Immingham Green Energy Terminal

TR030008

Volume 6

6.4 Environmental Statement Appendices

Appendix 12.B: Navigational Simulation Survey

Planning Act 2008

Regulation 5(2)(a)

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 (as amended)

September 2023

Infrastructure Planning

Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 (as amended)

Immingham Green Energy Terminal

Development Consent Order 2023

6.4 Environmental Statement Appendices

Appendix 12.B: Navigational Simulation Survey

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Project Soleil

Ship Navigation Simulation Study

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Prepared	Approved	Authorised
Mike Parr	Mark McBride	Mark McBride

Summary

ABP are intending to develop a new facility to transfer liquid ammonia and $C0_2$ cargoes at Immingham Harbour. The proposed "dual fuel transfer" facility will consist of two additional jetties located south east of the Immingham Oil Terminal (IOT).

As part of this work, HR Wallingford undertook a real time ship navigation simulation study to assess the feasibility of the development, referred to as the Immingham Green Energy Terminal (IGET). This work will inform the Navigational Risk Assessment (NRA) process and subsequent application for the Development Consent Order (DCO).

The navigation simulation study had the following objectives:

- Demonstrate that the agreed design vessels can navigate safely to and from the facility considering:
  - The facility location, orientation and general design. It was assumed that existing pilotage and navigational approaches were acceptable to within the general vicinity of the berths;
  - Adjacent infrastructure and the extent of any moored vessels;
  - The available options for approaching and departing the facility in routinely expected environmental conditions;
  - The available tug fleet likely to be allocated to provide berthing assistance;
  - Any pertinent industry best practice that was identified during the study.
- Demonstrate that the extent of the new facility, with vessels moored alongside, does not adversely affect the safety of vessels operating to and from the IOT facility, considering:
  - The existing operational practices;
  - Any industry best practice that might be applicable.
- Demonstrate that the IGET facility does not impose any additional restriction on vessels navigating in the main channel to the immediate north of the facility.

Given the nature of the cargoes being proposed for operations at IGET, the position of the proposed berthing line needed to take into account that the effect of any associated exclusion zone or safe passing ship distance should be minimised. The precise definition of the exclusion zone and safe passing distances would require the following 2 studies to be carried out:

- Analysis of the risk associated with an accidental gaseous discharge and the associated vapour cloud;
- A passing ship study considering the safe passing distance from the berths to minimise any interaction that may cause disruption of moored ships.

In lieu of results from these studies, 2 layouts were considered in this navigation simulation study as follows:

- Layout 1 assumed that a 150m exclusion zone;
- Layout 5 has the IGET berths set back and rotated slightly to enable a 250m exclusion zone.

The study concluded that both Layouts 1 and 5 are feasible designs from a navigational perspective, assuming that the required exclusion zones of 150m and 250 m, respectively, are confirmed.

The exclusion zone at IGET will require the approach and departure tracks for vessels operating at IOT to be adjusted. It was assessed that the changes in approach will be marginal and would not be expected to result in any significant additional time or resource requirements.

It was also found that the exclusion zone at IGET does not preclude or change the timings or execution of concurrent arrivals to IOT berths.

Additionally, the design and proposed location for IGET will enable concurrent arrivals to berths IGET 1 and IOT 3.

For the largest vessel expected at IGET, support from 4 x 45tBP ASD tugs were demonstrated as the minimum appropriate level of towage required to assist operations on arrival in challenging wind conditions, of 25 to 30 knots. This is consistent with existing practice within the Humber Passage Plan, which requires 4 tugs with a combined capacity of 170tBP at IOT.

For the largest vessel expected at IGET, support from 3 x 45tBP ASD tugs were assessed as an appropriate level of towage to assist operations on departure in challenging wind conditions 25 to 30 knots. This too is consistent with existing practice within the Humber Passage Plan, which requires 3 tugs with a combined capacity of 170tBP at IOT.

The relative location of IGET Layout 5, set back behind the line of IOT, was also assessed in credible emergency scenarios. This considered a tug failure at the most challenging times during arrival and departure manoeuvres, and the residual tug provision was found to be sufficient.

The additional constraint due to the IGET EZ was also considered with respect to river navigation. The EZs associated with Layouts 1 and 5 impose no additional restrictions on the ability of ships to navigate safely in the main channel when compared with the existing situation.

Assuming that ships will need to pass at 5 knots when to the north of IGET, as required by the present river bylaws, the additional berths will add approximately 1.5 minutes to the transit time. This assumes a restriction due to a single occupied berth (500 m). For 2 occupied IGET berths (1,000 m) the additional transit time would increase to 3 minutes. These estimates also assume that there is an EZ of no more than a 150m for Layout 1 and 250m for Layout 5.

Subsequent to completing the study, a further design was being considered, referred to as the RIBA Stage 2 final design. This was examined and the conclusions presented in this report with respect to the IGET Berth 1 (Layout 1) can be applied to the RIBA Stage 2 final design, as shown in Figure 2.6.

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Tables

Figures

1 Introduction

ABP are intending to develop a new facility to transfer liquid ammonia and $C0_2$ cargoes at Immingham Harbour. The proposed “dual fuel transfer” facility will consist of two additional jetties located south east of the Immingham Oil Terminal (IOT).

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- Demonstrate that the IGET facility does not impose any additional restriction on vessels navigating in the main channel to the immediate north of the facility.

2 Simulation configuration

2.1 Port layout

The port layout was based on a simulation model of the River Humber and Port of Immingham that was developed by HR Wallingford on behalf ABP and verified in other studies.

The existing infrastructure was modelled using a variety of engineering drawings, charting, and open-source satellite imagery (see Figure 2.3).

The layout for the proposed new dual fuel transfer facility was modelled based on engineering drawings provided by RAMBOL (References 3 and 4).

There were 2 designs prepared for the simulation session as follows:

- Option 1b – A design option in which the IGET berths are aligned with the current IOT berths (Figure 2.1), which is referred to as Layout 1;
- Option 5 – A design option in which the IGET berths are rotated to the south compared to the line of the IOT berths and set back, so that the berthing line is aligned with the natural line of the bank (see Figure 2.2), which is referred to as Layout 5.

The modelled layouts are shown in Figure 2.4 and Figure 2.5.

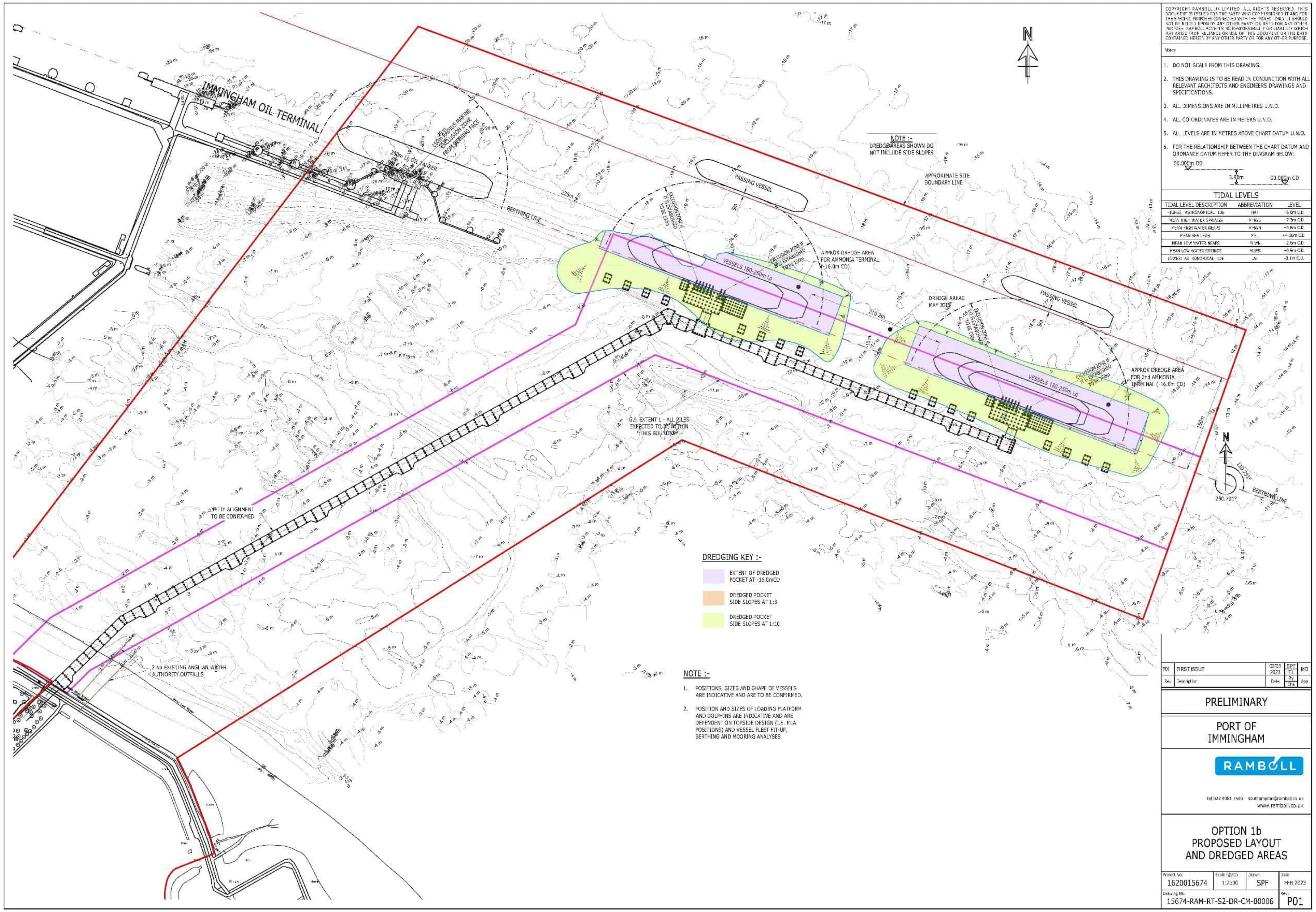


Figure 2.1: Option 1B

Source: Ramboll 15674-RAM-RT-S2-DR-CM-00006 P01 OPTION 1b

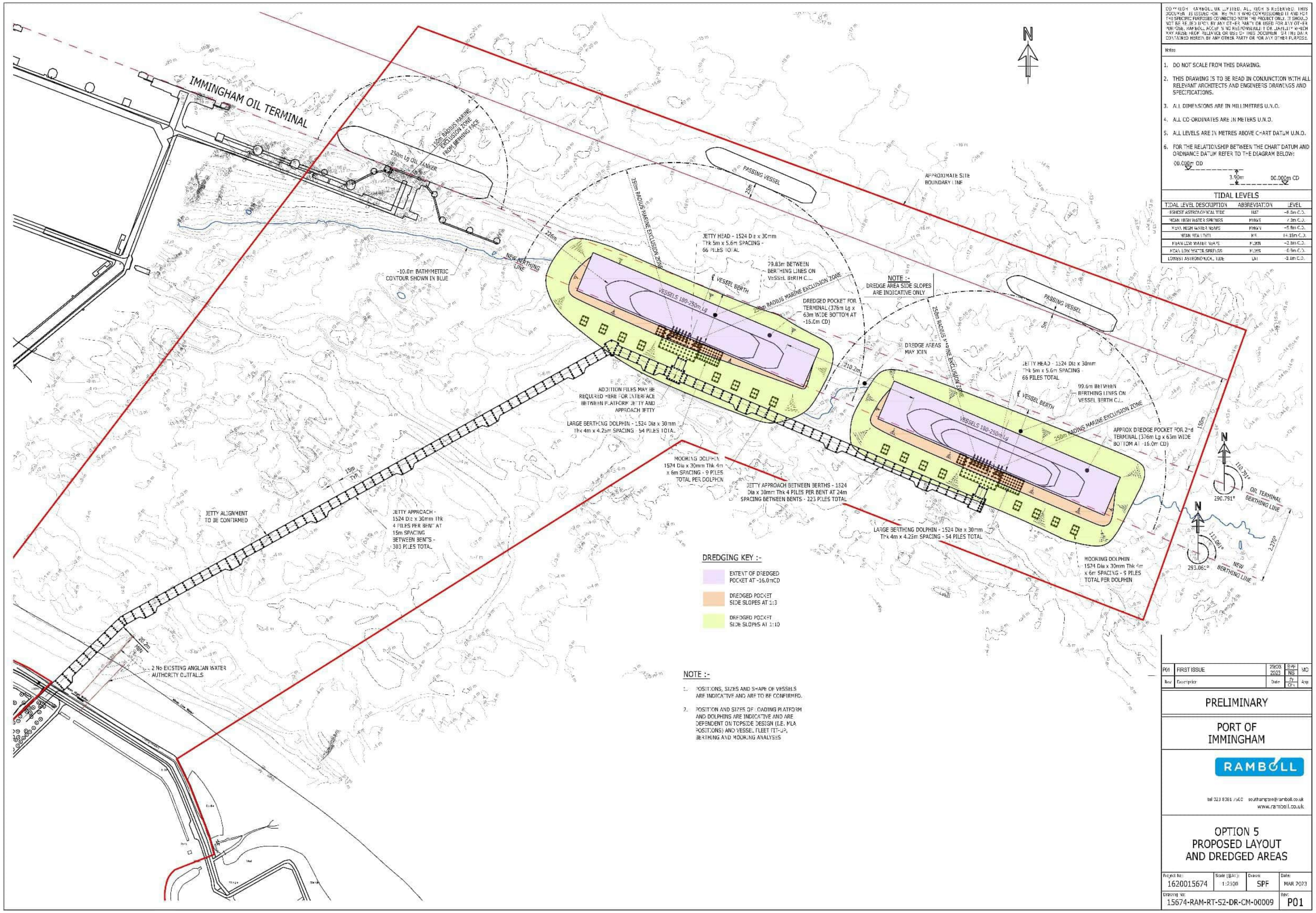


Figure 2.2: Option 5

Source: Ramboll 15674-RAM-RT-S2-DR-CM-00009 P01 OPTION 5

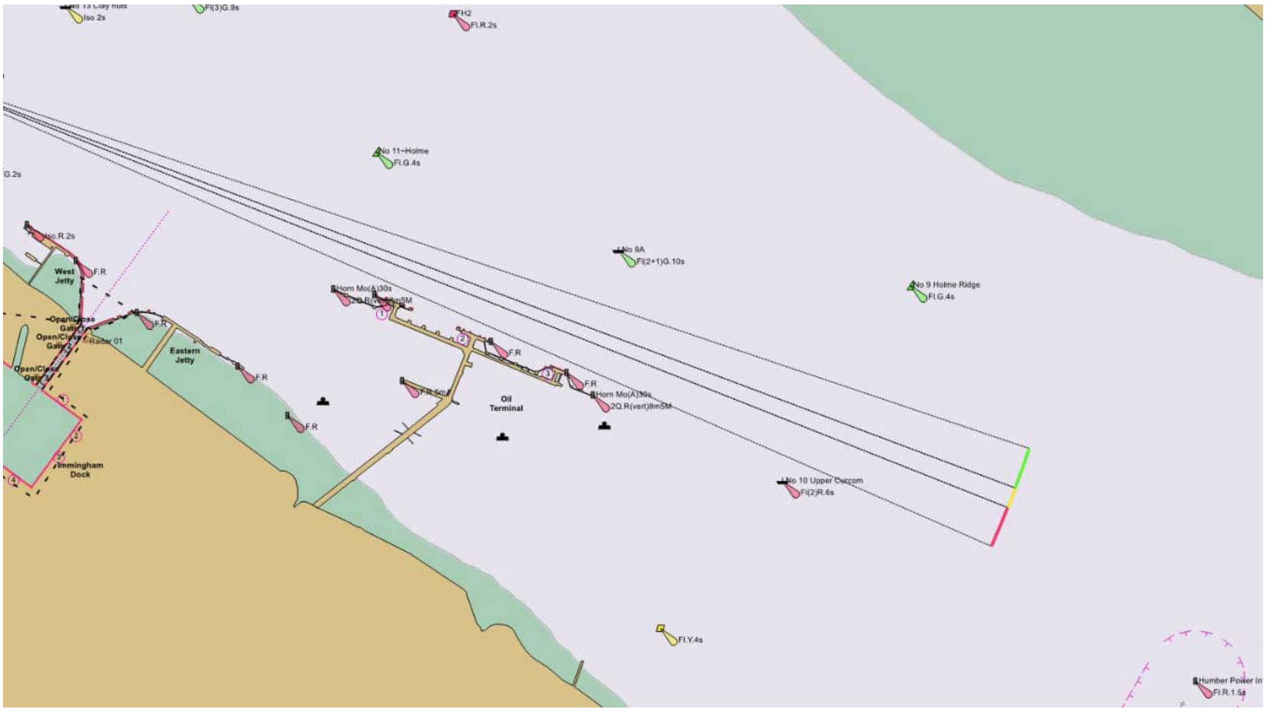


Figure 2.3: Approaches to Immingham Port as represented in the existing simulation layout

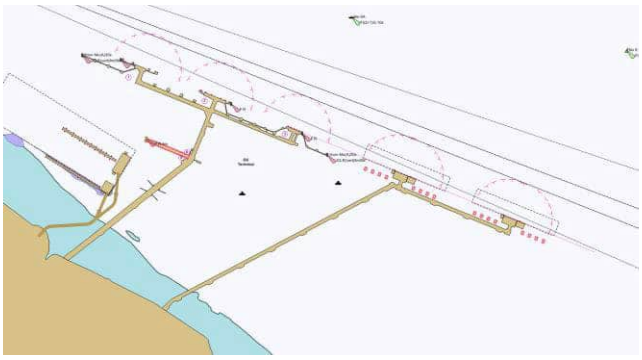


Figure 2.4: Option 1B as modelled as Layout 1

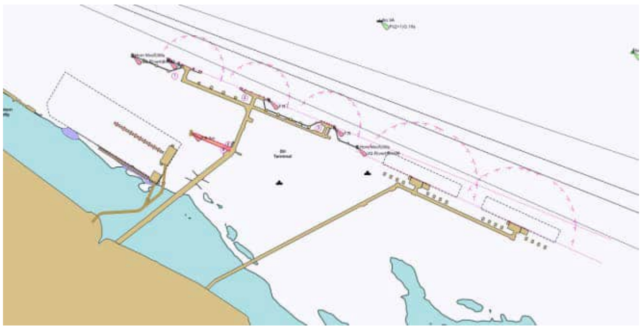


Figure 2.5: Option 5 as modelled as Layout 5

The study was carried out such that any subsequent adjustment to the design, within the general operational envelope associated with Layouts 1 and 5, could also be assessed as feasible, as long as the berth orientation to the flows, and the relative location with respect to adjacent structures, remained similar.

Ramboll further refined the design for the IGET terminal and in August 2023 HR Wallingford were asked to comment on the revised design, as shown in Figure 2.6, and referred to as the RIBA Stage 2 final design. The figure shows the final design being considered overlaid on Layouts 1 and 5 as simulated.

The RIBA Stage 2 layout is:

- No closer to the IOT terminal than IGET 1 for Layout 1, as was simulated;
- In a similar location and at a similar alignment to IGET 1 for Layout 1, as was simulated.

The Layout 1 IGET Berth 1 was extensively examined in the study and the conclusions from this study can be applied to the RIBA Stage 2 final design.

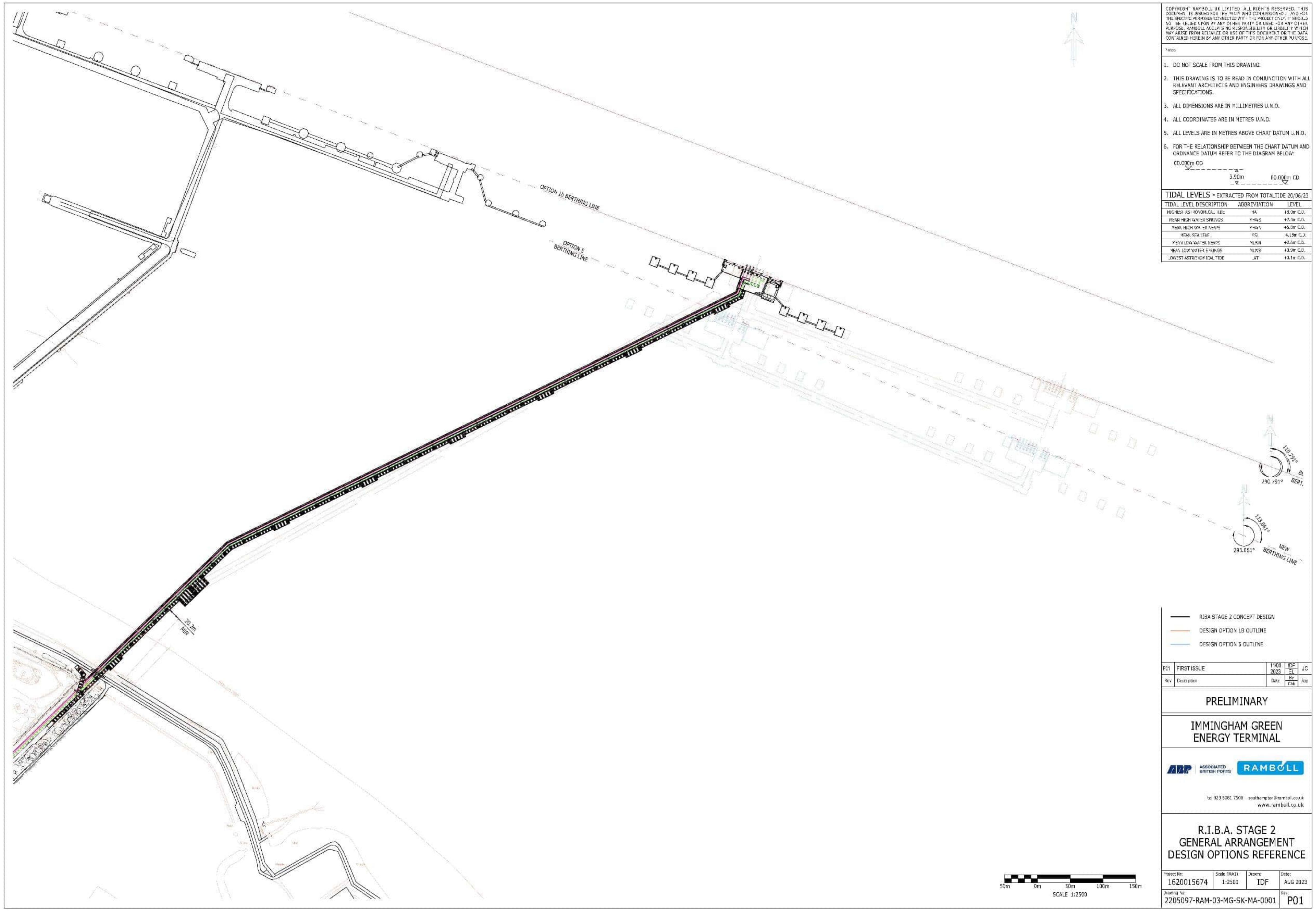


Figure 2.6: IGET RIBA Stage 2 final design option general arrangement

Source: Ramboll

2.2 Approaches to the port

The bathymetry and aids to navigation for the approaches to the port were based on the data previously provided by ABP. This was verified in conjunction with ABP HES prior to the simulation session.

There was no requirement to check the approaches to the port at night, as navigation in the area at night is well established and understood. Consequently, the simulation visual scene be configured for daytime only.

It was assumed that the existing procedures for pilot boarding and navigation, for vessels of similar sizes that already operate at Humber, will be appropriate. These may need to be reviewed as part of the NRA by Humber Estuary Services in due course.

2.3 Environmental conditions

2.3.1 Wind

The prevailing wind conditions at Immingham Outer Harbour (IOH) are south westerly, however, the strongest winds are experienced from a north easterly direction, often associated with an unstable air flow and gusts. This assessment of the wind conditions used in this study was supported by analysis of meteorological data provided by ABP Humber, as shown in Figure 2.7 and Figure 2.8.

Wind observations were taken from the top of the Immingham Maritime Control Centre at a height of 24m. The HR Wallingford ship manoeuvring models usually assume that the wind speed is taken at an elevation of 10m above sea level. Adjusting the wind speed from an elevation of 24m to 10m would result in a 10% to 15% reduction from the observed value. This could be taken into account in the analysis if it were considered to be an issue, but in this study no correction was made, which adds some conservatism to the overall assessment.

Based on this assessment and the experience of pilots operating at Immingham, the maximum likely operating winds (at a 10m elevation) at this facility are:

- South westerly winds up to 25 knots (about 12.5 m/s) with gusts up to 30 knots (about 15 m/s);
- North easterly winds up to 30 knots (about 15 m/s) with gusts up to 35 knots (about 17.5 m/s).

It was agreed that a challenging wind scenario, with either the wind setting directly onto or off the berth at between 25 knots and 30 knots, should be used for most simulation scenarios in this study, which was focused on testing feasibility. Future work will examine the operational limitations and procedures for the IGET facility, which will need to consider a wider range of wind conditions.

Structures and ships on adjacent berths may provide some wind sheltering and reduce the lateral forces experienced by a manoeuvring vessel, depending on the wind direction. The sheltering effect is not consistent, nor can it be guaranteed, so wind sheltering was not applied during the simulation runs.

It was considered that this approach provides the most conservative assessment of wind forces likely to be experienced at the berths. It may be appropriate to include an aspect of sheltering during training and the development of detailed operating limitations in due course.

The wind conditions for each simulation run were selected by the Simulation Team, based on this assessment and the objectives of the run.

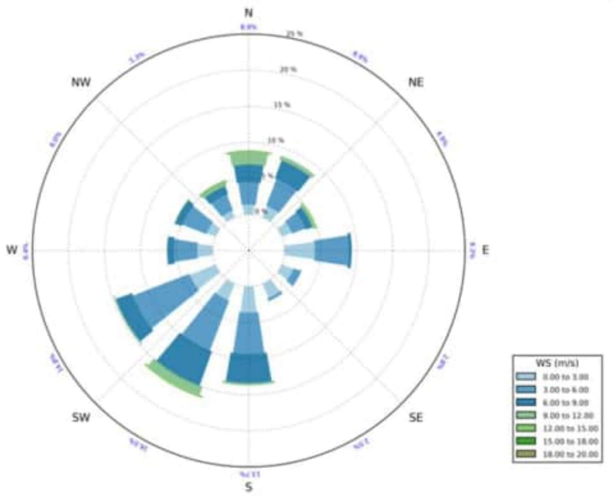


Figure 2.7: Wind rose at IOH

Source: ABP / HR Wallingford

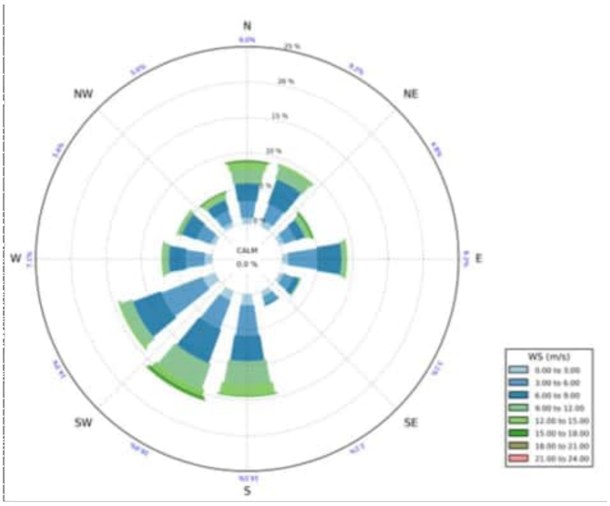


Figure 2.8: Wind rose of 30s averaged gusts

Source: ABP / HR Wallingford

2.3.2 Waves

ABP deployed an AWAC buoy at Immingham August 2022 to January 2023, which recorded the waves at that location. HR Wallingford used the data from the buoy to assess the magnitude and velocity of the prevailing sea and swell. The length of data collection was insufficient to be used detailed statistical analysis, but was suitable to provide indicative wave characteristics for the purposes of this navigation assessment.

The largest and most significant waves are from the south east and rarely exceed a significant wave height (Hs) of 0.6m (see Figure 2.9). The waves at the site will also be predominately short period at between 2 s and 6 s, as evidenced in Figure 2.10.

Where significant waves were identified, such as in the period 11 to 25 October 2022 (see Figure 2.11), the waves are only expected to exceed 0.6m for a limited time (of 2 to 4 hours) and will be coincident with a high south east winds. It was considered that this situation will be rare and should be within the contingencies of the normal port management.

There was no significant swell wave activity identified that would affect the location during the period of data collection. Furthermore, the sea waves were found to be such that it would be unlikely that they would significantly reduce the effectiveness of towage support or affect large ship navigation.

Consequently, the wave conditions applied during the simulation runs were taken from the data presented in Table 2.1, depending on the wind direction. In particular, the situation with southeast winds and moderate wave conditions was considered to be appropriate when examining emergency scenarios.

Table 2.1: Proposed wind and wave conditions

Wind direction	Wind speed (knots)	Significant wave height, Hs (m)	Peak wave period, Tp (s)
NE	30	0.6	4
NE	20	0.3	3
SW	30	0.5	3
SW	20	0.2	2
SE	30	1	6

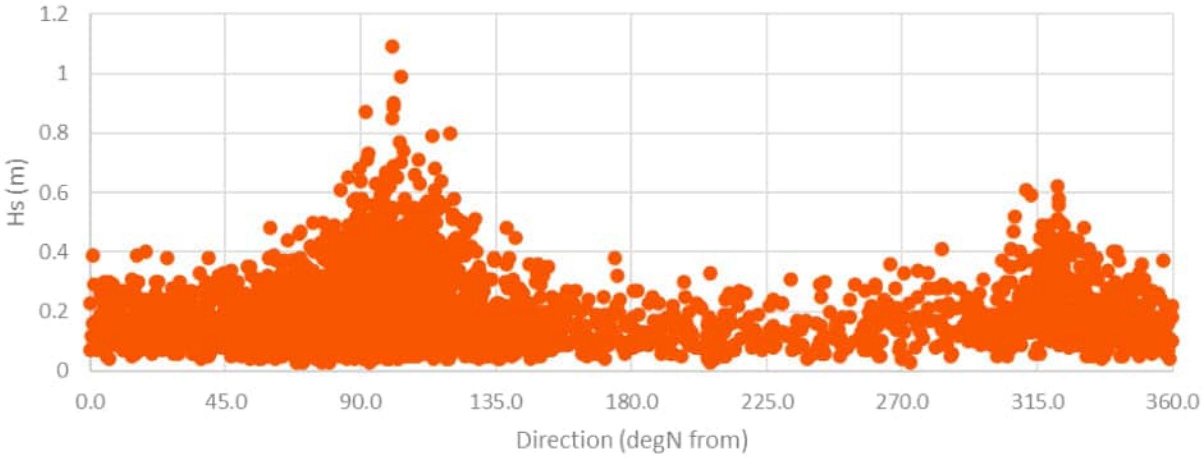


Figure 2.9: Wave Hs(m) plotted against direction based on AWAC data 10/22 – 01/23

Source: ABP Mer

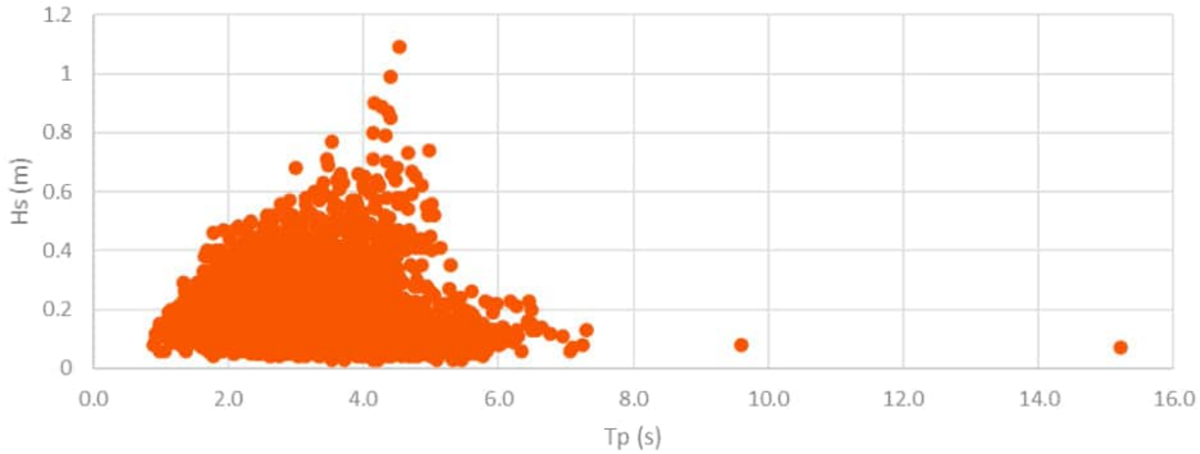


Figure 2.10: Wave Hs(m) plotted against period based on AWAC data 10/22 – 01/23

Source: ABP Mer

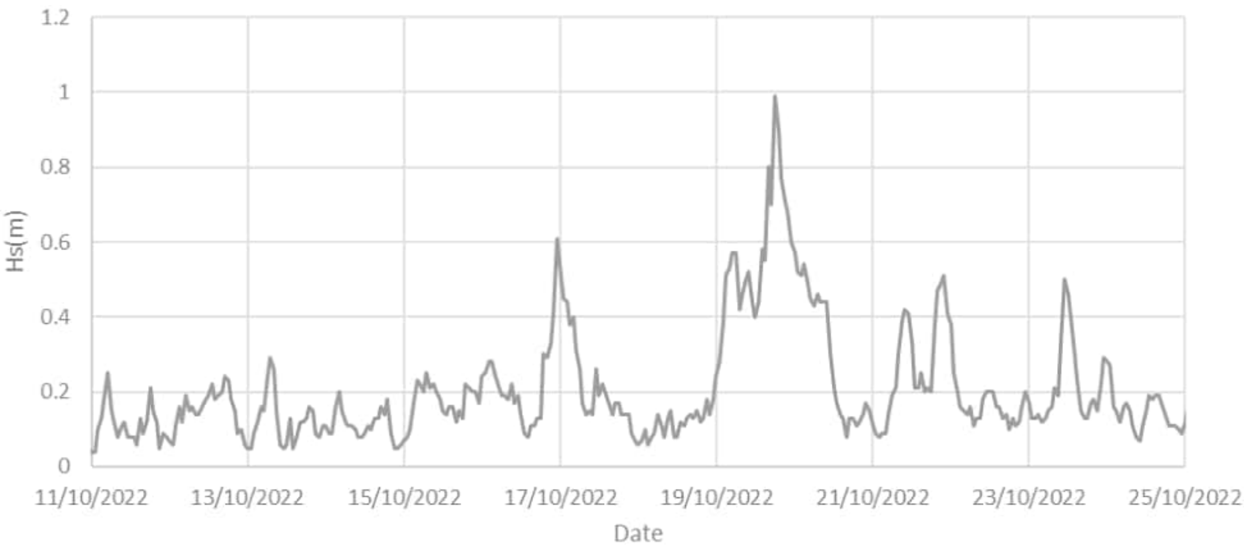


Figure 2.11: Peak wave observed 19-20 Oct 2022

Source: ABP Mer

2.3.3 Currents

HR Wallingford have previously produced flow models for Immingham and the approaches to the port. These were validated against single point AWAC measurements in the approaches to Immingham Dock taken between 2019 and 2022 and vessel mounted ADCP observations taken on November 2022. Details of this analysis are provided in References 1 and 2.

Between August 2022 and January 2022 a further AWAC instrument was deployed in the vicinity of the proposed IGET berths.

A summary of the flow data from those measurements, in the form of a current rose, is shown in Figure 2.12. The flows are more generally aligned on the flood and have a greater spread during ebb conditions. This is potentially due to the intermittent presence of deep draught vessels on the IOT, which was directly upstream of the observation point.

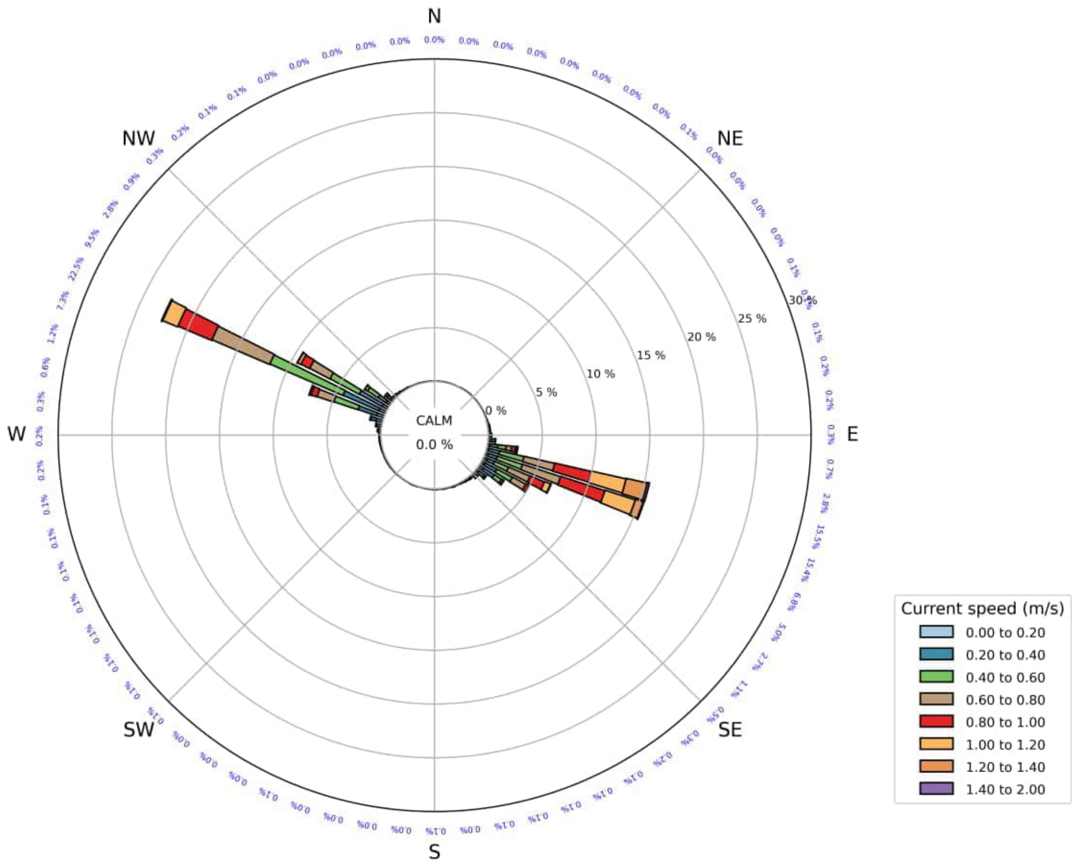


Figure 2.12: Current rose from AWAC data collected at Immingham Aug 22-Jan 23

The new AWAC data were analysed and compared with model flow data for the same location (see Figure 2.13 and Figure 2.14). A 24 hour period of flow data on a date which indicated a similar range to the 7.3m peak spring range modelled was selected for comparison.

The modelled flow data was compared with the AWAC data in the top 6m for the 24 hour period recorded on 12 October 2022. The comparisons were undertaken for all the data and then filtered to remove periods when the flow speed was less than 0.25 and 0.5 knots. This was to remove the inevitable directional ambiguity associated with slack water periods. The following results were determined:

- The mean absolute error in modelled speed for all the data was 0.16 m/s or within 17% of the observed speeds, on average. This value is 10% of the maximum observed current. This meets Environment Agency standards for flow modelling that requires modelled speeds to fall within ±10-20% of observed speeds for estuarine areas. It was recommended that the currents were scaled during the ebb tide by a factor of 1.15 to reduce the variance in modelled speed at the berth and ensure the peak ebb current speeds are representative of the observed data;

- On directions, the mean absolute error was 11.9° when all the data is considered. The model is within 20 degrees for 92% of the time. This meets Environment Agency criteria for flow modelling which requires that modelled flow directions are within 20°of observed directions for at least 90% of the time;
- Using the approach to only compare modelled directions when the current speed is more than 0.25 knots, reduces the mean absolute error in modelled direction to 10.4°. The model is within 20° of the observed current for 94% of the time;
- Further consideration, excluding the directional variability for currents less than 0.5 knots, reduced the mean absolute error in the modelled direction to 7.7° and the simulated current directions were within 20° of those observed for 96% of the time;
- In considering the ebb flood tide directions separately for currents greater than 0.5 knots, the average observed flood current direction was 296.5°N and the modelled average direction was 297.7°N, which is 1.2° different to that observed. During the ebb tide the average observed current direction was 107.7°N and the modelled average direction was 113.9°N, which was 6.2° different to that observed.

Because the orientation of the proposed IGET berths and dredging was close to the general direction of the flows and the alignment of the existing IOT infrastructure, and because it is known based on AWAC data that flow direction is already complex at the location, it was not expected that further flow modelling would provide significant additional detail in understanding the effect of construction and dredging beyond the results of the existing modelling. Indeed, it was considered that the variation in flows at adjacent berths will be similar to the variation which would be experienced (at IOT), depending on berth occupancy at adjacent berths.

There were 2 flow model result sets extracted in the simulation. They were depth averaged over the top 12m of the water column to represent conditions experienced by the design vessel and its draught. The flow model results used were based on the following tidal ranges:

- Peak spring flow (equivalent of a 7.3m range);
- Mean spring flow (equivalent to a 6.5m range).

It was reported anecdotally that the current in the main channel immediately to the north of the berths has a more northerly set at peak flood and a more southerly set on peak ebb than is represented in the flow model. Consequently, the modelled flow direction was manually adjusted for simulation runs which needed to be completed in these conditions so that the direction met the river users' understanding of the conditions.

2.3.4 Bathymetry in the vicinity of the berth

HR Wallingford had detailed bathymetry, included in the flow model, covering the approaches and the vicinity of the berth already modelled. This was based on survey data provided by ABP in 2021.

However, this model bathymetry did not include the proposed new dredged berthing boxes in the vicinity of the IGET berths, so these were added as a separate feature. The complex nature of the flows and the natural variations identified in measured data was greater than any expected variation that might result from this localised dredging. Consequently, for the purposed of this study, additional flow modelling was not considered to be necessary.

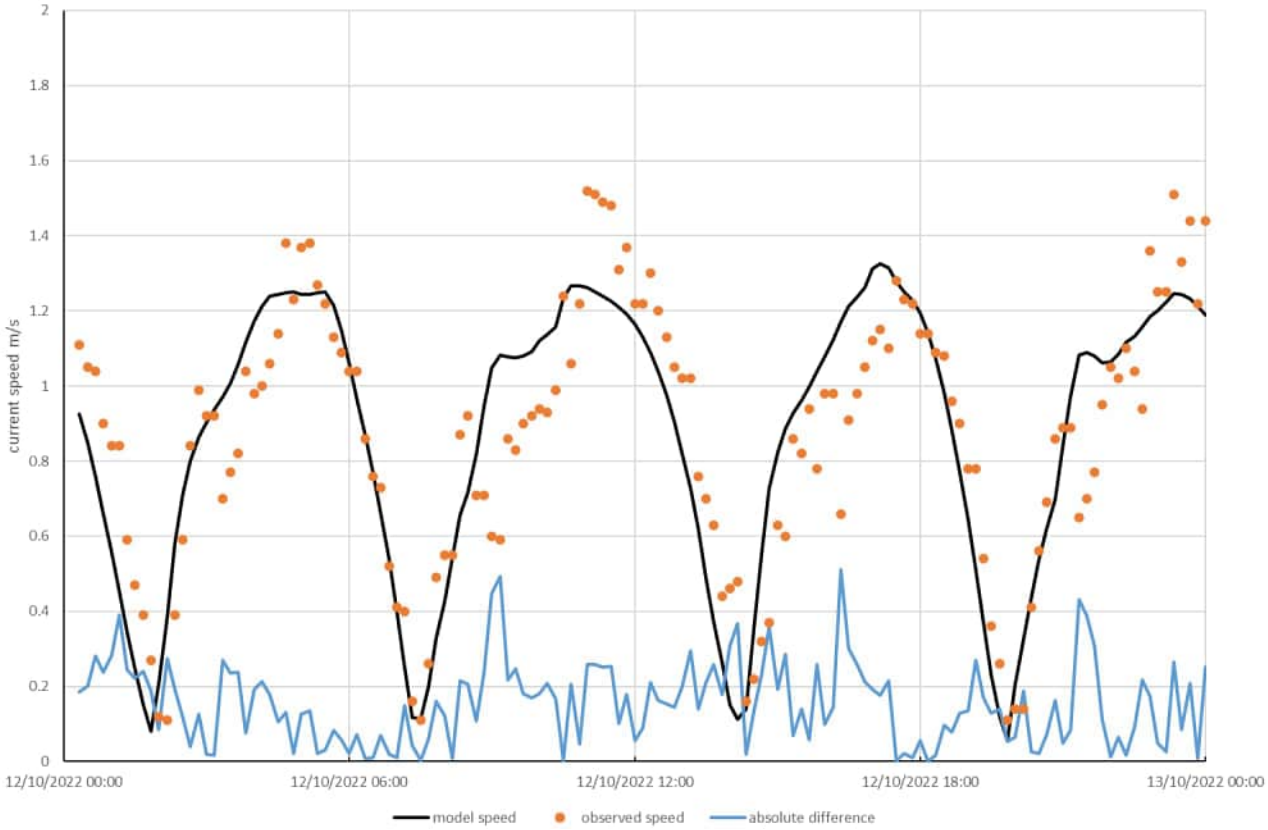


Figure 2.13: Comparison of observed and simulated current speed in upper 6m – IGET AWAC

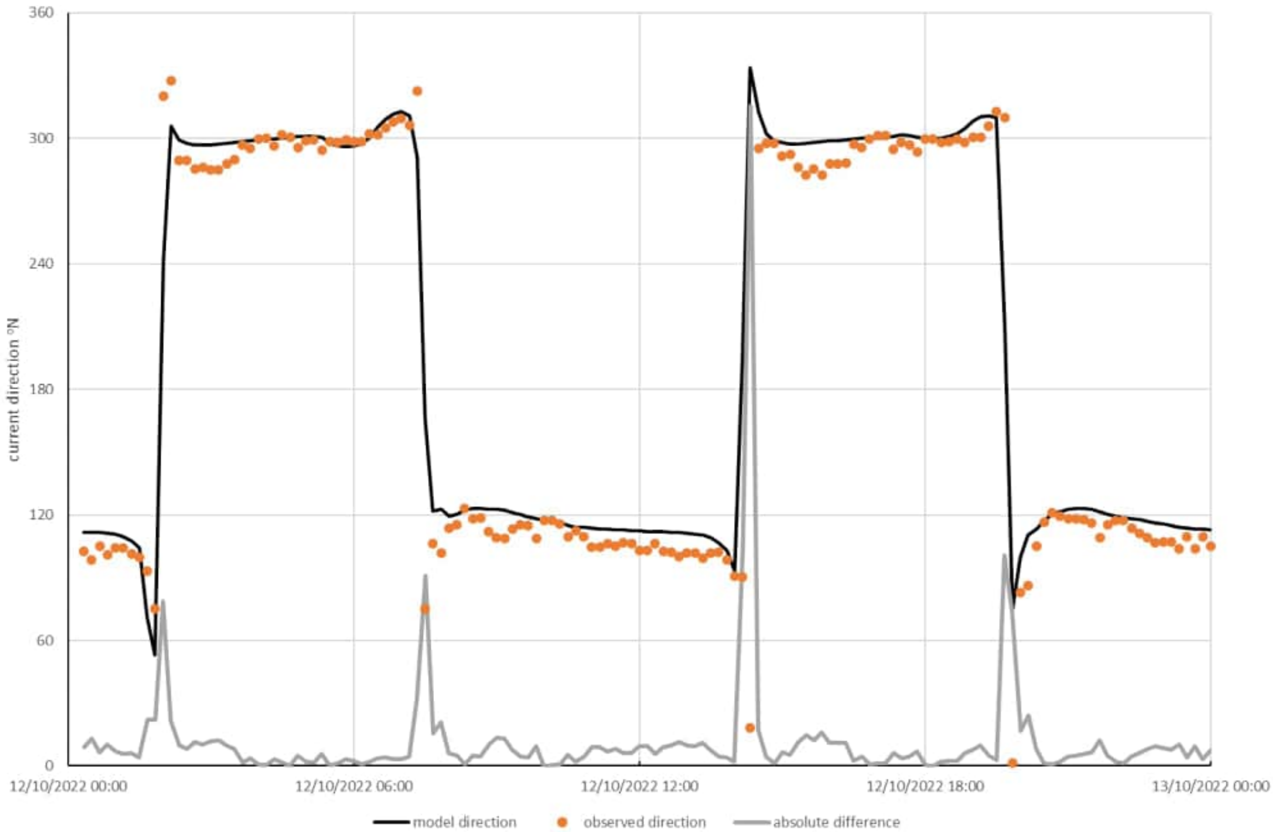


Figure 2.14: Comparison of observed and simulated current direction in upper 6m – IGET AWAC

3 Design vessels

3.1 Ships

During the navigation simulation, the behaviour and performance of each vessel, in terms of the response to any helm, engine or tug control, along with the effects of the local wind, wave and current conditions, is governed by a mathematical ship / tug manoeuvring model.

The mathematical model of the vessel must behave in such a way that the position, velocity, swept path and heading of the simulated ship are always representative of real ship behaviour.

There were 3 primary design vessels identified to be considered in this study, as presented in Table 3.1.

Table 3.1: Proposed design vessel characteristics

Vessel	Capacity (m^3)	Length (m)	Beam (m)	Draught (m)	Proposed ship manoeuvring model
Large products tanker	80,000 DWT	230	44	12.8	243m x 42m products tanker
Large RoRo	-	240	35	8	CLdN G9 8MT
Large ferry	-	220	32	7	220m x 32m RoPax ferry

The large product tanker was selected as it was considered to be representative of the regular tankers that operate at IOT, and the largest most constrained vessels expected to operate at the IGET berths. The ship was modelled in both ballast and laden conditions (see Figure 3.1 and Table 3.2).

The large RoRo vessel (Figure 3.2 and Table 3.3) and the large ferry (Figure 3.3 and Table 3.4) were also considered to be representative of the largest vessels of these types likely to be operating nearby.

Once the basis for operations is confirmed and the vessel which will routinely visit the IGET are identified, then additional simulations or analysis will need to be completed to ensure that the specific characteristics and limitations of the vessels are fully considered. This will be particularly important at this facility due to the nature of the cargoes.

The large ferry and Large RoRo have been selected to represent traffic that will be likely to pass north of IOT and IGET running to schedule and need to minimise their passage in the river.

Figure 3.1: 243m x 42m products tanker ship manoeuvring model

Table 3.2: Ship manoeuvring characteristics 243m products tanker

Characteristic	Unit	243m x 42m_Product_Tanker_Ballast		243m x 42m_Product_Tanker_Part_Laden_13 mT	
Ship type		Tanker		Tanker	
Length overall	m	243.7		243.7	
Length between perpendiculars	m	234		234	
Beam overall	m	42		42	
Distance bridge to stern	m	41.85		41.85	
Modelled conditions					
Draught forward	m	6		13	
Draught aft	m	8		13	
Block coefficient		0.760		0.802	
Displacement	t	53,600		10,5000	
Propulsion					
Main engine type		Slow Speed Diesel		Slow Speed Diesel	
Engine power (total)	kW	12440		12440	
No. of propellers, type		1 x fixed pitch		1 x fixed pitch	
Bow thrusters	t	none		none	
Stern thrusters	t	none		none	
Rudder type		Standard		Standard	
Max rudder angle	°	35		35	
Manoeuvring engine order		**RPM**	**Speed (knots)**	**RPM**	**Speed (knots)**
Full Ahead		70	13.4	70	12.5
Half Ahead		55	10.5	55	9.8
Slow Ahead		40	7.6	40	7.2
Dead Slow Ahead		25	4.8	25	4.5
STOP		0	0.0	0	0.0
Dead Slow Astern		-25	- 3.5	-25	- 3.2
Slow Astern		-40	- 5.6	-40	- 5.1
Half Astern		-55	- 7.7	-55	- 7.0
Full Astern		-70	- 9.8	-70	- 8.9
Windage					
Windage lateral	m^2	3,836		2,392	
Windage frontal	m^2	925		715	
Wind speed (knots)		**Beam wind force (t)**		**Beam wind force (t)**	
15		14		9	
20		25		15	
25		39		24	
30		56		35	
35		76		47	

Figure 3.2: CLdN RoRo vessel

Table 3.3: Ship manoeuvring characteristics CLdN RoRo vessel

Characteristic	Unit	CLdN G9 8 mT	
Ship type		RoRo	
Length overall	m	234.06	
Length between perpendiculars	m	226	
Beam overall	m	35	
Distance bridge to stern	m	216	
Modelled conditions			
Draught	m	8	
Block coefficient		0.780	
Displacement	t	50,600	
Propulsion			
Main engine type		MAN BW 9L60ME	
Engine power (total)	kW	21060	
No. of propellers, type		1 x CPP	
Bow thrusters	t	69	
Stern thrusters	t	62.5	
Rudder type		Flapped	
Max rudder angle	°	45	
Manoeuvring engine order		**RPM**	**Speed (knots)**
Full Ahead		100	19.4
STOP		0	0
Full Astern		100	- 13.6
Windage			
Windage lateral	m^2	6,682	
Windage frontal	m^2	1,197	
Wind speed (knots)		**Beam wind force (t)**	
15		24	
20		43	
25		68	
30		97	
35		133	

Figure 3.3: 220m RoPax ferry

Table 3.4: Ship manoeuvring characteristics 220m RoPax ferry

Characteristic	Unit	220m x 32m RoPax	
Ship type		Ro-Pax Ferry	
Length overall	m	220	
Length between perpendiculars	m	203.4	
Beam overall	m	32	
Distance bridge to stern	m	194.2	
Modelled conditions			
Draught forward	m	6.2	
Draught aft	m	6.4	
Block coefficient		0.690	
Displacement	t	29,000	
Propulsion			
Main engine type		4 x CAT MAK 9M43	
Engine power (total)	kW	31200	
No. of propellers, type		2 x CPP	
Bow thrusters	t	111	
Stern thrusters	t	37	
Rudder type		Flapped	
Max rudder angle	°	45	
Manoeuvring engine order		**RPM**	**Speed (knots)**
Full Ahead		100	21.3
STOP		0	0
Full Astern		-100	- 13.9
Windage			
Windage lateral	m^2	5,902	
Windage frontal	m^2	1,048	
Wind speed (knots)		**Beam wind force (t)**	
15		22	
20		38	
25		60	
30		86	
35		117	

3.2 Tugs

In previous studies at Immingham, manoeuvring models of ASD tugs providing 45tBP and 70tBP were used, based on the following actual tugs:

- 24m long 70tBP ASD tug based on the SMS tug Superman (see Figure 3.4 and Table 3.5);
- 24m long 45tBP ASD tug based on the SMS tug Merchantman (see Figure 3.5 and Table 3.5).

The 70tBP ASD tug provides a good representation of the larger class of tug employed for on the river. The 45tBP ASD tug provides a suitably conservative representation of the smallest type of tug (50t BP) likely to be used on the river to support.

Figure 3.4: 70tBP ASD tug

Figure 3.5: 45tBP ASD tug

Table 3.5: Manoeuvring characteristics for tug models

Characteristic	Unit	70t ASD2411 Tug 2021	45 t 24m x 9m ASD tug
Length overall	m	24.55	24.4
Beam overall	m	11.33	9.15
Draught	m	5.56	4.8
Main engine type		2 x Caterpillar 3516C TA HD	2 x Cat 3512C
Engine power (total)	kW	4200	2460
Propulsion		2 x Azipod	2 x Azipod

HR Wallingford’s navigation simulation system supports two types of tug models:

Centrally controlled tugs: The tug(s) assisting the vessel are controlled by the Simulator Operator following the Pilot’s commands, and in a manner similar to that which would be expected in practice, with realistic delays applied. The response of each centrally-controlled tug is governed by a tug performance model that ensures the response times and maximum force deliverable by each tug varies with tug type, winch type, vessel water speed and assist mode (push, direct pull, powered indirect, indirect pull and transverse arrest) as well as the local wave conditions and any hull sheltering effects.

Independently controlled tugs: The independently controlled tugs are operated by a tug master from separate, but linked simulator bridge(s) configured as a tug. The behaviour and performance of each independent tug model, in terms of the response to any helm, engine and towline / fender forces, along with the effects of the local wind, wave and current conditions, is governed by a full mathematical tug manoeuvring model. The tug model represents motions in all six degrees of freedom (6DOF), i.e. surge, sway, heave, roll, pitch and yaw motions, and includes tug interactions with waves, the tow line, winches and fenders. Independent tugs can be used in conjunction with centrally controlled tugs to complete the full tug complement required for a manoeuvre.

With the independently controlled tug models, the operating delays and performance degradation are automatically taken into account. The centrally controlled tugs are subject to operating delays as shown in Table 3.6, and tug performance curves as shown in Figure 3.6 and Figure 3.7.

Table 3.6: Centrally controlled tug response settings

Tug response delay			Delay
Time to attach and secure			5 minutes (+ 3 minutes line pay-out)
Time to react to new thrust level command			1 minute
Time to react to change in thrust level			20 seconds
Time to change thrust direction	Direct	up to 90˚	Up to 1 minute
		90 to 180˚	Up to 2 minutes
	Indirect	Roll into assist	Up to 30 seconds
		quarter to quarter	Up to 1 minute
Time to detach	Push / pull mode		1 minute

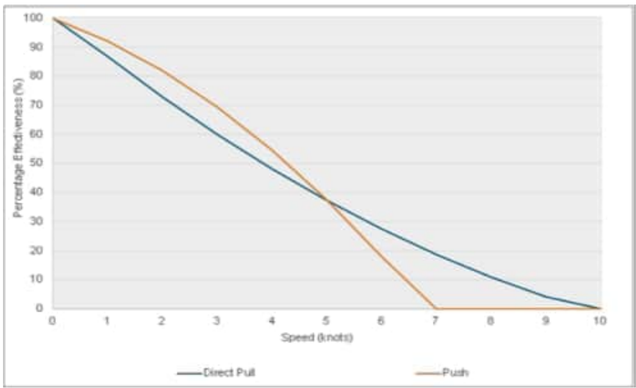


Figure 3.6: Effectiveness of centrally controlled tugs with water speed

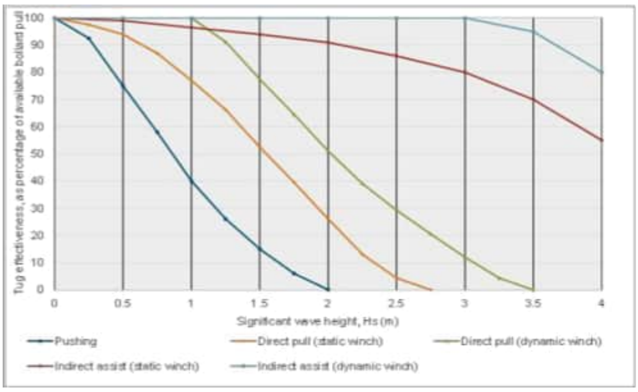


Figure 3.7: Effectiveness of centrally controlled tugs with wave height

4 Navigation simulation

4.1 Simulation session

4.1.1 Outline

The simulation session for this real time navigation simulation study was held at HR Wallingford's UK Ship Simulation Centre in Wallingford, Oxfordshire, over 3 days between 11 and 13 April 2023.

4.1.2 Simulation Team

The Simulation Team was made up of representatives from all stakeholders invited to attend the session, HR Wallingford's staff and the attending pilots / masters. The Simulation Team was as detailed in Table 4.1.

Table 4.1: Simulation Team

Name	Role	Representing	Tue 11 Apr	Wed 12 Apr	Thu 13 Apr
Dr Mark McBride	Project Director	HR Wallingford	Remote	Remote	Remote
Mike Parr	Project Manager	HR Wallingford	Y	Y	Y
Liam Monahan-Smith	Simulator Operator	HR Wallingford	Y	Y	Y
Captain Ian Simpson	Staff Mariner / Pilot	HR Wallingford	Y	Y	Y
Guagan Jackson	Project Lead	ABP	Y	Y	Y
Capt Vikas Chaudary	Marine advisor	Air Products	Y	Y	Y
Scott Dunn	Project Engineer	Jacobs	Y	Y	Y
Matthew Leslie	Design Engineer	Ramboll	Y	Remote	Remote
Andrew Firman	Harbour Master	ABP HES	Y	Y	Y
Joe Smith	Port Ops	ABP HES	Y	Y	Y
Tim Aldridge	Risk Assessment	ABP Mer	Y	Y	Y
Ian Cousins	Pilot	HES	Y	Y	Y
Jason Melles-Sawyers	Pilot	HES	Y	Y	Y
Simon Gutherless	Tug Master	SMS Towage	Y	Y	Y
Gareth Bonner	Tug Master	Svitzer	Y	Y	Y
Neal Keena	Marine Superintendent	APT	–	–	Y
Olly Smith	Marine Superintendent	APT	–	–	Y

Most representatives and stakeholders were able to attend in person. The simulation was hosted virtually for those unable to attend directly. Remote attendees were able to contribute to all the briefing and discussions and monitor the runs during execution.

4.1.3 General procedures

The general simulation session procedures were as follows:

- Before each run, the objectives and the run conditions were agreed by the Simulation Team;
- The Simulation Team were able to observe the run and will be encouraged to participate in the debrief and review which takes place immediately on completion of the run;
- Each run was be graded (as a success, marginal or fail) based on agreed criteria and the consensus of the Simulation Team;
- Subsequent runs and the overall flow of the simulation session was informed by the outcome of previous runs as agreed by the Simulation Team.

The key runs, objectives and priorities were agreed in outline in the Basis of simulation and methodology paper (Reference 6). The run sequence was adapted to ensure a range of scenarios were demonstrated during the last day of simulation for which APT stakeholders were able to be present.

The simulation session also Discussions around the operations at IGET were broad and far reaching. Where issues were raised which were pertinent but not directly related to considering the feasibility of the design from the perspective of ship navigation, then representatives from ABP Mer and ABP were asked to register the issues for inclusion in the subsequent NRA.

4.2 Assumptions

Immediately before the start of the real time navigation simulations ABP advised HR Wallingford that they will be proceeding with a single berth option for IGET. In lieu of an alternative detailed design, it was agreed to proceed with the 2 berth layouts described as Layout 1 and Layout 5, which had already been prepared and modelled. However, it was agreed to prioritise the manoeuvres to IGET Berth 1 associated with Layout 5, as that provided the most challenging navigational manoeuvres. A series of runs for Layout 1 and IGET Berth 2 were also included, as required, to test the sensitivity of the locations from a navigational perspective.

The following assumptions were used during the simulation session:

- Approaches to the IGET and IOT will only be undertaken at HW slack;
- Concurrent approaches will be planned and coordinated by HES in conjunction with operators;
- Single vessel departures may be permitted at LW slack;
- All arrivals will be supported by 4 x ASD tugs;
- All departures will be supported by 3 x ASD tugs;
- Arrivals and departures at IOT 3 will be the most constrained with respect to the IGET development;
- Vessels larger or more constrained that the design vessel (243m long products tanker) may operate at IOT, but only at IOT 1 and 2, and their arrivals and departures can be managed such that they are independent of any operations at IGET;
- Concurrent operations at IGET and IOT will be necessary;
- The existing practice of allowing ship to ship coordination for passing vessels immediately north of IOT will be maintained;
- In due course a safe passing distance and an exclusion zone will need to be defined and they may result in ships needing to pass greater than 150m from the berthing line (Layout 1B) or greater than 250m from the berthing line (Layout 5).

4.3 Recording

Immediately after each simulation run, the pilot who conducted the run was debriefed and their views on various aspects of the run recorded.

Additionally, there was a full digital record of each run which was used for post-run analysis and the production of supporting information.

4.3.1 Simulation run summary

Following each run, a simulation run summary table entry was recorded. This details the set-up, configuration of the vessel / vessels, the manoeuvre, tug configuration, environmental factors and run grading, as presented in Table 4.2.

4.3.2 Simulation track and data plots

The results of each navigation simulation run are available in the form of plots of the vessel tracks and graphs of key data parameters recorded during the run. These data are presented in Appendix B.

The vessel data and track plots show:

- The position of the ship and the tugs at one minute intervals are indicated by a succession of black and blue vessel outlines. Red vessel outlines indicate the vessel's position every 10 minutes from the start of the run;
- The positions of port structures and aids to navigation;
- A north arrow;
- Wind vector;
- Current vector;
- A scale bar.

Seabed contours (bed levels in mCD). The data graphs plot the variation of various key parameters against elapsed simulation time and graphs have been included for all vessels in all of the runs. These graphs are presented by vessel, starting with the ship, and then the independent tug (where applicable). The vessel ID is identified in the text block on the bottom right of each page.

The ship graphs comprise:

- Ship's under keel clearance(s) in metres and speed over the ground (knots). The data plotted in these UKC graphs does not take account of wave-induced ship motions;
- Speed (knots) and direction (°N) of the wind acting on the ship;
- Significant wave height and direction;
- Current speed and direction;
- Lateral wind force acting on the ship (tonnes);
- Ship's rate of turn (°/min) and heading in °N;
- Ship's course over the ground and drift angle in degrees;
- Ship's speed (over the ground and through the water) in knots, expressed in terms of longitudinal and lateral components relative to the ship's head;
- Ship's rate of turn (°/min);
- Ship's rudder angle (degrees);
- Ship's bow and / or stern thruster power (%).

Where there are no plots for a particular parameter, for example for bow thruster power, this indicates that the particular parameter was not relevant for the particular run, or no bow thruster was available.

Table 4.2: Simulation run summary

Run ID	Pilot	Layout	Manoeuvre	Objective	Vessel	Tugs	Tide (reference Immingham)	Wind (dir, knots)	Waves (dir Hs Tp)	Assessment
01	IC	Layout 5	Arrival IGET2	Familiarisation and model verification	243m products tanker part-laden	4 x 70 t ASD Tug 1: CLF (CCT) Tug 2: SS (CCT) Tug 3: SQ (CCT) Tug 4: CLA (ICT)	HW-30 mins	NE 15	-	Success
02	JMS	Layout 5	Departure IGET 1	Familiarisation and model verification	243m products tanker ballast	3 x 70 t ASD Tug 1: SS (CCT) Tug 2: SM (ICT) Tug 3: SQ (CCT)	HW-40 mins	SW 15	-	Success
03	IC	Layout 5	Arrival IGET 1	Demonstrate that berth design for IGET is appropriate for berthing and unberthing in challenging conditions	243m products tanker part-laden	4 x 70 t ASD Tug 1: CLF (CCT) Tug 2: SS (CCT) Tug 3: SQ (CCT) Tug 4: CLA (ICT)	HW-35 mins	SW 27.5 ± 2.5	SW 0.5m 3.0s	Success
04	JMS	Layout 5	Arrival IGET 1	Demonstrate that berth design for IGET is appropriate for berthing and unberthing in challenging conditions	243m products tanker part-laden	4 x 70 t ASD Tug 1: CLF (CCT) Tug 2: SS (CCT) Tug 3: SQ (CCT) Tug 4: CLA (ICT)	HW-35 mins	NE 27.5 ± 2.5	NE 0.5m 3.0s	Success
05	IC	Layout 5	Departure IGET 1	Demonstrate that berth design for IGET is appropriate for berthing and unberthing in challenging conditions	243m products tanker ballast	3 x 70 t ASD Tug 1: SS (CCT) Tug 2: SM (ICT) Tug 3: SQ (CCT)	HW-40 mins	SW 27.5 ± 2.5	SW 0.5m 3.0s	Success

Run ID	Pilot	Layout	Manoeuvre	Objective	Vessel	Tugs	Tide (reference Immingham)	Wind (dir, knots)	Waves (dir Hs Tp)	Assessment
06	JMS	Layout 5	Departure IGET 1	Demonstrate that berth design for IGET is appropriate for berthing and unberthing in challenging conditions	243m products tanker ballast	3 x 70 t ASD Tug 1: SS (CCT) Tug 2: SM (ICT) Tug 3: SQ (CCT)	HW-40 mins	NE 27.5 ± 2.5	NE 0.5m 3.0s	Success
07	IC	Layout 5	Arrival IOT 3	Demonstrate that berth design for IGET will not affect safe operations at IOT 3	243m products tanker part-laden	4 x 70 t ASD Tug 1: CLF (CCT) Tug 2: SS (CCT) Tug 3: SQ (CCT) Tug 4: CLA (ICT)	HW-20 mins	NE 27.5 ± 2.5	NE 0.5m 3.0s	Success
08	JMS	Layout 5	Arrival IOT 3	Demonstrate that berth design for IGET will not affect safe operations at IOT 3	243m products tanker part-laden	4 x 70 t ASD Tug 1: CLF (CCT) Tug 2: SS (CCT) Tug 3: SQ (CCT) Tug 4: CLA (ICT)	HW-20 mins	SW 27.5 ± 2.5	SW 0.5m 3.0s	Success
09	IC	Layout 5	Departure IOT 3	Demonstrate that berth design for IGET will not affect safe operations at IOT 3	243m products tanker ballast	3 x 70 t ASD Tug 1: SS (CCT) Tug 2: SM (ICT) Tug 3: SQ (CCT	HW-40 mins	SW 27.5 ± 2.5	SW 0.5m 3.0s	Success
10	JMS	Layout 5	Departure IOT 3	Demonstrate that berth design for IGET will not affect safe operations at IOT 3	243m products tanker ballast	3 x 70 t ASD Tug 1: SS (CCT) Tug 2: SM (ICT) Tug 3: SQ (CCT)	HW-40 mins	NE 27.5 ± 2.5	NE 0.5m 3.0s	Success

Run ID	Pilot	Layout	Manoeuvre	Objective	Vessel	Tugs	Tide (reference Immingham)	Wind (dir, knots)	Waves (dir Hs Tp)	Assessment
11	IC	Layout 5	Departure IOT 3	Demonstrate that LW departure will still be feasible at IOT	243m products tanker ballast	3 x 70 t ASD Tug 1: SS (CCT) Tug 2: SM (ICT) Tug 3: SQ (CCT)	LW-40 mins	NE 27.5 ± 2.5	NE 0.5m 3.0s	Success
12	JMS	Layout 5	Departure IGET 1	Demonstrate that LW departure will be feasible at IGET	243m products tanker ballast	3 x 70 t ASD Tug 1: SS (CCT) Tug 2: SM (ICT) Tug 3: SQ (CCT)	LW-40 mins	SW 27.5 ± 2.5	SW 0.5m 3.0s	Success
13	IC	Layout 5	Arrival IGET 1 late arrival and abort	Demonstrate that there is a safe procedure to abort if unable to complete berthing manoeuvre for whatever reason	243m products tanker part-laden	2 x 70 tASD Tug 1: CLF (CCT) Tug 2: CLA (ICT)	HW-20 mins	NE 27.5 ± 2.5	NE 0.5m 3.0s	Success
14	JMS / IC	Layout 5	Concurrent arrival at IOT 2 and 3	Demonstrate that the design of IGET and any exclusion zone does not affect the ability to undertake concurrent arrivals at IOT	2 x 243m products tanker part-laden	4 x 70 t ASD Tug 1: CLF (CCT) Tug 2: SS (CCT) Tug 3: SQ (CCT) Tug 4: CLA (CCT)	HW-20 mins	NE 27.5 ± 2.5	NE 0.5m 3.0s	Success
15	IC	Layout 5	Arrival at IGET 1	Demonstrate that with IGET set back from IOT proposed arrival window and allocated tug resources are sufficient to deal with emergency on approach	243m products tanker part-laden	4 x 70 t ASD Tug 1: CLF (CCT) Tug 2: SS (CCT) Tug 3: SQ (CCT) Tug 4: CLA (ICT)	HW-10 mins	NE 27.5 ± 2.5	NE 0.5m 3.0s	Success

Run ID	Pilot	Layout	Manoeuvre	Objective	Vessel	Tugs	Tide (reference Immingham)	Wind (dir, knots)	Waves (dir Hs Tp)	Assessment
16	JMS / IC	Layout 5	Passing traffic at IOT and IGET	Demonstrate that traffic will be able to pass safely to north of IGET and IOT based on same principles used at present to manage traffic in this location	1 x CLdN RoRo 1 x 220m ferry	-	HW + 4 Peak Ebb	NE 27.5 ± 2.5	NE 0.5m 3.0s	Success
17	JMS / IC	Layout 5	Passing traffic at IOT and IGET	Demonstrate that traffic will be able to pass safely to north of IGET and IOT based on same principles used at present to manage traffic in this location	1 x CLdN RoRo 1 x 220m ferry	-	HW -3 Peak Flood	NE 27.5 ± 2.5	NE 0.5m 3.0s	Success
18	IC	Layout 1	Arrival at IGET 1	Consider sensitivity from a navigational perspective between Layout 1 and Layout 5	243m products tanker part-laden	4 x 70t ASD Tug 1: CLF (CCT) Tug 2: SS (CCT) Tug 3: SQ (CCT) Tug 4: CLA (ICT)	HW-20 mins	SW 27.5 ± 2.5	SW 0.5m 3.0s	Success
19	JMS	Layout 5	Arrival at IOT 3 abort	Demonstrate that there is a safe procedure to abort if unable to complete berthing manoeuvre for whatever reason	243m products tanker part-laden	4 x 70t ASD Tug 1: CLF (CCT) Tug 2: SS (CCT) Tug 3: SQ (CCT) Tug 4: CLA (ICT)	HW-10 mins	NE 27.5 ± 2.5	NE 0.5m 3.0s	Success
20	JMS / IC	Layout 5	Arrival concurrent IOT 2 and 3	Demonstrate that the design of IGET and any exclusion zone does not affect the ability to undertake concurrent arrivals at IOT	2 x 243m products tanker part-laden	4 x 70 t ASD Tug 1: CLF (CCT) Tug 2: SS (CCT) Tug 3: SQ (CCT) Tug 4: CLA (CCT)	HW-20 mins	SW 27.5 ± 2.5	SW 0.5m 3.0s	Success

Run ID	Pilot	Layout	Manoeuvre	Objective	Vessel	Tugs	Tide (reference Immingham)	Wind (dir, knots)	Waves (dir Hs Tp)	Assessment
21	JMS / IC	Layout 5	Arrival concurrent IGET 1 and IOT 3	Demonstrate that the design of IGET and any exclusion zone does not affect the ability to undertake concurrent arrivals at IGET and IOT	2 x 243m Product Tanker part-laden	4 x 70 t ASD Tug 1: CLF (CCT) Tug 2: SS (CCT) Tug 3: SQ (CCT) Tug 4: CLA (CCT)	HW-20 mins	NE 27.5 ± 2.5	NE 0.5m 3.0s	Success
22	IC	Layout 5	Departure from IGET 1 with tug failure		243m products tanker ballast	3 x 70 t ASD Tug 1: SS (CCT) Tug 2: SM (ICT) Tug 3: SQ (CCT)	HW-40 mins	SE 27.5 ± 2.5	SE 1.0m 6.0s	Success
23	IC	Layout 5	Arrival to IGET 1 with swing	Demonstrate that a vessel can arrive at IGET, swinging before arrival and then berthing starboard side alongside	243m products tanker part-laden	4 x 70 t ASD Tug 1: CLF (CCT) Tug 2: PS (CCT) Tug 3: PQ (CCT) Tug 4: CLA (ICT)	HW-1 hour	NE 27.5 ± 2.5	NE 0.5m 3.0s	Success
24	JMS	Layout 5	Arrival to IGET 1 with swing	Demonstrate that a vessel can arrive at IGET, swinging before arrival and then berthing starboard side alongside	243m products tanker part-laden	4 x 70 t ASD Tug 1: CLF (CCT) Tug 2: PS (CCT) Tug 3: PQ (CCT) Tug 4: CLA (ICT)	HW-30 mins	SW 27.5 ± 2.5	SW 0.5m 3.0s	Success
25	IC	Layout 5	Departure IGET 1	Consider sensitivity with respect to tug power	243m products tanker ballast	3 x 45 t ASD Tug 1: SS (CCT) Tug 2: SM (ICT) Tug 3: SQ (CCT)	HW-40 mins	NE 27.5 ± 2.5	NE 0.5m 3.0s	Success

Run ID	Pilot	Layout	Manoeuvre	Objective	Vessel	Tugs	Tide (reference Immingham)	Wind (dir, knots)	Waves (dir Hs Tp)	Assessment
26	IS	Layout 1	Arrival at IGET 1	Consider sensitivity from a navigational perspective between Layout 1 and Layout 5	243m products tanker part-laden	4 x 45 t ASD Tug 1: CLF (CCT) Tug 2: SS (CCT) Tug 3: SQ (CCT) Tug 4: CLA (CCT)	HW-20 mins	NE 27.5 ± 2.5	NE 0.5m 3.0s	Success
27	IS	Layout 1	Arrival at IGET 1	Consider sensitivity from a navigational perspective between Layout 1 and Layout 5	243m products tanker part-laden	4 x 45 t ASD Tug 1: CLF (CCT) Tug 2: SS (CCT) Tug 3: SQ (CCT) Tug 4: CLA (CCT)	HW-20 mins	SW 27.5 ± 2.5	SW 0.5m 3.0s	Success

Notes: Tug positions: CLF = centre lead forward, CLA = centre lead aft, SS = starboard shoulder, SQ = starboard quarter, SM = starboard midships, PS = port shoulder, PQ = port quarter

CCT = centrally controlled tug

5 Discussion of results

5.1 General

Given the nature of the cargoes being proposed for operations at IGET, the position of the proposed berthing line needed to take into account that the effect of any associated exclusion zone or safe passing ship distance should be minimised. The precise definition of the exclusion zone and safe passing distances would require the following 2 studies to be carried out:

- Analysis of the risk associated with an accidental gaseous discharge and the associated vapour cloud;
- A passing ship study considering the safe passing distance from the berths to minimise any interaction that may cause disruption of moored ships.

In lieu of results from these studies, 2 layouts were considered in this navigation simulation study as follows:

- Layout 1 (Figure 5.1) assumed that a 150m exclusion zone;
- Layout 5 (Figure 5.2) has the IGET berths set back and rotated slightly to enable a 250m exclusion zone.

Otherwise form a navigation perspective the layouts are similar.

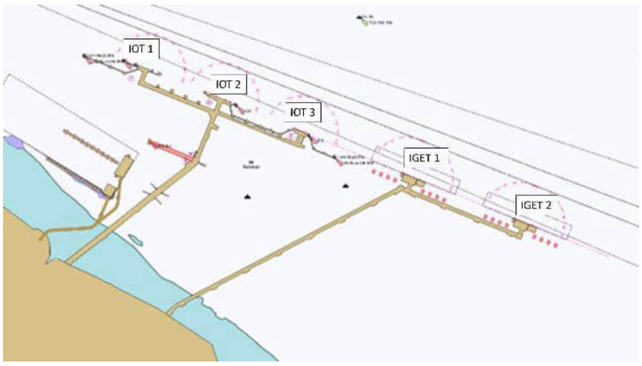


Figure 5.1: Layout 1B

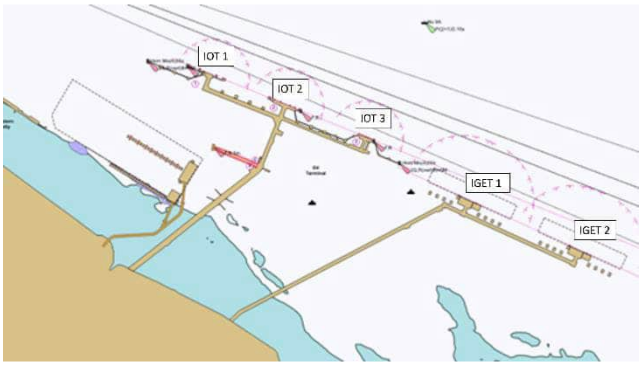


Figure 5.2: Layout 5

5.2 Initial familiarisation runs

The initial runs were used to enable the attending pilots to familiarise themselves with the simulation environment and to verify the key characteristics of the ship manoeuvring models. These were also used to establish the broad tidal criteria to be adopted during the subsequent simulation runs.

All runs were conducted by Humber Estuary Service Class 1 Pilots with current operational experience on the river, or by HR Wallingford's experience Pilot, who has piloted similar vessels and has operational experience of the river Humber.

In the real situation, the pilots time their arrival passing Sunk Spit Buoy no later than 75 minutes before HW 'Albert' . This ensures that the vessel arrives in the vicinity of IOT and is berthing during slack water. It is not advisable to attempt berthing when the ebb is underway, which is consistent with the procedure in the Humber Passage Plan (Reference 5).

On departure the pilot will aim to leave the berth between 1 hour before HW and HW at Albert.

Due to the close vicinity of the IGET facility to IOT and the similar classes of ships involved, the Humber Harbour Master advised that similar timings should be used for IGET. The familiarisation Runs 1 and 2 enabled the pilots to confirm this assumption and refine their timing.

For subsequent simulation runs the start of the run was initiated to enable a comparable situation. The timing was calculated using the passage times during the familiarisation runs and using tidal data for Immingham lock. Figure 5.3 shows the simulated tidal information, illustrating the process used to select the start point in the tidal cycle for each run.

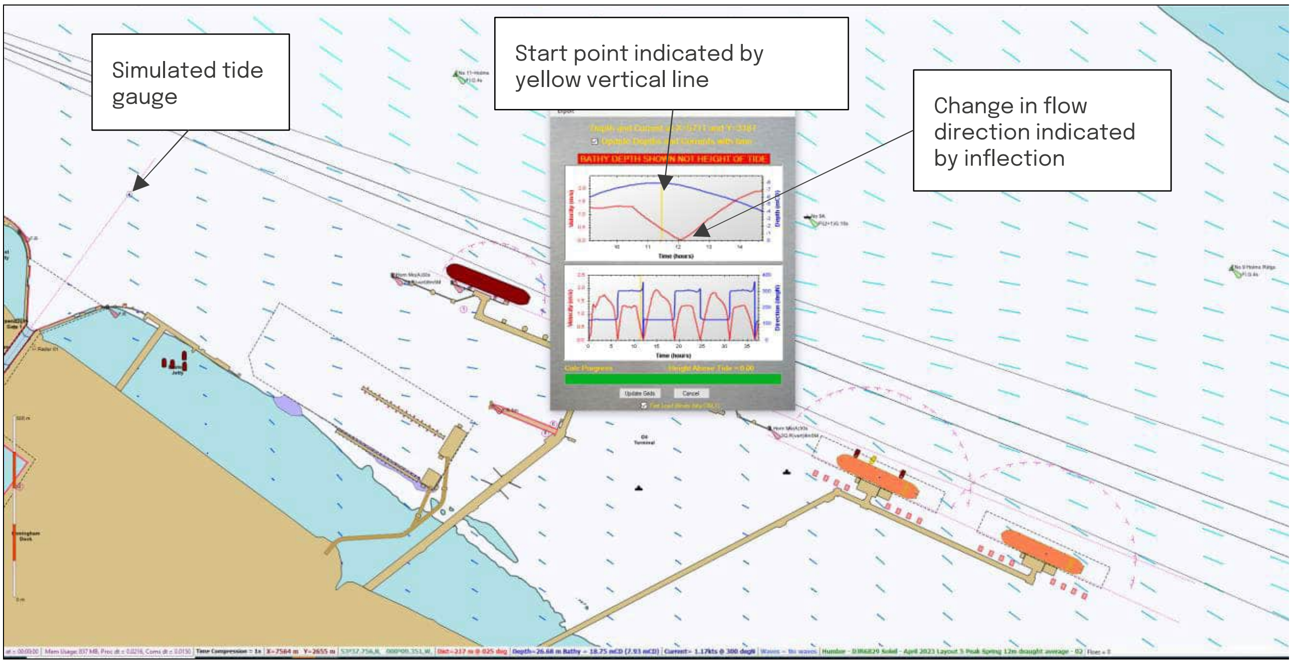


Figure 5.3: Screen dialogue illustrating simulated tide gauge and curves

It was agreed by the Simulation Team that an appropriate wind strength to demonstrate the feasibility of the design should be 25 to 30 knots, and the manoeuvres should be considered with the wind setting both on and off the IGET berths.

The tug allocation was agreed as 4 x ASD tugs for arrivals and 3 x ASD tugs for departures. This allocation is in line with existing procedures at IOT for similar sized vessels, as included in the Humber Passage Plan.

Adjacent berths were considered to be occupied and exclusion zones enforced in all runs.

5.3 Standard manoeuvres at IGET

A total of 9 arrival and departure manoeuvres were undertaken to IGET 1 and IGET 2 berths, with 6 simulating Layout 5 and 3 simulating Layout 1B (Runs 1 to 6, 18, 26 and 27).

All runs were assessed as successful, and no significant issues were raised by the pilots.

The procedures in the Humber Passage Plan (Reference 5) for IOT arrivals were used and found to be appropriate with minor adjustments to account for the slightly shorter passage time.

All runs assumed that the ships will berth port side alongside, as this is expected to be the normal procedure.

The approach technique for IGET 1 and 2 was consistent for both layouts. Also the approach line from the Sunk spit Buoy is similar, with any amendment required predominately due to the leeway induced by the wind.

There were no issues with the approaching vessel and supporting tugs keeping clear of any exclusion zone when simulating either layout.

On arrival, once stemming any flow, parallel to the berth, the pilot used the tugs and any environmental advantage available, to move laterally towards the berth at a safe speed. There was found to be no significant difference in the final stages of the approach, due to subtle variations in flow direction relative to the berthing line.

Figure 5.4 shows a typical general approach route for approaches to IGET (Run 3) and Figure 5.5 shows the detail of a typical final approach to IGET 1.

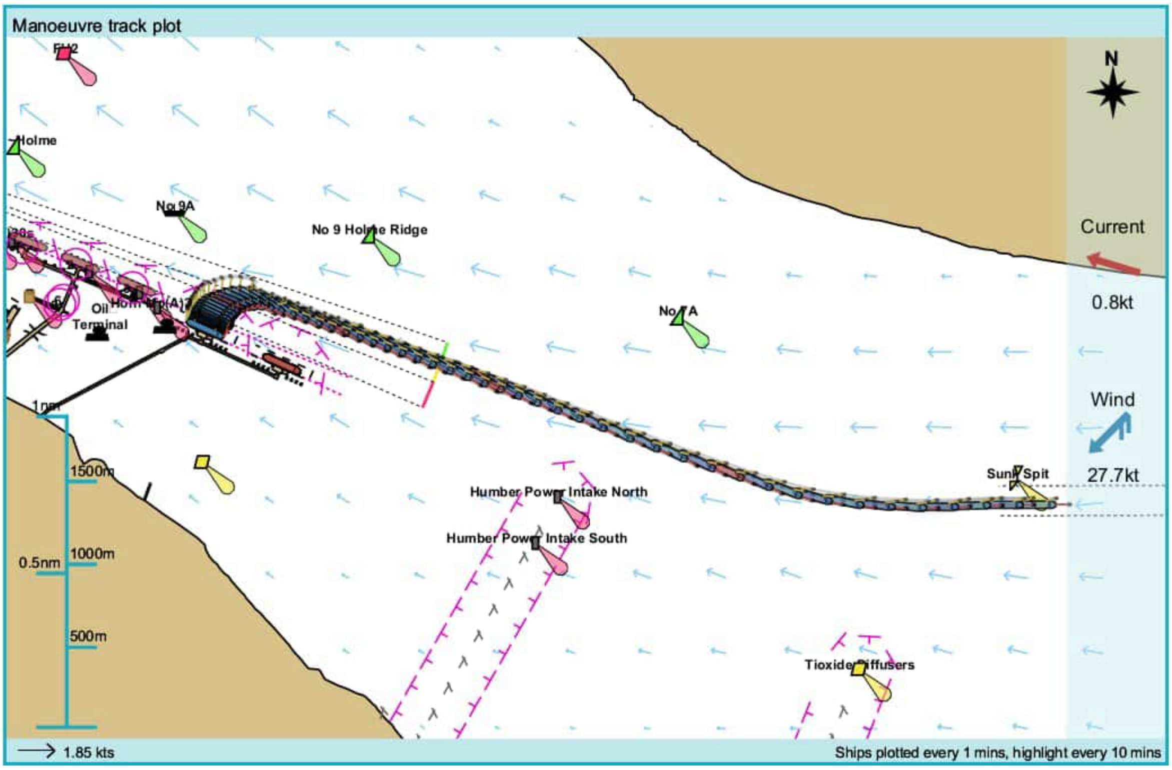


Figure 5.4: Run 3 showing typical approach route to IGET

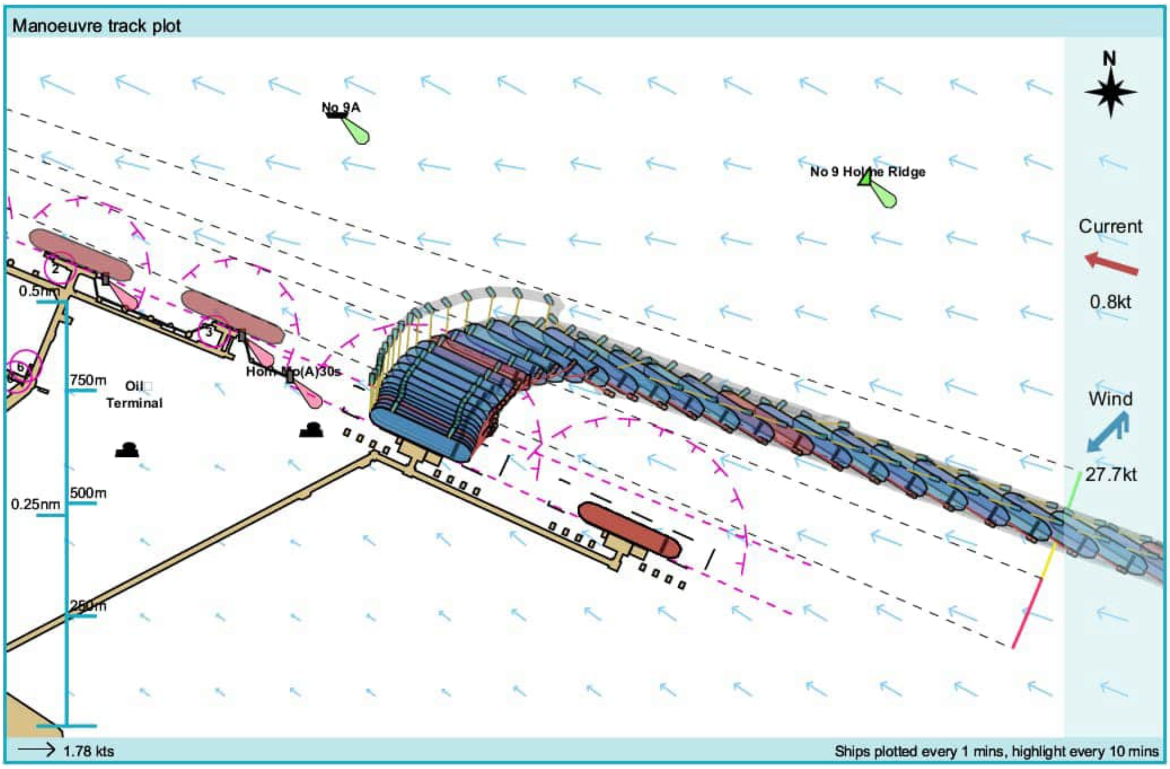


Figure 5.5: Run 3 showing typical final approach IGET 1

The departure technique for IGET 1 and 2 was consistent for both layouts. Here the pilot used the tugs and any environmental advantage to move laterally away from the berth at a safe speed. Once sufficiently clear of the berth and adjacent exclusion zones, the pilot initiated a swing in the main part of the river, selecting the swing direction based on prevailing conditions.

There was found to be sufficient sea room to swing, as long as the manoeuvre was conducted at slack water, which is consistent with existing operations at IOT.

Figure 5.6 shows the typical swept path and track for a vessel departing an IGET berth (Run 5).

Once heading out to sea there was no difference in the departure track compared to existing departures from IOT.

In the event of any minor changes to the berth design, it is considered that no further navigation simulation studies would be required to examine feasibility if:

- The mooring dolphins are located in relatively similar positions compared to the main jetty;
- The berthing line is at the same orientation as either Layout 1B or Layout 5;
- The berthing line lies within the margins of an area constrained by the berthing lines of Layout 1B and Layout 5;
- The design vessel is unchanged;
- There is no change to the assumptions outlined in Section 4.2.

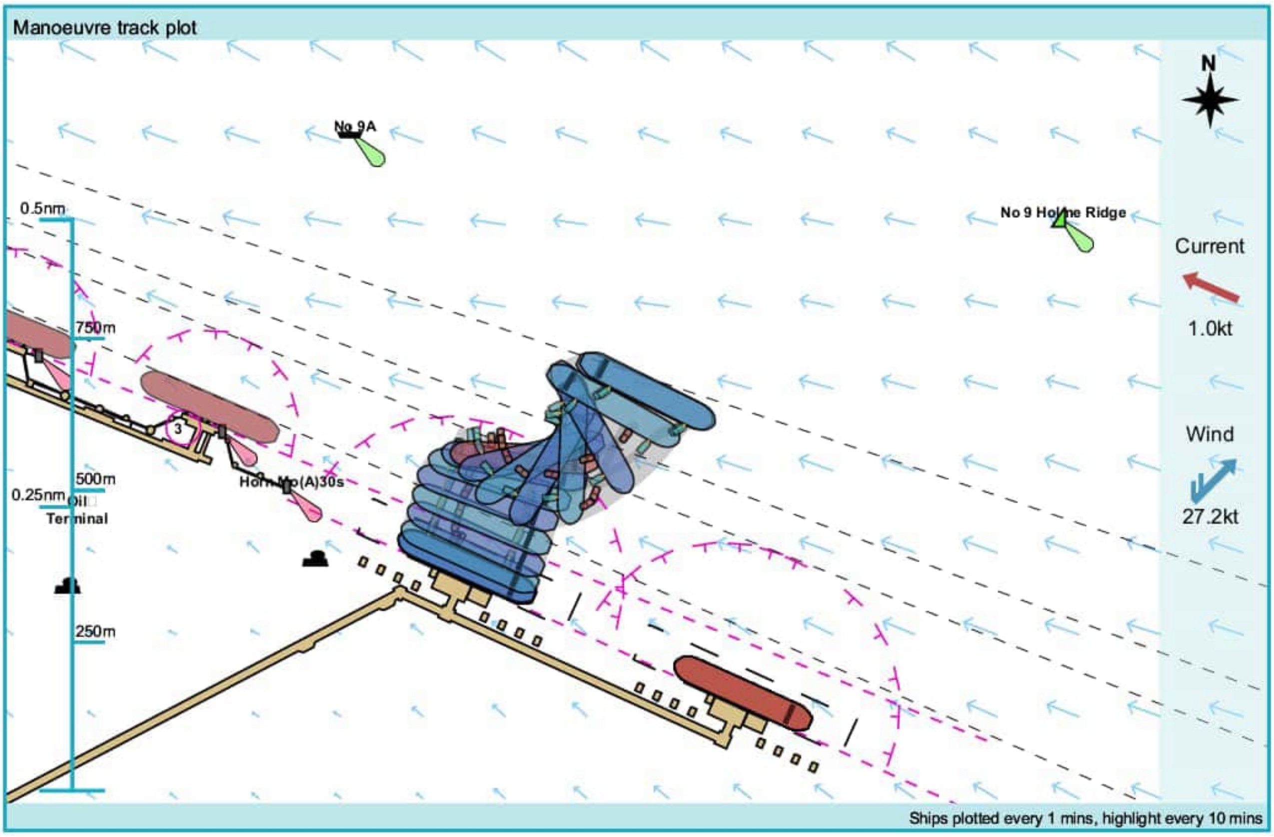


Figure 5.6: Run 5 showing a typical departure manoeuvre

5.4 IOT

A total of 4 standard arrival and departure manoeuvres were undertaken to IOT 3 (Runs 7 to 10). All runs were assessed as successful and no significant issues arose.

The timings and procedures in the Humber Passage Plan (Reference 5) for IOT were used and found to be appropriate.

The presence of the exclusion zone at IGET required the pilots to adjust their approach line from their existing practice, as the revised approach takes the vessel further to the north in the main channel. There were no safety issues identified with the revised approach line.

The approach and departure technique for IOT was not significantly affected by changes to the IGET layout. It should be noted that the exclusion zone for Layout 5 extends marginally further into the river, so Layout 5 was selected for all IOT approaches.

It was agreed by the Simulation Team that the presence of IGET would have the most effect on operations at IOT 3, and that there were no exceptional cases with respect to IOT 1 and 2 that should be considered.

The approach line from the Sunk Spit Buoy was similar to that used for IGET, with any change required due to the leeway induced by the wind. So there were no issues with the approaching vessel and supporting tugs keeping clear of any exclusion zone.

Once stemming any flow parallel to the berth, the pilot used the tugs and any environmental advantage to move laterally towards the berth at a safe speed.

The approach is similar to the existing practice at IOT, with the overall manoeuvre taking a similar time, taking into account the IGET exclusion zone.

The wider approach lane may make it more difficult for other vessels to pass, however, the manoeuvre takes place at slack high water so there are no challenging cross currents and there is 400m width of adequate depth of water to the north for most vessels. During the simulation run debrief discussions, the pilots considered that most vessels operating on the river could safely coordinate to pass in the same manner as with the existing situation.

On departure, the pilots used the tugs and any environmental advantage to move laterally away from the berth at a safe speed. Once sufficiently clear of the berth and adjacent to the exclusion zone, the pilot initiated a swing in the main part of the river, selecting the swing direction based on the prevailing conditions.

There was a 650m wide area of safe water in which to swing, as long as the manoeuvre was conducted at slack water. The time to swing was consistent with existing operations at IOT.

Once heading out to sea there was no difference in the departure track compared to existing departures from IOT.

Figure 5.7 and Figure 5.8 show the overview and detail from Run 7 and are indicative of typical approaches to IOT considering the IGET exclusion zone.

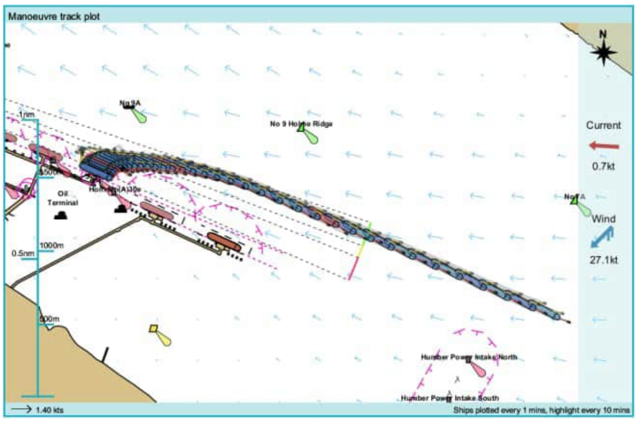


Figure 5.7: Run 7 showing typical approach route to IOT 3

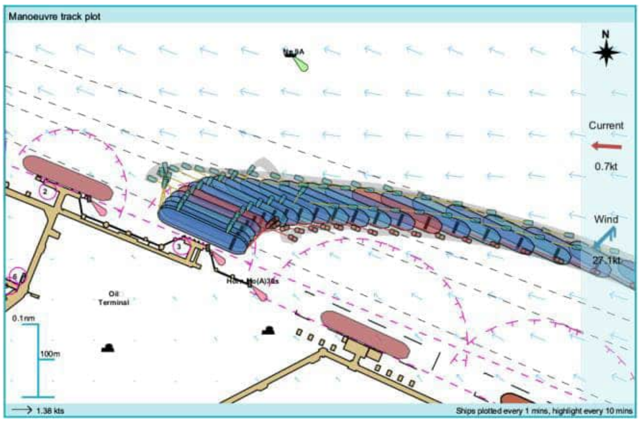


Figure 5.8: Run 7 showing typical final approach

5.5 LW departures

There is a procedure for low water departures in the Humber Passage Plan (Reference 5). The Simulation Team were informed that LW arrivals at IOT are feasible, but rare and are only undertaken by relatively small vessels (less than 60,000DWT). This would be an unusual operation and would receive special attention in planning, therefore they were not prioritised in the simulation session.

Nevertheless, 2 runs (Runs 11 and 12) were completed to assess whether or not the new infrastructure would affect the existing procedures at IOT and if a similar practice could be established in due course at IGET.

Both runs were assessed as successful, and no significant issues arose. The vessels and supporting tugs were able to be manoeuvred without encroaching into the exclusion zones for adjacent berths. Hence, the existing procedures for LW departures at IOT will not need any significant amendment for low water departures to accommodate IGET.

The results from these departure manoeuvres indicated that there are not expected to be any navigational safety issues continuing this practice due to the IGET infrastructure and associated exclusion zones.

5.6 Concurrent arrivals

At present vessels arrive at IOT in convoy, separated by approximately 1,000m and effectively berth concurrently. The convoy sequence is based on berth allocation, with the vessel at the most westerly berth heading the convoy, and the one with the most easterly berth at the back.

