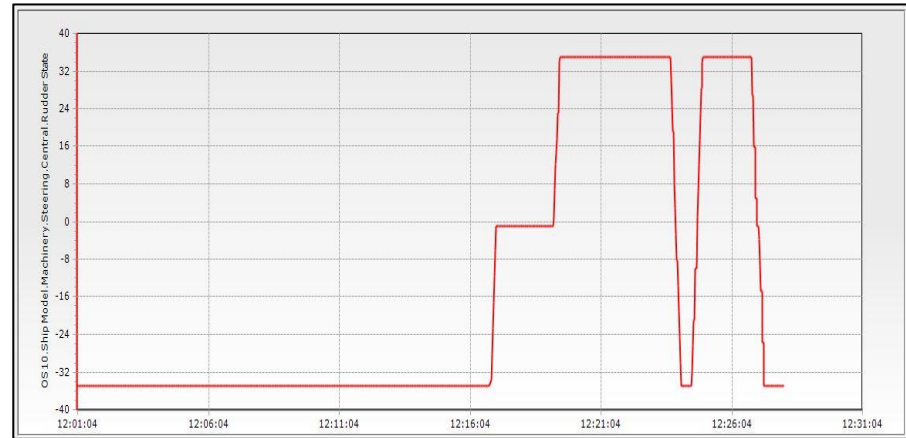
Ship Model	Container Ship, 396m LOA, Loaded	Tugboats, 4 x 70t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship successfully unberths and departed from CT17 whilst maintaining sufficient clearances from the other transiting vessels. Run rated Pass		Duration: 27minutes



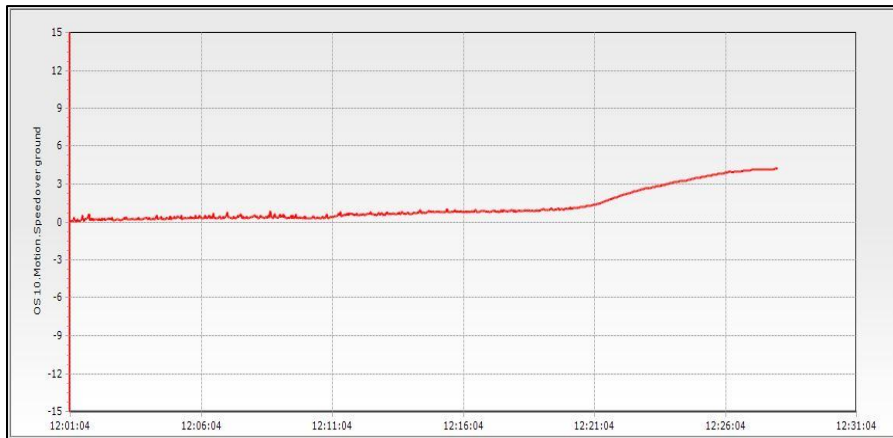
Engine RPM



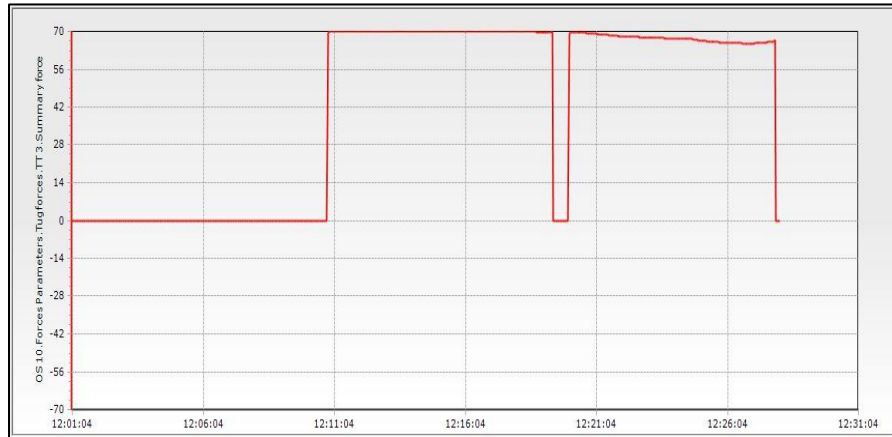
Rudder Angle



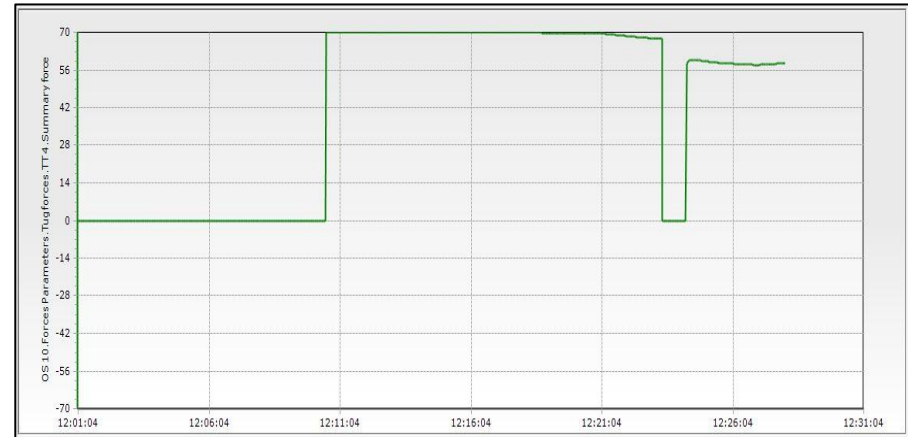
Speed Over Ground (Knots)



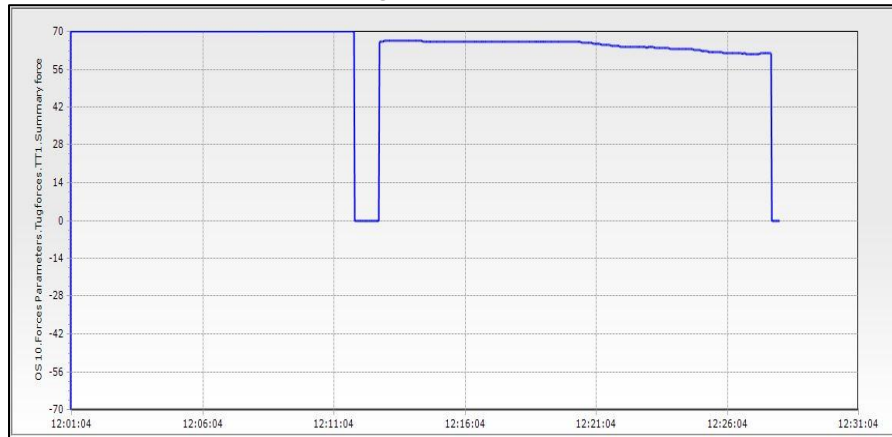
Tugboat 1 Force (t)



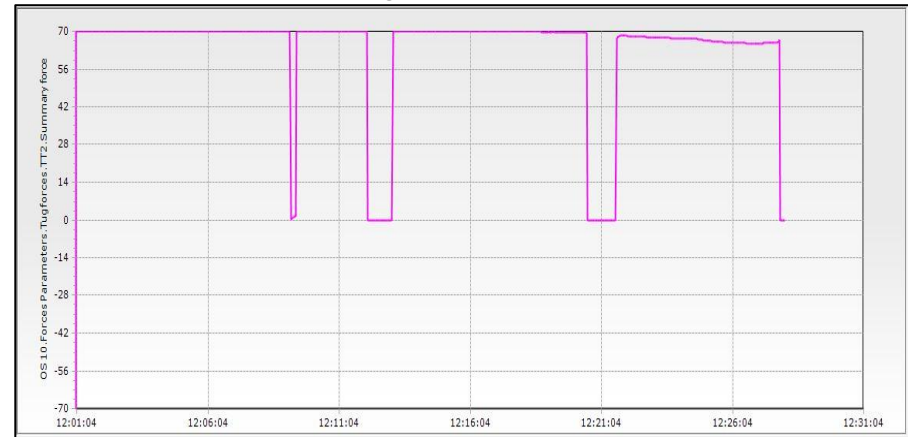
Tugboat 2 Force (t)



Tugboat 3 Force (t)

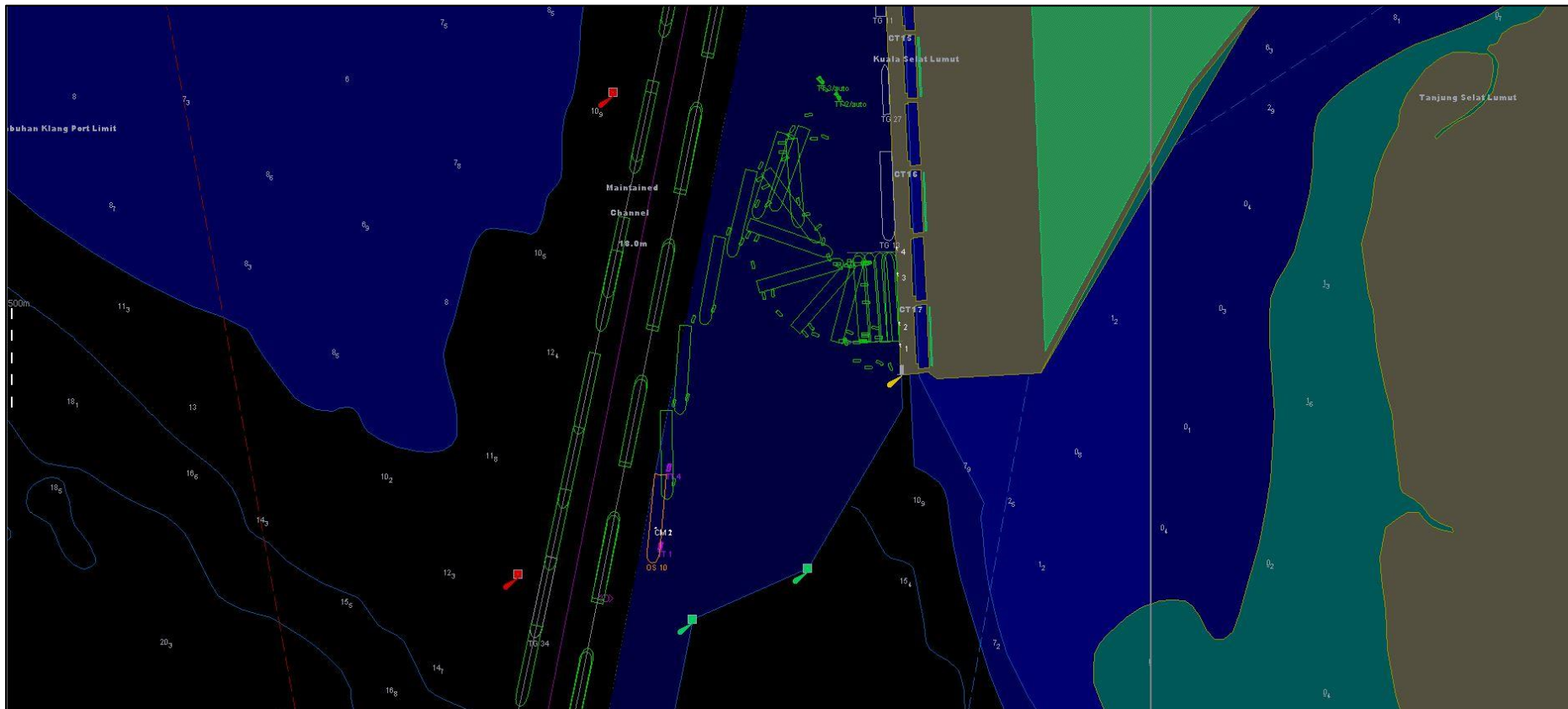


Tugboat 4 Force (t)

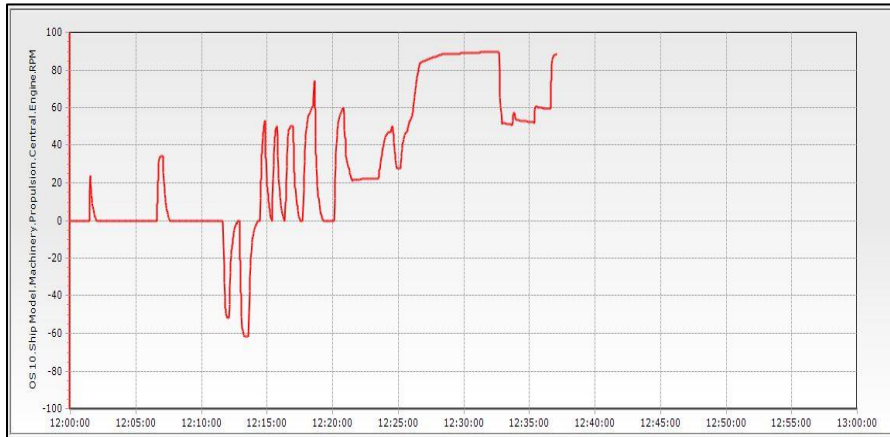


Run 27 – Container Ship Unberthing and Departing from CT17 Simultaneously with An Inbound Vessel and An Outbound Vessel

Ship Model	Container Ship, 396m LOA, Loaded	Tugboats, 4 x 70t ASD Tugboats	
Environmental Conditions	Current: Ebb	Wind: 20 – 25 knots / NE	Wave: 1 – 1.5m / NE
Run Outcome	Ship successfully unberths, turned and departed from CT17 whilst maintaining sufficient clearances from the other transiting vessels. Run rated Pass		Duration: 37minutes



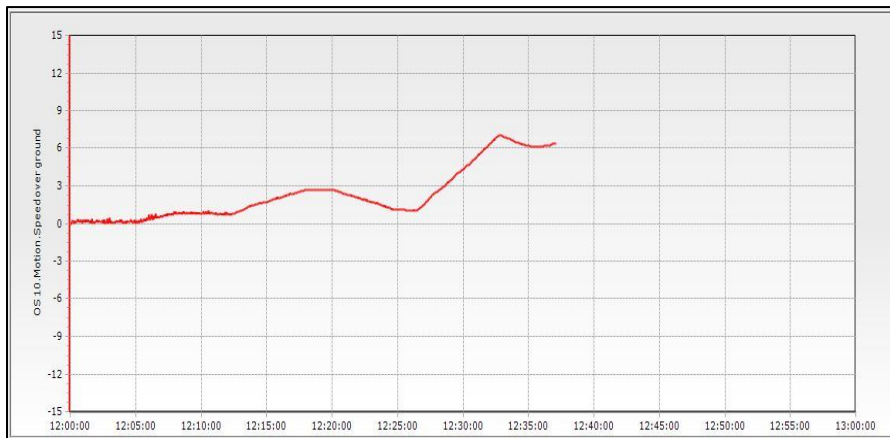
Engine RPM



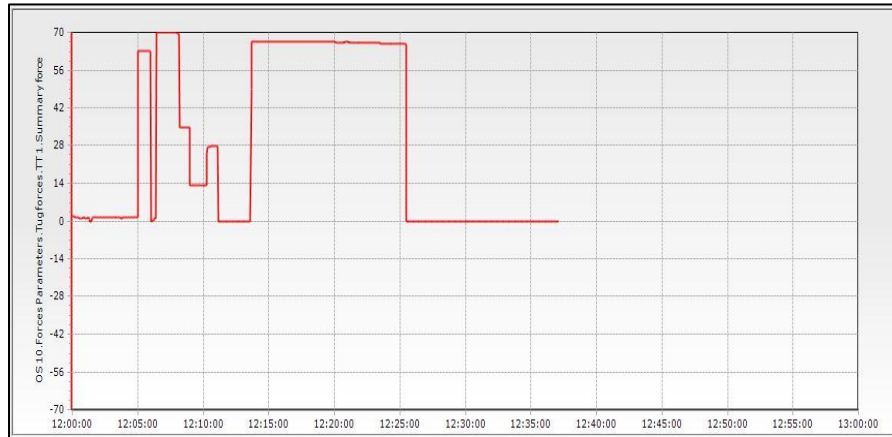
Rudder Angle



Speed Over Ground (Knots)