Considering this operation, 3 simulation runs were performed considering:

- If the presence of IGET berths and the proposed exclusion zones would present any difficulties to the existing procedures;
- If concurrent berthing at IOT and IGET would be feasible.

Runs 14, 20 and 21 considered these situations and all runs were assessed as successful, with no significant issues (see example image from one of these runs in Figure 5.9).

It was therefore found that concurrent berthing at IOT is expected to be feasible, based on existing procedures.

Concurrent berthing of vessels at IOT and IGET was also found to be feasible, from a navigational standpoint, although consideration may also need to be given to the nature of the cargo and ensuring other vessels maintain a safe distance during transit.

Specifically, concurrent berthing at IOT and IGET may need to be re-examined if it is subsequently found that vessels transporting ammonia require a safe separation distance of greater than 1,000m.

Concurrent departures were not examined, as they are coordinated between pilots and effectively the departing vessels operate individually, so the assessment presented in Section 5.4 is applicable.

The additional berths at IGET may add some additional traffic to the arrival and departure window at HW. This was discussed amongst the Simulation Team and with representatives from APT. It was agreed that the normal level of coordination by harbour authorities in accordance with existing procedures will be appropriate and sufficient to deconflict the planned movements at IGET and IOT.

Figure 5.9: View of concurrent arrivals simulated at IOT and IGET

5.7 Abort and emergency scenarios

Abort and emergency procedures were simulated to ensure that the proposed arrangements for the IGET infrastructure did not introduce any additional restrictions or create additional hazards.

For approaching ships, the existing procedures require that 2 tugs are made fast and that the pilot is confident that the ship will be at the berth at slack water no later than when passing the Humber Power intake.

Run 13 considered the situation where the pilot needed to abort an approach to IOT at this point. Both IGET layouts being considered will reduce the safe water area available for vessels to swing during this abort. However, swinging between IGET and No 9 Buoy to achieve the abort was demonstrated to be safe with 25 to 30 knots of wind setting the vessel toward the exclusion zone. It may be prudent to revise the Humber Passage Plan to include an earlier decision point to avoid swinging to abort adjacent to IGET.

Run 19 considered the situation where the pilot determines an abort is necessary when nearly adjacent to the IOT. It was demonstrated that, even considering the IGET infrastructure and associated exclusion zone, and with 25 to 30 knots wind setting towards the berth, a swing to abort was navigationally safe in the space available.

Run 15 considered the situation with a tug failure at a critical point during the approach. This was again simulated with 25 to 30 knots of wind setting the ship onto the berth and failing 1 of the 4 assisting tugs. It was found that there was sufficient residual power in the remaining 3 tugs to continue the berthing manoeuvre.

Run 22 considered the situation where 1 of 3 tugs failed during a departure from IGET Berth 1 and Layout 5. The environmental conditions were set to the most challenging, determined from the AWAC data collected in late 2022 at the site. So south eastly winds of 25 to 30 knots with Hs 1m waves and on the last of the ebb, all setting the departing vessel towards IOT 3. The emergency was initiated when the vessel was beam onto the wind and tide, and adjacent to IOT 3. The pilot was able to safely control the vessel and complete the swing before heading to sea on a standard departure route, despite the failure.

Run 25 repeated the scenario from Run 22, but the tug support was changed to 3 x 45tBP ASD tugs, so with a total of 135tBP. This was undertaken to provide a direct comparison with the requirements of the Humber Passage Plan (Reference 5), which requires a minimum of 150tBP. The outcome of the run demonstrated that, as long as none of the tugs are rated below 45tBP, it was safe to adopt the procedures in the Passage Plan as the basis for the future operations at IGET.

An emergency scenario on arrival was not repeated with the lower rated tugs. This was because the availability of 4 tugs distributed along the length of the ship reduces the hazard of a single tug failure. Also, analysis of Run 15 shows that, even after the tug failed, full power was used only once in the subsequent action, and 50tBP was requested for only approximately 45 seconds. It was concluded that the manoeuvre would have also been successful using less power for slightly longer.

It was considered that testing a single tug failure in challenging environmental conditions, which are setting the vessel towards the most significant hazard, at the most critical point, demonstrates that the risks associated with a manoeuvre are manageable.

It was therefore concluded that the abort and emergency manoeuvres simulated demonstrated that the design for IGET Layouts 1B and 5 are safe from a navigational perspective, with the following caveats:

- A similar assessment will be required to ensure that any reduction in overall tug power for smaller vessels at IGET remain appropriate;
- Further consideration, in due course, on the requirement to escort ammonia or gas carriers in the Sunk Channel and other narrow parts of the pilotage route.

5.8 Passing traffic

Existing procedures do not require vessels passing north of IOT to follow any specific reporting policy, other than reporting on departing their berth or passing Sunk Spit when inbound.

Vessels passing north of IOT are required to keep at least 150m clear of the IOT berthing line and reduce their speed to 5 knots when vessels are alongside.

There is no prohibition on vessels navigating in the river from passing each other directly to the north of IOT. The area available to complete such a manoeuvre is limited and, in particular, during peak ebb or peak flood flow conditions, the ability of vessels to achieve such a manoeuvre would be challenging. It is considered normal practice that operators on the river coordinate with each other and manage their situational awareness to ensure that such a situation does not arise.

During the study, 2 runs were used to assess if the design of IGET and any associated exclusion zone would compromise the ability for vessels to safely navigate in the main river.

Run 16 and 17 considered the situation for inbound and outbound ferries creating a possible passing scenario in the vicinity of IOT and IGET. There was coordination between the pilots on each ship, using the standard reporting policy and navigation practice.

Figure 5.9 is a view taken during the simulation run showing the relative positions of passing ferries to IGET.

Figure 5.10: View from Run 16 showing ferries passing north of IGET

The environmental conditions were set to consider the peak flood flow, setting across the river, with 25 to 30 knots of wind also setting in the same direction, which were considered to be challenging conditions.

The runs provided a clear demonstration that the presence of IGET and any associated exclusion zone did not affect the ability of vessels to safely transit the river and coordinate passing, when compared to the existing situation.

In addition, the presence of the additional IGET berths, did not significantly increase the transit time for vessels, including when considering a passing situation.

Assuming that ships will need to pass at 5 knots when to the north of IGET, as required by the present river bylaws, the additional berths will add approximately 1.5 minutes to the transit time. This assumes a restriction due to a single occupied berth (500 m). For 2 occupied IGET berths (1,000 m) the additional transit time would increase to 3 minutes. These estimates also assume that there is an EZ of no more than a 150m for Layout 1 and 250m for Layout 5.

It is likely that the outcome of a passing ship study will determine that potentially increasing the passing safety distance to 150m hull to hull will not only increase safety, but enable the vessels to transit more quickly against the flow. The same assessment could be applied to the IOT in due course, which may potentially improve efficiency of transits on the river, and support a less ambiguous definition for safe passing speed.

5.9 Starboard side arrivals

It is understood that approaches to IOT are usually planned to moor port side alongside, so swinging on departure. Whereas, it is normal practice in many places for gas carriers to swing on arrival, so, in some cases, allowing a more straightforward departure in case of emergency. Considering this, and based on a specific request by APT, arrivals considering berthing starboard side alongside were simulated in Runs 23 and 24. Both runs were successful and no significant issues arose.

It was agreed that departures from starboard side alongside did not need to be considered as the situation for departing port side alongside was more challenging and had already been demonstrated to be achievable safely.

An emergency scenario during a starboard side alongside arrival were also considered to have already been considered in Run 22. This run simulated a vessel in a similar location relative to IOT, with the outcome safely managed when one of the assisting tugs suffered a failure.

It maybe possible to use ships berthing starboard side alongside at the terminal to deconflict with inbound traffic to IOT, where a vessel arriving to berth starboard side alongside will plan to be swinging and berthing earlier in the tidal cycle. However, the detailed timing for this was not assessed during this study.

5.10 Use of tugs

The Humber Passage Plan requires that operations at IOT with a vessel between 80,000 and 150,000 DWT should be allocated:

- 4 tugs for arrivals with a minimum total capacity of 170tBP;
- 3 tugs for departures with a minimum total capacity of 150tBP.

These requirements were considered for the IGET manoeuvres and so a tug allocation of 4 x 70tBP ASD tugs on arrival and 3 x 70t BP ASD tugs on departure were simulated, to monitor the overall power requirements.

A preliminary assessment showed that this number of tugs and their allocation were appropriate, and the total power was also considered to be adequate, so these tugs were used in the simulation session.

Runs 25, 26 and 27 considered the use of 3 smaller tugs, which may be appropriate at times, with a minimum total power of 135tBP. These were found to be sufficient for safe navigation, even with a single tug failure.

Nevertheless, the operators of the vessels may also expect a minimum tug allocation and this must also be consistent with the existing practices and procedures on the Humber, which may need to be adapted accordingly.

Similarly, defining any requirement to provide escort towage for gas carriers in other parts of the channel will need to be considered as part of operational planning when the vessels and their characteristics are better defined.

5.11 Other considerations

The safety of navigation for vessel transporting ammonia to the east of Sunk Spit Buoy and, in particular, in the Sunk Channel and other narrow parts of the transit, will need to be considered in due course. It will be appropriate to do this once the specific hazards with regard to the cargo and the associated risks are fully understood.

There is no indication from this study, and based on HR Wallingford's experience, that the proposed operations cannot be carried out safely. However, there are likely to be additional requirements identified in the wider NRA for vessels transporting ammonia and other vessels operating in their vicinity, that will need to be considered.

During this study, the term "exclusion zone" has been used generally to consider the area around a berth or manifold from which other vessels needs to remain clear. However, the details of such an exclusion zone still need to be determined.

As the design and operational planning become more advanced, it is suggested that the project adopt a more discrete terminology, to enable the risks and issues to be better presented. In due course and for general communications it may be appropriate to revert to a single term, although the following terminology may also be used:

- Toxicity Safety Zone: Based on the hazard to health and life in the event of an inadvertent discharge of cargo. Vessels that do not have specific safety adaptations and trained personnel with adequate personnel protective equipment should be prohibited from entering this zone. The zone will be static around the vessel when berthed, and consideration should be given to providing a moving zone during general navigation;
- Explosive Safety Zone: Based on the risk of any cargo to ignite and / or explode in the event of an inadvertent discharge of cargo. Vessels that do not have specific safety adaptations and trained personnel with adequate personnel protective equipment should be prohibited from entering this zone. The zone will be static around the vessel when berthed, and consideration should be given to providing a moving zone during general navigation;
- Safe Passing Ship Distance: Based on the following:
  - The interaction effect from a passing ship which may cause a moored vessel to move significantly, so increasing the risk of disruption to cargo handling or the parting of mooring line(s);
  - Reducing the risk of a moored vessel making contact with port infrastructure, other than the berth fenders, to the minimum level;
  - The safe passing distance will be sensitive to the size and draught of both the moored and passing ships, and the speed of the passing ship through the water. In the Humber, the effect may be exaggerated due to the relatively high tidal flows, if the passing ship is stemming the tide. It is recommended that a passing ship study is completed to assist in defining safe passing distances and passing speeds;
  - Due consideration should also be given to maximising the navigable width of the channel directly to the north of IGET. This will enable passing vessels to plan the widest path possible and give the Harbour Authority the greatest latitude in providing guidance or implementing procedures to ensure the safety of vessels at IGET.
- Moving Safety Zone: Many ports enforce moving safety zones around LNG carriers manoeuvring in restricted waters. This may also be appropriate for ammonia or other gas carriers in transit.

5.12 Operational limits

At this stage in the design process there are still a number of factors to be determined, which will need to be included in the detailed operational planning for IGET. These include:

- The overall risks associated with the cargoes being transported and additional constraints that they may impose on navigation;
- The procedure for abort and managing emergency scenarios with an ammonia or gas carrier in the approaches to the port;
- Detailed guidance on berth limitations, procedures, and practices suitable for inclusion in the revised Passage Plan.

These aspects may need more detailed operational assessments and planning to be fully addressed.

The navigational procedures and strategies required at IOT can broadly be adapted for IGET, so in this respect, pilot and tug master training for the new facility will be straightforward. However, the quantity and nature of the associated hazards is likely to be new, so appropriate training will need to be provided to pilots, tug masters, VTS and other river operators to ensure that any special procedures required to ensure safety are understood and implemented.

6 Conclusions and recommendations

The study concluded that both Layouts 1 and 5 are feasible designs from a navigational perspective, assuming that the required exclusion zones of 150m and 250 m, respectively, are confirmed.

The exclusion zone at IGET will require the approach and departure tracks for vessels operating at IOT to be adjusted. It was assessed that the changes in approach will be marginal and would not be expected to result in any significant additional time or resource requirements.

It was also found that the exclusion zone at IGET does not preclude or change the timings or execution of concurrent arrivals to IOT berths.

Additionally, the design and proposed location for IGET will enable concurrent arrivals to berths IGET 1 and IOT 3.

For the largest vessel expected at IGET, support from 4 x 45tBP ASD tugs were demonstrated as the minimum appropriate level of towage required to assist operations on arrival in challenging wind conditions, of 25 to 30 knots. This is consistent with existing practice within the Humber Passage Plan, which requires 4 tugs with a combined capacity of 170tBP at IOT.

For the largest vessel expected at IGET, support from 3 x 45tBP ASD tugs were assessed as an appropriate level of towage to assist operations on departure in challenging wind conditions 25 to 30 knots. This too is consistent with existing practice within the Humber Passage Plan, which requires 3 tugs with a combined capacity of 170tBP at IOT.

The relative location of IGET Layout 5, set back behind the line of IOT, was also assessed in credible emergency scenarios. This considered a tug failure at the most challenging times during arrival and departure manoeuvres, and the residual tug provision was found to be sufficient.

The additional constraint due to the IGET EZ was also considered with respect to river navigation. The EZs associated with Layouts 1 and 5 impose no additional restrictions on the ability of ships to navigate safely in the main channel when compared with the existing situation.

Assuming that ships will need to pass at 5 knots when to the north of IGET, as required by the present river bylaws, the additional berths will add approximately 1.5 minutes to the transit time. This assumes a restriction due to a single occupied berth (500 m). For 2 occupied IGET berths (1,000m) the additional transit time would increase to 3 minutes. These estimates also assume that there is an EZ of no more than a 150m for Layout 1 and 250m for Layout 5.

Subsequent to completing the study, a further design was being considered, referred to as the RIBA Stage 2 final design. This was examined and the conclusions presented in this report with respect to the IGET Berth 1 (Layout 1) can be applied to the RIBA Stage 2 final design, as shown in Figure 2.6.

7 References

1. HR Wallingford, “Project Sugar – ABP Humber – Immingham East Development – Quasi-static force assessment,” Report no. DJR6612-RT0004-01-00, 08 Jul 22.
2. HR Wallingford, “Project Sugar – ABP Humber – Immingham East Development – Flow model comparison with October 2022 ADCP survey – November 2022”, Report no. DJR6612-RT0007-01-00, 22 Nov 22.
3. Ramboll,” Option 1B Proposed layout and dredged areas”, 15674-RAM-RT-S2-DR-CM-00006 P01 OPTION 1b, 03 March 2023.
4. Ramboll,” Option 5 Proposed layout and dredged areas”, 15674-RAM-RT-S2-DR-CM-00009 P01 OPTION 5, 03 March 2023.
5. ABP,” Humber Passage Plan,” -,2021.
6. HR Wallingford,” Soleil-Basis of simulation and methodology,” DJR6829-RT001-R01-01, 6 April 2023.

Appendices

A Ship and tug simulation at HR Wallingford

Ship and tug simulation at HR Wallingford

Overview

At HR Wallingford, we operate 10 real time simulators from our Ship Simulation Centres in Wallingford, UK and Fremantle, Australia. Our simulators are full bridge, real time manoeuvring simulators specifically designed for port design and ship operations applications, but are also used for training and pilot familiarisation purposes.

They have been developed over 35 years and have been used successfully in over 500 studies world-wide in the last 15 years alone. They have proved to be reliable, flexible and cost-effective design and evaluation tools that can be used for optimising harbour layouts, establishing operational strategy, and training in safe manoeuvring procedures.

We operate a combination of ship simulators and dedicated tug simulators, and to maximise the flexibility of our simulation capability, all of our ship simulators can also be adapted to represent tugs with suitable consoles and controls.

Our simulators are fully integrated such that they can be used to represent one or more piloted ships, or a ship and independently manned tugs, all within the same simulated environment. Alternatively the simulators can be used independently, which enables more "hands-on" time for pilots and tug masters during training or familiarisation sessions. When operating in this mode, an independent ship can also be controlled from another simulators to maximise the training opportunities for tug masters.

The system is capable of real time simulation of vessel behaviour in a range of environmental conditions making the simulators suitable for a wide range of design, assessment and training tasks including:

- Pre-feasibility studies, in the form of desk studies or simulation aided desk studies
- Optimisation of site specific terminal/port/harbour and approach channel designs
- Assessment of safety standards and procedures for shipping and port management operations
- Feasibility studies for new vessels using existing harbours / ports
- Effective training in manoeuvring procedures for pilots, tug masters and ships’ officers

A mobile version of the real-time simulator can be used for on-site pilot training and port design.

Ship Simulation Centres

Our Ship Simulation Centres in the UK and Australia house the simulators within a dedicated suite of rooms including separate ship’s bridges with their own briefing/observation rooms, control rooms, a dedicated tug bridge, and a conference room.

Ship Simulator Bridges

For the Ship Simulators the main room in each facility provides a representation of the bridge of a ship. From the bridge, a pilot can view and control ship manoeuvres and monitor the vessel’s status throughout the simulation. A wide range of controls can be provided to represent conventional, azipod or other ship specific control systems. The console also provides radar and electronic chart display (ECDIS).

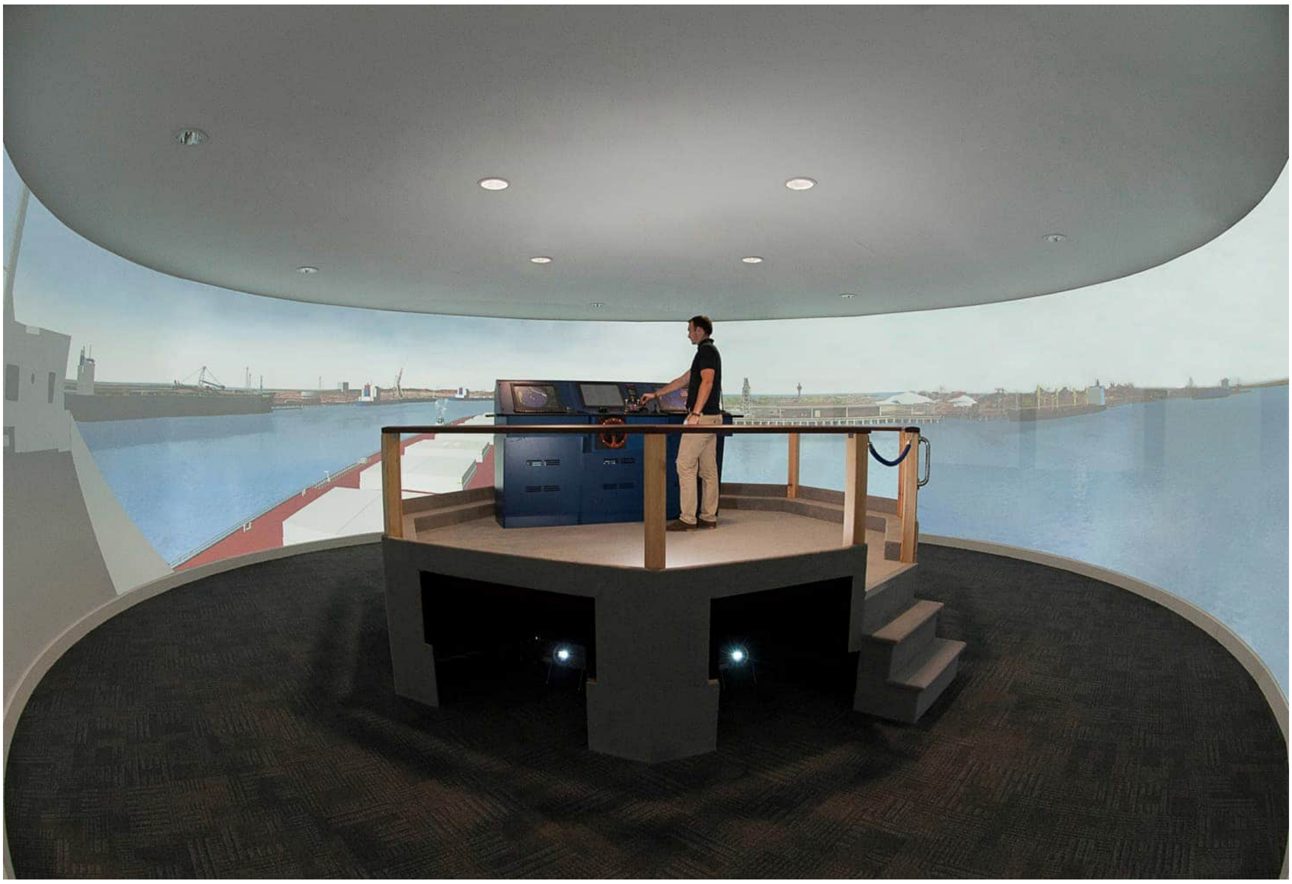


Figure 1: Ship Simulator bridge

Visual scene

The visual scene is a major component of navigation simulation, as piloting a ship or tug is essentially a visual process. Most manoeuvring decisions are made by interpretation of the view from the bridge windows. It is therefore essential that this information is presented in a realistic manner.

Figure 2: Photograph taken at study site

Figure 3: Simulator visual scene

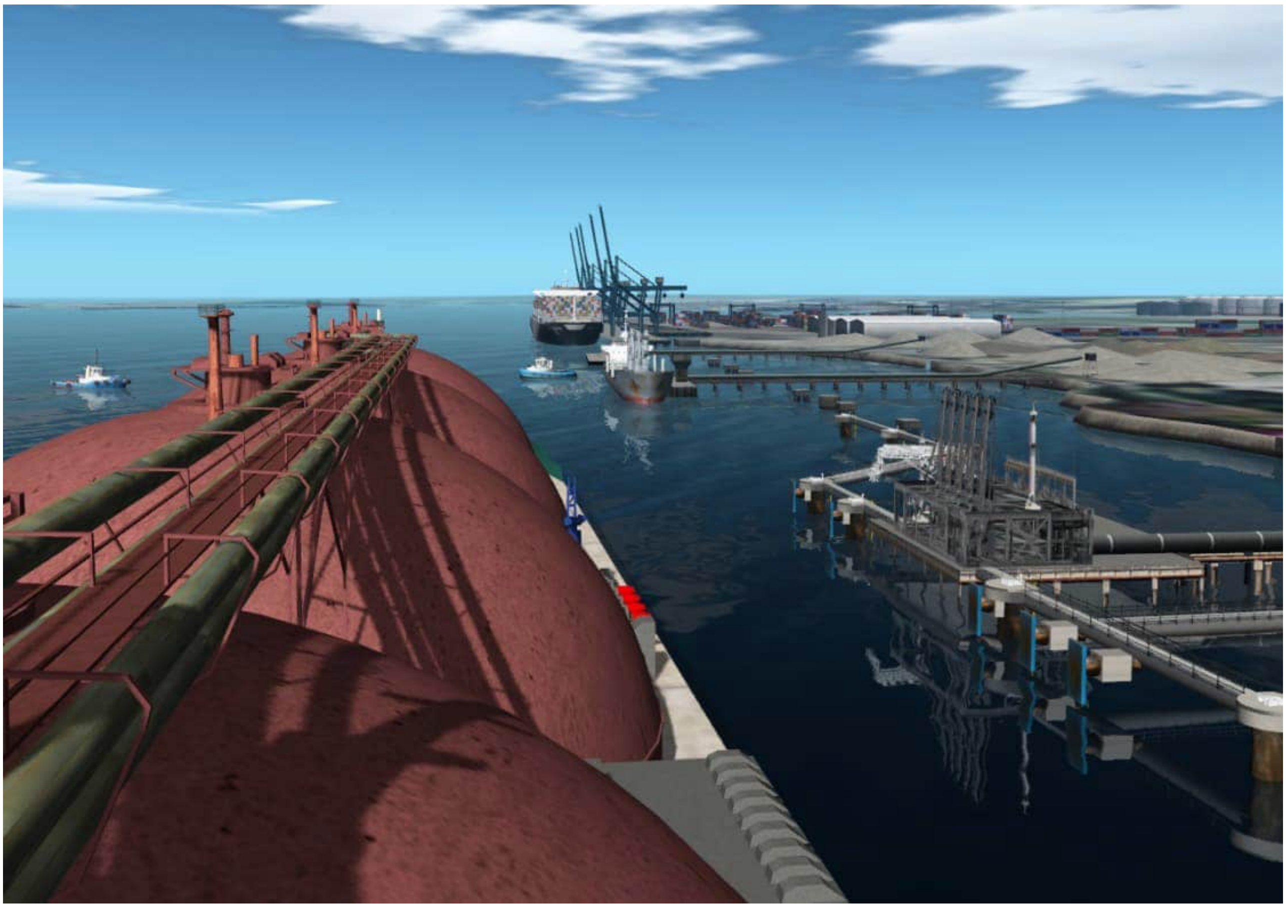


Figure 4: Example visual scene for LNG terminal from ship's starboard bridge wing

Figure 5: Example visual scene for cruise terminal

The screens wrap around the bridge console and provide a continuous visual angle of 360°. A “look-around” facility is also incorporated that allows the pilot’s viewpoint to be moved from the centre of the bridge to either bridge wing, and all around the ship, along with viewing down along the ship’s side.

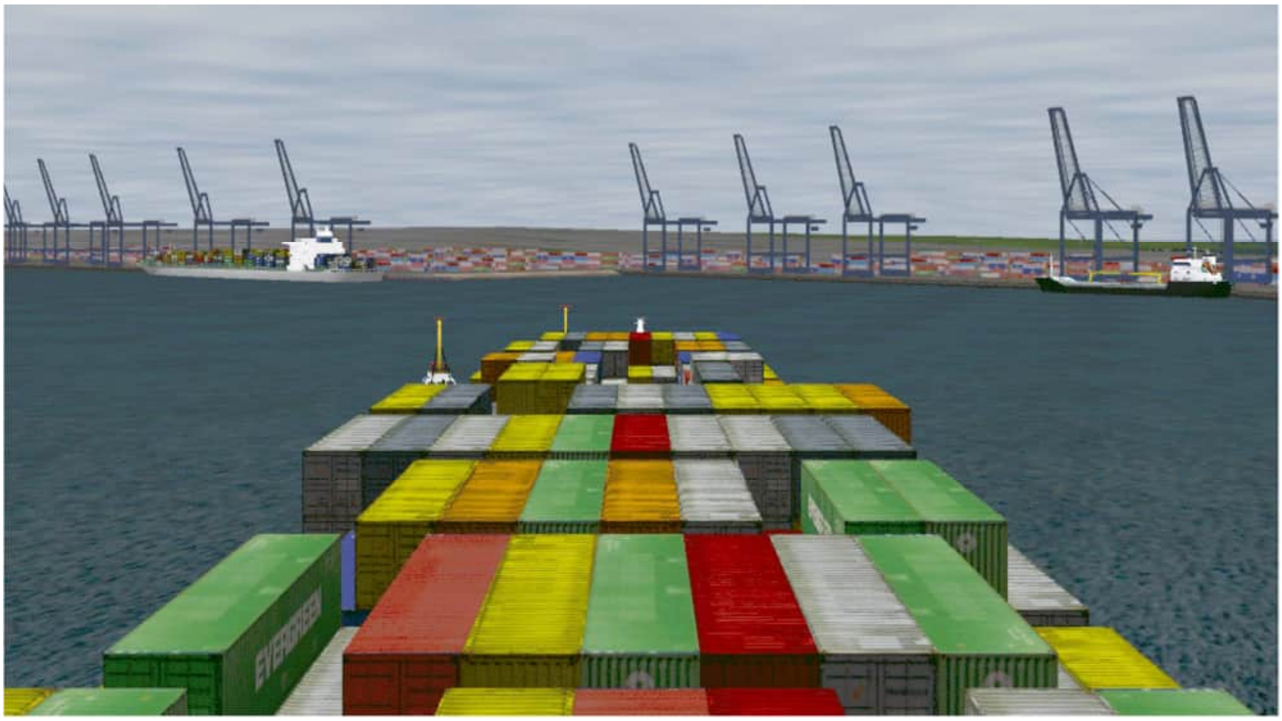


Figure 6: Example visual scene for container terminal

Figure 7: Realistic tug modelling

The lighting level can be adjusted between full daylight and full night time, in a range of visibility conditions, from excellent, long range visibility to thick fog. In night time simulations, shore lights and other vessel lights can be included, and all navigation marks can be set with the correct light configuration and characteristics.

Figure 8: Example visual scene of bulker terminal at night, with ship lights in distance

Figure 9: Example visual scene in mist

Control consoles

The control console on each bridge is flexible, but the conventional configuration has ship helm, engine and thruster controls along with instrument, radar, ECDIS/situation displays.

A range of helm and engine controls are available including:

- Wheel, tiller or joystick or twin rudder controls
- Single or twin engine telegraph controls
- Azipod propulsor controllers, including twin and triple azipod control arrangements
- Bow and stern thruster controls.

Alternative control consoles can also be provided if required.

The instrument display presents information on the ship status including:

- Ground or water speed ahead and athwartships at midships or at bow, stern and midships
- Heading
- Rate of turn in graphical or digital display form
- Depth under the keel in graphical or digital display form
- Relative wind speed and heading
- Engine settings
- Helm indicator, showing applied wheel
- Rudder indicator, showing actual rudder angle.

There is also an electronic situation display available, in place of the ECDIS, where required, which enables the pilot to monitor the ship's position relative to key features. This displays information in the form of a plan view, similar to an electronic chart/ECDIS display, and includes a scaled ship outline and any planned developments in the area of interest.

Tug bridges

The dedicated Tug Simulators comprise a bridge with a chair and two consoles. Similarly to the Ship Simulators, from the bridge a tug master can view and control tug manoeuvres in a realistic manner and can monitor the vessel's status throughout the simulation.

A wide range of controls can be provided to represent ASD, (Aquamaster) type controls, Rotor Tug, convention, throttle and joystick or Voith Schneider type controls. The consoles also provide radar and electronic chart display (ECDIS), along with line tension meters, where applicable.

In addition, a winch control panel is also provided and the simulated winch can represent a standard, static type winch or a dynamic, render recovery type winch.

As with the Ship Simulators, the tug visual scene is generate using three dimensional, fully textured, computer generated graphics, which are projected onto a range of large screens in an array to provide a full 360 degree view, including upper and lower screens.

A full VHF radio system is available to enable communications with the central Control Room, and the simulated ship when operating in the integrated mode.

Figure 10: Tug Simulator bridge

Figure 11: Tug Simulator bridge

Simulator control room

Each simulation scenario is configured and initiated by a Simulator Operator, who is stationed at a dedicated console in one of the Control Rooms, immediately adjacent to the bridge on each of the Ship Simulators. There is a window and intercom system between the bridge and Control Room allowing full visual and verbal communications at all times. During a simulation run, the operator can monitor the simulation but can also control the application of the tugs (that are not independently controlled), anchors and mooring lines, and adjust light and environment settings as required. The operator can also introduce failures at any time, along with other vessels in the simulation.

Briefing / observation and meeting rooms

Immediately adjacent to each bridge are Briefing/Observation Rooms, with a suite of monitors that relay the instrument and situation displays from the bridge control console, along with simulation visuals, as seen from the bridge.

These enables project team members to observe and monitor the simulation runs without disturbing either the pilot. There are also meeting rooms nearby, which can act as a base for the Client's project team, and where all members of the Simulation Team can gather to discuss each simulation in detail and to consider any issues raised by the runs.

Ship and tug manoeuvring models

Within the simulators, the behaviour of the ship or tug, in terms of its response to any helm and engine actions and the local environmental effects, is governed by a mathematical manoeuvring model which includes the following effects:

- Shallow water effects including increase in turning radius and drag
- Squat
- Bank effects
- Wind response allowing for both lift and drag
- Response to waves
- Response to current
- Fluid mud efects
- Tug operations
- Ship to ship interaction
- Collision/contacts with any fixed structure or another vessel
- Mooring lines
- Anchors
- Lock blockage.

Mathematical manoeuvring models are tailored to particular studies based on the design ship(s)/tug(s) dimensions, drawings and, whenever possible, ship trials data. HR Wallingford also has an extensive library of ship and tug models for vessels of different sizes and hull forms.

All ship manoeuvring models are verified by professional mariners/pilots and navigation experts.

Real time navigation simulation runs

During the simulation runs, a professional mariner or pilot is in command of the simulated ship. This may be either a visiting, local pilot, who is familiar with the particular ship or study site, or one of HR Wallingford's experienced pilots.

At the start of each run, the desired scenario (vessel, port layout, tidal state, wind and wave conditions, lighting level and visibility) are configured within the simulator and the ship is initialised with a suitable position, heading, and forward and transverse speeds. During the run, the wind, waves, light levels and visibility can be altered as required. Furthermore, the pilot can call upon the assistance of tugs, which are controlled in response to verbal commands from the pilot.

Effective and appropriate use of tugs is often essential to safe manoeuvring at slow speed. Consequently the performance of assisting tugs needs to be realistically simulated. This is achieved in the Ship Simulators by representing the interaction of a complex series of factors including the type of tug, the number, type and position of the tug's propulsors, the prevailing wind and wave conditions, the location of the tug with respect to the ship (ie. it may be protected from some wave activity by the ship), the ship's speed, the current speed and direction, and the operating mode of the tug.

Alternatively, the Ship Simulator(s) can be integrated with the Tug Simulator so that one or two of the tugs are operated independently by a tug master.

Of particular importance at many sites is the effectiveness of tugs in waves. HR Wallingford has considerable experience of this issue based on detailed discussions and simulated trials with a range of tug operators. This has resulted in a series of tug efficiency curves for varying wave heights and periods for each operational mode.

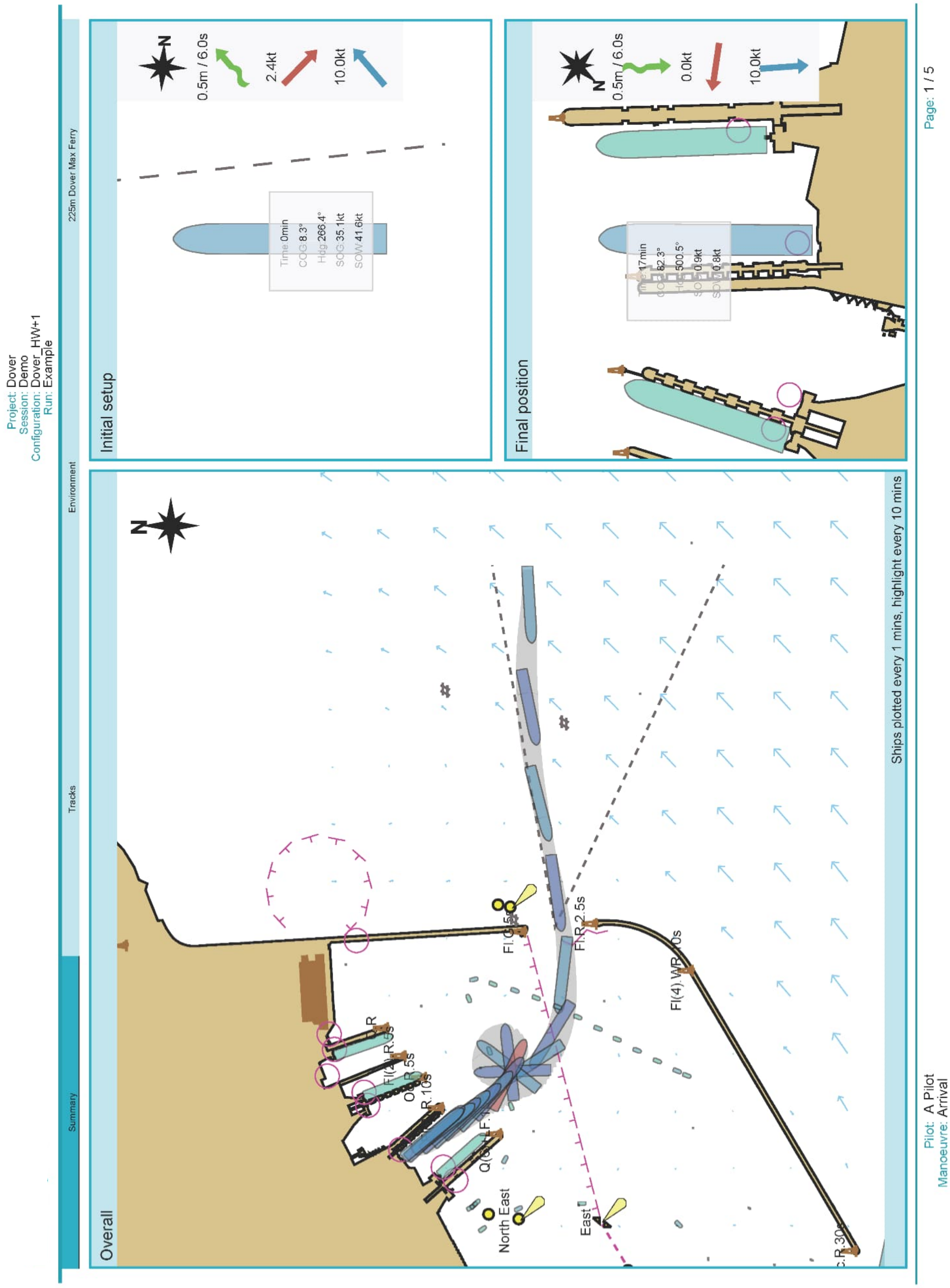
Any number of other vessels can also be present in the simulation. These can be used as vessels on berths or in passing ship manoeuvres. The position and behaviour of these ships are either controlled in a simplified manner or the two Ship Simulators can be integrated so that a pilot can operate the other ship from other Ship Simulator bridge.

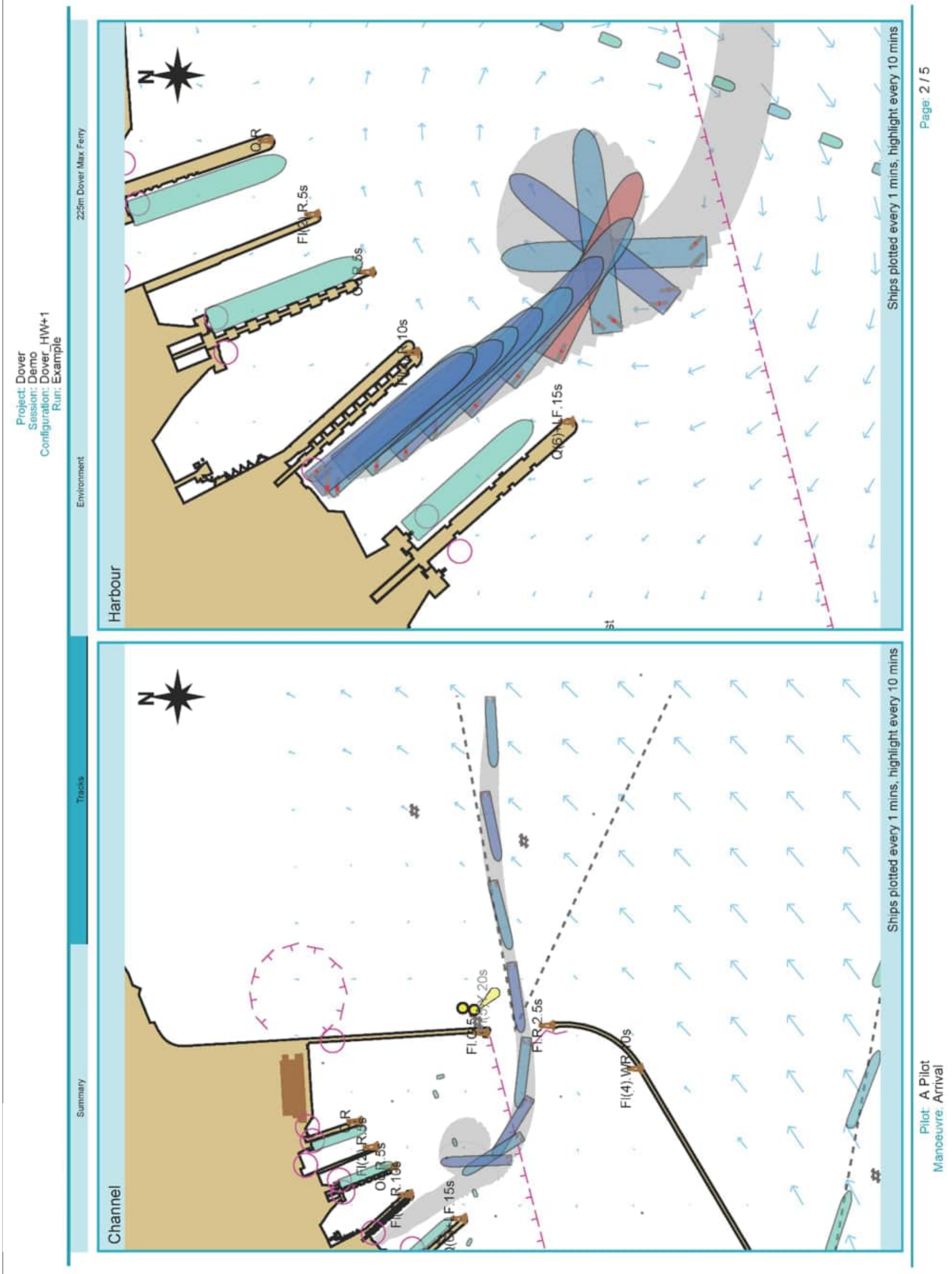
As each simulation run proceeds, the pilot is presented with the visual and other information that allow representative ship handling decisions to be made, based on accepted navigation practice, skill and experience. In particular, the use of experienced mariners ensures that realistic limits of ship controllability are reproduced and accounted for within the simulation.

Simulation data is recorded at an appropriate frequency (typically every 1 second) for later analysis and reporting. The list of data parameters recorded can vary, but typically includes:

- Elapsed time
- Ship position and heading
- Speed and rate of turn
- Rudder and engine settings
- Under keel clearance
- Tug and thruster activity
- Current and wave conditions at the ship
- Position and heading of any target ships.

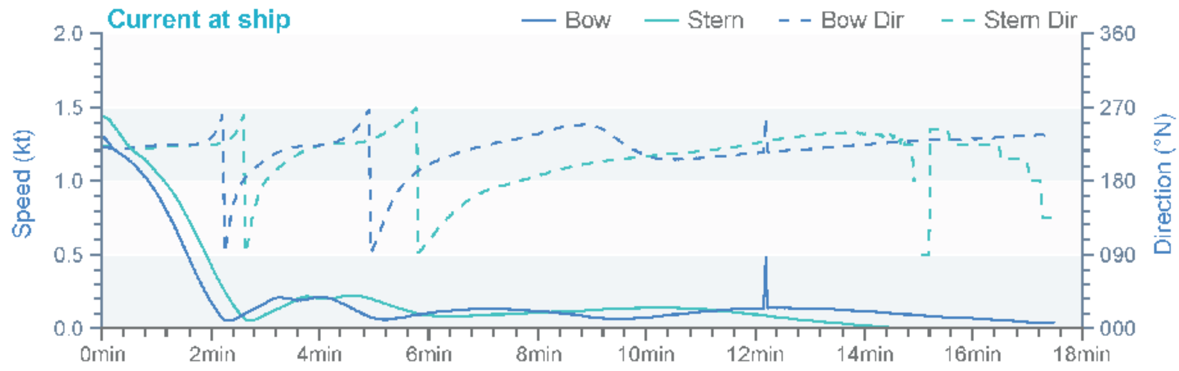
This information is presented in a series of vessel track and data plots as shown in the following figures.

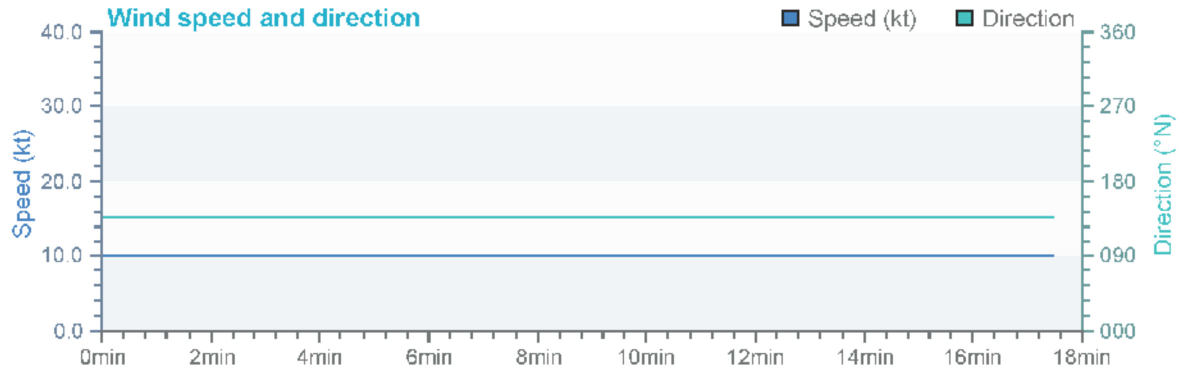

Project: Dover
Session: Demo
Configuration: Dover_HW+1
Run: Example
Summary
Tracks
Environment
225m Dover Max Ferry
Initial setup
0.5m / 6.0s
2.4kt
10.0kt
Time 0min
COG 8.3°
Hdg 266.4°
SOG 35.1kt
SOW 41.6kt
Final position
0.5m / 6.0s
0.0kt
10.0kt
Overall
Ships plotted every 1 mins, highlight every 10 mins
North East
East
Fl(4).WR
Pilot: A Pilot
Manoeuvre: Arrival
Page: 1 / 5

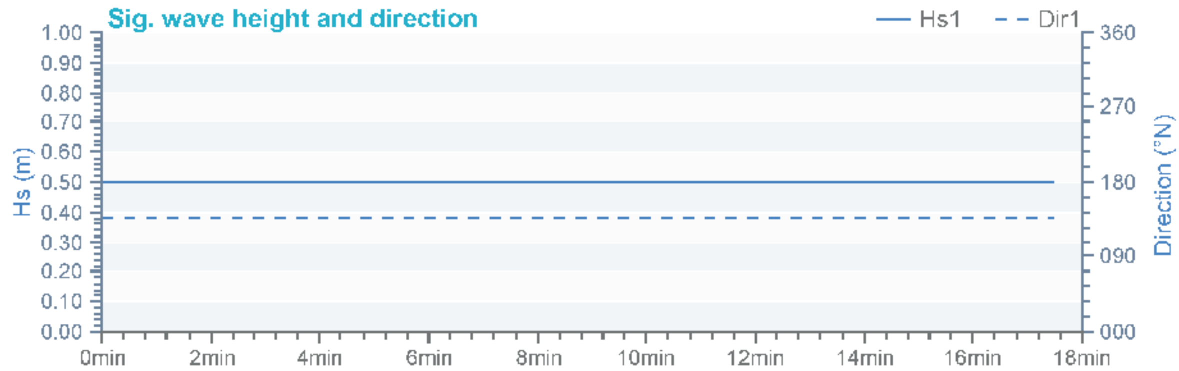

Project: Dover
Session: Demo
Configuration: Dover_HW+1
Run: Example
Summary
Tracks
Environment
225m Dover Max Ferry
Harbour
Channel
Ships plotted every 1 mins, highlight every 10 mins
Ships plotted every 1 mins, highlight every 10 mins
Page: 2 / 5
Pilot: A Pilot
Manoeuvre: Arrival

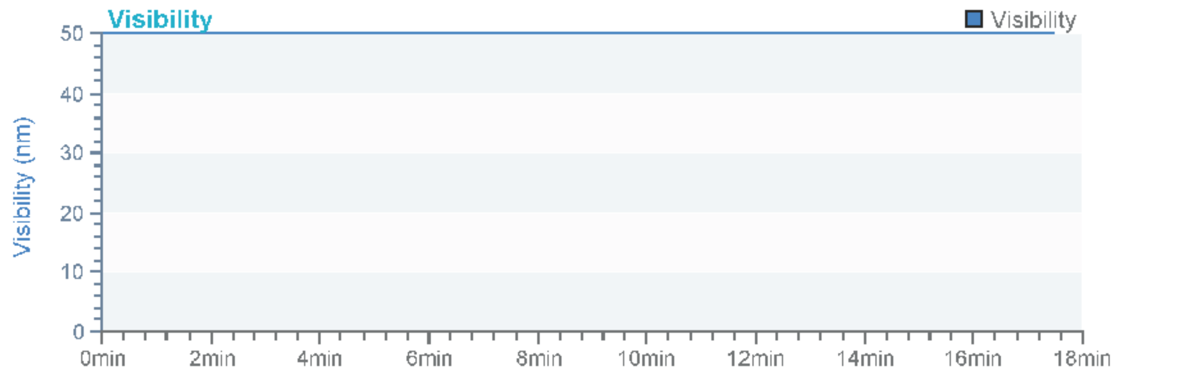
Project: Dover
Session: Demo
Configuration: Dover_HW+1
Run: Example

Summary	Tracks	Environment	225m Dover Max Ferry





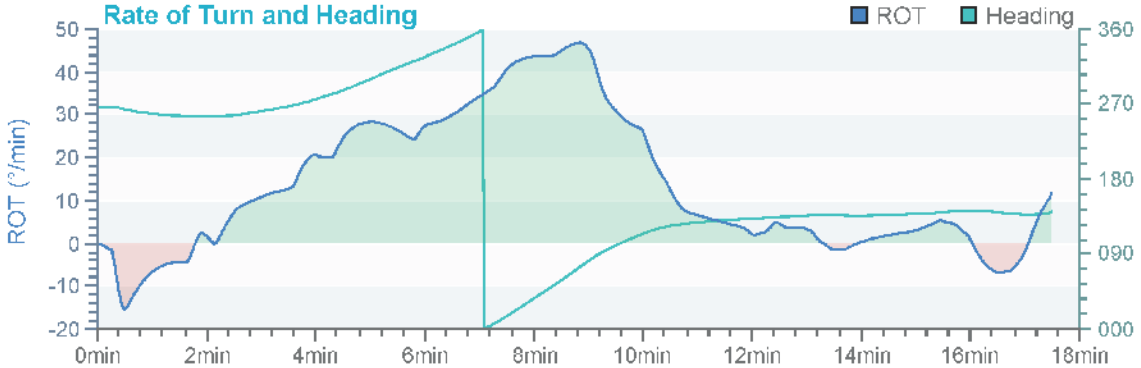


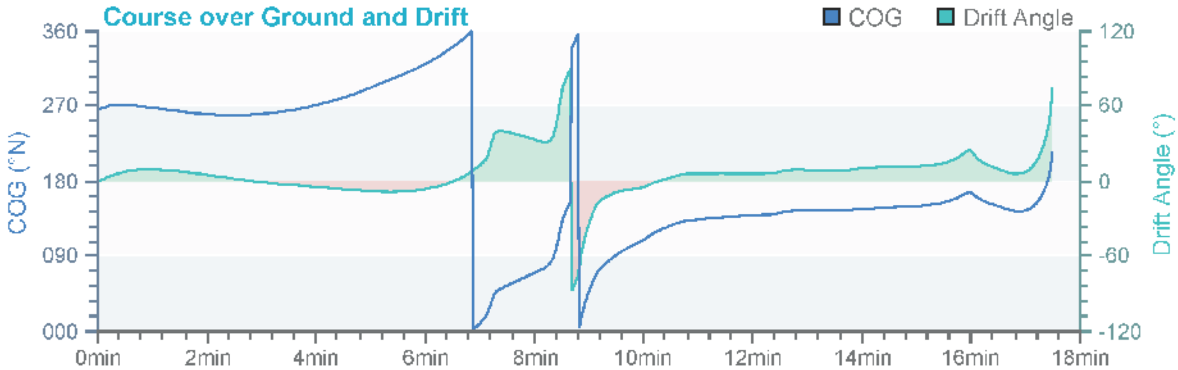


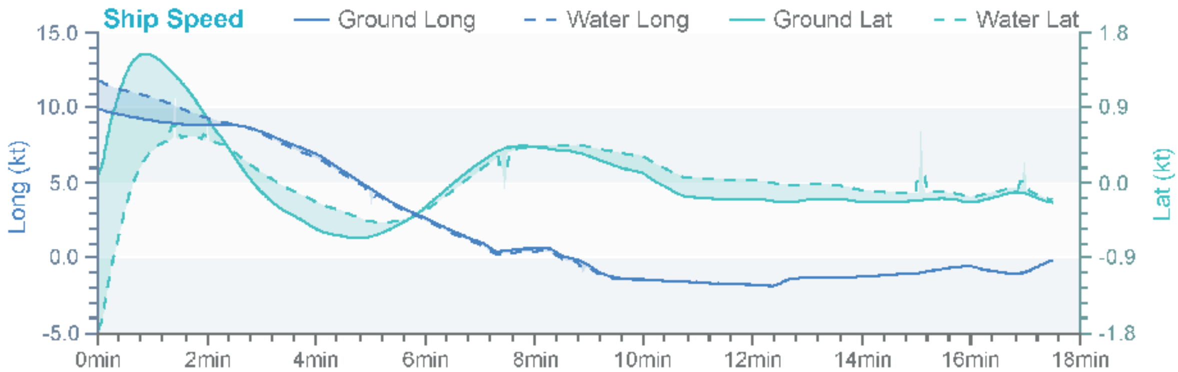
Pilot: A Pilot
Manoeuvre: Arrival
Ship: 225m Dover Max Ferry
Page: 3 / 5

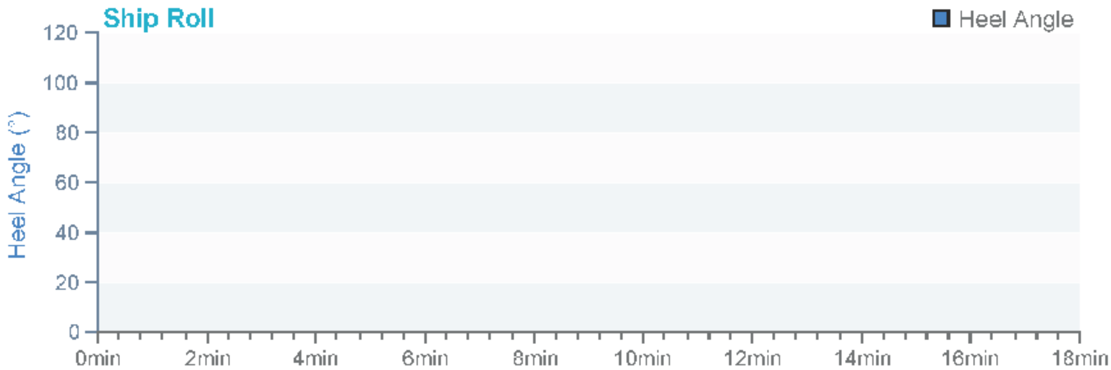
Project: Dover
Session: Demo
Configuration: Dover_HW+1
Run: Example

Summary | Tracks | Environment | 225m Dover Max Ferry





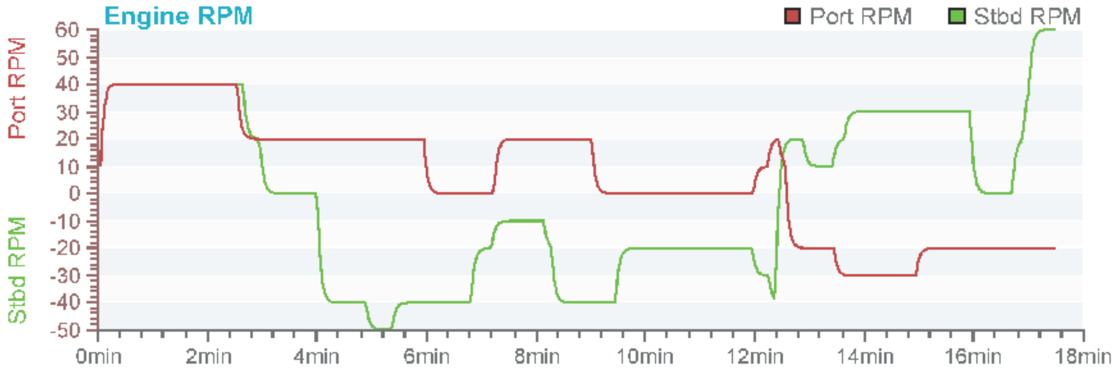


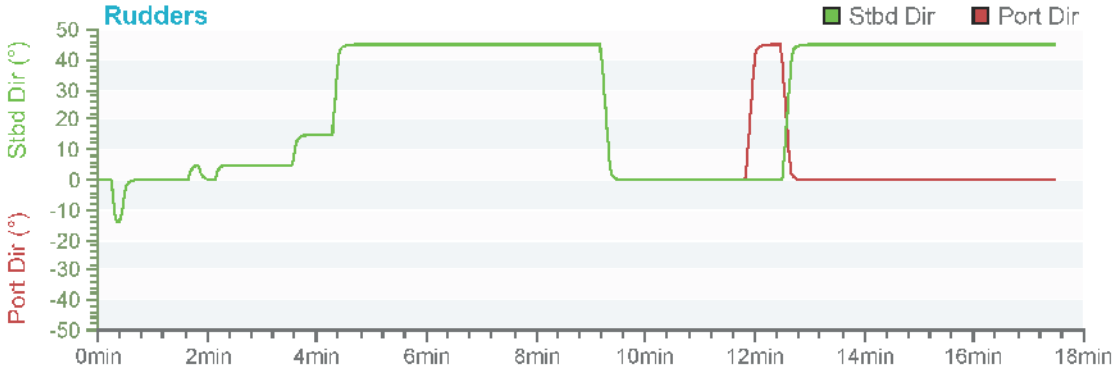


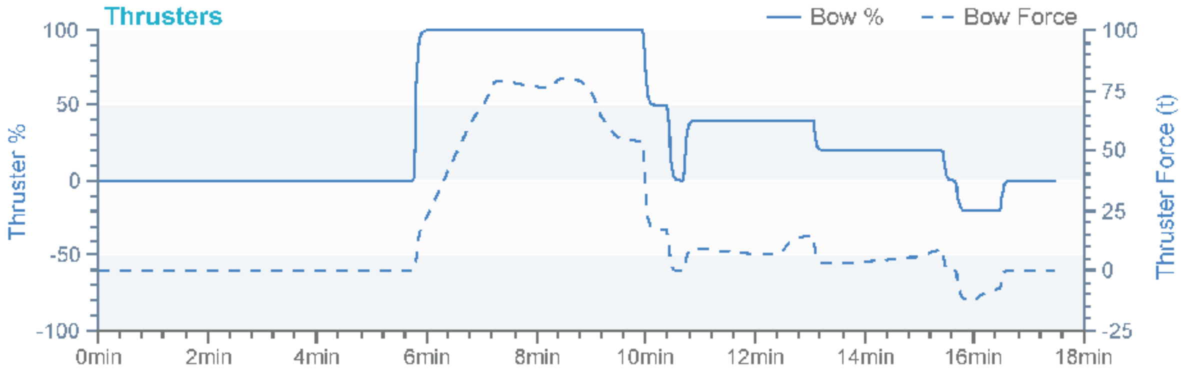
Pilot: A Pilot
Manoeuvre: Arrival
Ship: 225m Dover Max Ferry
Page: 4 / 5

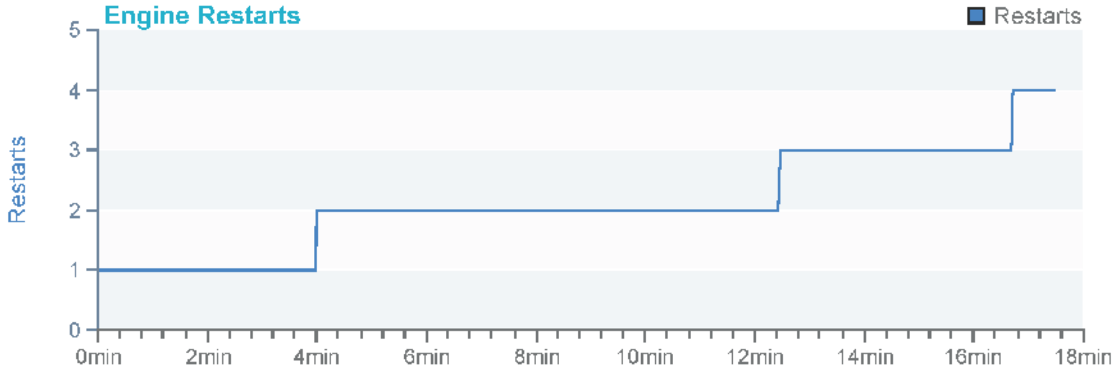
Project: Dover
Session: Demo
Configuration: Dover_HW+1
Run: Example

Summary	Tracks	Environment	225m Dover Max Ferry





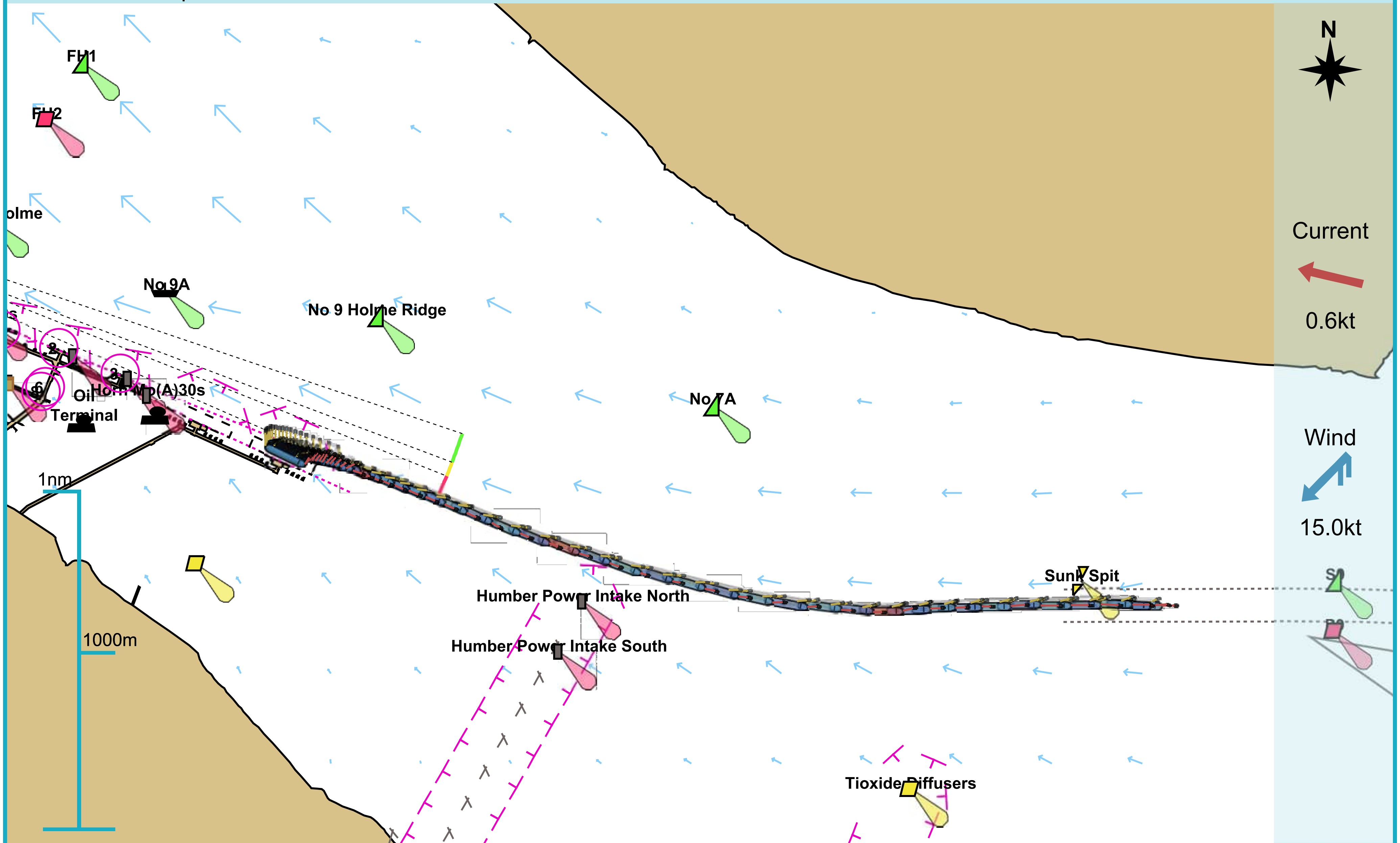




Pilot: A Pilot
Manoeuvre: Arrival
Ship: 225m Dover Max Ferry
Page: 5 / 5

B Simulation track and data plots

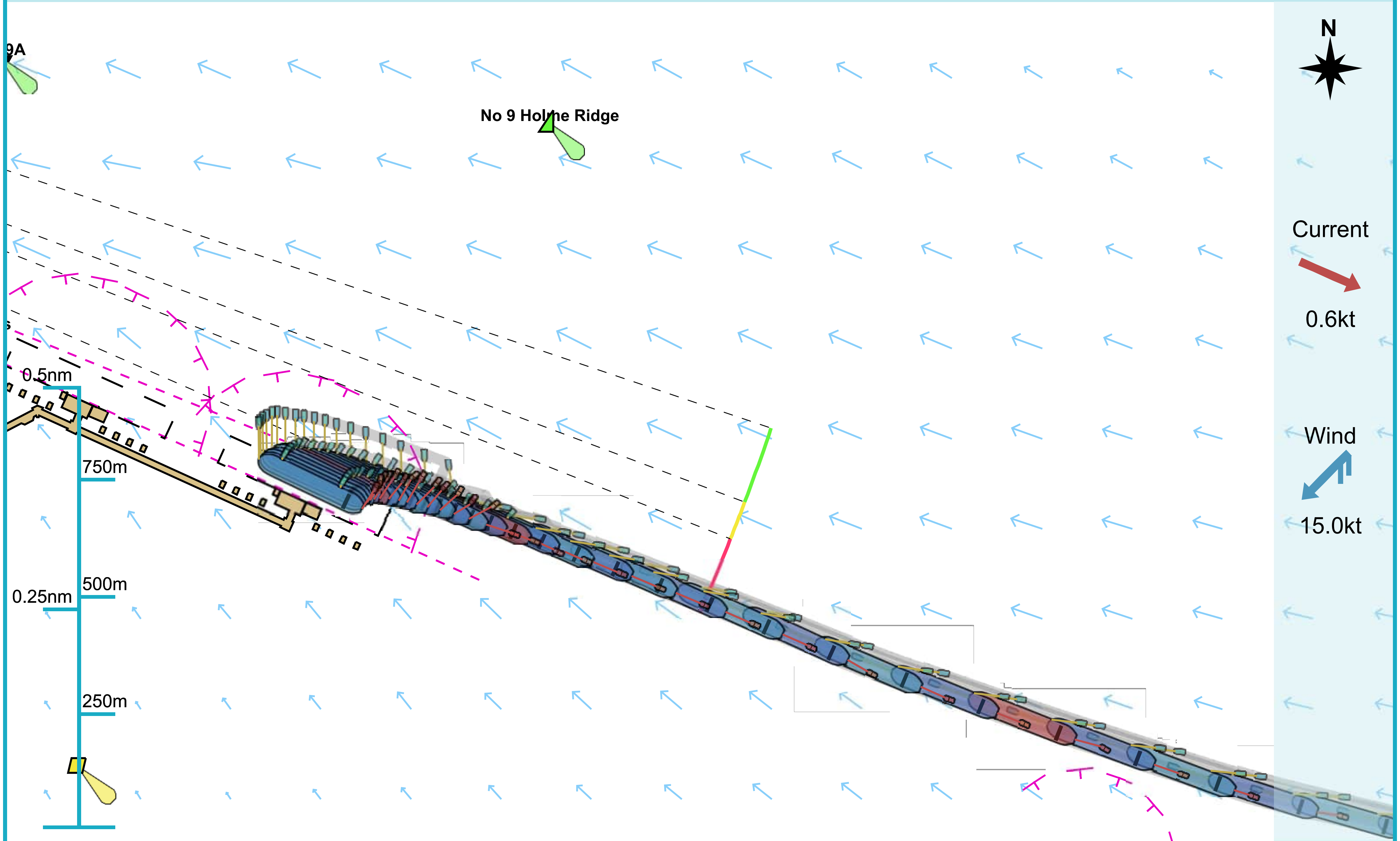
Manoeuvre track plot



1.36 kts

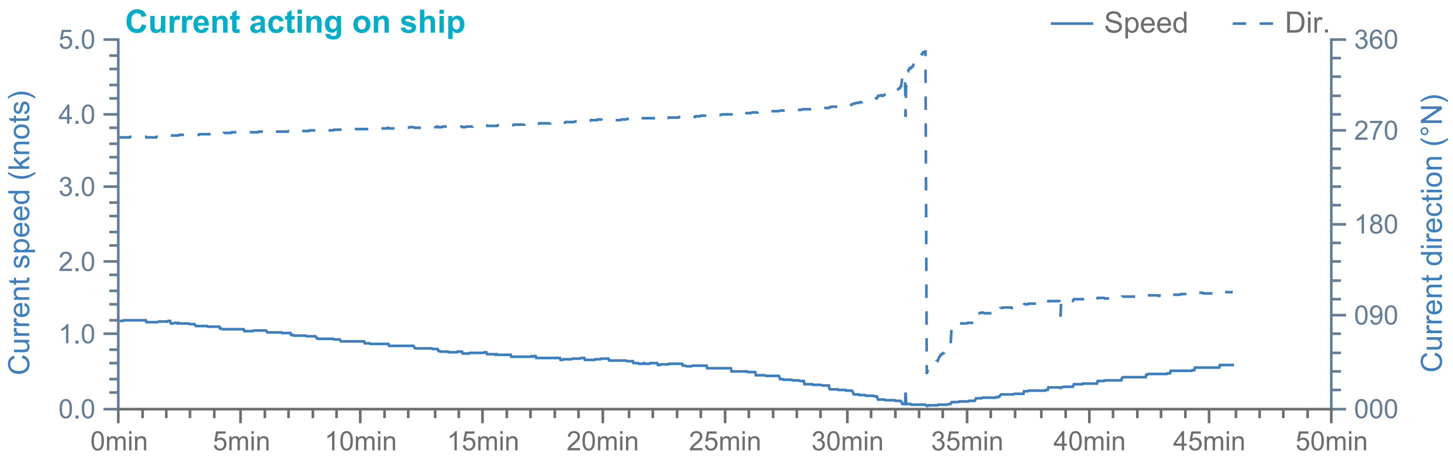
Ships plotted every 1 mins, highlight every 10 mins

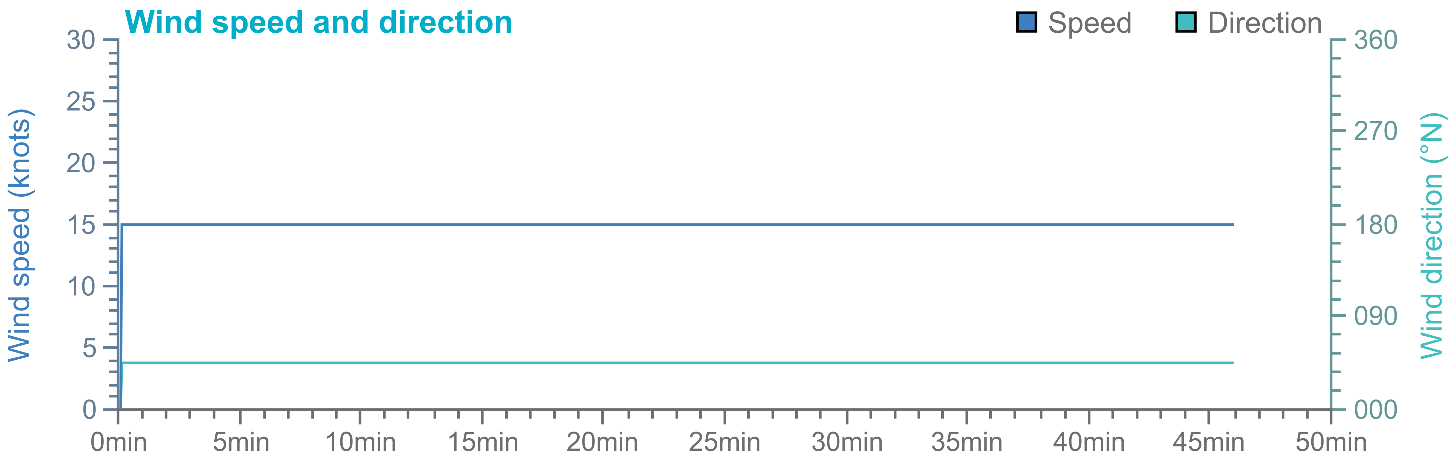
Manoeuvre track plot

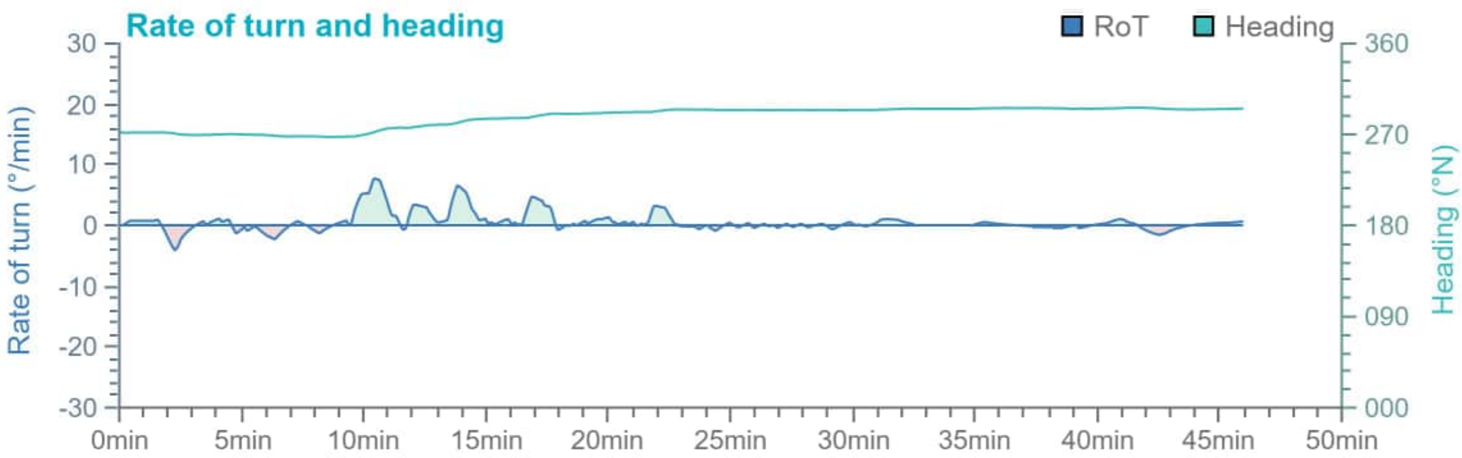


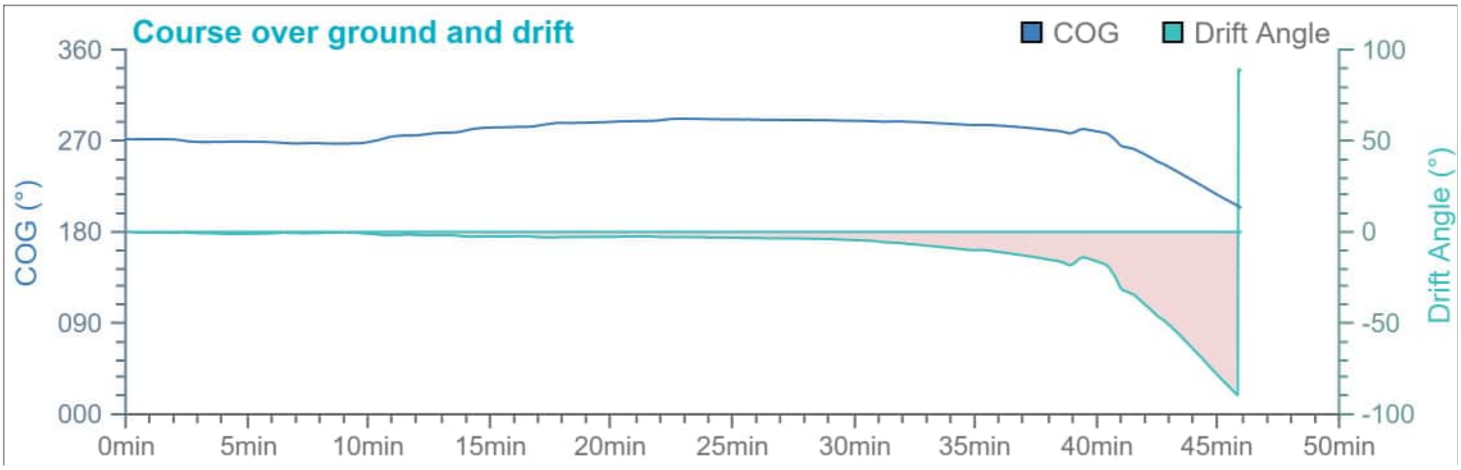
1.23 kts

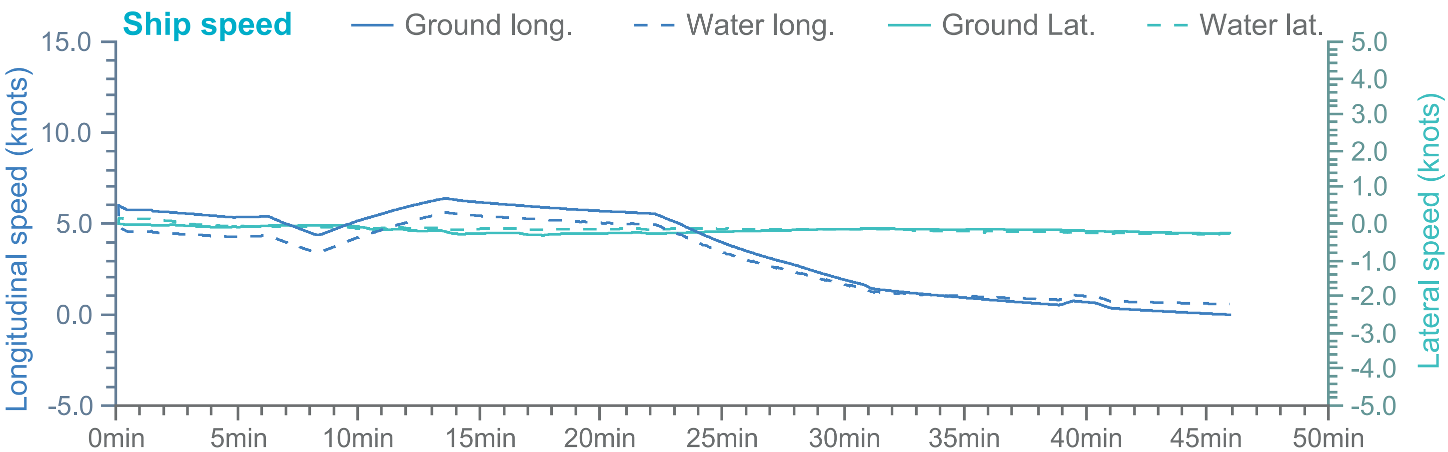
Ships plotted every 1 mins, highlight every 10 mins

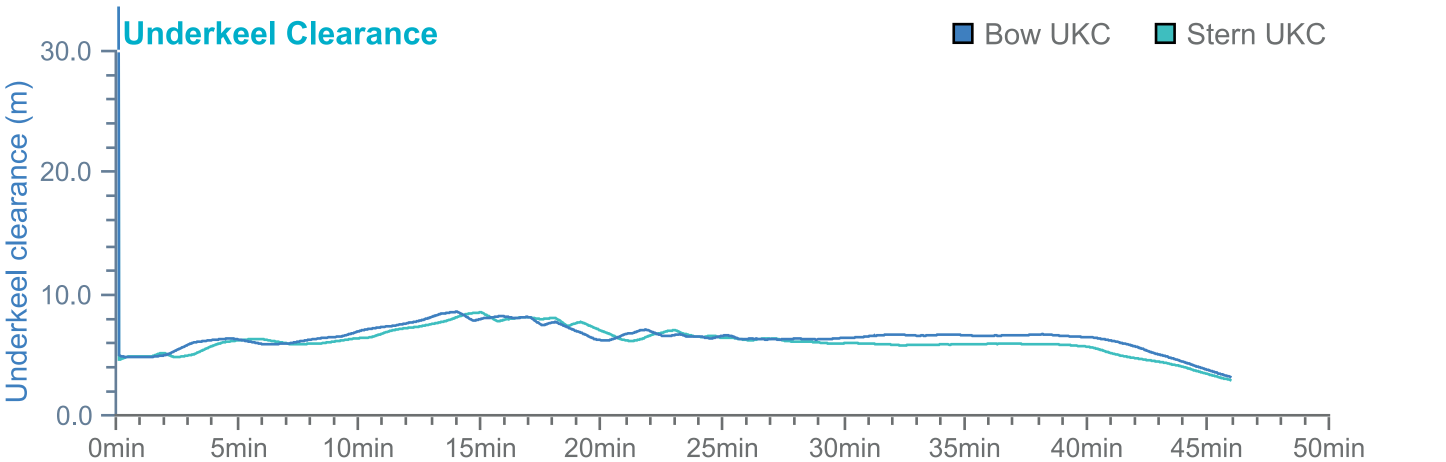

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min
50min

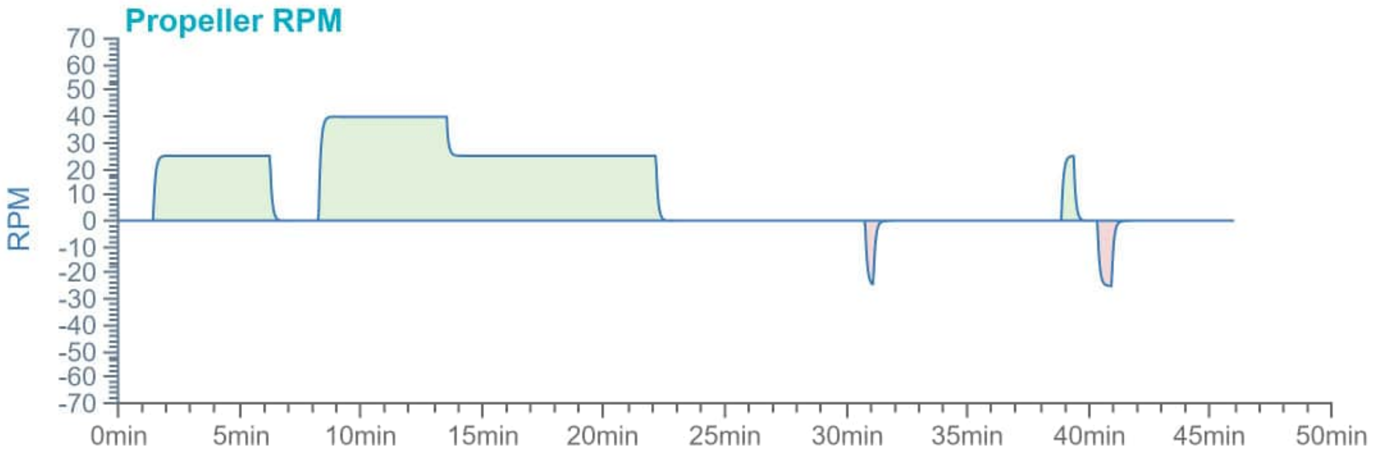

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min
50min


Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min
50min

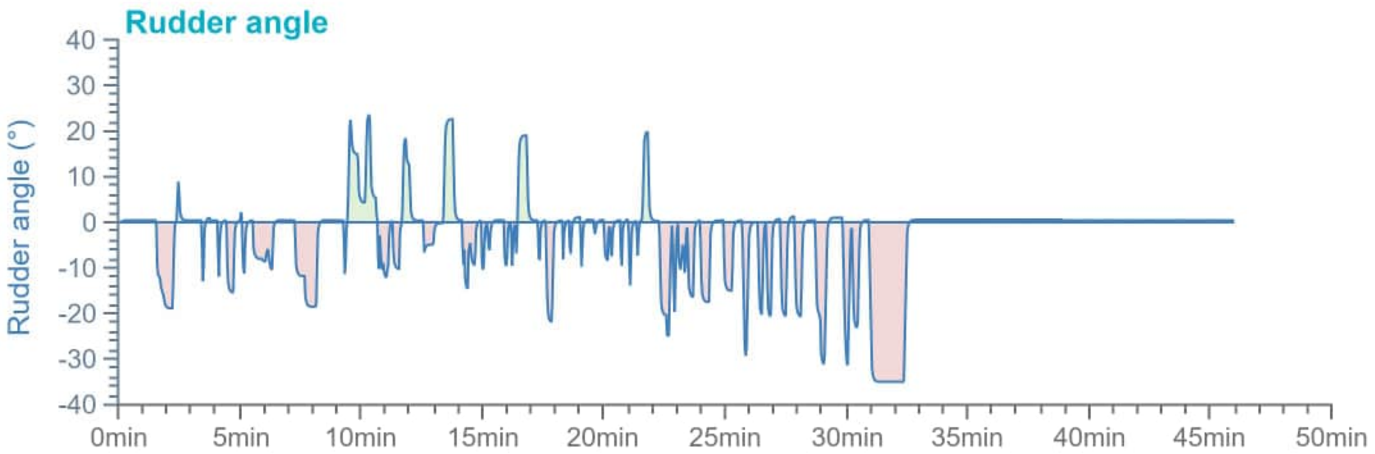

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min
50min


Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min
50min

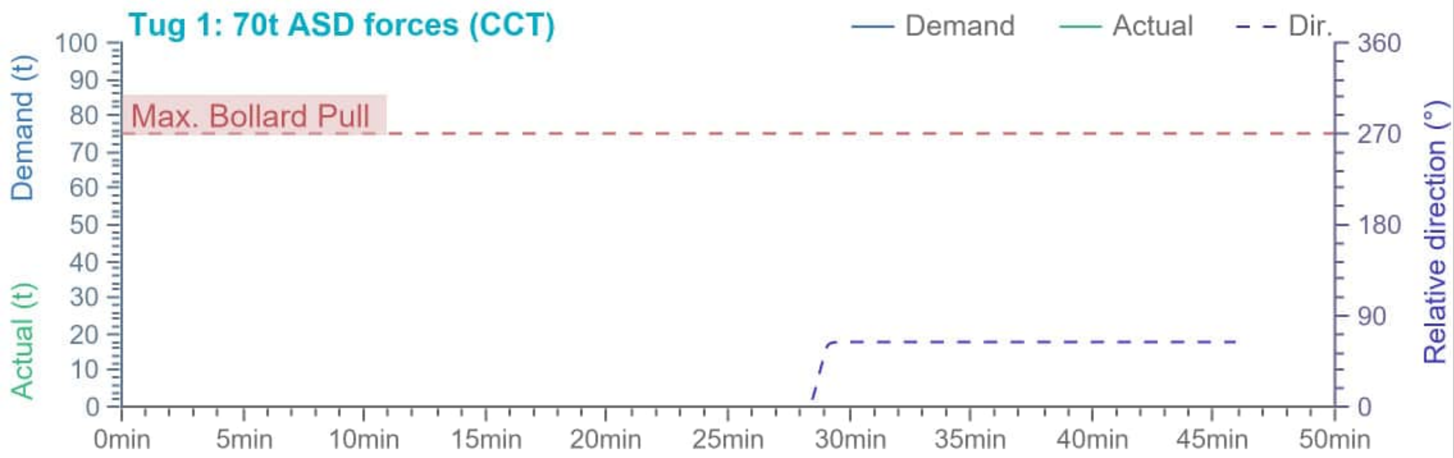

Underkeel Clearance
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min
50min

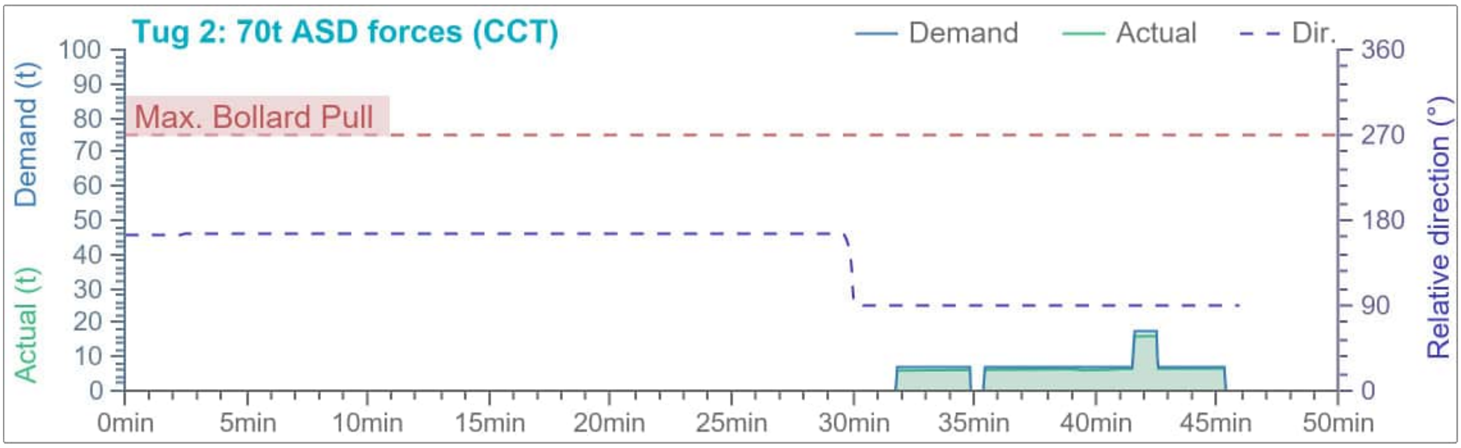


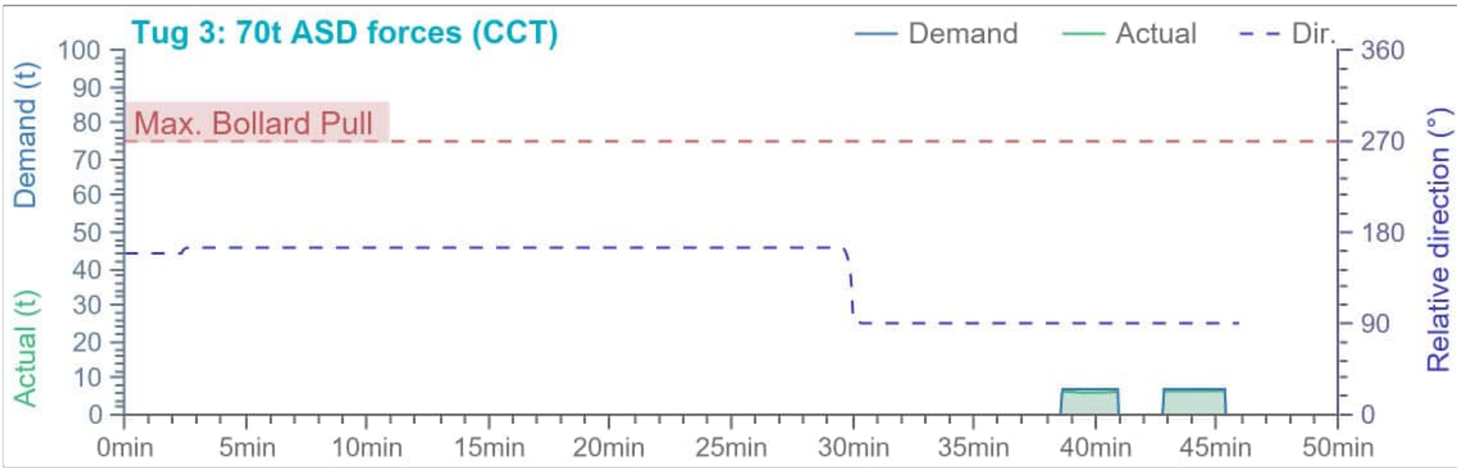
Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min
50min



Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min
50min

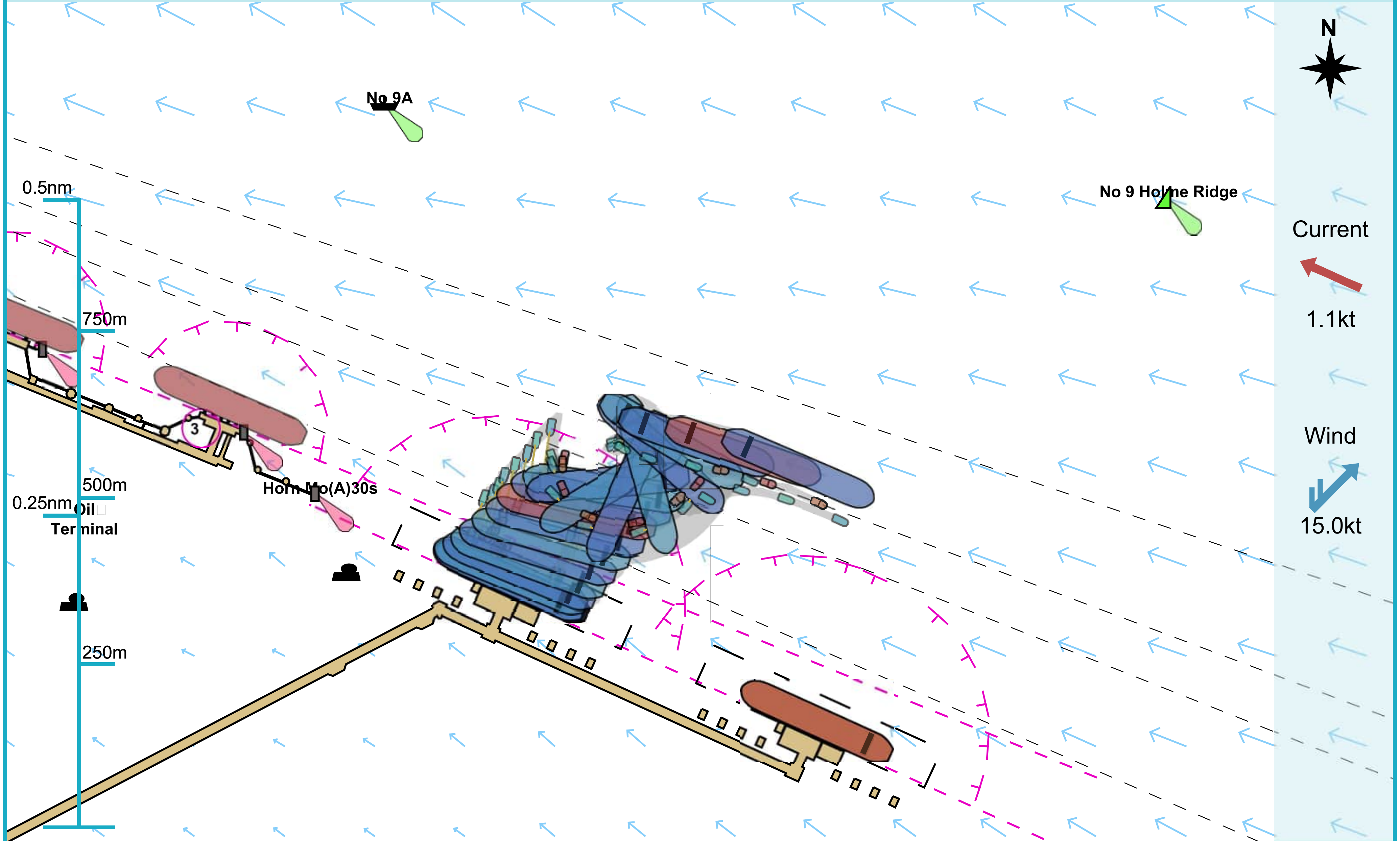

Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min 5min 10min 15min 20min 25min 30min 35min 40min 45min 50min


Tug 2: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min 5min 10min 15min 20min 25min 30min 35min 40min 45min 50min

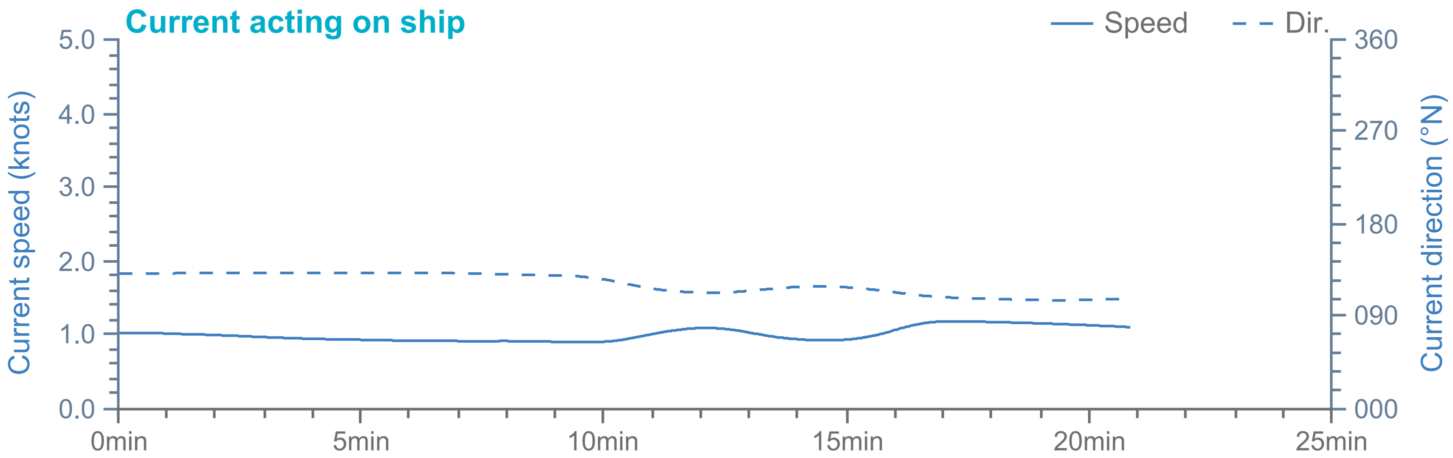

Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min 5min 10min 15min 20min 25min 30min 35min 40min 45min 50min

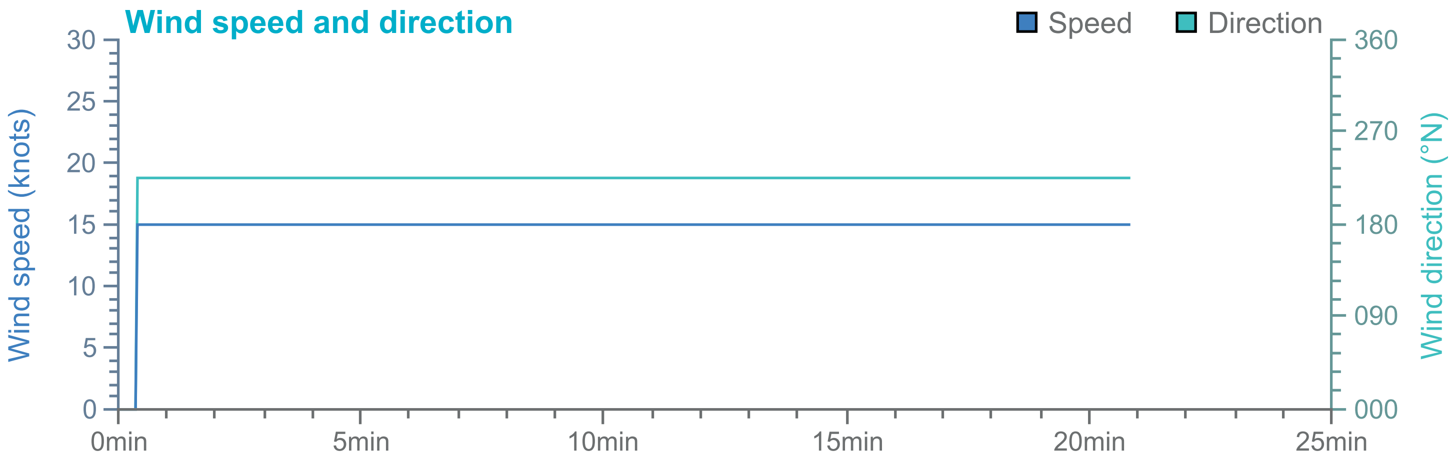

Tug 4: 70t ASD forces (ICT)
Max. Bollard Pull
Force (tonnes)
0min 5min 10min 15min 20min 25min 30min 35min 40min 45min 50min