Tugboat 1 Force (t)



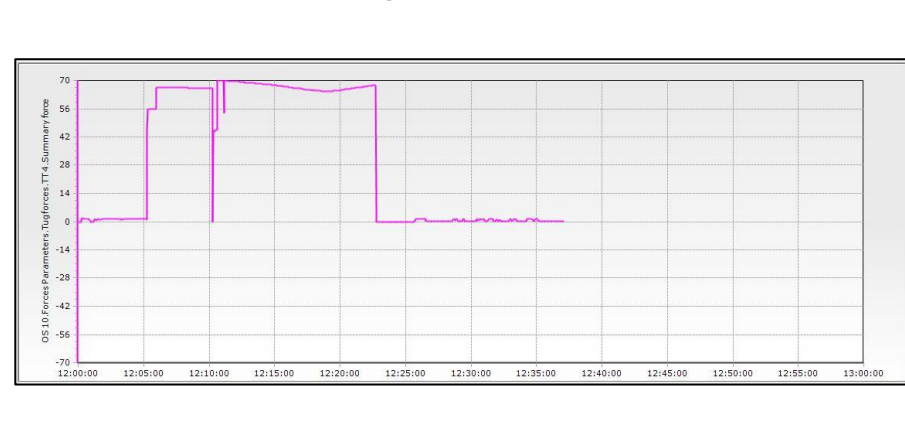
Tugboat 2 Force (t)



Tugboat 3 Force (t)

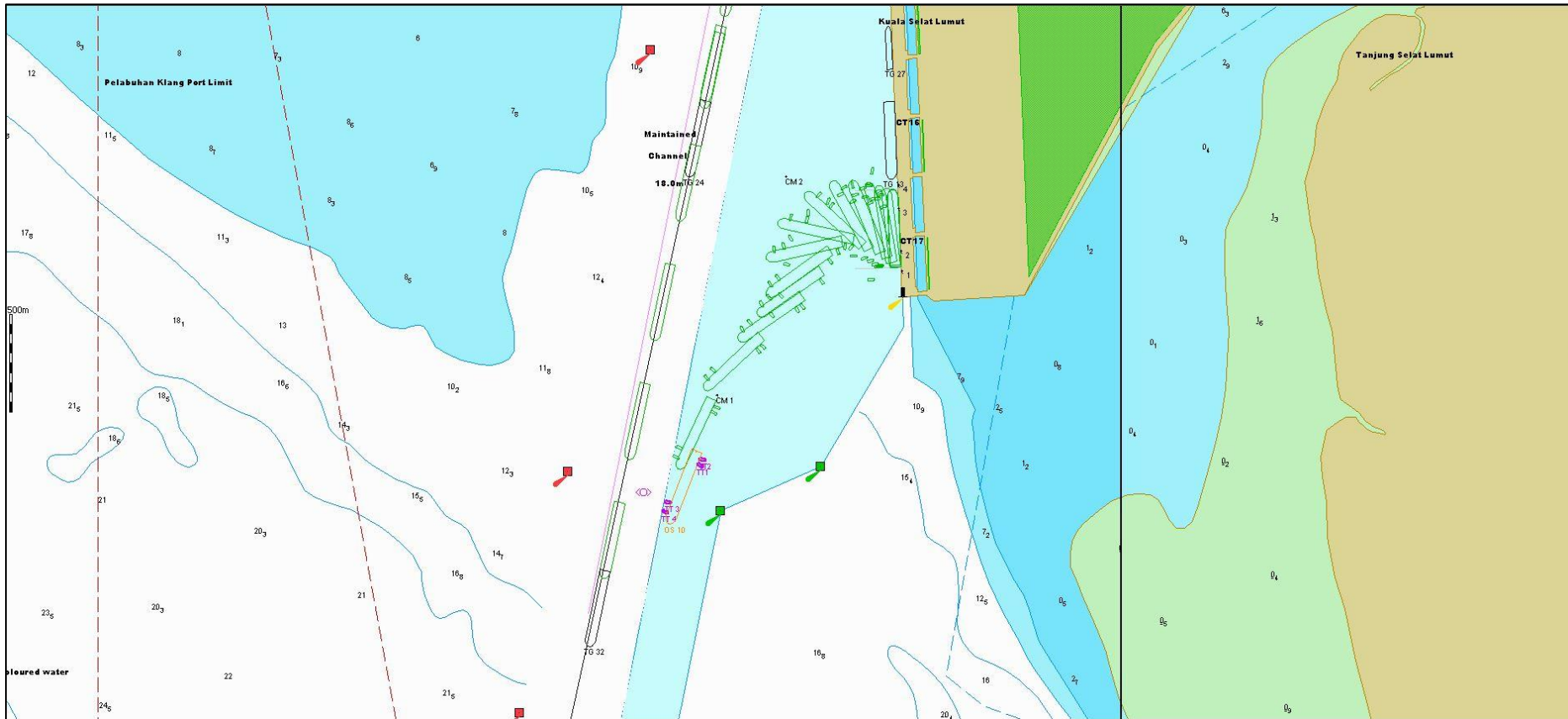


Tugboat 4 Force (t)

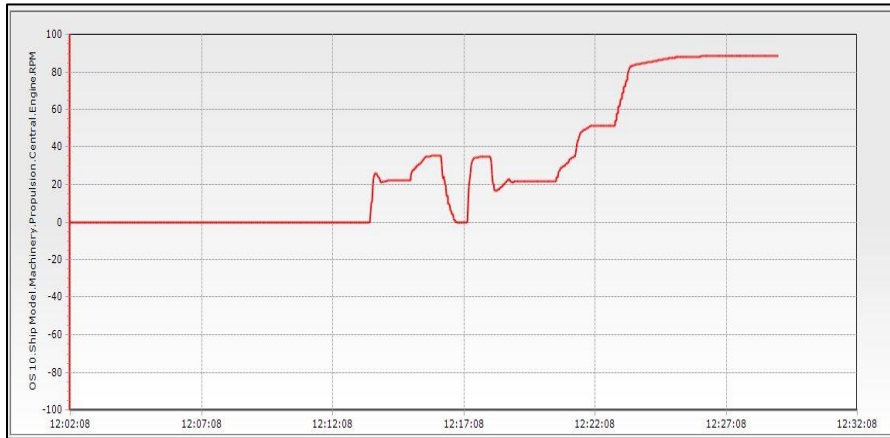


Run 28 – Container Ship Unberthing and Departing from CT17 Simultaneously with An Outbound Vessel

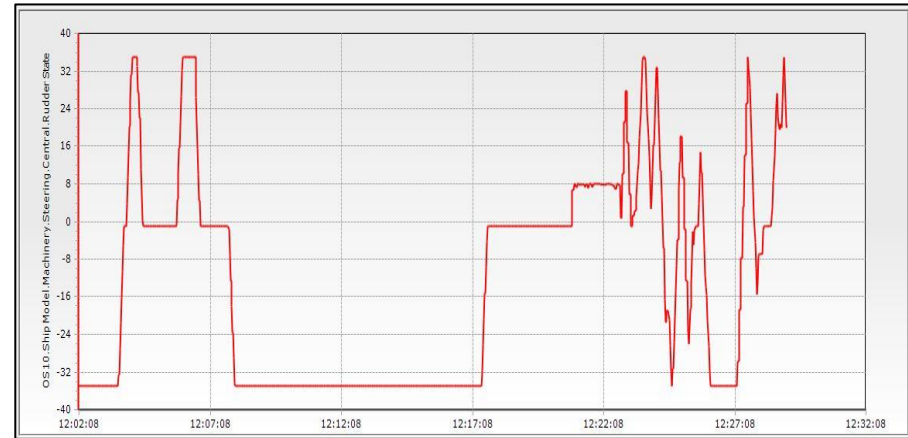
Ship Model	Container Ship, 396m LOA, Loaded	Tugboats, 4 x 70t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship successfully unberths, turned and departed whilst maintaining sufficient clearances from the outbound vessel. Run rated Pass		Duration: 29minutes



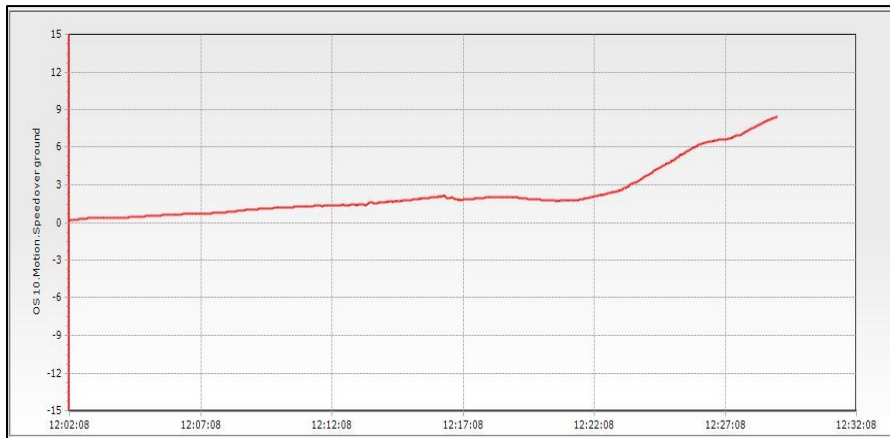
Engine RPM



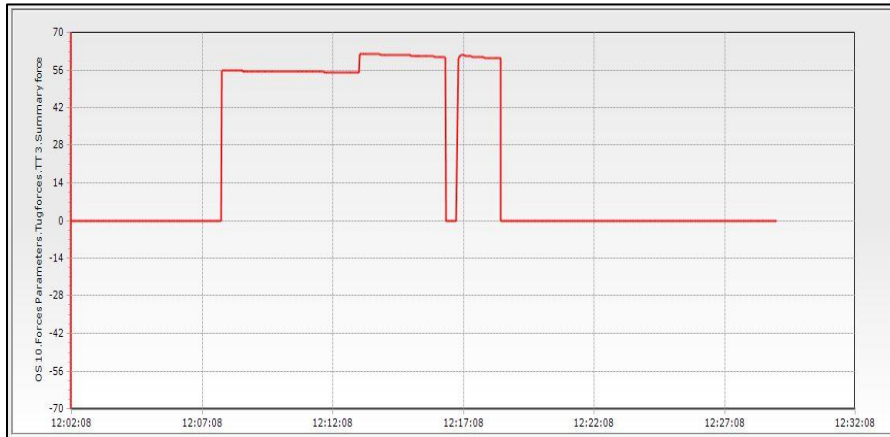
Rudder Angle



Speed Over Ground (Knots)



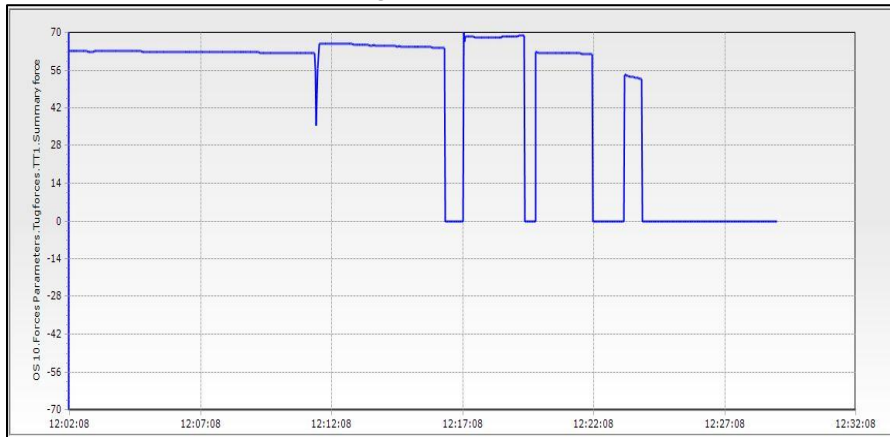
Tugboat 1 Force (t)



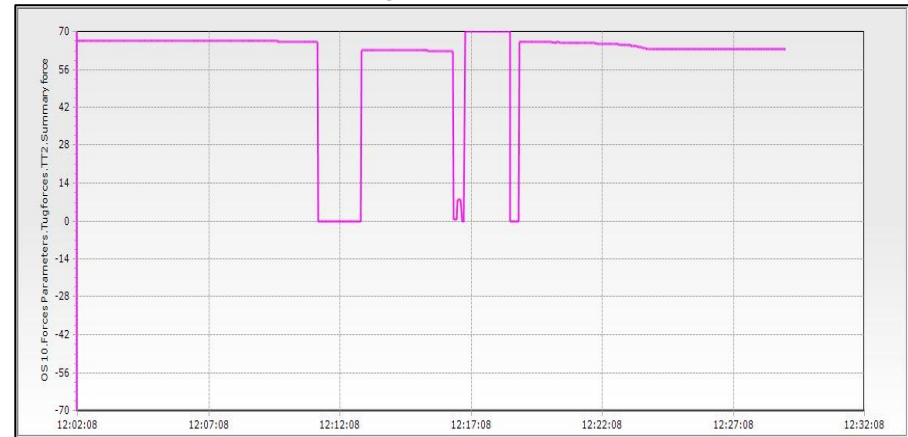
Tugboat 2 Force (t)



Tugboat 3 Force (t)