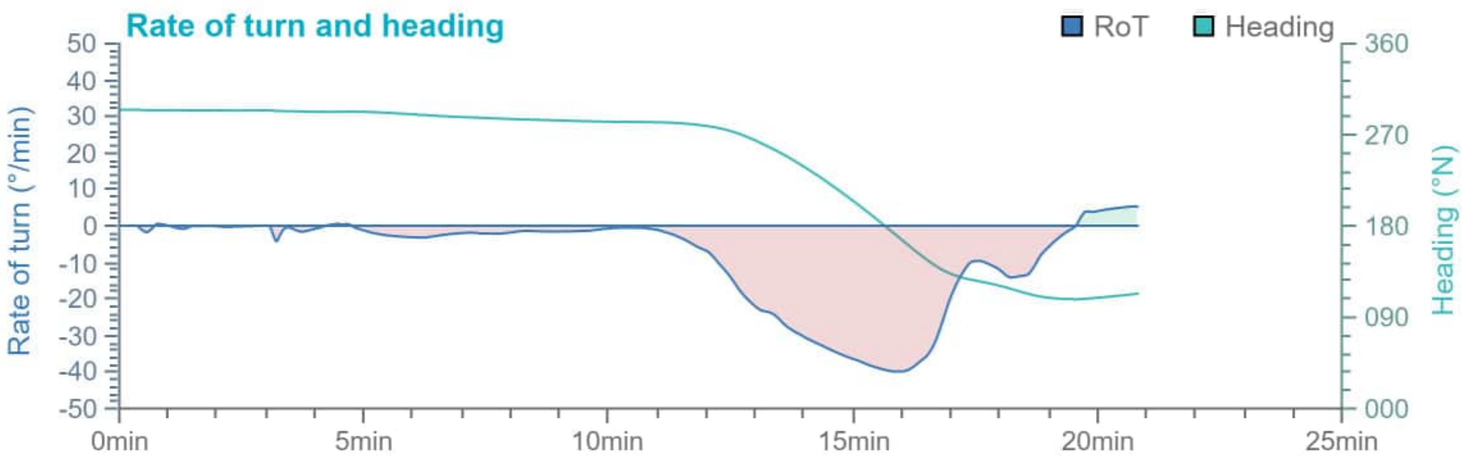
Manoeuvre track plot

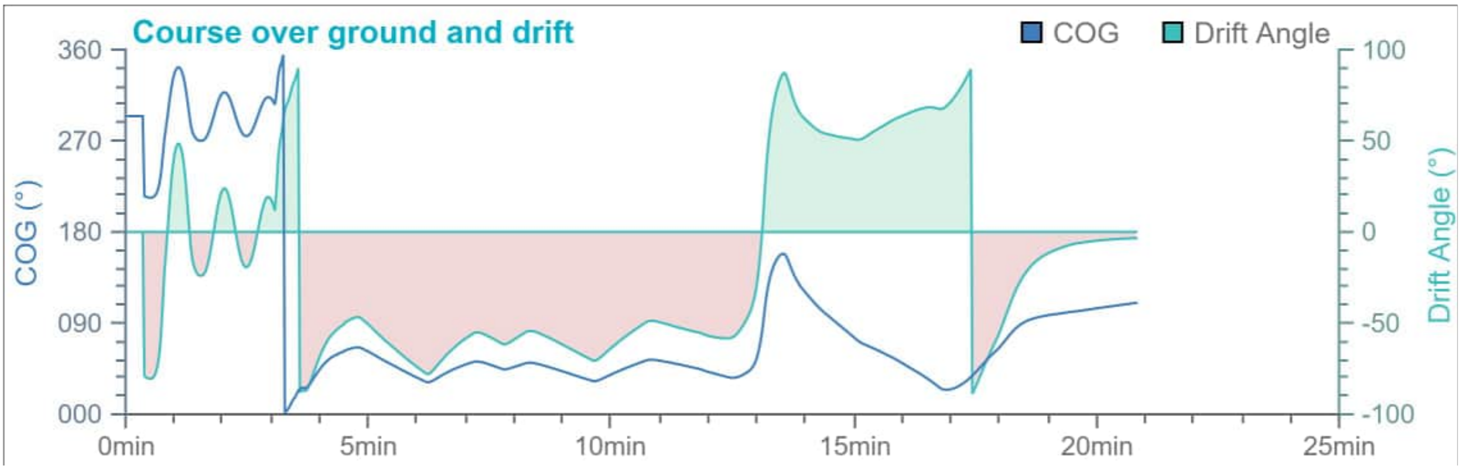


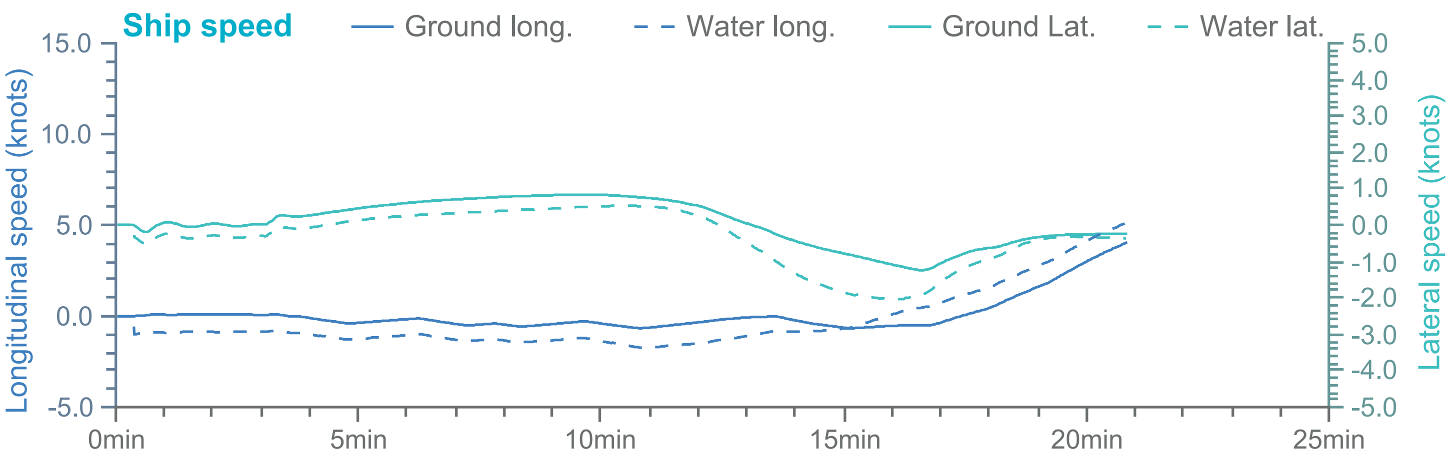
Ships plotted every 1 mins, highlight every 10 mins

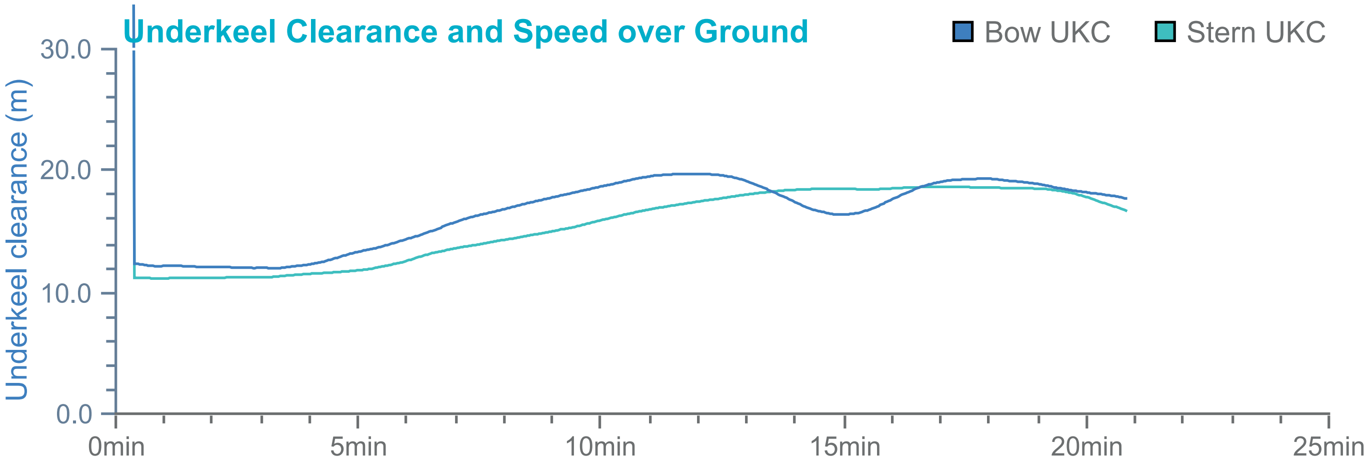

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min

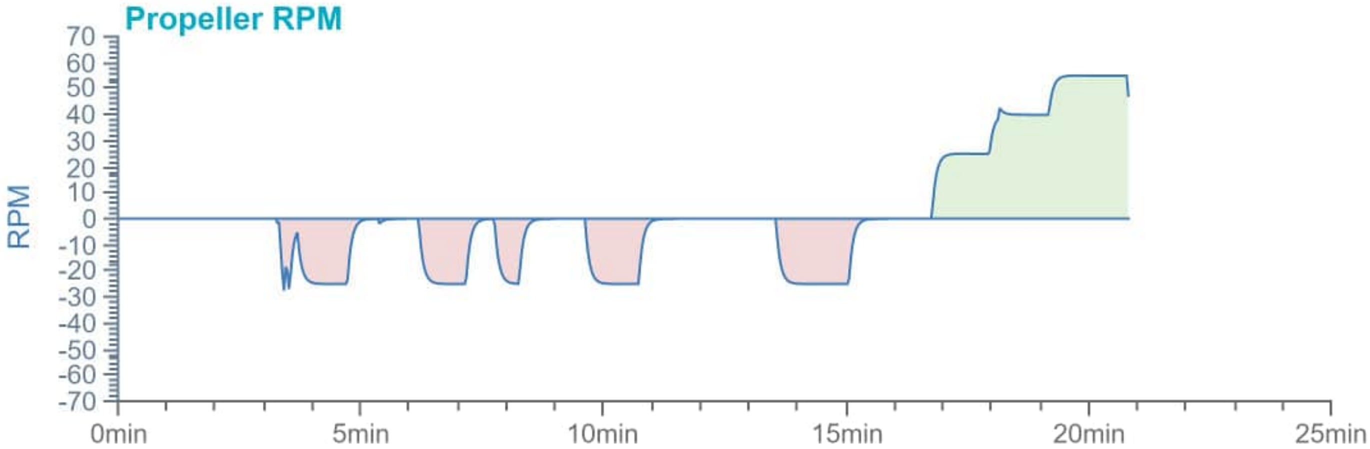

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min

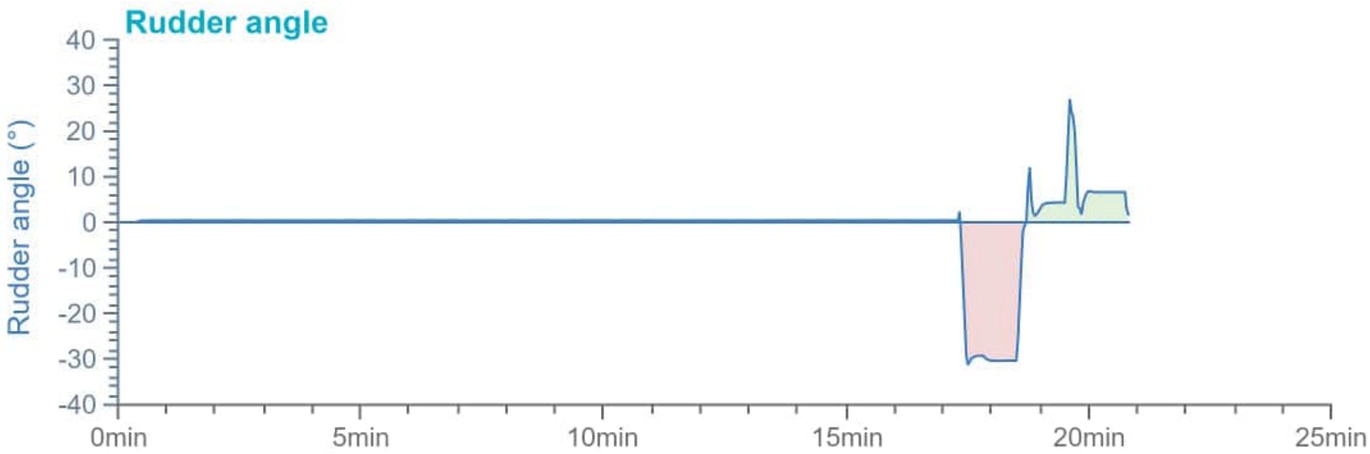

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
50
40
30
20
10
0
-10
-20
-30
-40
-50
360
270
180
090
000
0min
5min
10min
15min
20min
25min

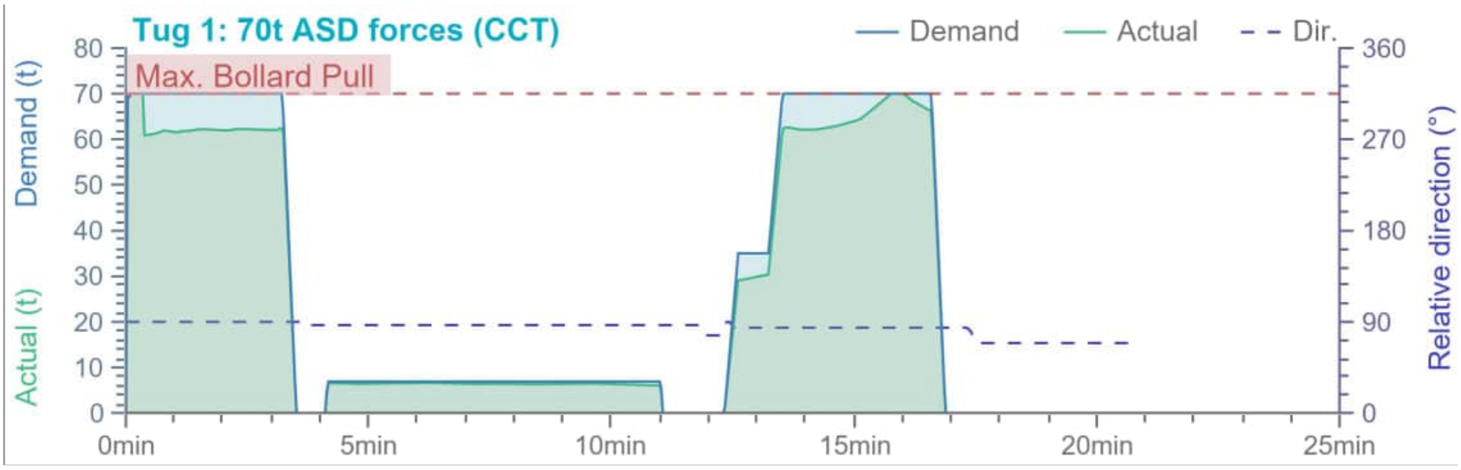

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min

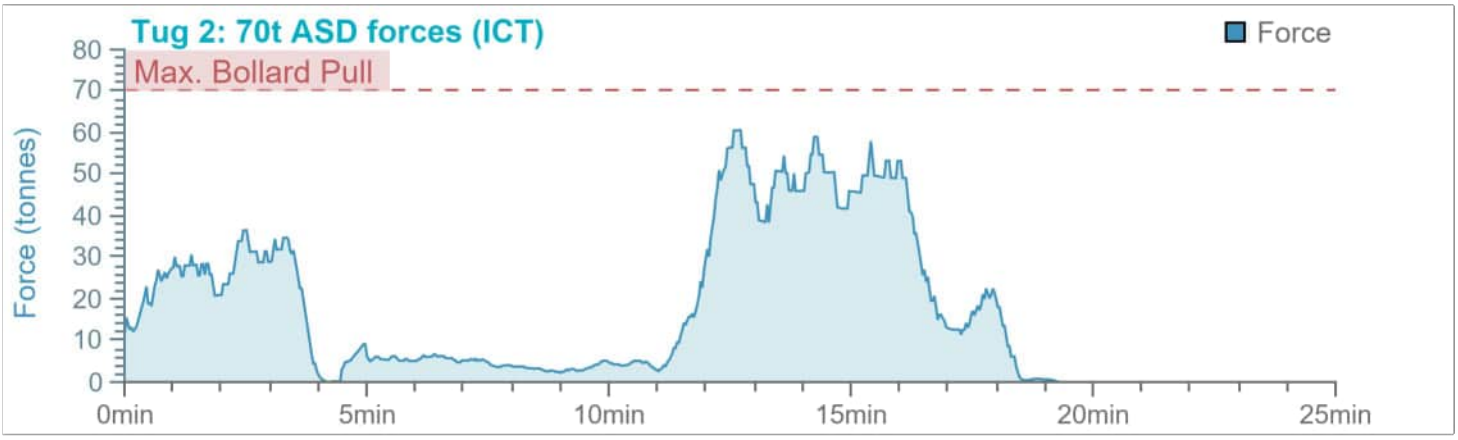

Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min

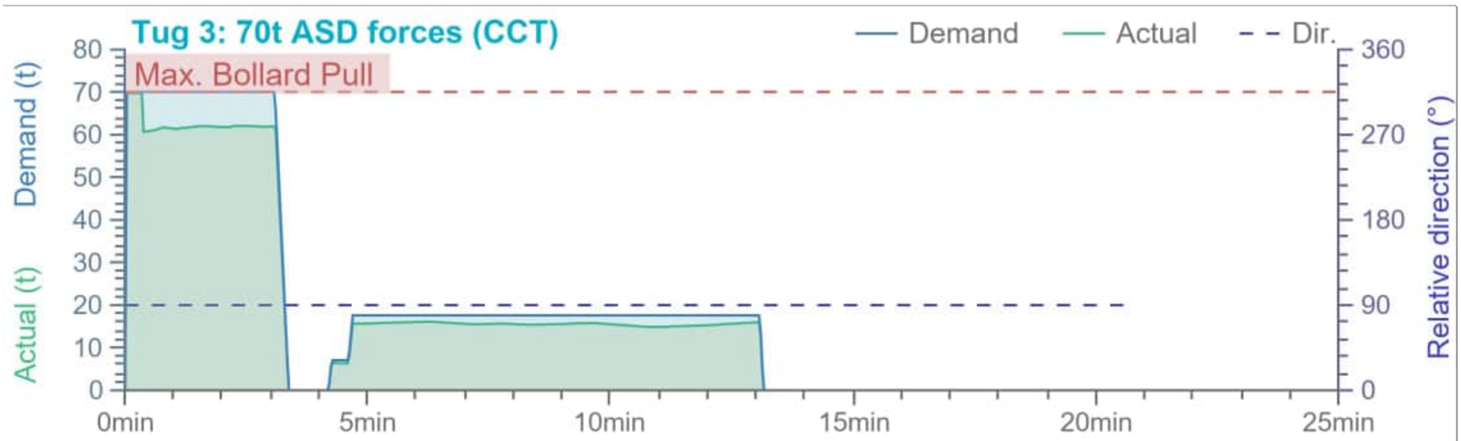

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min


Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min

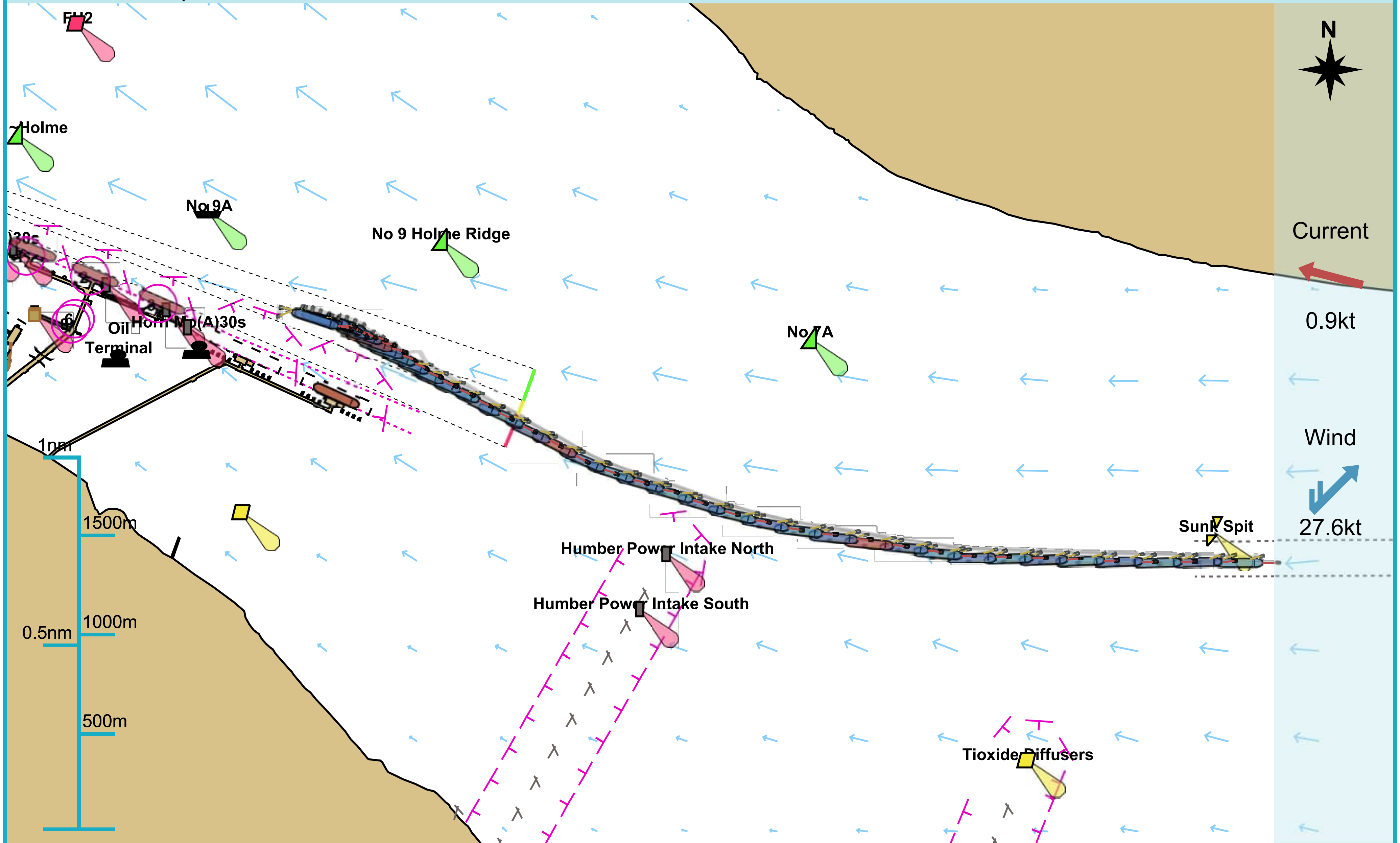

Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min


Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
60
70
80
90
180
270
360
0min
5min
10min
15min
20min
25min


Tug 2: 70t ASD forces (ICT)
Force
Max. Bollard Pull
Force (tonnes)
0
10
20
30
40
50
60
70
80
0min
5min
10min
15min
20min
25min


Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
60
70
80
90
180
270
360
0min
5min
10min
15min
20min
25min

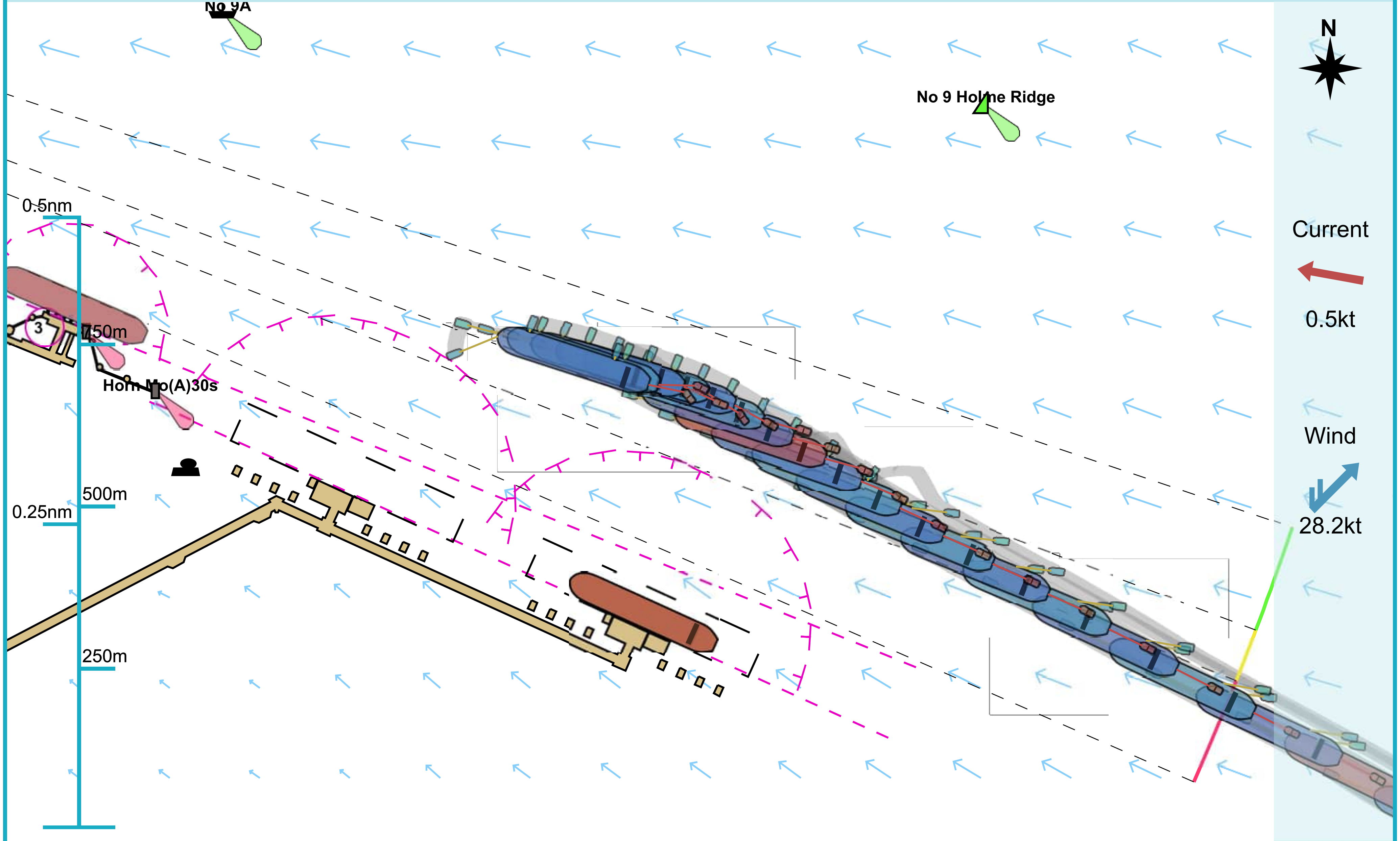
Manoeuvre track plot



1.85 kts

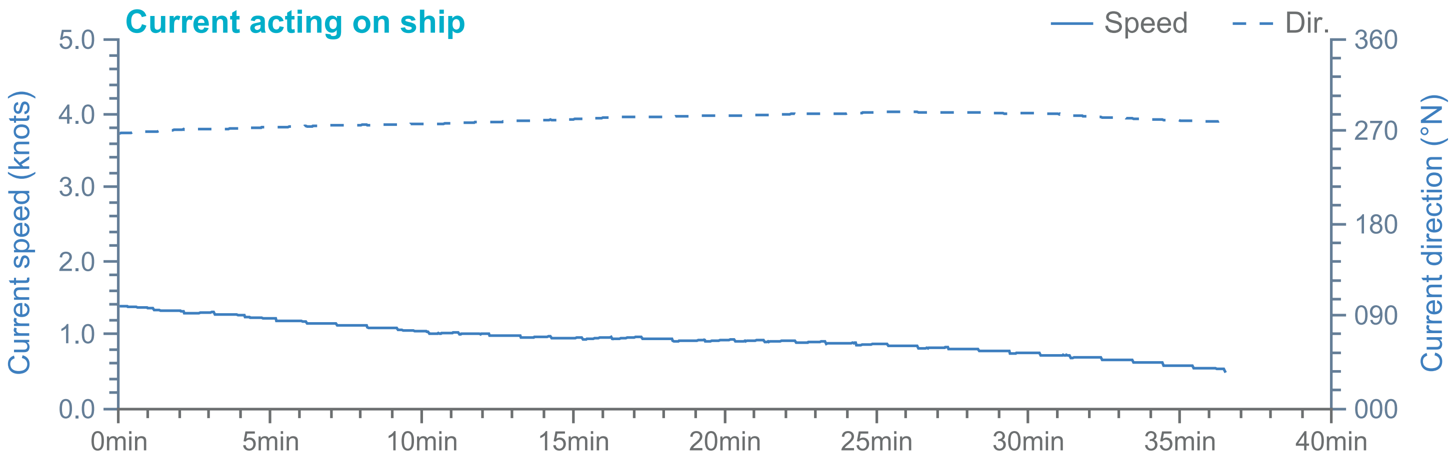
Ships plotted every 1 mins, highlight every 10 mins

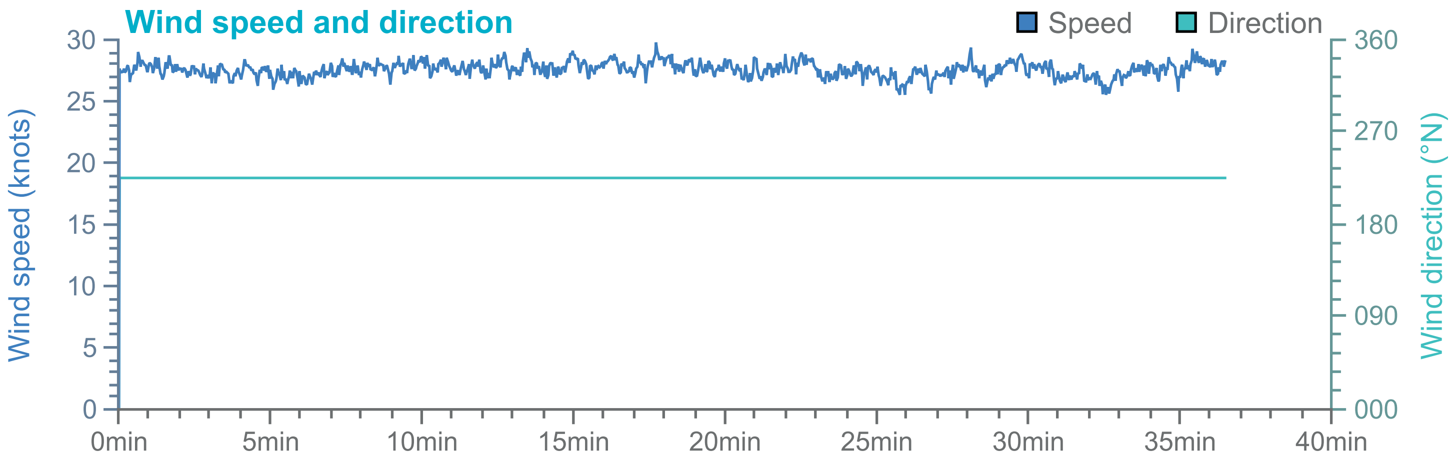
Manoeuvre track plot



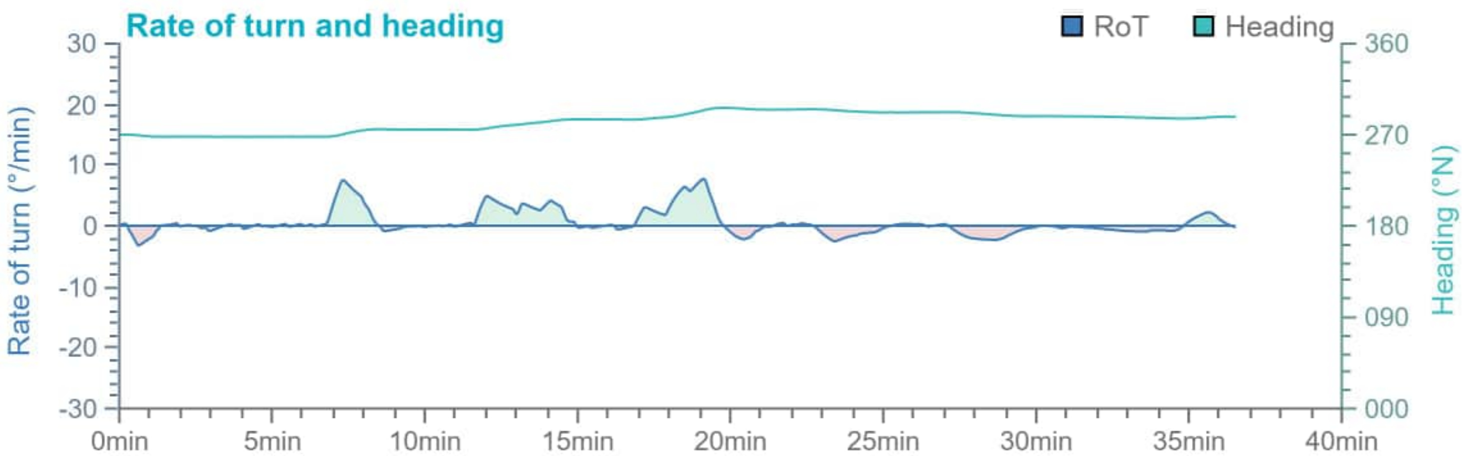
1.79 kts

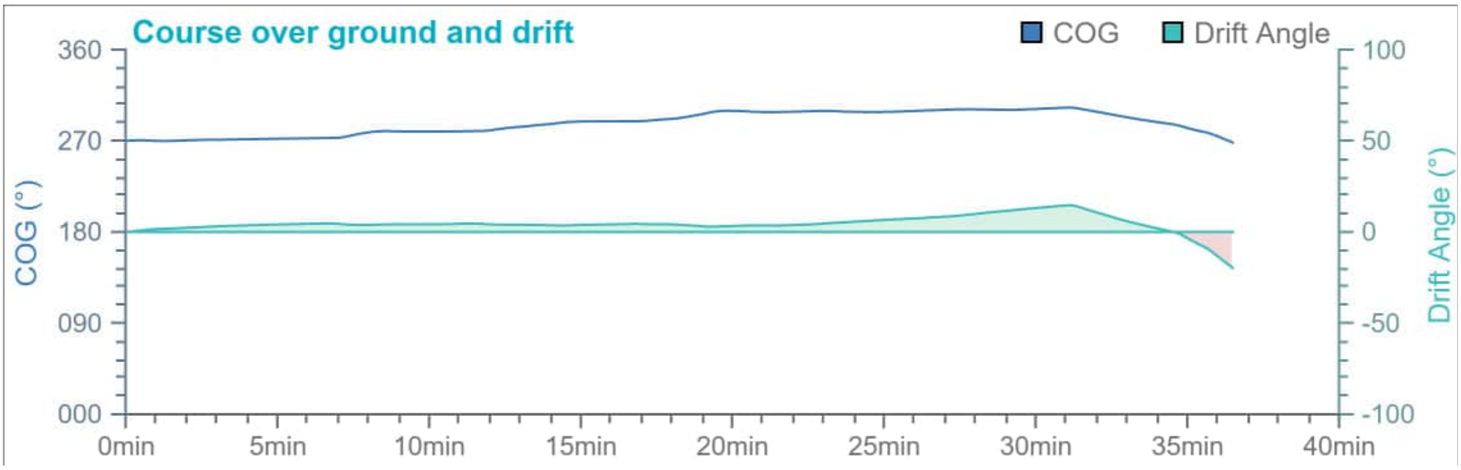
Ships plotted every 1 mins, highlight every 10 mins

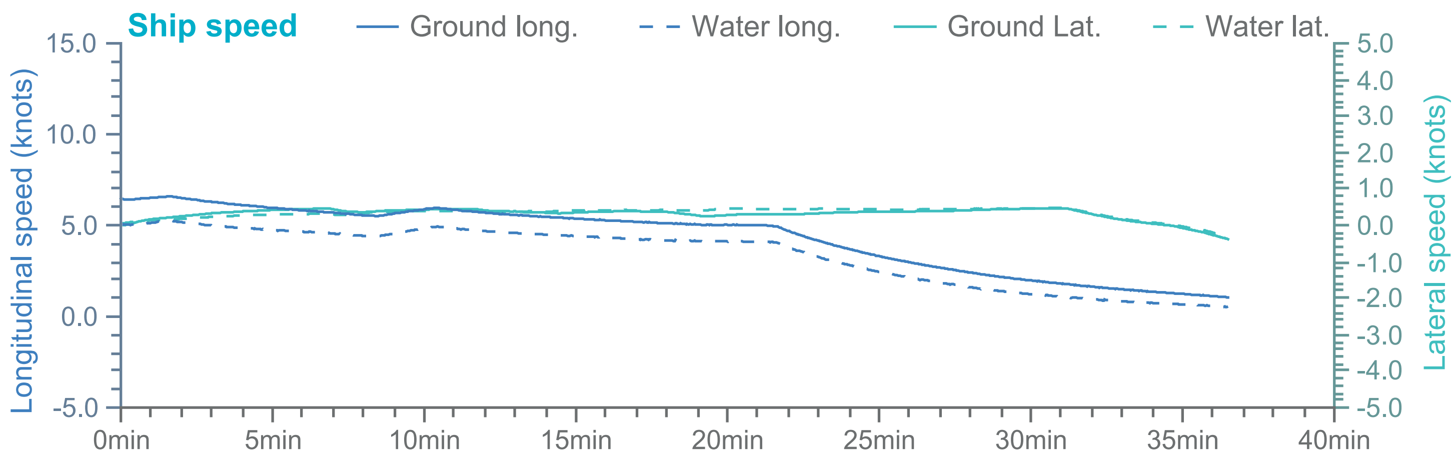

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min

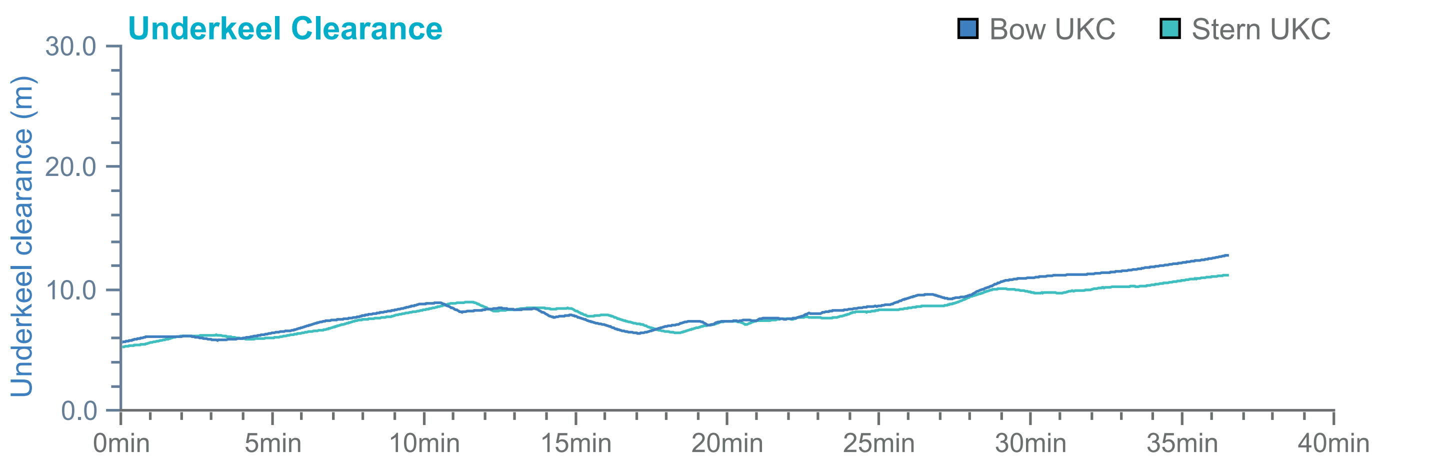

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min

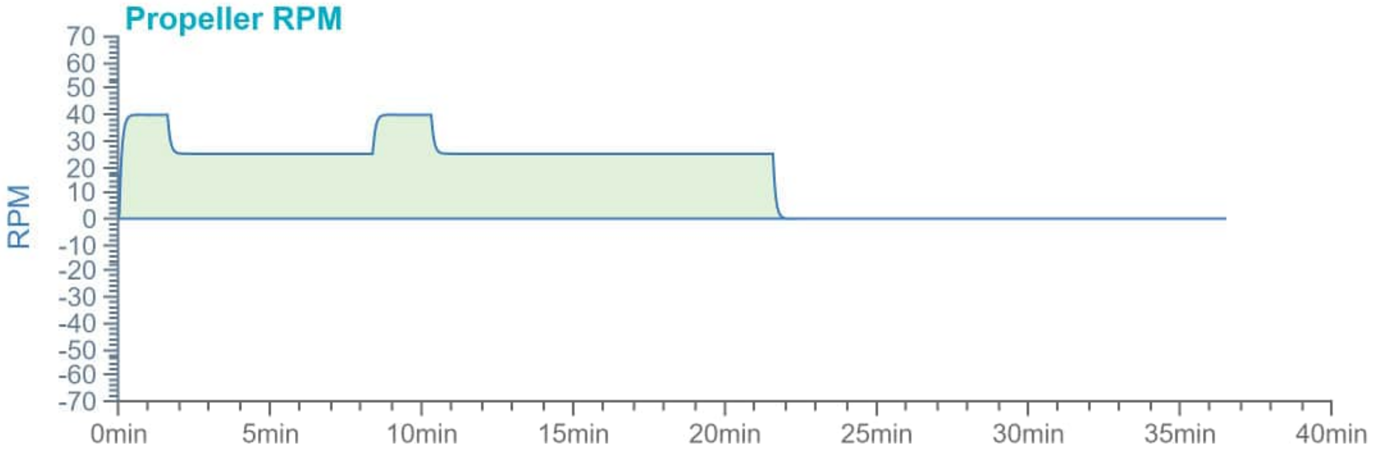
Overview	Environment	243m Product Tanker	Tug

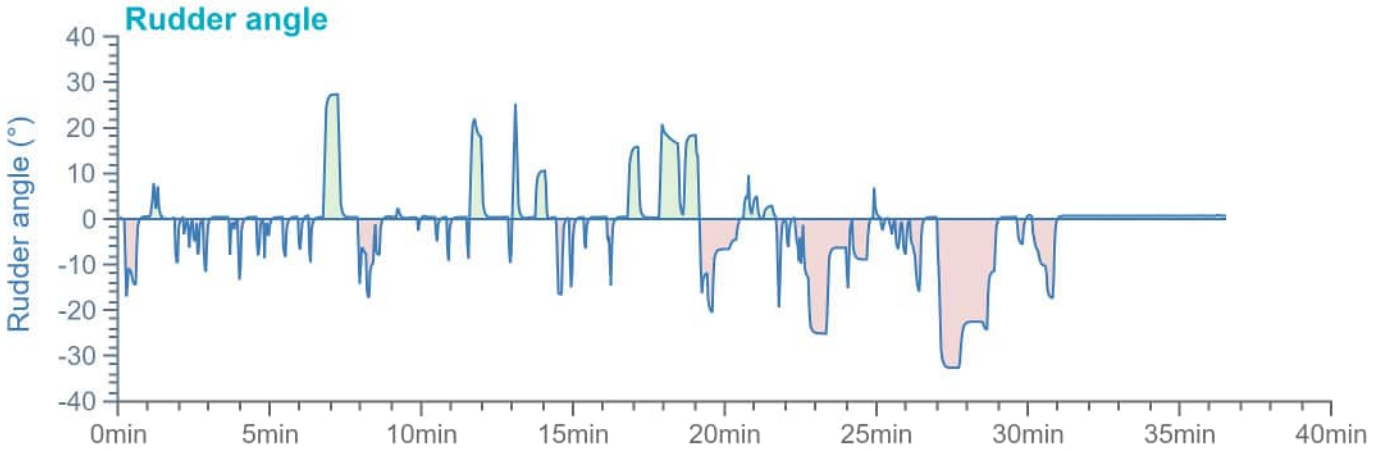




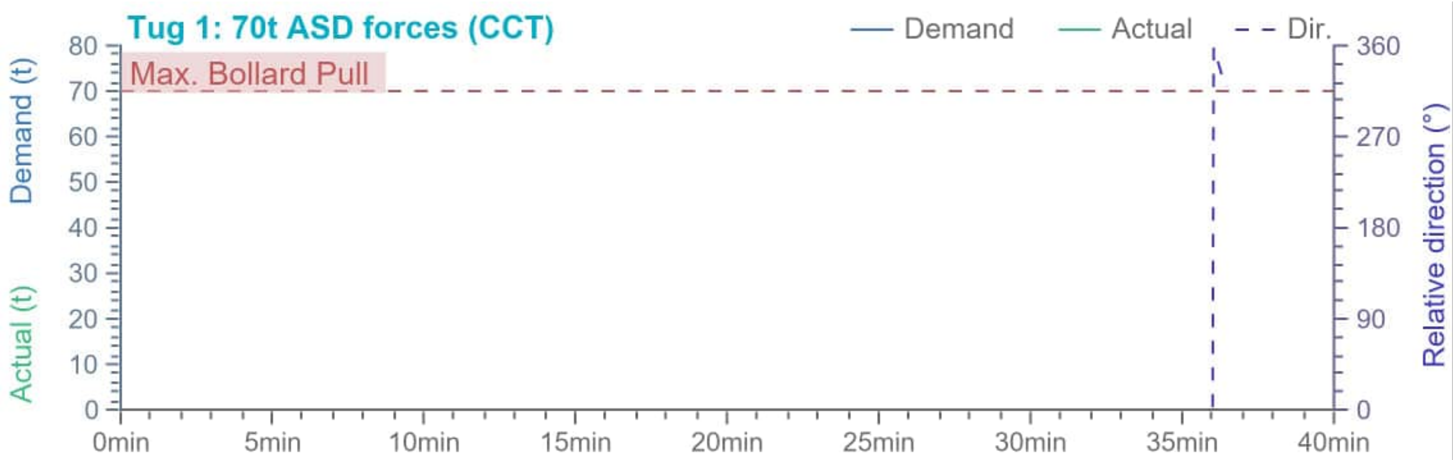


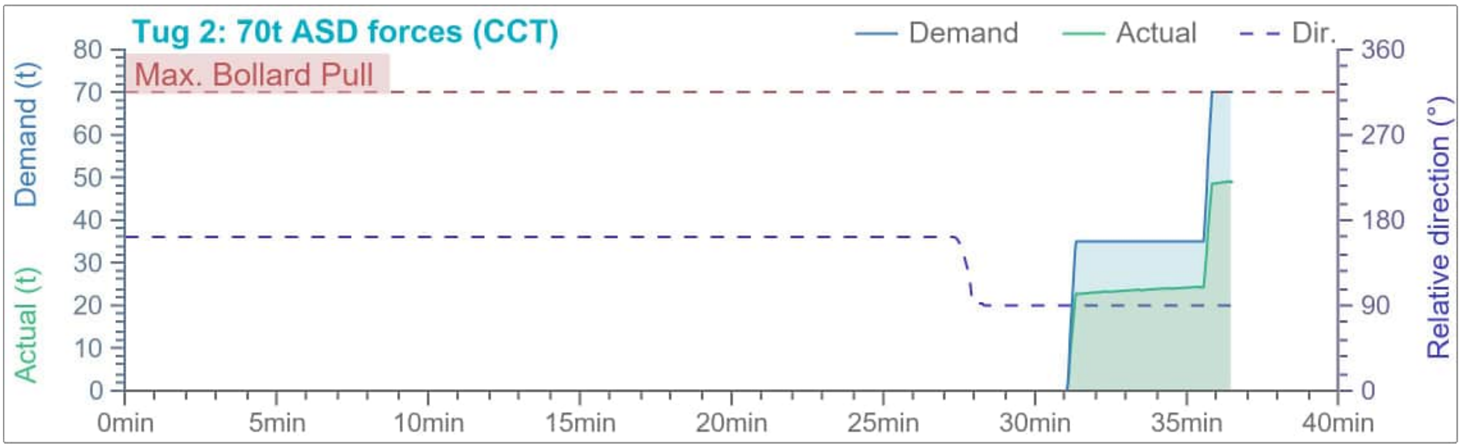


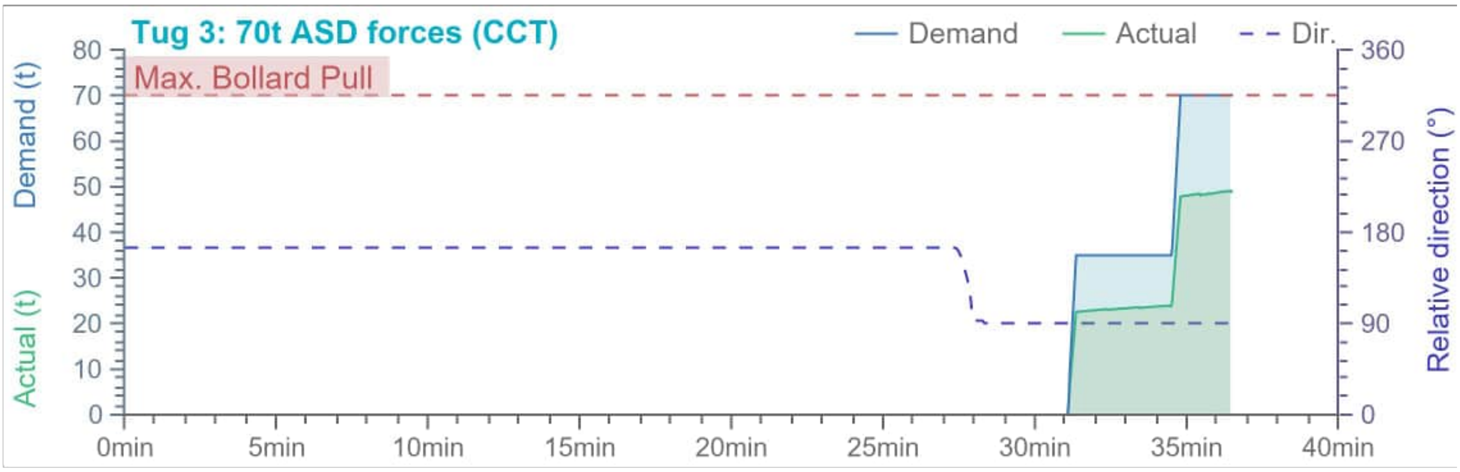

Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min
30min
35min
40min

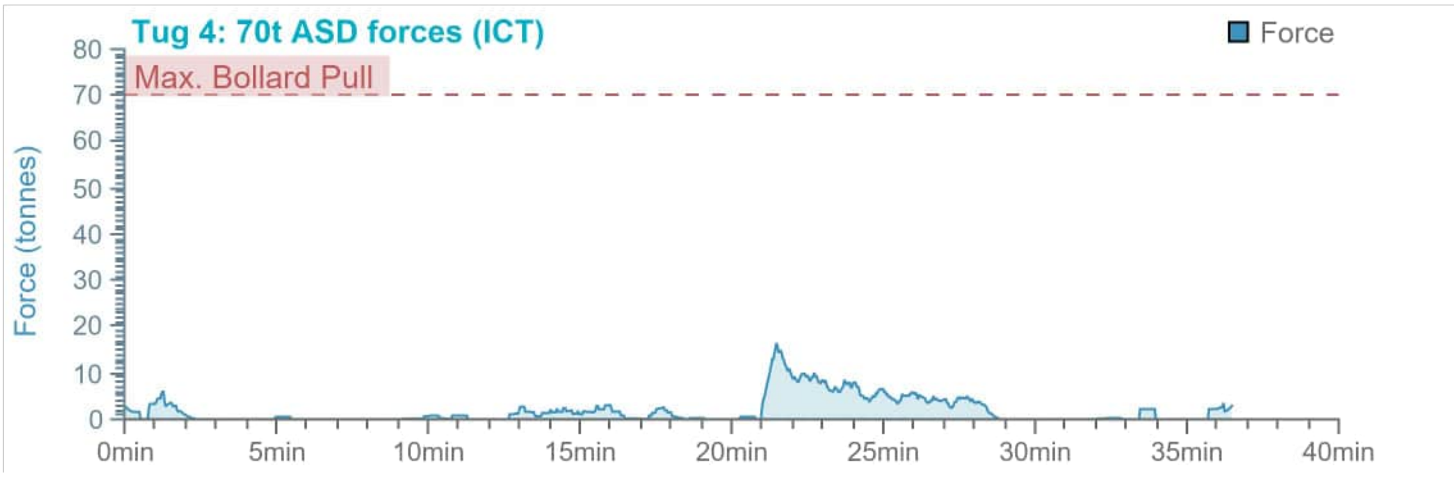

Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min
30min
35min
40min

Overview | Environment | 243m Product Tanker | Tug

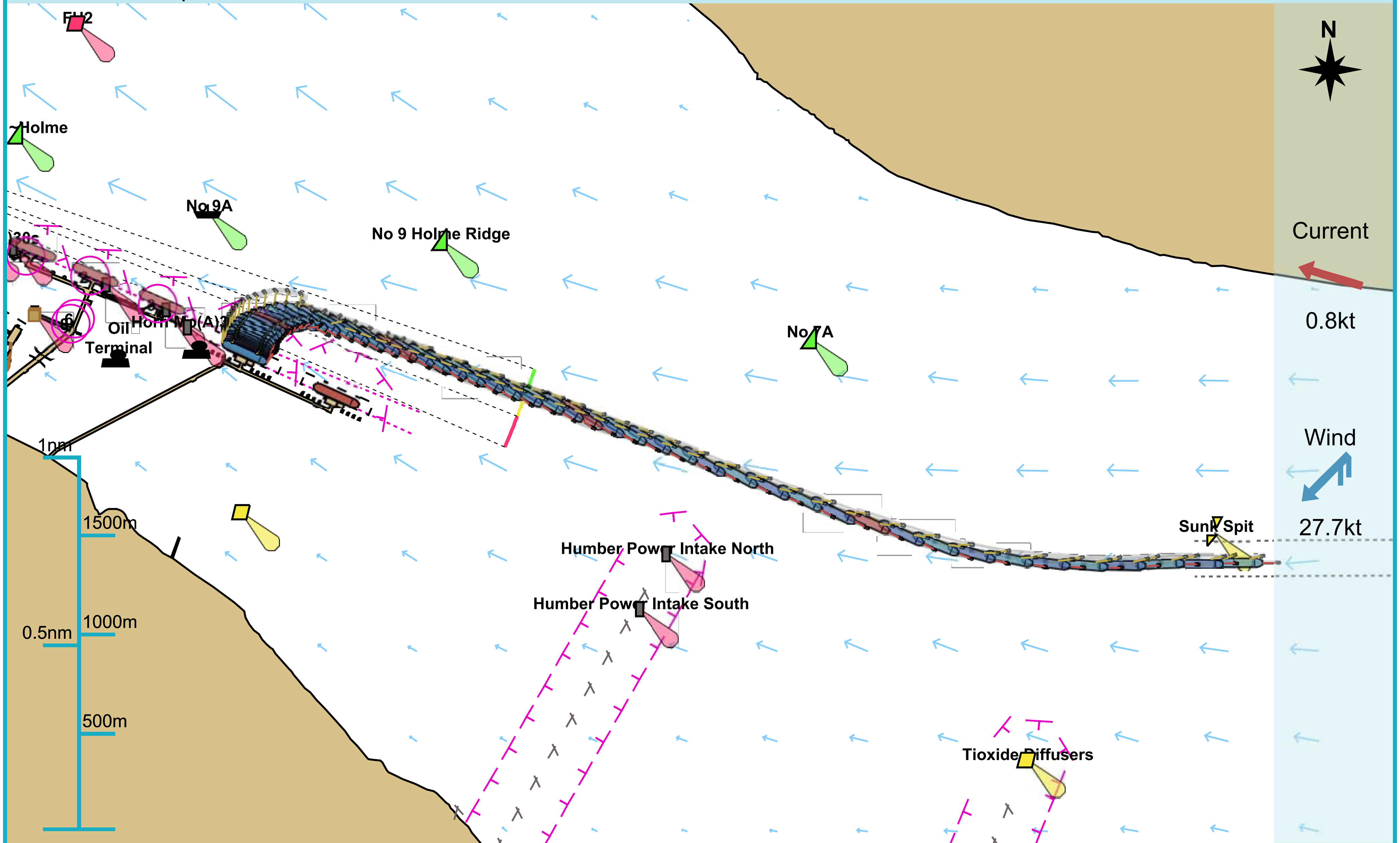








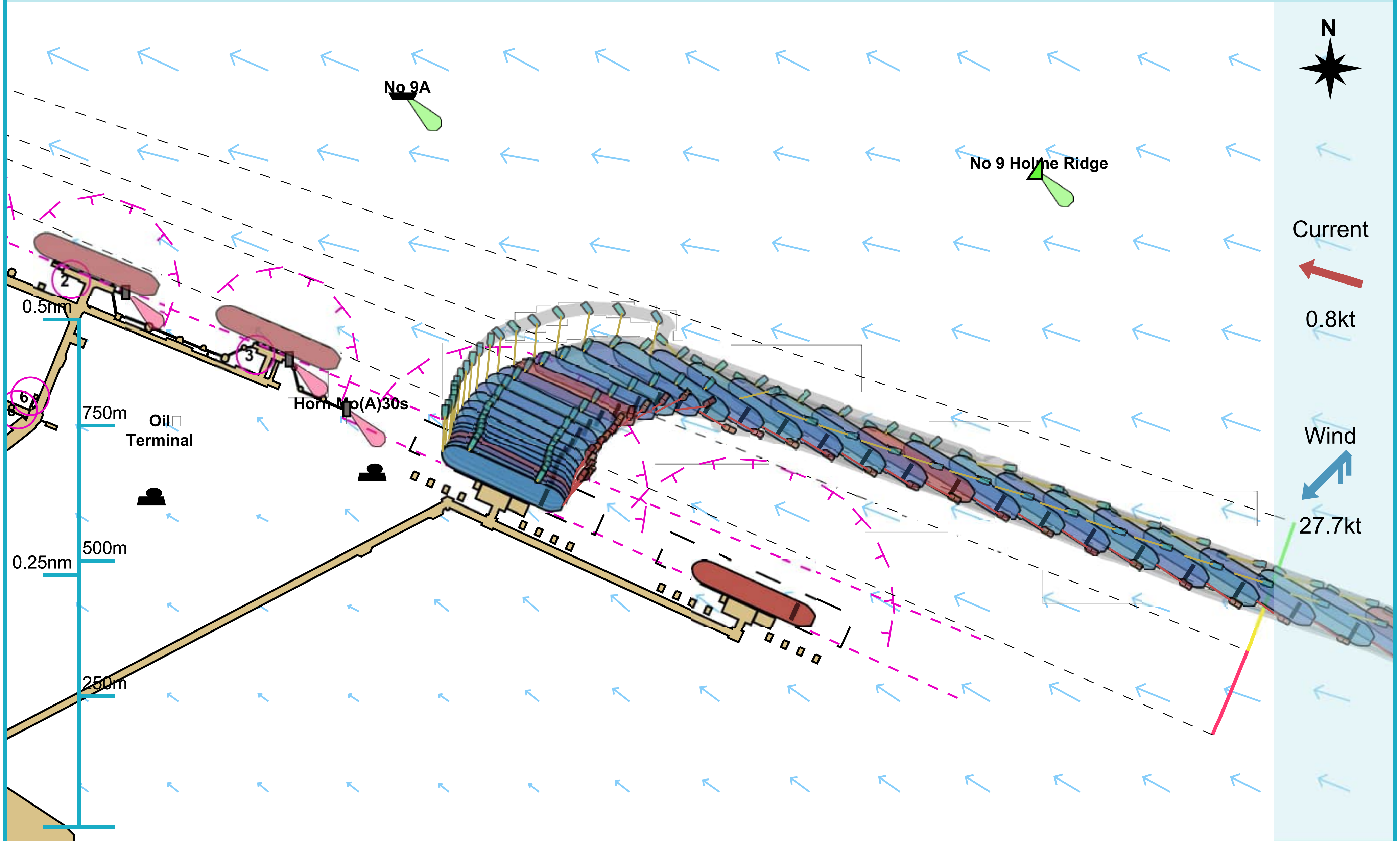
Manoeuvre track plot



1.85 kts

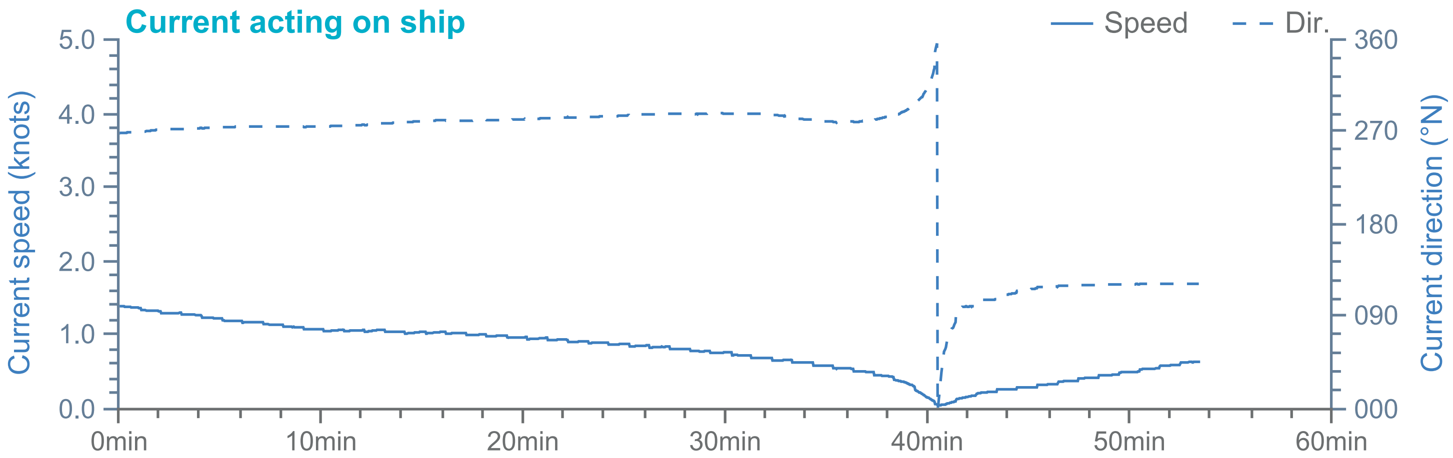
Ships plotted every 1 mins, highlight every 10 mins

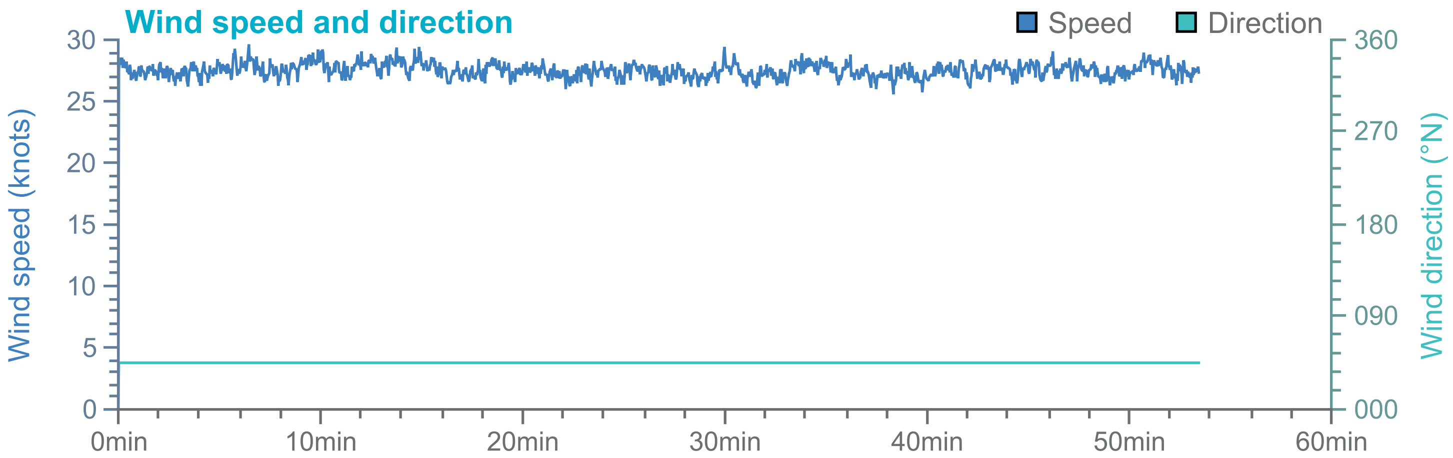
Manoeuvre track plot

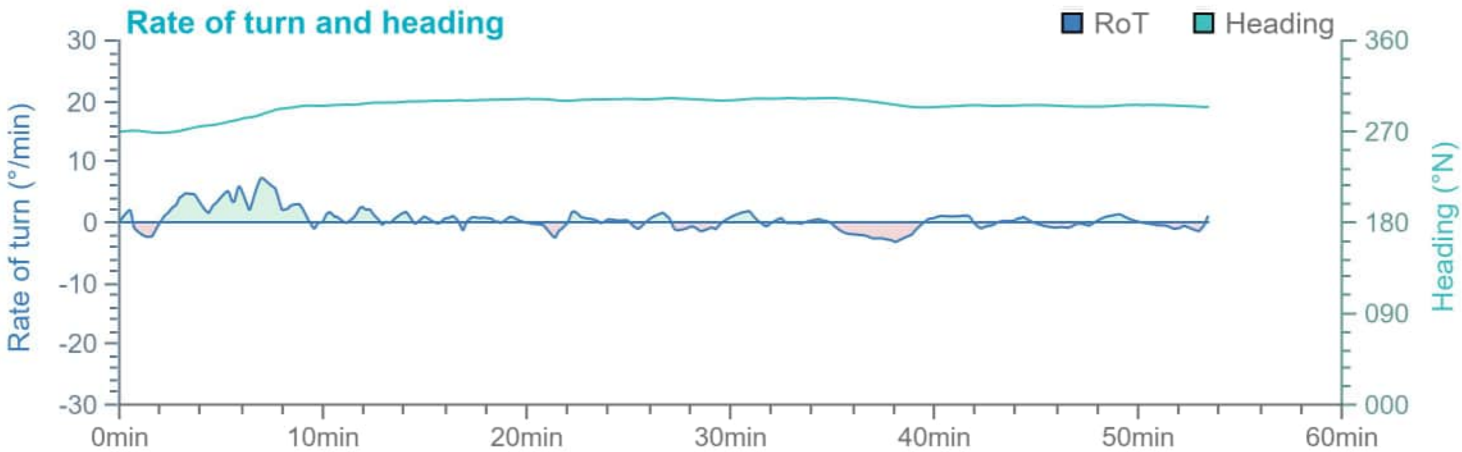


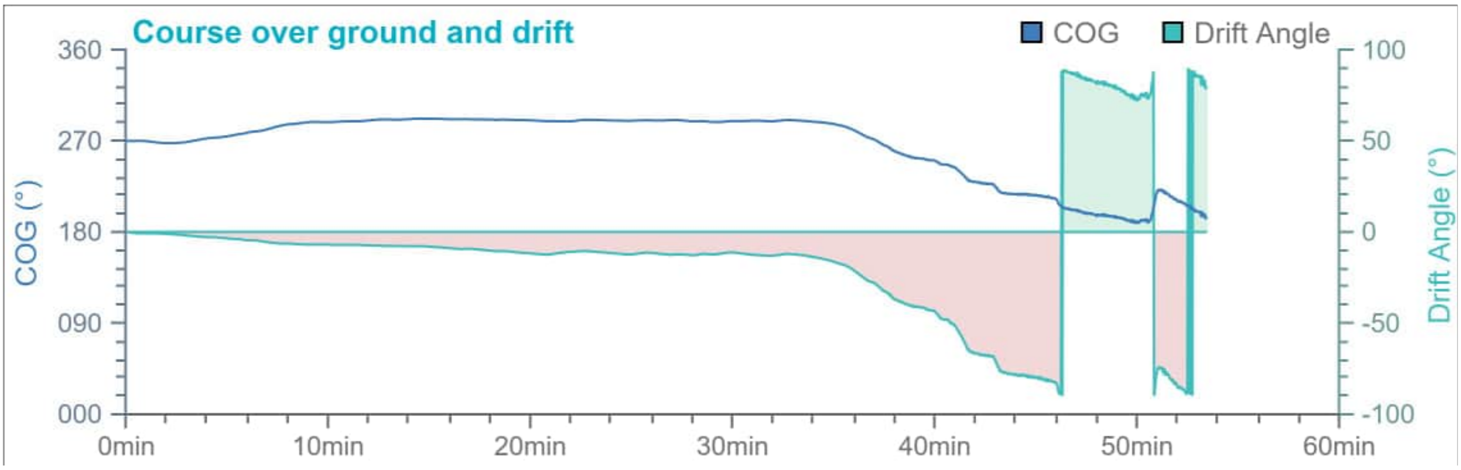
1.78 kts

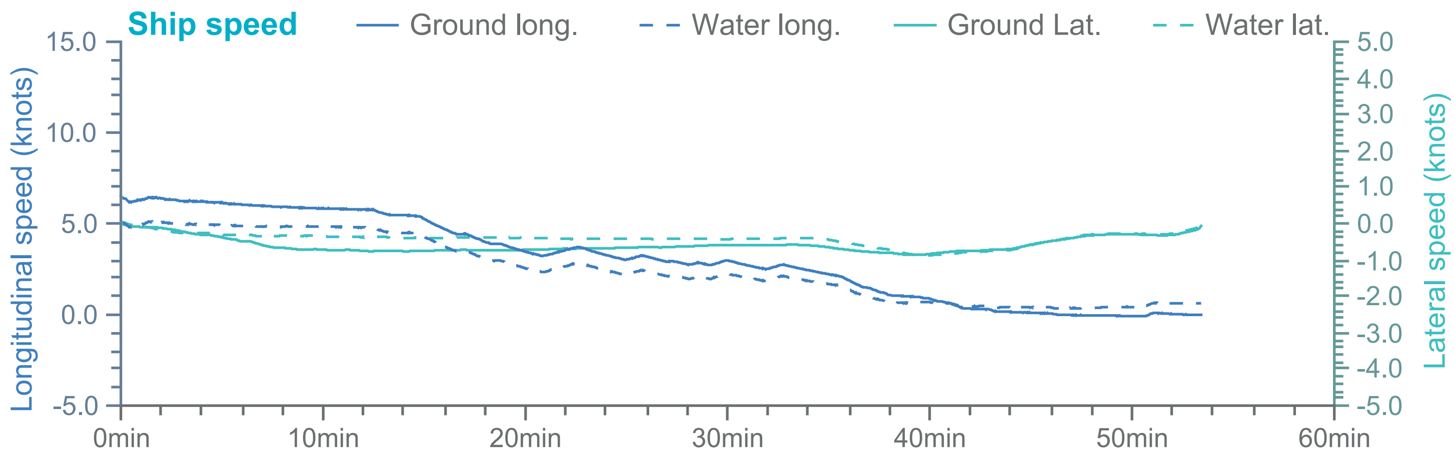
Ships plotted every 1 mins, highlight every 10 mins

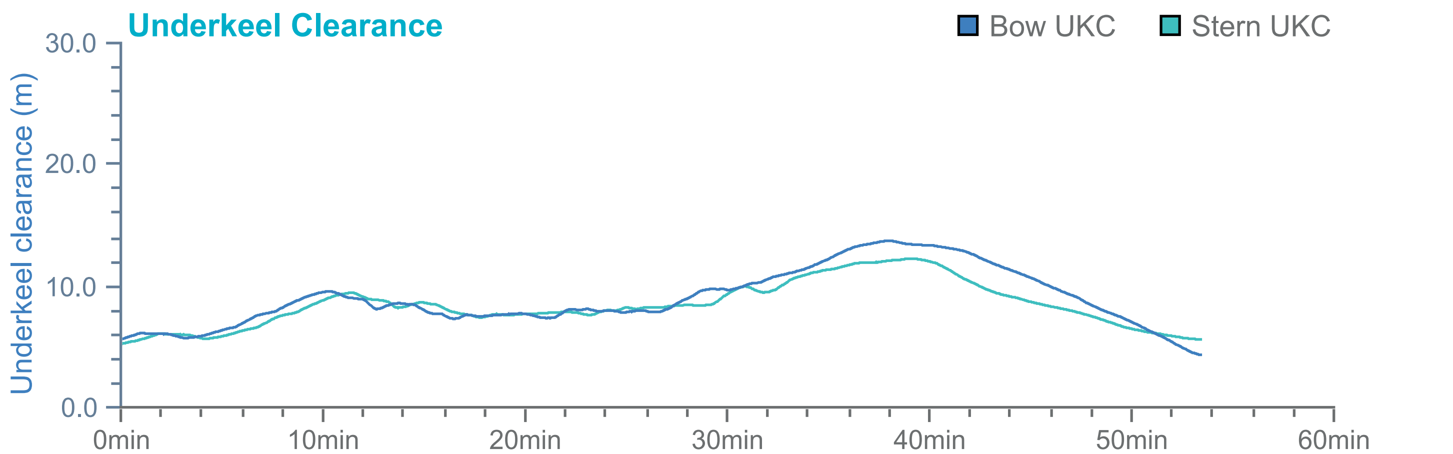

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
10min
20min
30min
40min
50min
60min

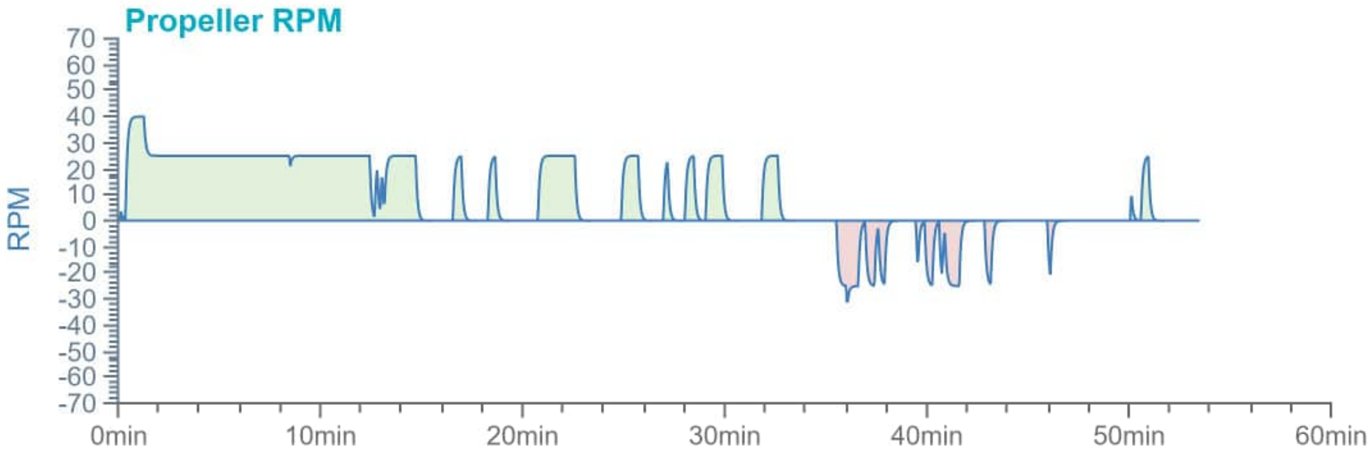

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
10min
20min
30min
40min
50min
60min

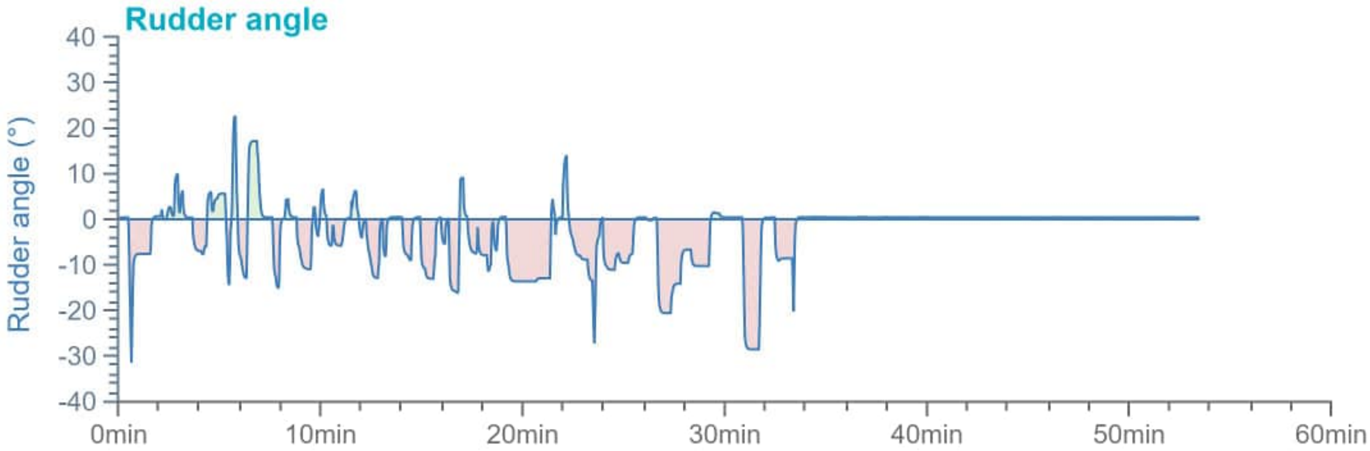

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
10min
20min
30min
40min
50min
60min


Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
10min
20min
30min
40min
50min
60min

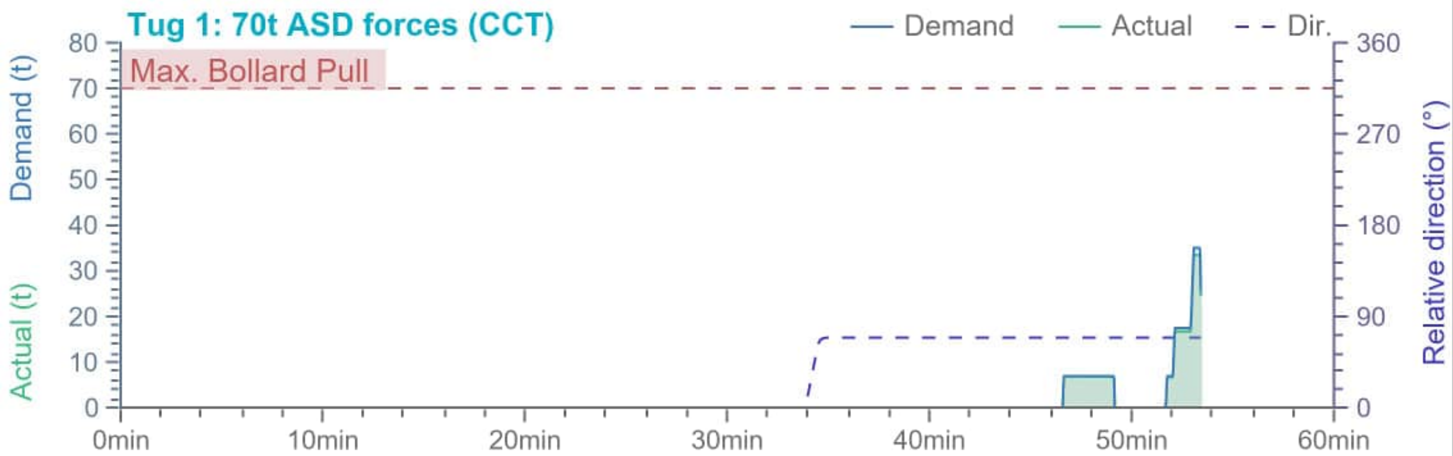

Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
10min
20min
30min
40min
50min
60min

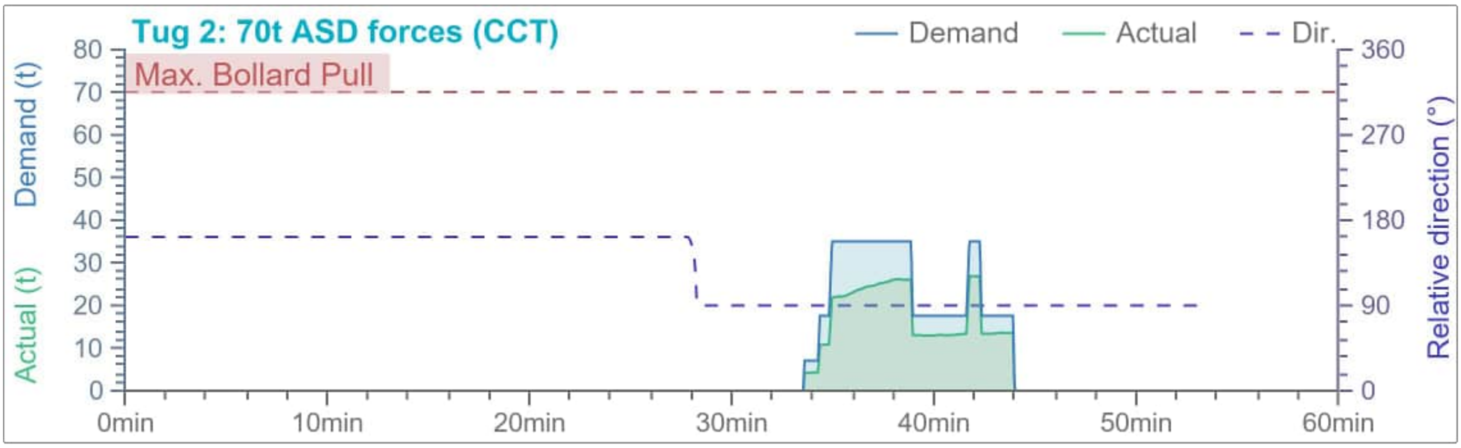

Underkeel Clearance
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
10min
20min
30min
40min
50min
60min

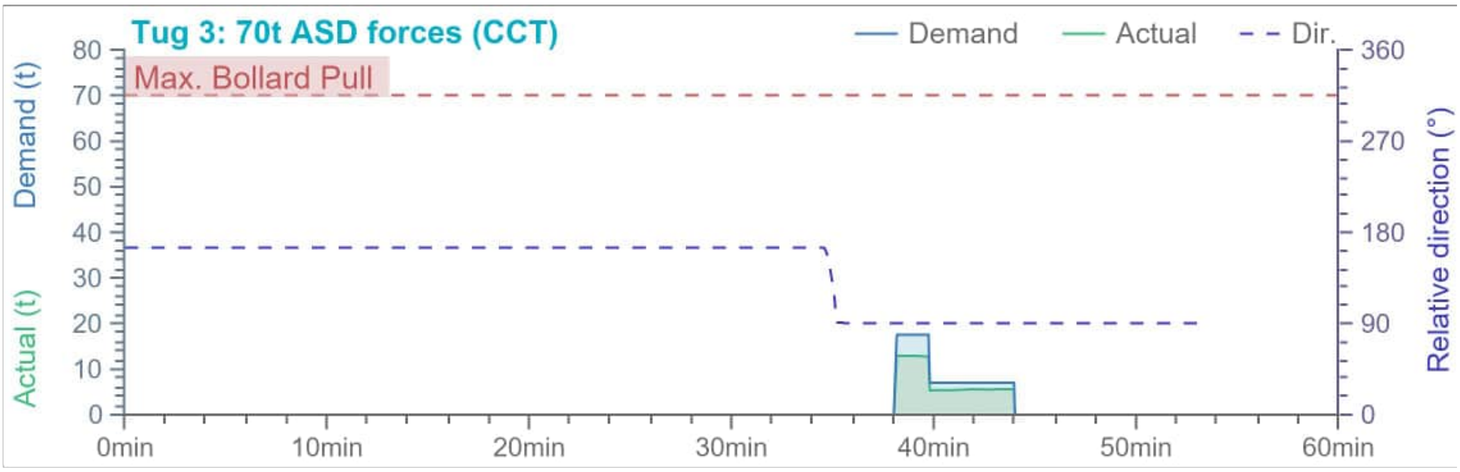

Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
10min
20min
30min
40min
50min
60min

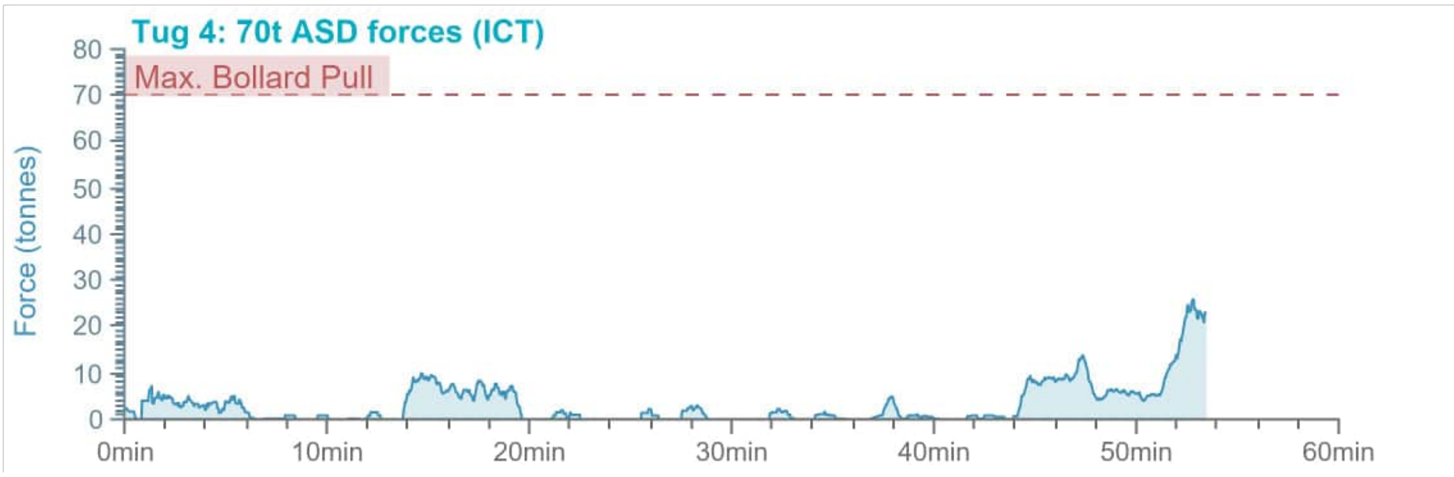

Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
10min
20min
30min
40min
50min
60min

Overview	Environment	243m Product Tanker	Tugs

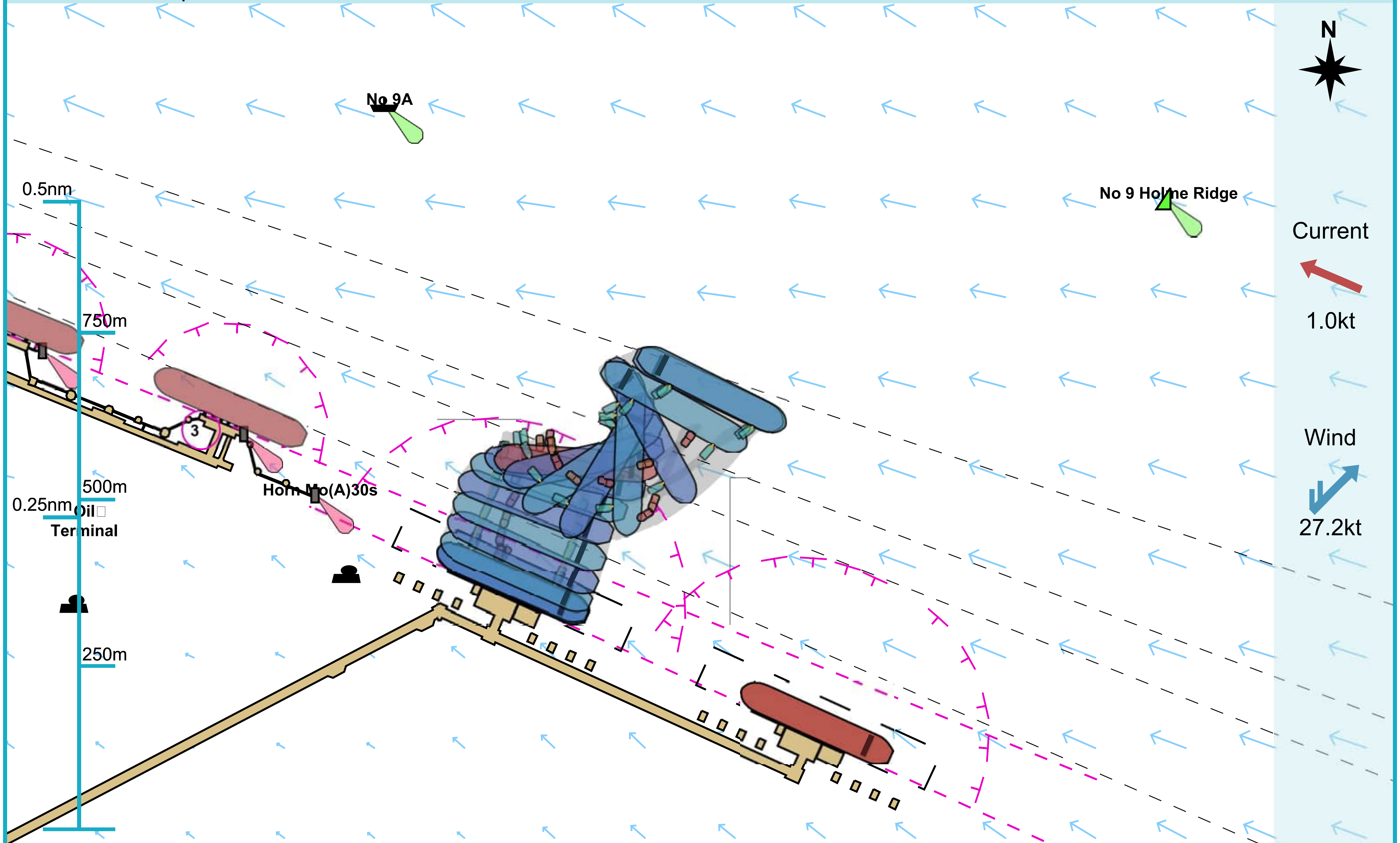






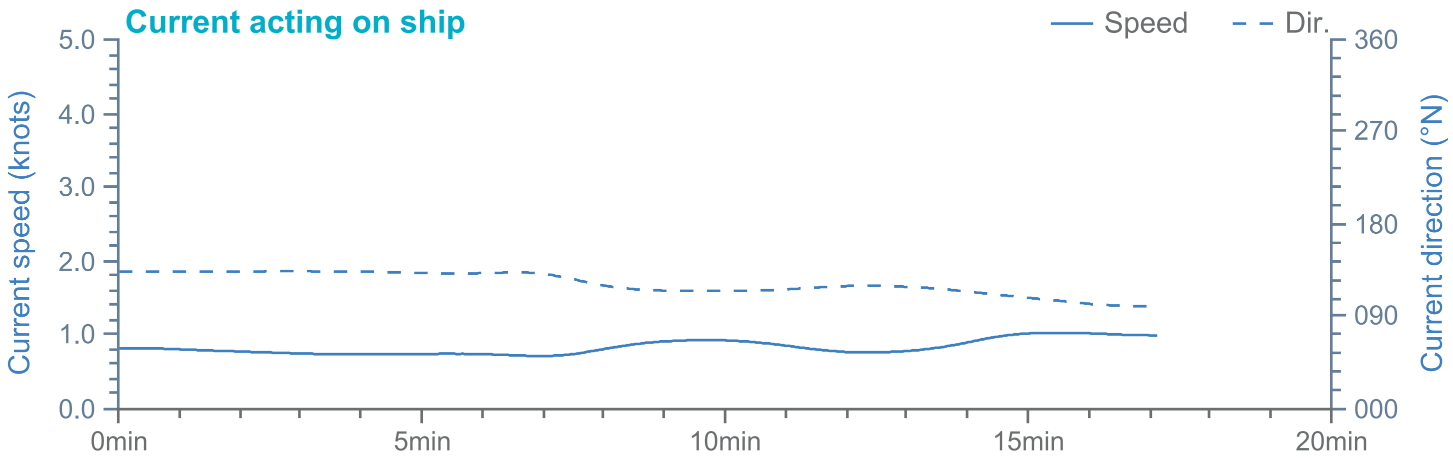


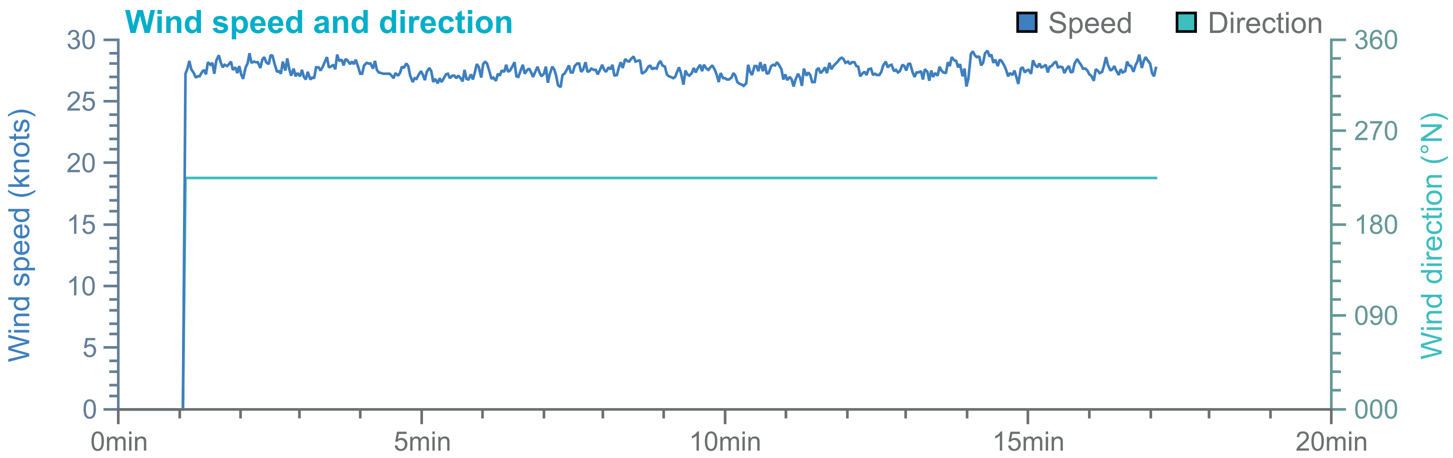
Manoeuvre track plot

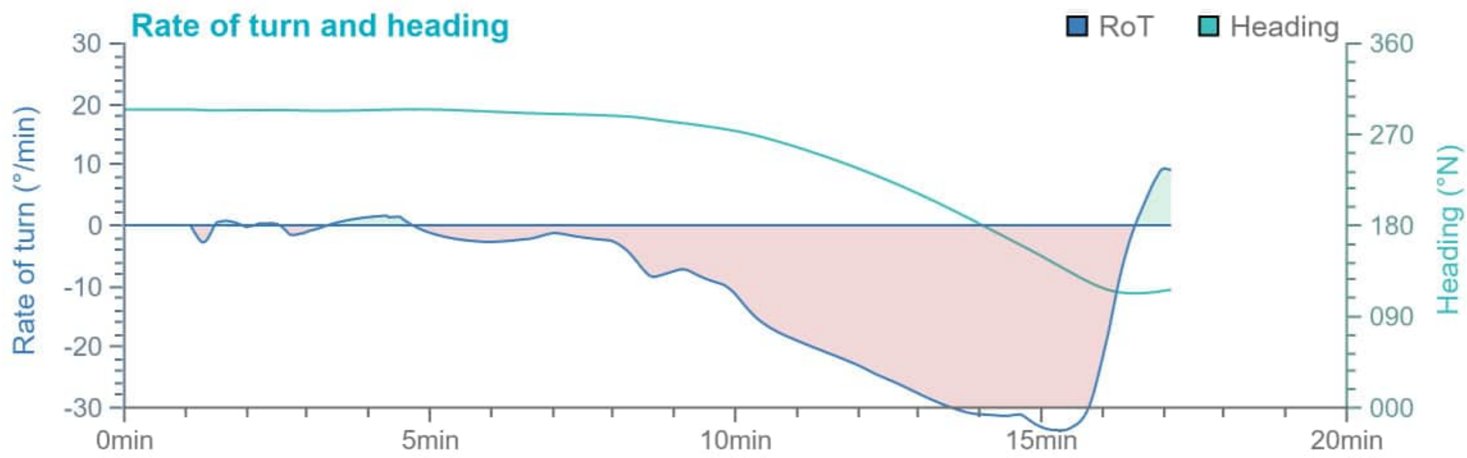


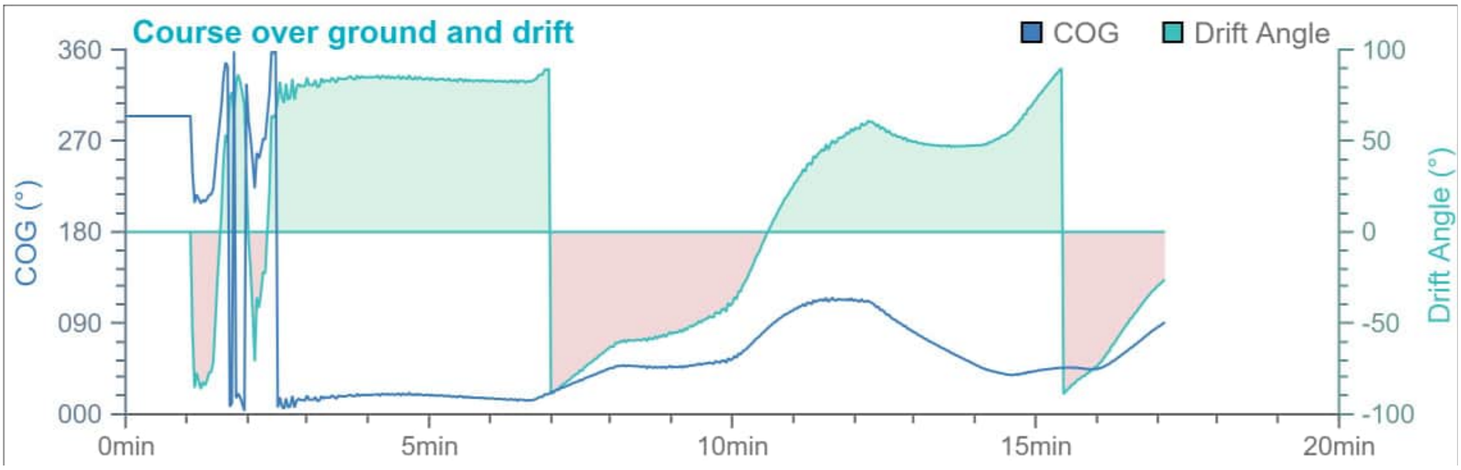
Ships plotted every 1 mins, highlight every 10 mins

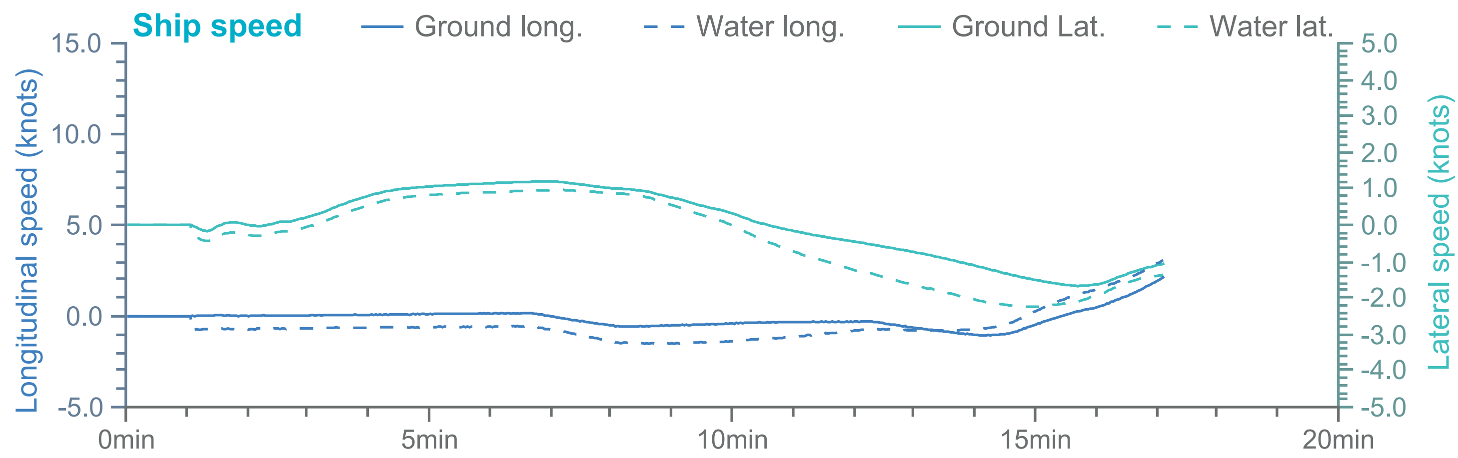
Overview | Environment | 243m Product Tanker | Tugs