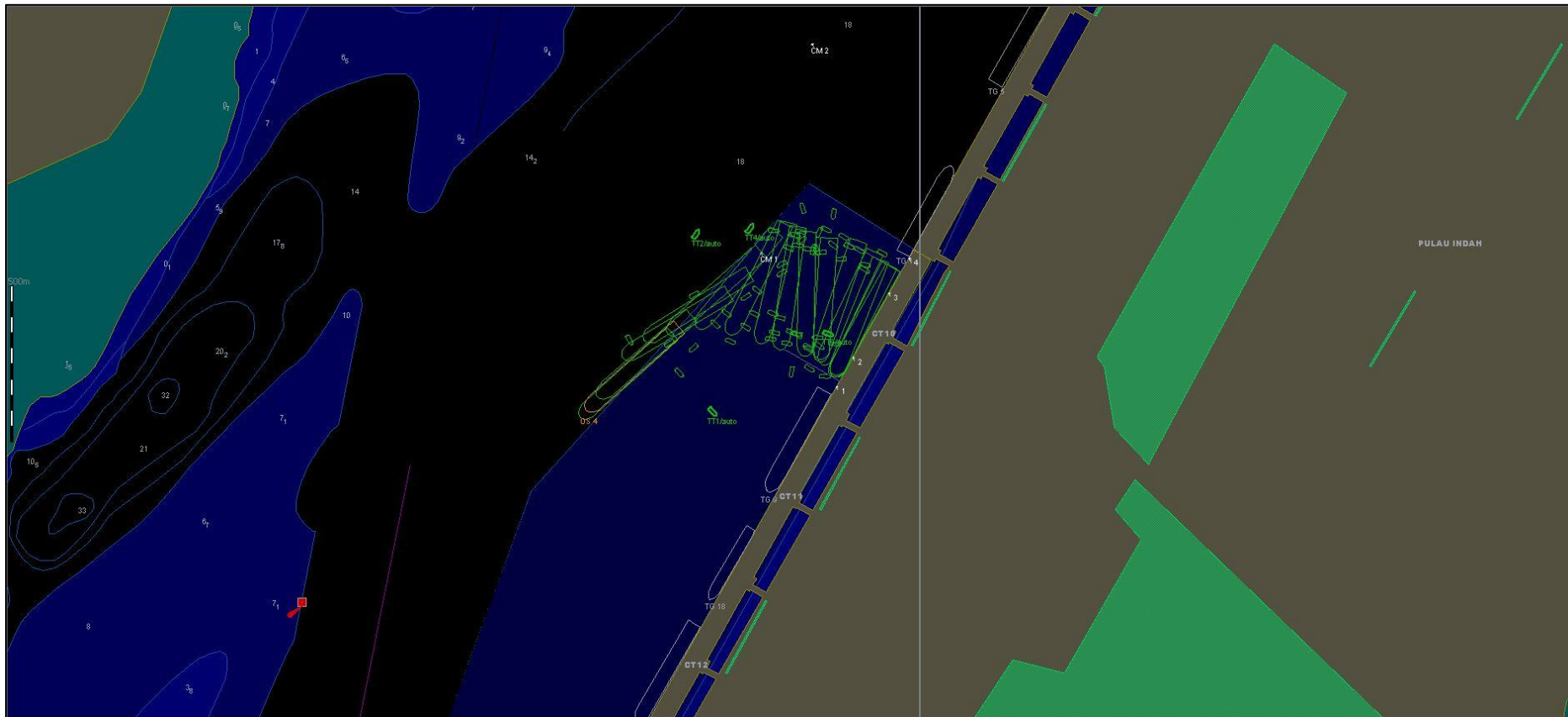


Tugboat 4 Force (t)



Run 29 – Container Ship Unberthing from CT17 – Steering Failure

Ship Model	Container Ship, 396m LOA, Loaded	Tugboats, 4 x 70t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship successfully unberths. Run rated Pass		Duration: 28minutes



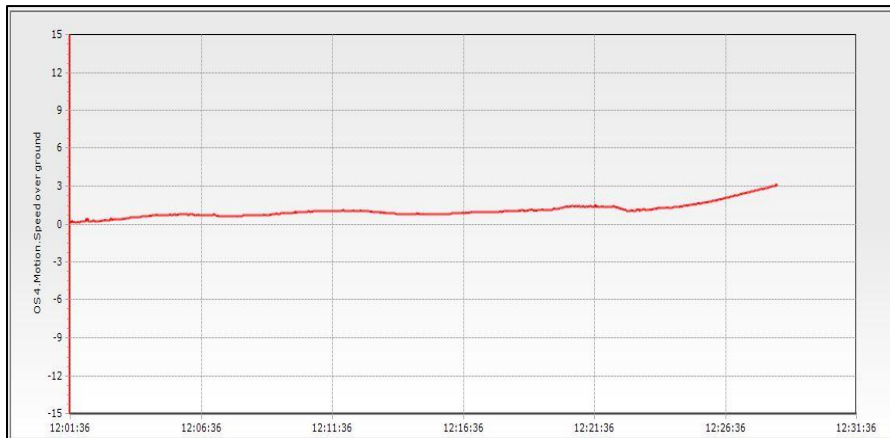
Engine RPM



Rudder Angle



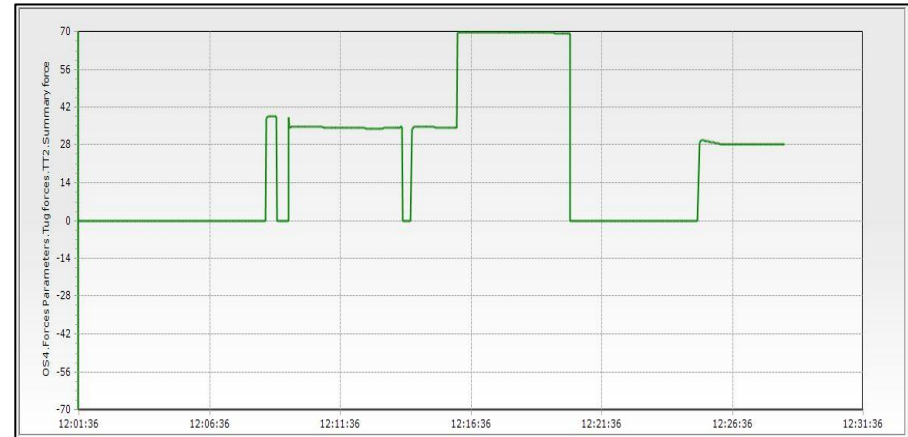
Speed Over Ground (Knots)



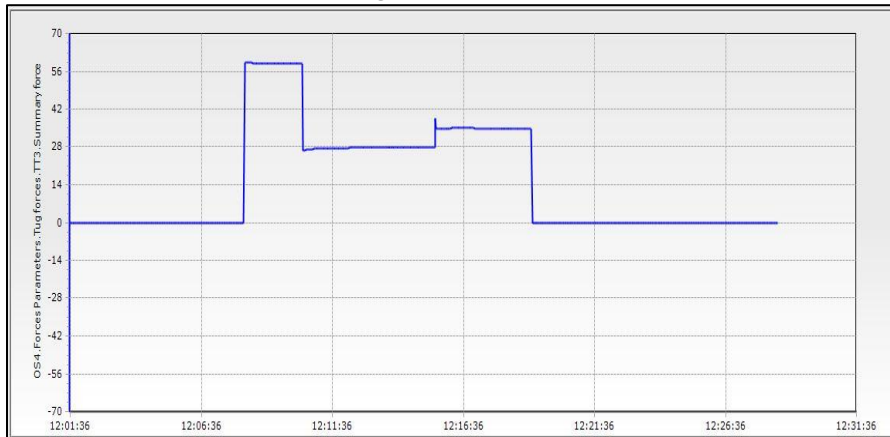
Tugboat 1 Force (t)



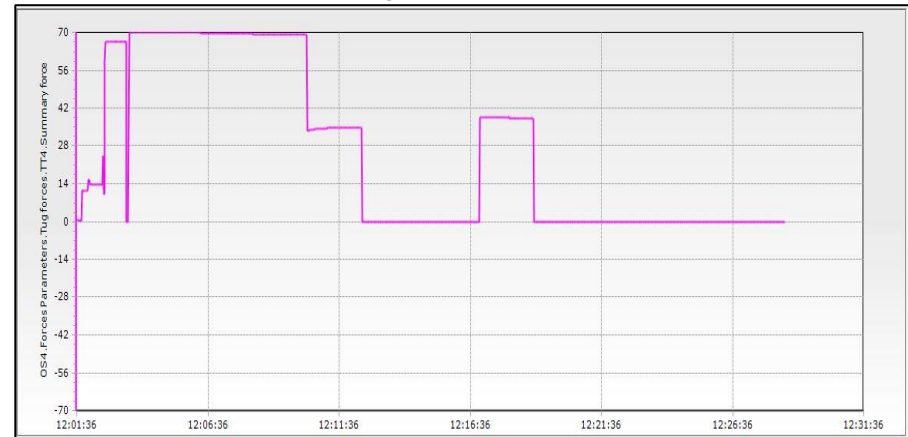
Tugboat 2 Force (t)



Tugboat 3 Force (t)

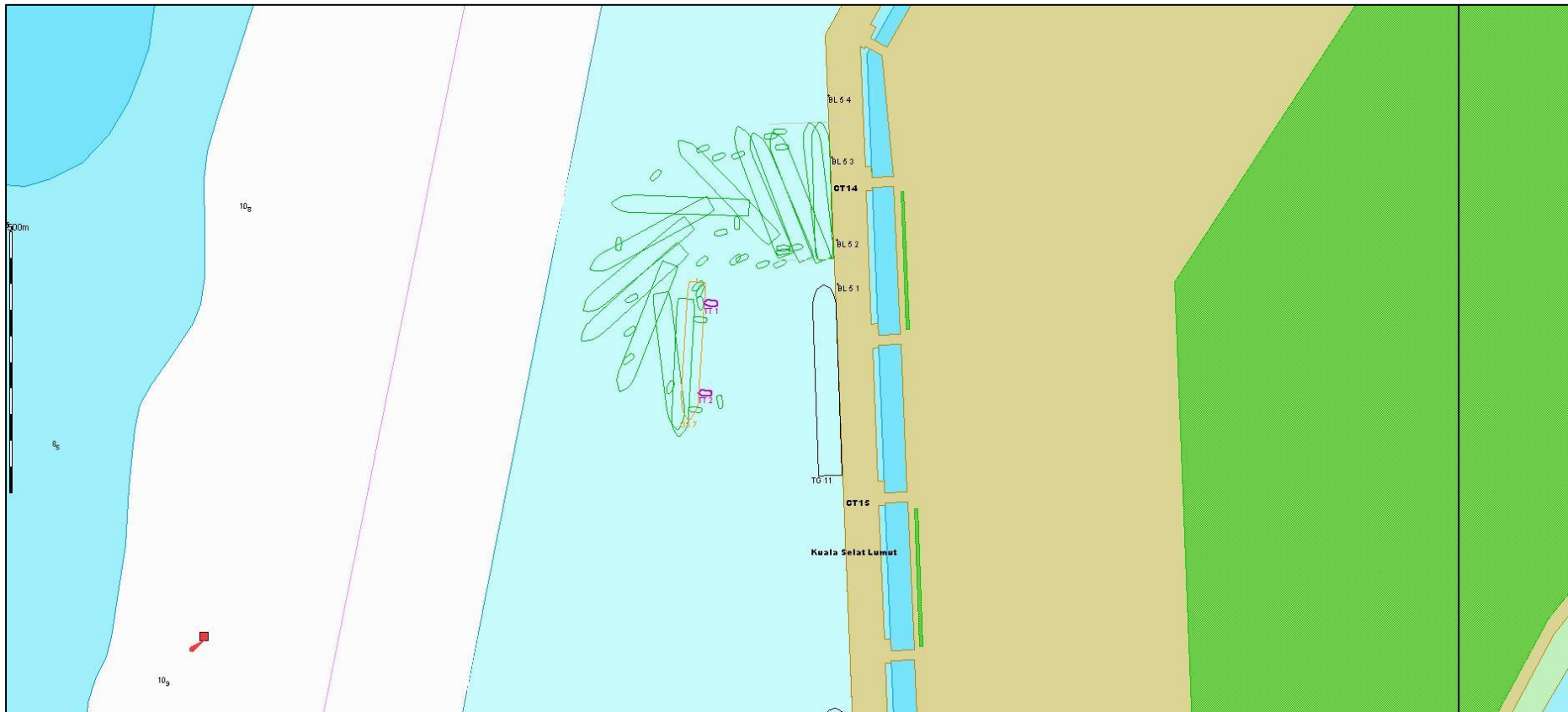


Tugboat 4 Force (t)



Run 30 – Container Ship Unberthing from CT14 – Engine Failure

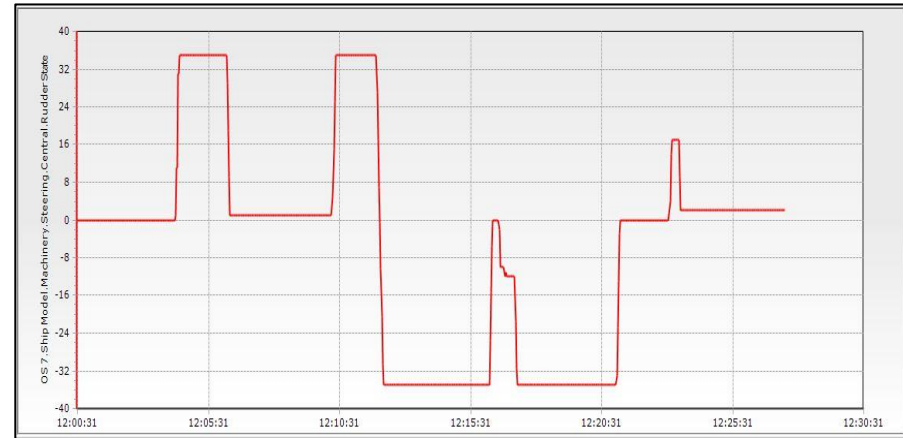
Ship Model	Container Ship, 261.4m LOA, Loaded	Tugboats, 2 x 50t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship successfully unberths. Run rated Pass		Duration: 27minutes



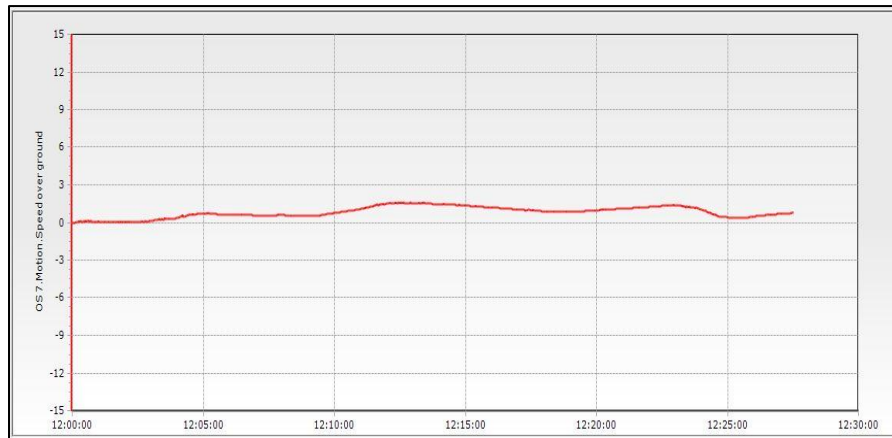
Engine RPM



Rudder Angle



Speed Over Ground (Knots)



Tugboat 1 Force (t)