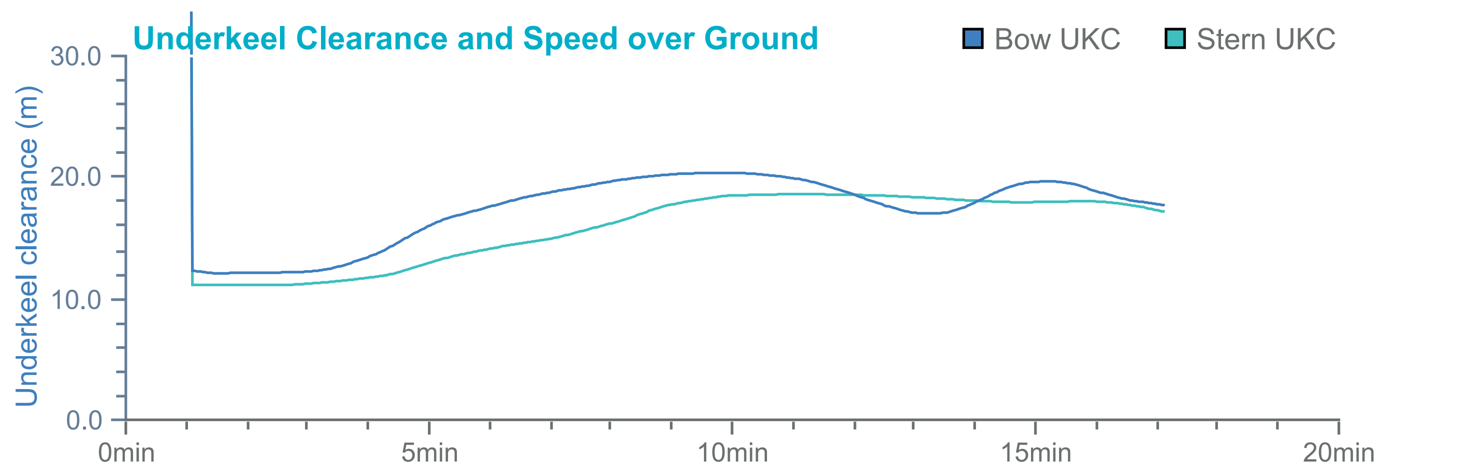


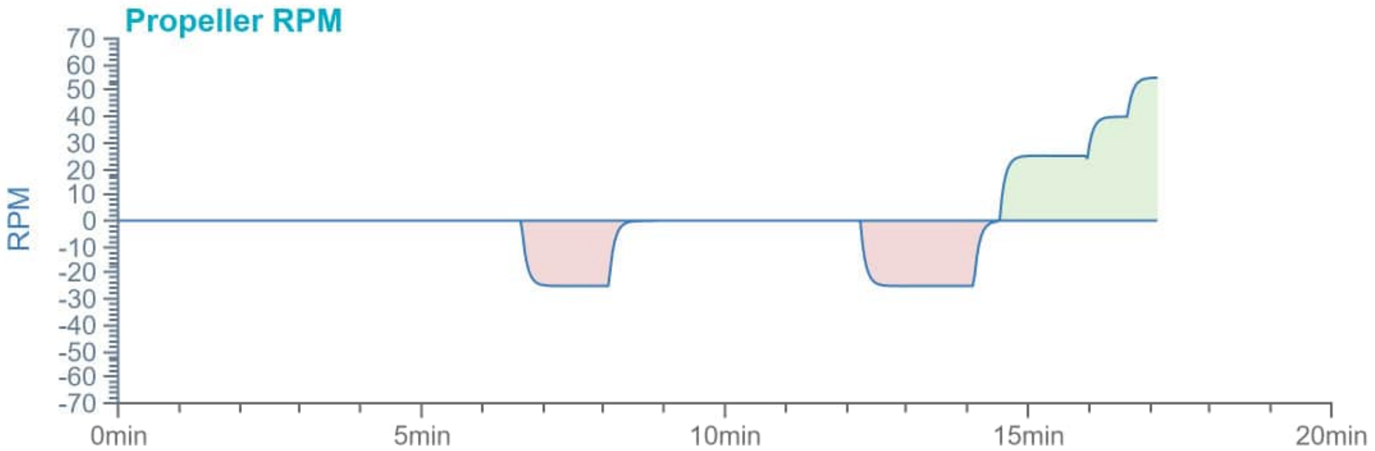


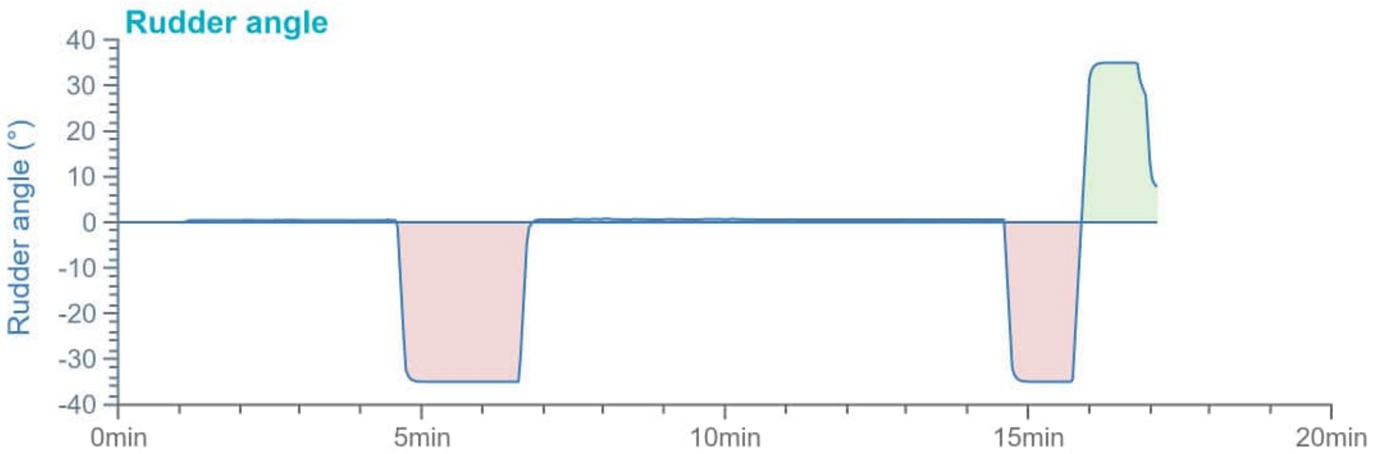

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min
15min
20min

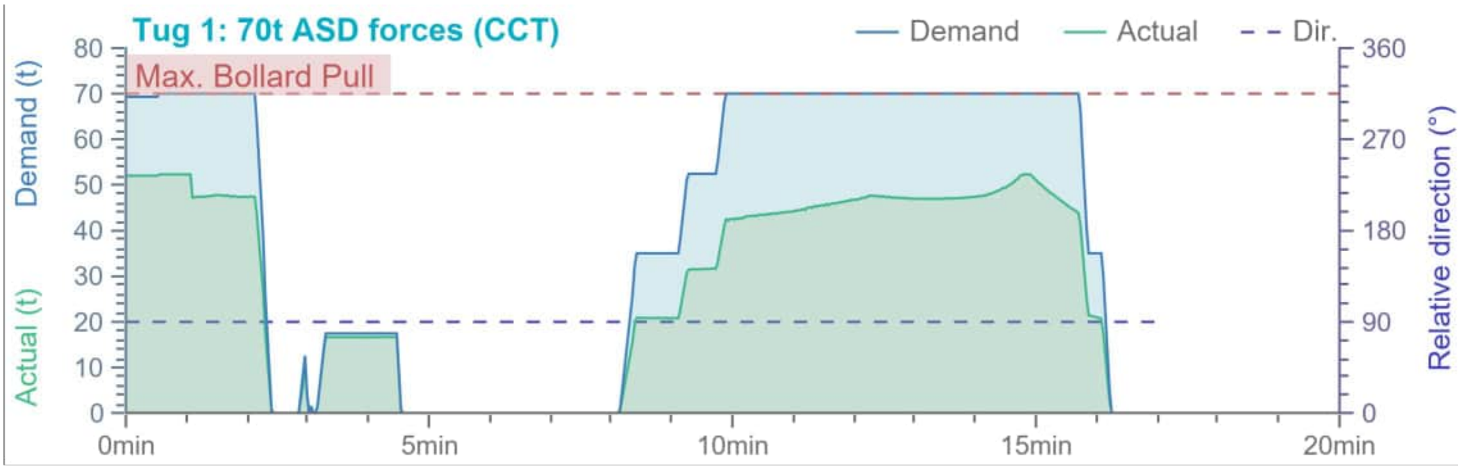

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min

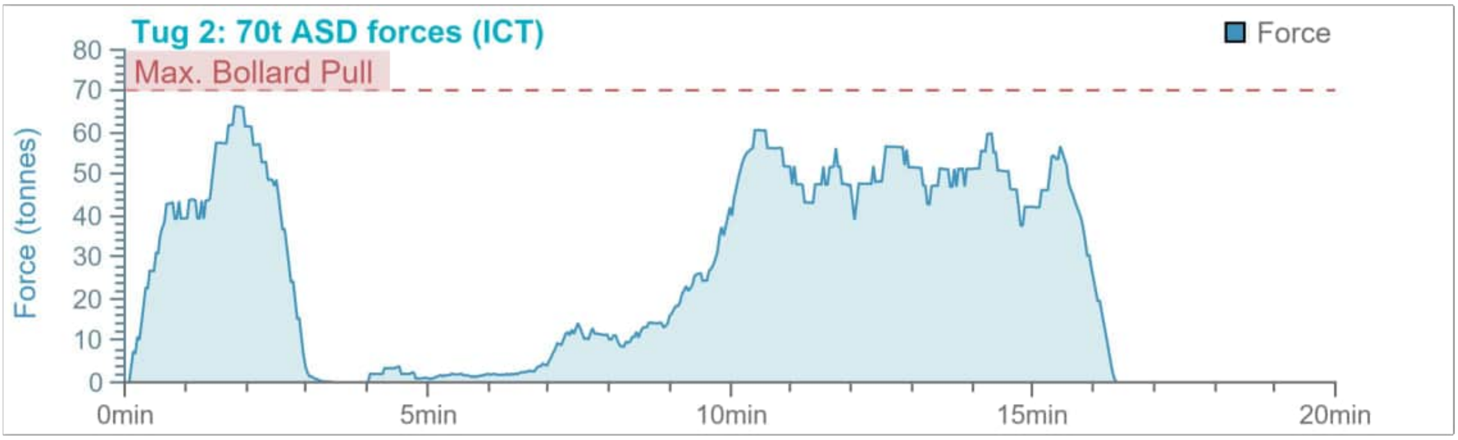

Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min

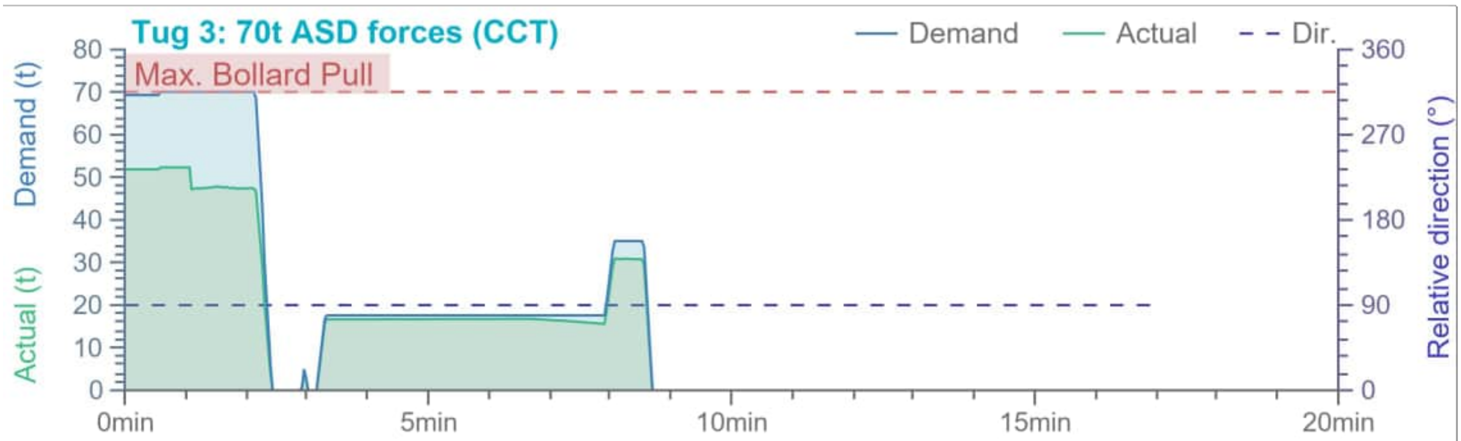

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min


Propeller RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
RPM
0min
5min
10min
15min
20min


Rudder angle
40
30
20
10
0
-10
-20
-30
-40
Rudder angle (°)
0min
5min
10min
15min
20min

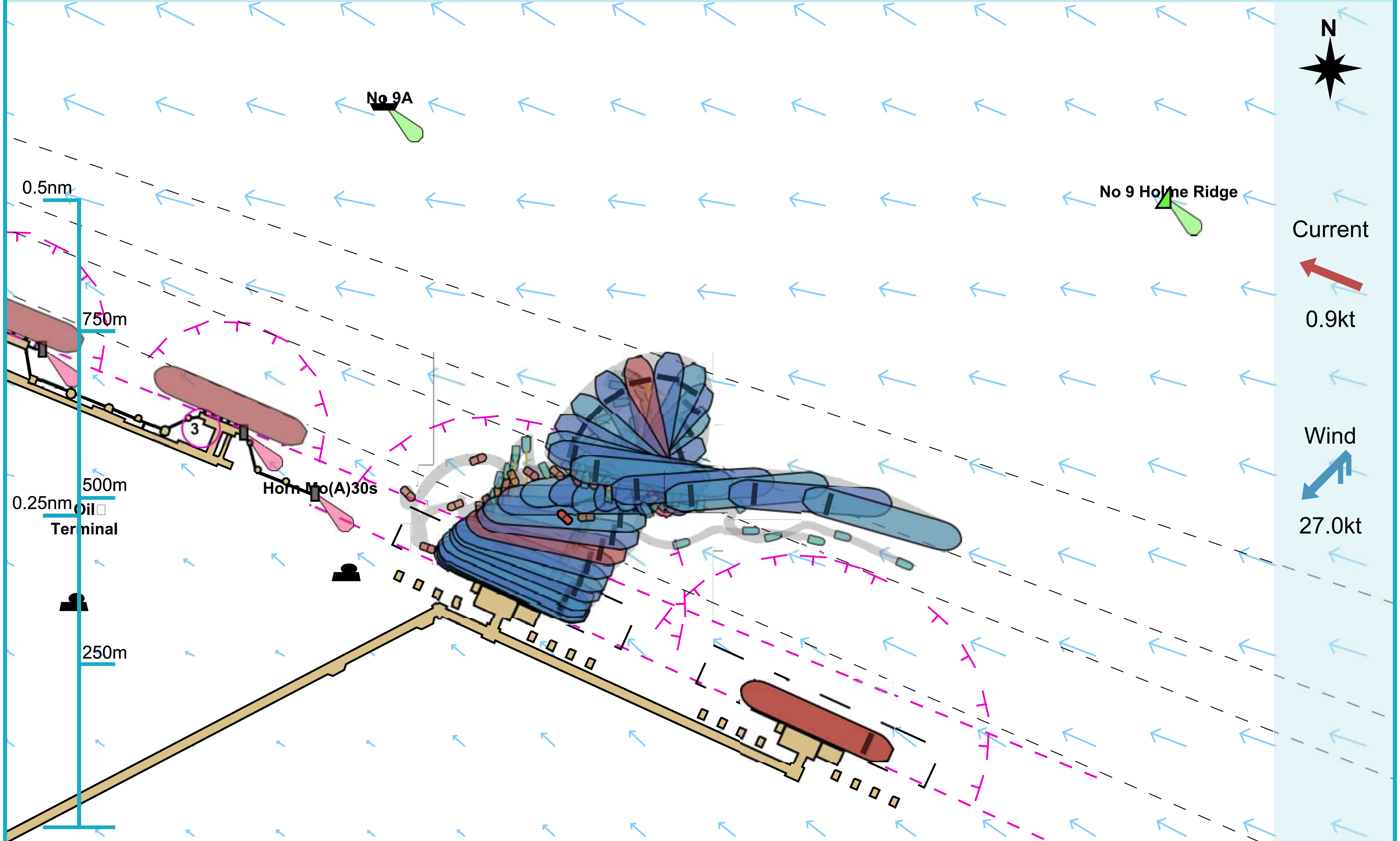

Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
80
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min
20min


Tug 2: 70t ASD forces (ICT)
Force
Max. Bollard Pull
Force (tonnes)
80
70
60
50
40
30
20
10
0
0min
5min
10min
15min
20min

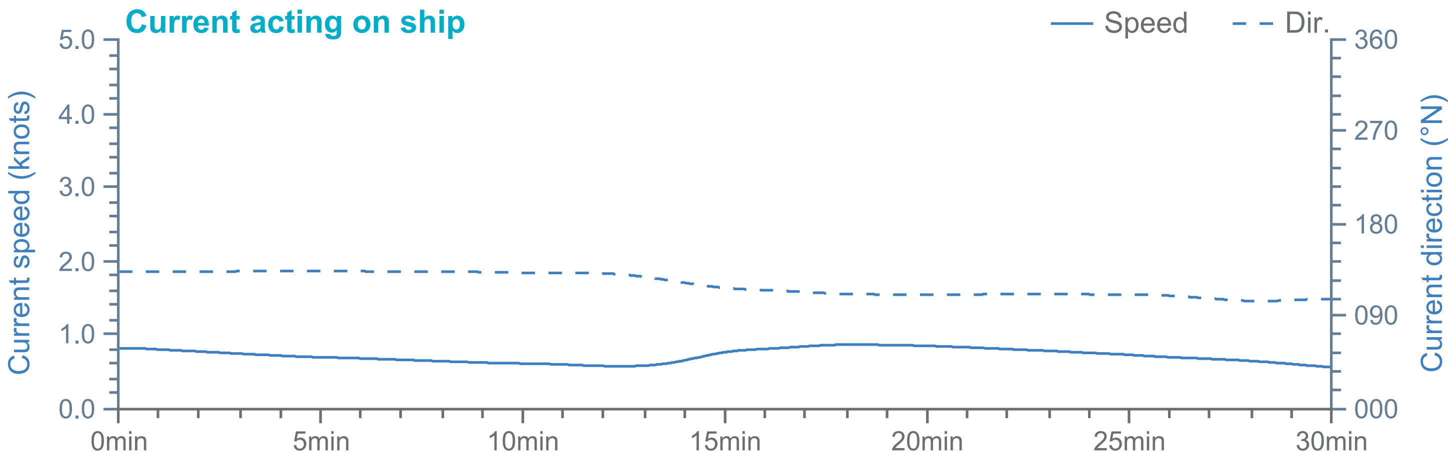

Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
80
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min
20min

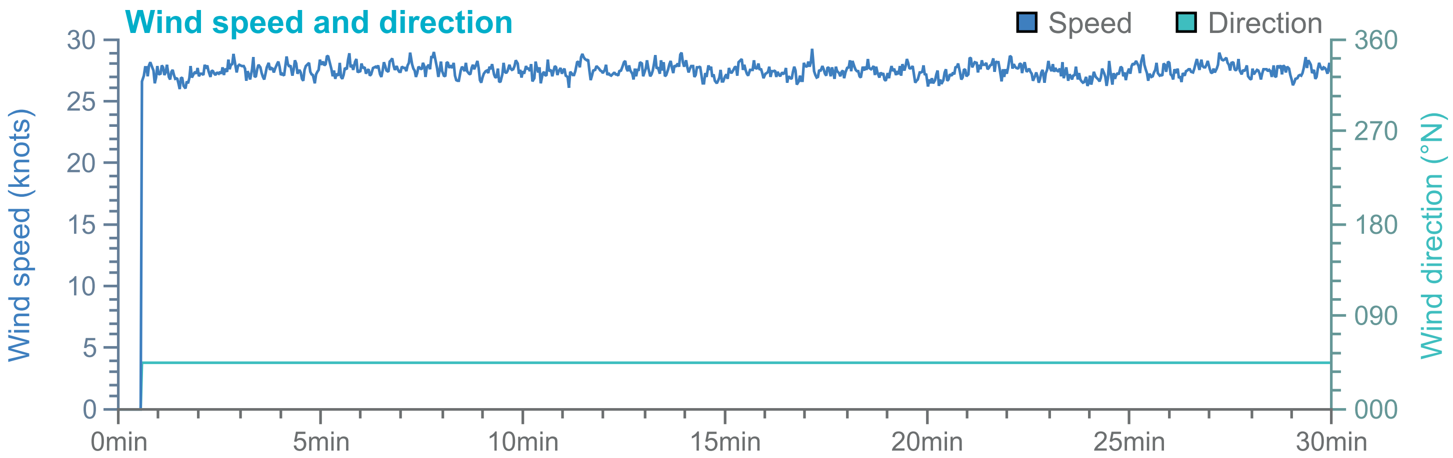
Overview | Environment | 243m Product Tanker | Tugs

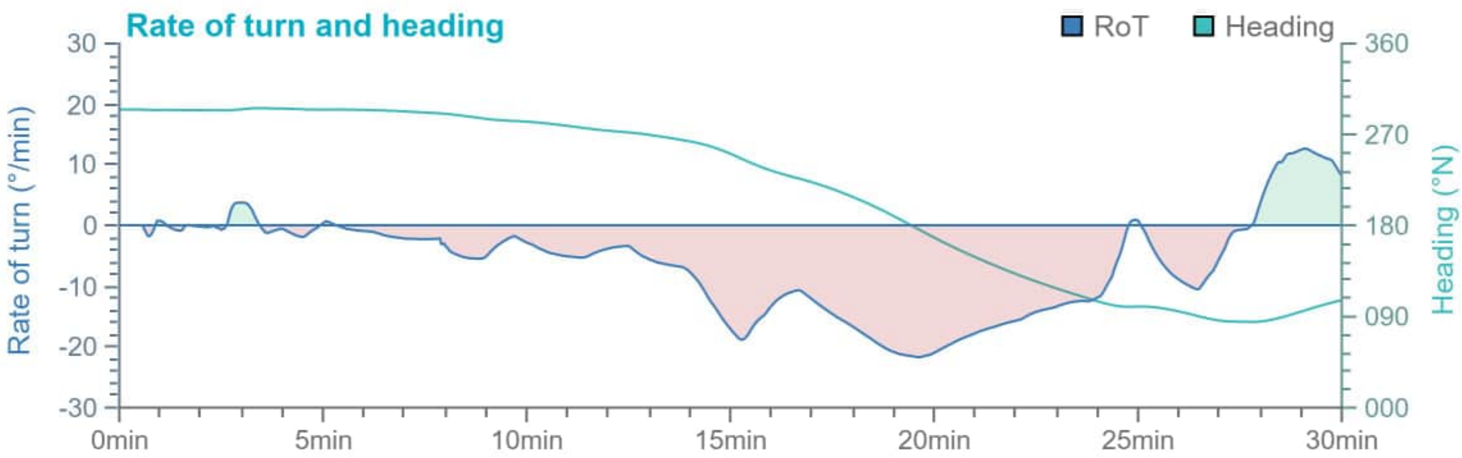
Manoeuvre track plot

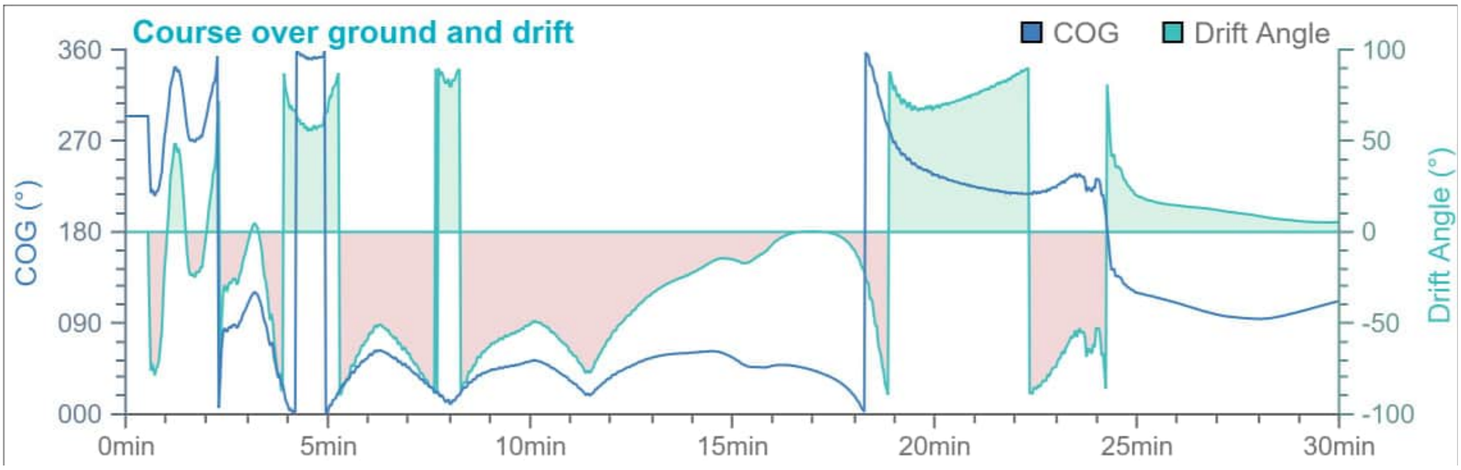


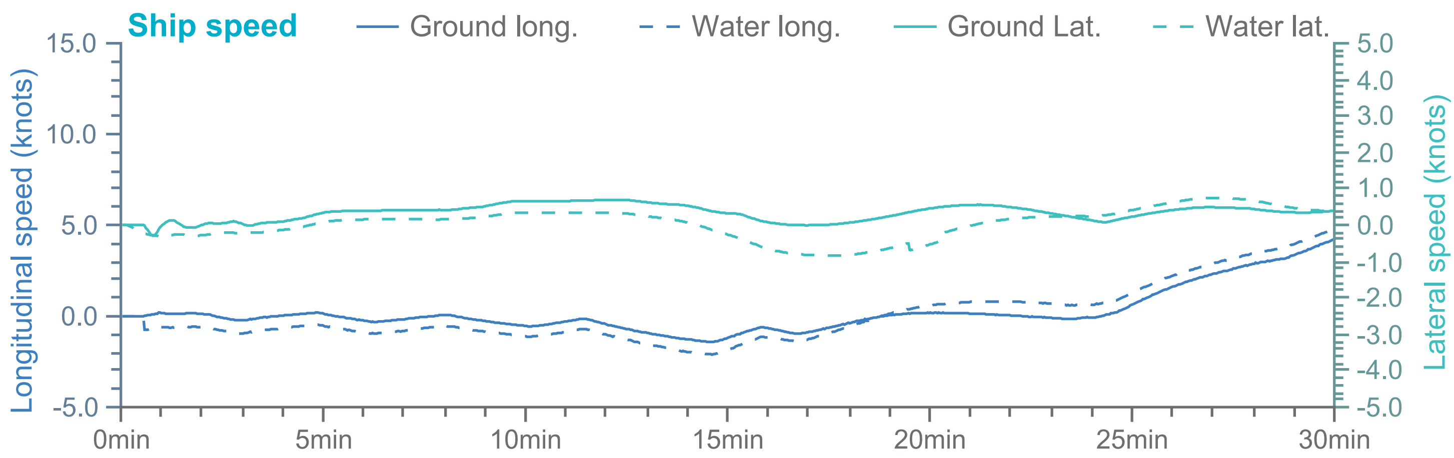
Ships plotted every 1 mins, highlight every 10 mins

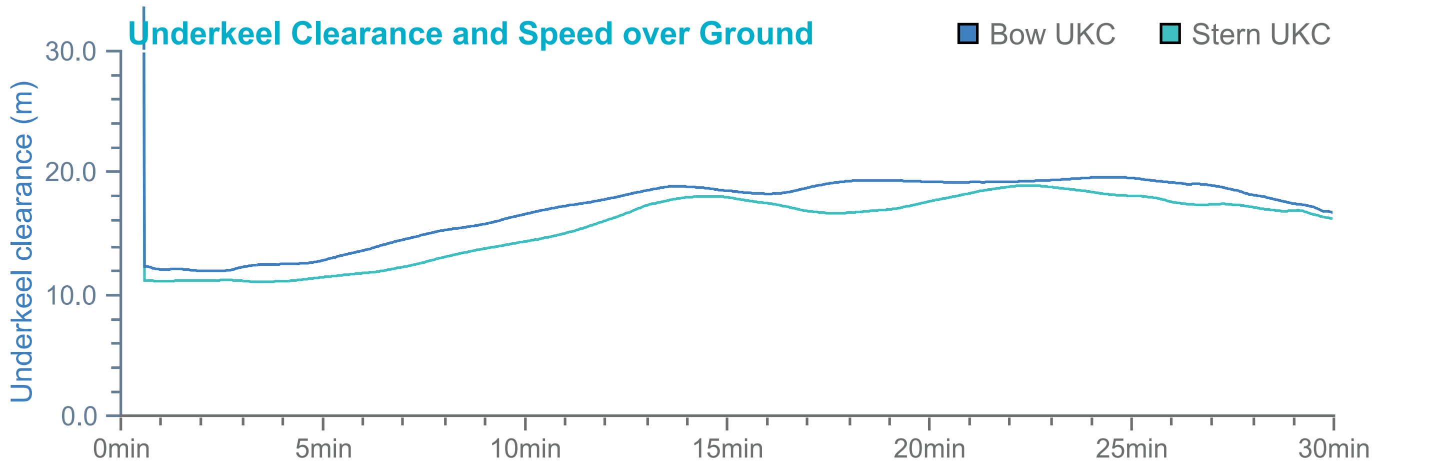

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min

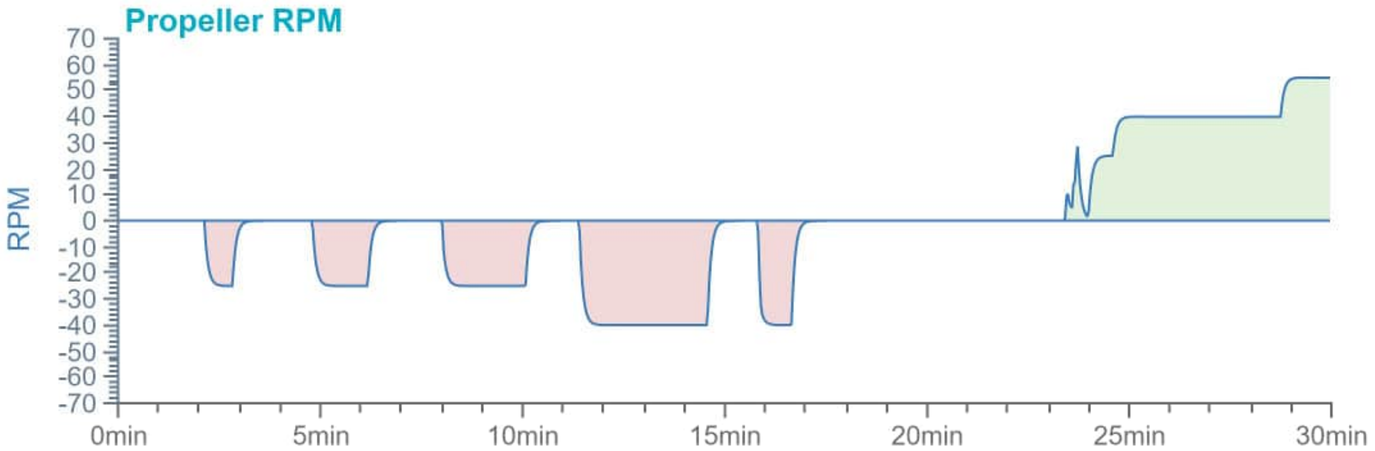

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min

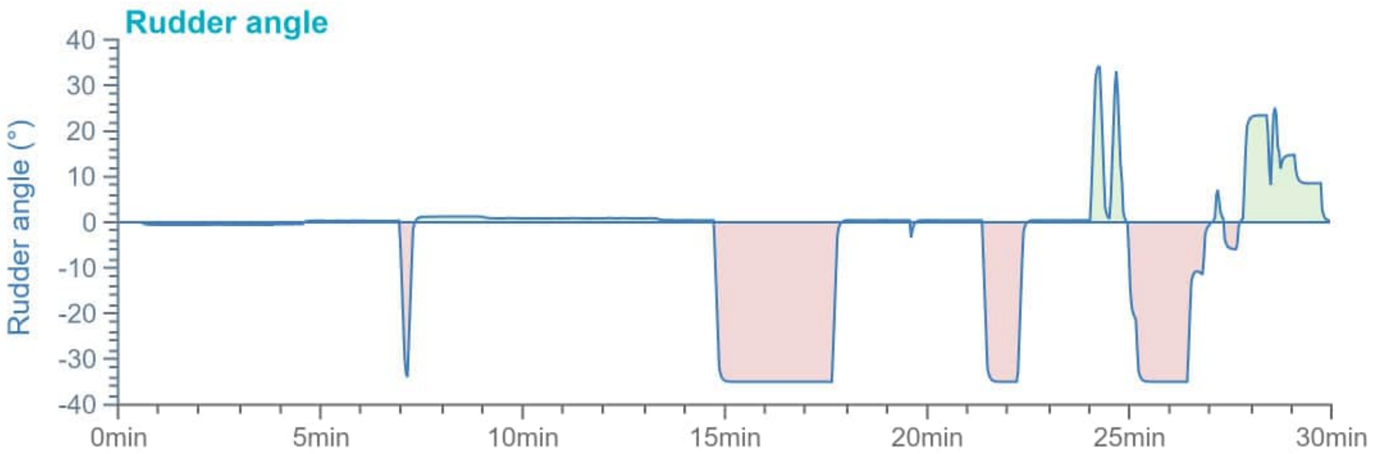

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min

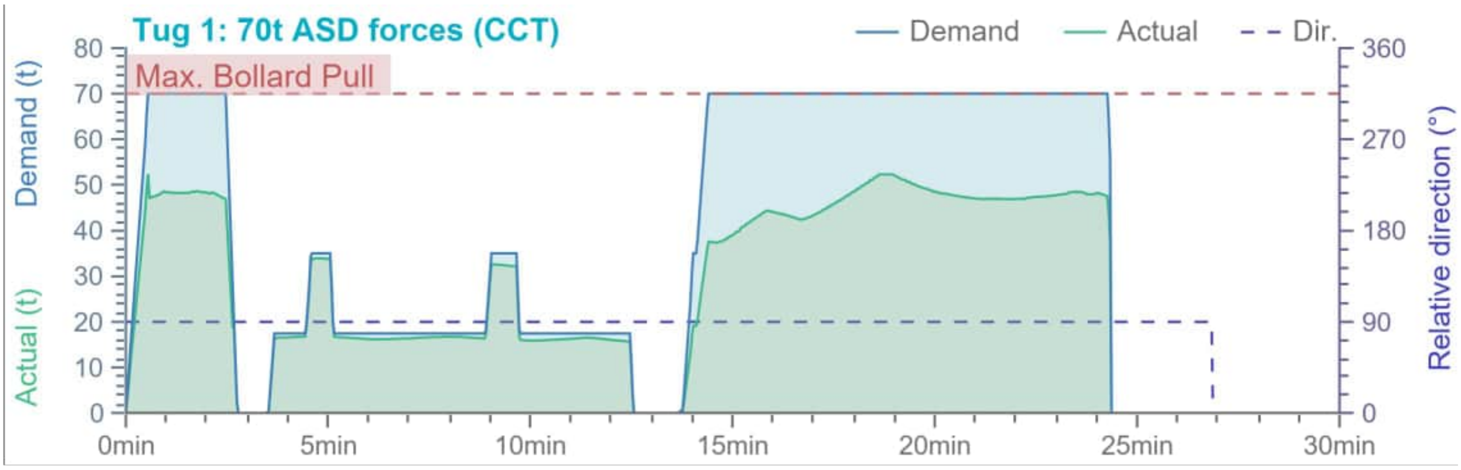

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min

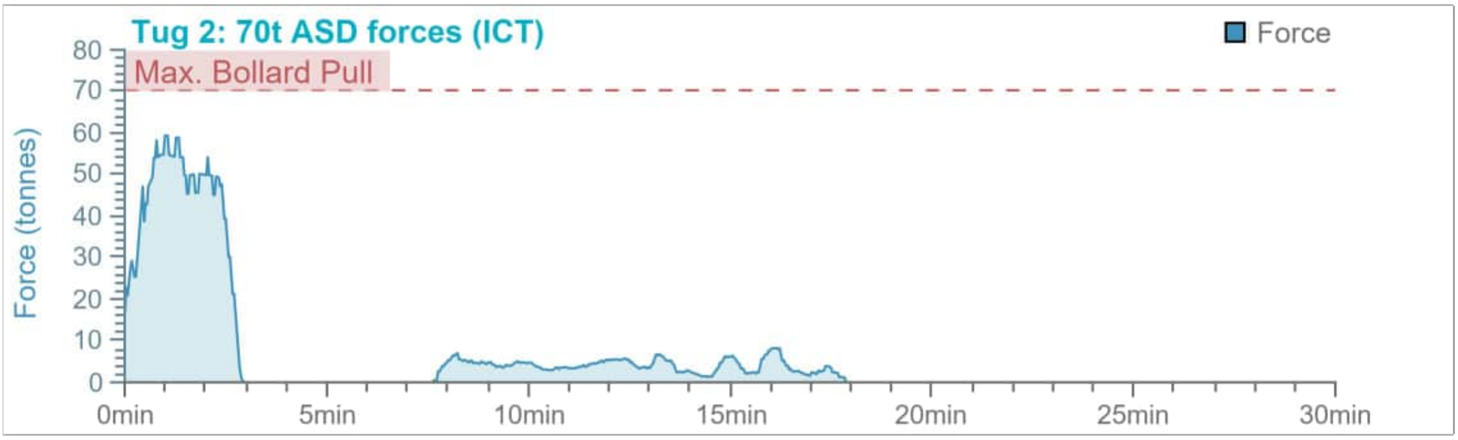

Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min

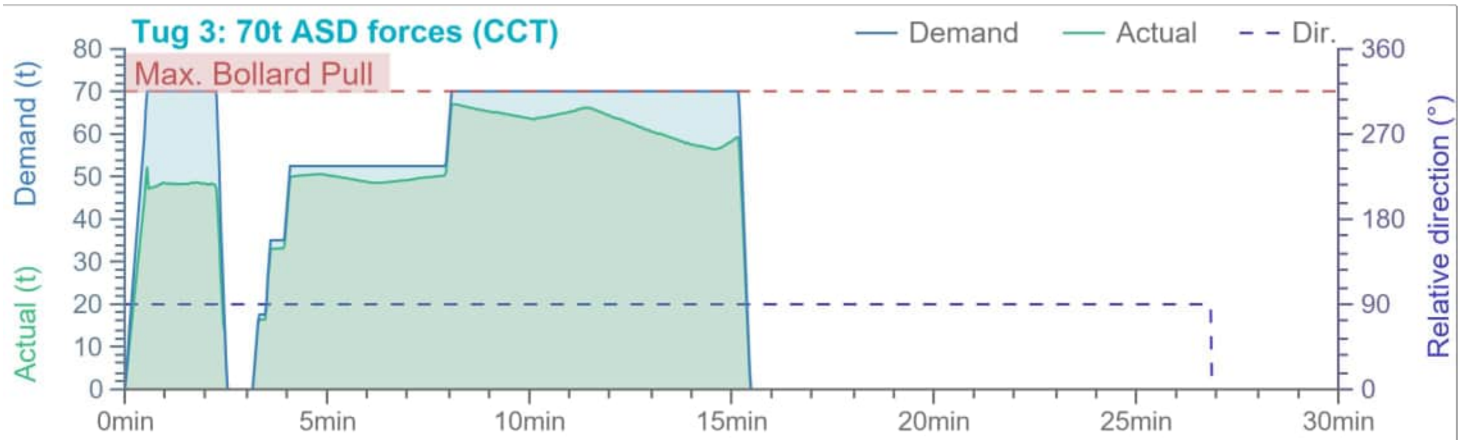

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min


Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min
30min

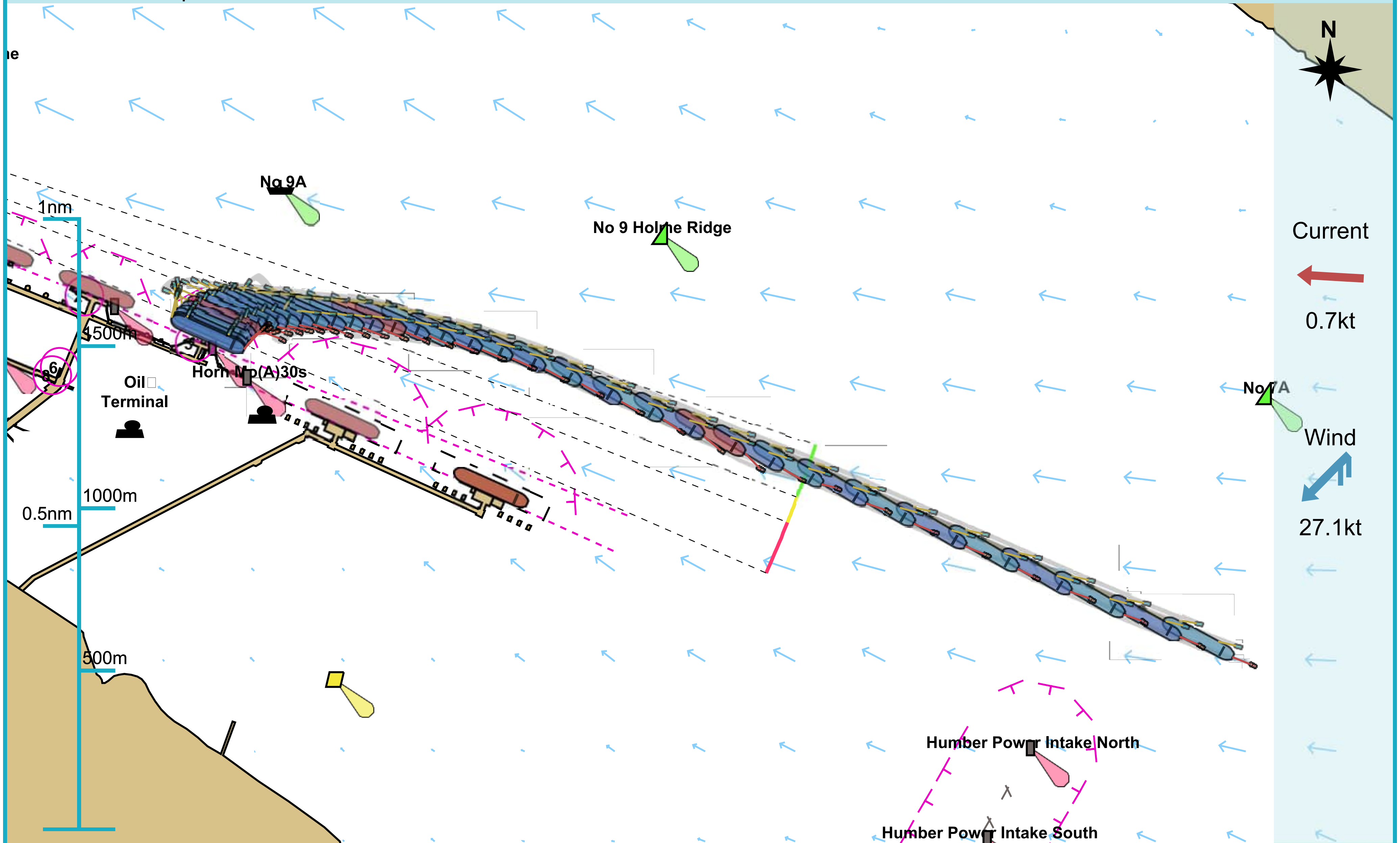

Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min
30min


Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
60
70
80
90
180
270
360
0min
5min
10min
15min
20min
25min
30min


Tug 2: 70t ASD forces (ICT)
Force
Max. Bollard Pull
Force (tonnes)
0
10
20
30
40
50
60
70
80
0min
5min
10min
15min
20min
25min
30min


Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
60
70
80
90
180
270
360
0min
5min
10min
15min
20min
25min
30min

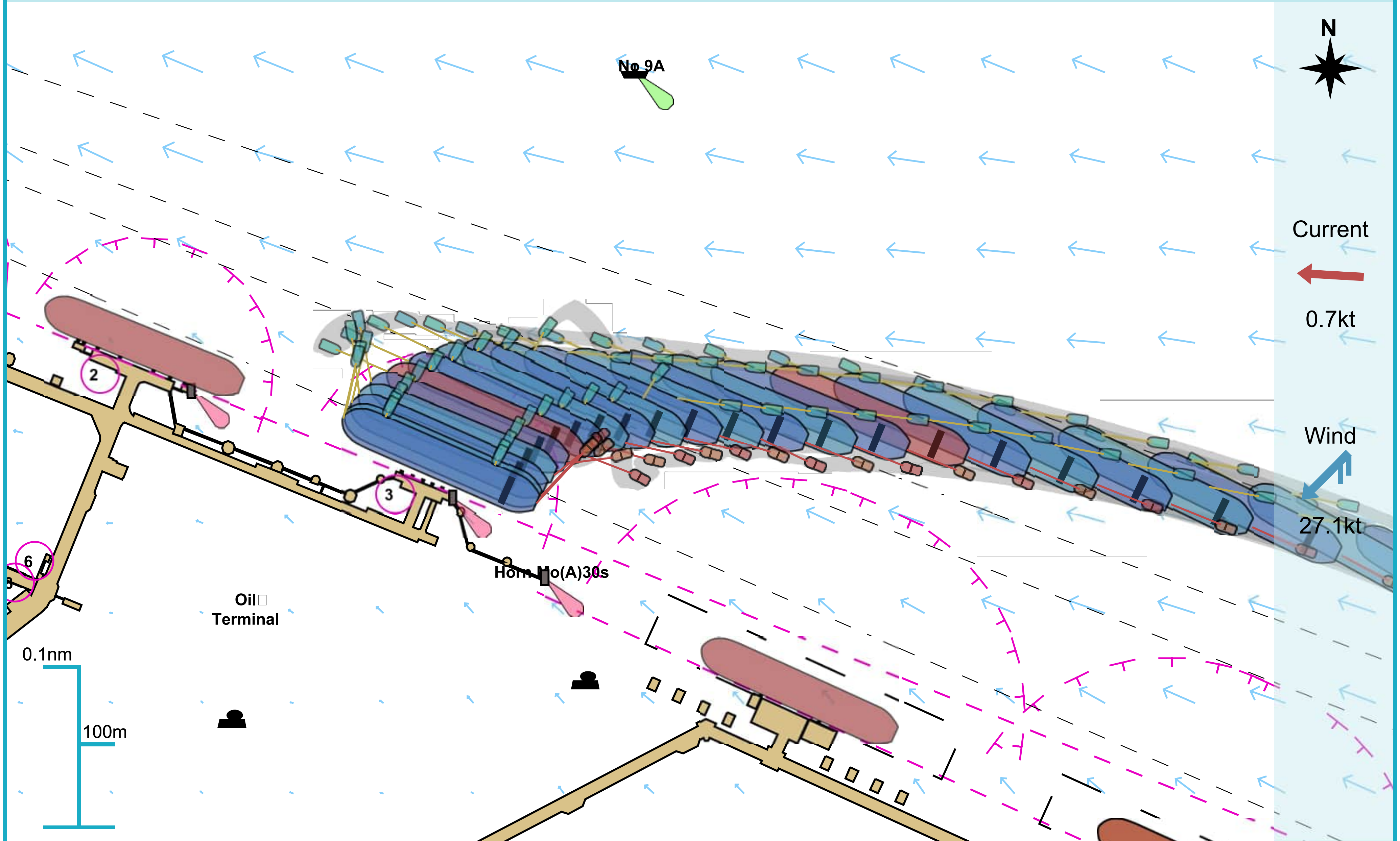
Manoeuvre track plot



1.40 kts

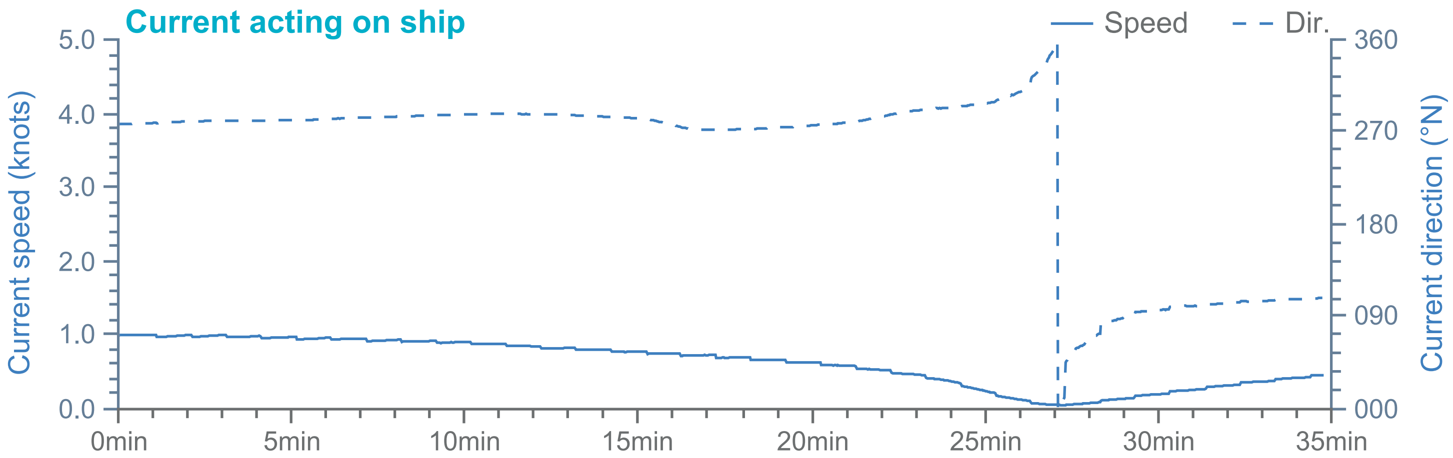
Ships plotted every 1 mins, highlight every 10 mins

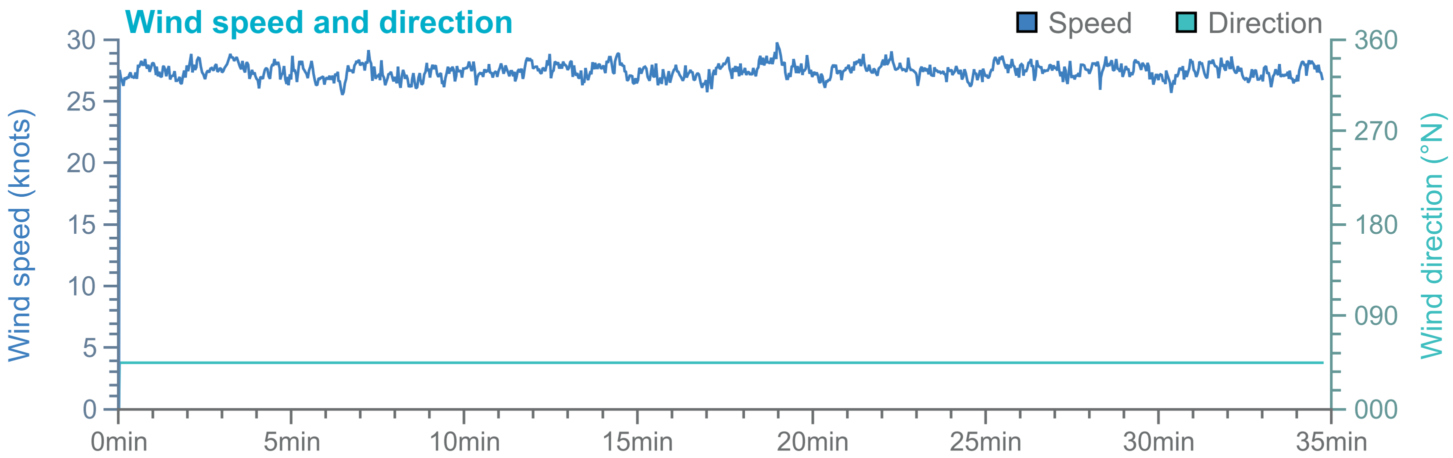
Manoeuvre track plot



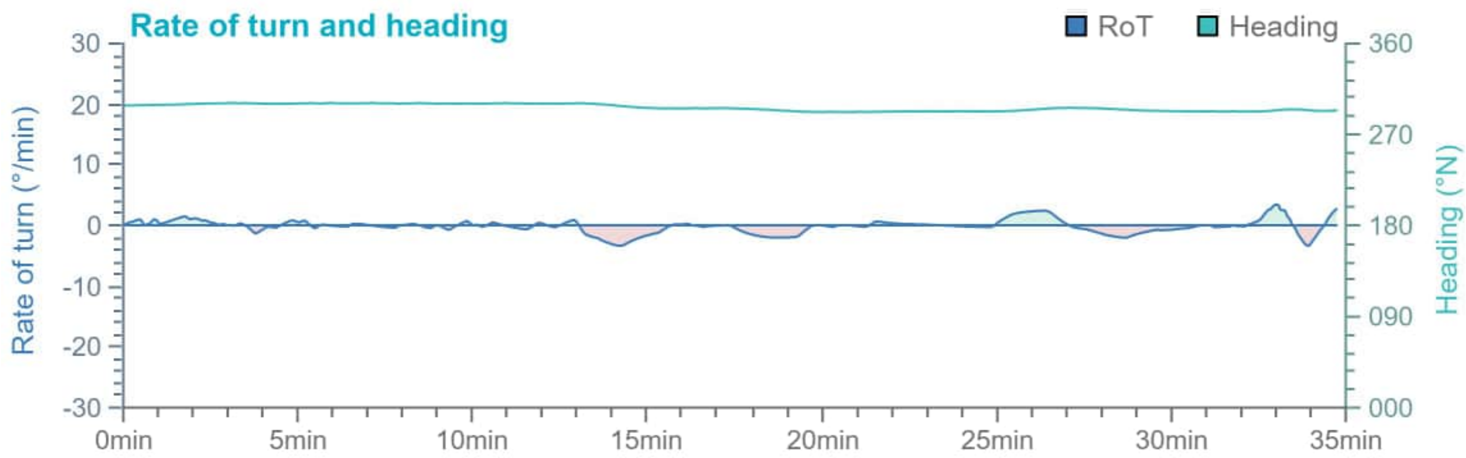
1.38 kts

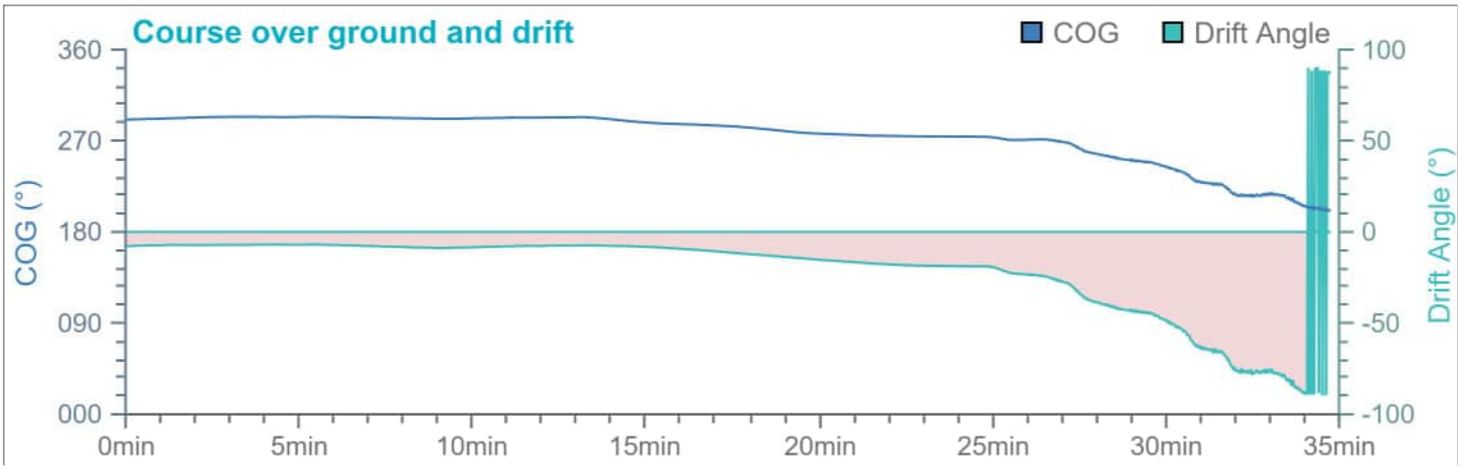
Ships plotted every 1 mins, highlight every 10 mins

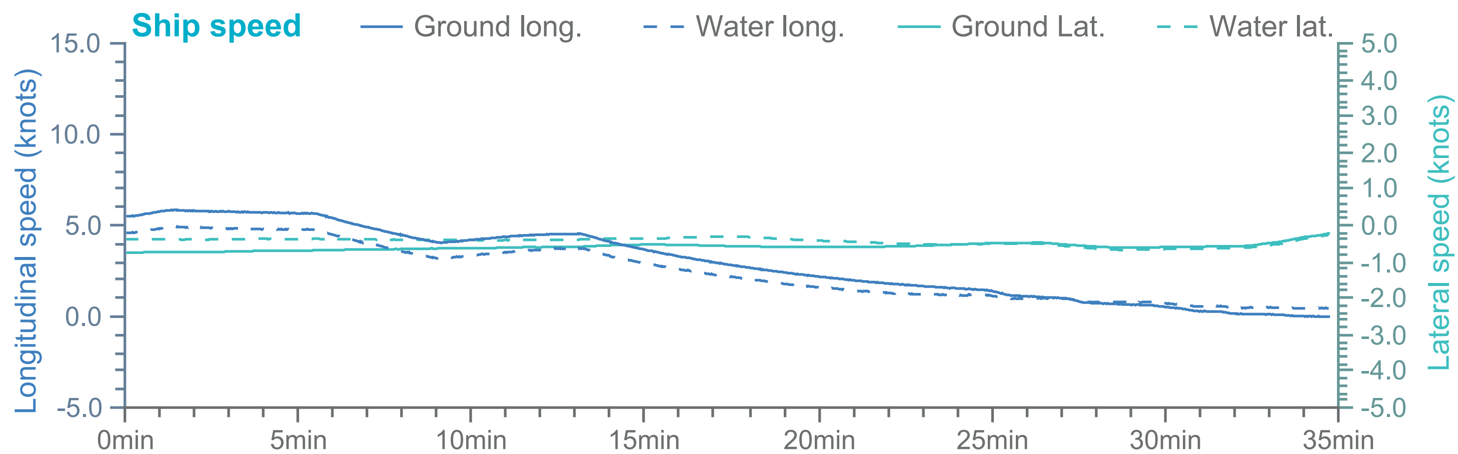

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

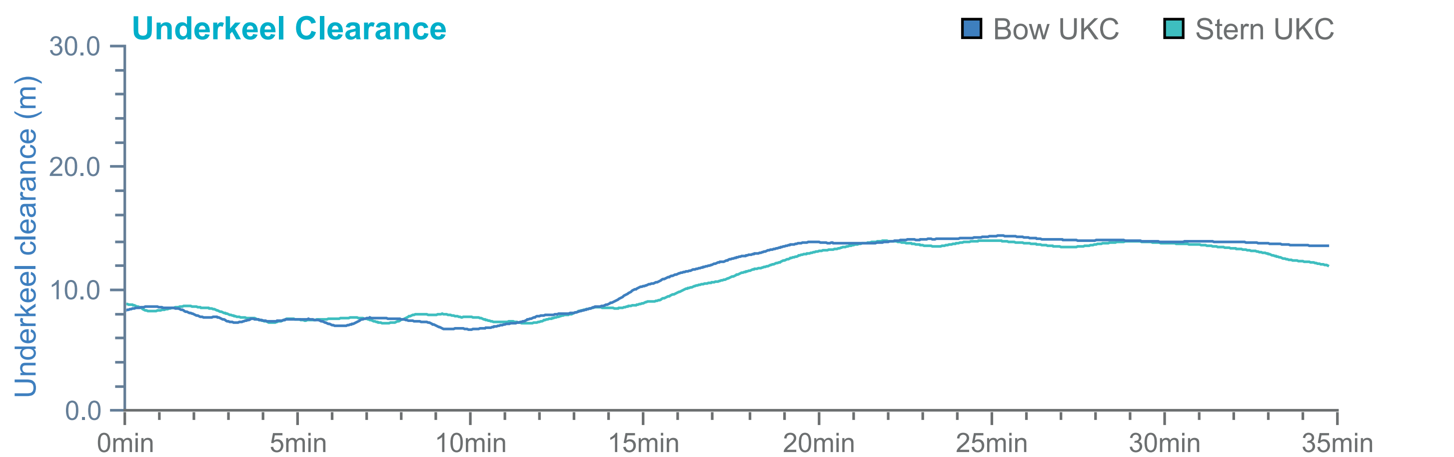

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

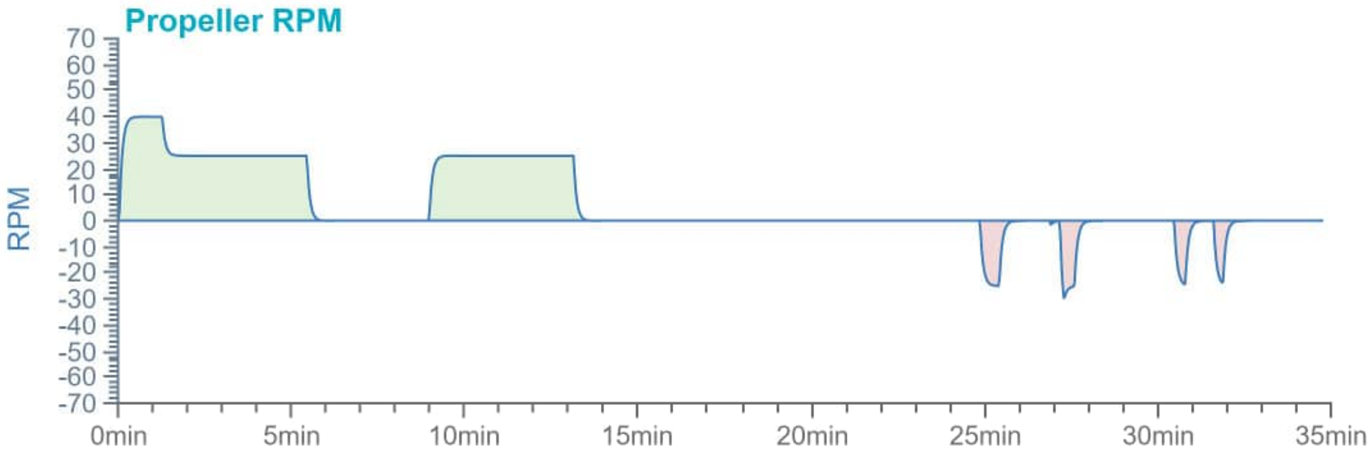
Overview	Environment	243m Product Tanker	Tugs

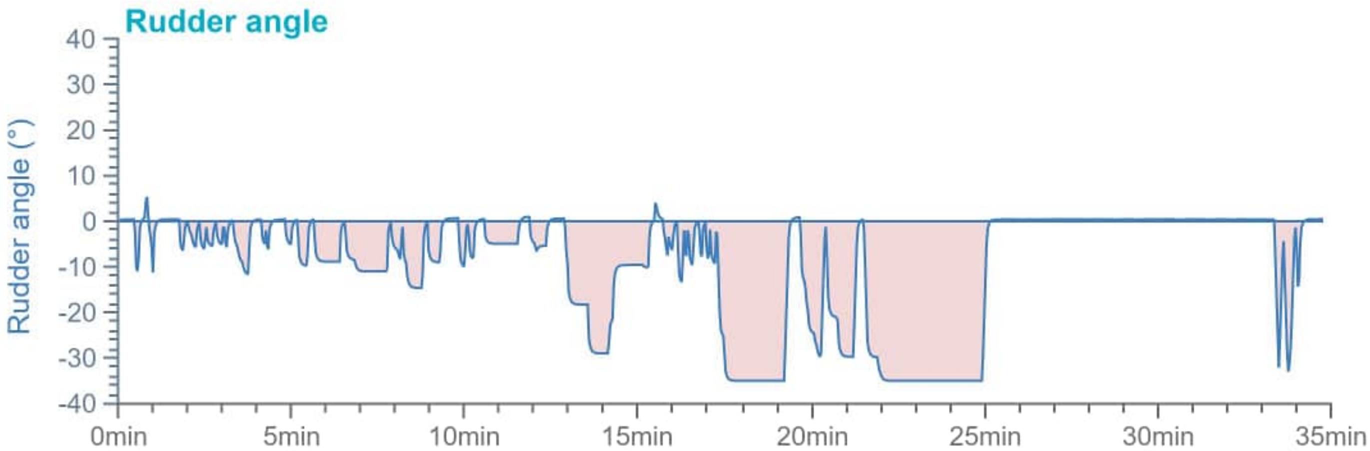


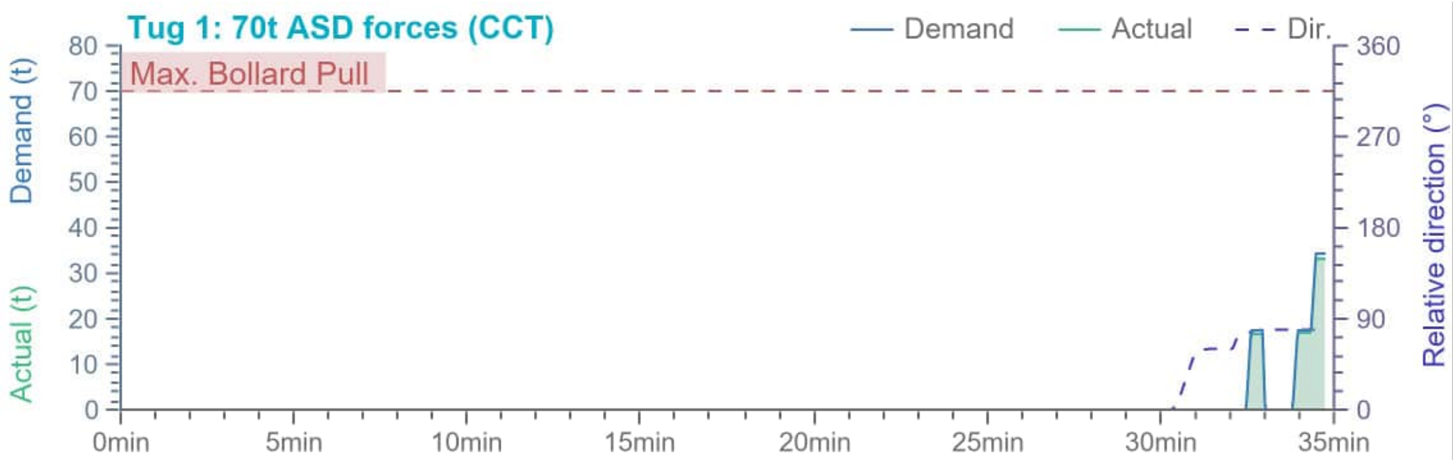


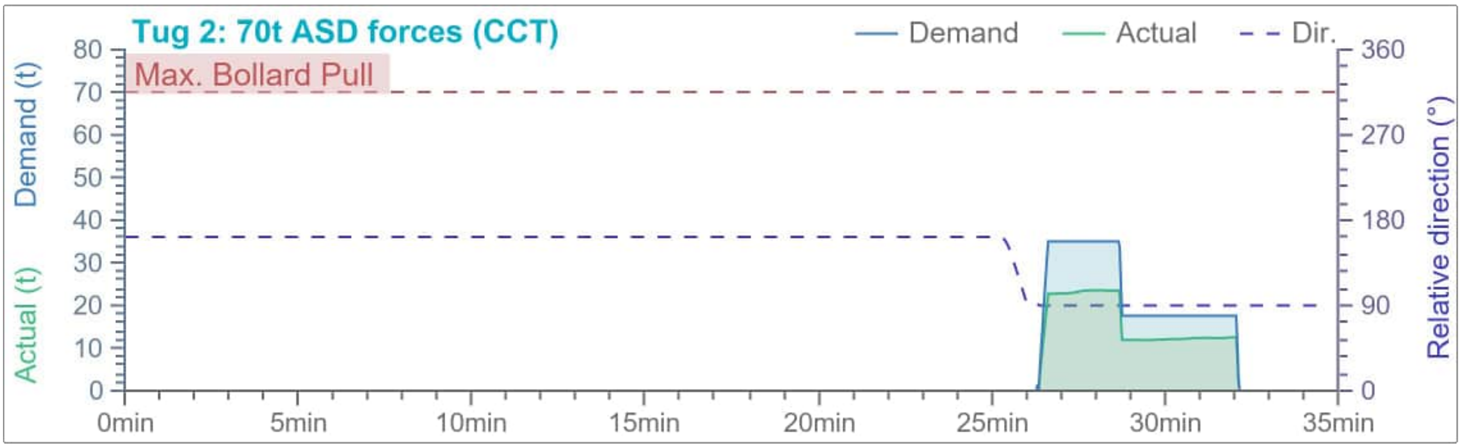


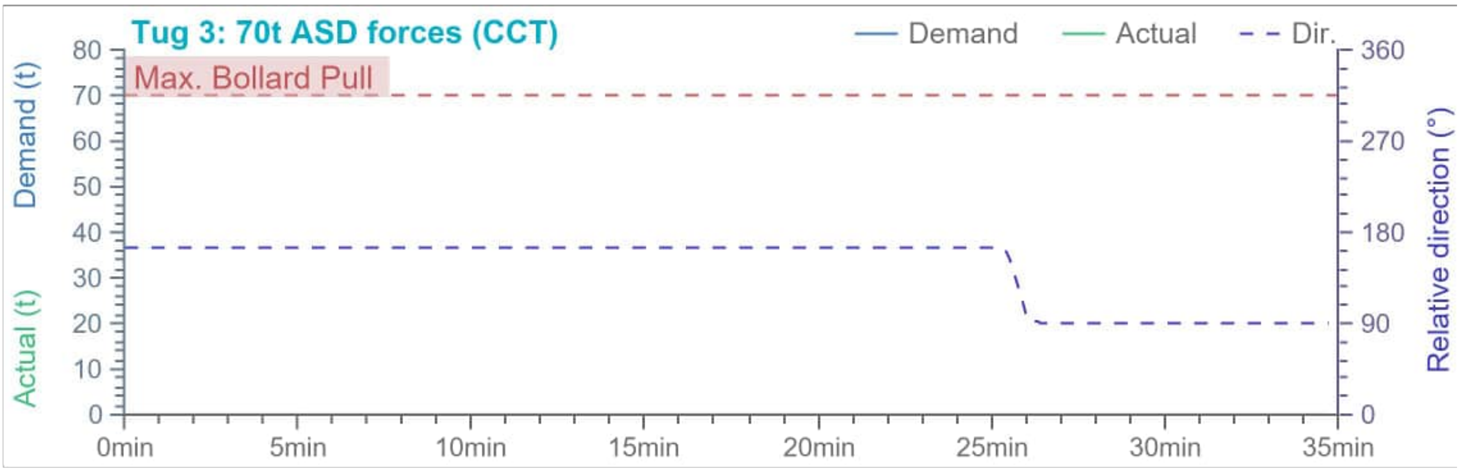


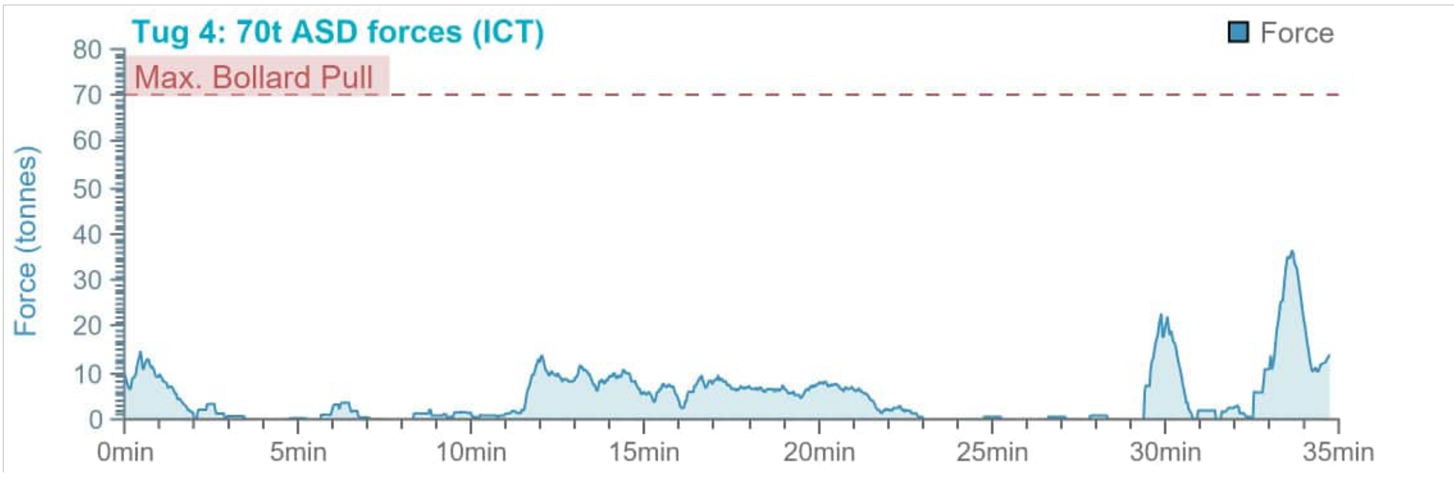

Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min
30min
35min


Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min
30min
35min


Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0 10 20 30 40 50 60 70 80
0 90 180 270 360
0min 5min 10min 15min 20min 25min 30min 35min

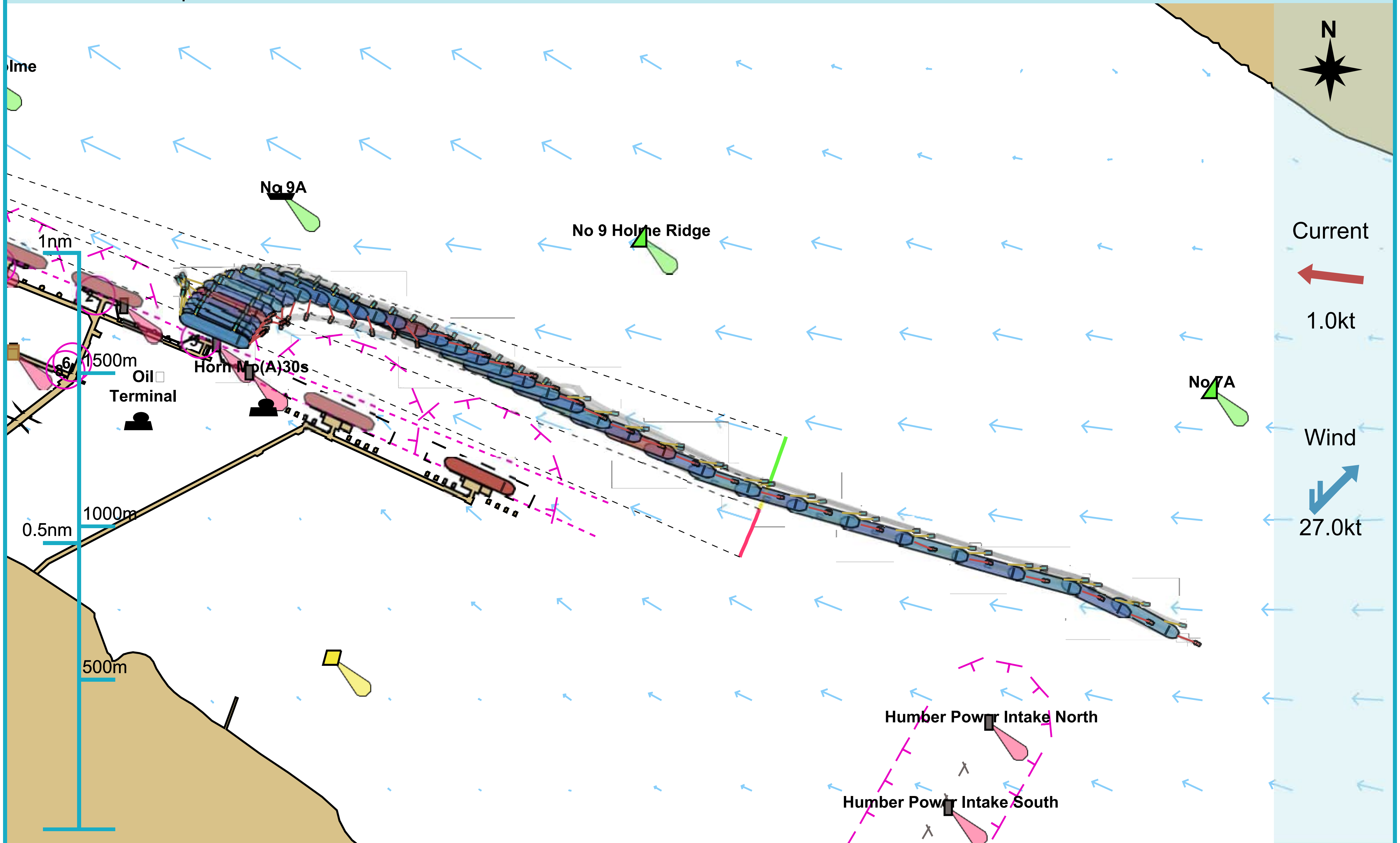

Tug 2: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0 10 20 30 40 50 60 70 80
0 90 180 270 360
0min 5min 10min 15min 20min 25min 30min 35min


Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0 10 20 30 40 50 60 70 80
0 90 180 270 360
0min 5min 10min 15min 20min 25min 30min 35min


Tug 4: 70t ASD forces (ICT)
Force
Max. Bollard Pull
Force (tonnes)
0 10 20 30 40 50 60 70 80
0min 5min 10min 15min 20min 25min 30min 35min

Overview | Environment | 243m Product Tanker | Tugs

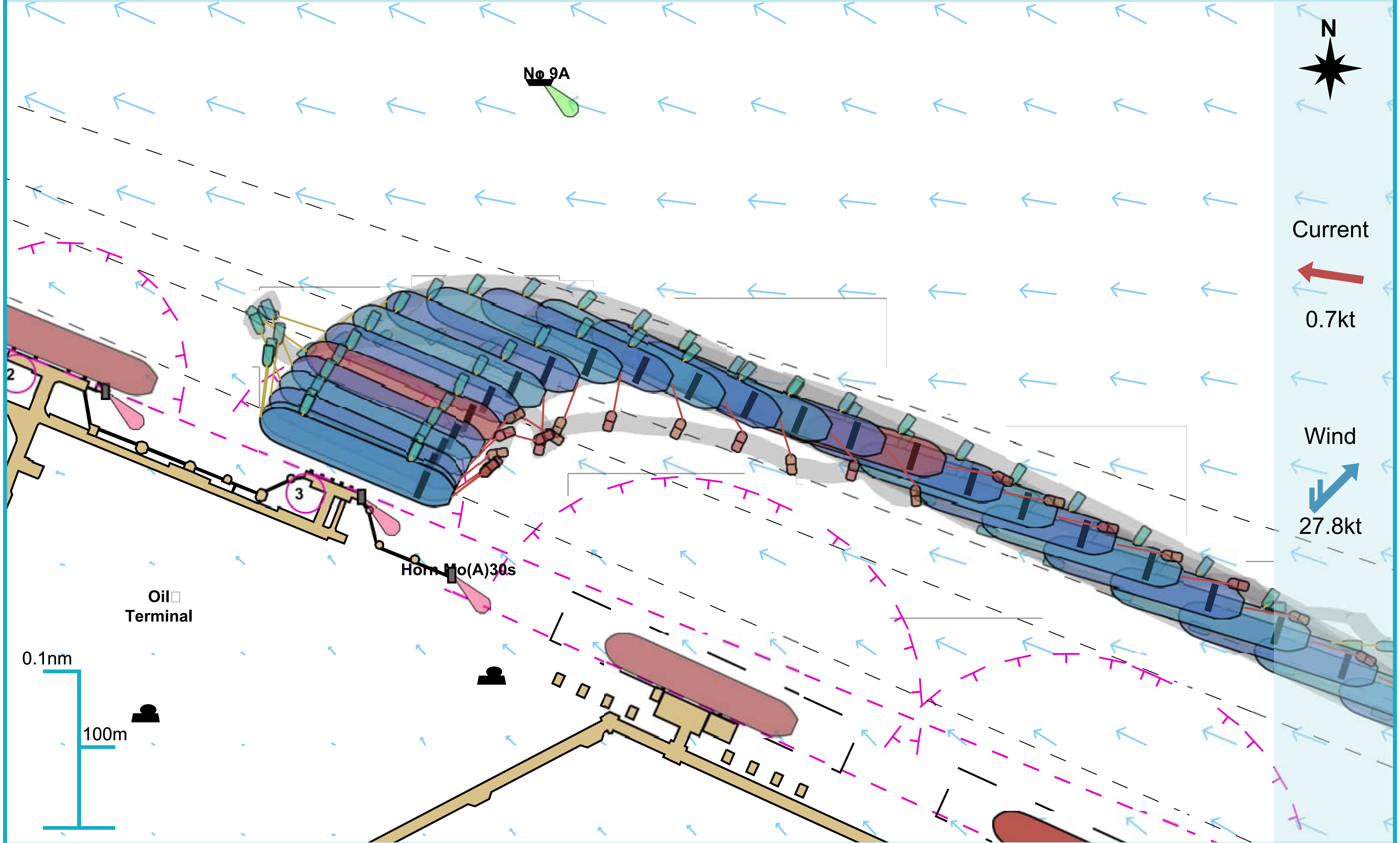
Manoeuvre track plot

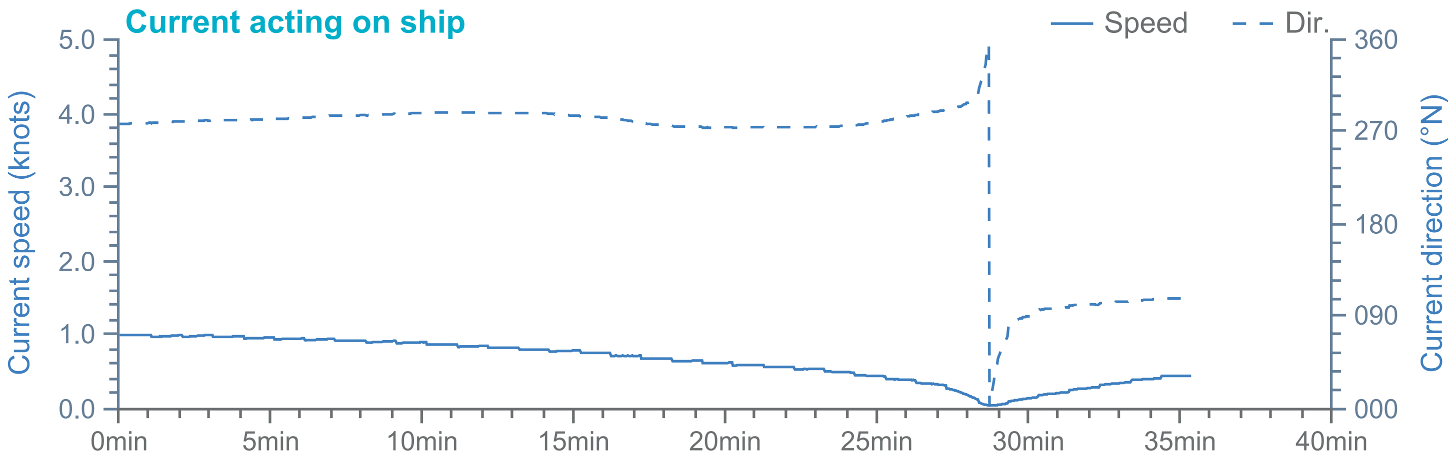


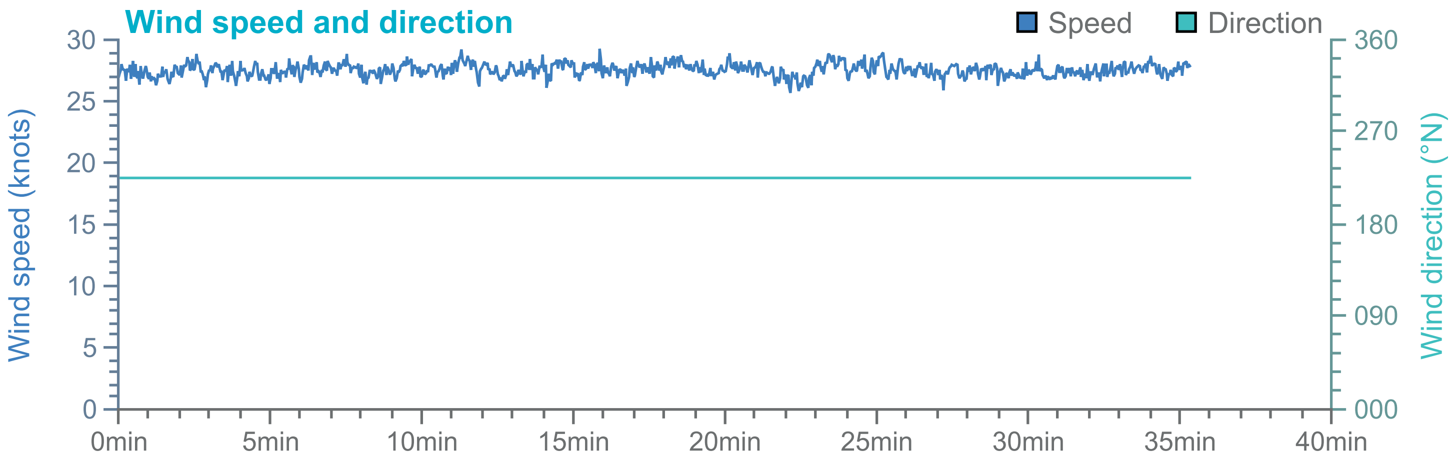
1.38 kts

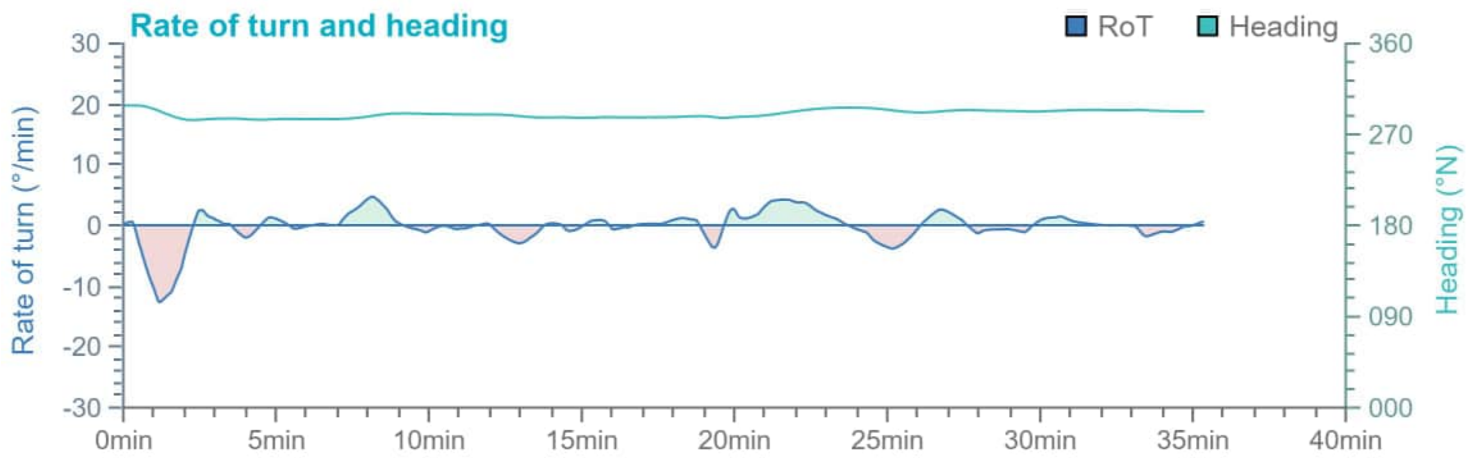
Ships plotted every 1 mins, highlight every 10 mins

Manoeuvre track plot

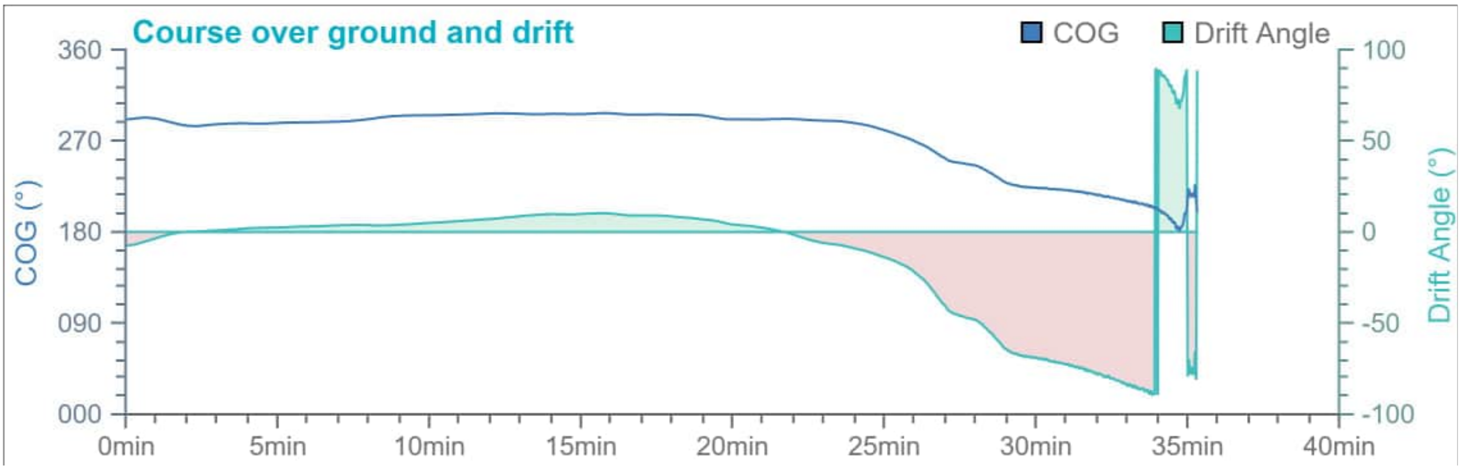



Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min

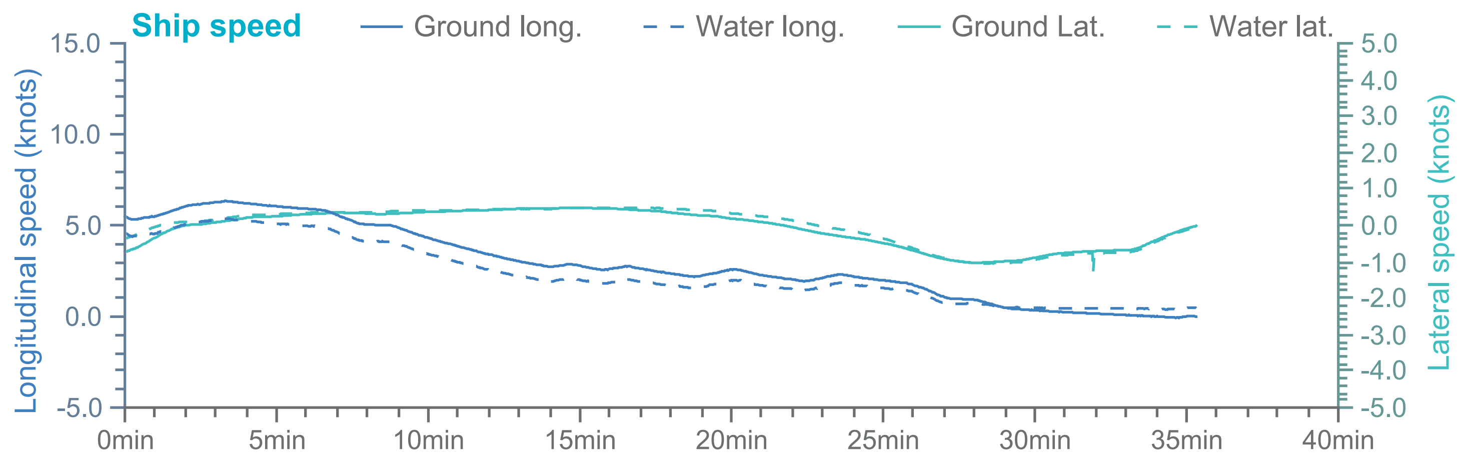

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min



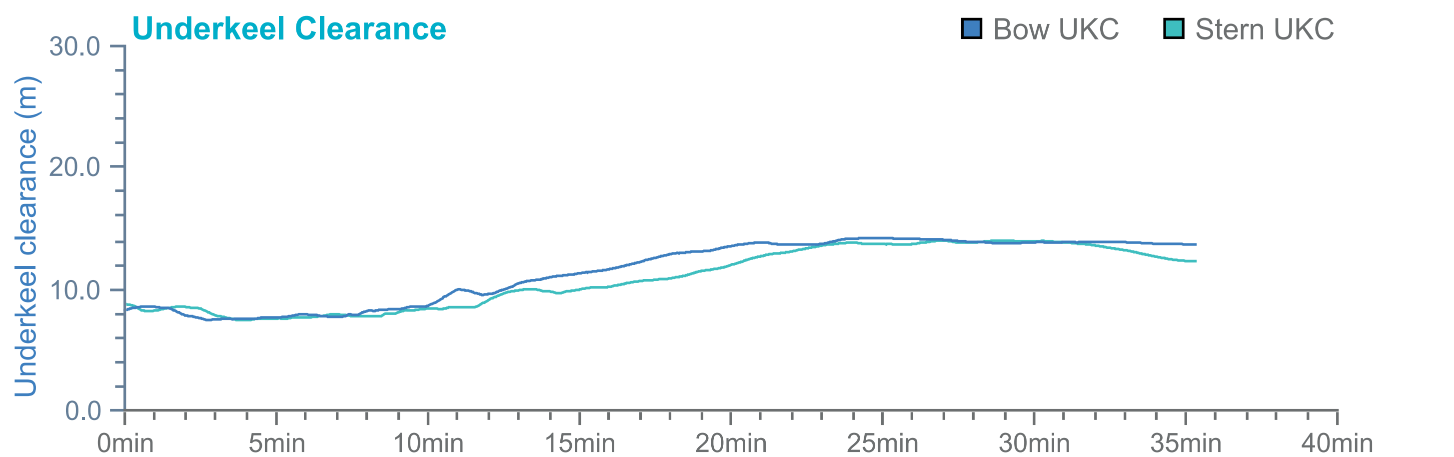
Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min



Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min
40min

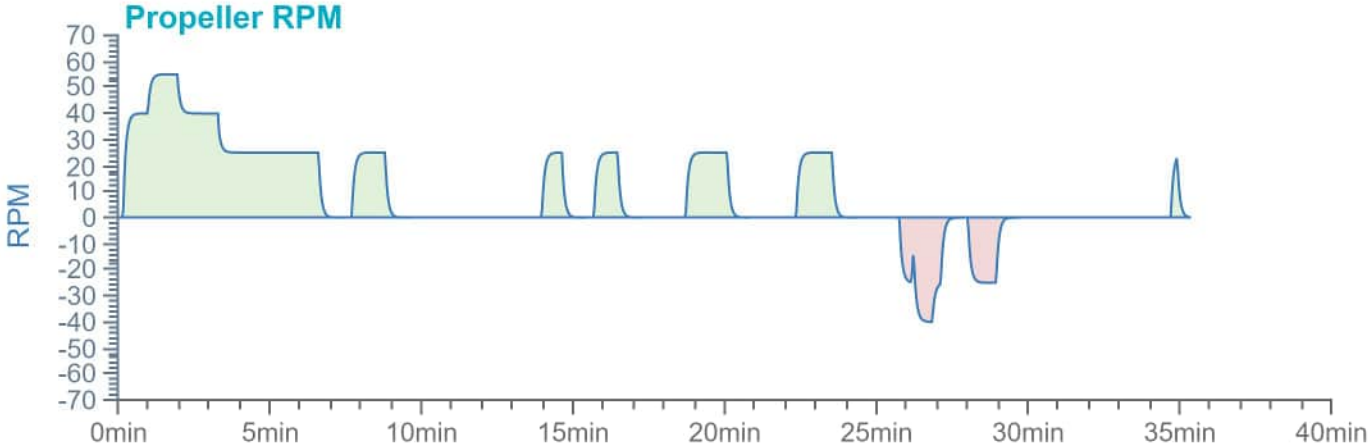


Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min
35min
40min

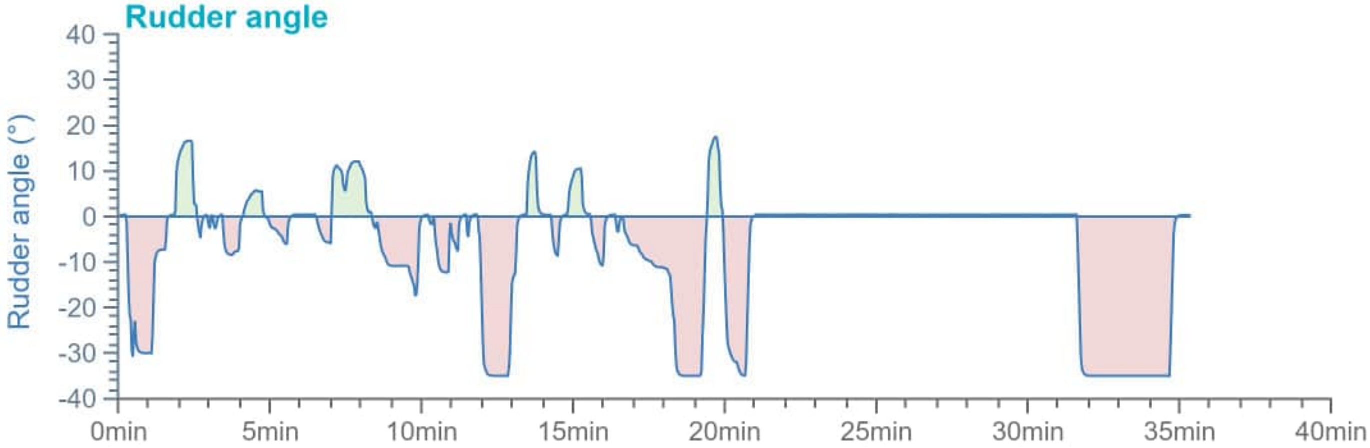


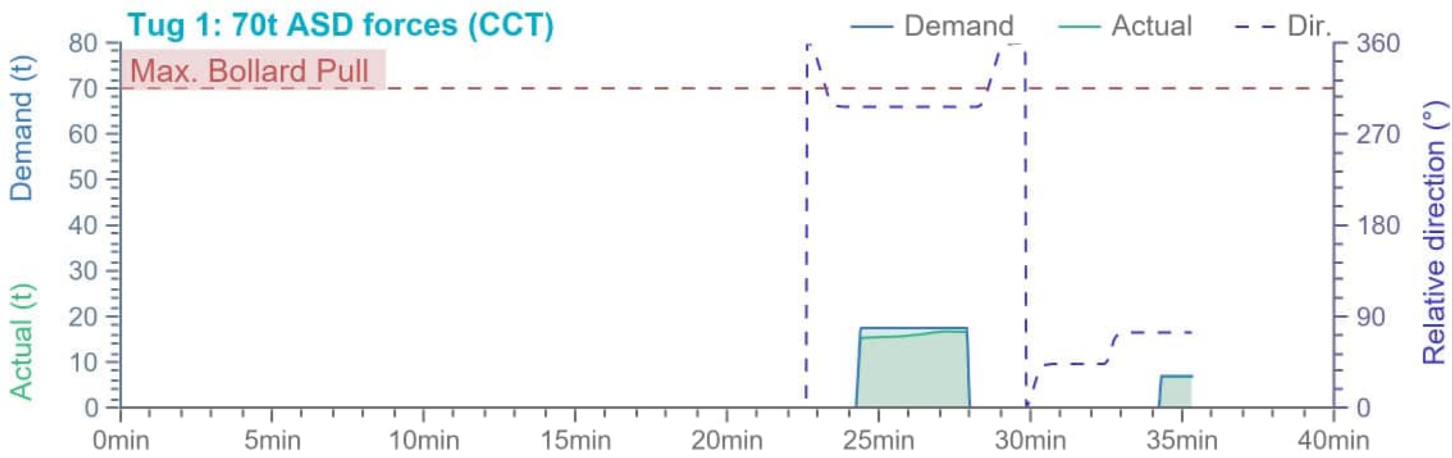
Underkeel Clearance
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min
35min
40min