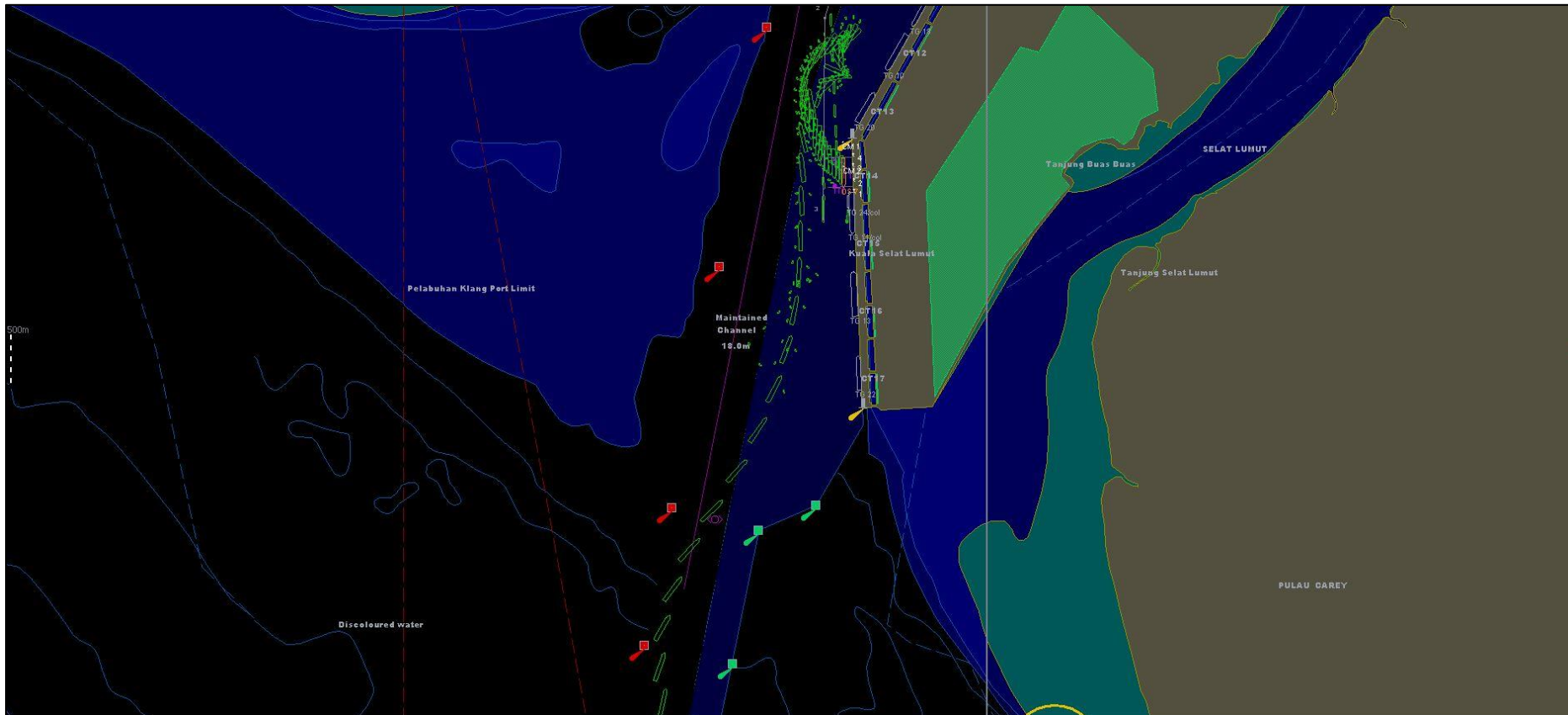


Tugboat 2 Force (t)



Run 31 – Container Ship Berthing at CT14 – Engine Failure

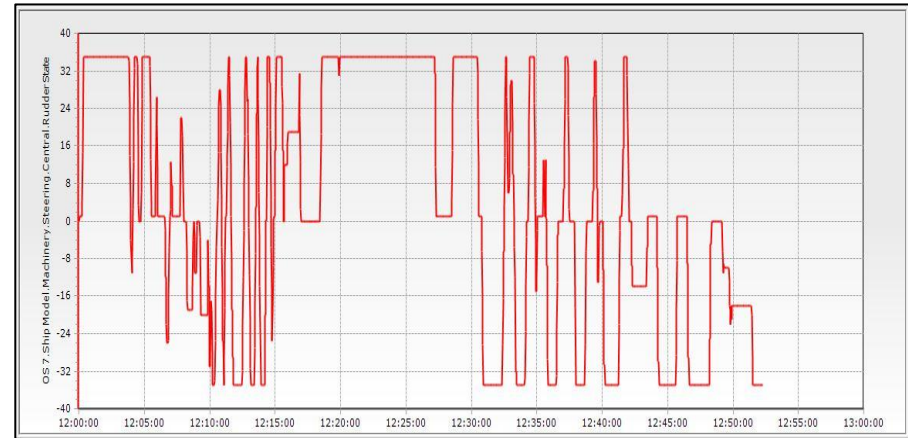
Ship Model	Container Ship, 261.4m LOA, Loaded	Tugboats, 3 x 50t ASD Tugboats	
Environmental Conditions	Current: Ebb	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship successfully berth alongside. Run rated Pass		Duration: 52minutes



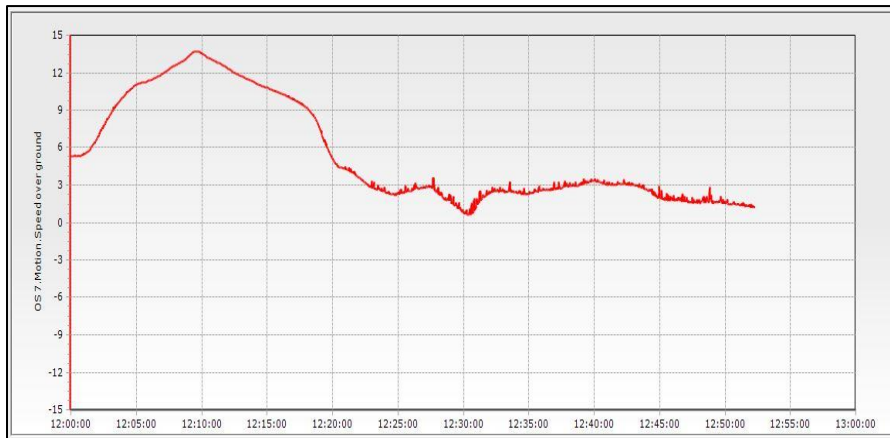
Engine RPM



Rudder Angle



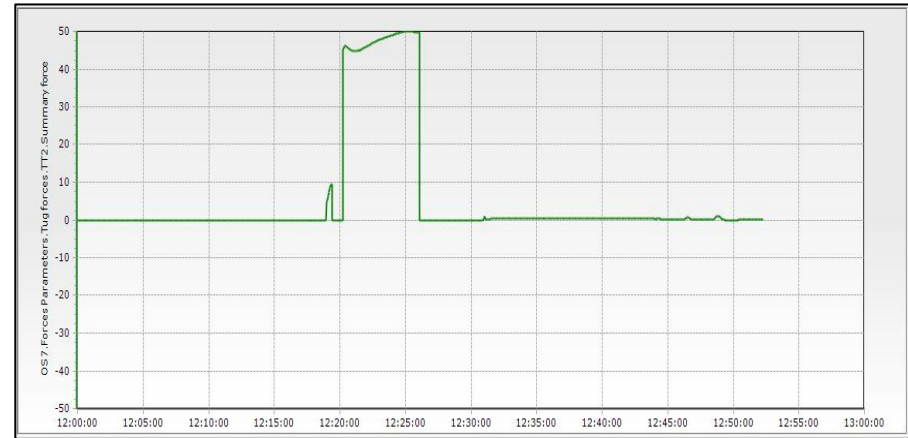
Speed Over Ground (Knots)



Tugboat 1 Force (t)



Tugboat 2 Force (t)

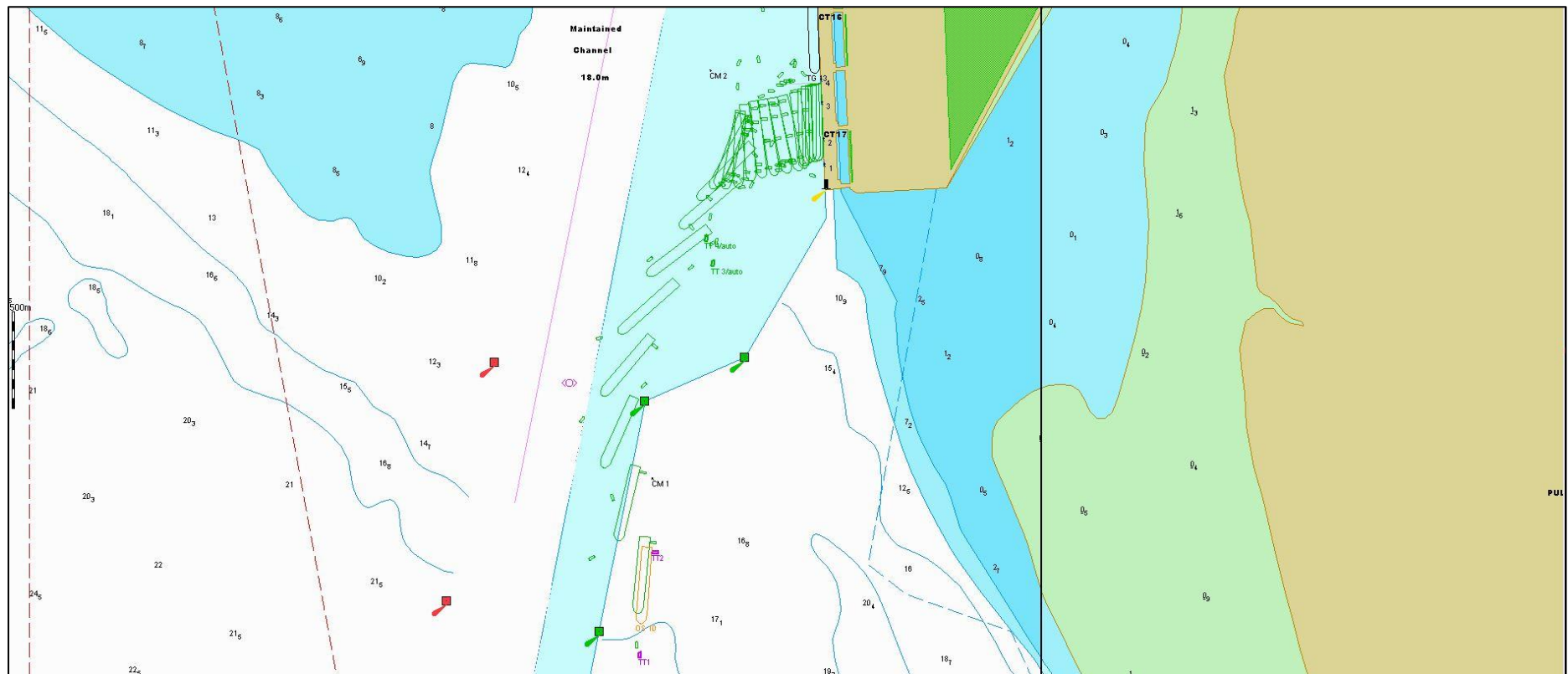


Tugboat 3 Force (t)

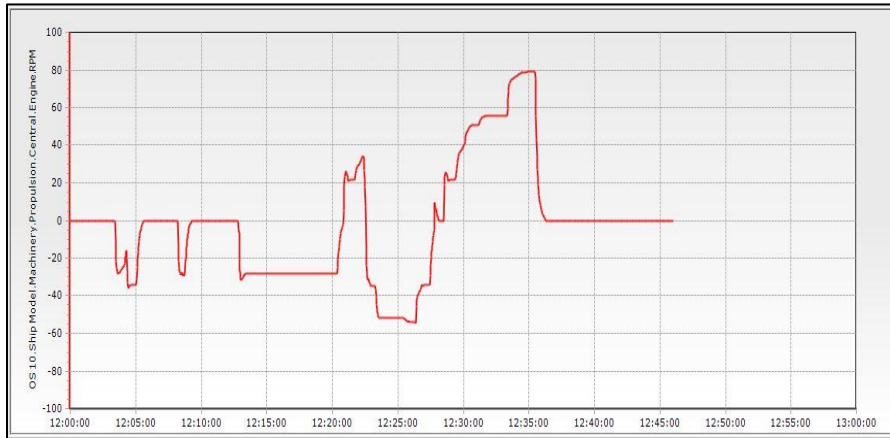


Run 32 – Container Ship Unberthing from CT17 – Extreme Wind & Engine Failure

Ship Model	Container Ship, 396m LOA, Loaded	Tugboats, 4 x 70t ASD Tugboats	
Environmental Conditions	Current: Flood	Wind: 20 – 25 knots / SW	Wave: 1 – 1.5m / SW
Run Outcome	Ship was unable to maintain inside the channel. However, pilot successfully manoeuvred the vessel to deep water without alliding with any buoys. Run rated Marginal		Duration: 46 minutes
Recommendation	Tugboats should escort vessels departing from CT17 until it clears the channel due to strong cross currents within the approach channel, in case of an emergency situation such as a vessel engine failure or tugboat failure.		



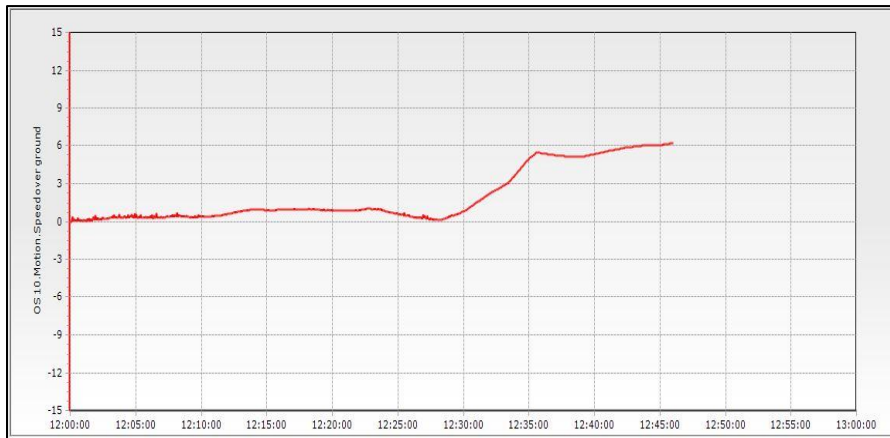
Engine RPM



Rudder Angle



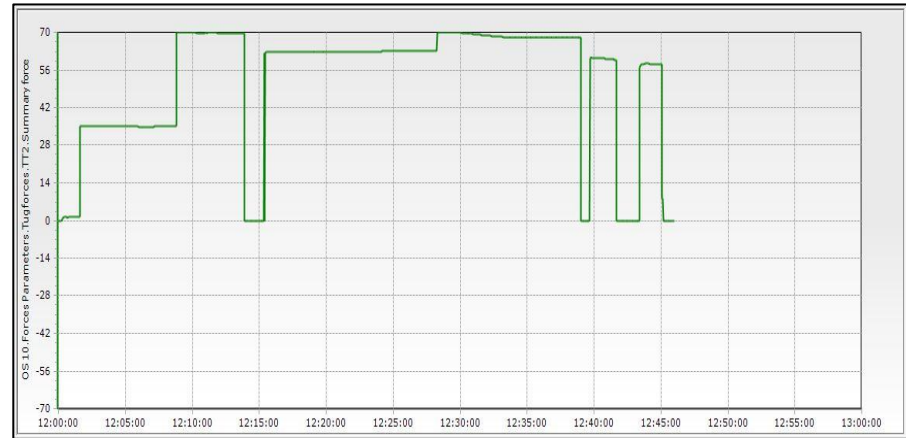
Speed Over Ground (Knots)



Tugboat 1 Force (t)



Tugboat 2 Force (t)



Tugboat 3 Force (t)



Tugboat 4 Force (t)