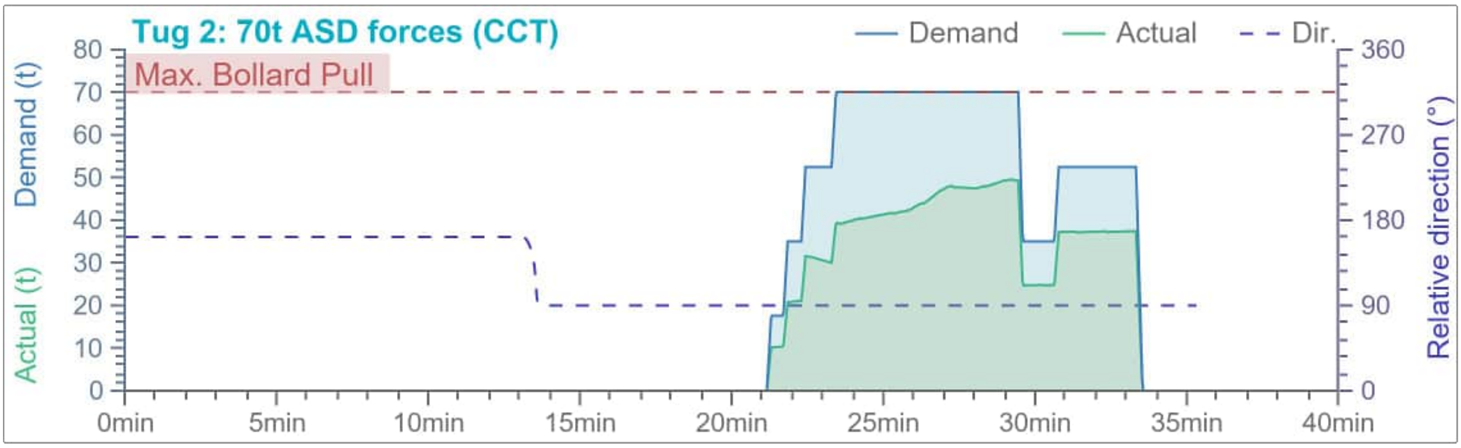
Propeller RPM

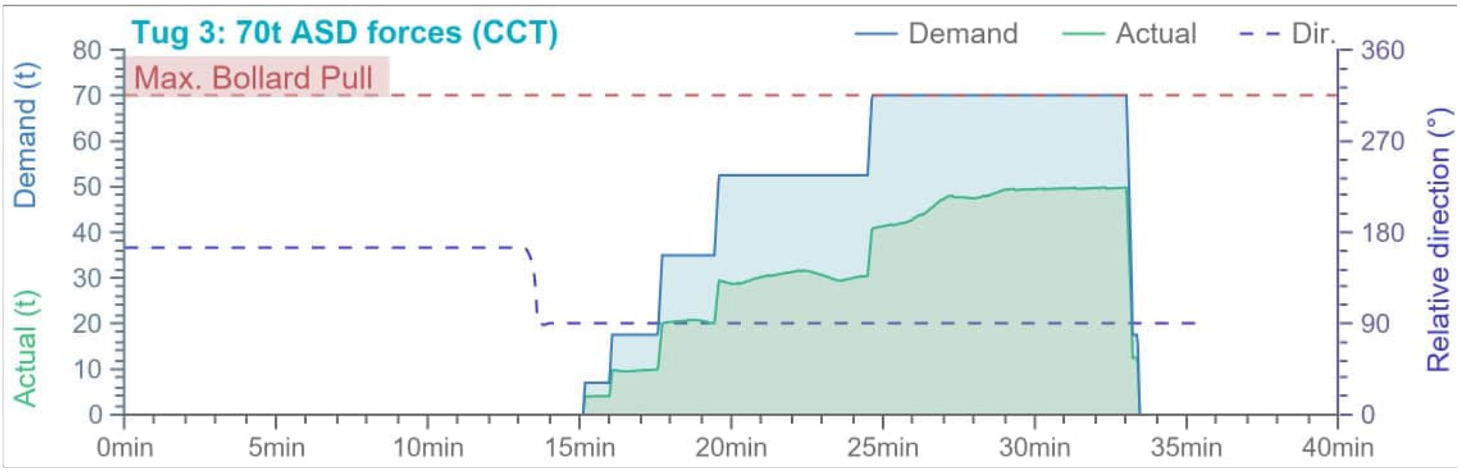


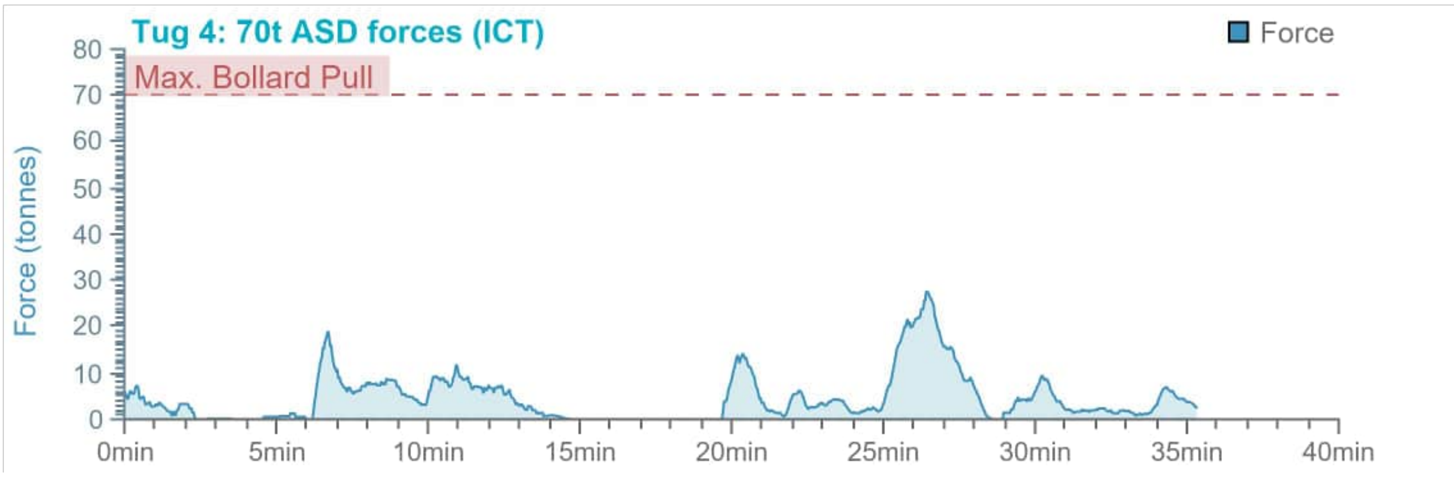
Rudder angle



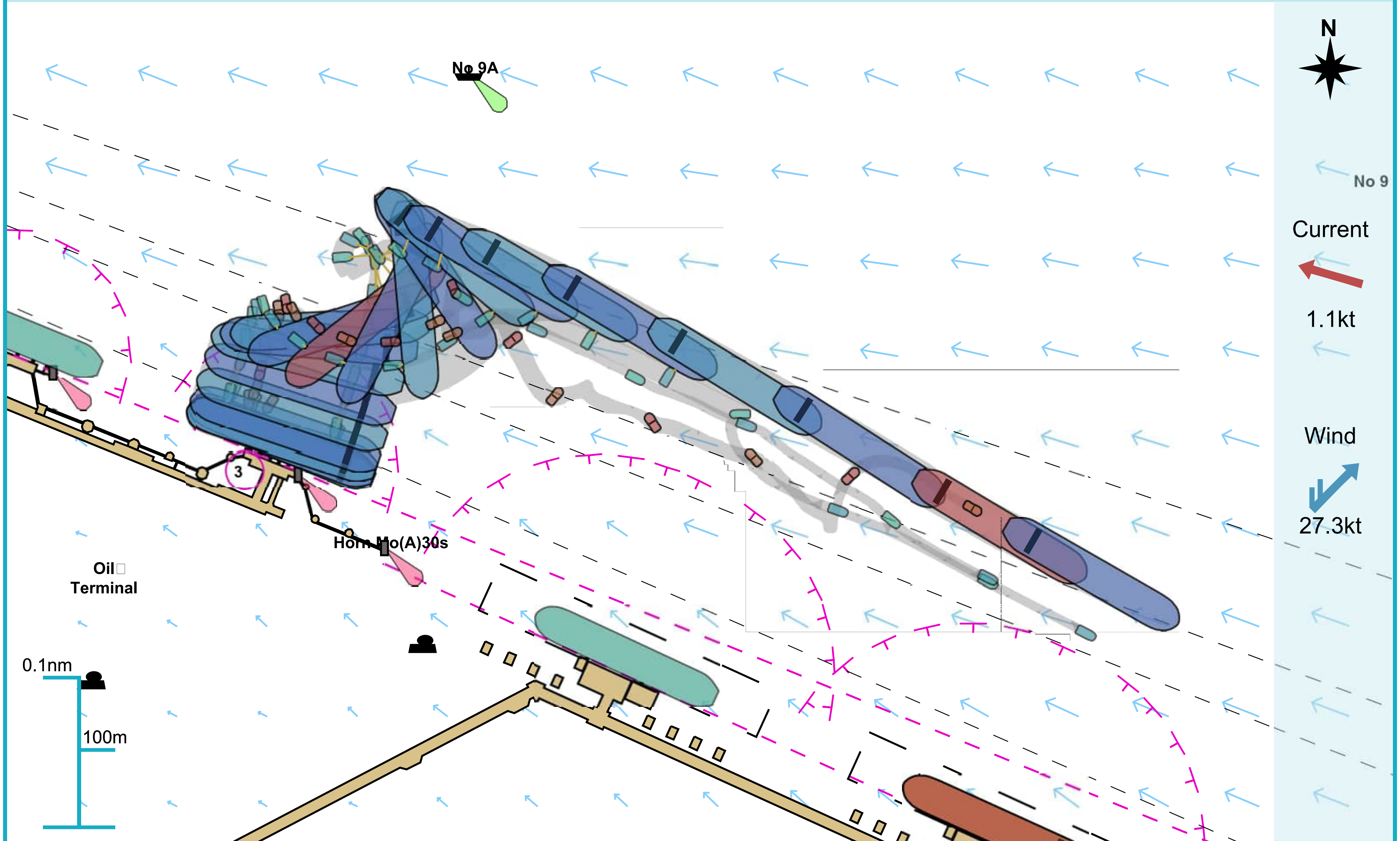

Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min
35min
40min


Tug 2: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min
35min
40min

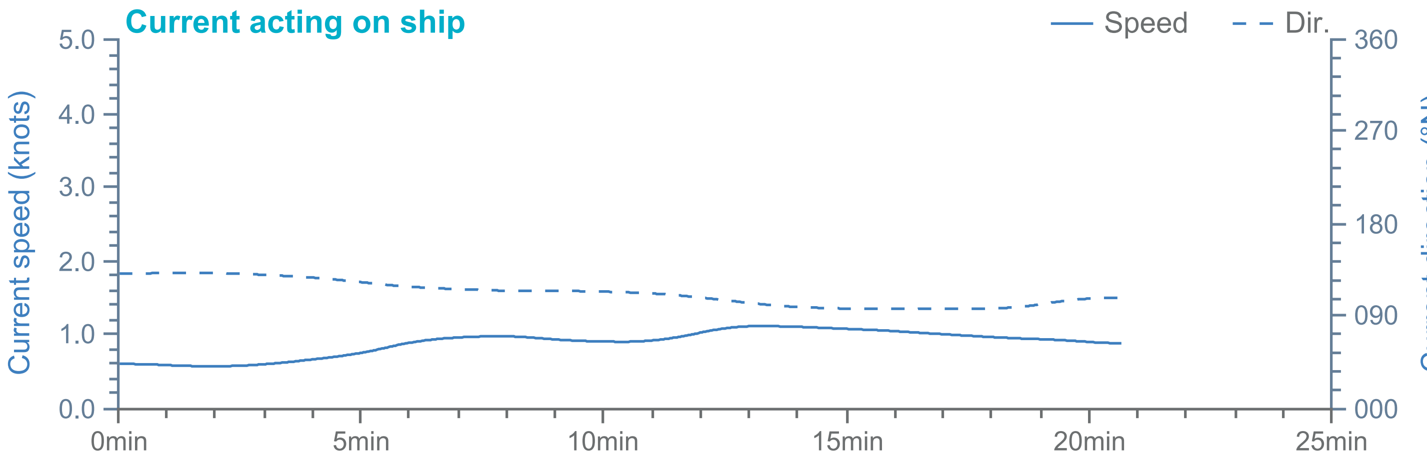

Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min
35min
40min

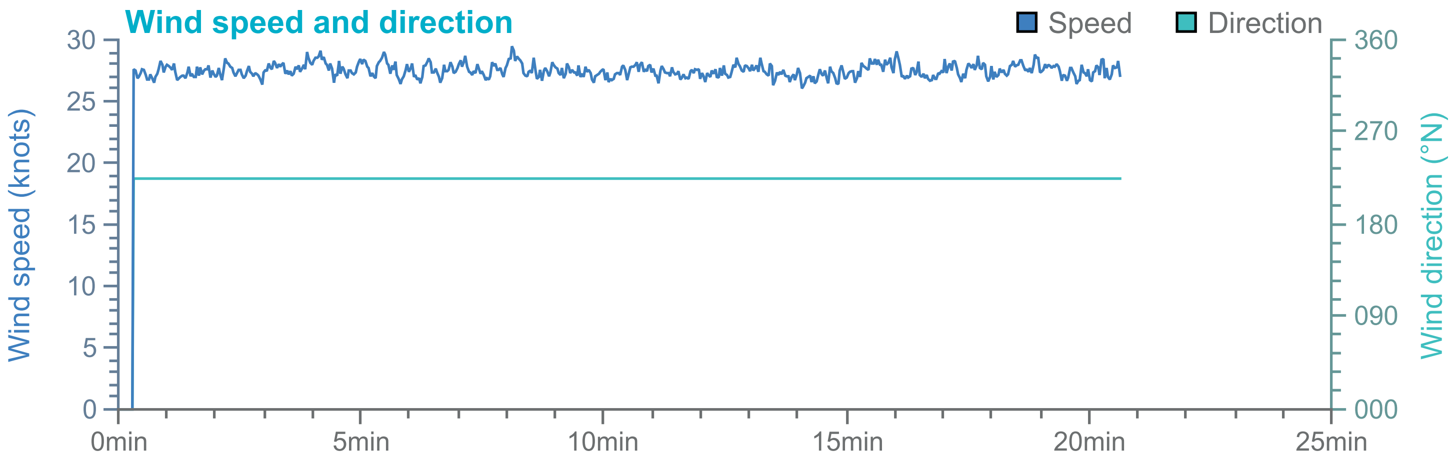

Tug 4: 70t ASD forces (ICT)
Force
Max. Bollard Pull
Force (tonnes)
0min
5min
10min
15min
20min
25min
30min
35min
40min

Manoeuvre track plot

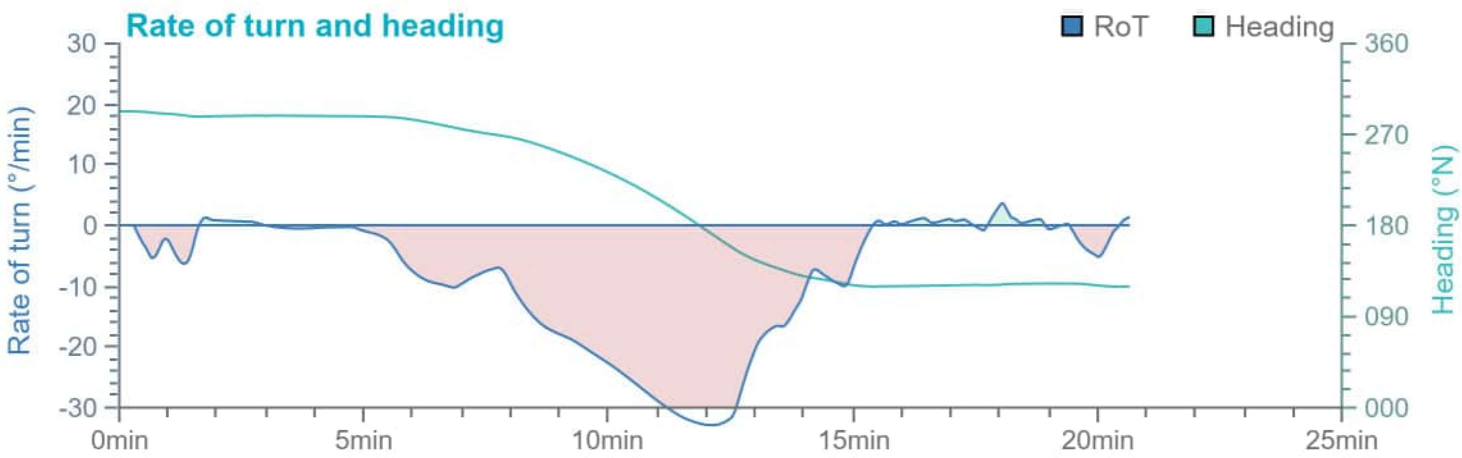


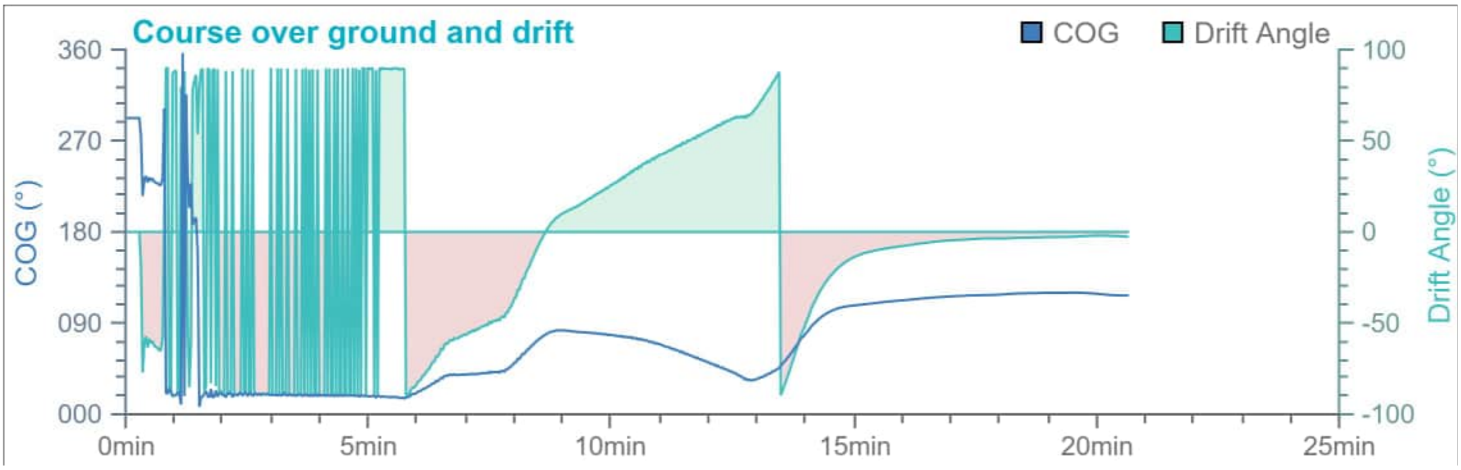
Ships plotted every 1 mins, highlight every 10 mins

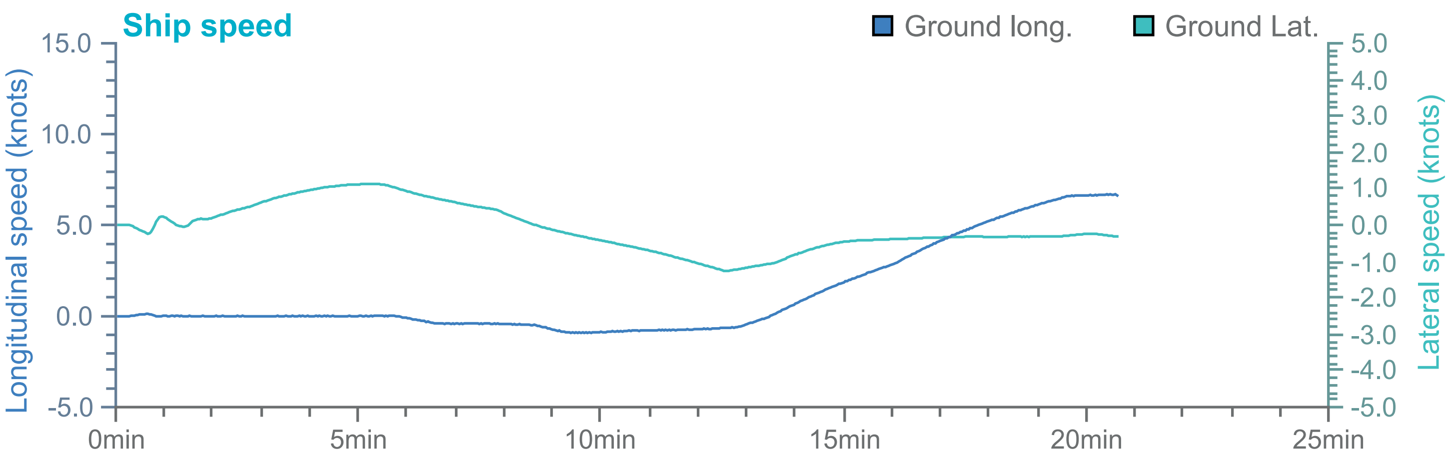

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min

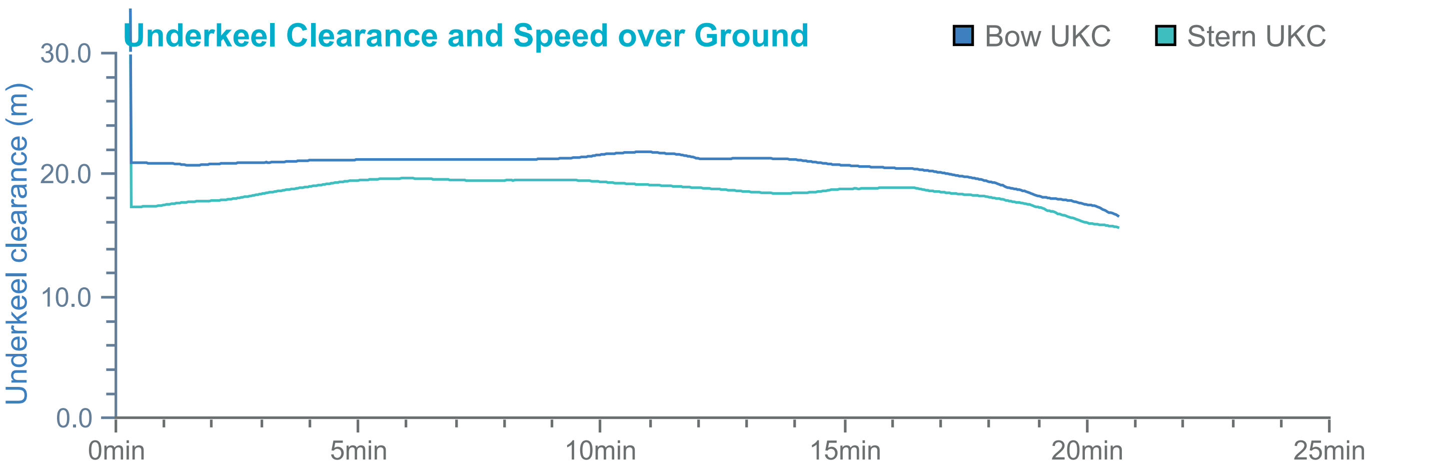

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min

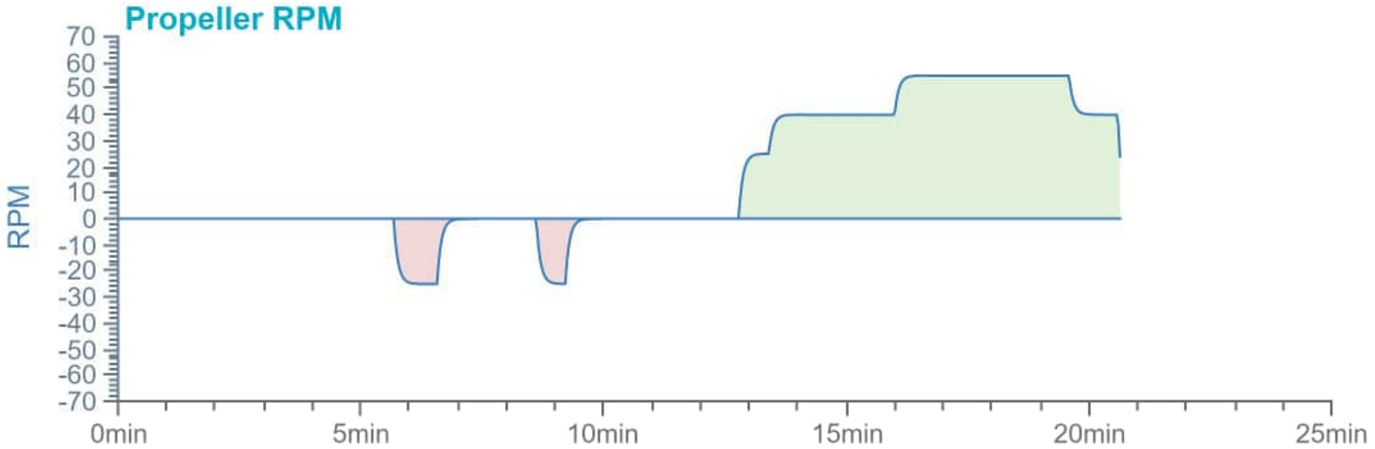
Overview | Environment | 243m Product Tanker | Tugs

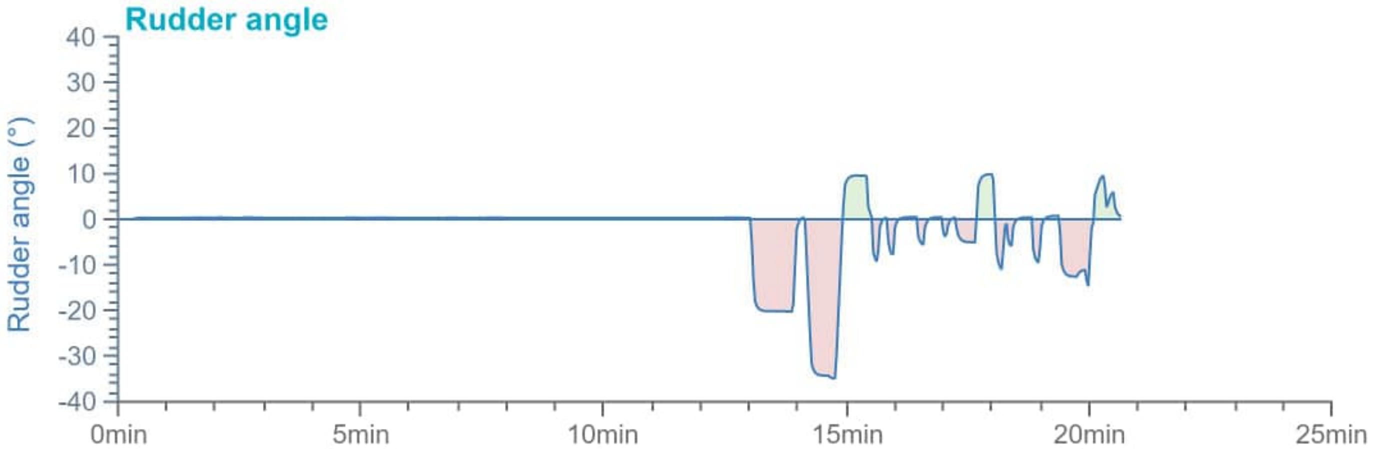


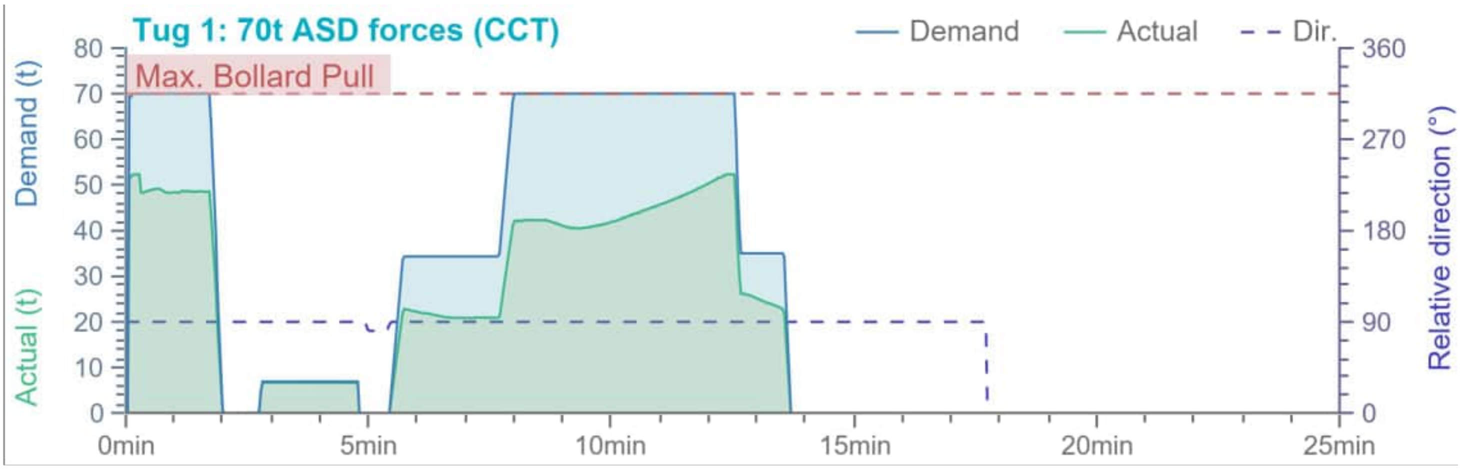


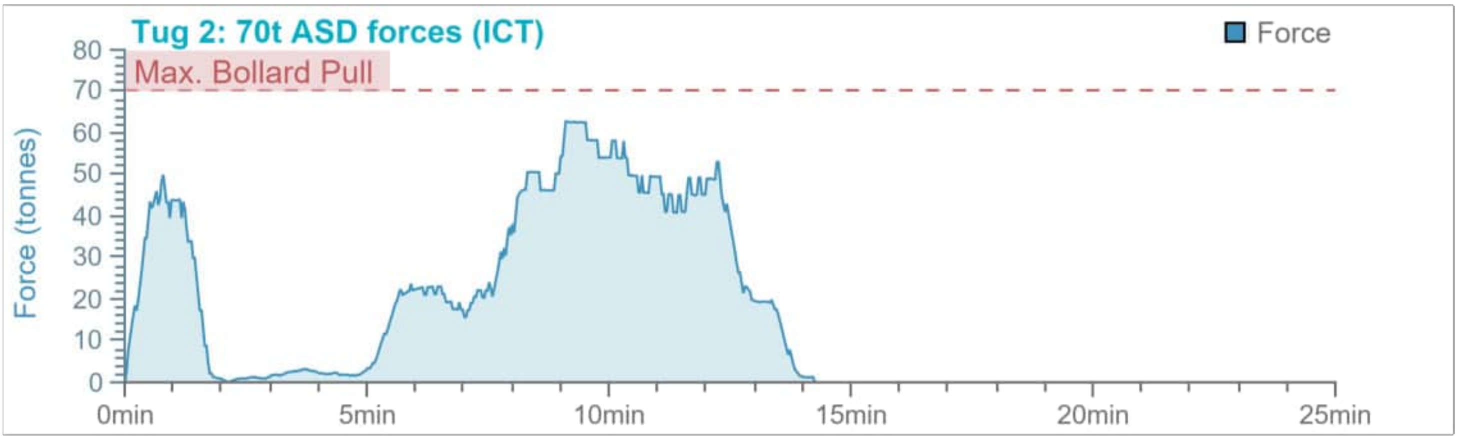


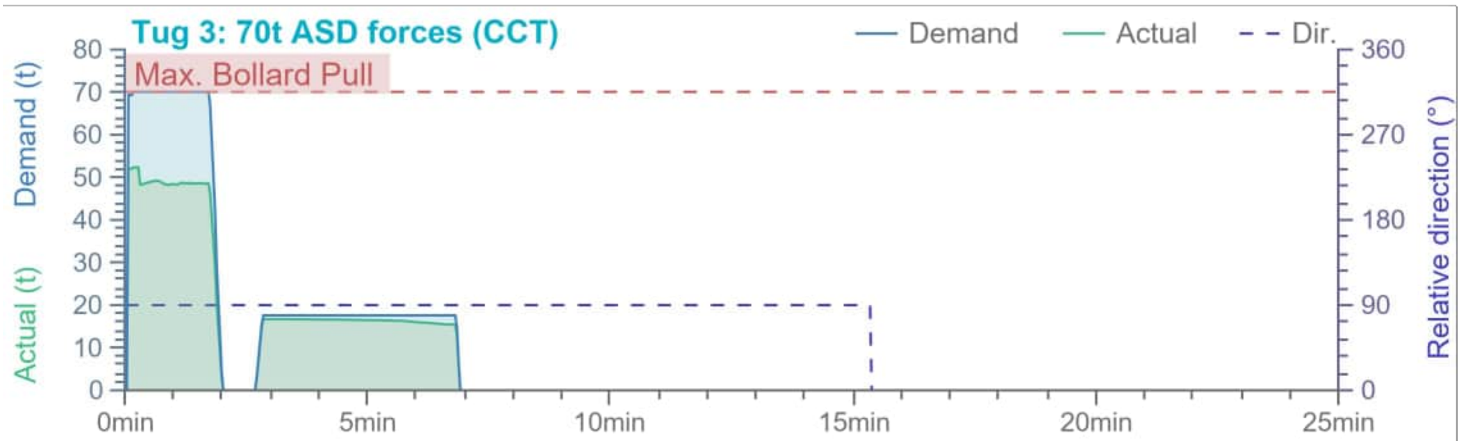



Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min

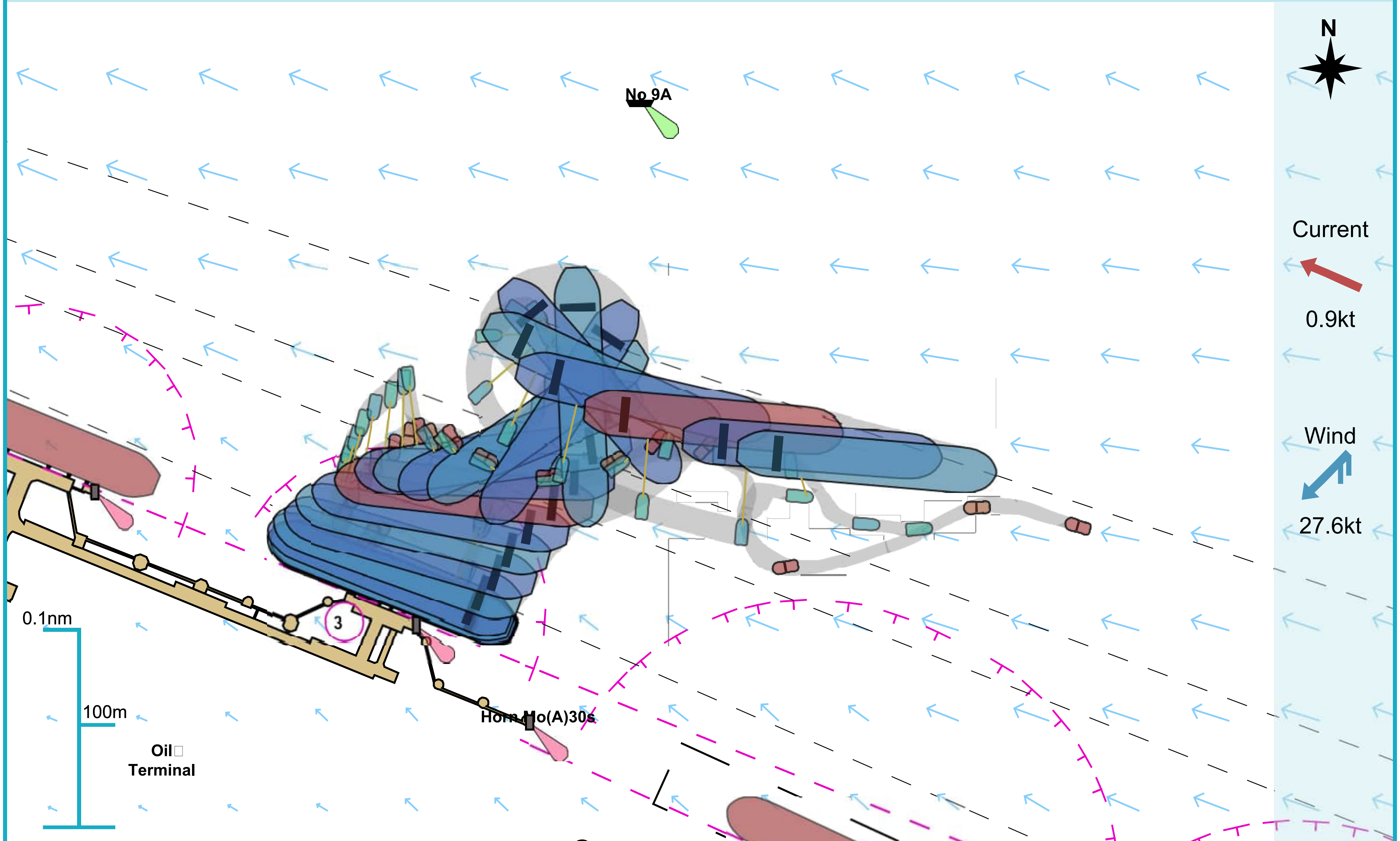

Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min


Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
60
70
80
90
180
270
360
0min
5min
10min
15min
20min
25min


Tug 2: 70t ASD forces (ICT)
Force
Max. Bollard Pull
Force (tonnes)
0
10
20
30
40
50
60
70
80
0min
5min
10min
15min
20min
25min

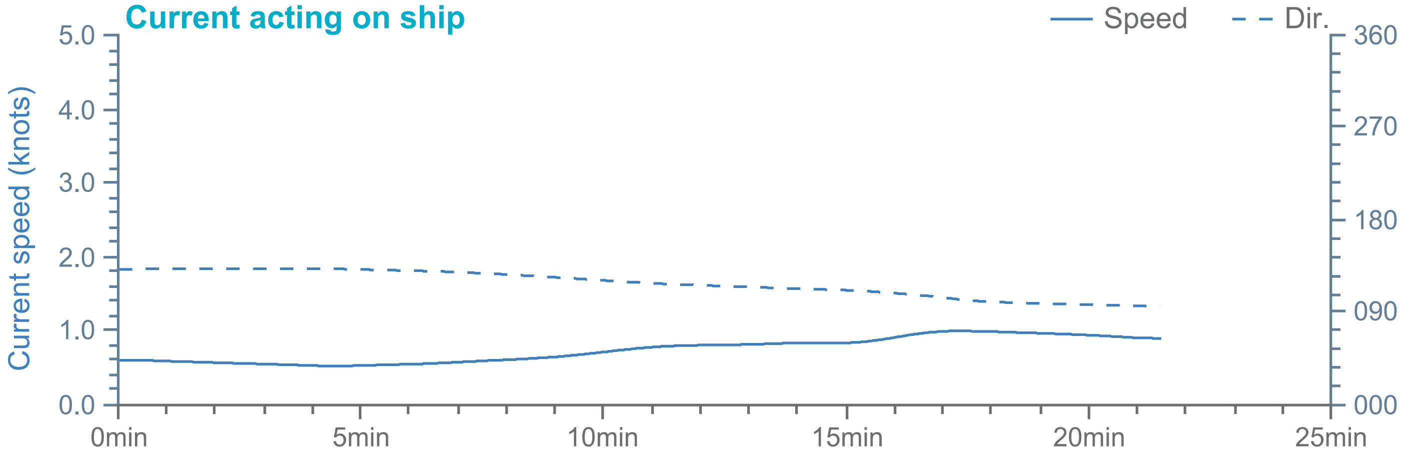

Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
60
70
80
90
180
270
360
0min
5min
10min
15min
20min
25min

Manoeuvre track plot

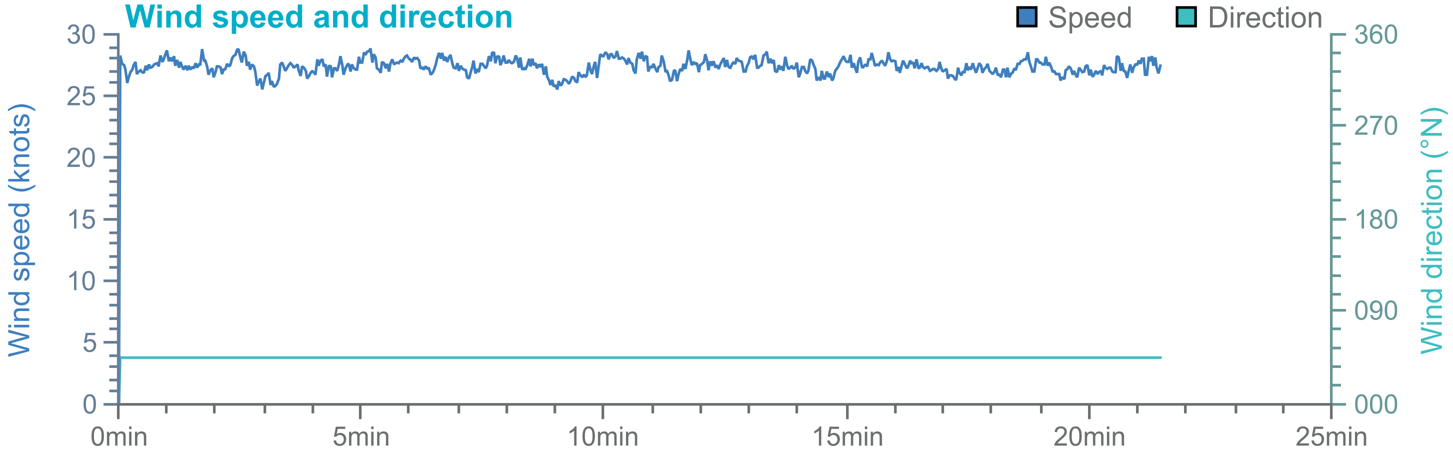


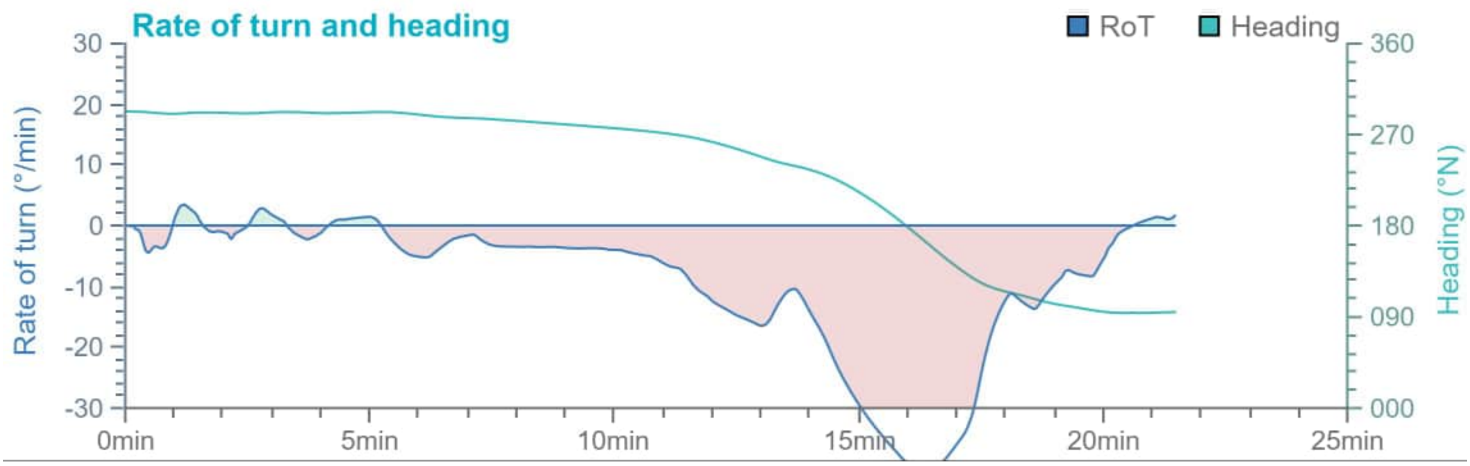
Ships plotted every 1 mins, highlight every 10 mins

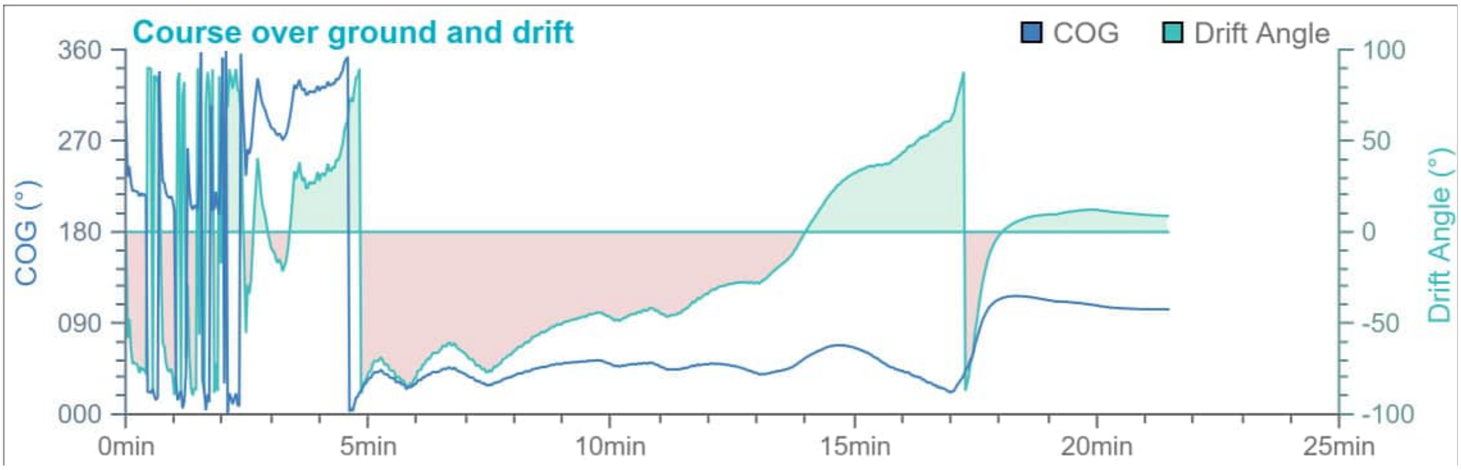
Current acting on ship

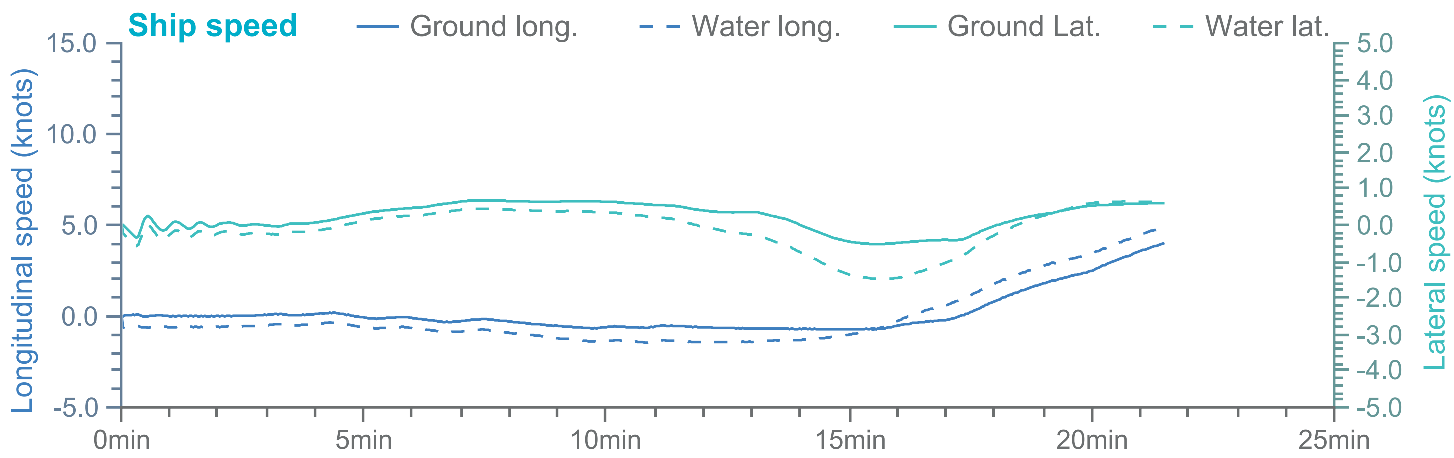


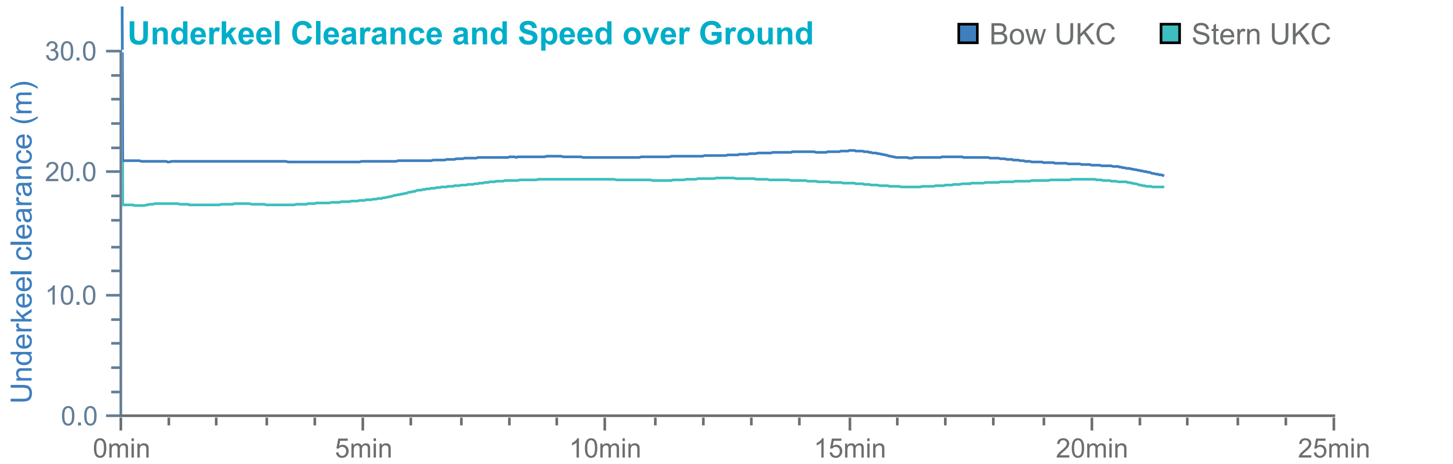
Wind speed and direction

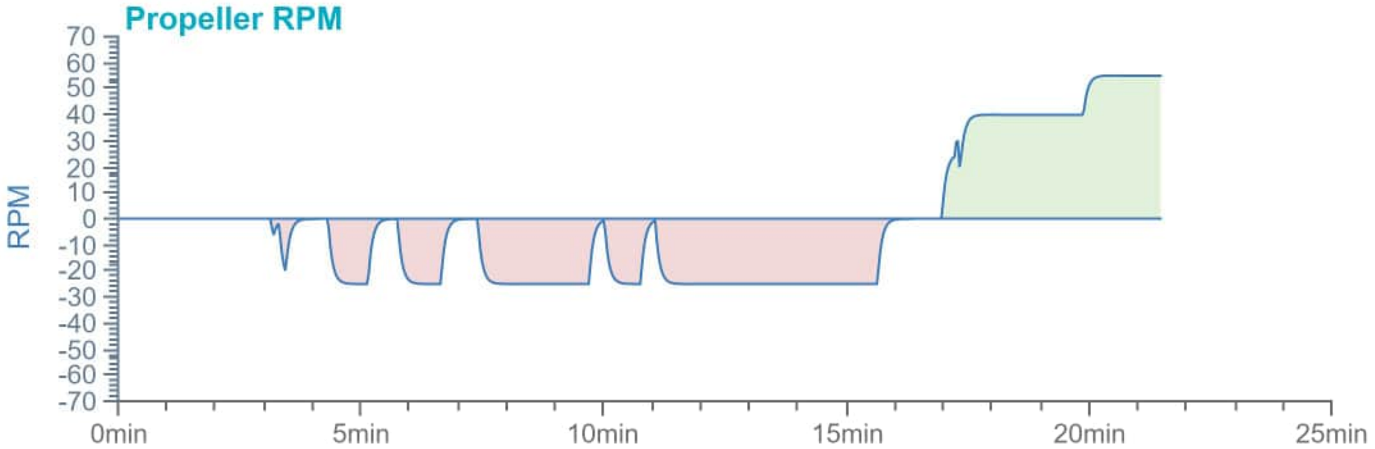


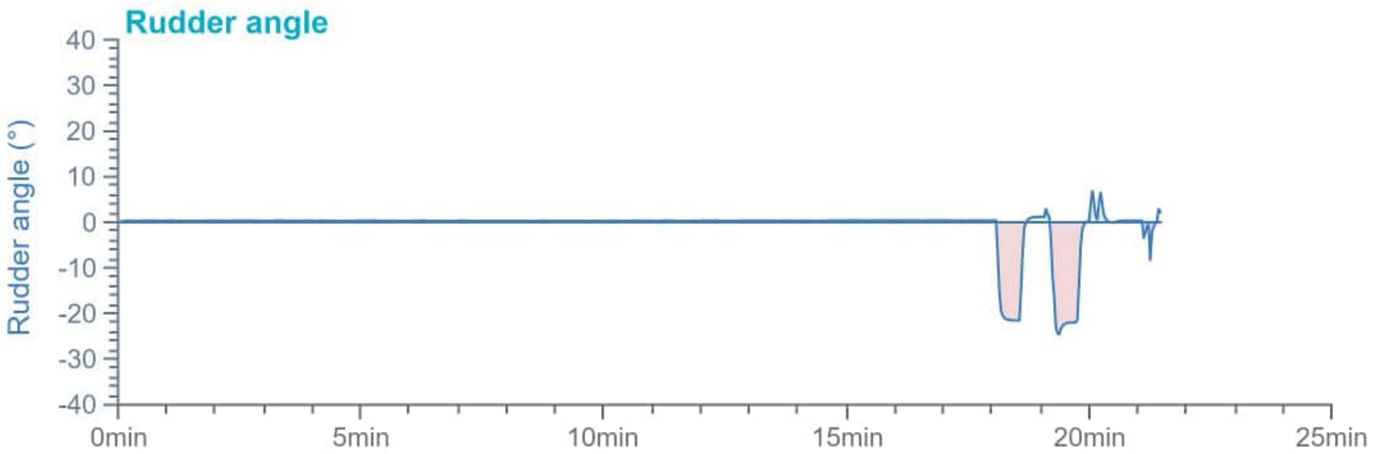

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min
15min
20min
25min

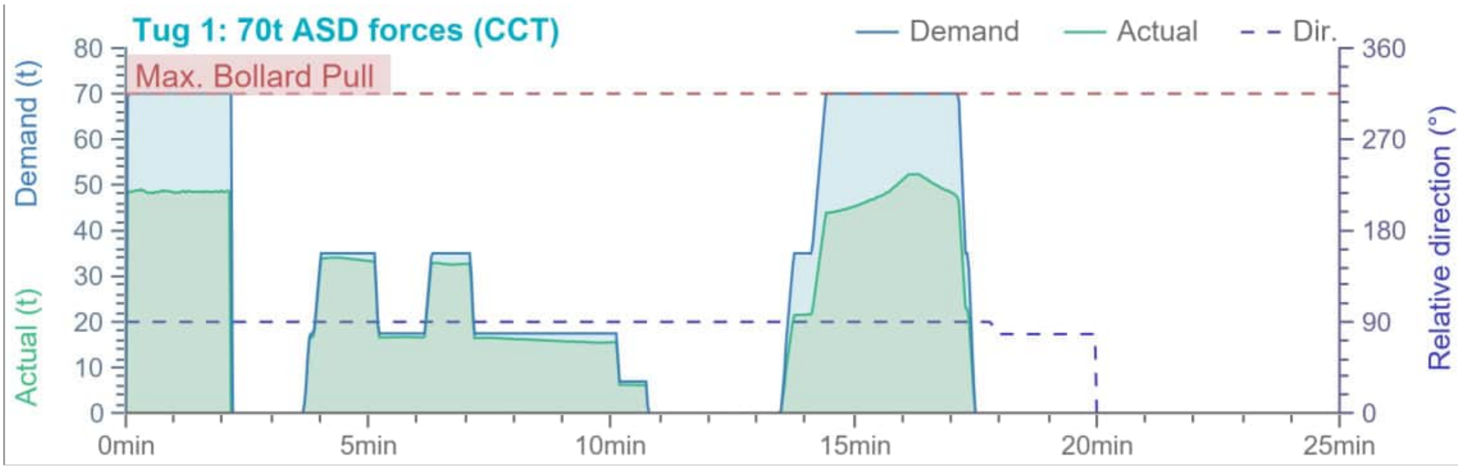

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min

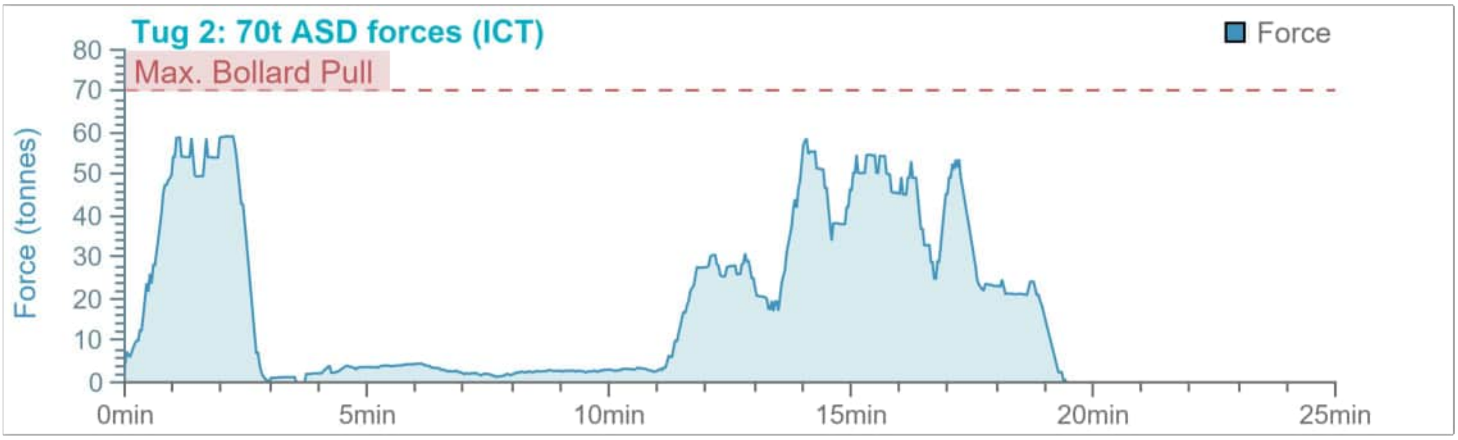

Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min

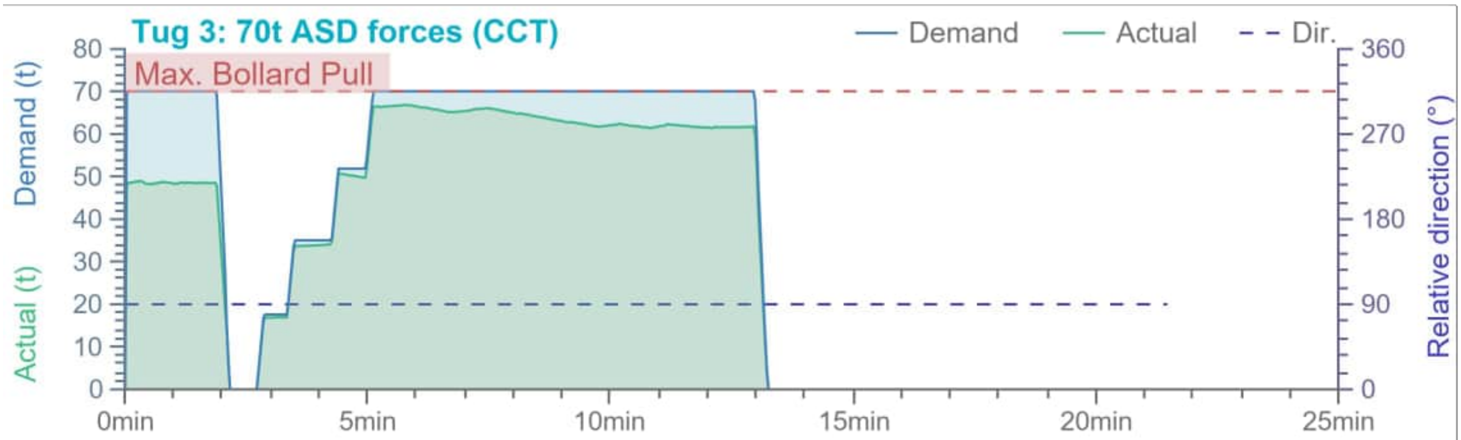

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min


Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min

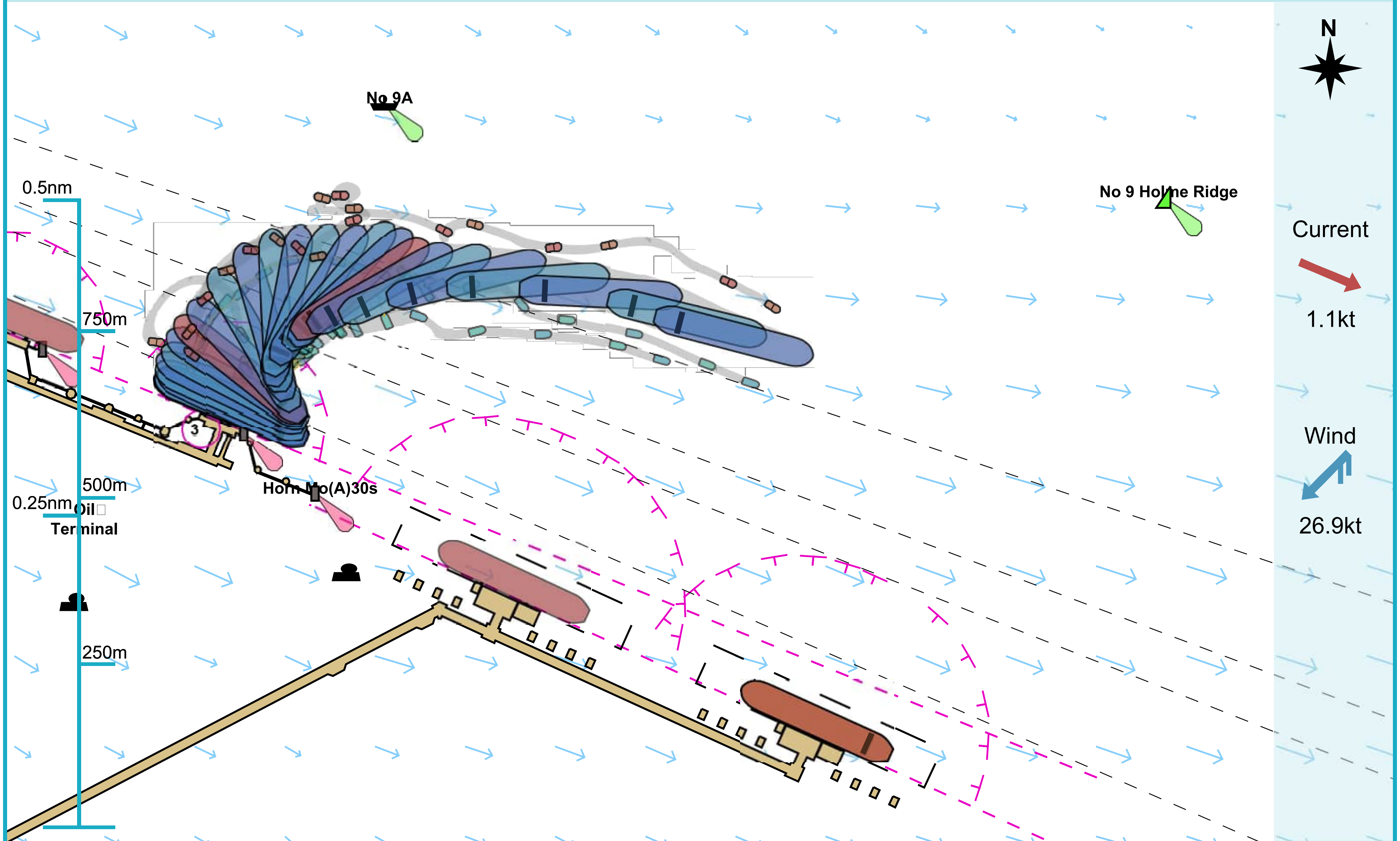

Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min


Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min


Tug 2: 70t ASD forces (ICT)
Force
Max. Bollard Pull
Force (tonnes)
0min
5min
10min
15min
20min
25min

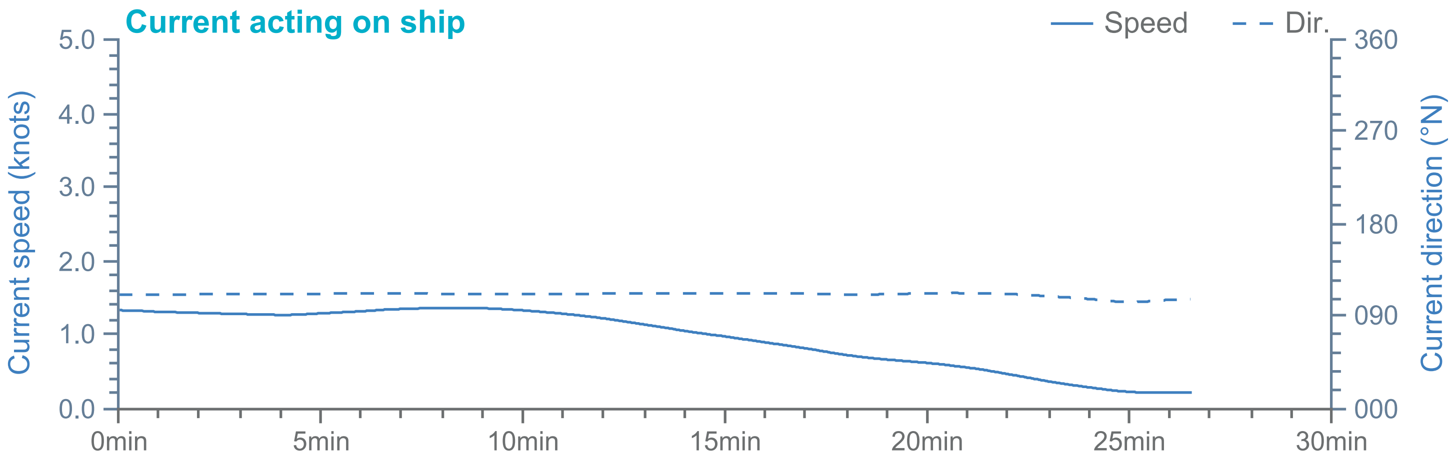

Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min

Manoeuvre track plot

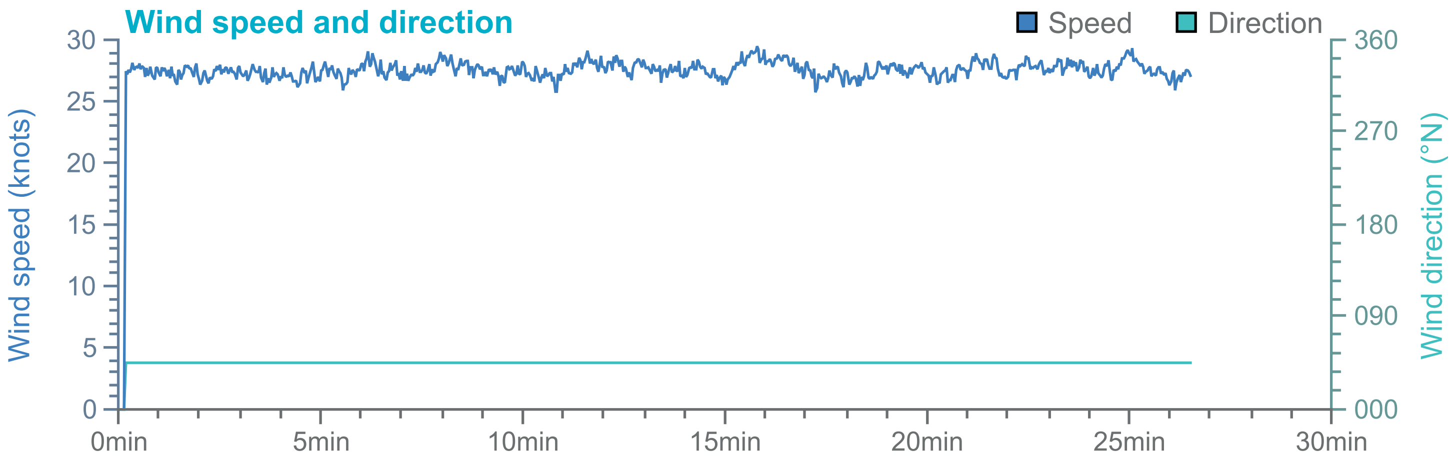


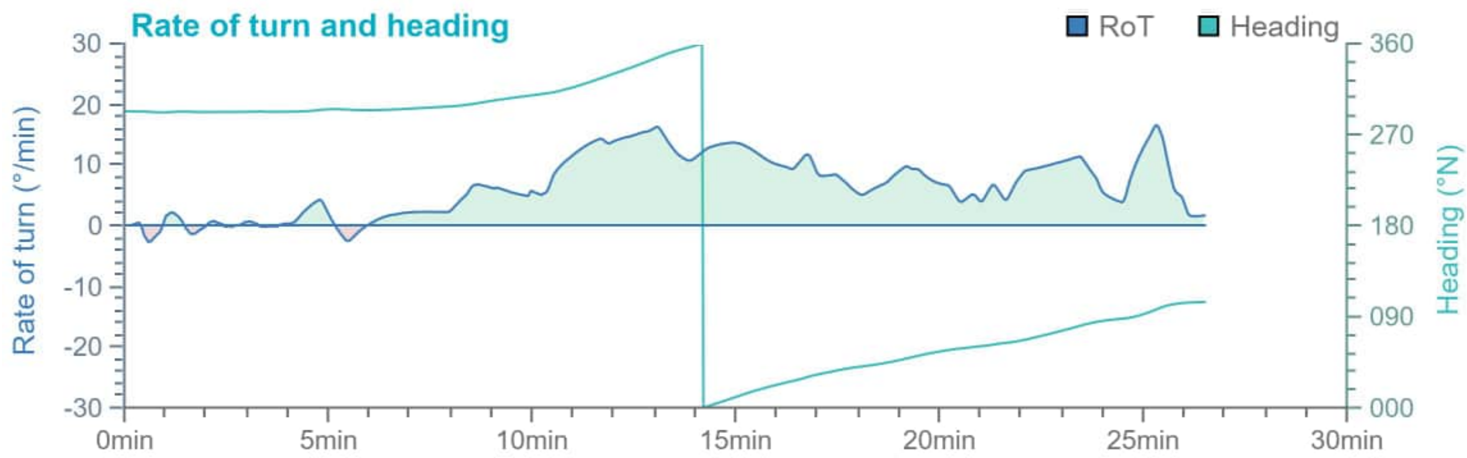
Ships plotted every 1 mins, highlight every 10 mins

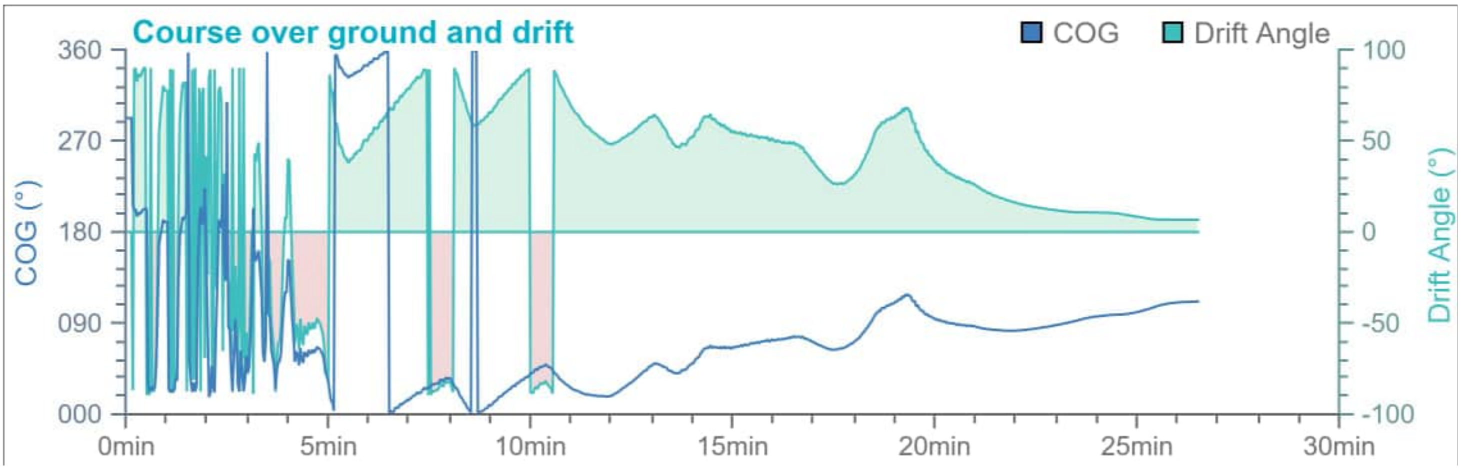
Current acting on ship

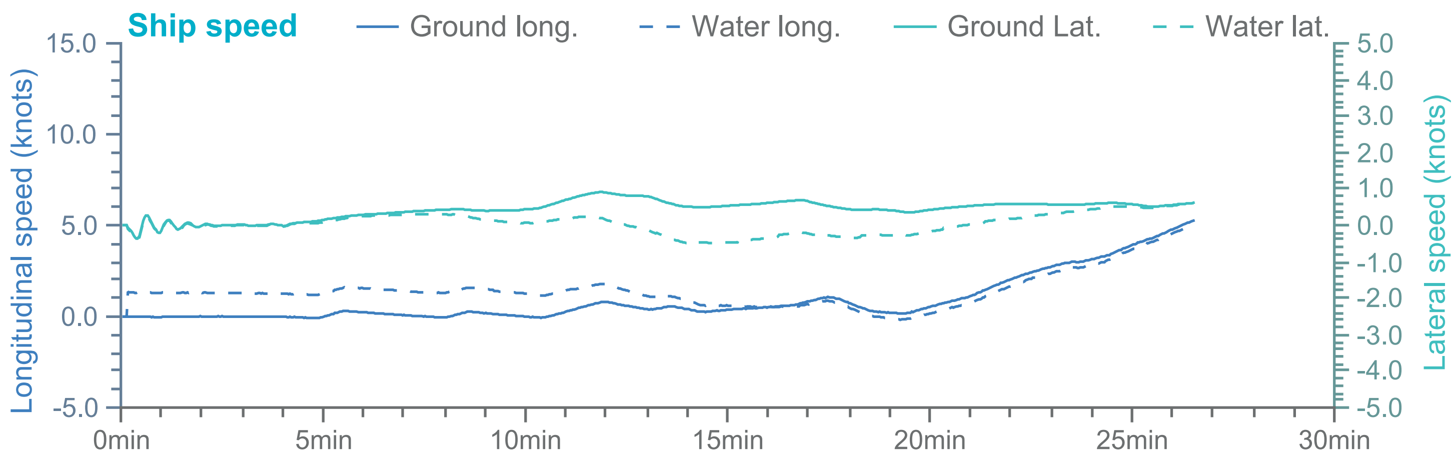


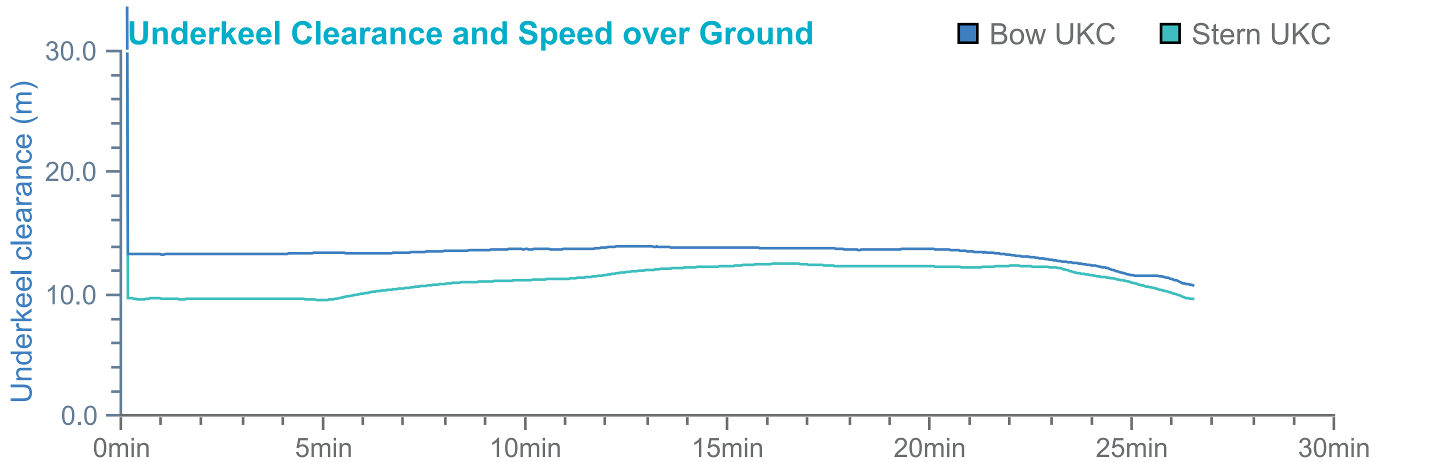
Wind speed and direction

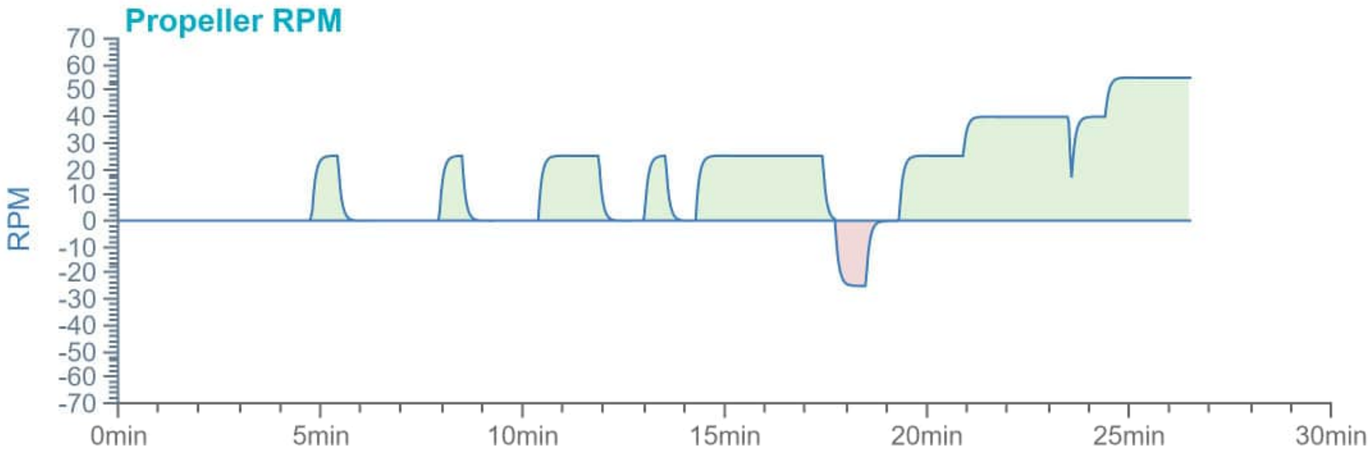


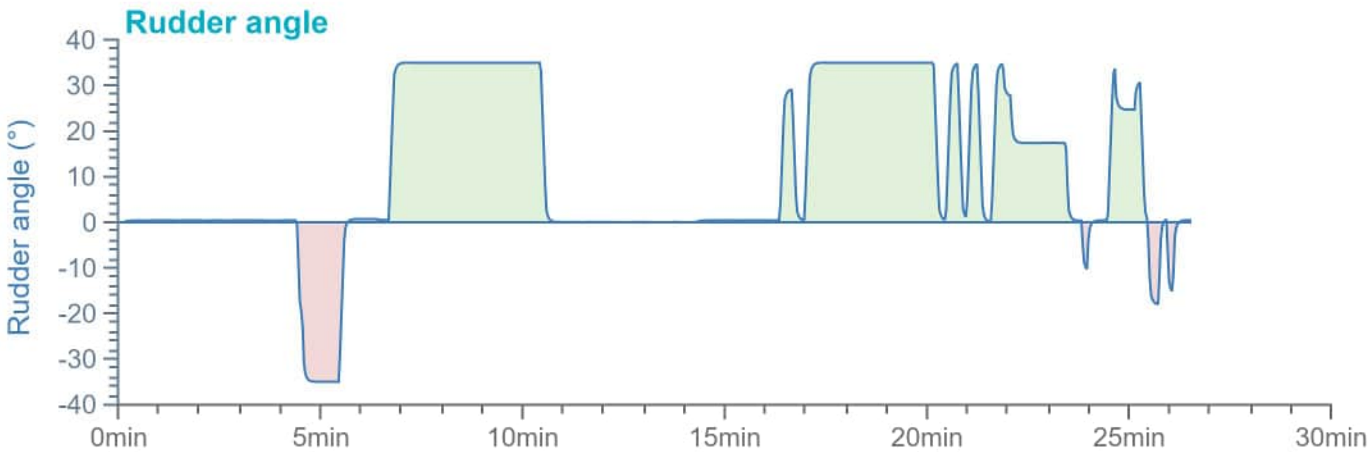

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min

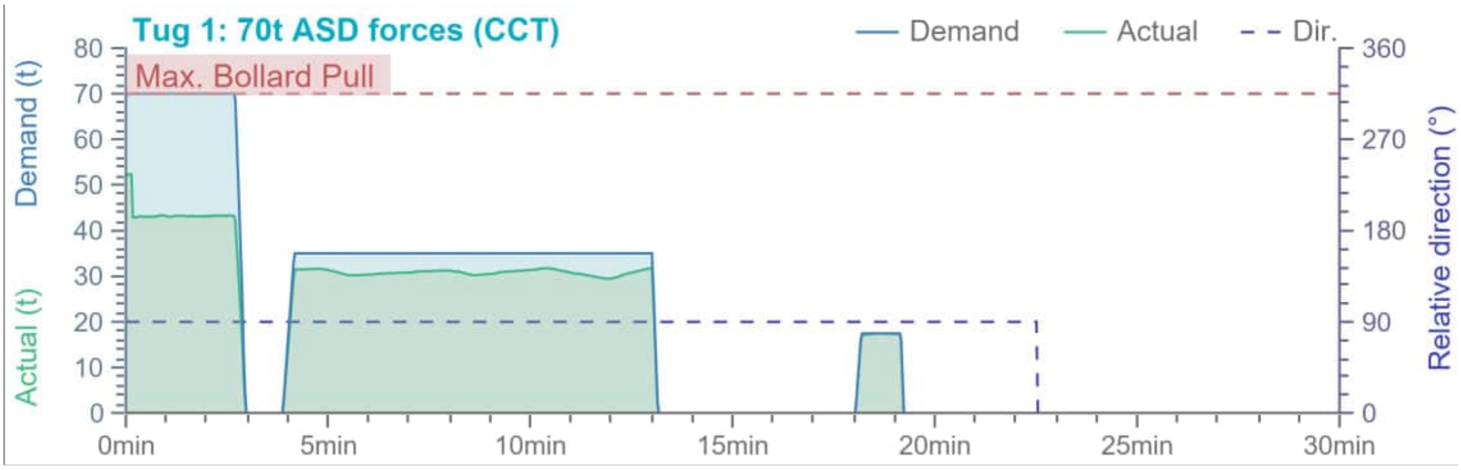

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min

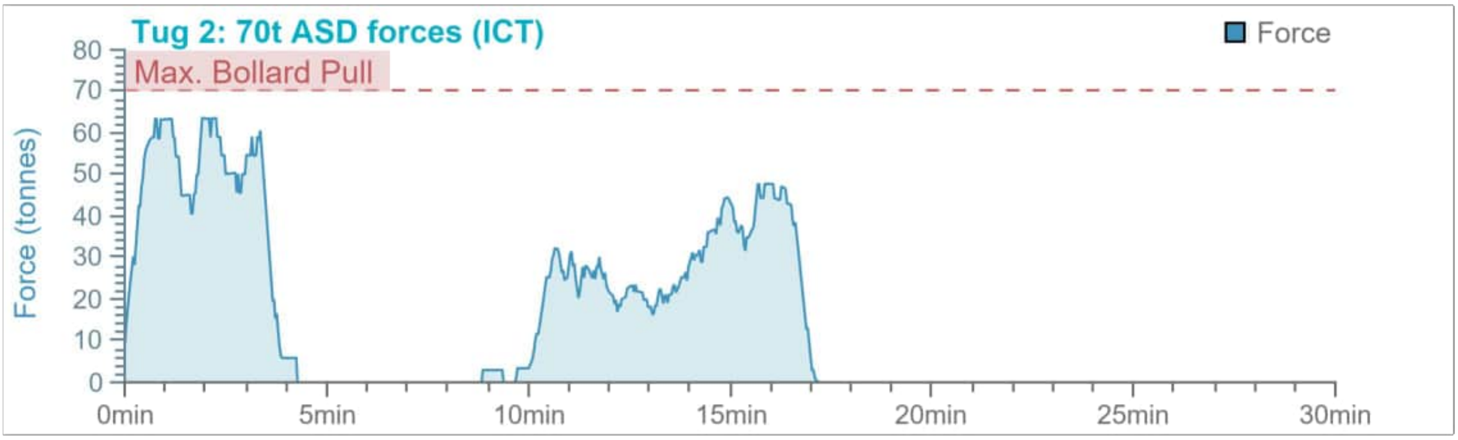

Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min

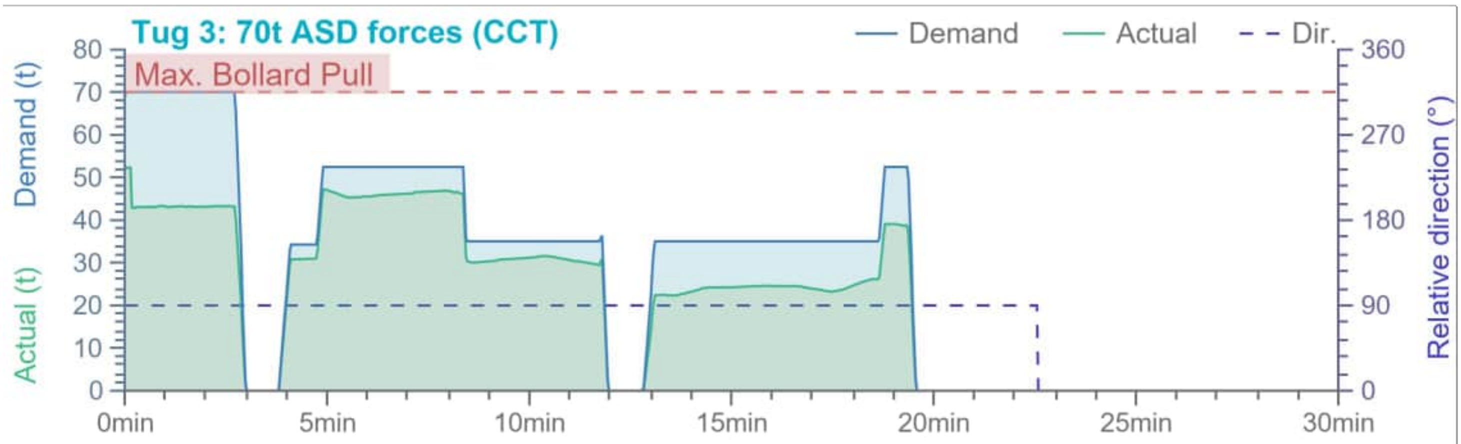

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min


Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min
30min

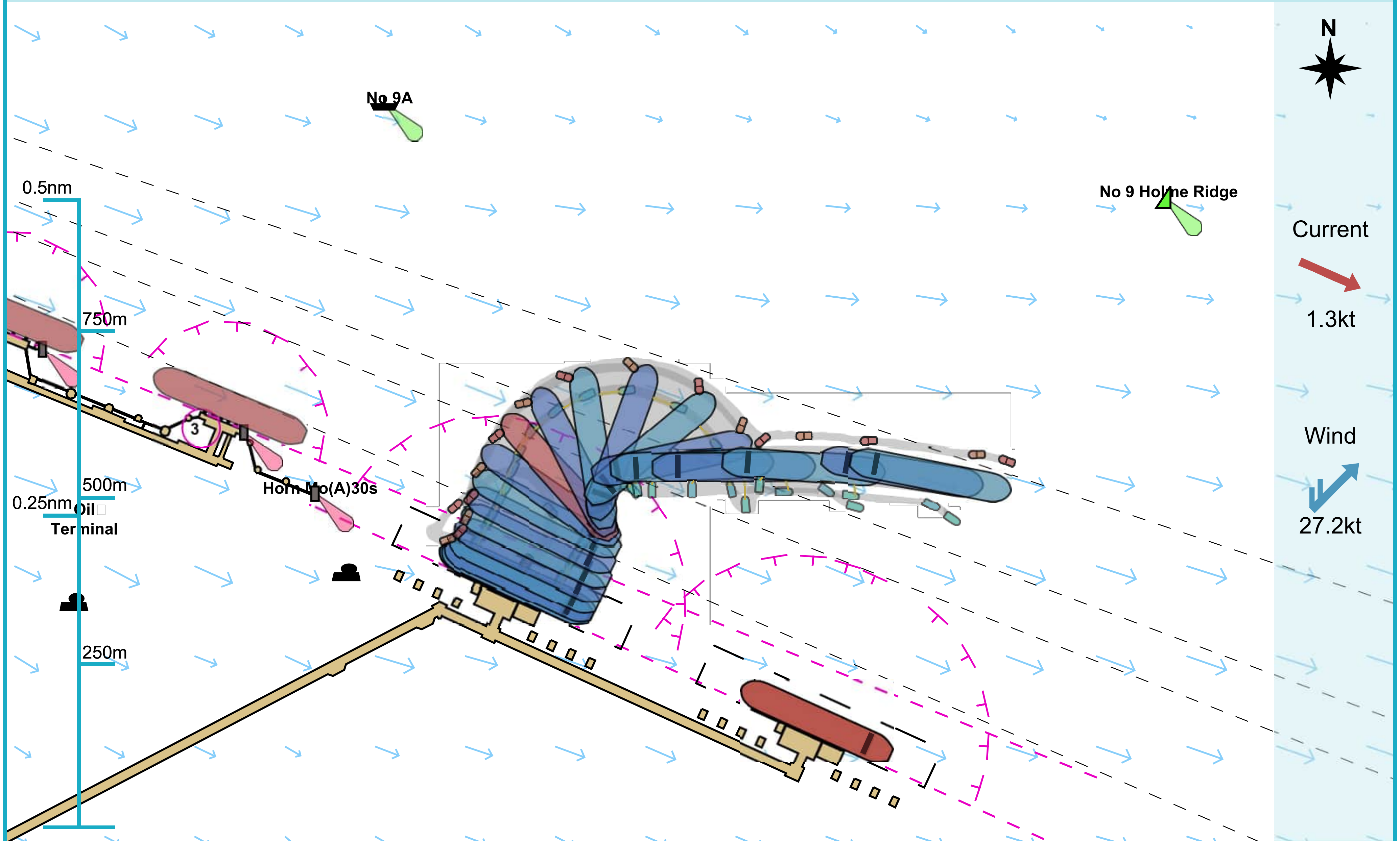

Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min
30min


Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min

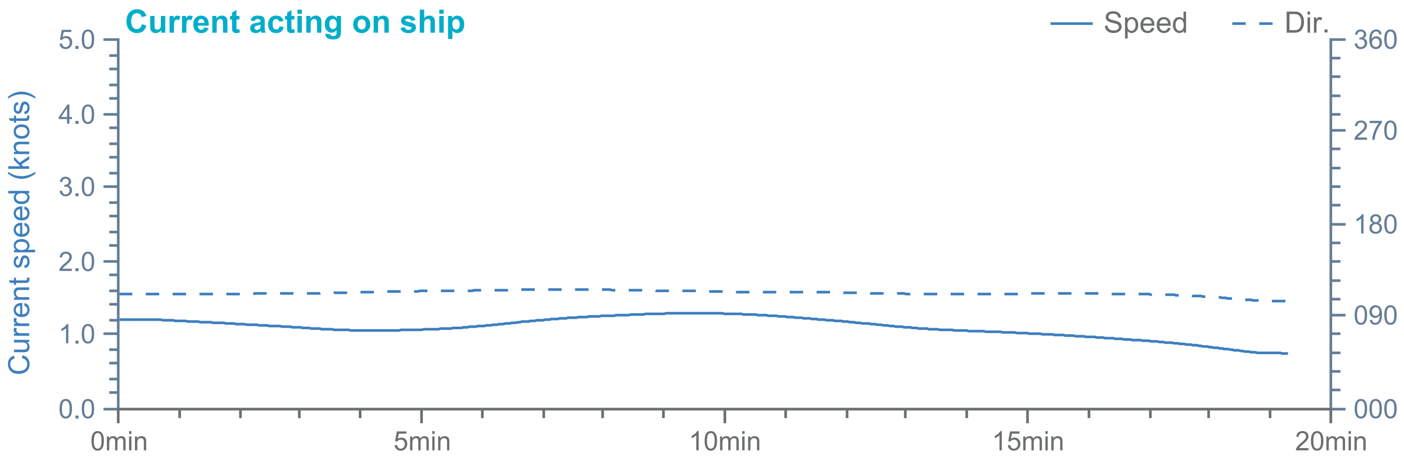

Tug 2: 70t ASD forces (ICT)
Force
Max. Bollard Pull
Force (tonnes)
0min
5min
10min
15min
20min
25min
30min

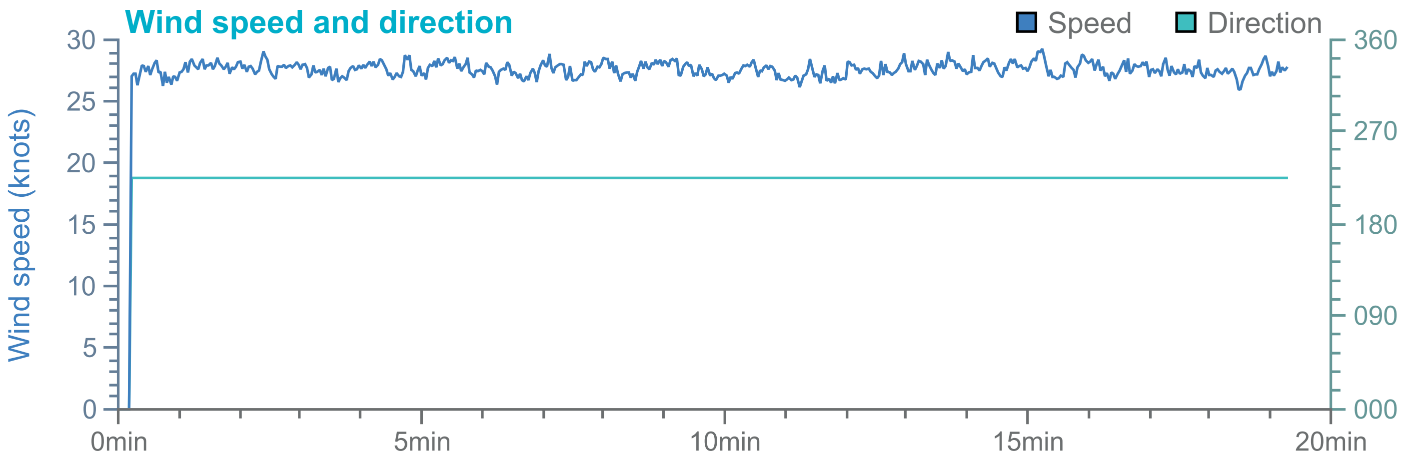

Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min

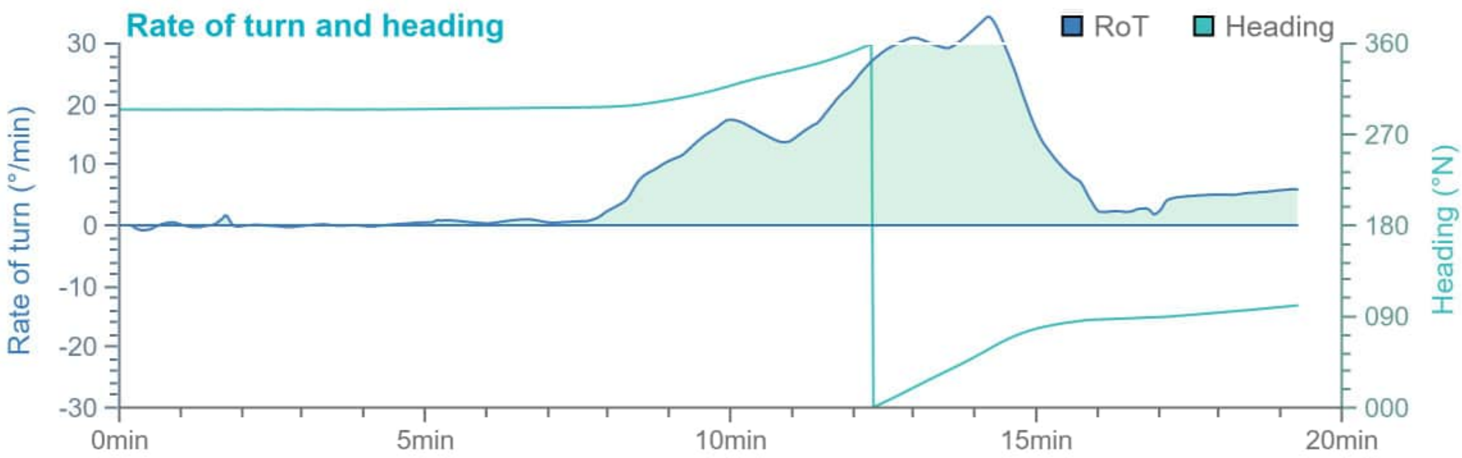
Manoeuvre track plot

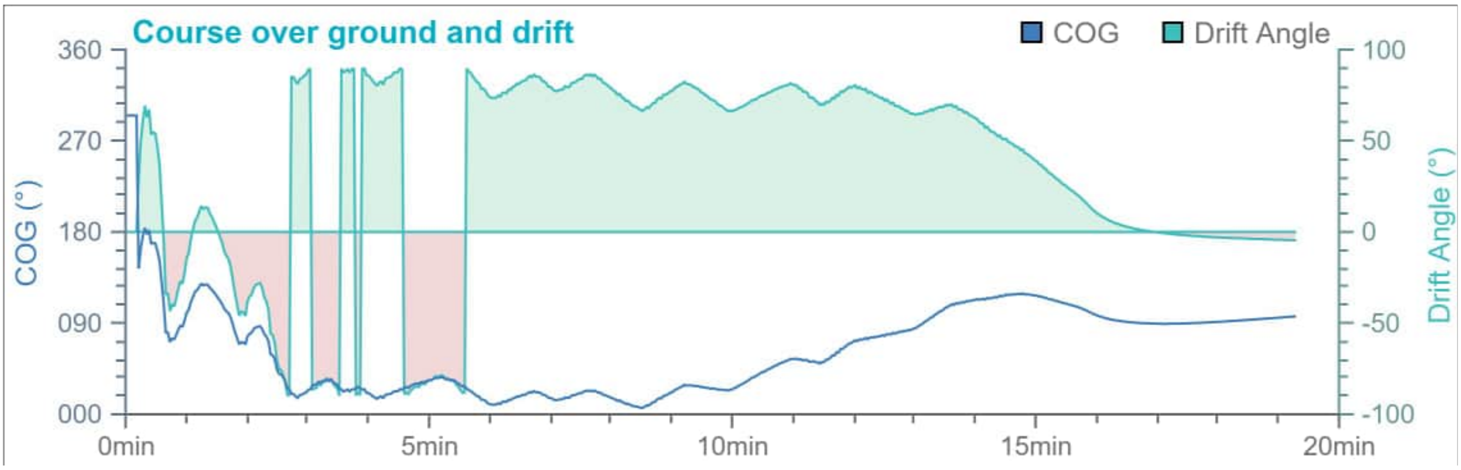


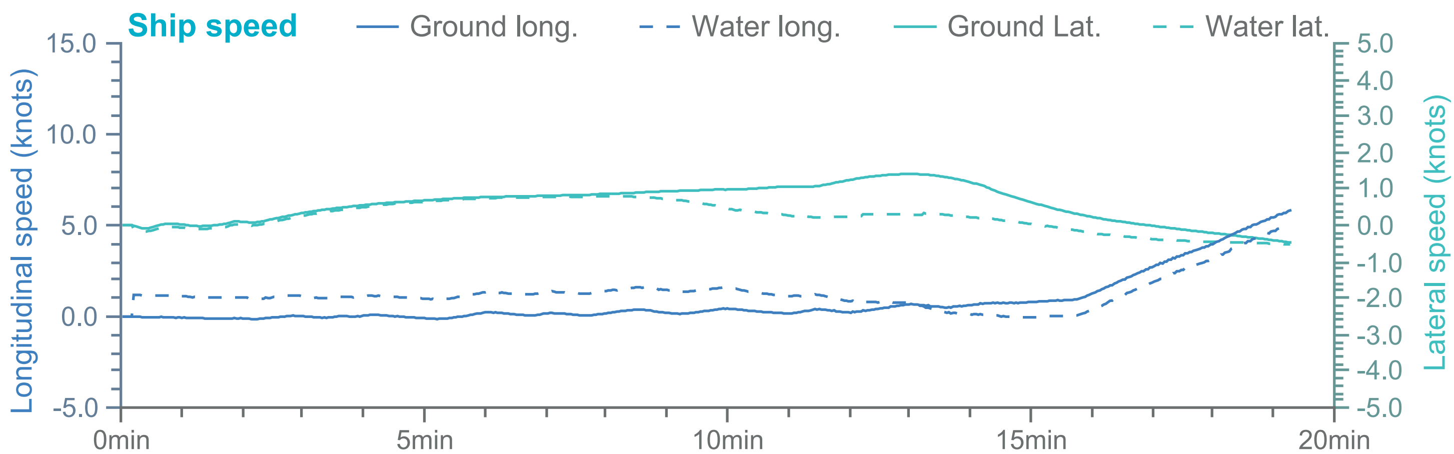
Ships plotted every 1 mins, highlight every 10 mins

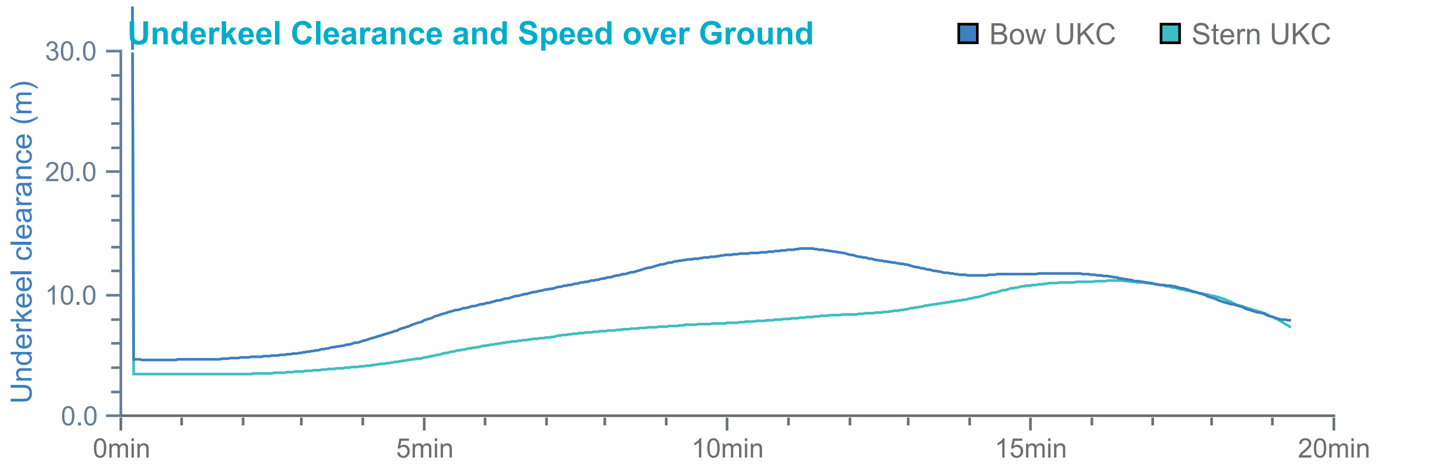

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min

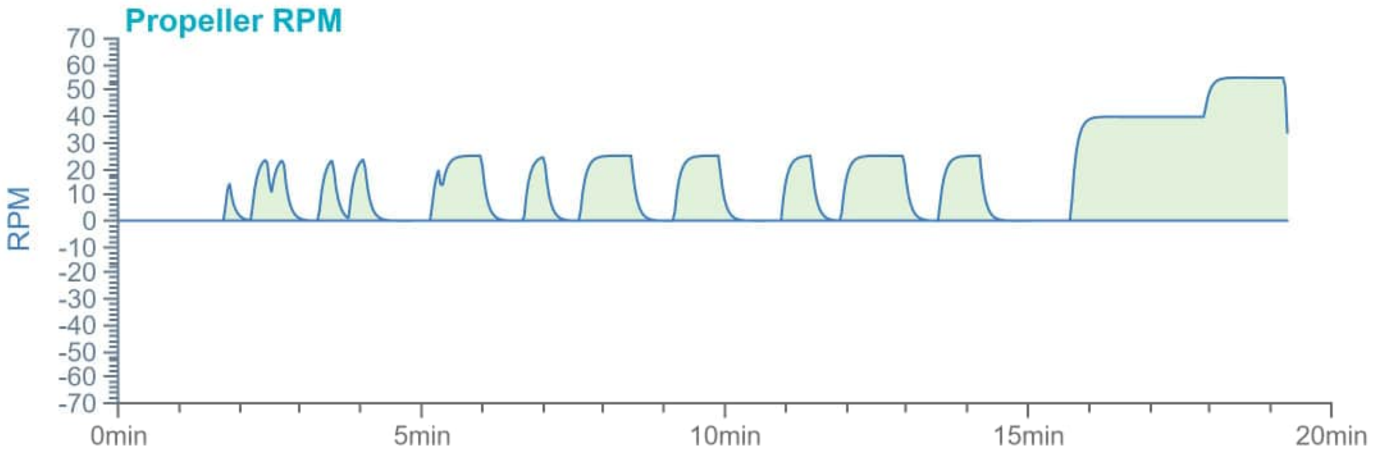

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min

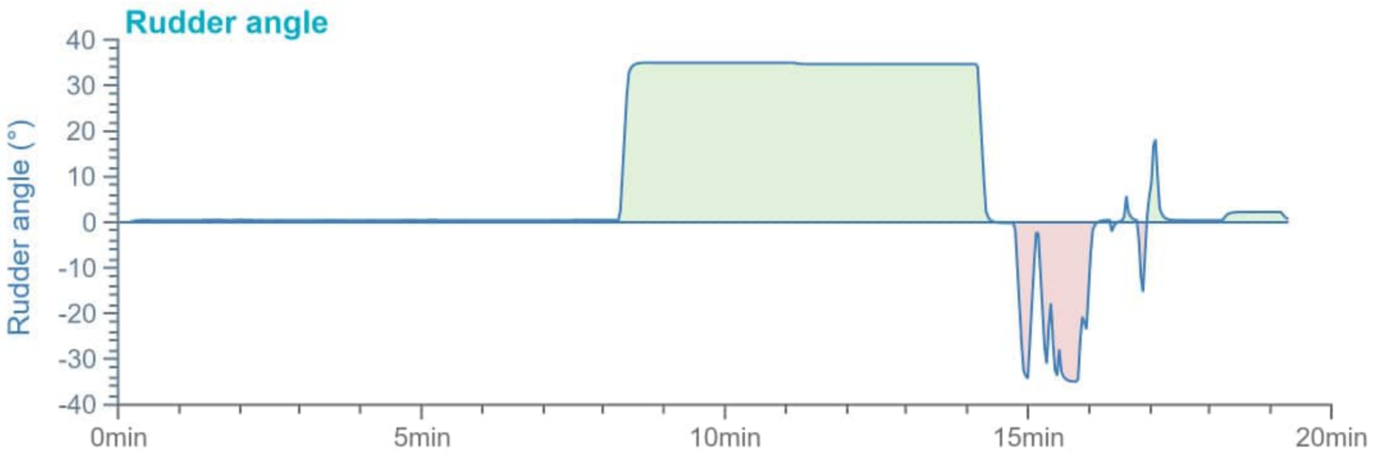

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min
15min
20min


Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min

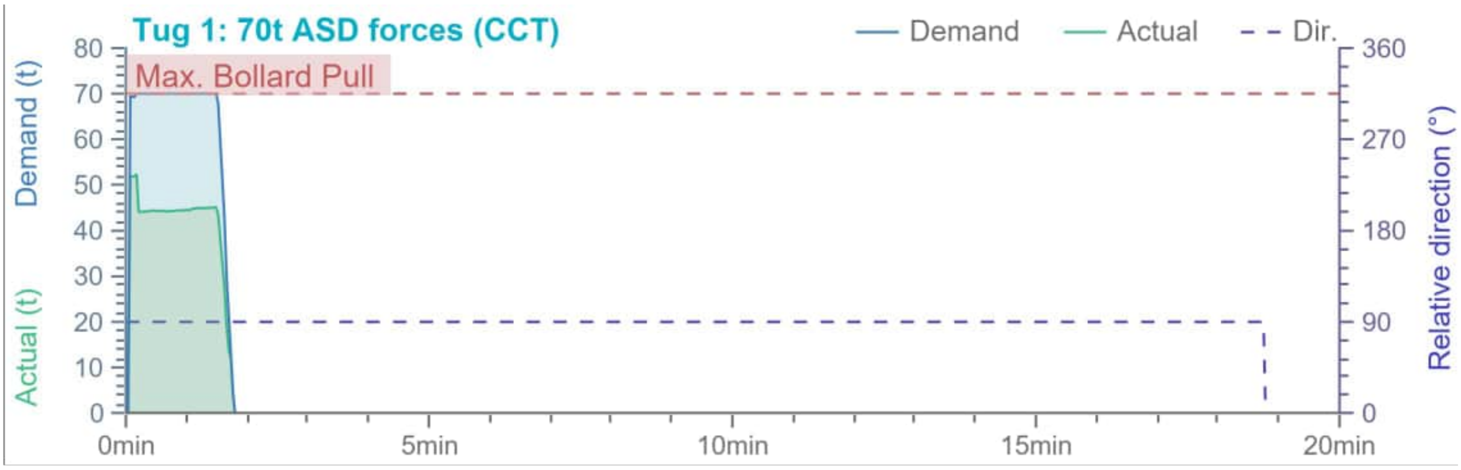

Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min

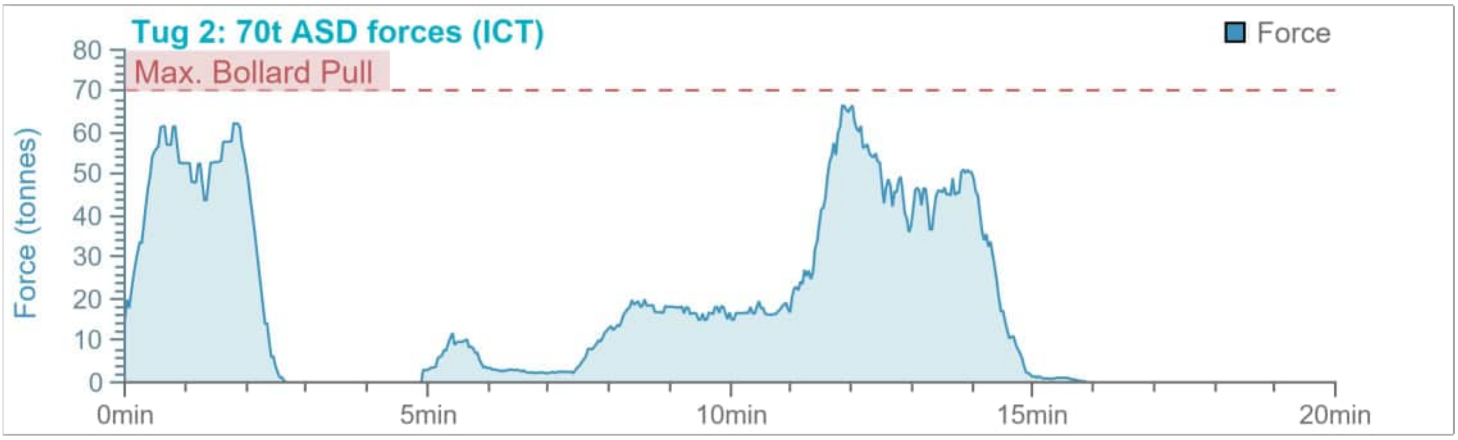

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min

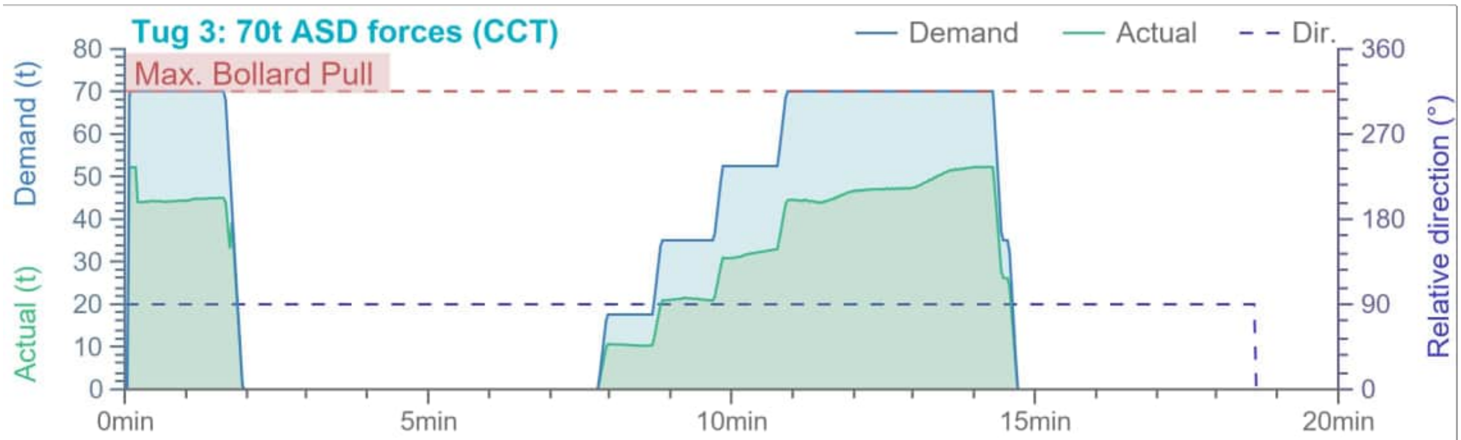

Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min


Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min

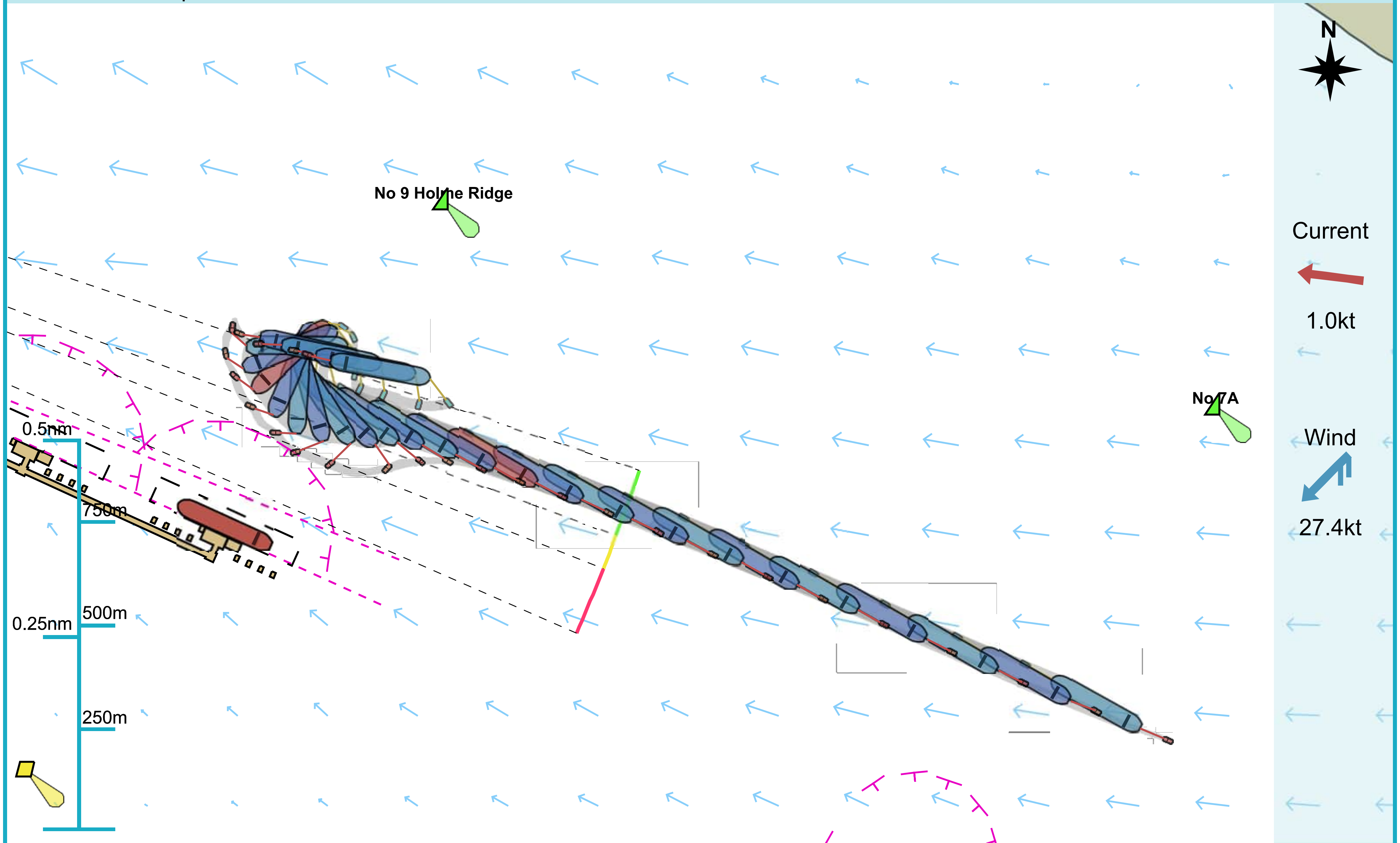
Overview | Environment | 243m Product Tanker | Tugs







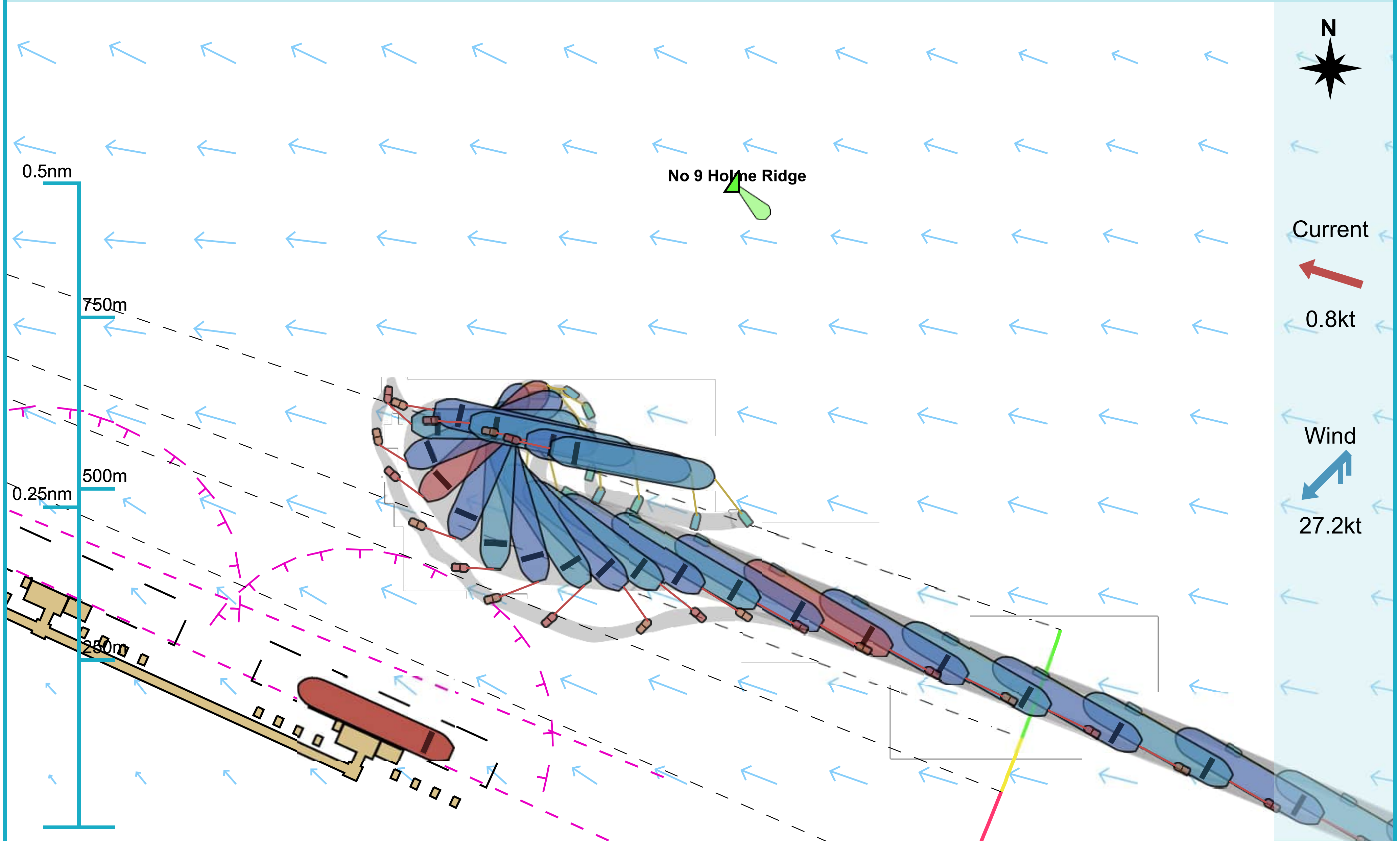
Manoeuvre track plot



1.26 kts

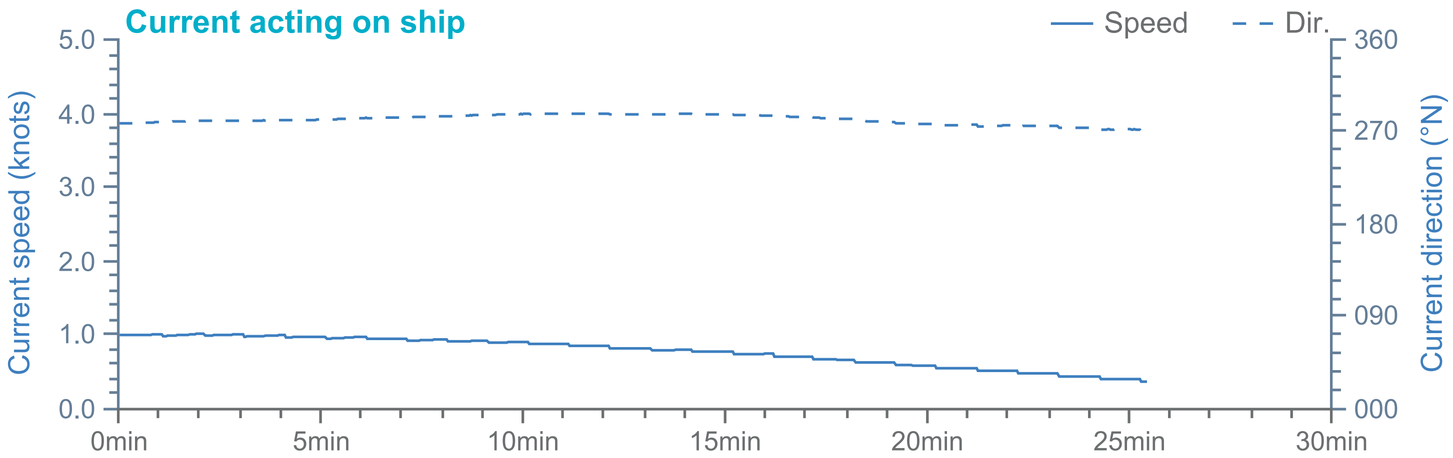
Ships plotted every 1 mins, highlight every 10 mins

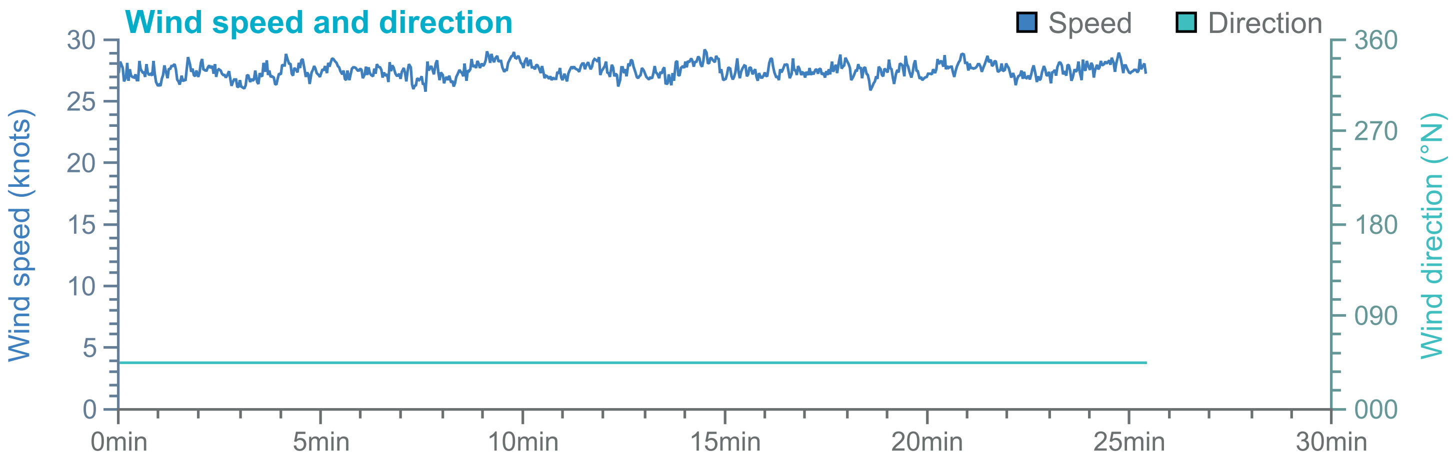
Manoeuvre track plot



1.26 kts

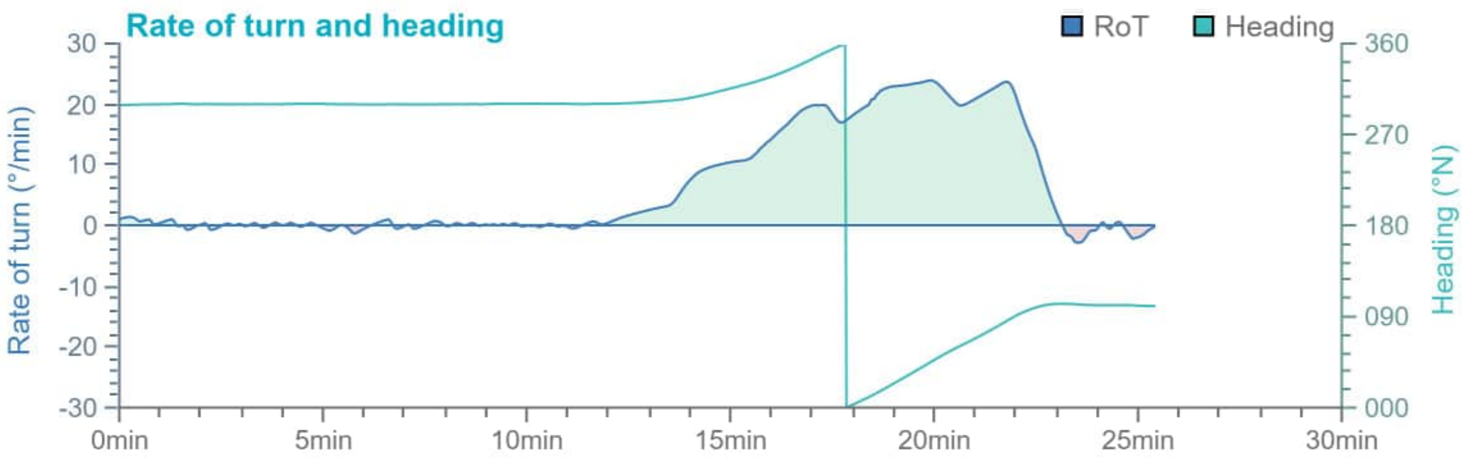
Ships plotted every 1 mins, highlight every 10 mins

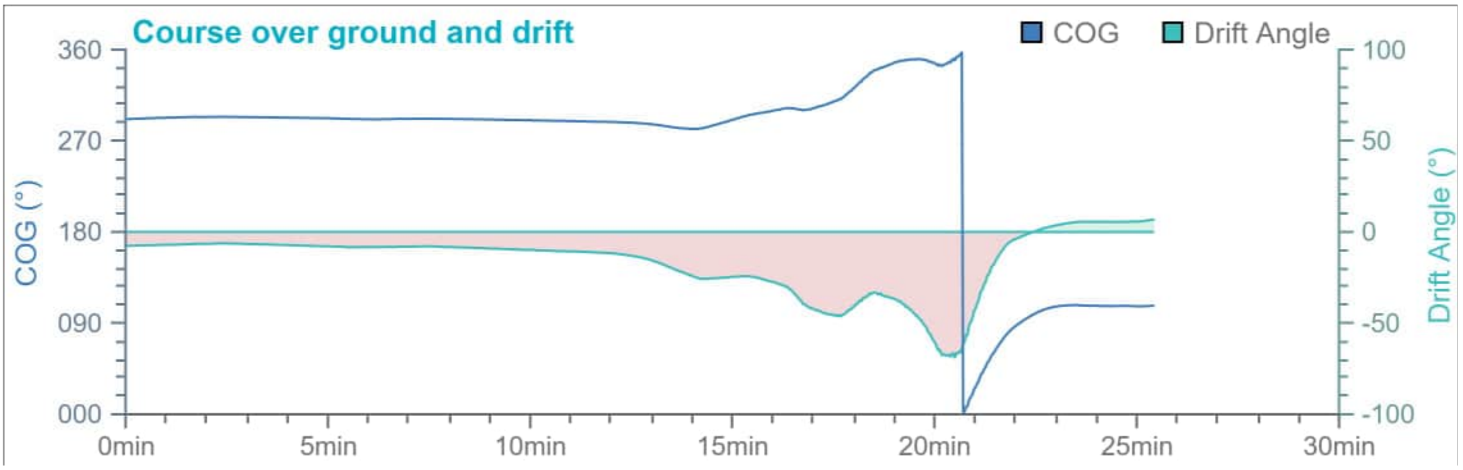

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min

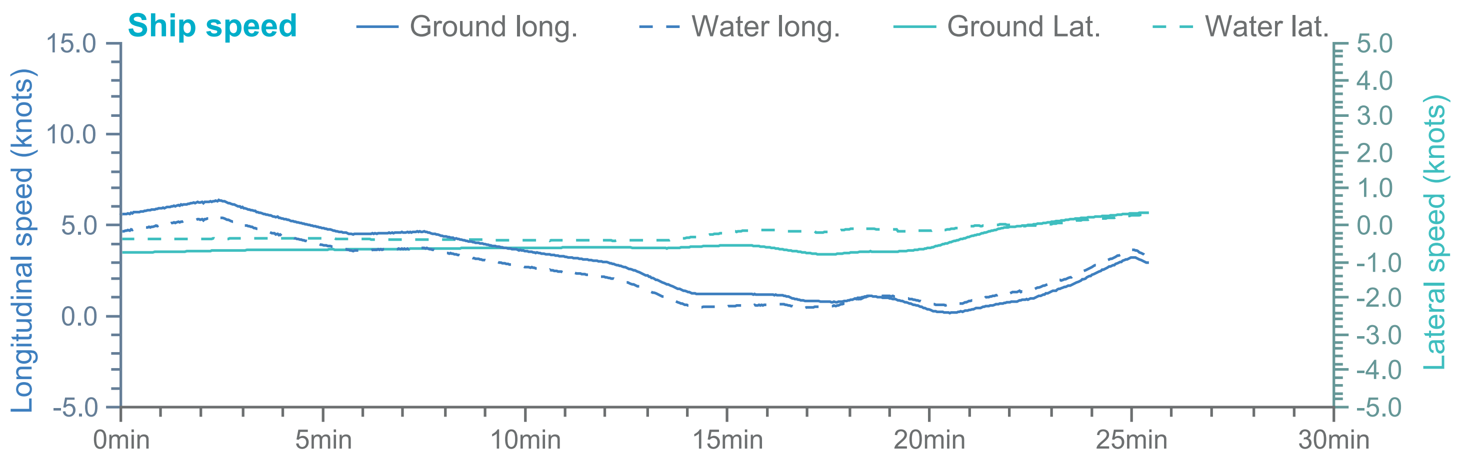

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min

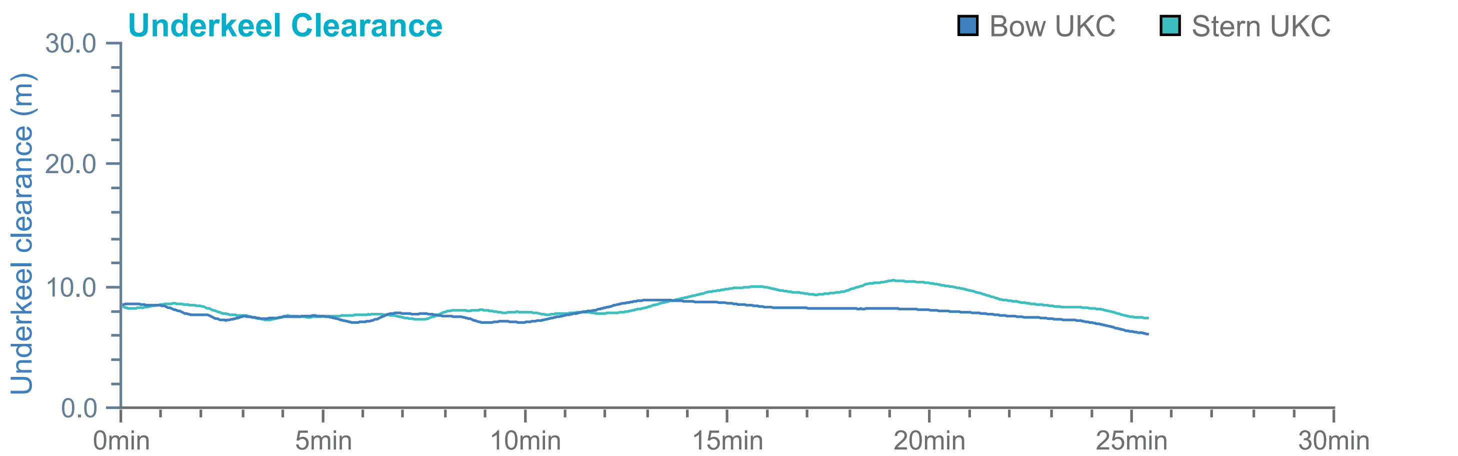
Project: Humber
Session: DJR6829 Soleil
Configuration: April 2023 Layout 5 Peak Spring 12
Run: 13

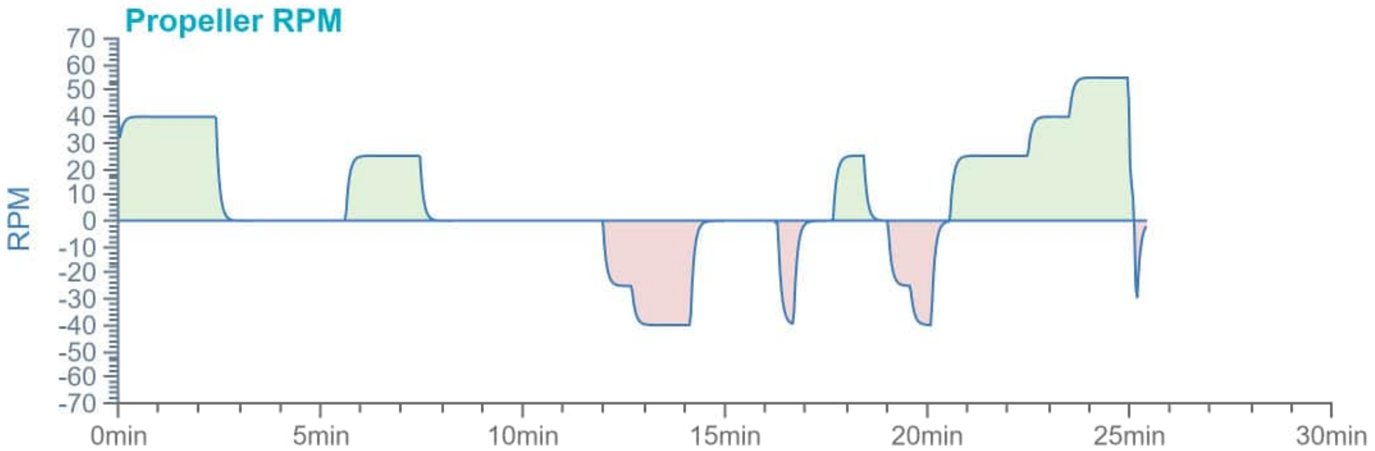
Overview | Environment | 243m Product Tanker | Tugs

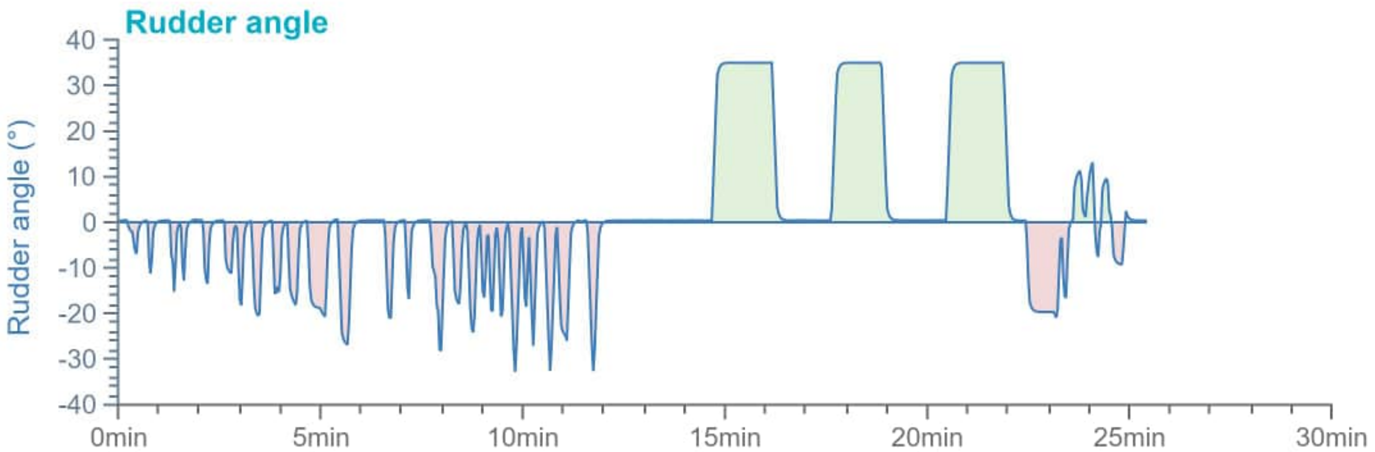


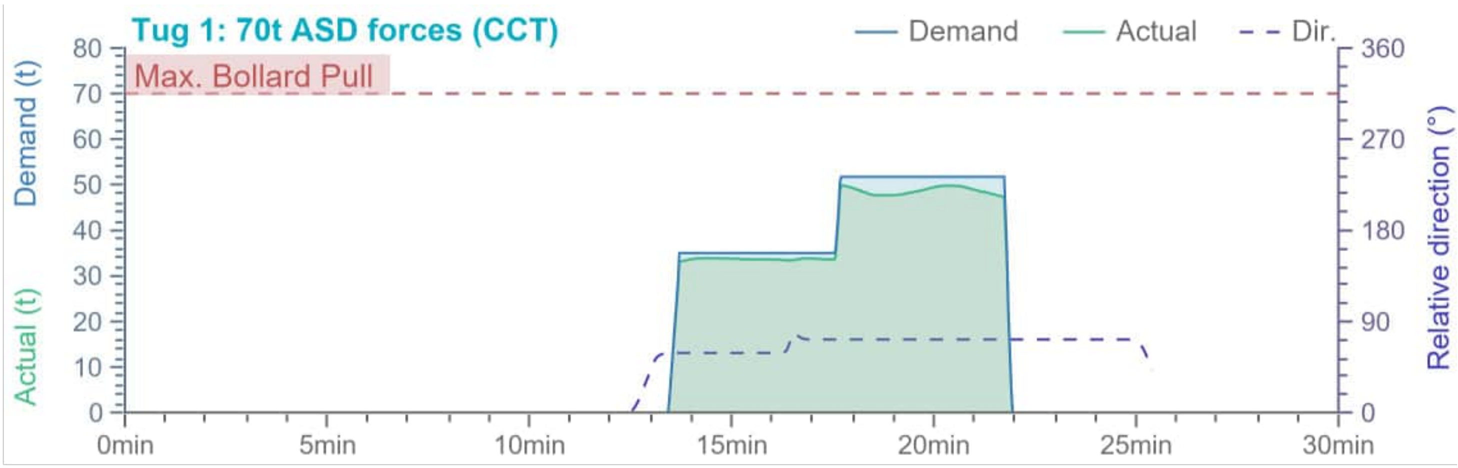


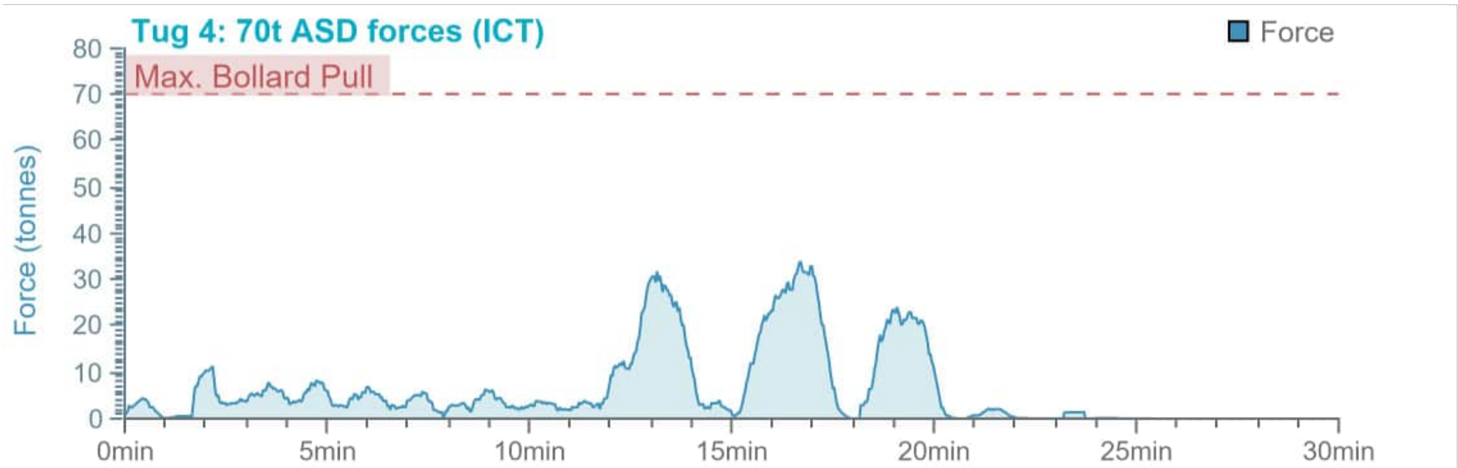




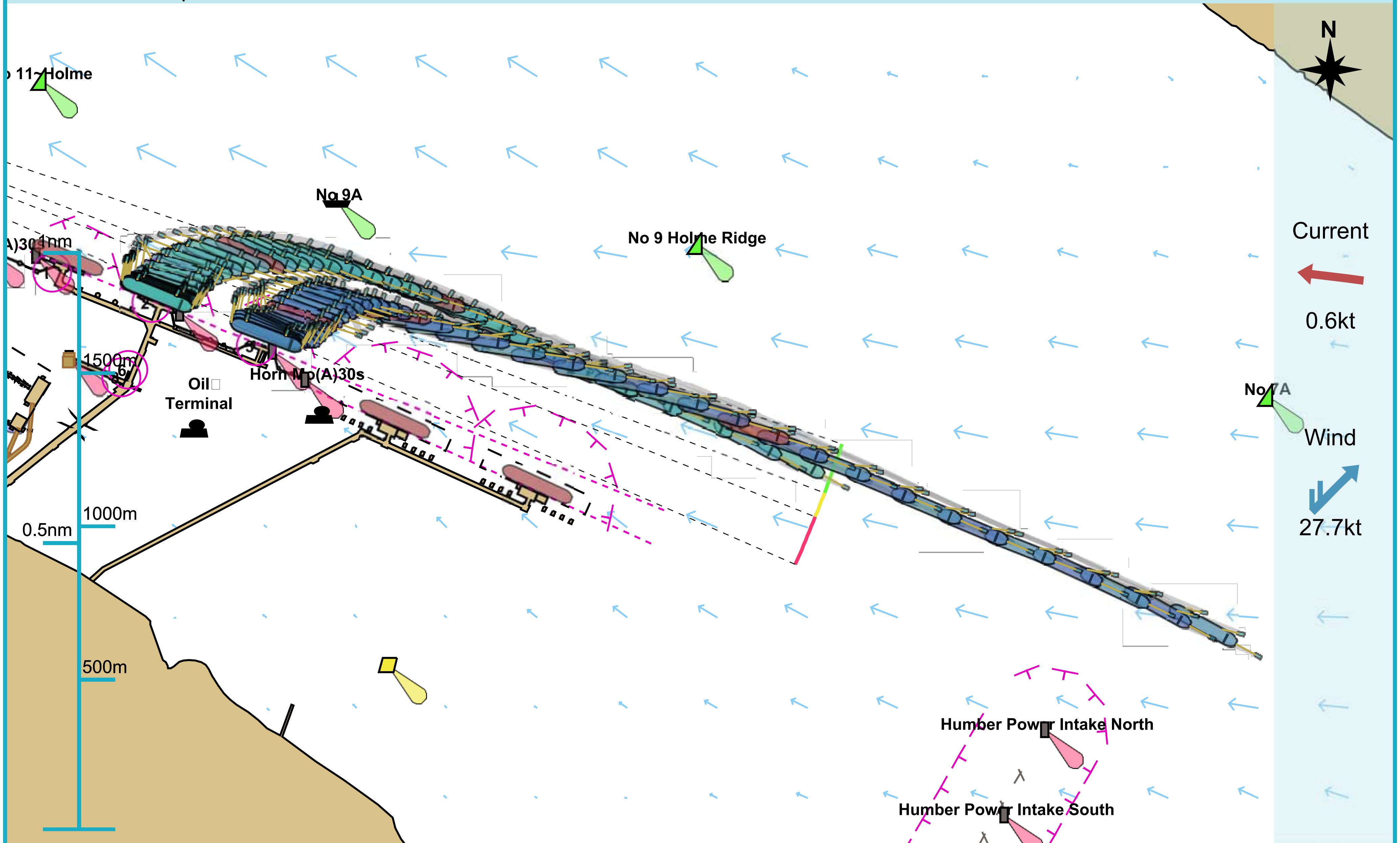

Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min
30min


Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min
30min


Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
60
70
80
90
180
270
360
0min
5min
10min
15min
20min
25min
30min


Tug 4: 70t ASD forces (ICT)
Force
Max. Bollard Pull
Force (tonnes)
0
10
20
30
40
50
60
70
80
0min
5min
10min
15min
20min
25min
30min

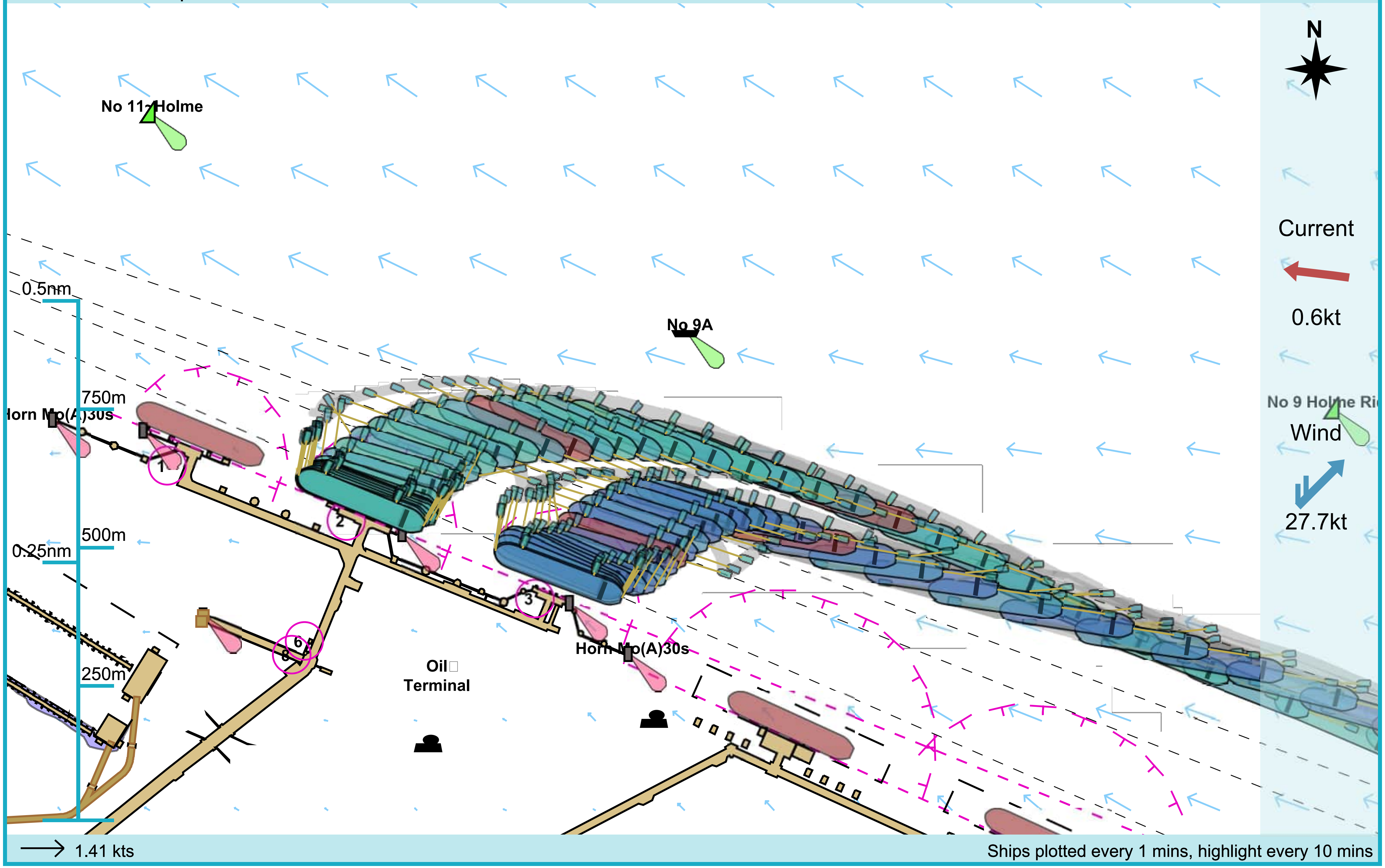
Manoeuvre track plot

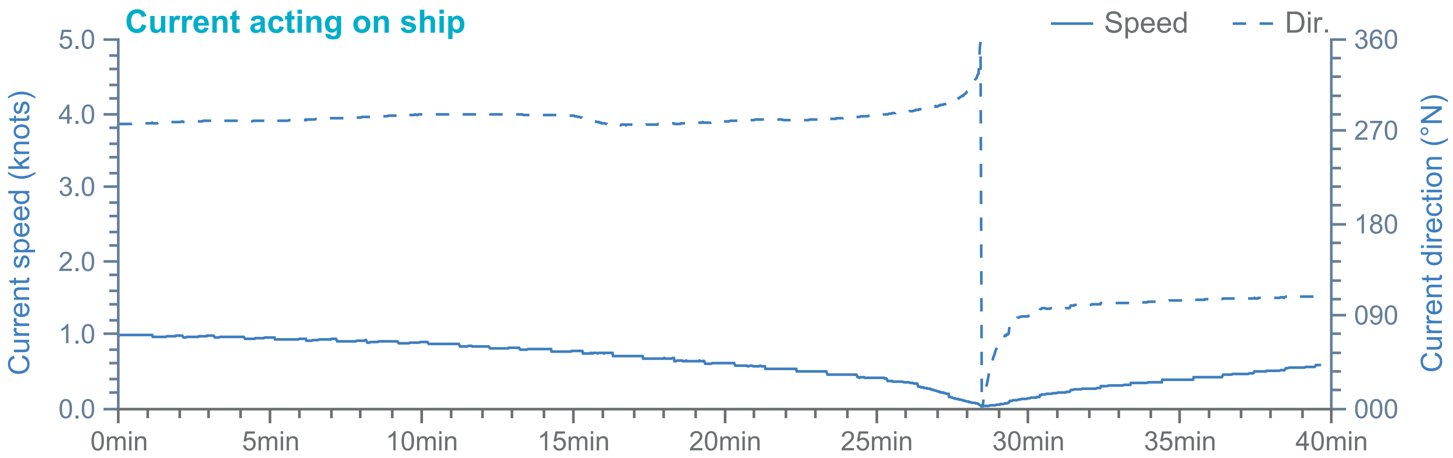


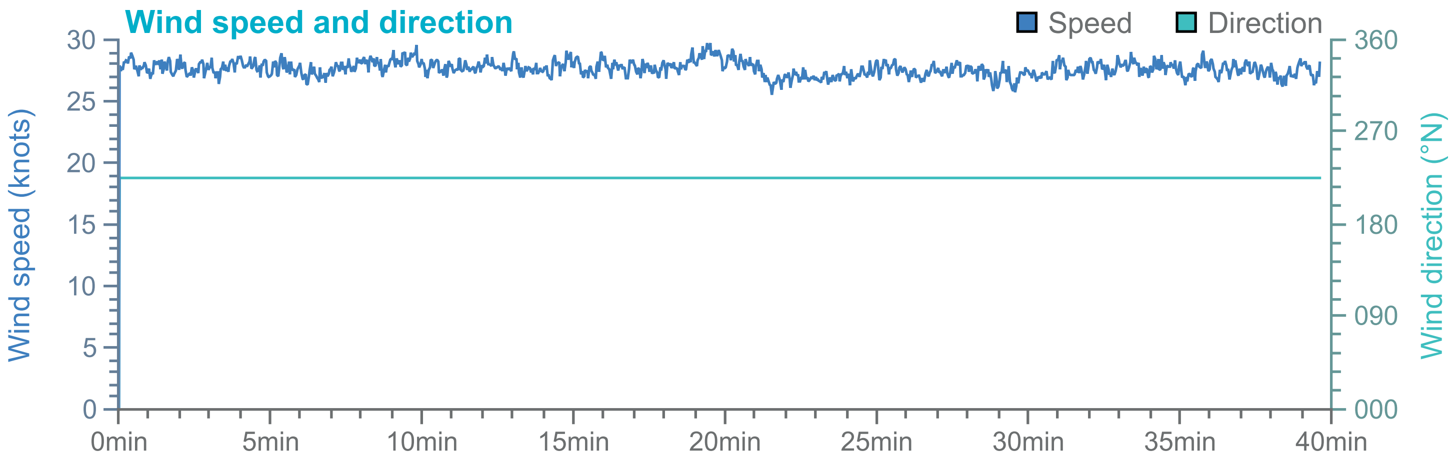
1.38 kts

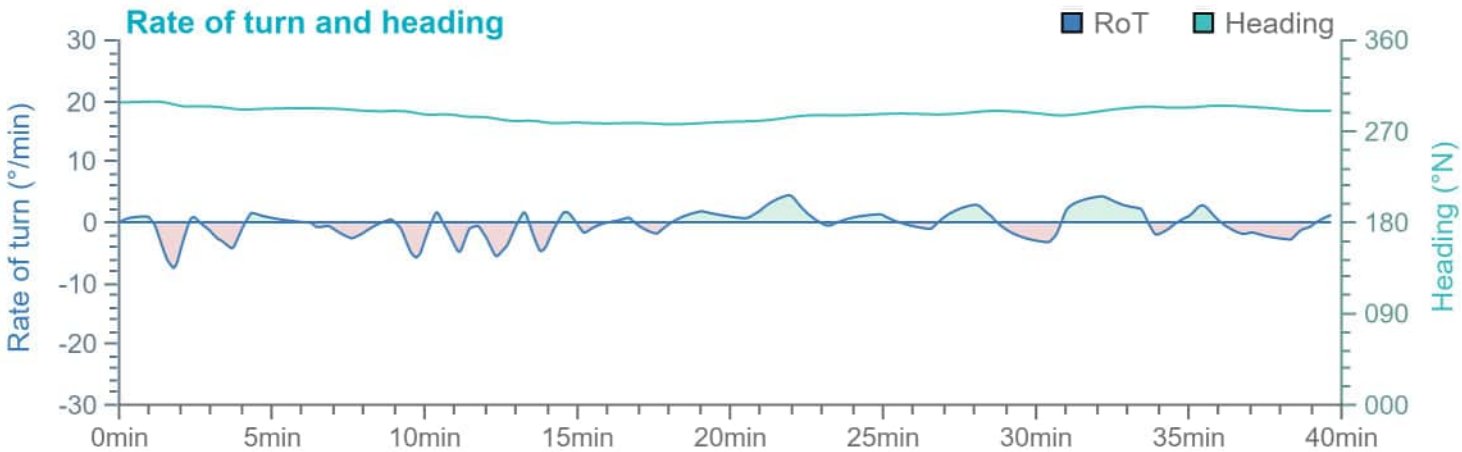
Ships plotted every 1 mins, highlight every 10 mins

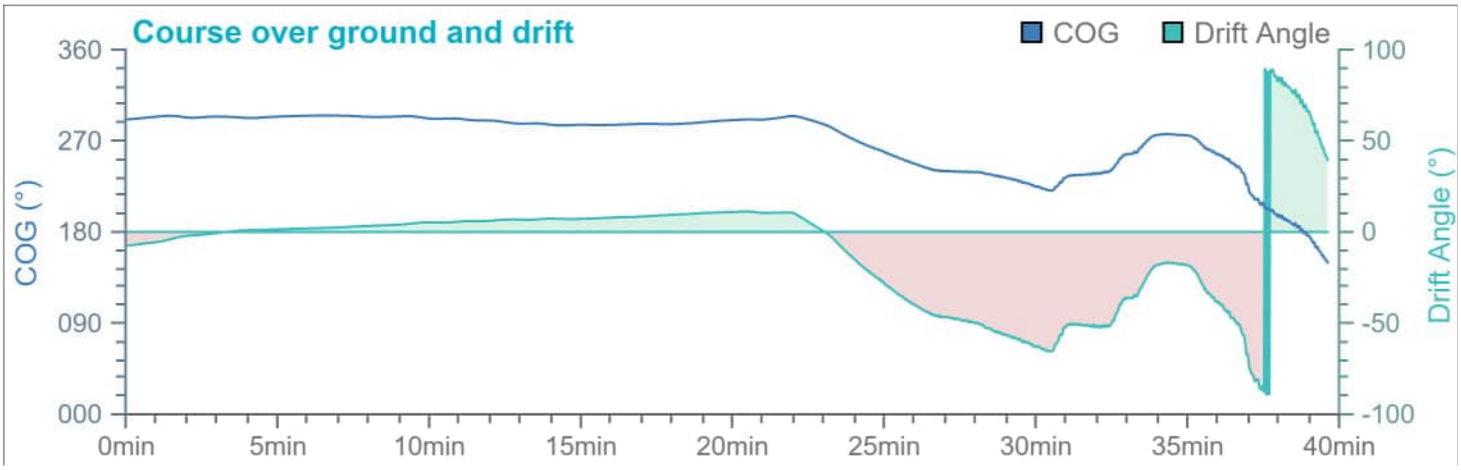
Manoeuvre track plot

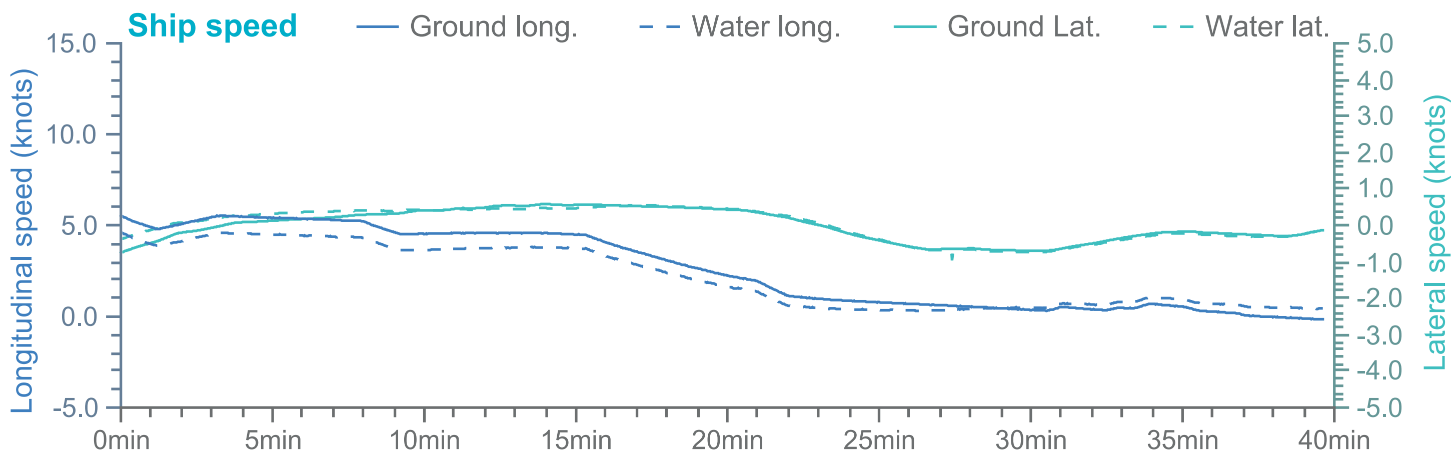


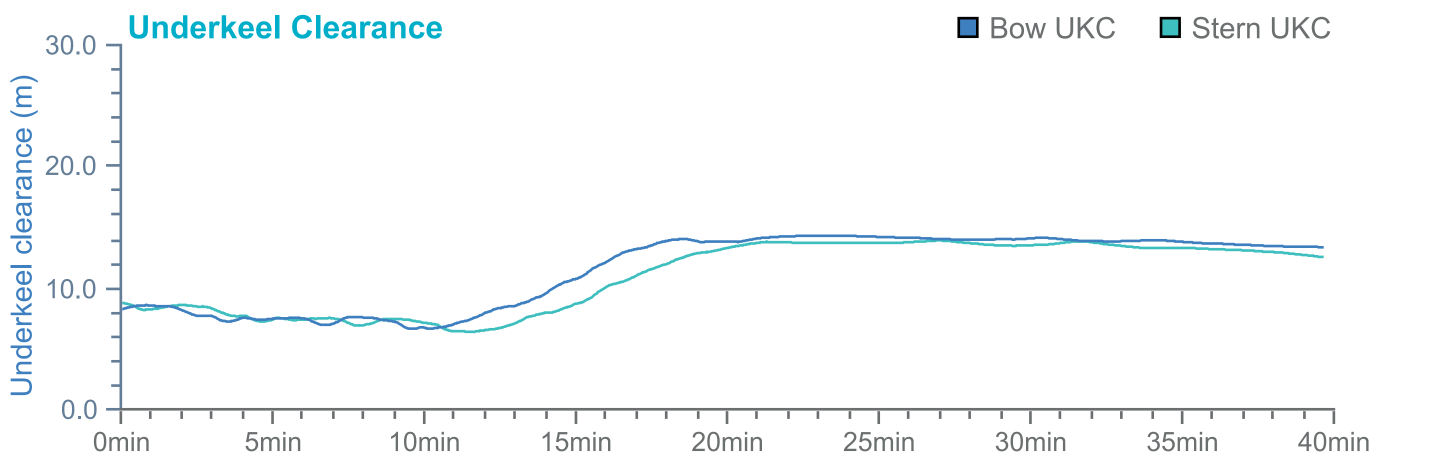

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min

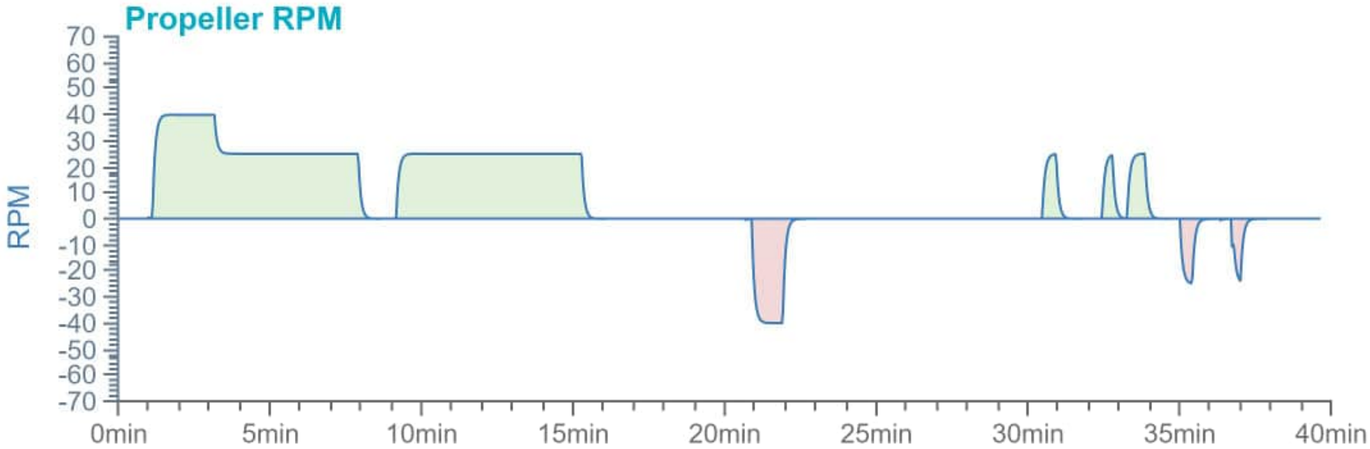

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min

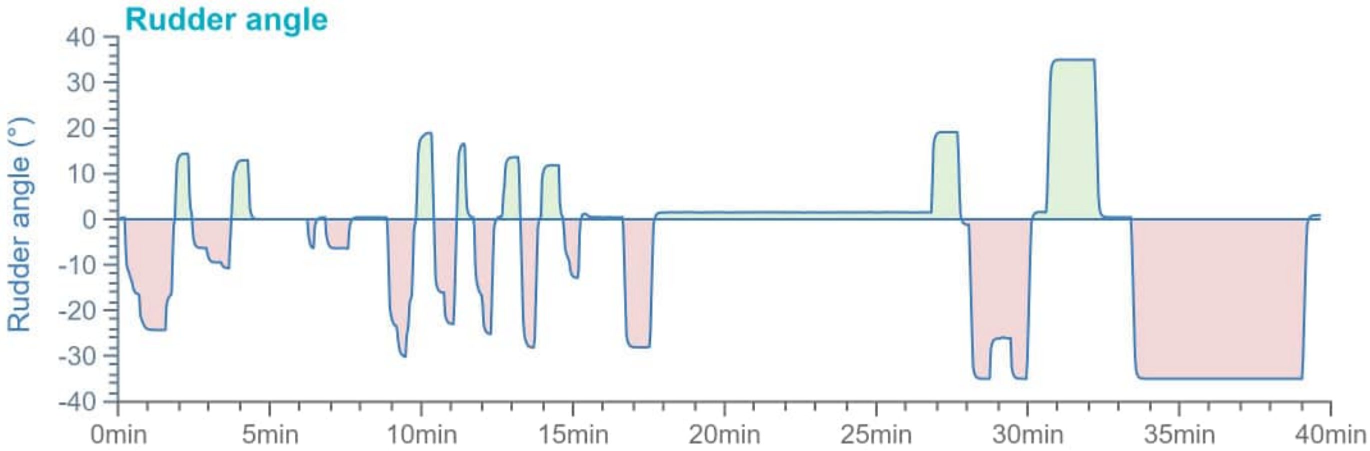

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min

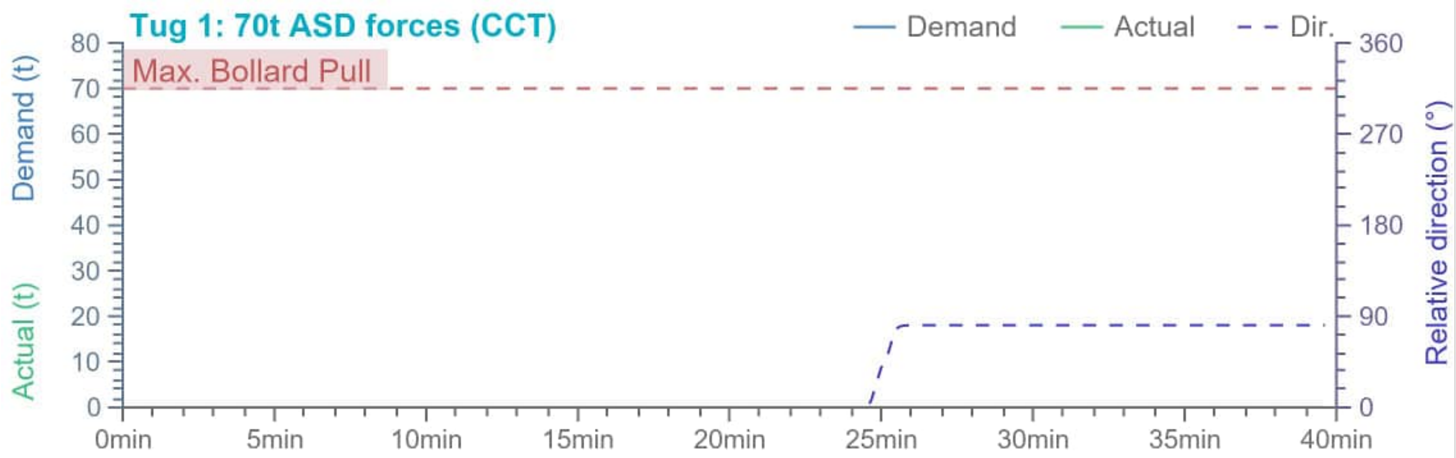

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min
40min

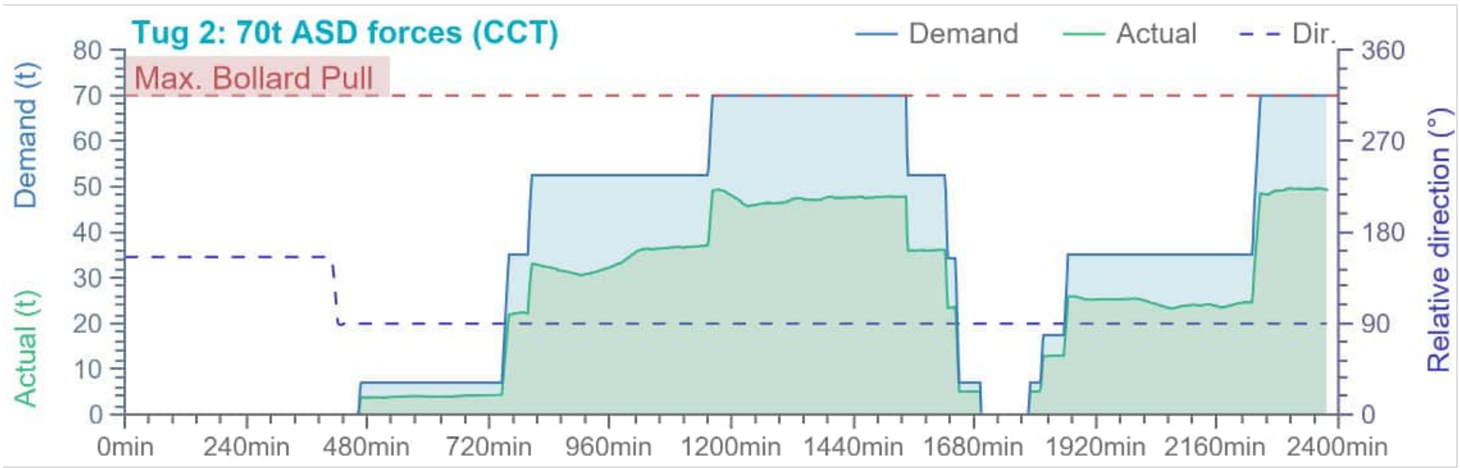

Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min
35min
40min

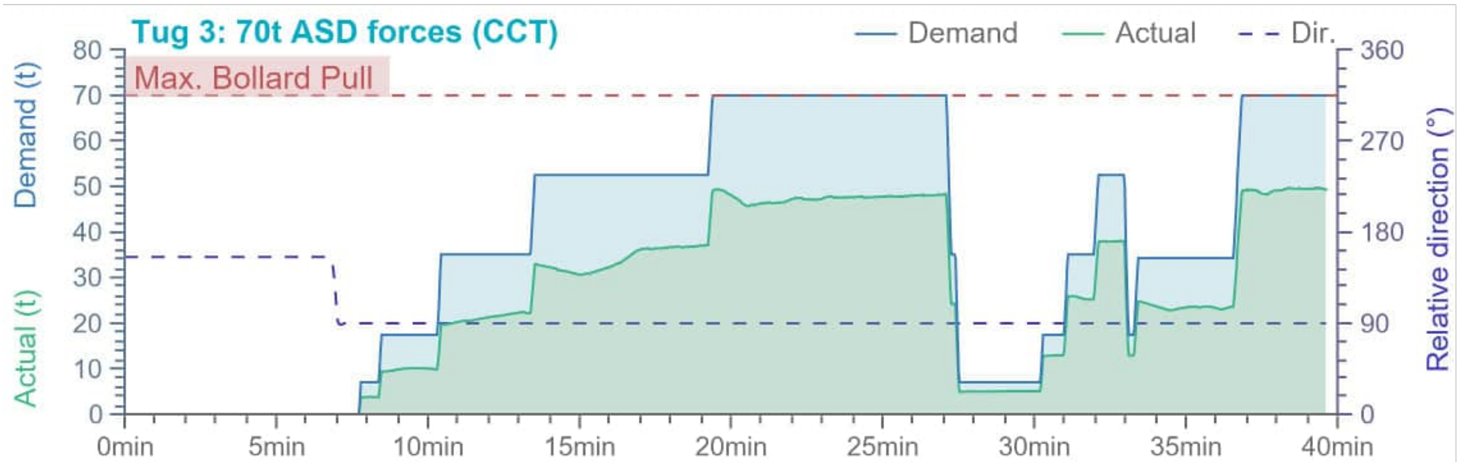

Underkeel Clearance
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min
35min
40min

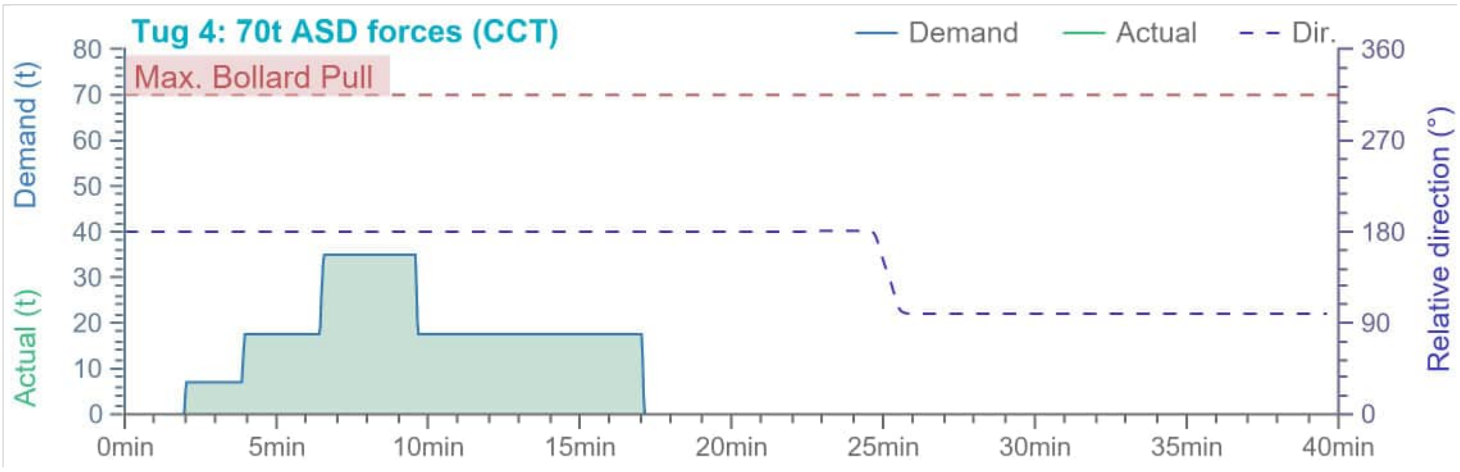

Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min
30min
35min
40min

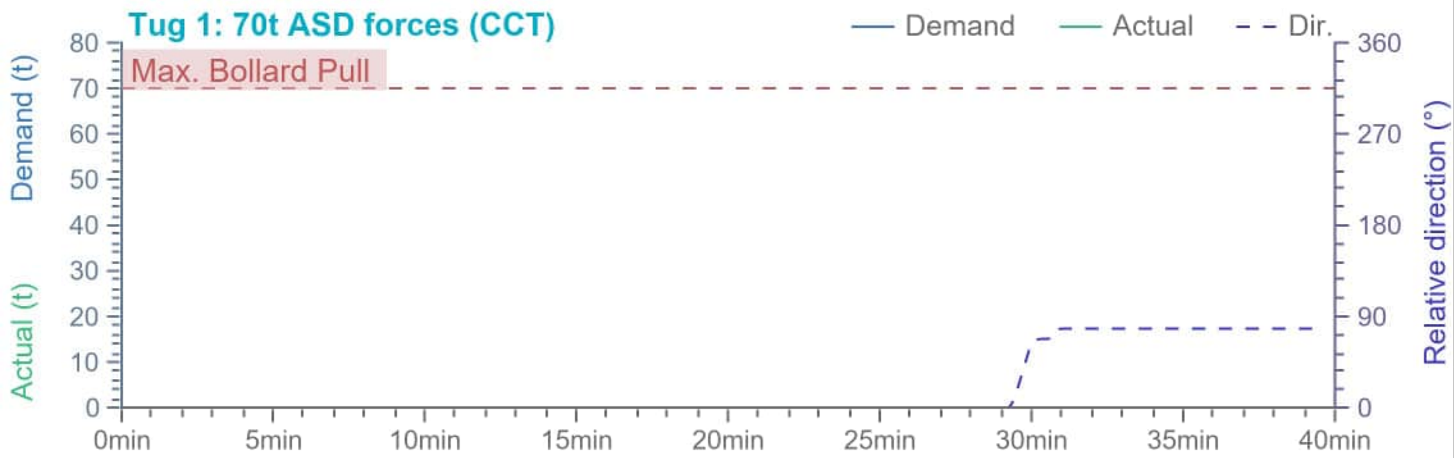

Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min
30min
35min
40min

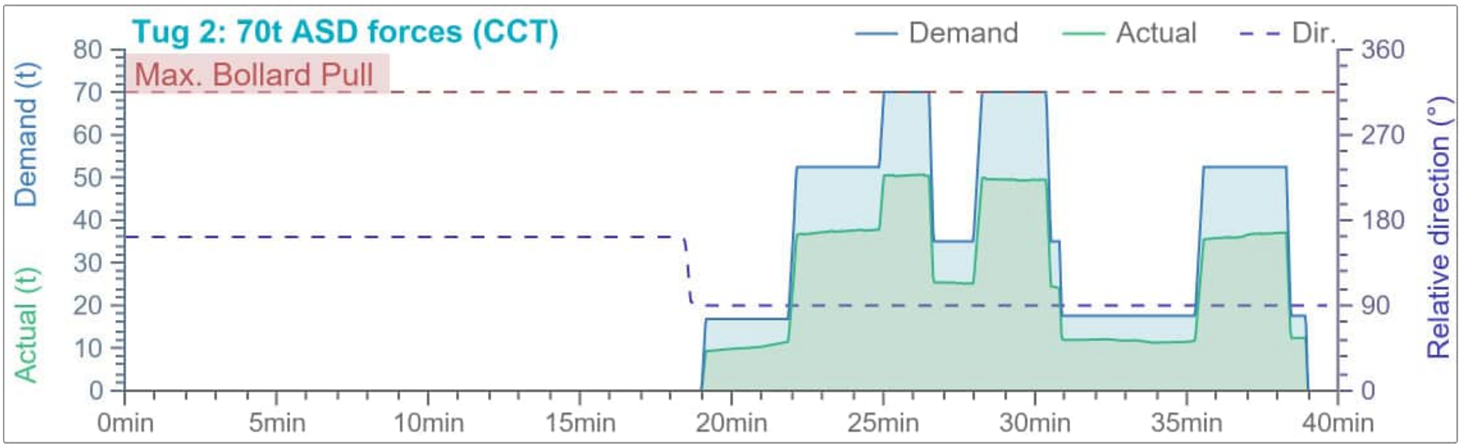

Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min
35min
40min

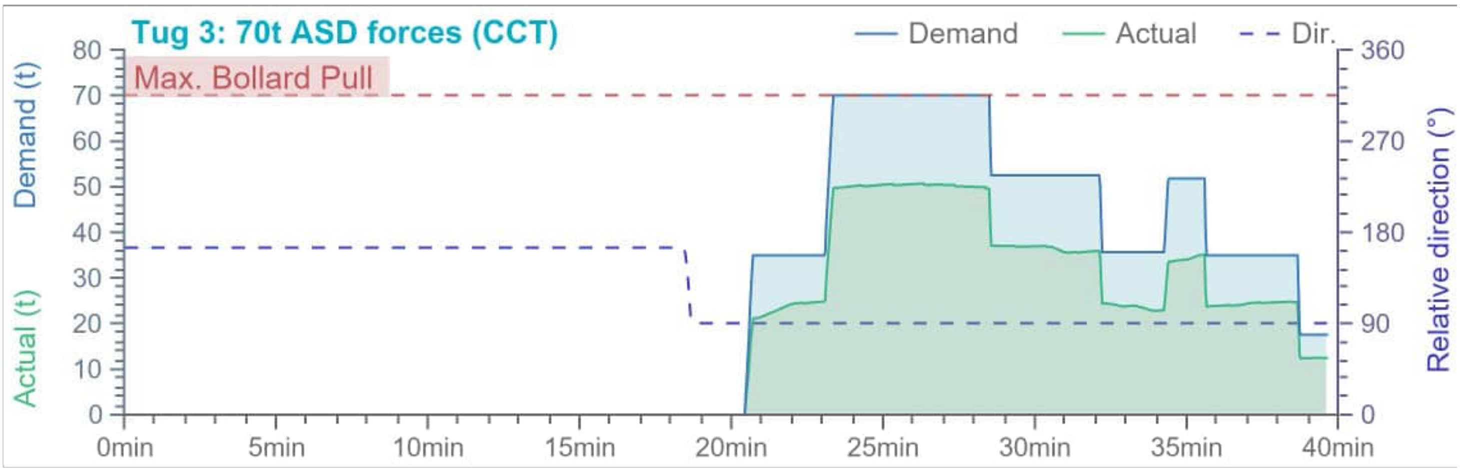

Tug 2: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
240min
480min
720min
960min
1200min
1440min
1680min
1920min
2160min
2400min

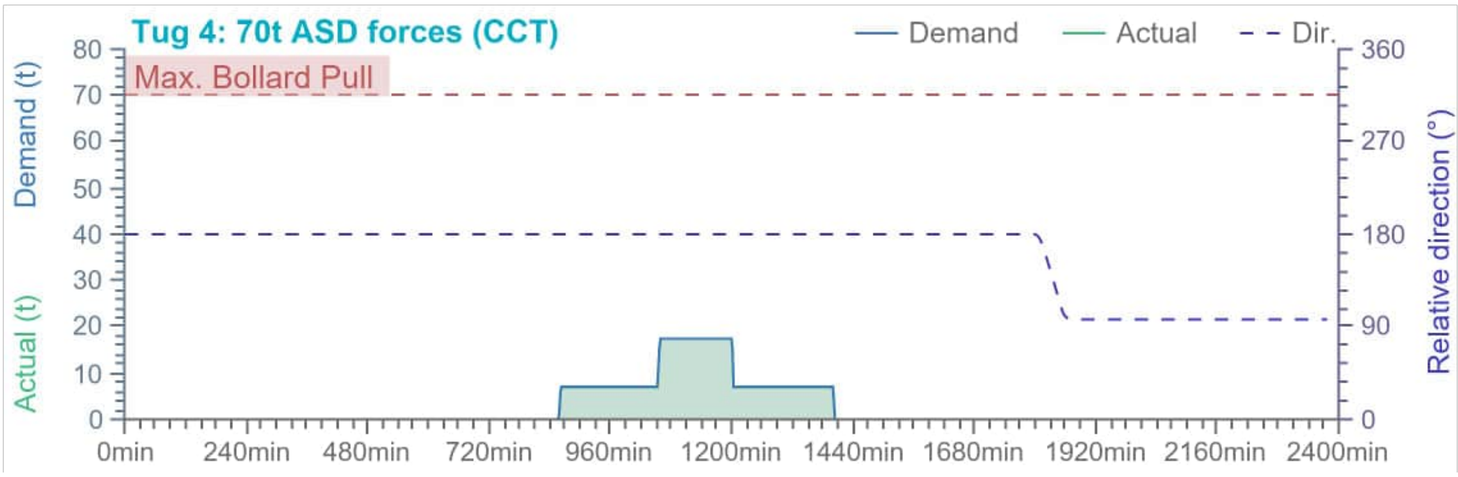

Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min
35min
40min


Tug 4: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min
35min
40min


Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min
35min
40min

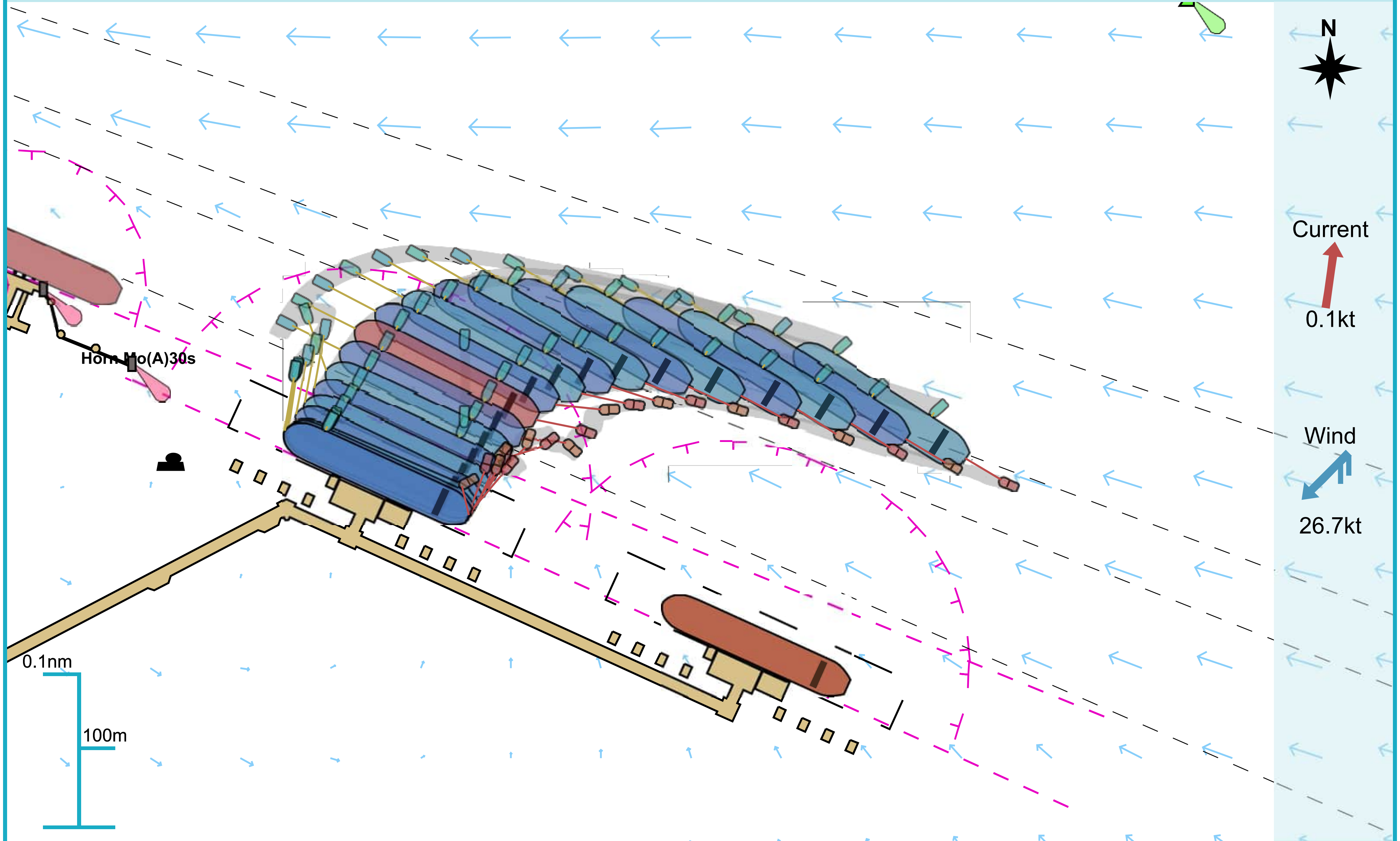

Tug 2: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min
35min
40min


Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min
35min
40min


Tug 4: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
240min
480min
720min
960min
1200min
1440min
1680min
1920min
2160min
2400min

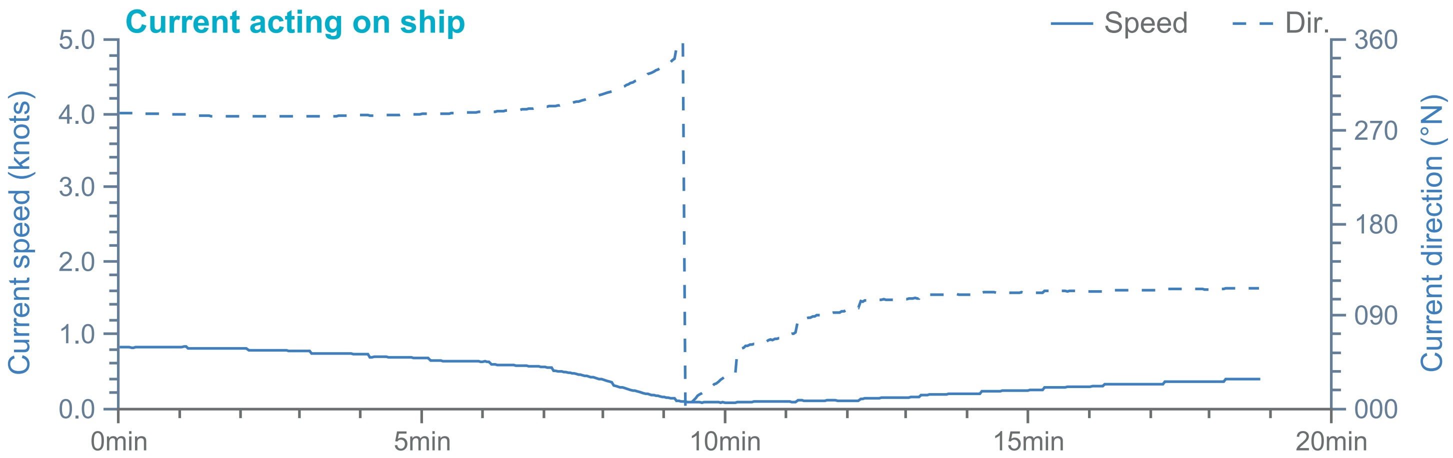
Overview | Environment | 243m Product Tanker | Tugs

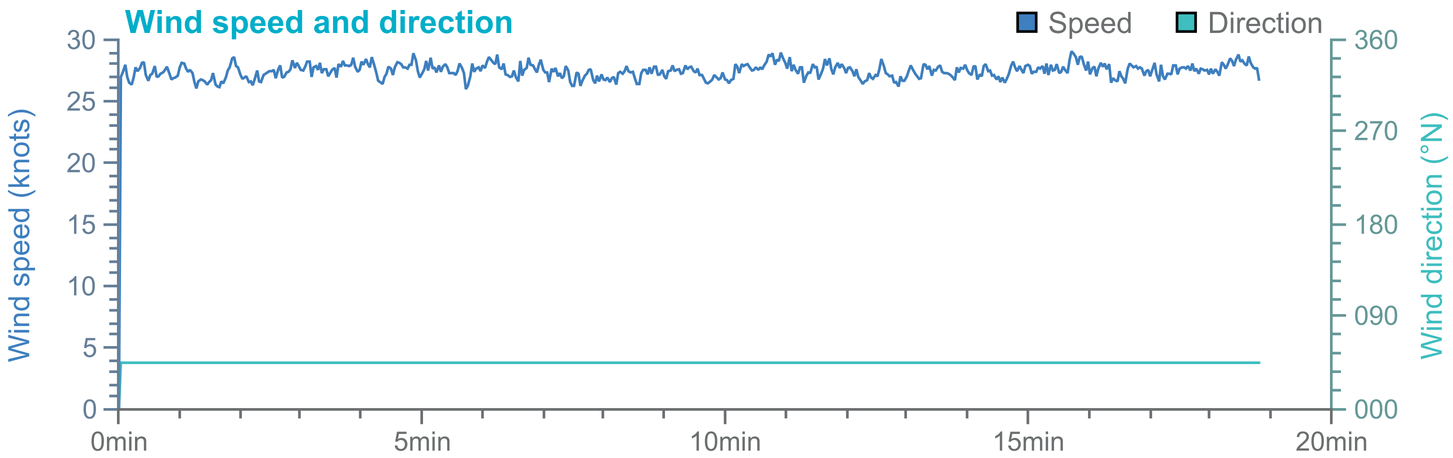
Manoeuvre track plot

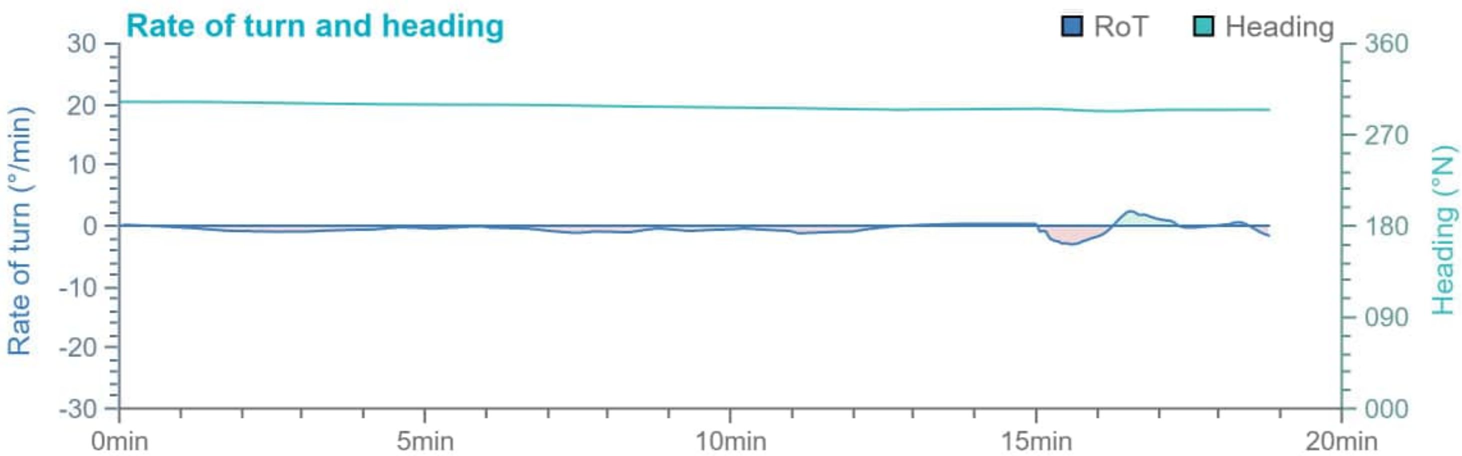


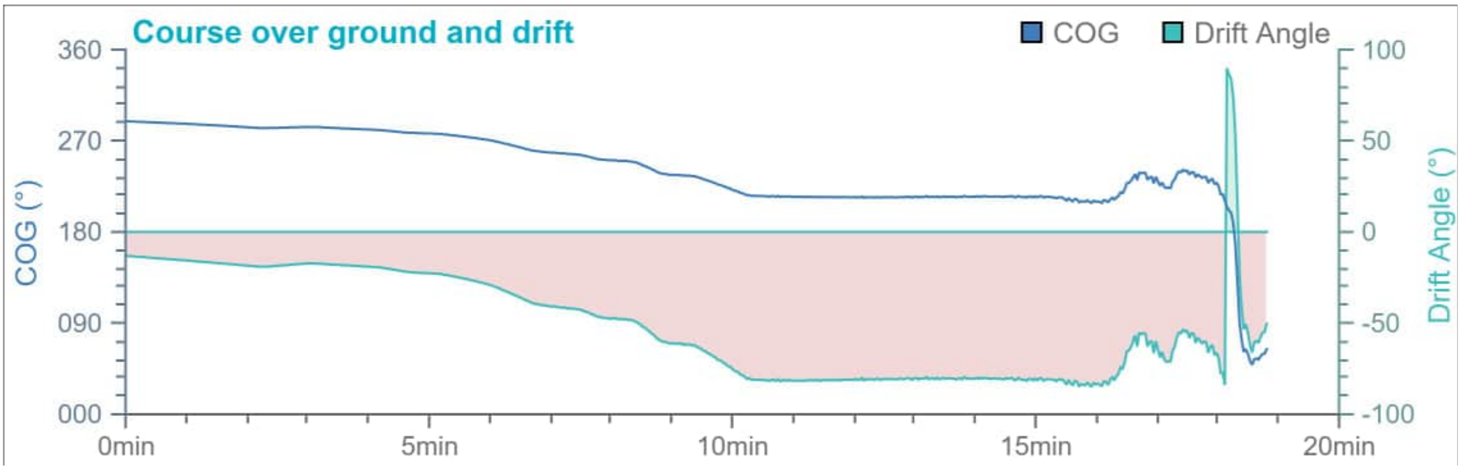
0.93 kts

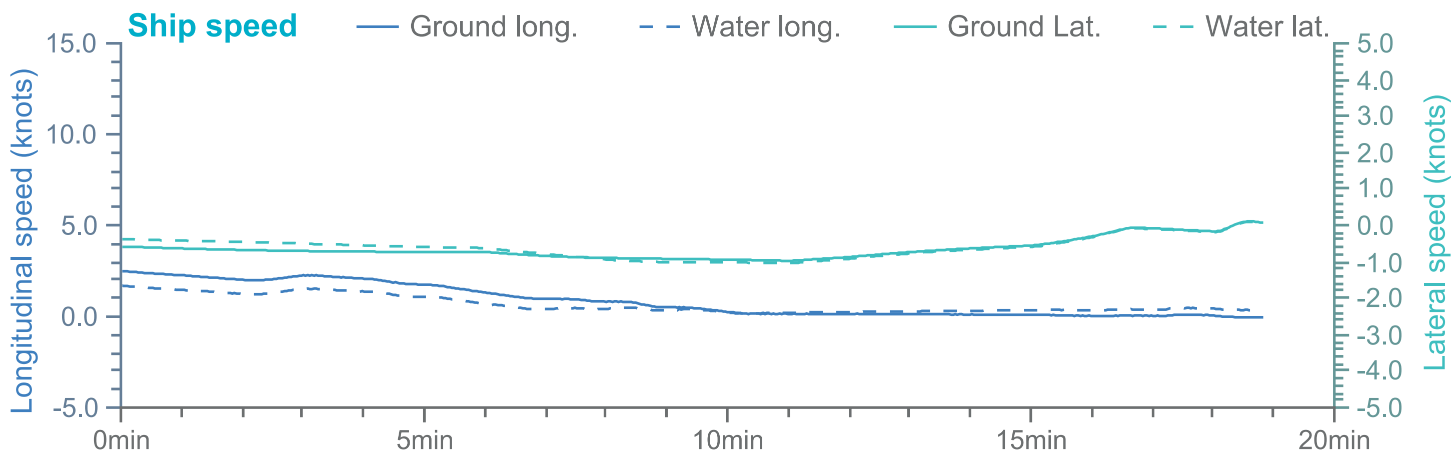
Ships plotted every 1 mins, highlight every 10 mins

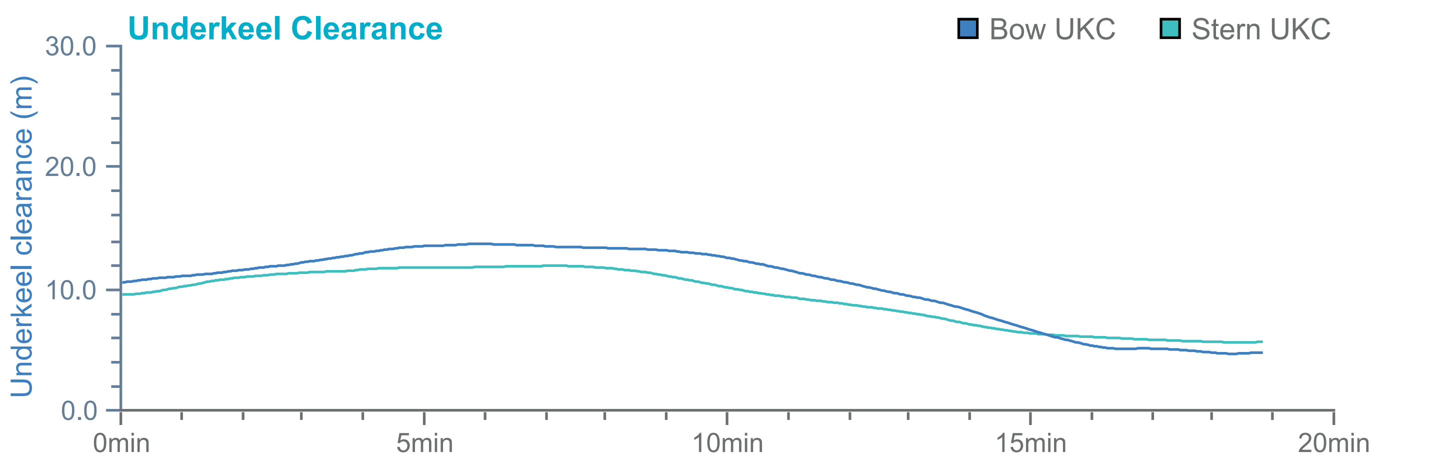

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min


Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min

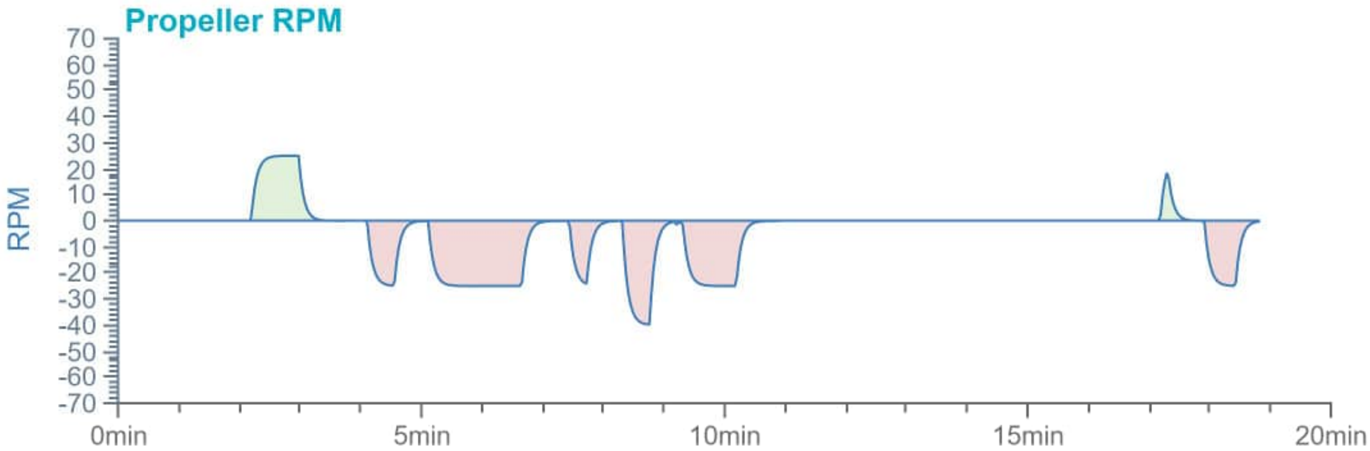

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min
15min
20min

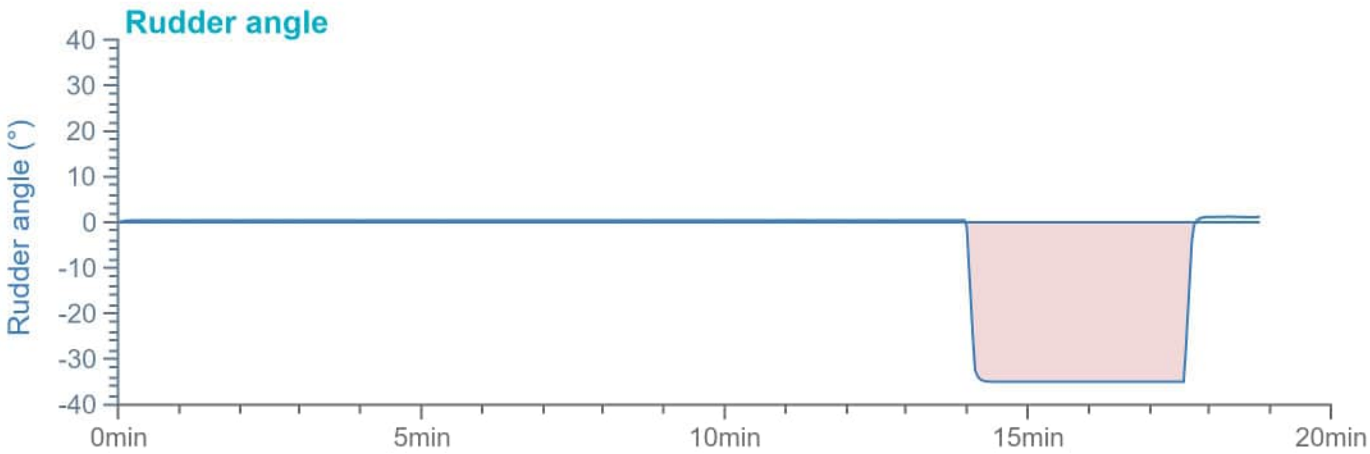

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min


Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min

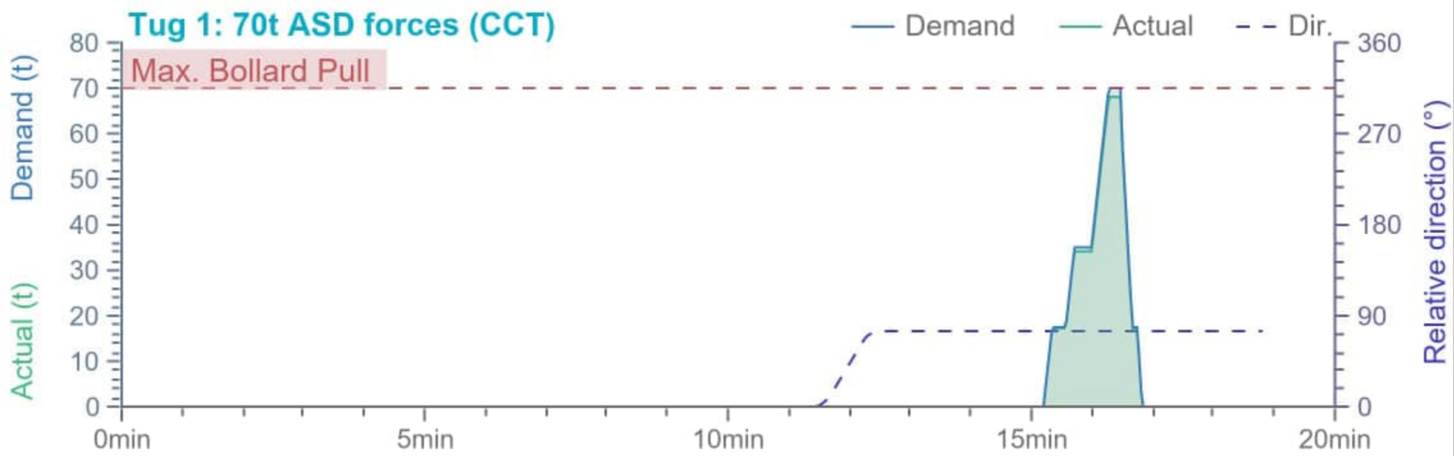

Underkeel Clearance
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min

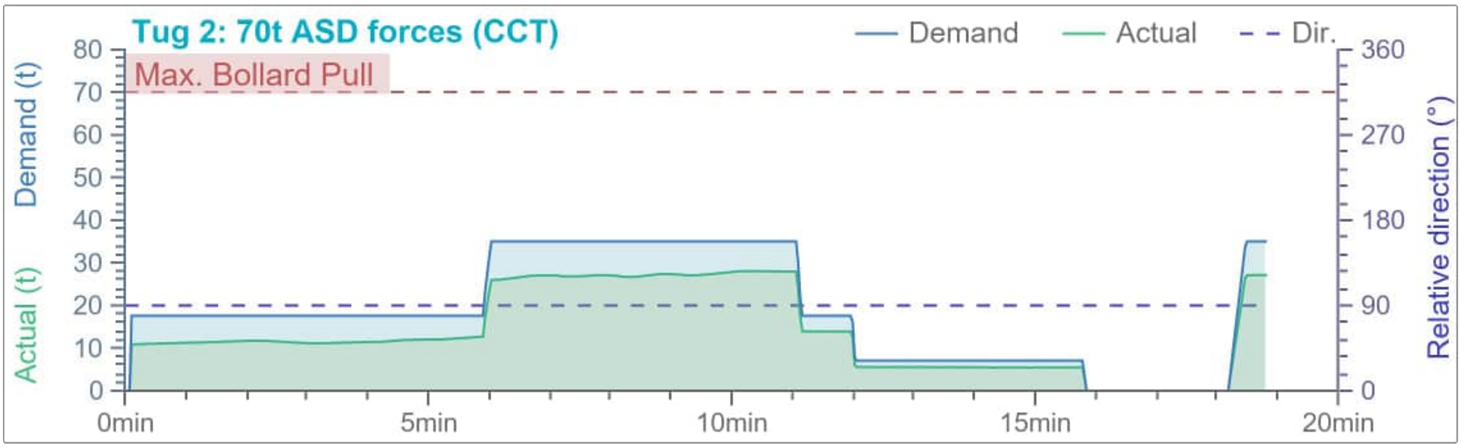
Overview | Environment | 243m Product Tanker | Tugs

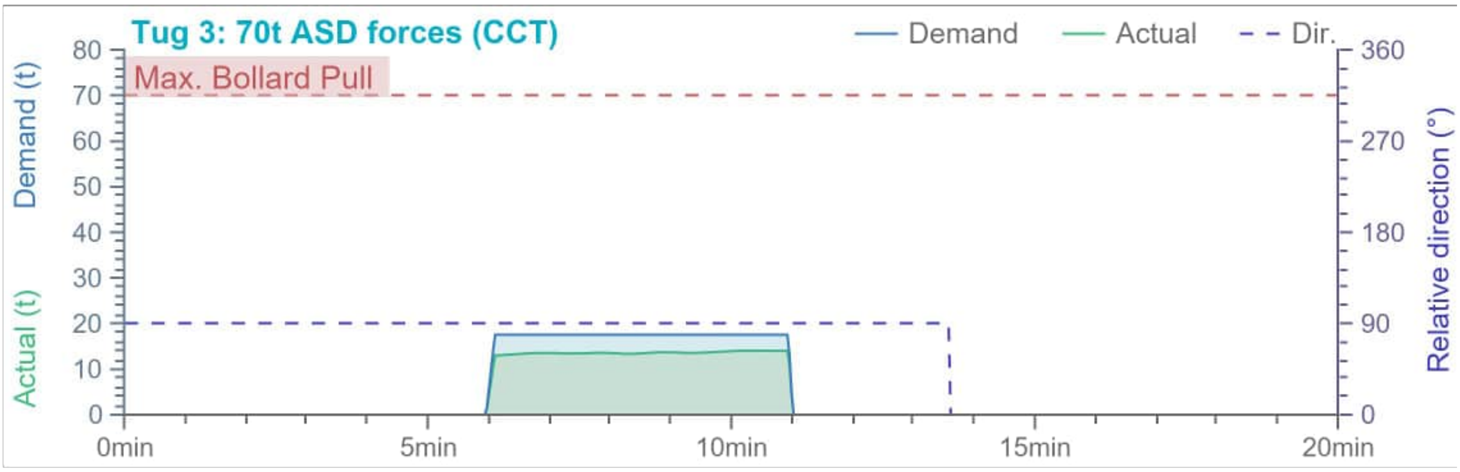


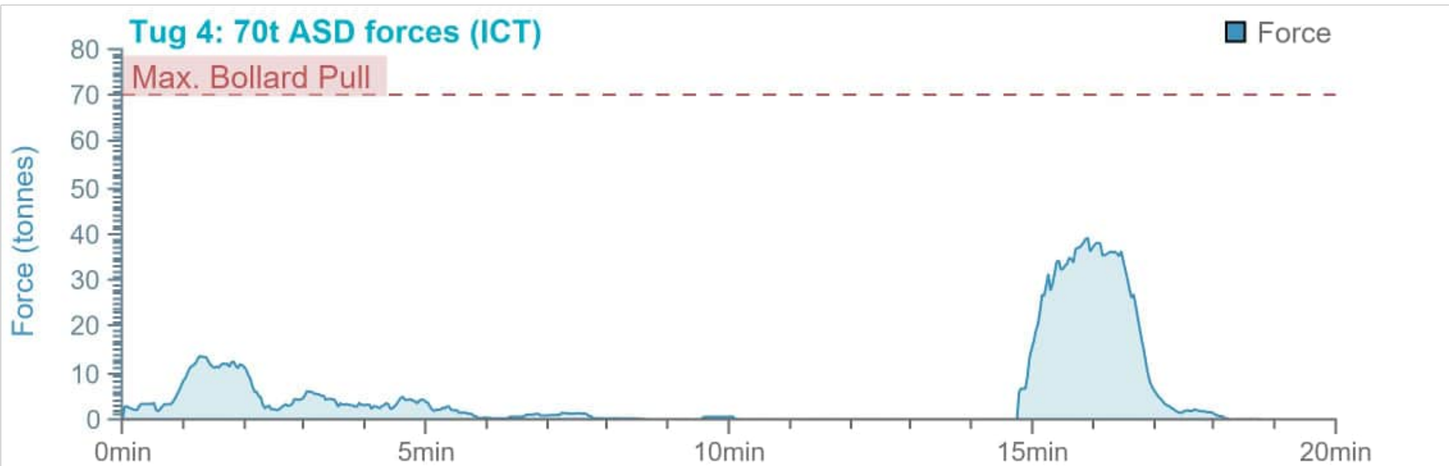


Overview | Environment | 243m Product Tanker | Tugs



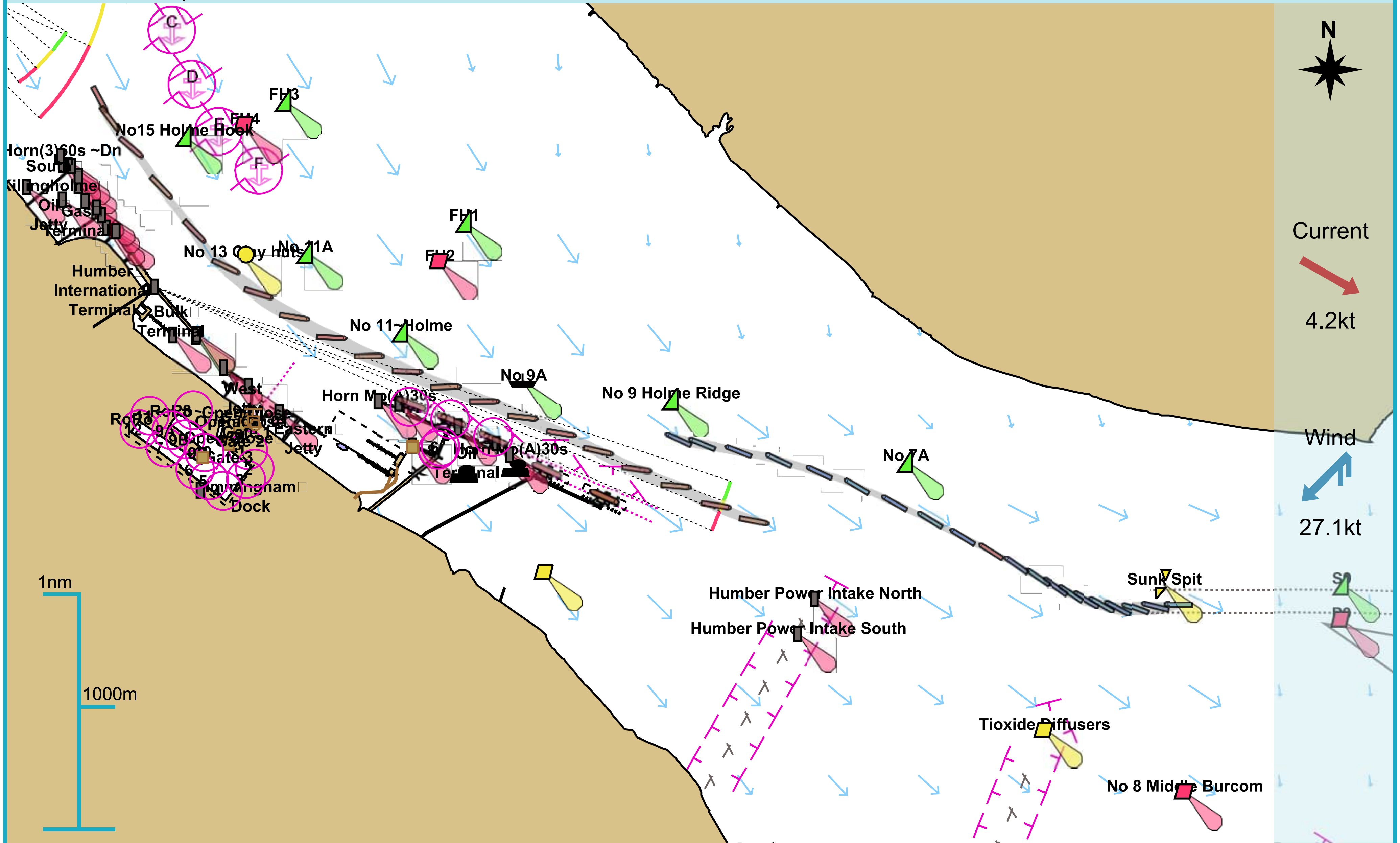






Overview | Environment | MV Celine

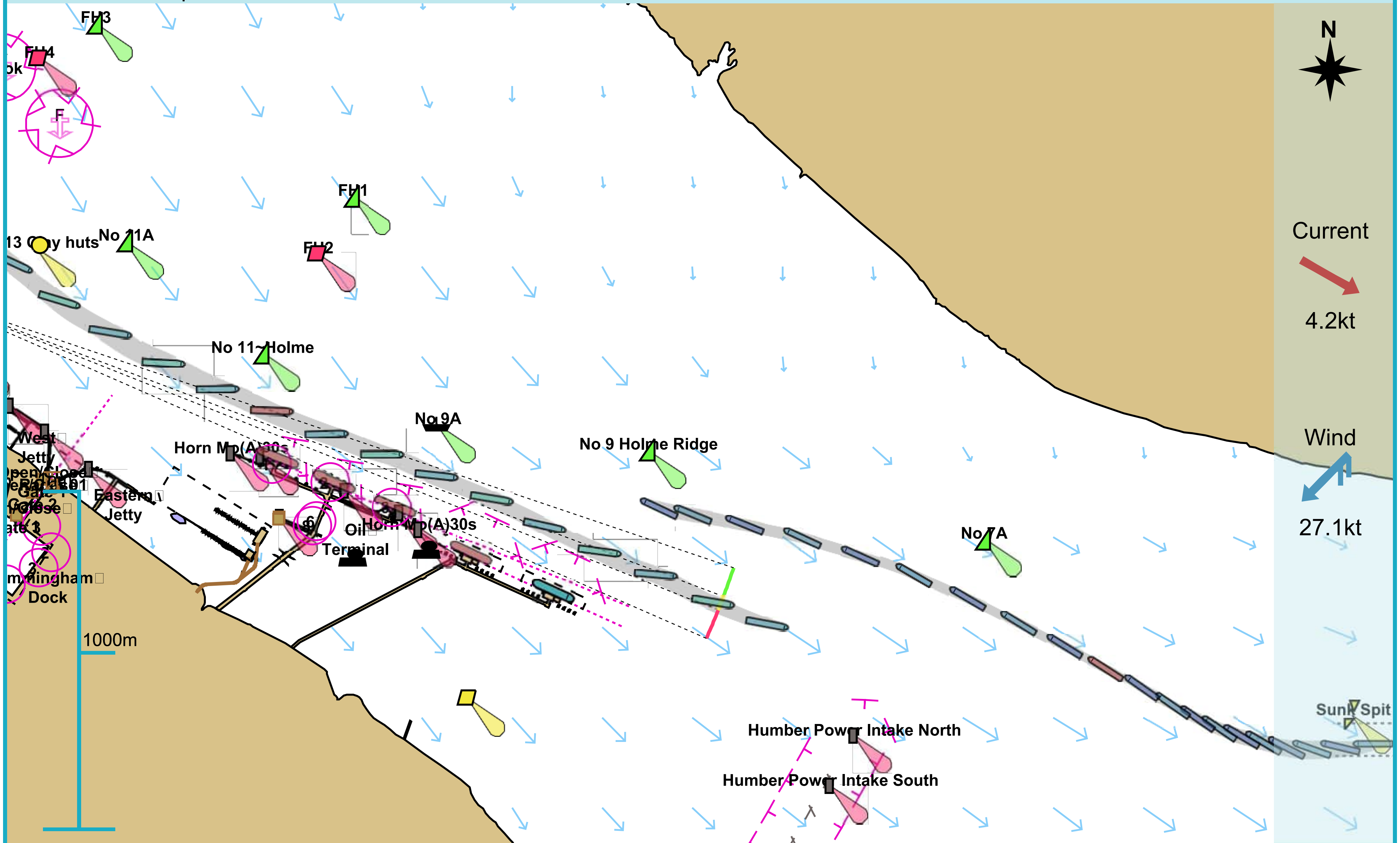
Manoeuvre track plot



4.97 kts

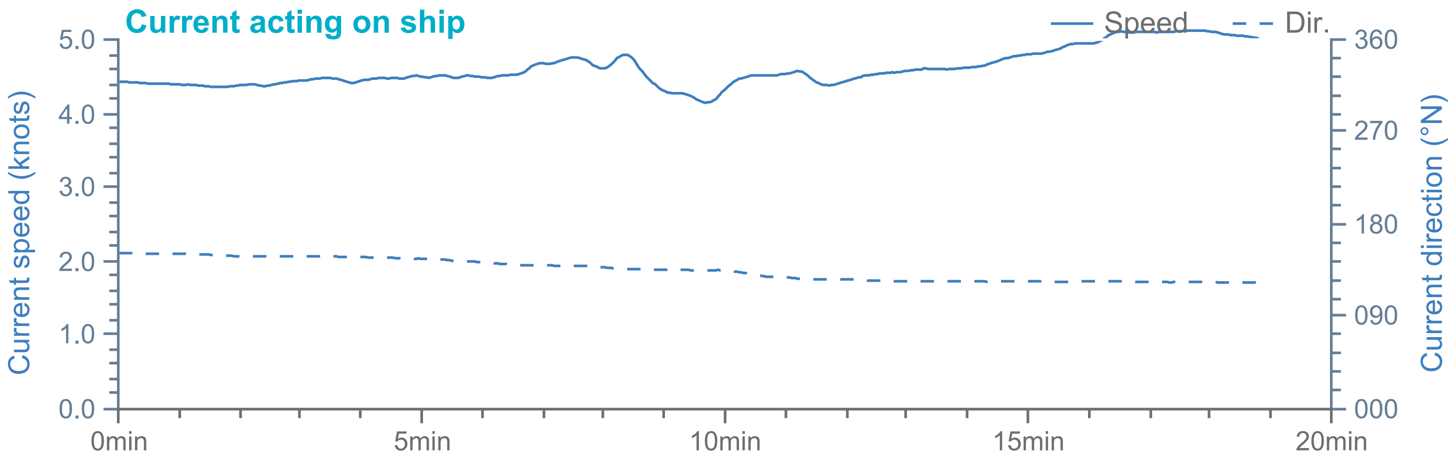
Ships plotted every 1 mins, highlight every 10 mins

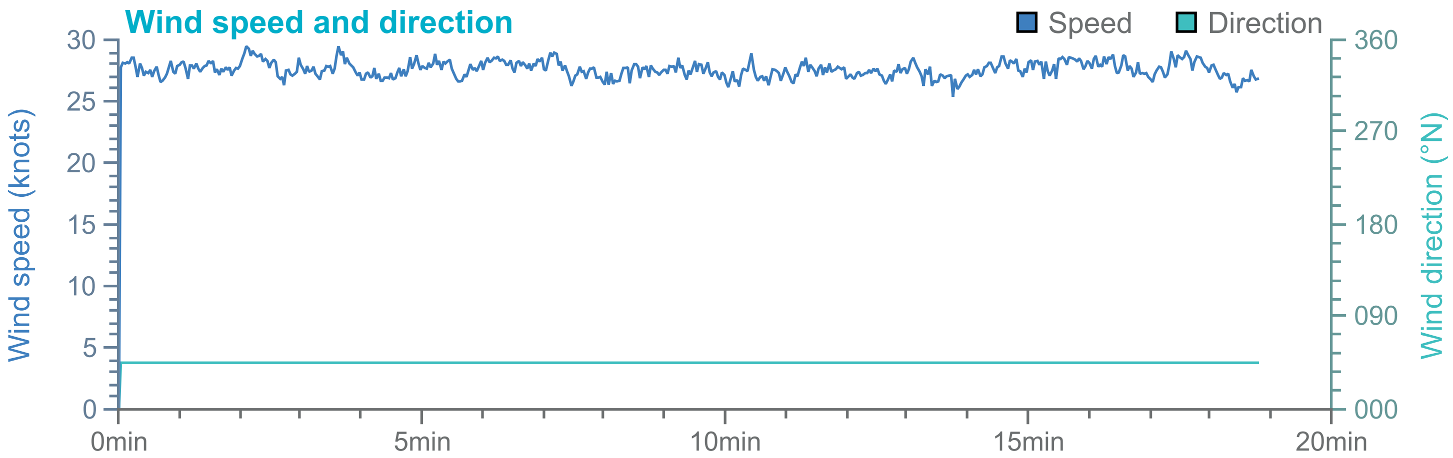
Manoeuvre track plot



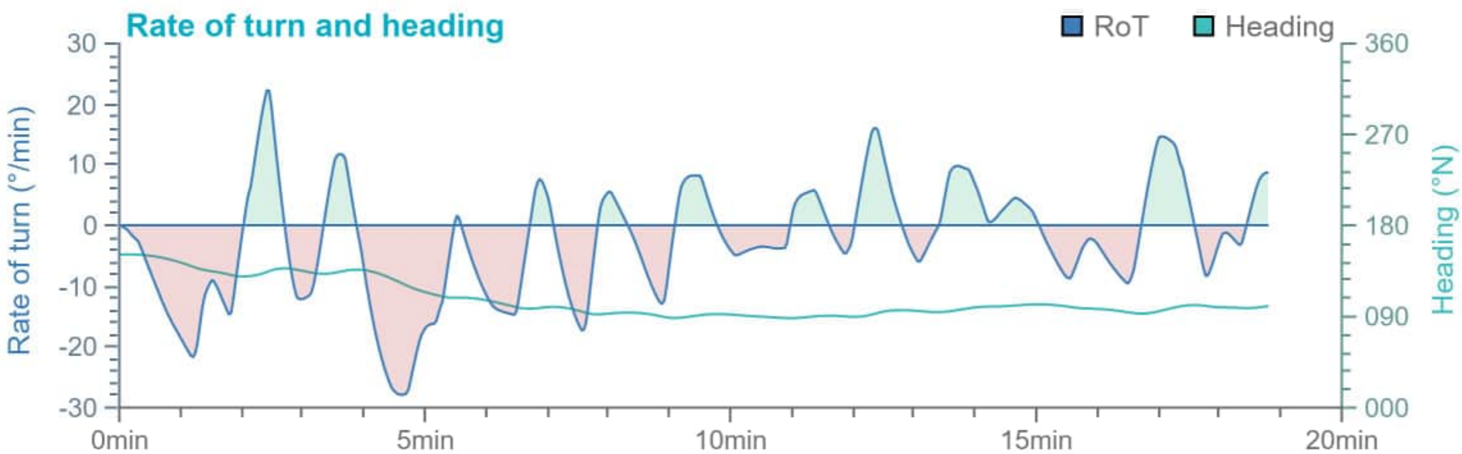
4.95 kts

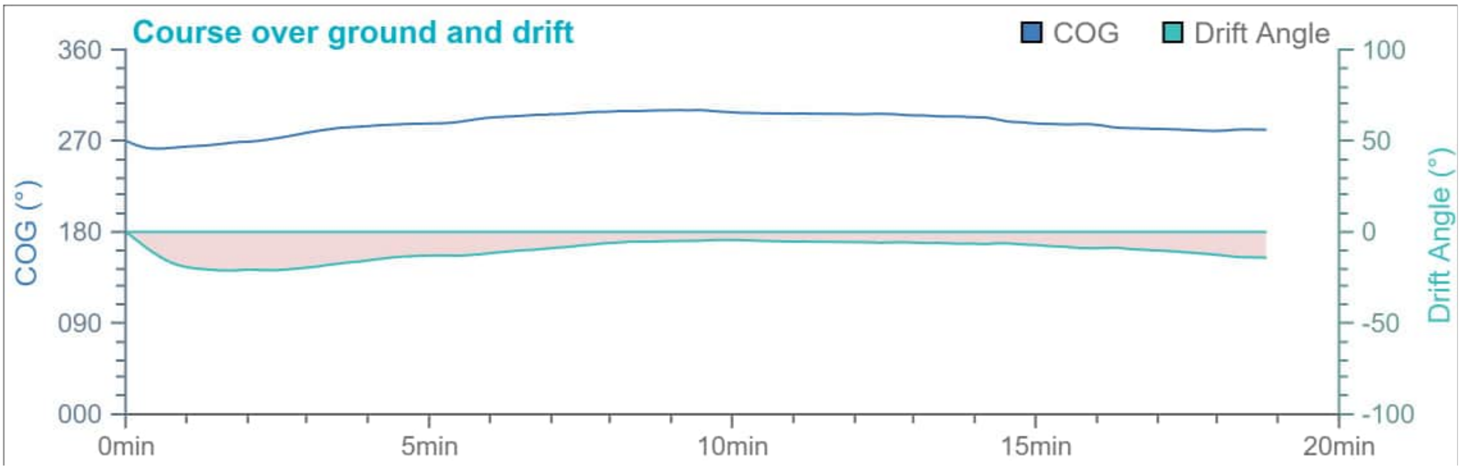
Ships plotted every 1 mins, highlight every 10 mins

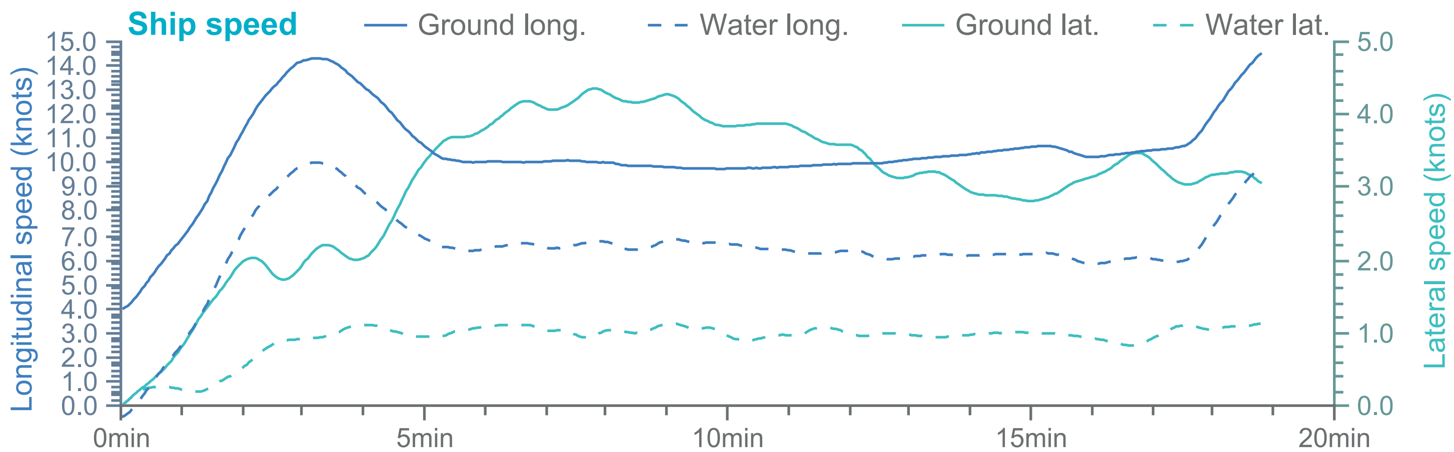

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min

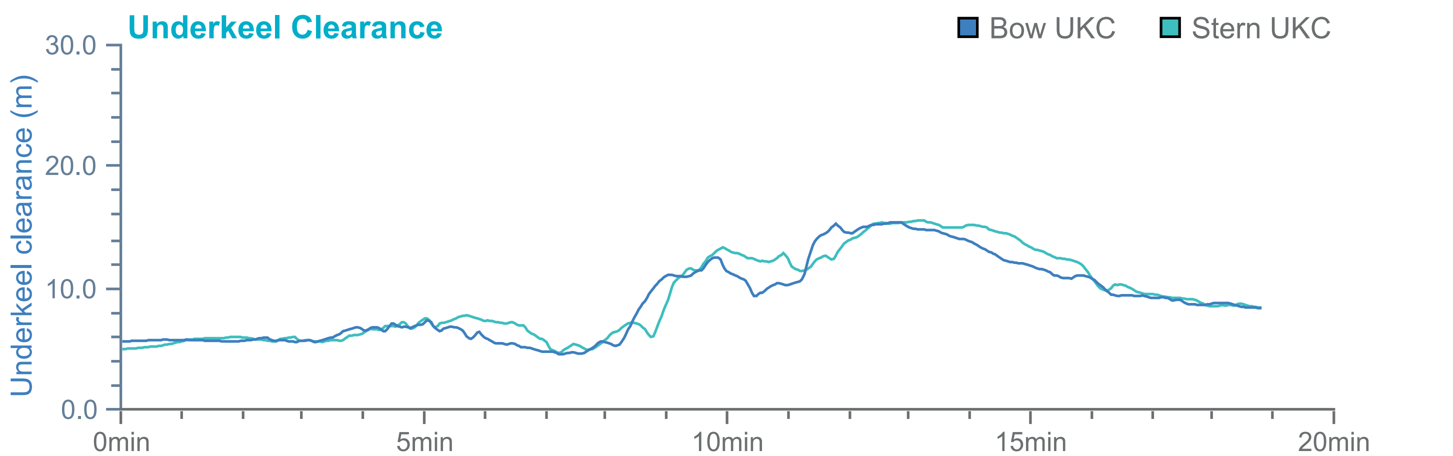

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min

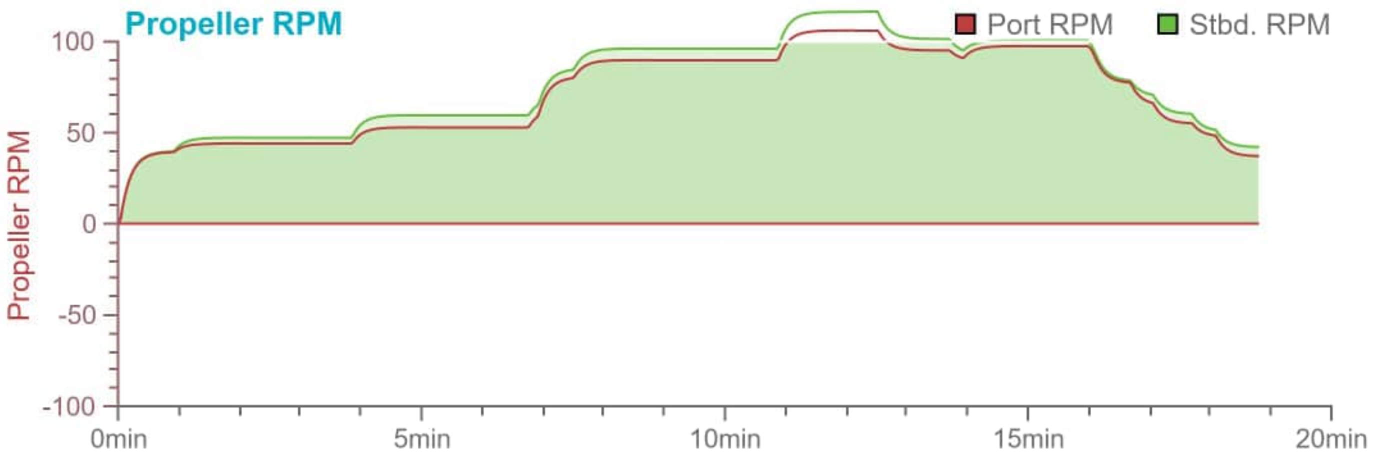
Overview | Environment | MV Celine

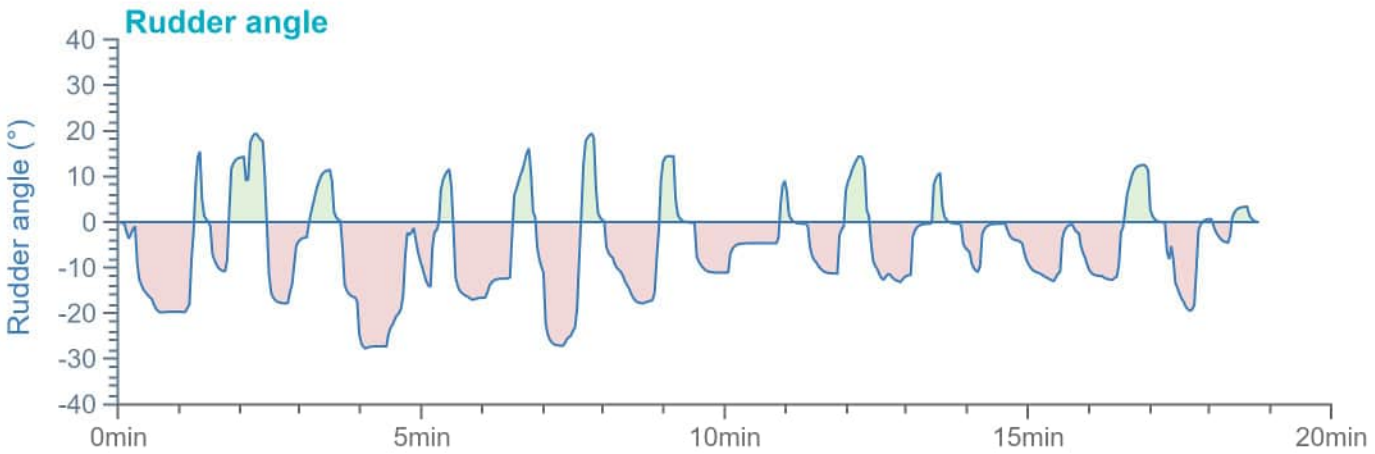




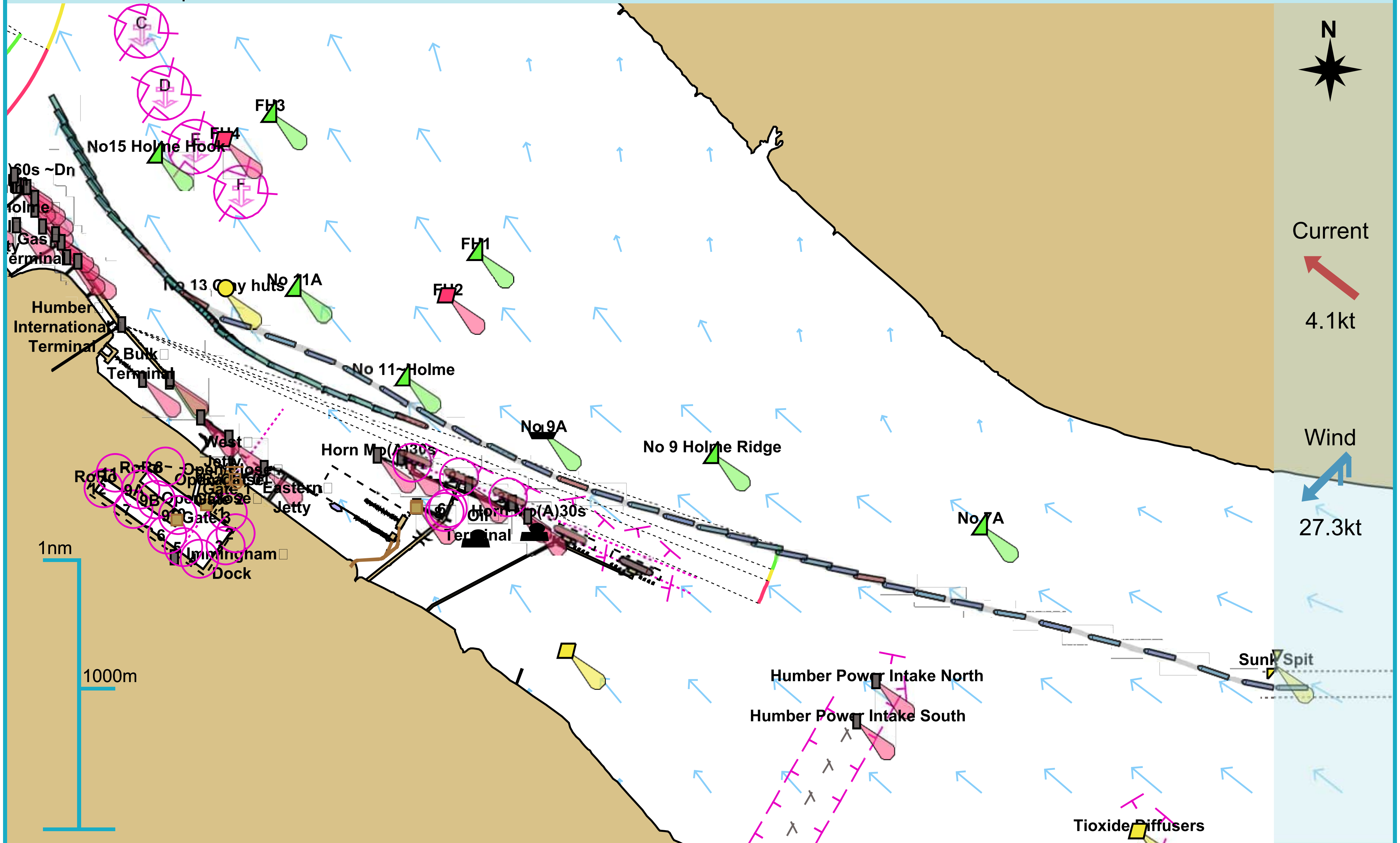





Propeller RPM
Port RPM
Stbd. RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min
20min


Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min

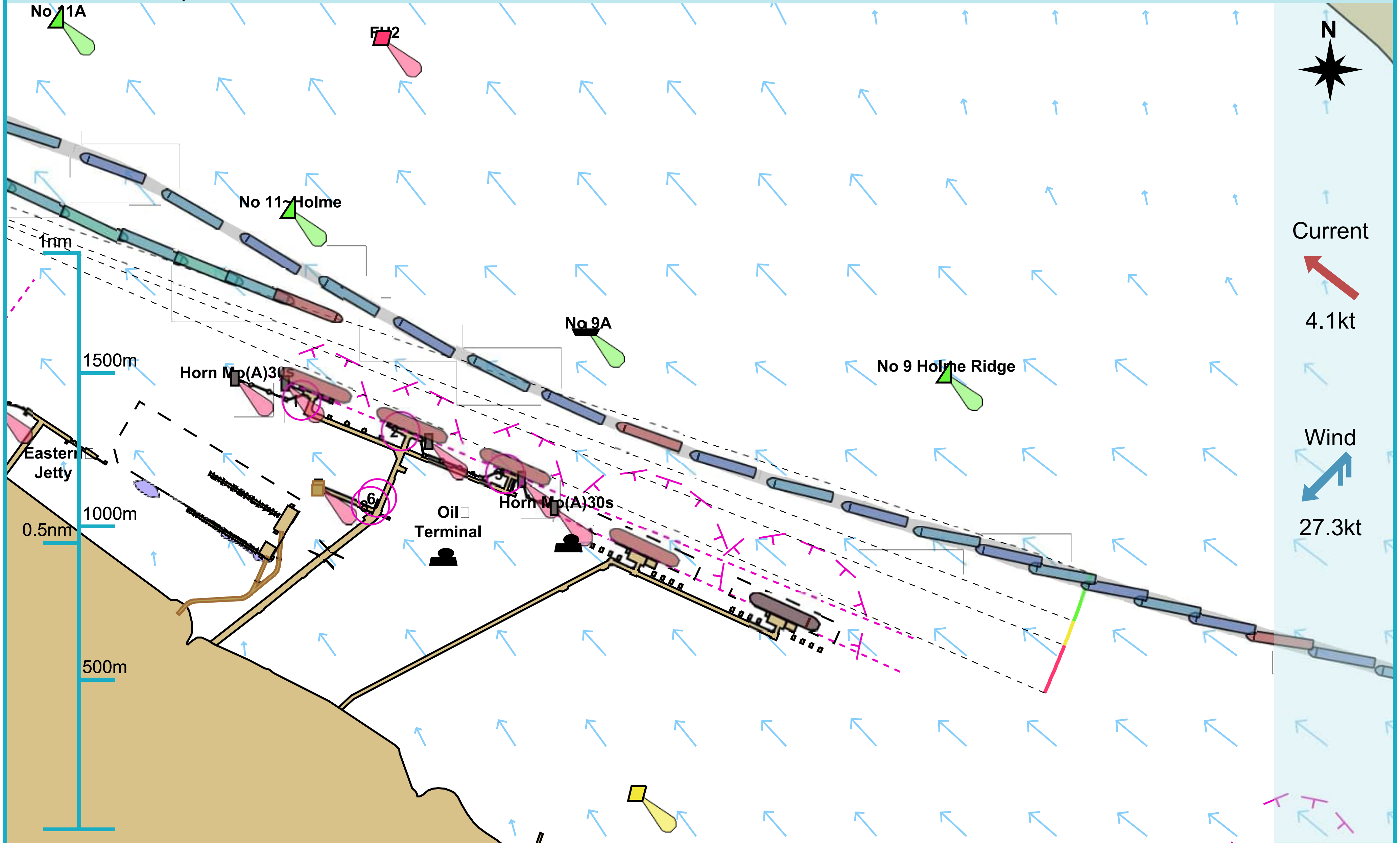
Manoeuvre track plot



→ 3.92 kts

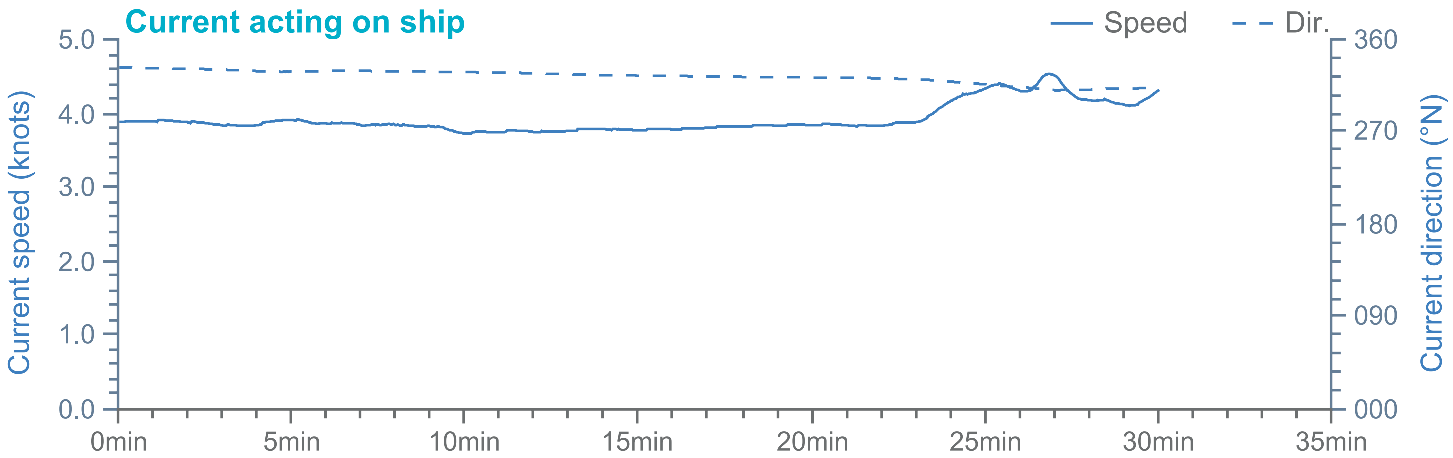
Ships plotted every 1 mins, highlight every 10 mins

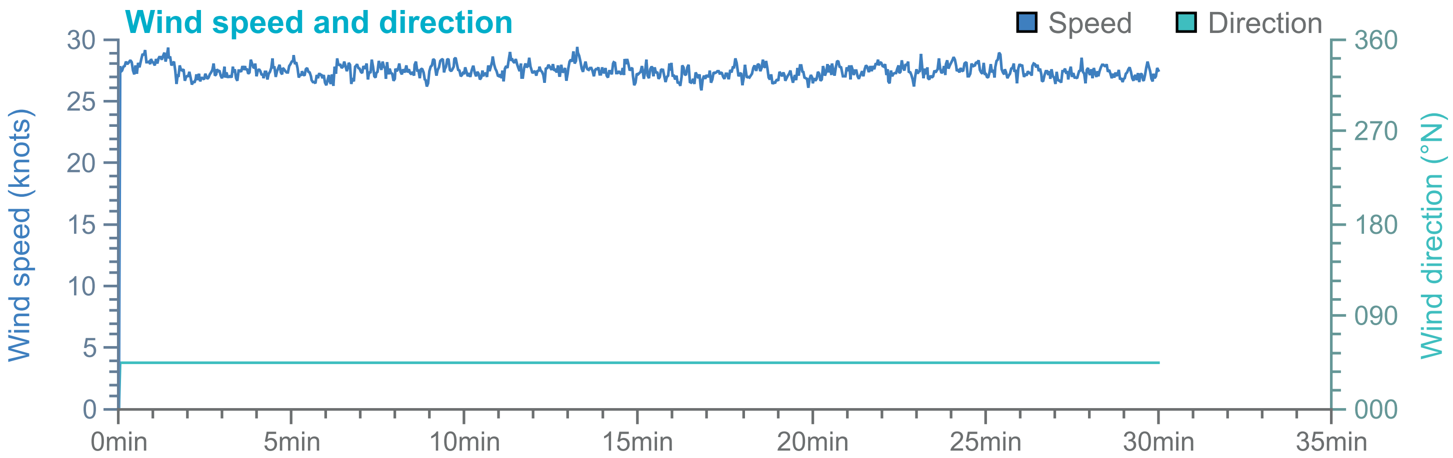
Manoeuvre track plot

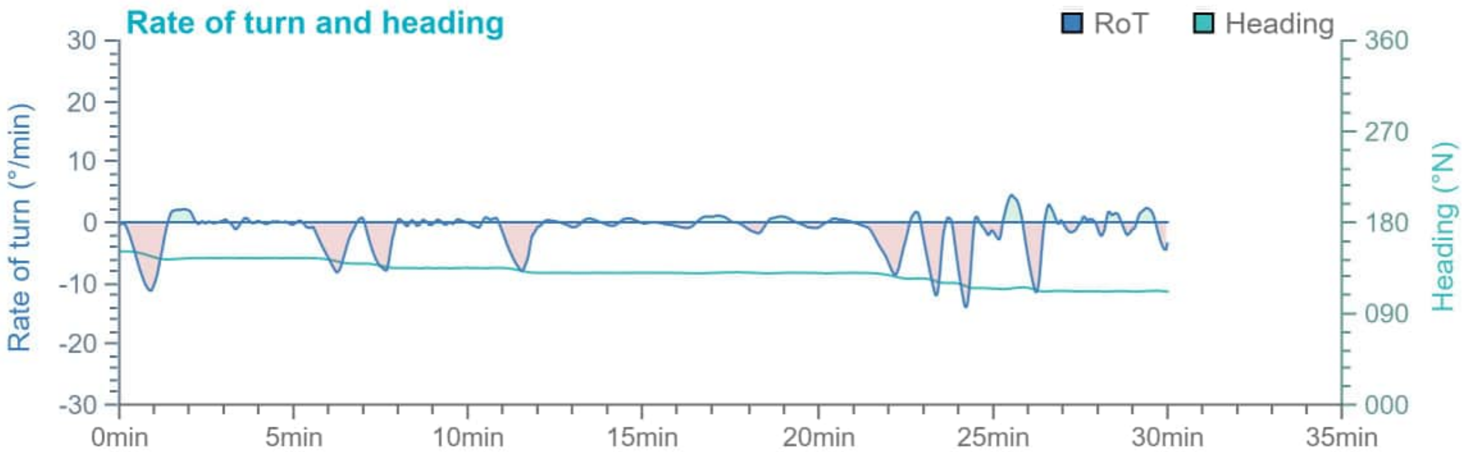


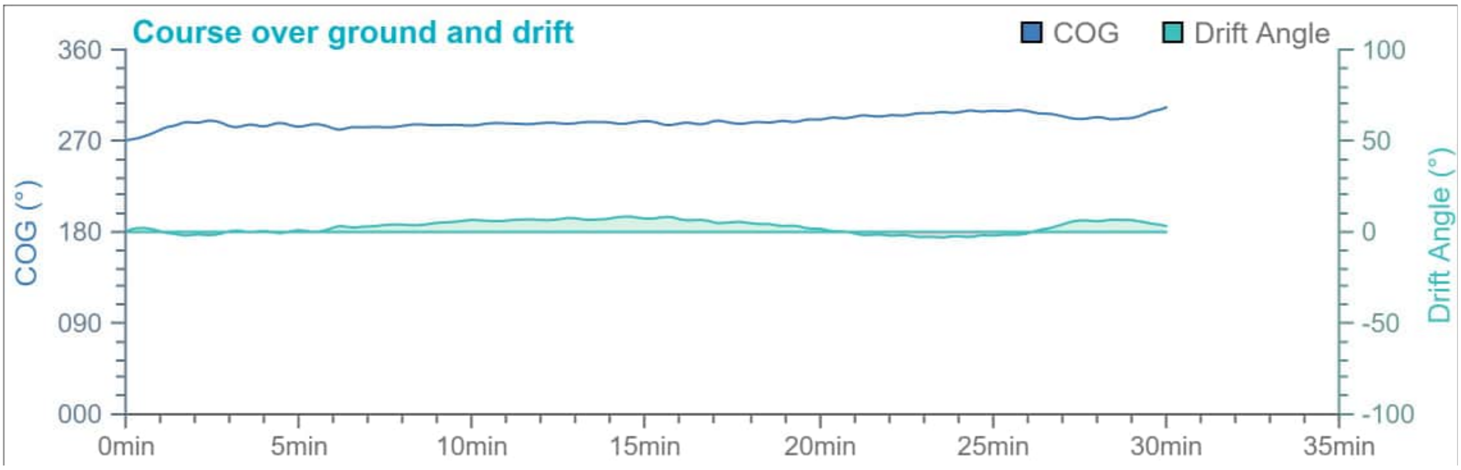
4.00 kts

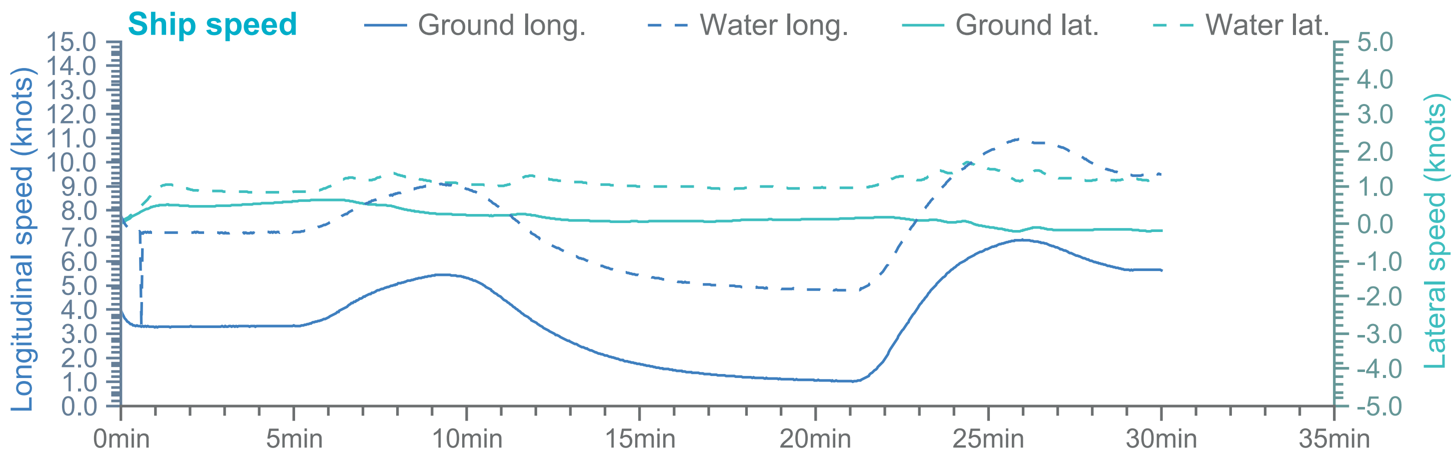
Ships plotted every 1 mins, highlight every 10 mins

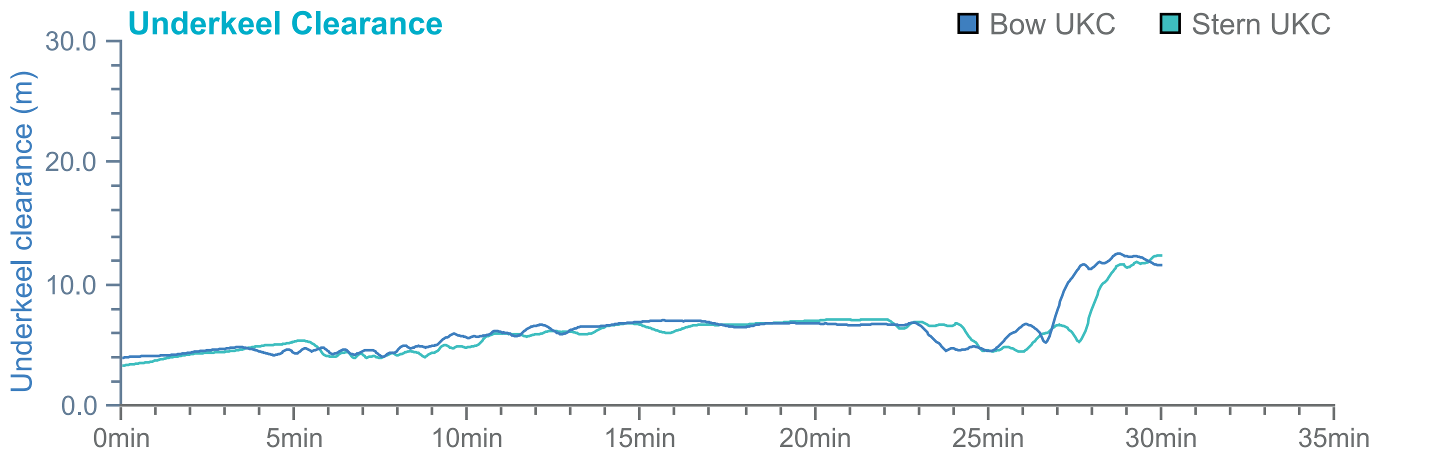

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

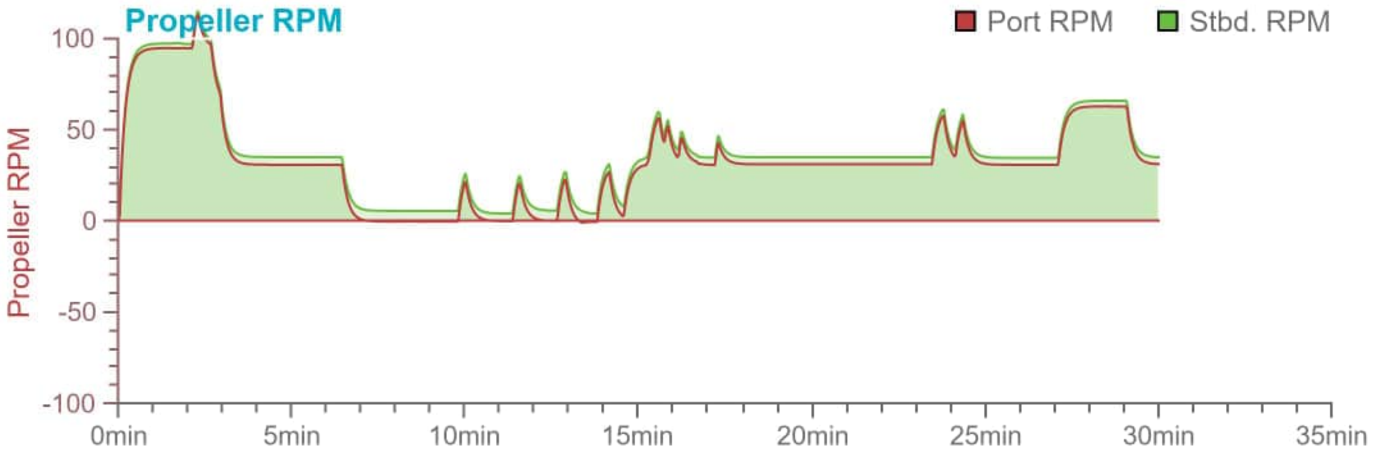

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

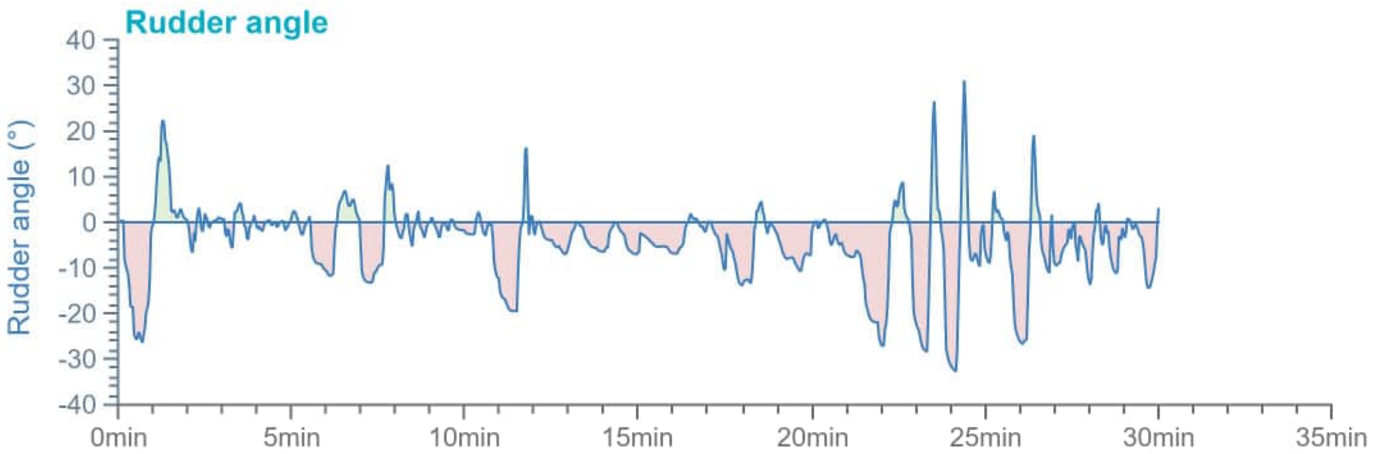

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30 20 10 0 -10 -20 -30
360 270 180 090 000
0min 5min 10min 15min 20min 25min 30min 35min


Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360 270 180 090 000
100 50 0 -50 -100
0min 5min 10min 15min 20min 25min 30min 35min

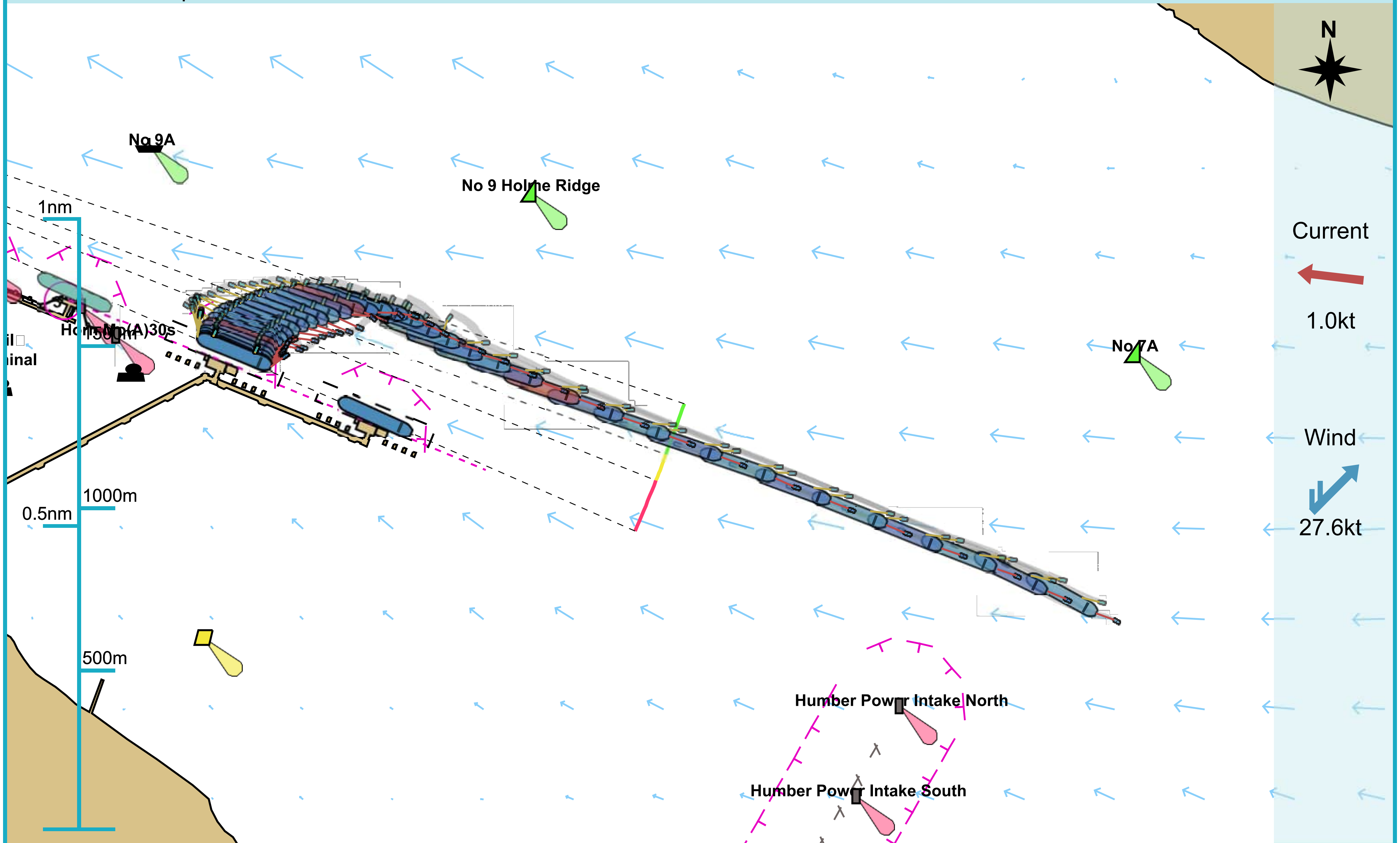

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0 14.0 13.0 12.0 11.0 10.0 9.0 8.0 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0.0
5.0 4.0 3.0 2.0 1.0 0.0 -1.0 -2.0 -3.0 -4.0 -5.0
0min 5min 10min 15min 20min 25min 30min 35min


Underkeel Clearance
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0 20.0 10.0 0.0
0min 5min 10min 15min 20min 25min 30min 35min


Propeller RPM
Port RPM
Stbd. RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min


Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min
30min
35min

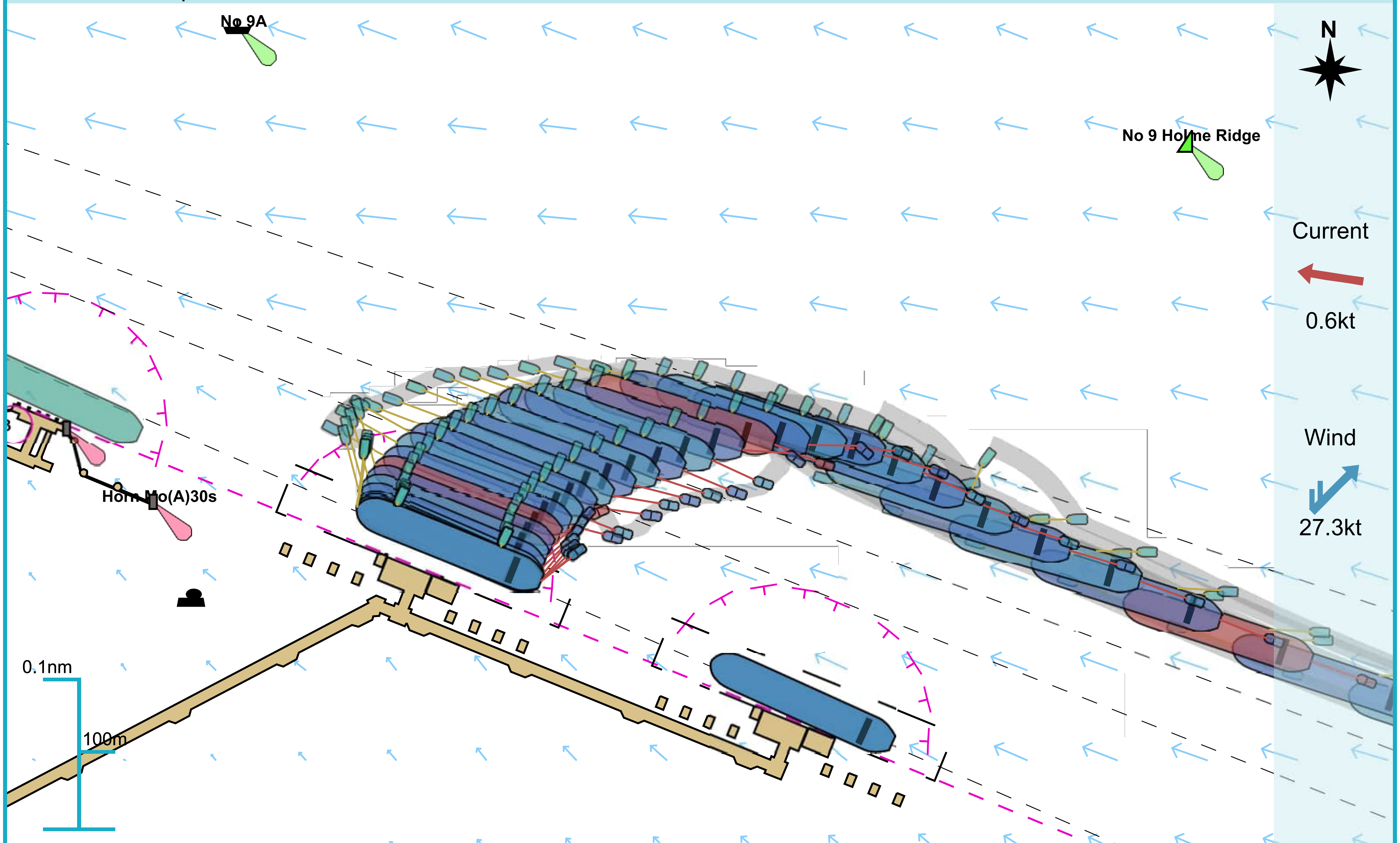
Manoeuvre track plot



1.30 kts

Ships plotted every 1 mins, highlight every 10 mins

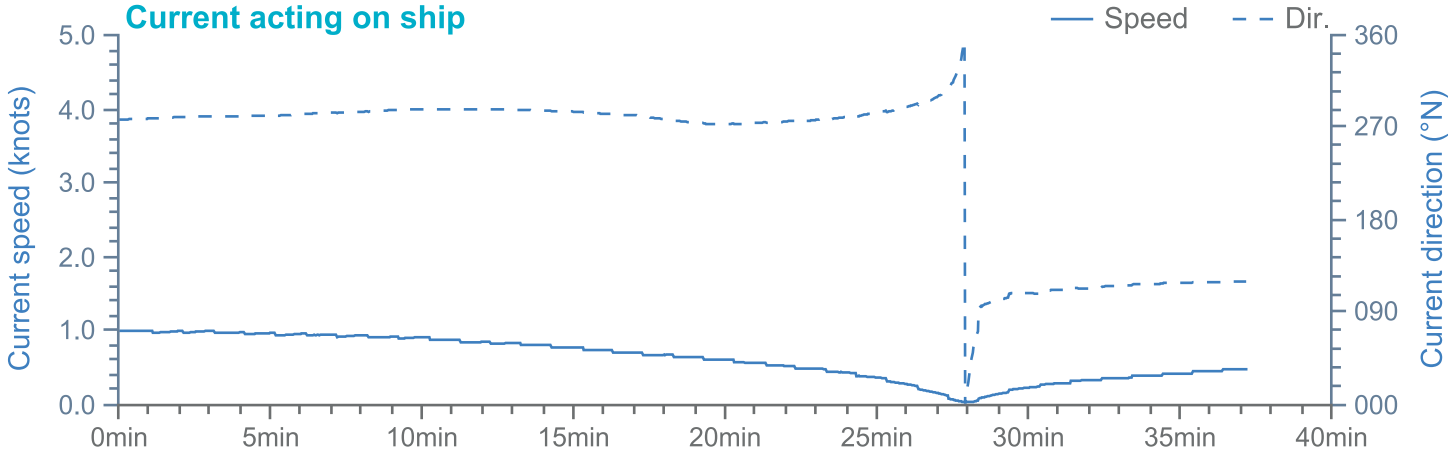
Manoeuvre track plot



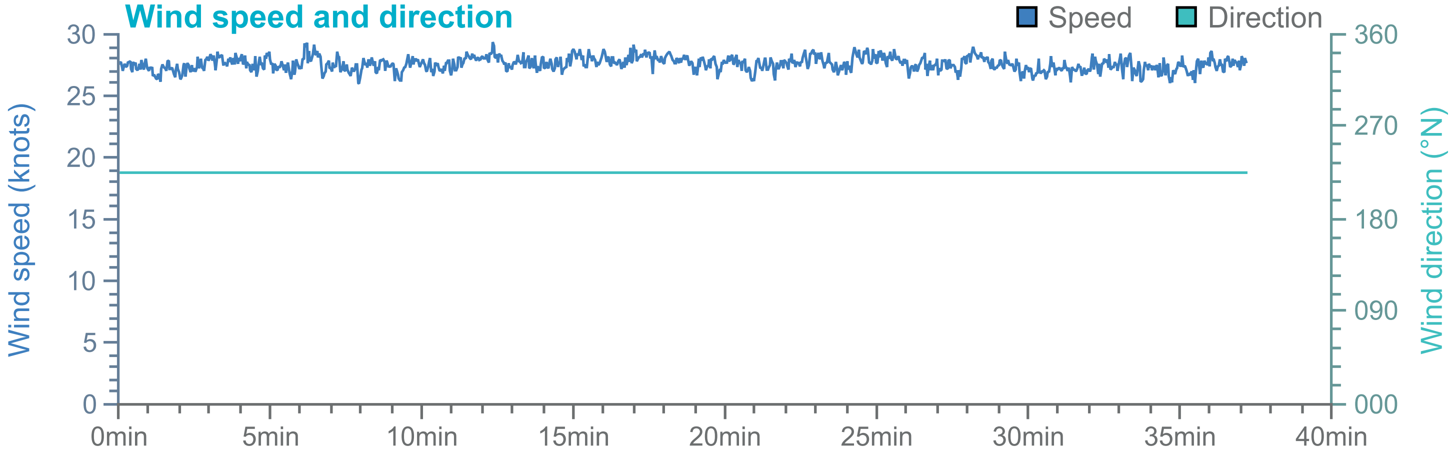
1.34 kts

Ships plotted every 1 mins, highlight every 10 mins

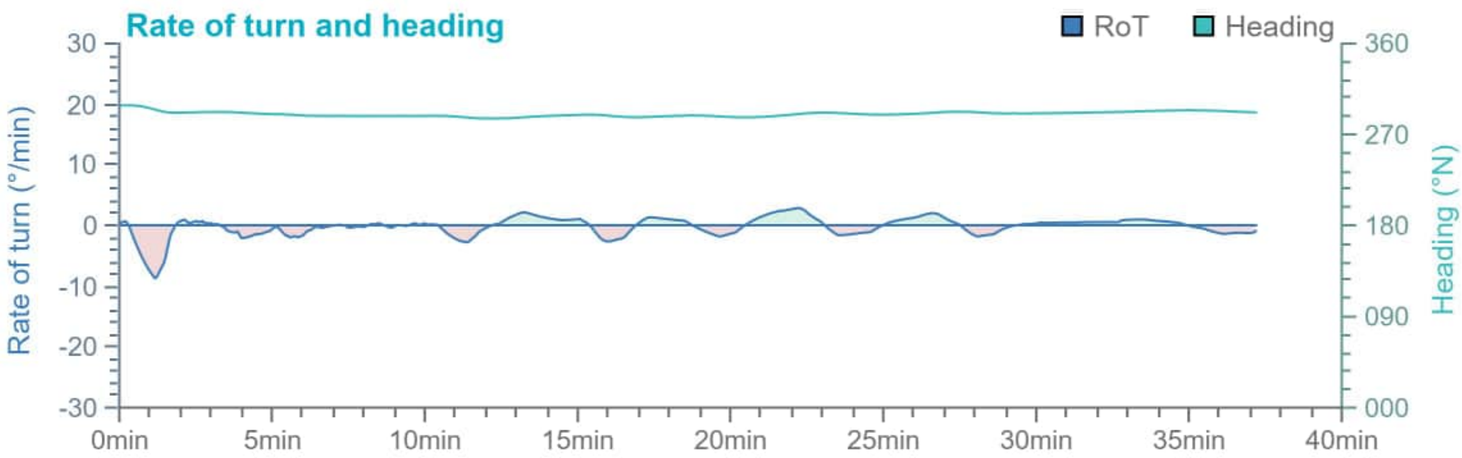
Current acting on ship

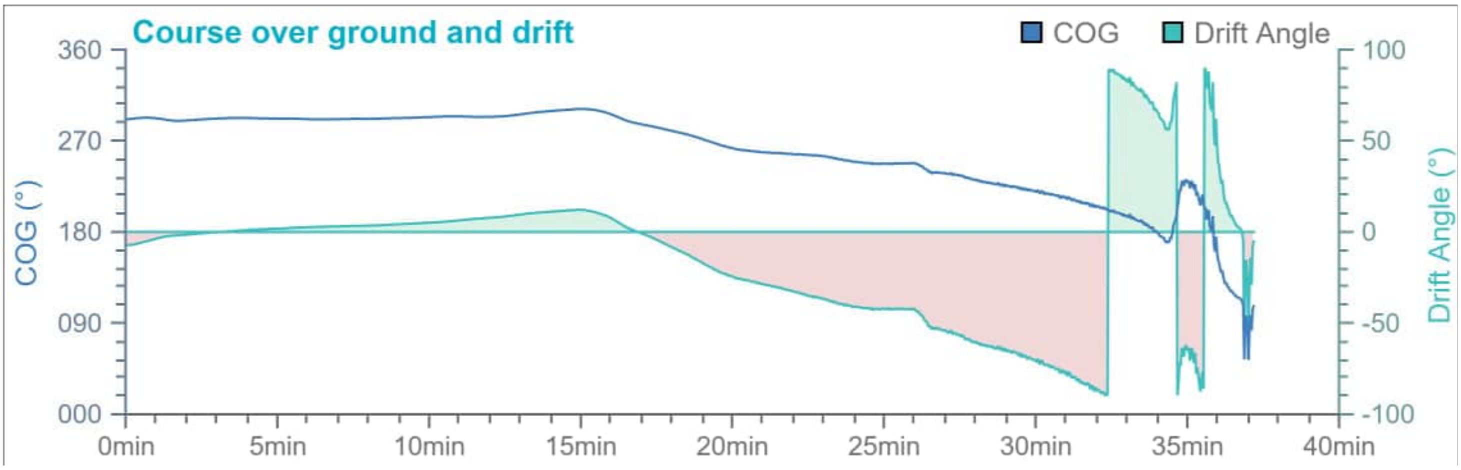


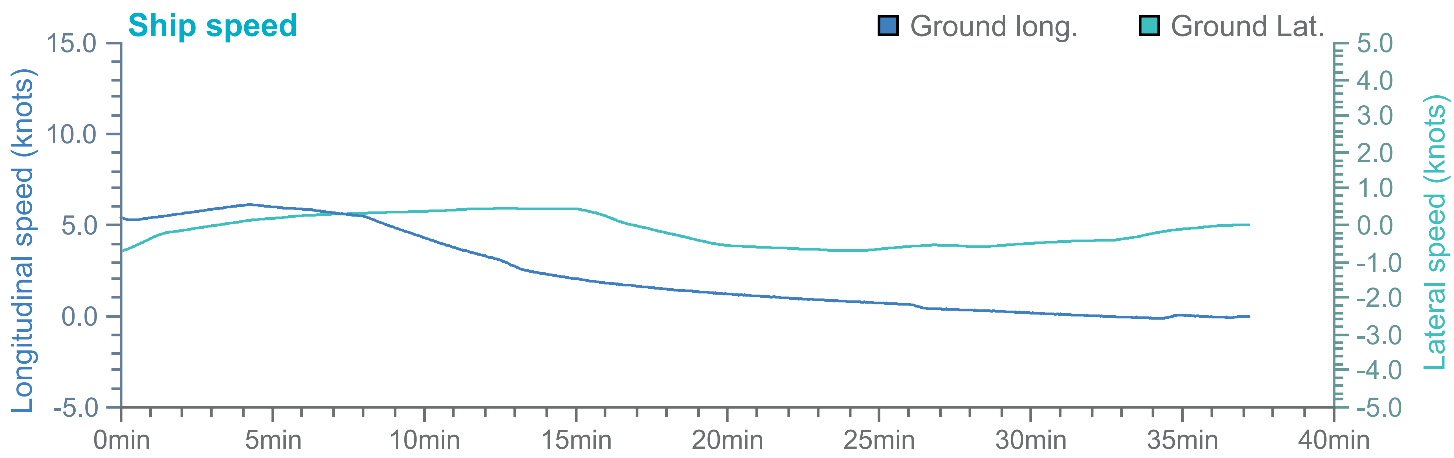
Wind speed and direction

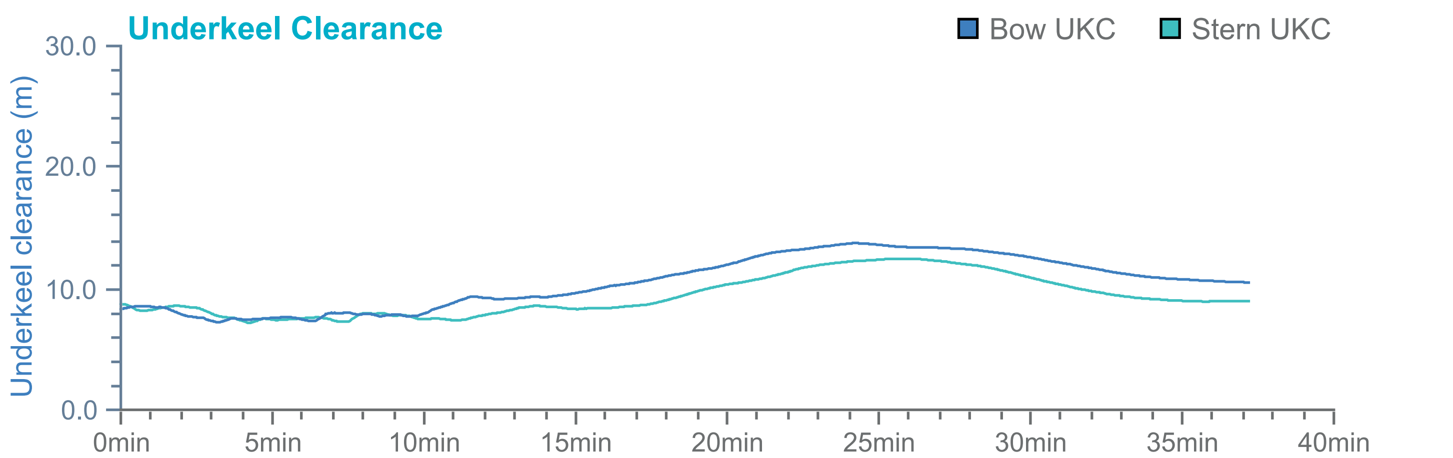


Overview | Environment | 243m Product Tanker | Tug

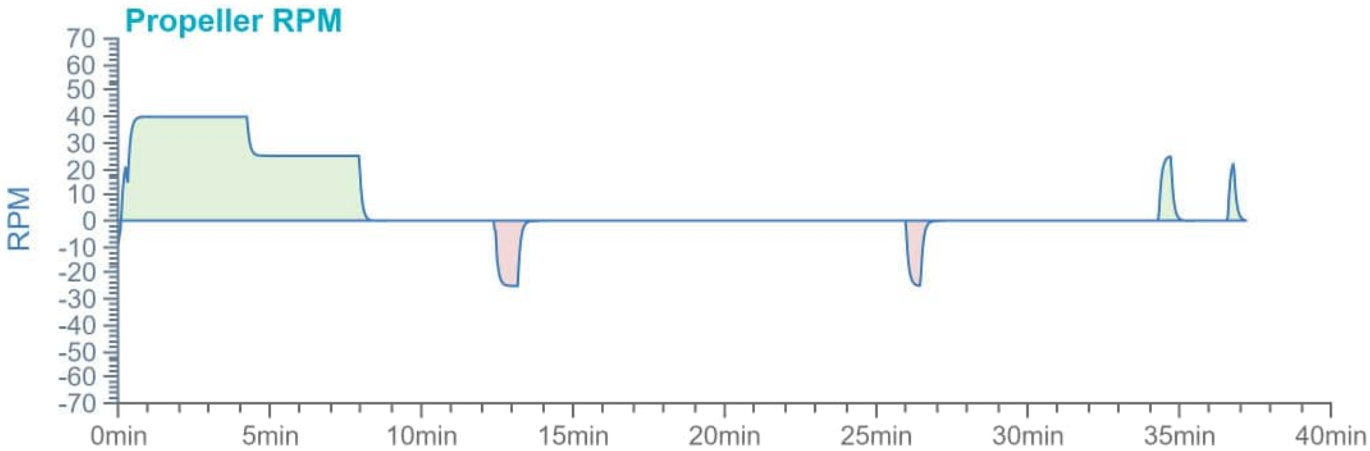


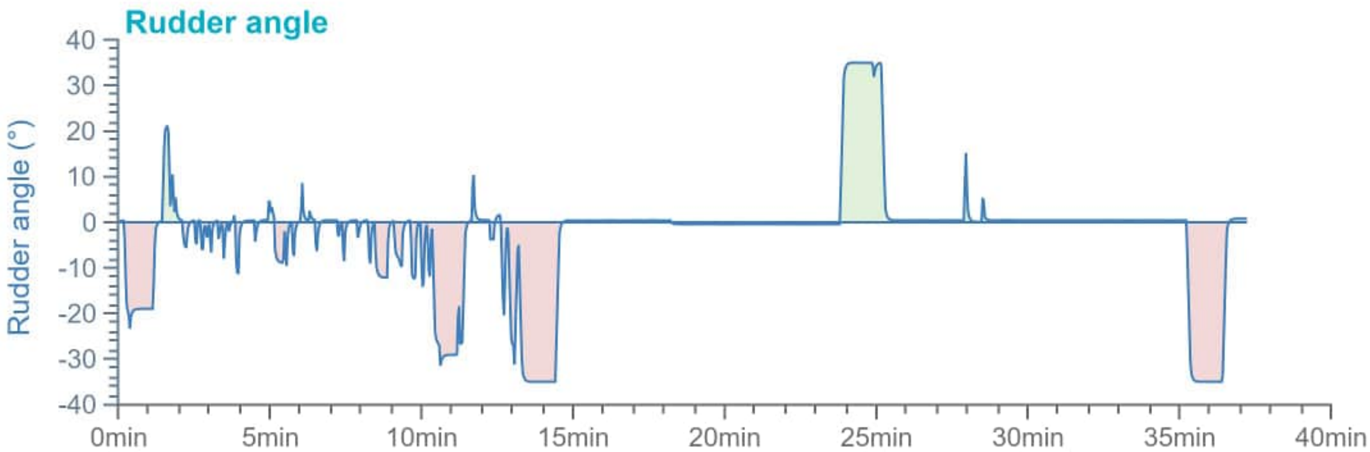


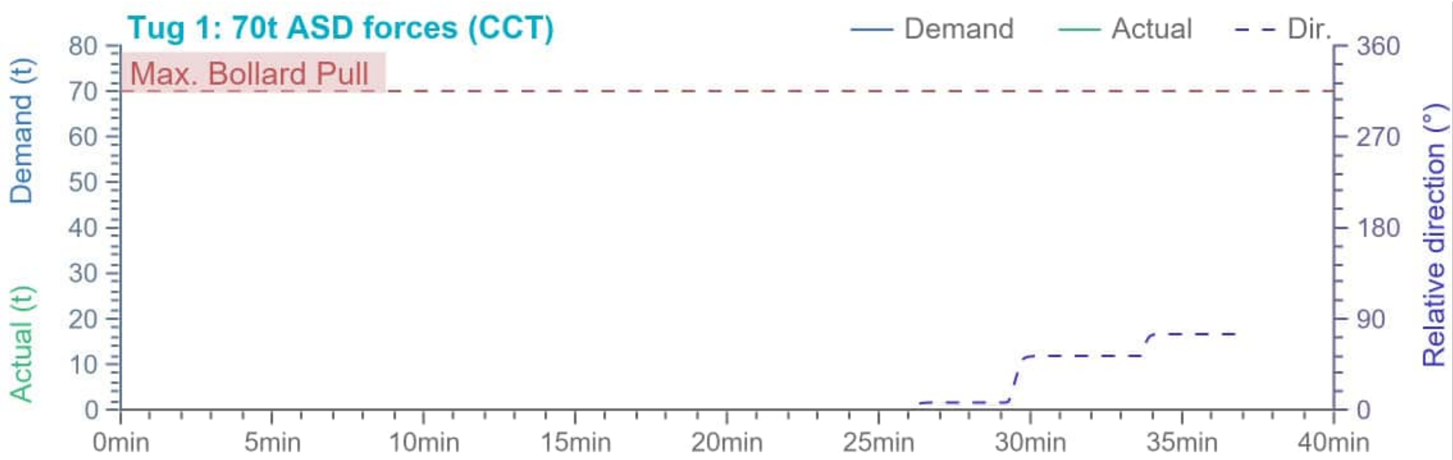


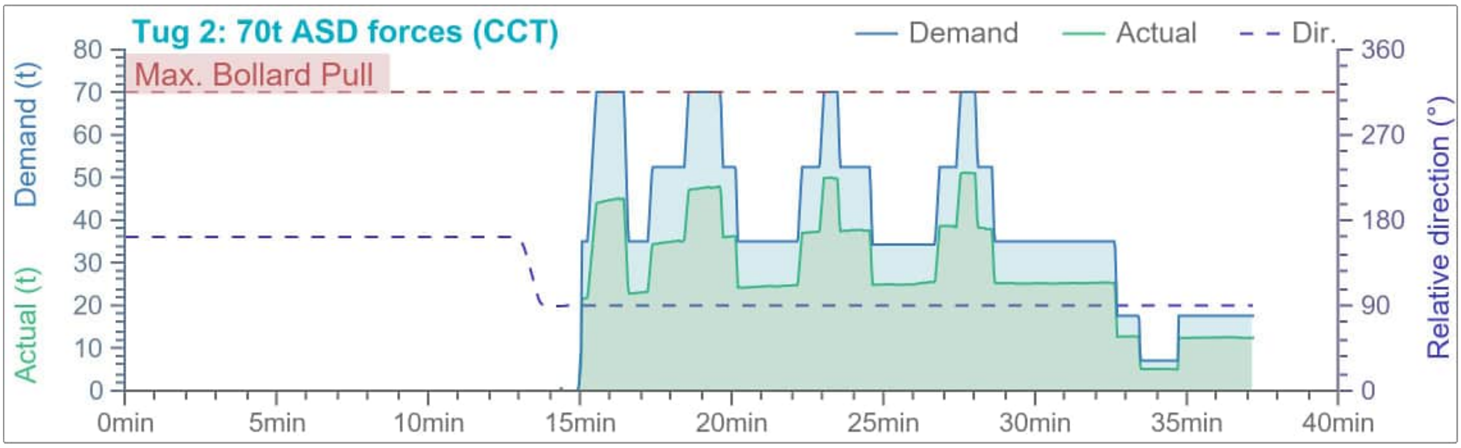


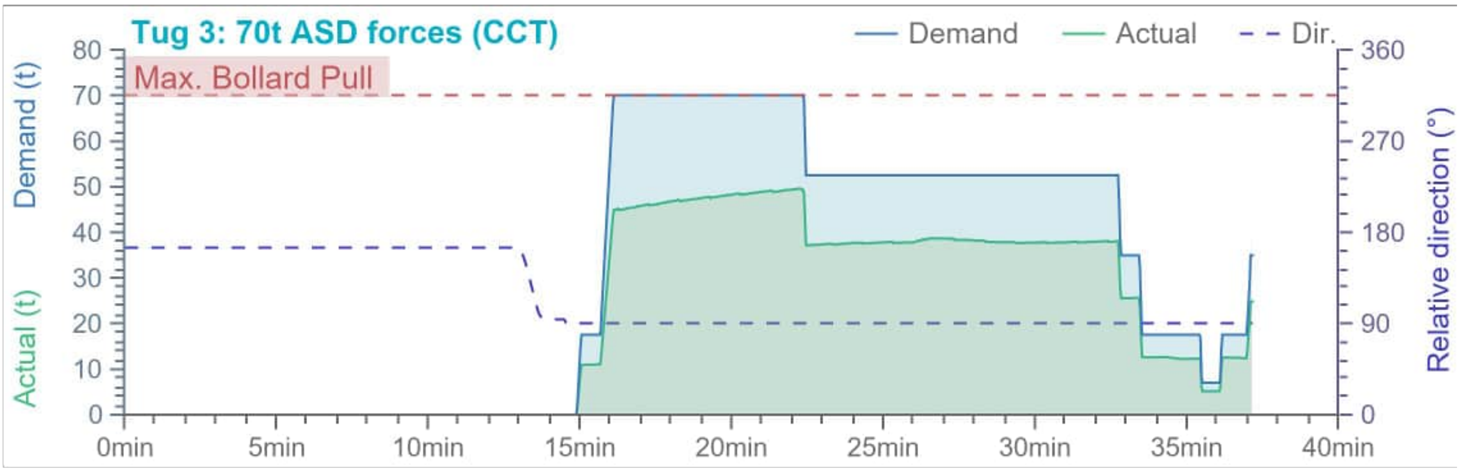
Overview | Environment | 243m Product Tanker | Tug

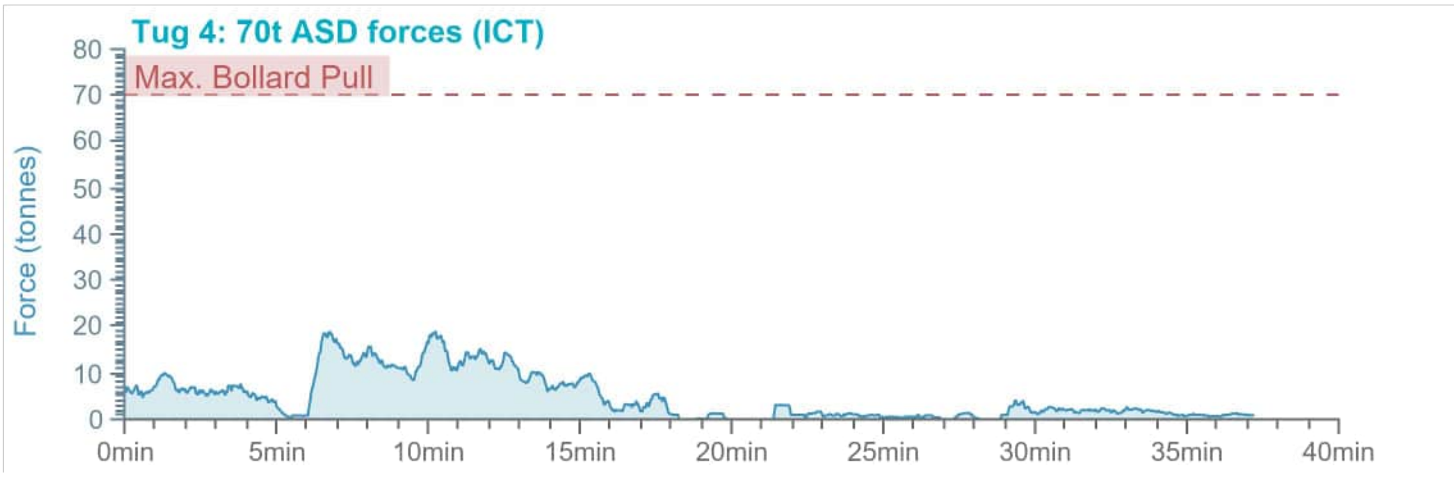





Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
60
70
80
0
90
180
270
360
0min
5min
10min
15min
20min
25min
30min
35min
40min

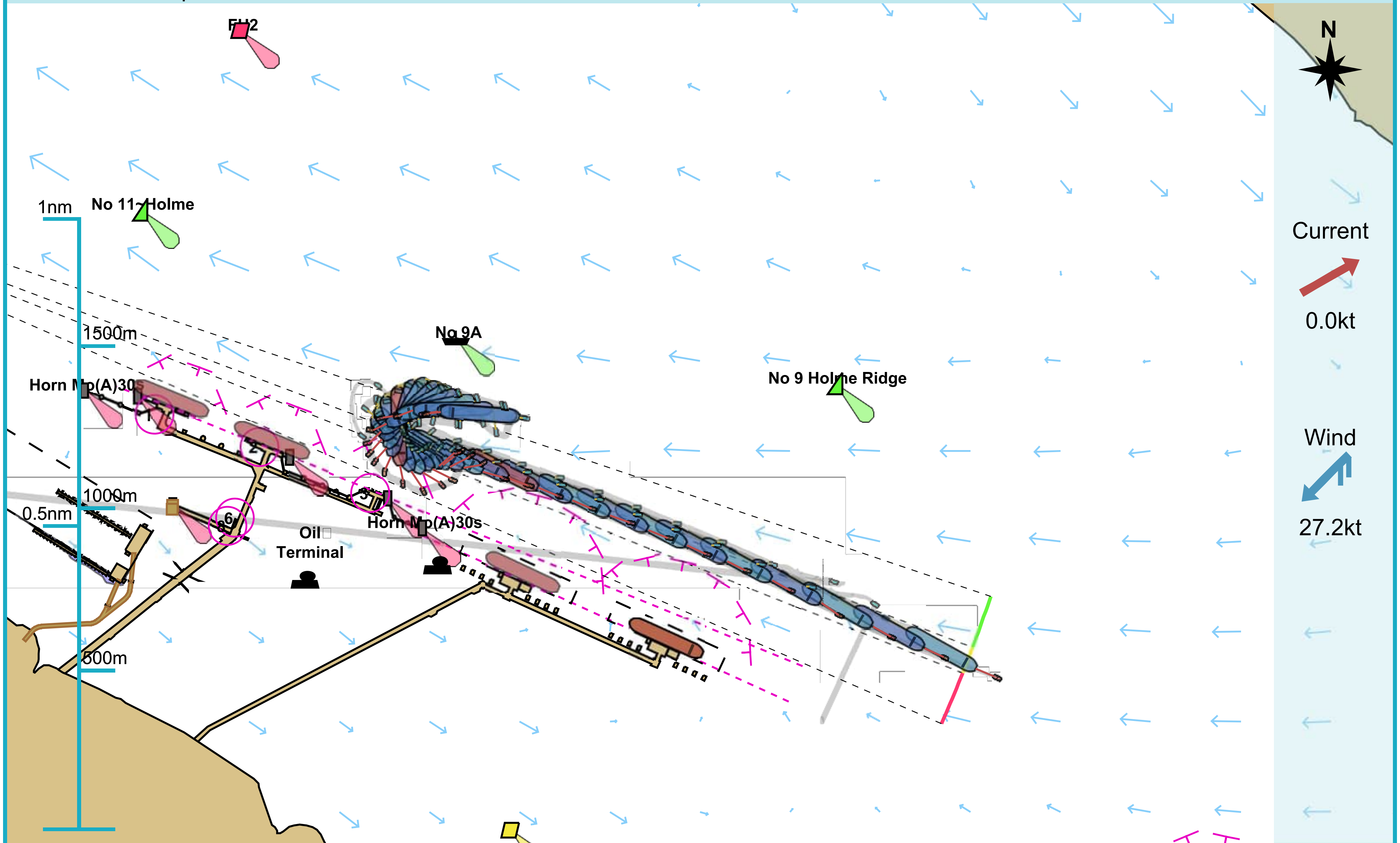

Tug 2: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
60
70
80
0
90
180
270
360
0min
5min
10min
15min
20min
25min
30min
35min
40min


Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
60
70
80
0
90
180
270
360
0min
5min
10min
15min
20min
25min
30min
35min
40min


Tug 4: 70t ASD forces (ICT)
Max. Bollard Pull
Force (tonnes)
0
10
20
30
40
50
60
70
80
0min
5min
10min
15min
20min
25min
30min
35min
40min

Overview | Environment | 243m Product Tanker | Tugs

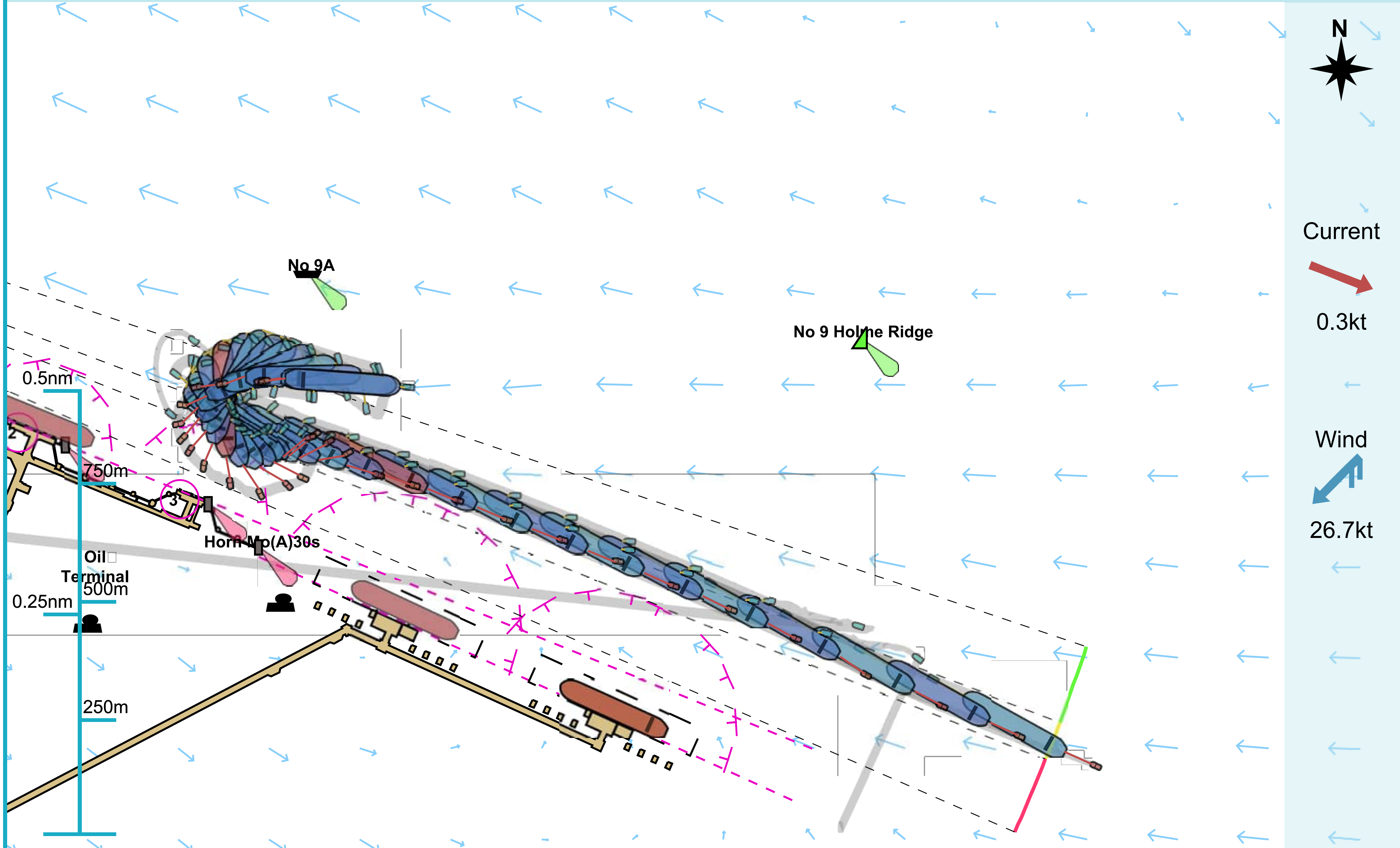
Manoeuvre track plot



0.85 kts

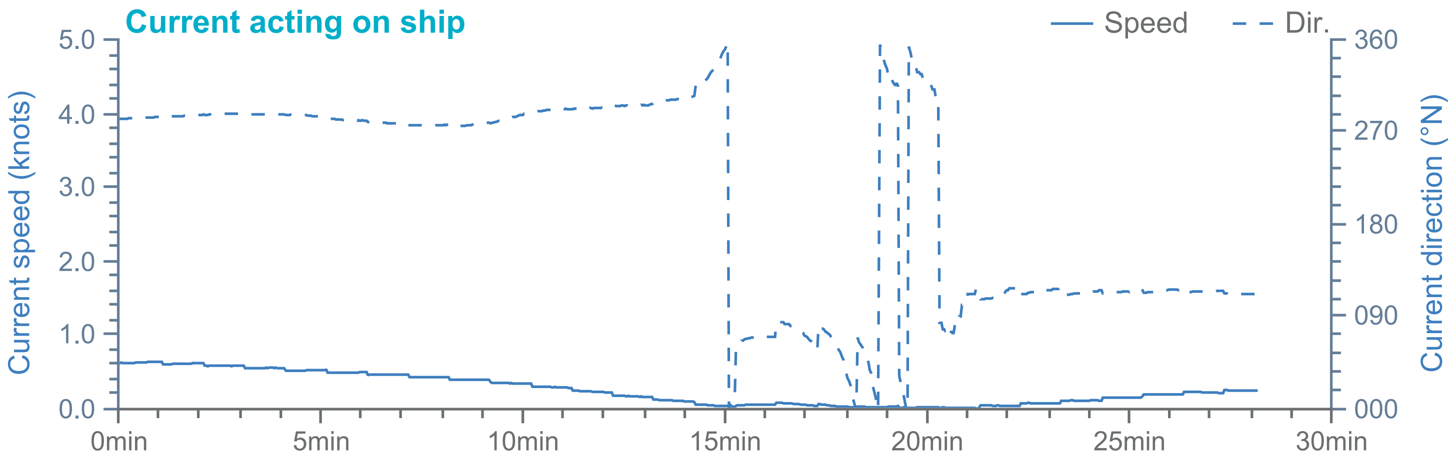
Ships plotted every 1 mins, highlight every 10 mins

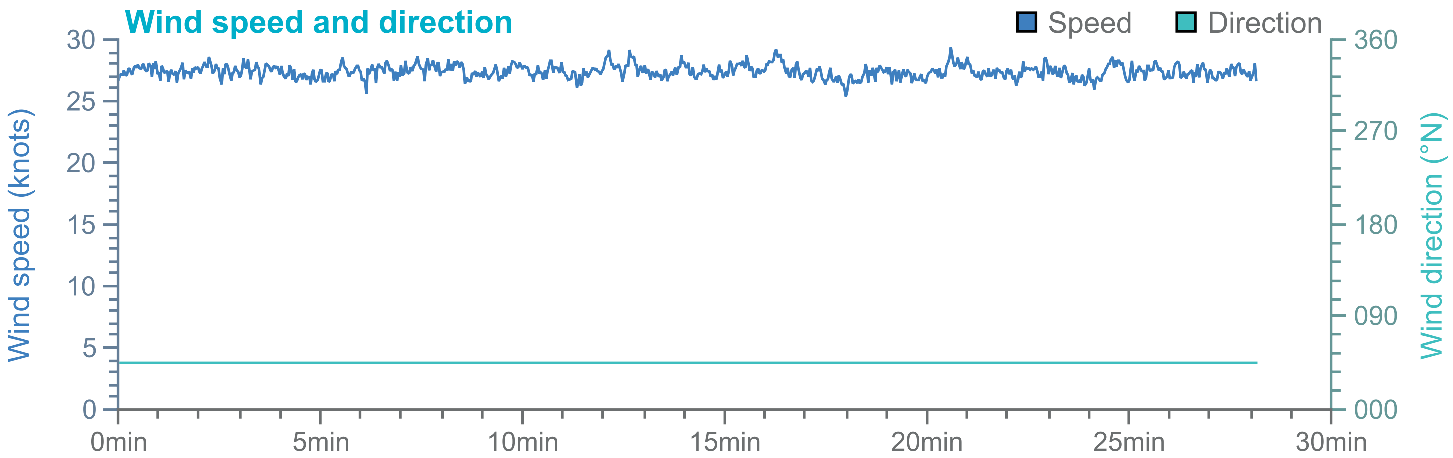
Manoeuvre track plot

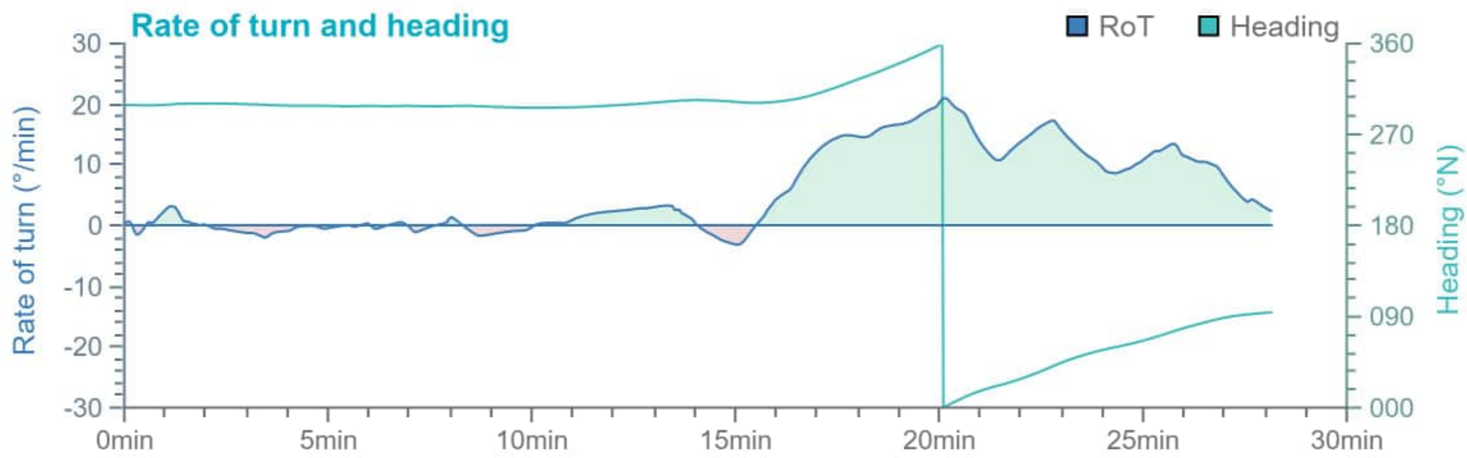


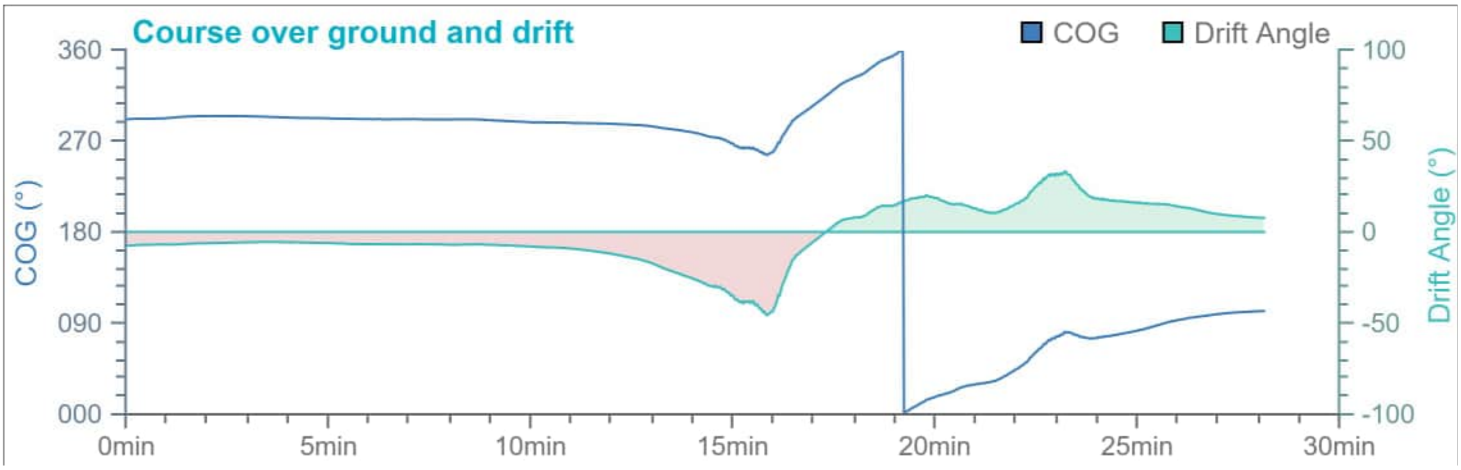
0.83 kts

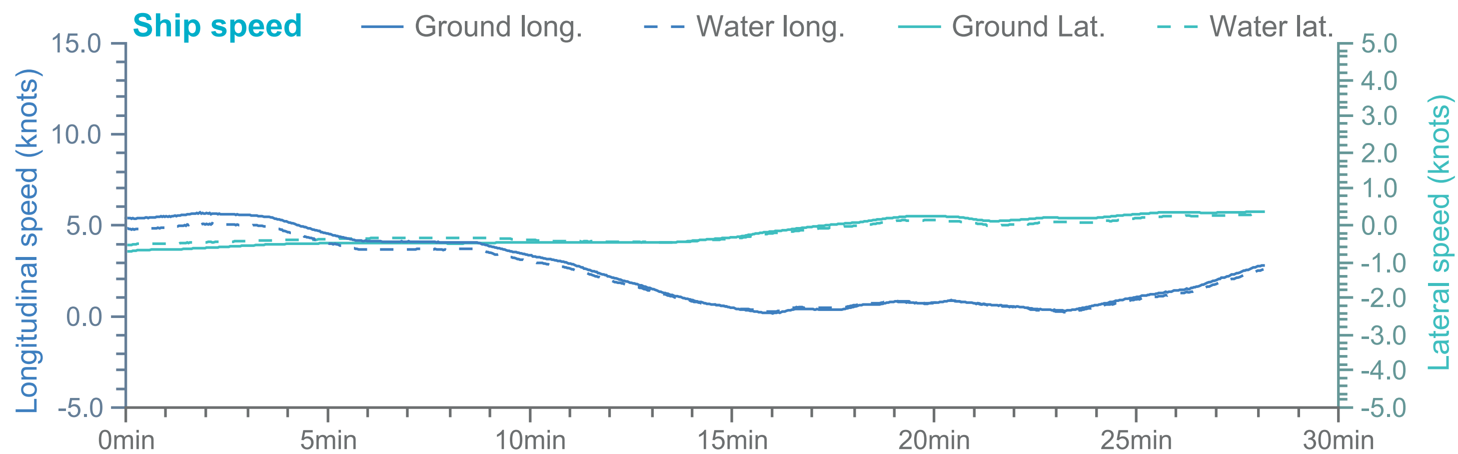
Ships plotted every 1 mins, highlight every 10 mins

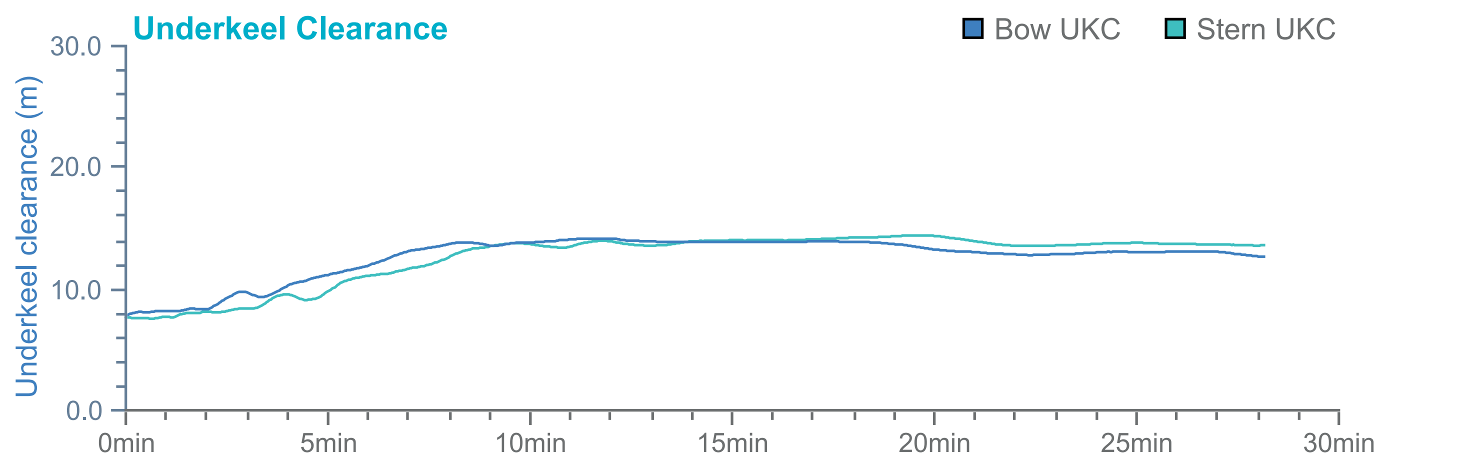

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min

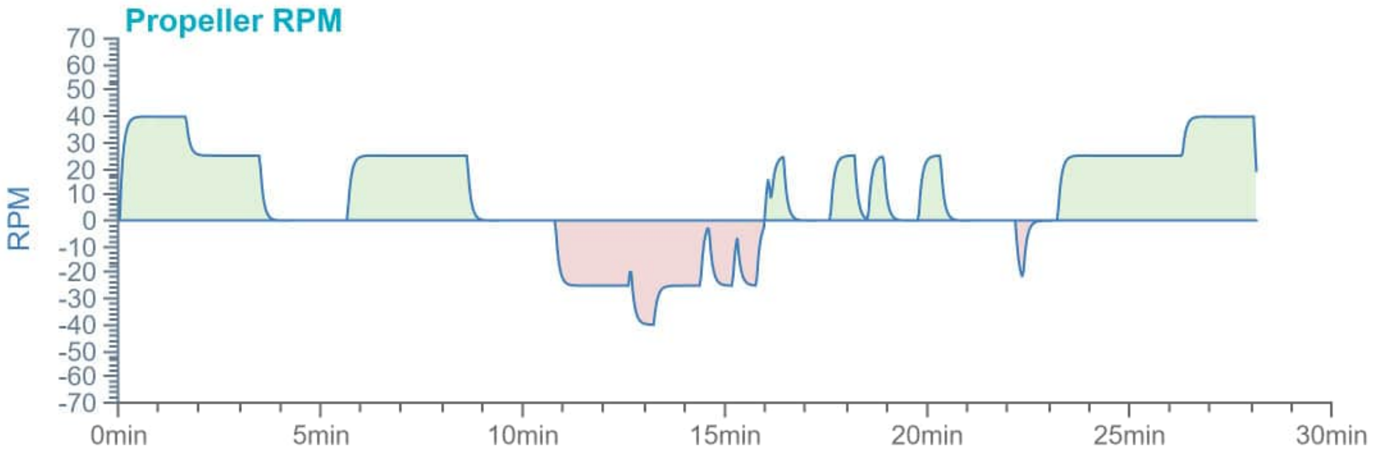

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min

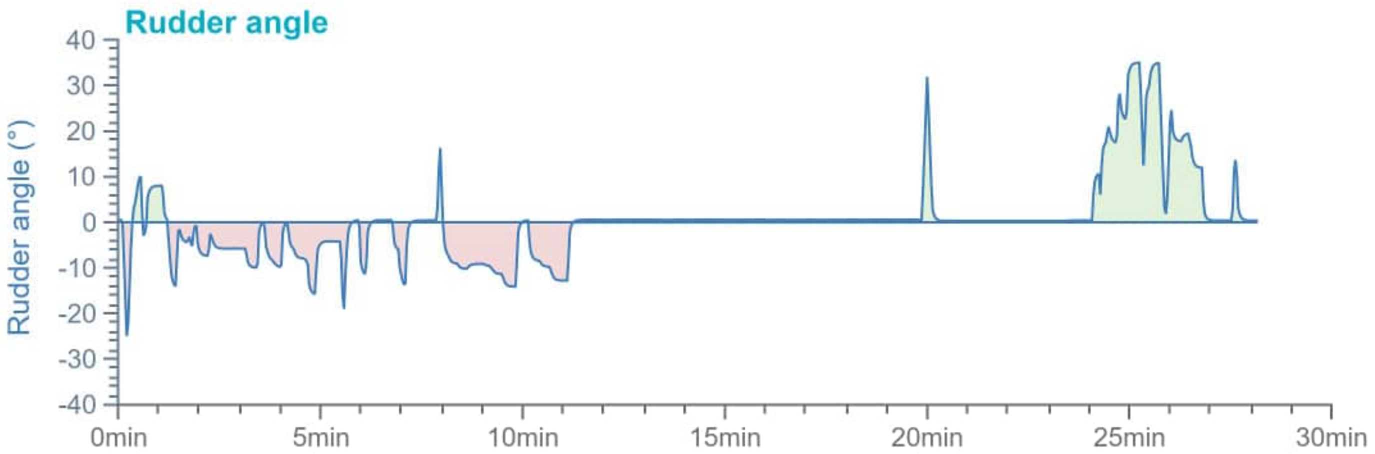

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min

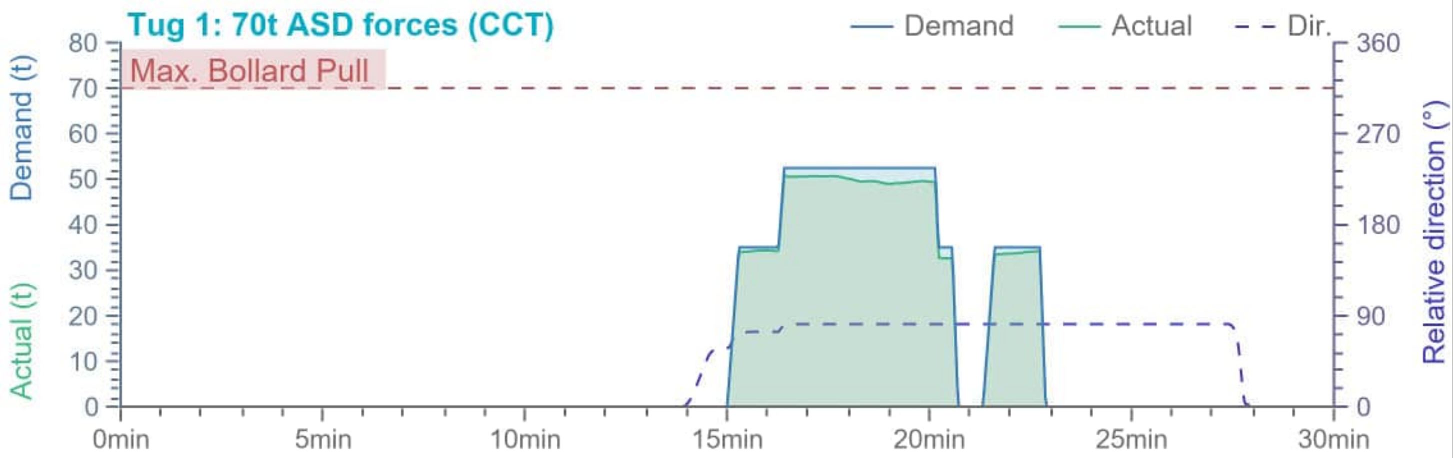

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min

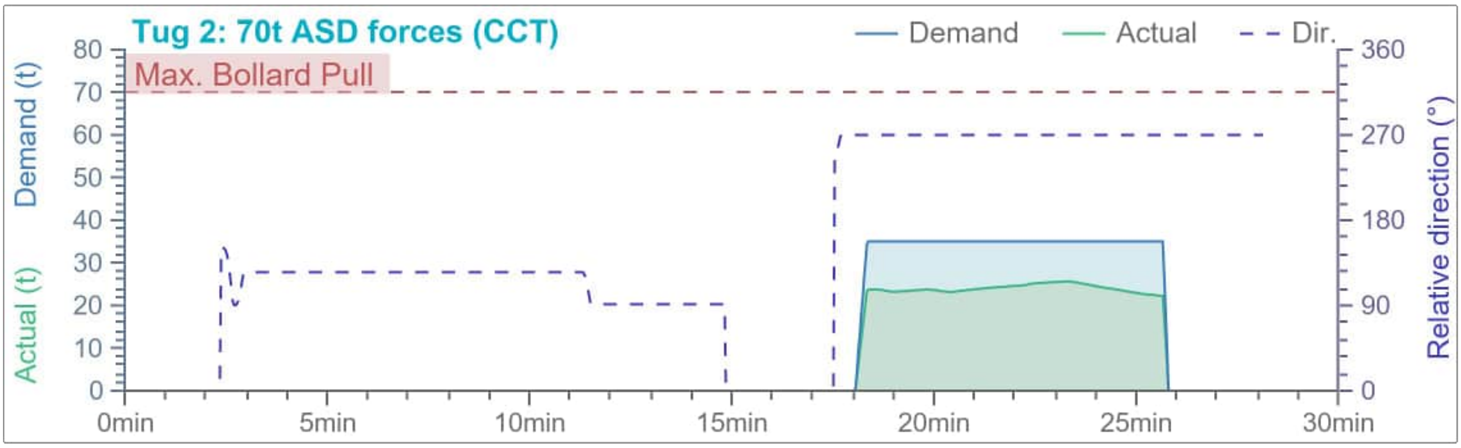

Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min

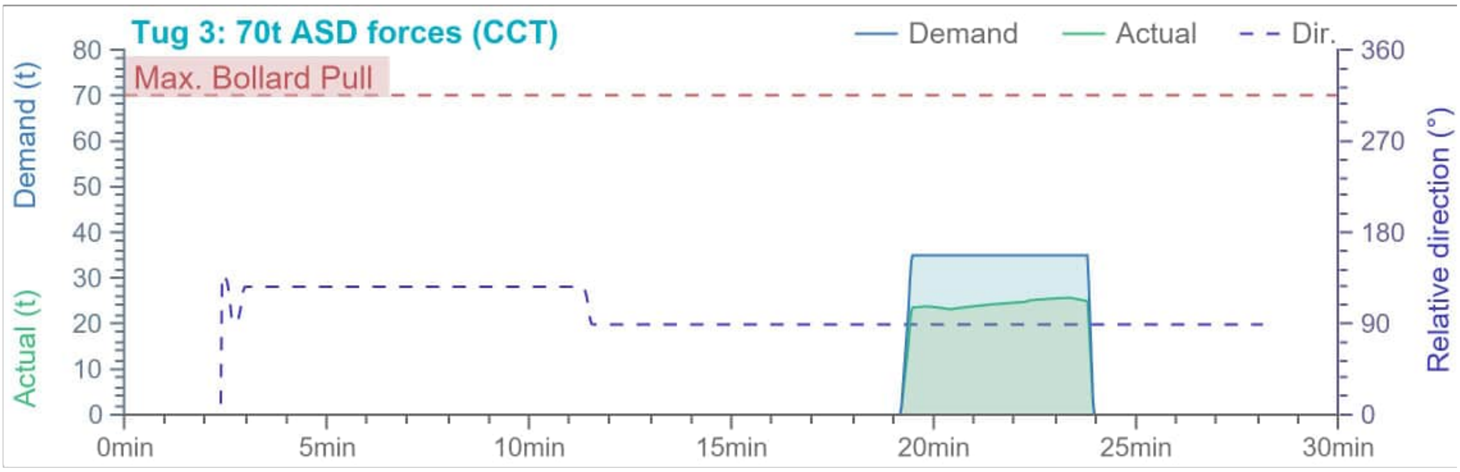

Underkeel Clearance
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min

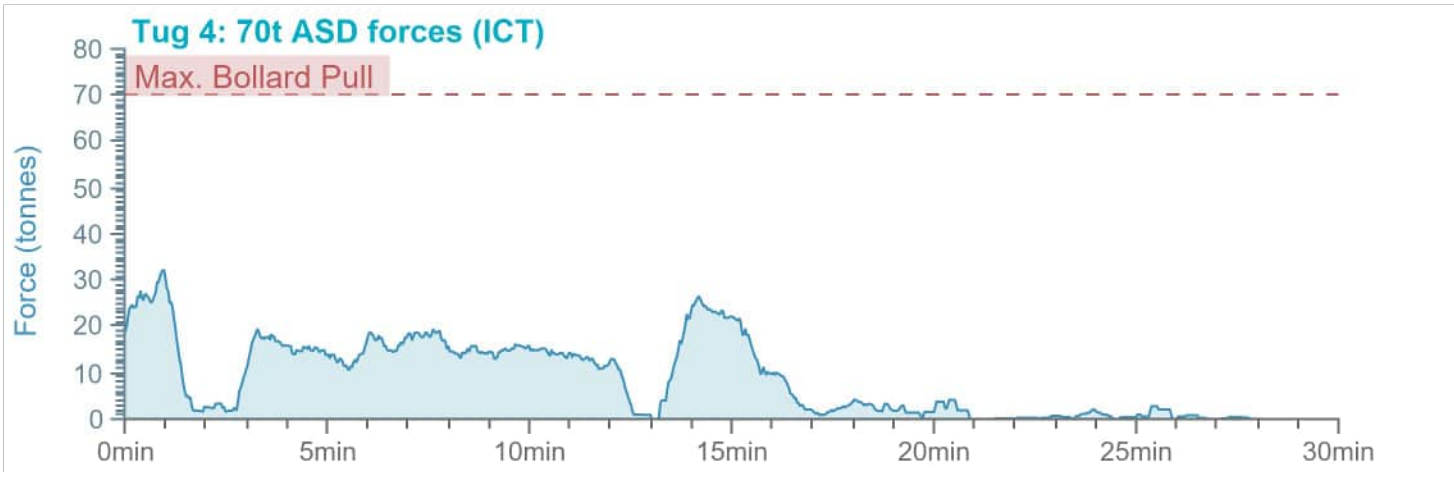

Propeller RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
RPM
0min
5min
10min
15min
20min
25min
30min


Rudder angle
40
30
20
10
0
-10
-20
-30
-40
Rudder angle (°)
0min
5min
10min
15min
20min
25min
30min


Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
60
70
80
0
90
180
270
360
0min
5min
10min
15min
20min
25min
30min

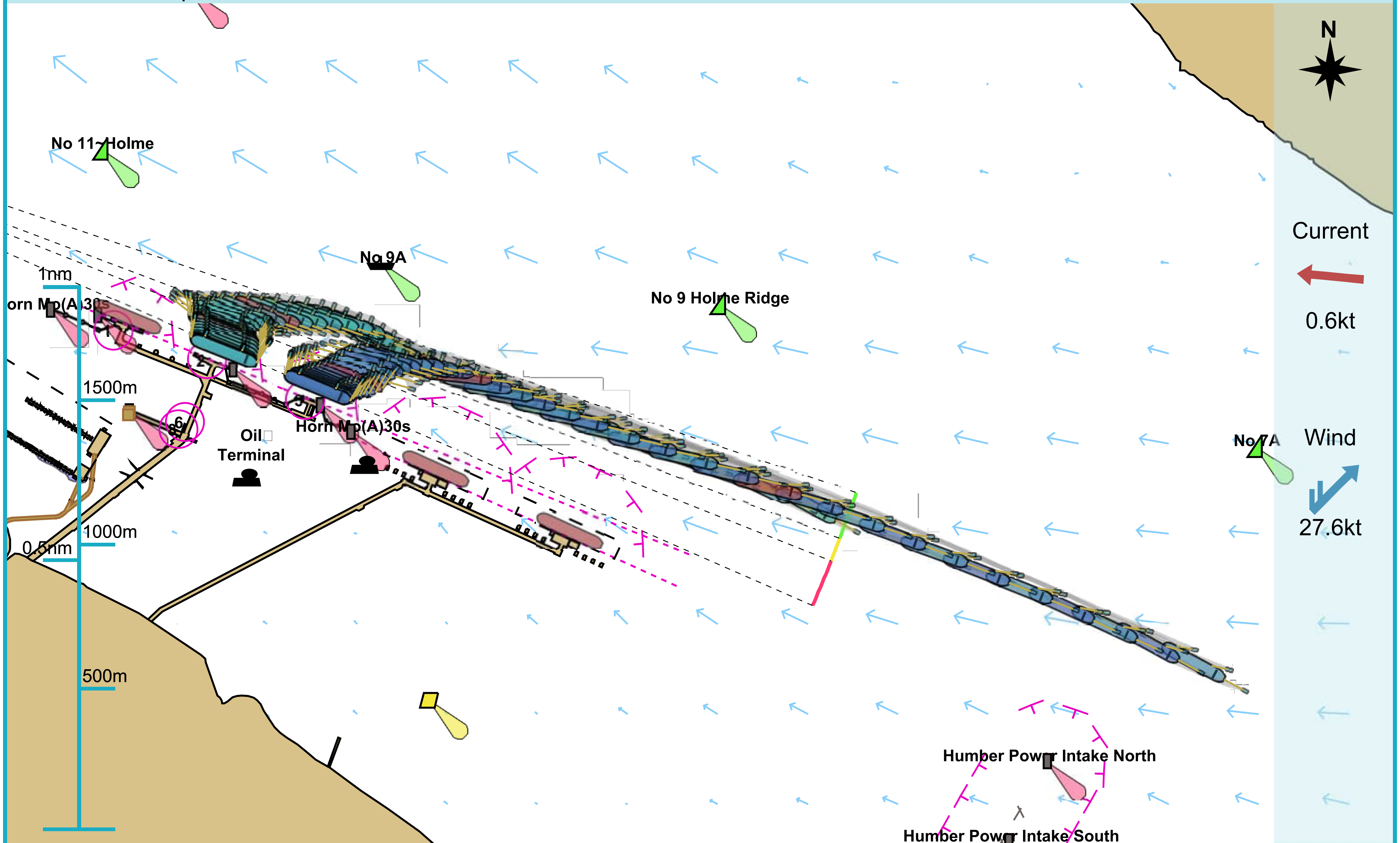

Tug 2: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
60
70
80
0
90
180
270
360
0min
5min
10min
15min
20min
25min
30min


Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
60
70
80
0
90
180
270
360
0min
5min
10min
15min
20min
25min
30min


Tug 4: 70t ASD forces (ICT)
Max. Bollard Pull
Force (tonnes)
0
10
20
30
40
50
60
70
80
0min
5min
10min
15min
20min
25min
30min

Overview | Environment | 243m Product Tanker | Tugs

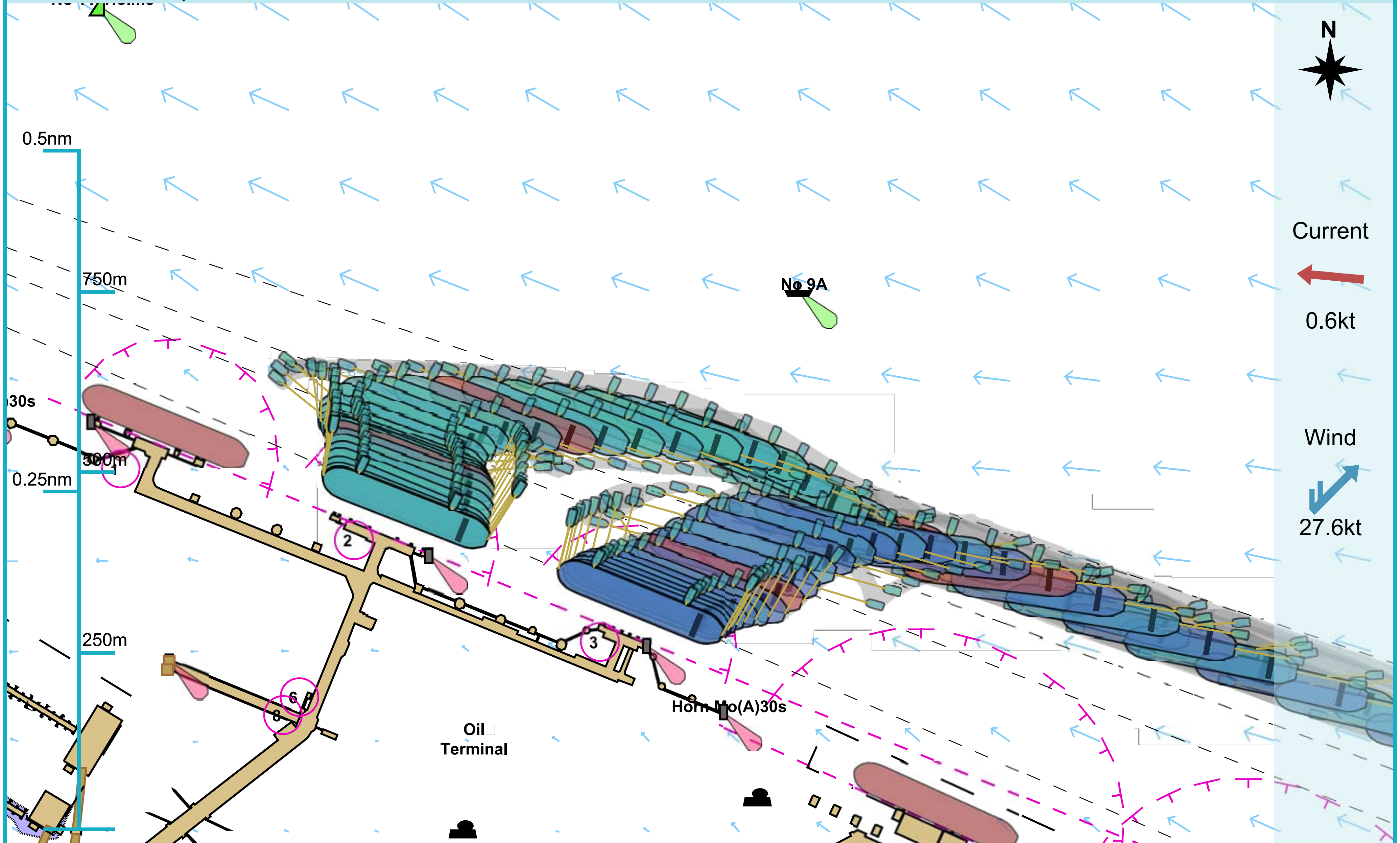
Manoeuvre track plot



1.36 kts
Ships plotted every 1 mins, highlight every 10 mins

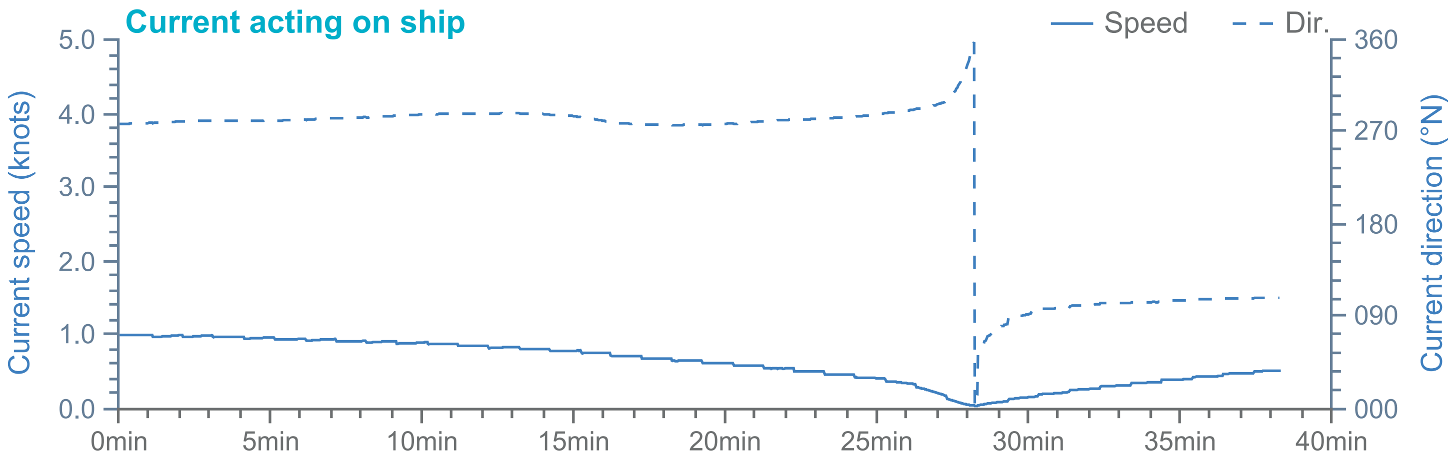
Pilot: IC/JMS
Manoeuvre: Arrival

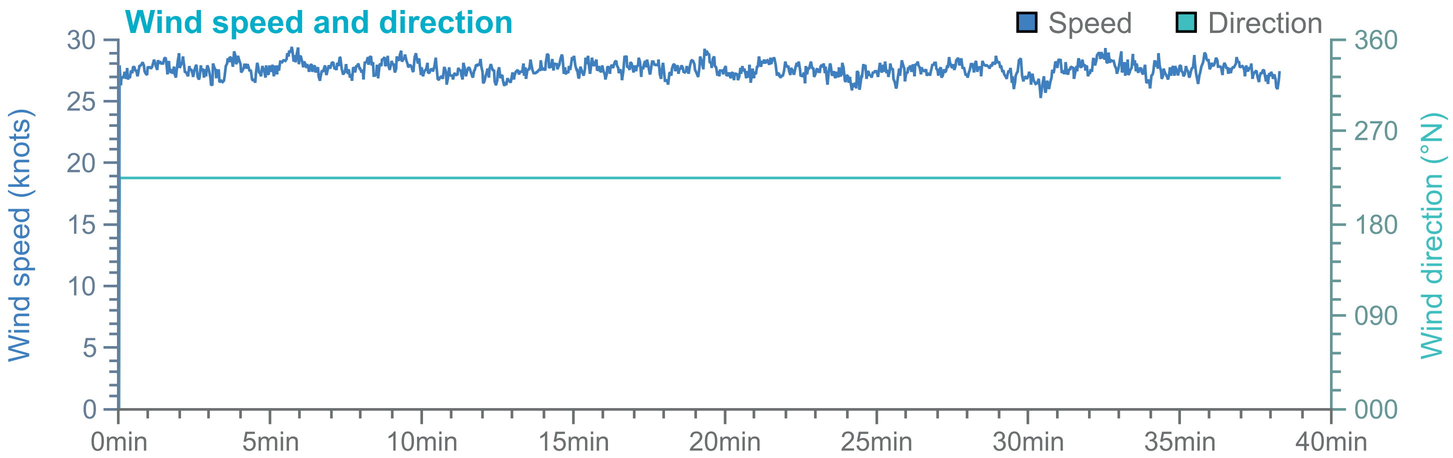
Manoeuvre track plot

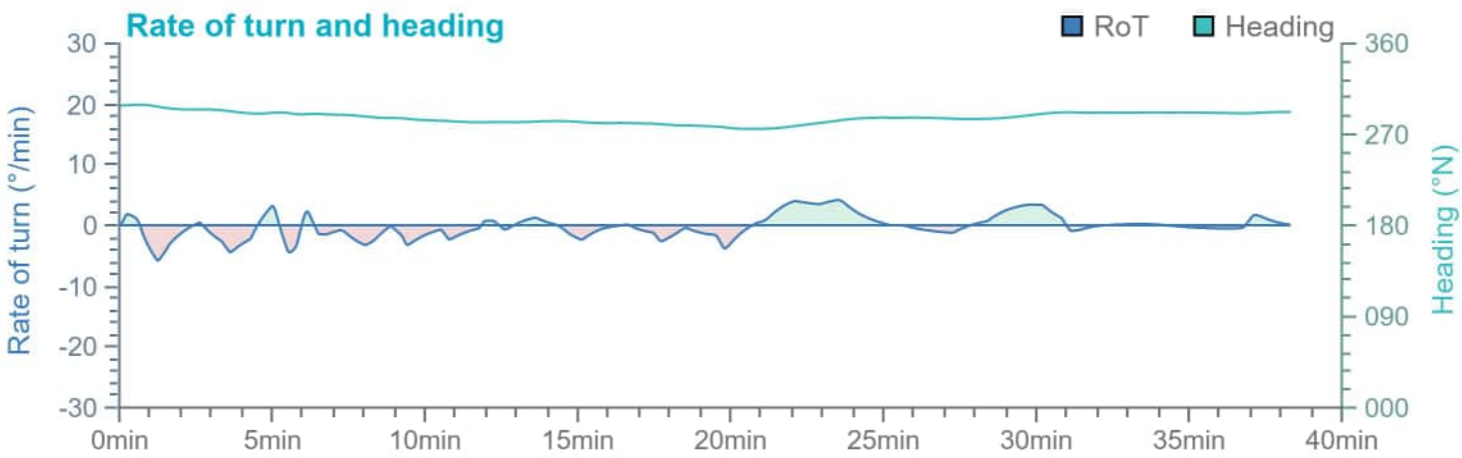


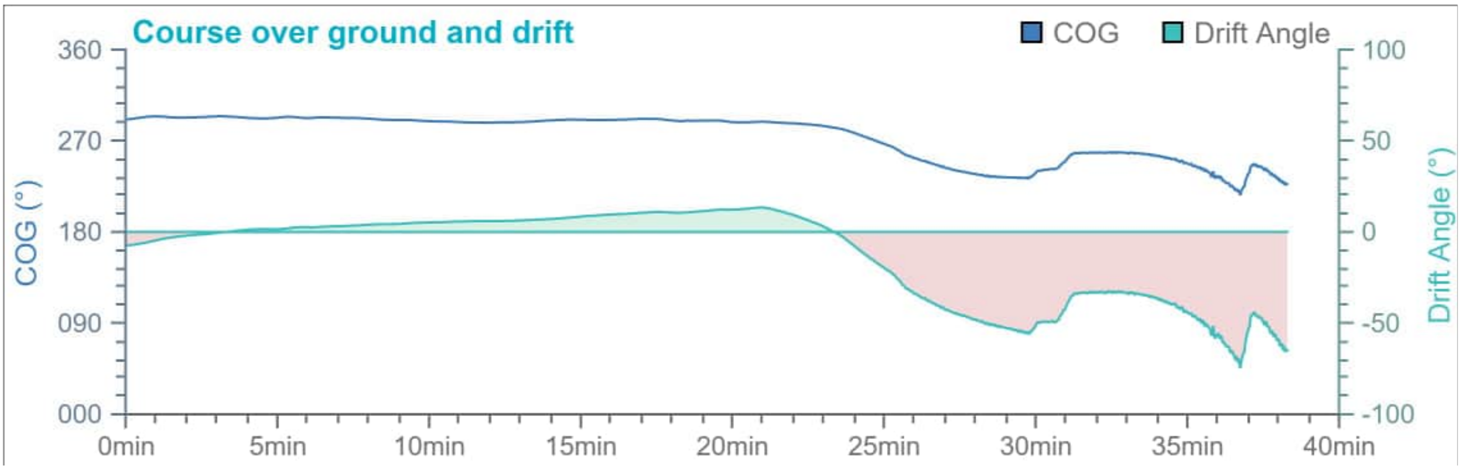
1.42 kts

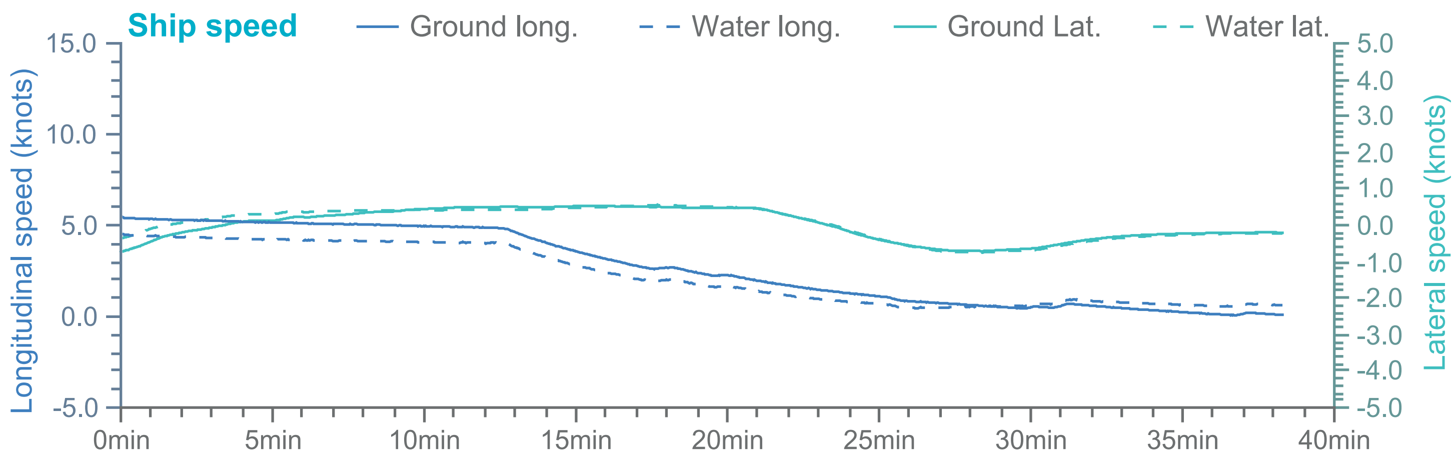
Ships plotted every 1 mins, highlight every 10 mins

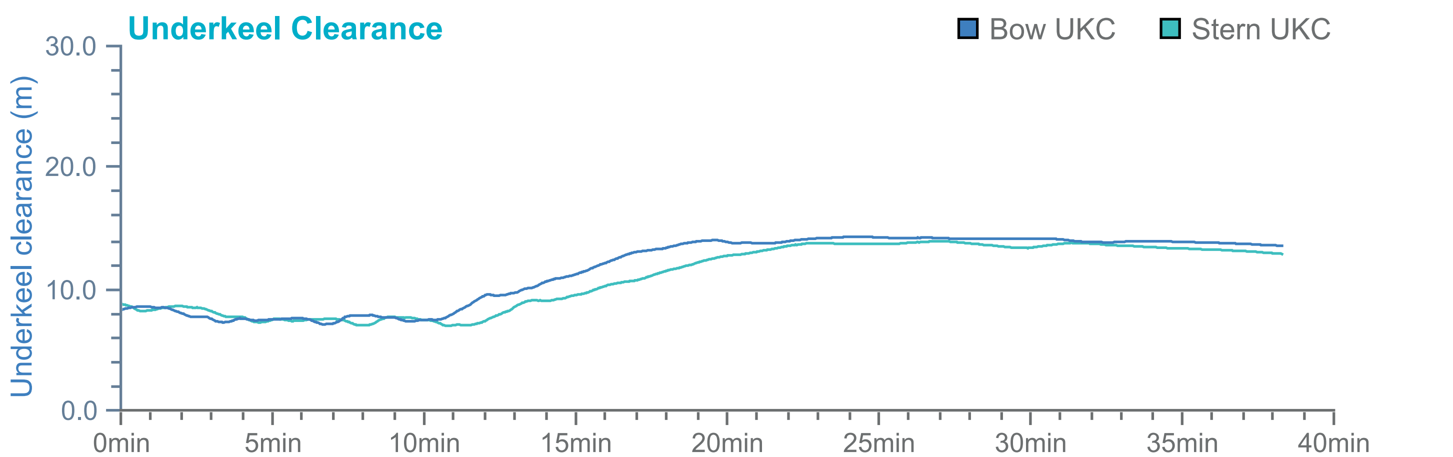

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min

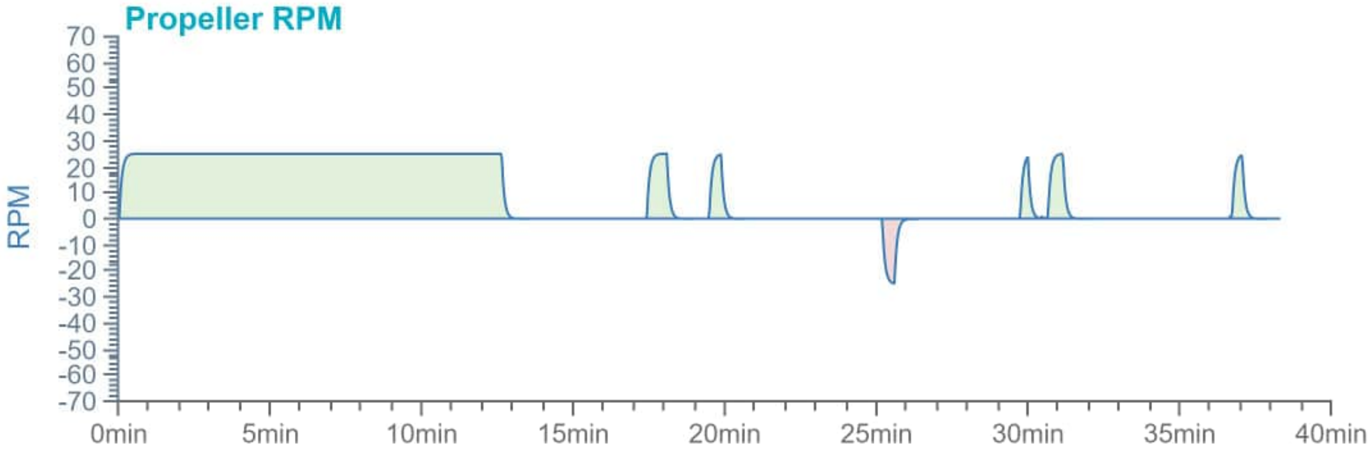

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min

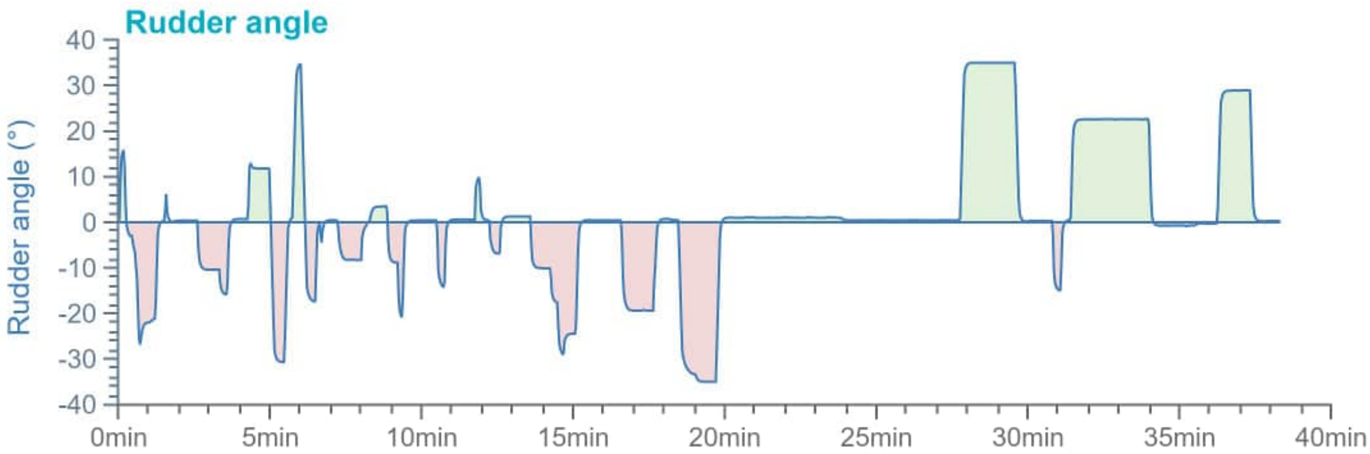

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min

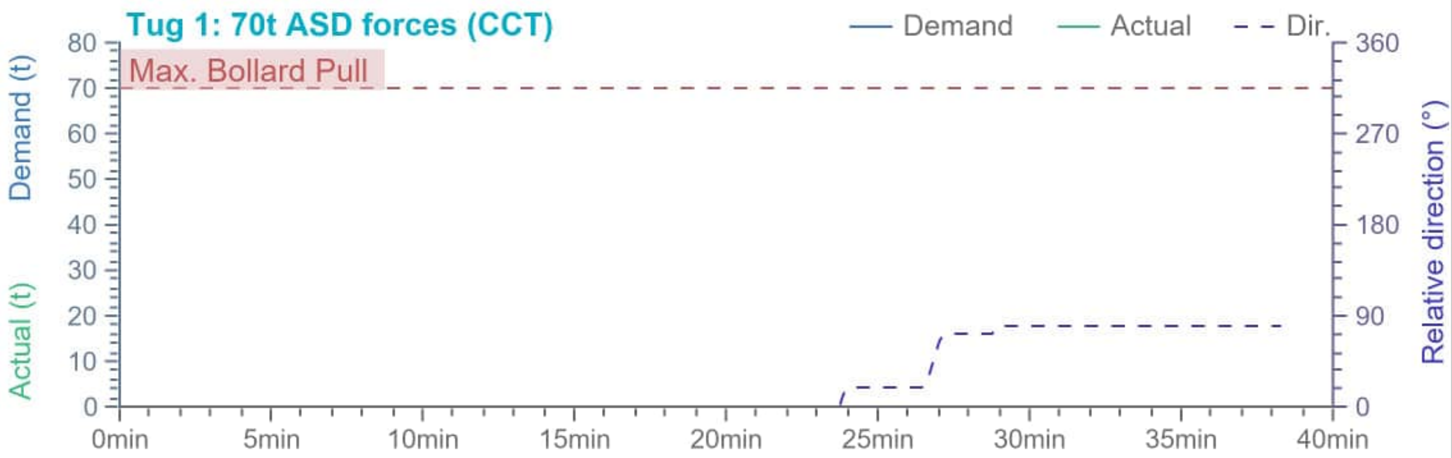

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min
40min

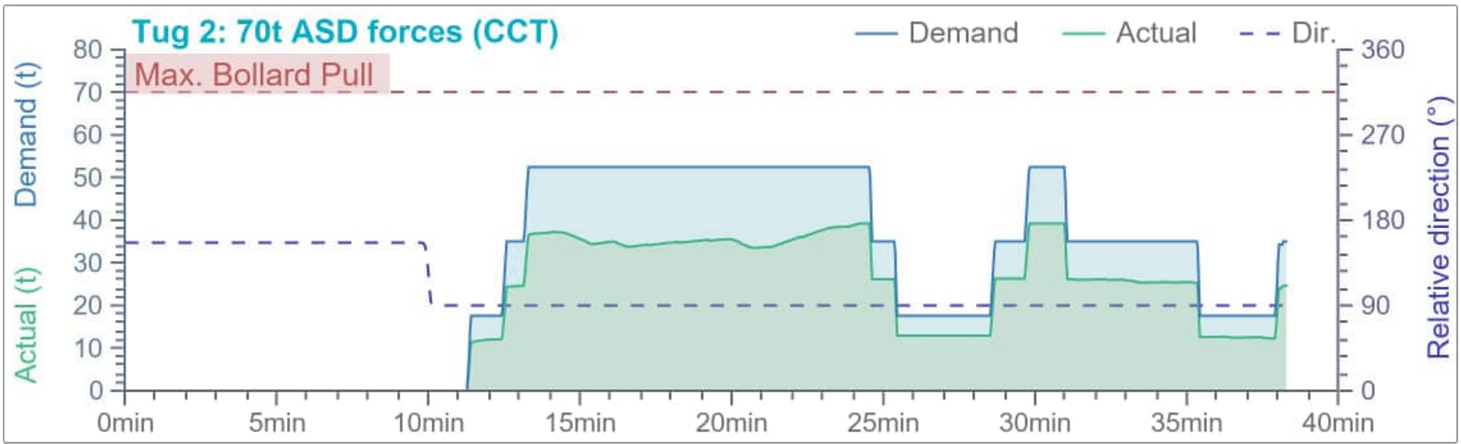

Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min
35min
40min

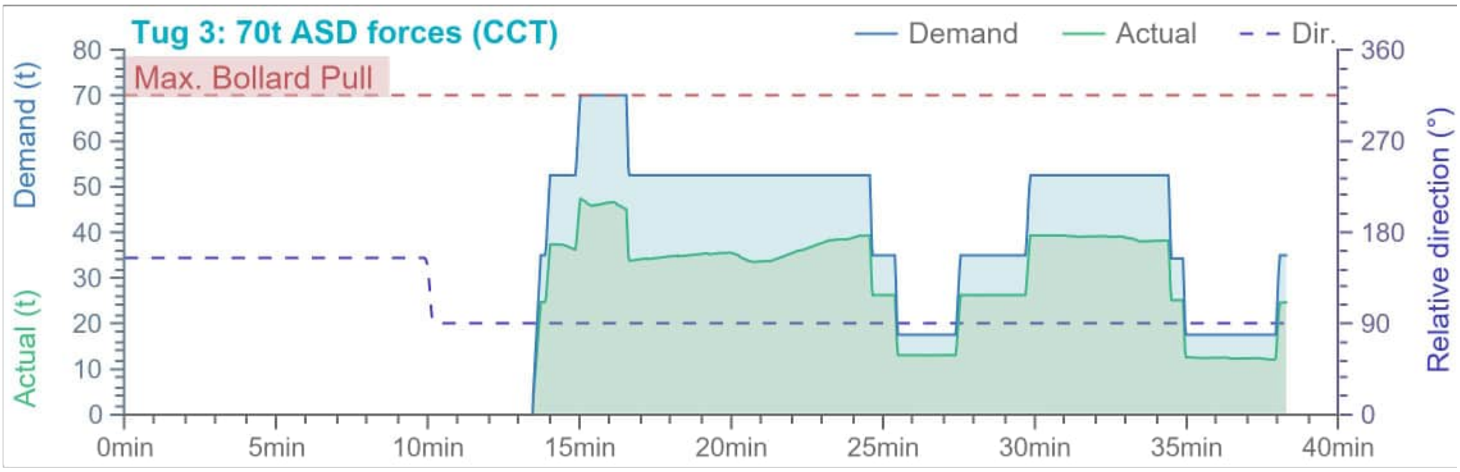

Underkeel Clearance
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min
35min
40min

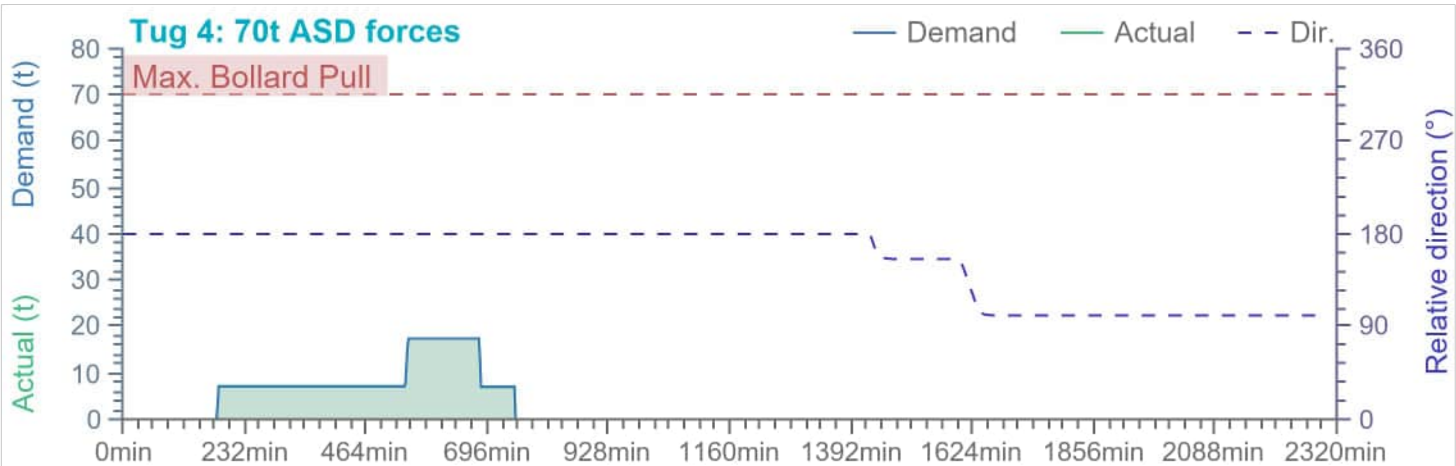

Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min
30min
35min
40min

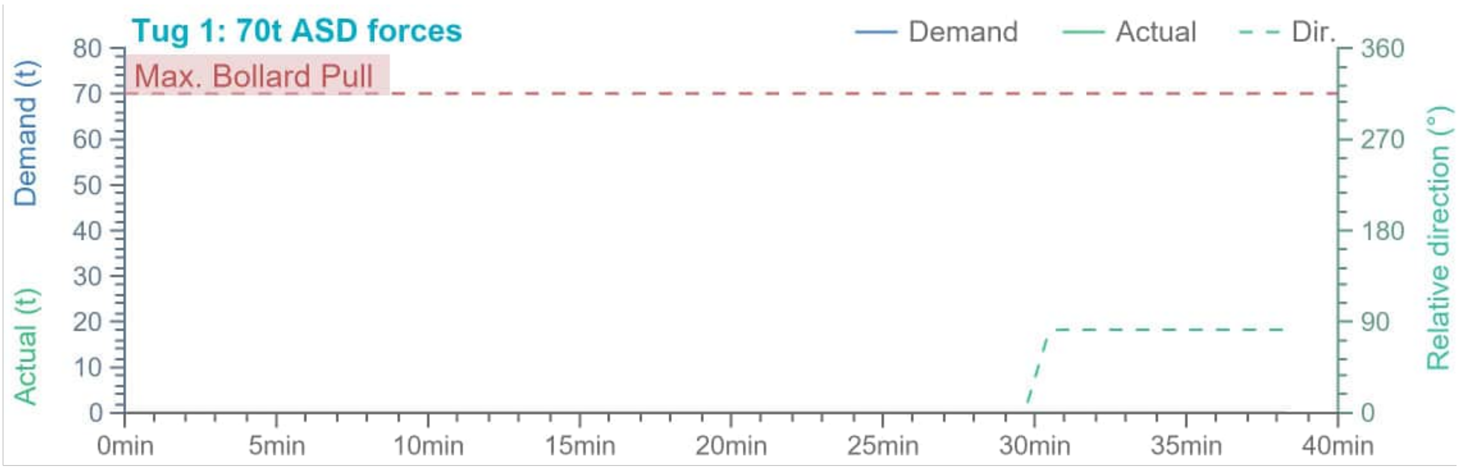

Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min
30min
35min
40min

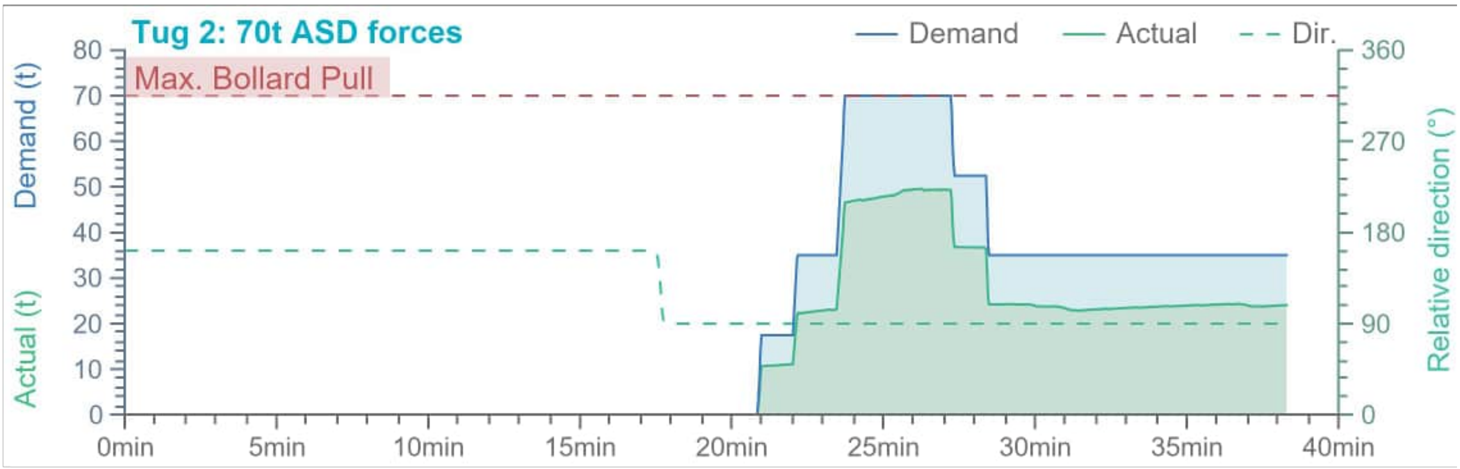

Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min
35min
40min

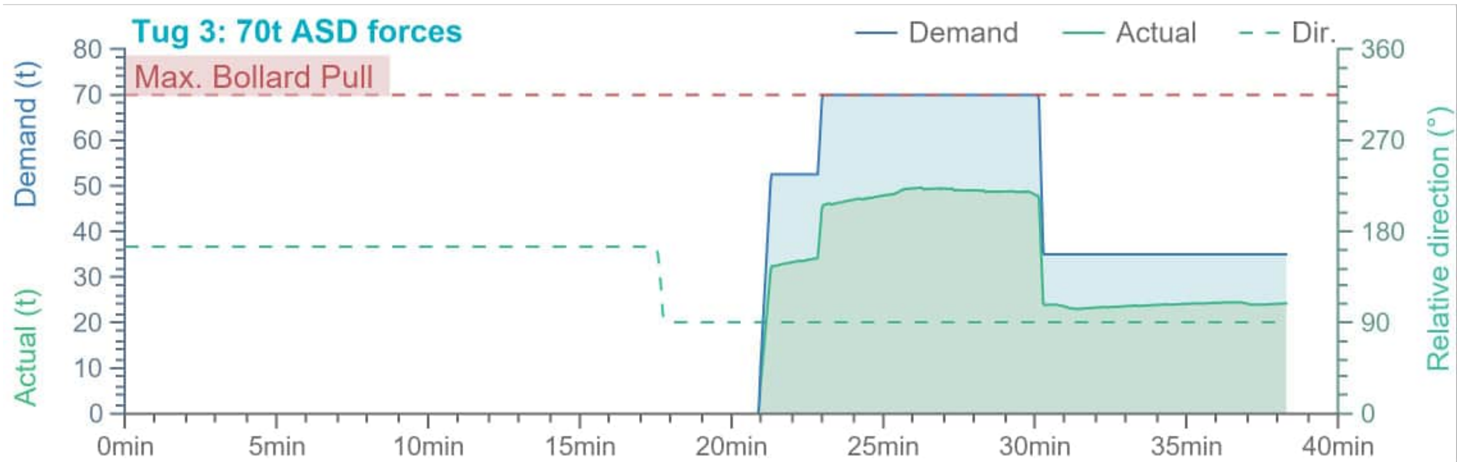

Tug 2: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min
35min
40min

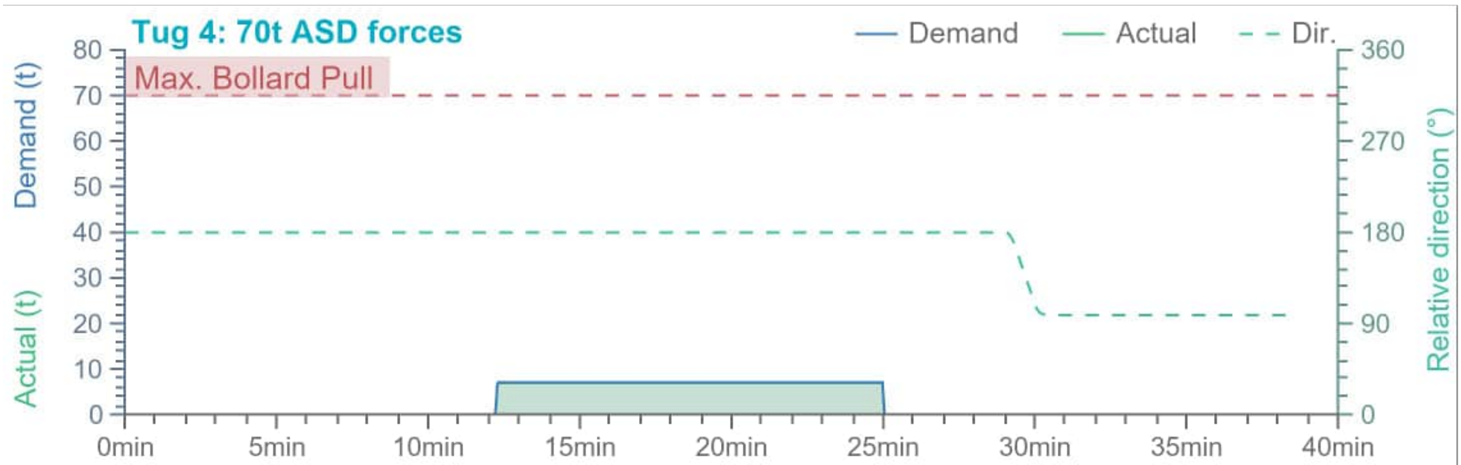

Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min
35min
40min


Tug 4: 70t ASD forces
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
232min
464min
696min
928min
1160min
1392min
1624min
1856min
2088min
2320min

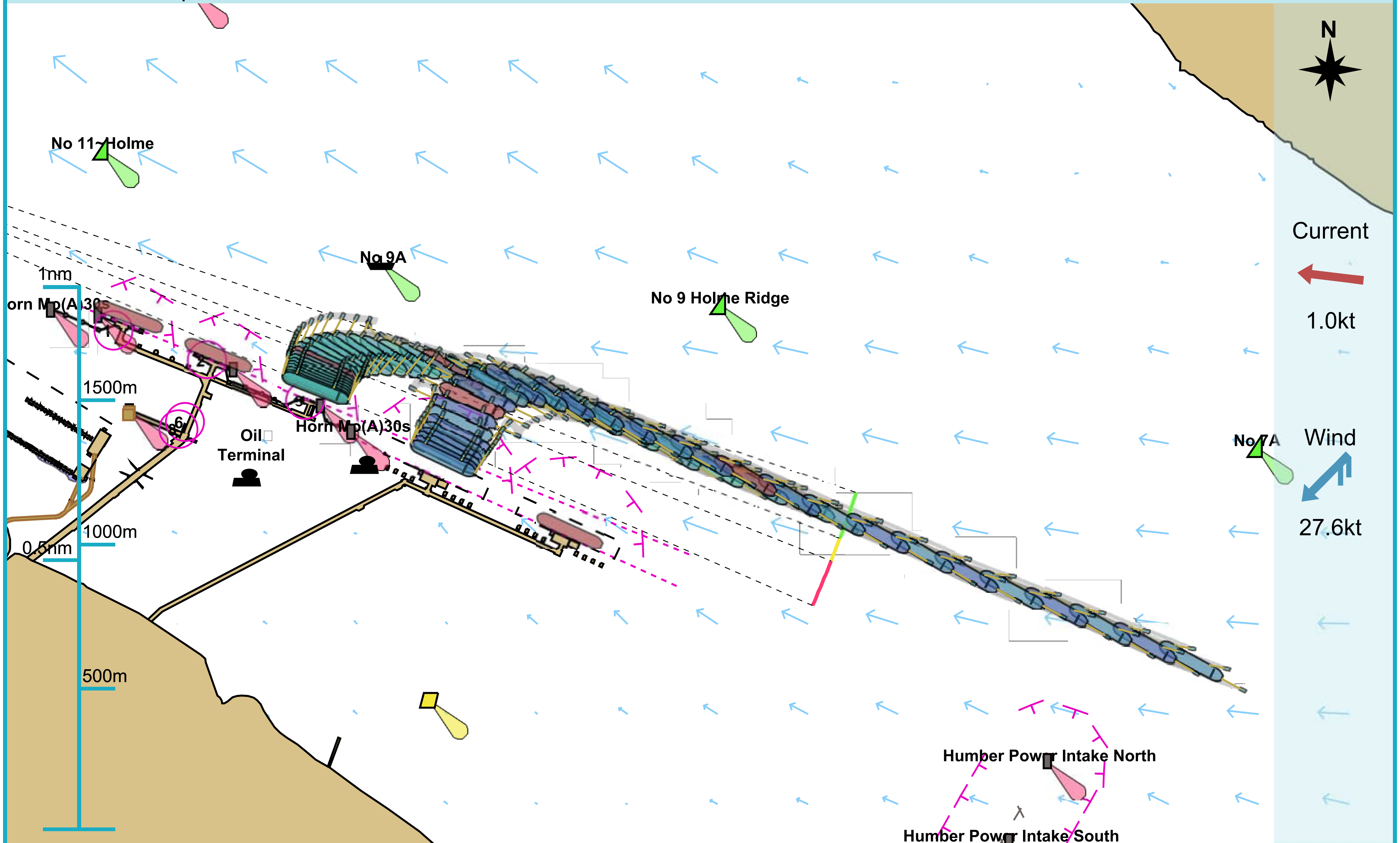

Tug 1: 70t ASD forces
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
80
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min
20min
25min
30min
35min
40min


Tug 2: 70t ASD forces
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
80
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min
20min
25min
30min
35min
40min


Tug 3: 70t ASD forces
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
80
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min
20min
25min
30min
35min
40min


Tug 4: 70t ASD forces
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
80
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min
20min
25min
30min
35min
40min

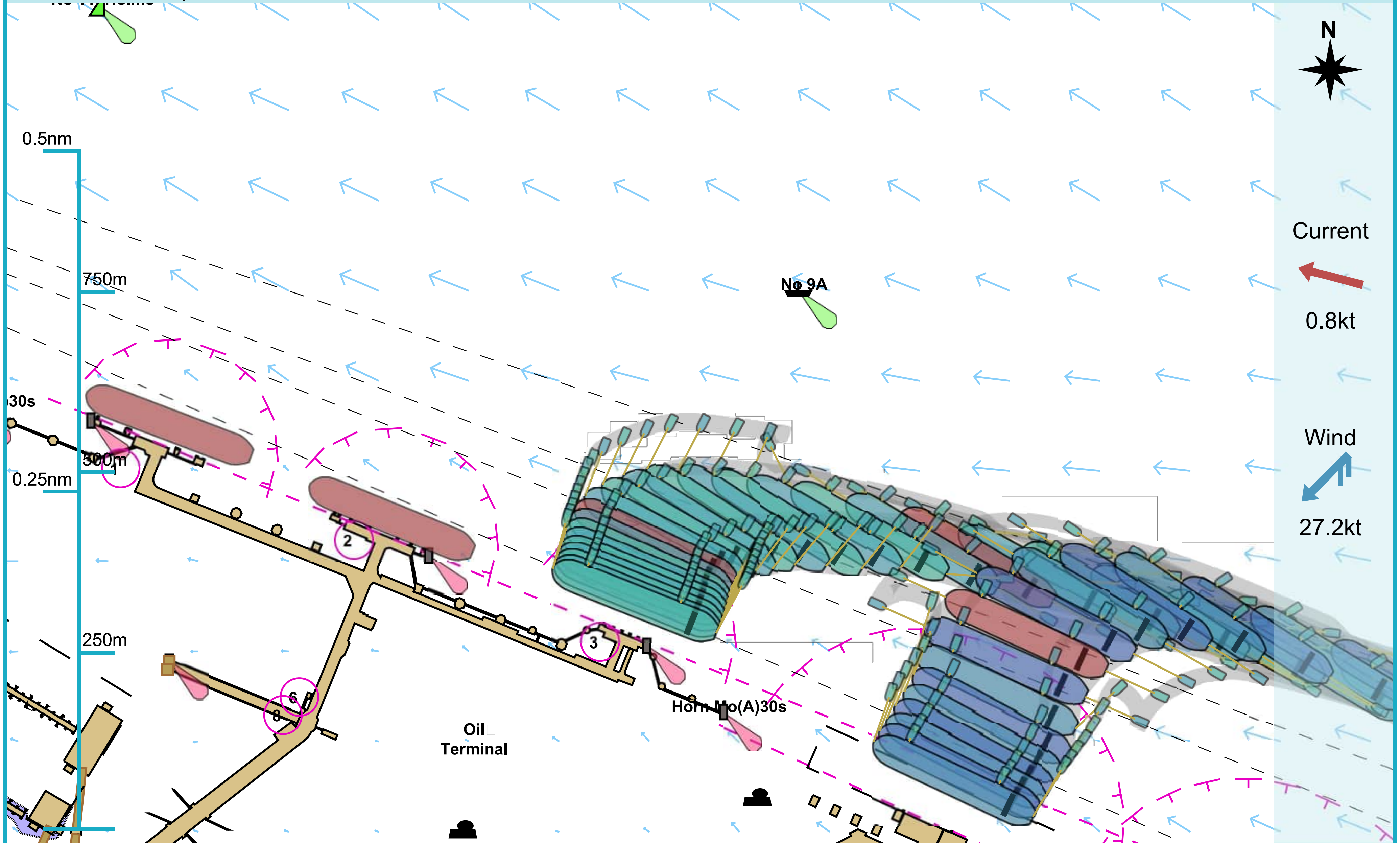
Manoeuvre track plot



1.36 kts

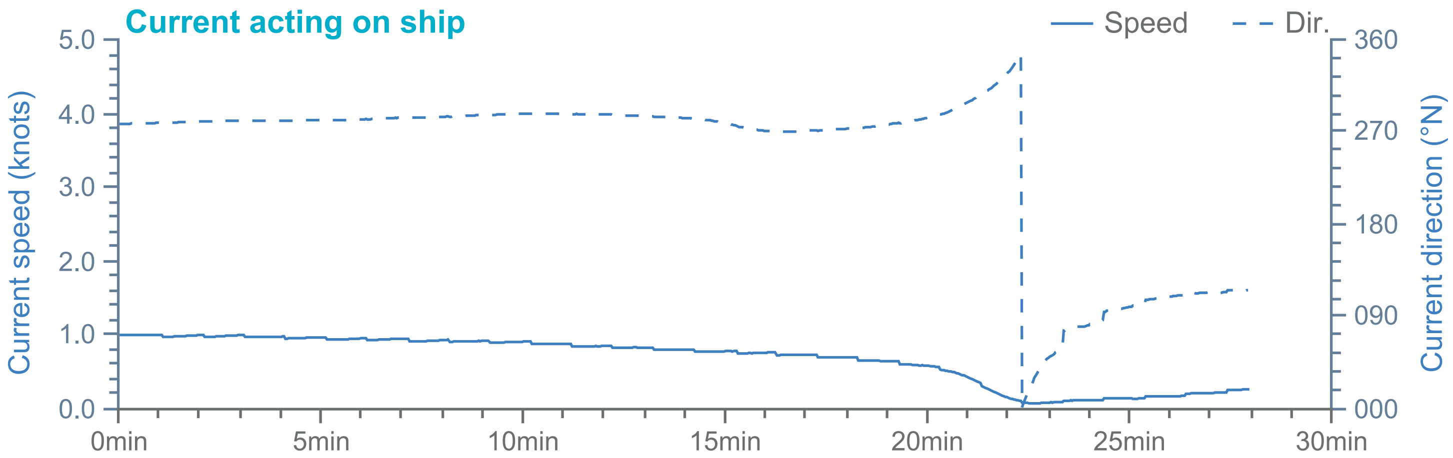
Ships plotted every 1 mins, highlight every 10 mins

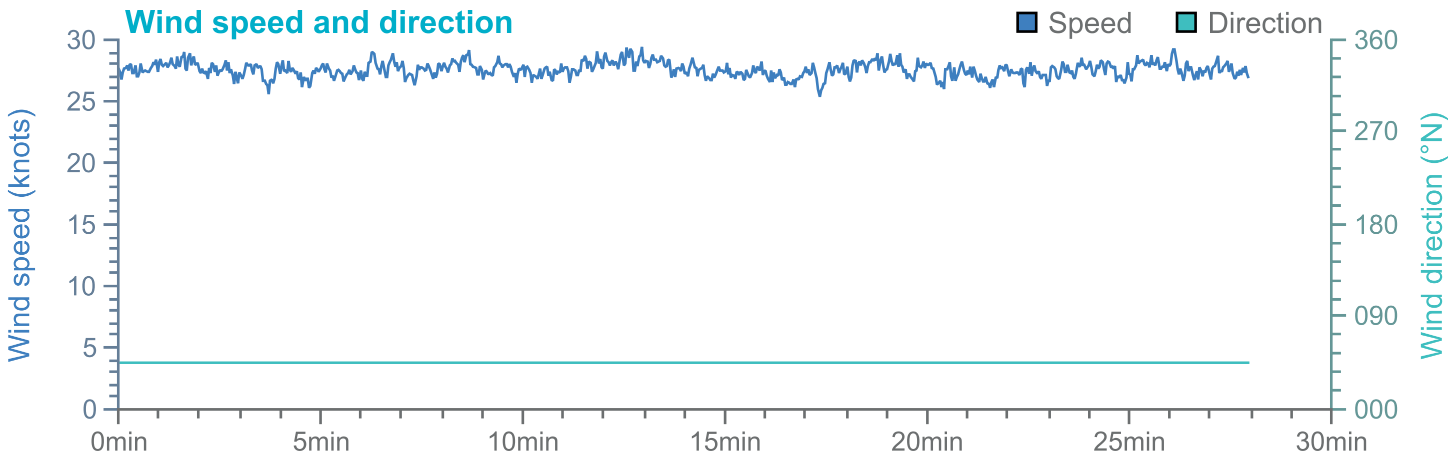
Manoeuvre track plot

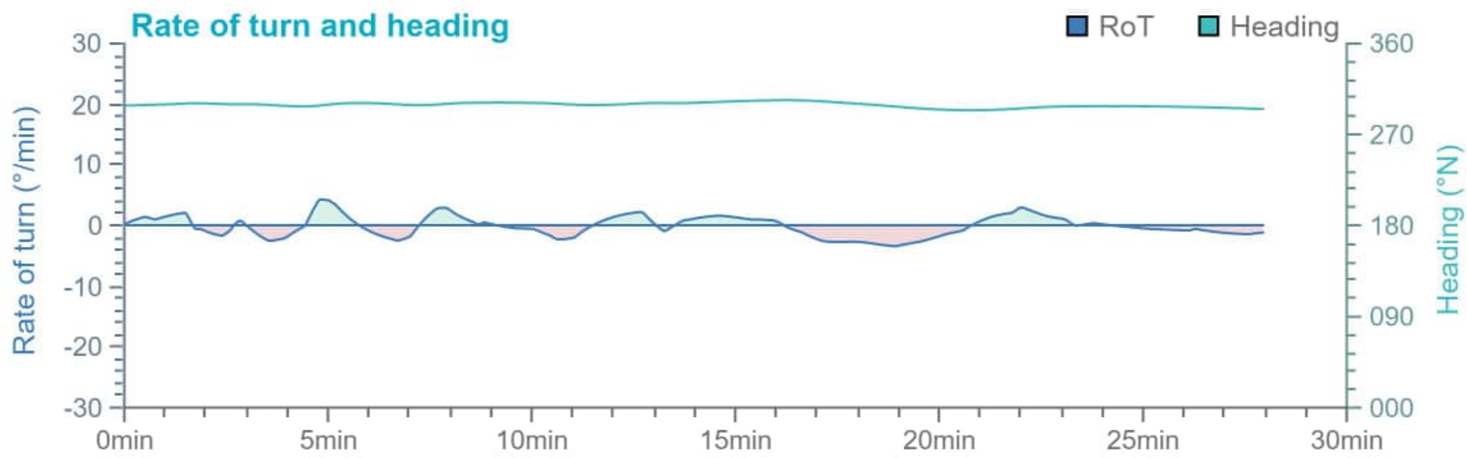


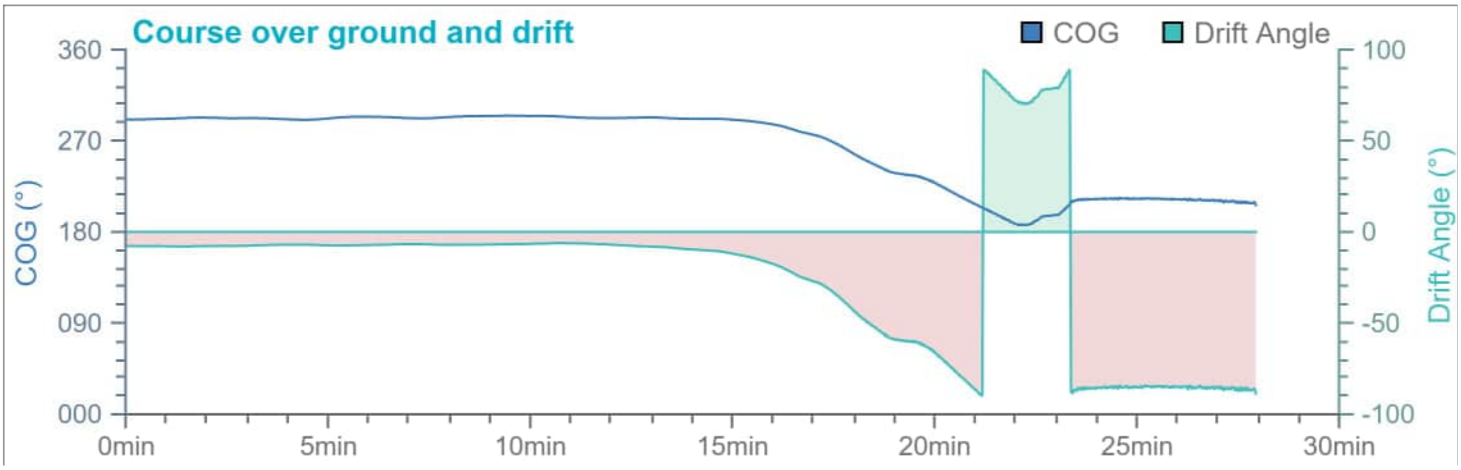
1.42 kts

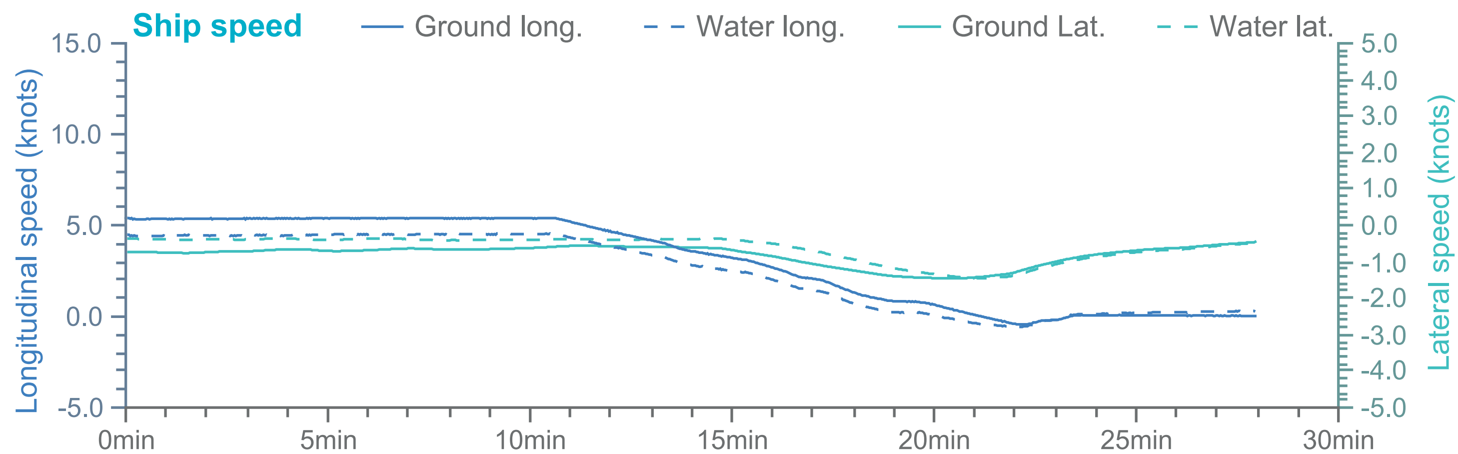
Ships plotted every 1 mins, highlight every 10 mins

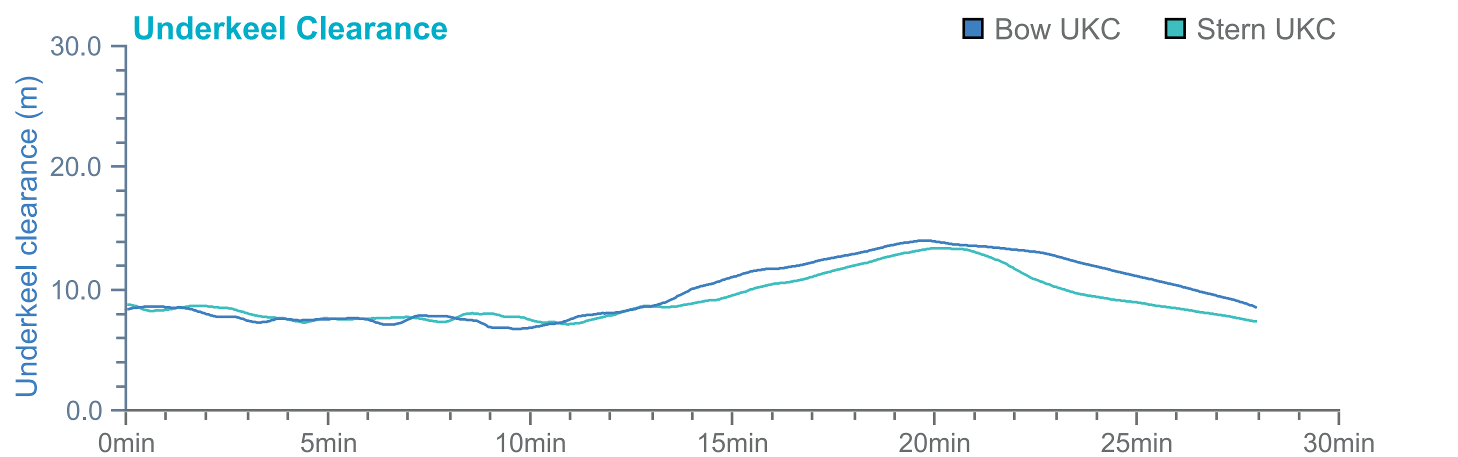

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min

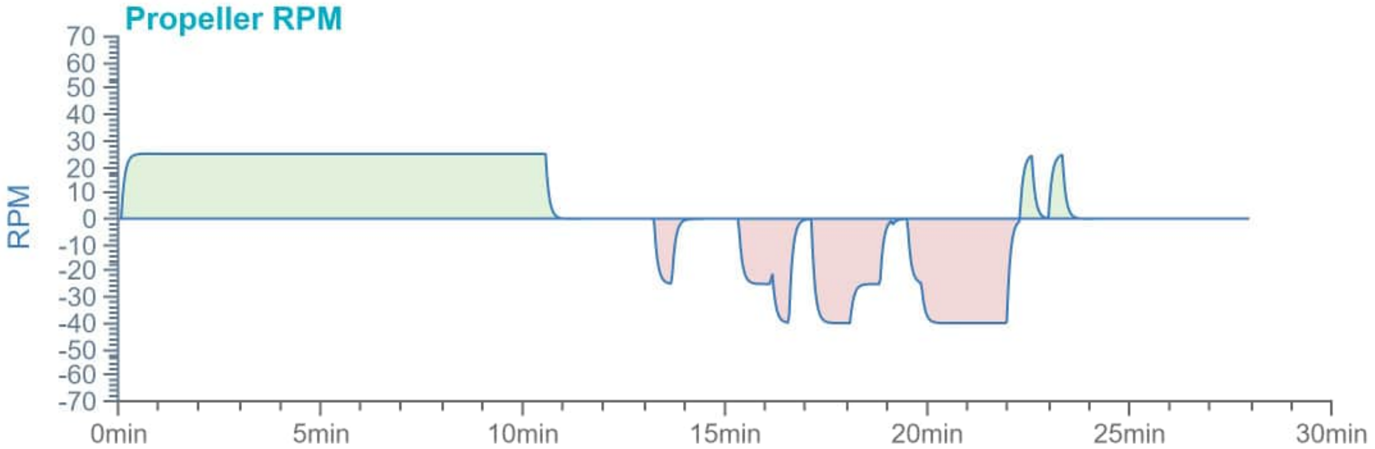

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min

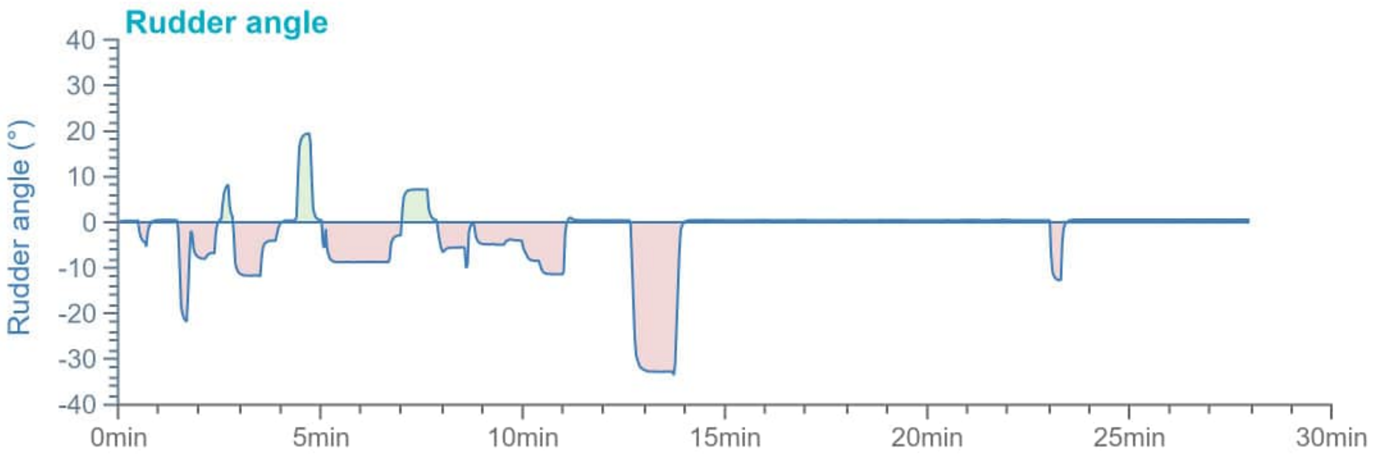

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min

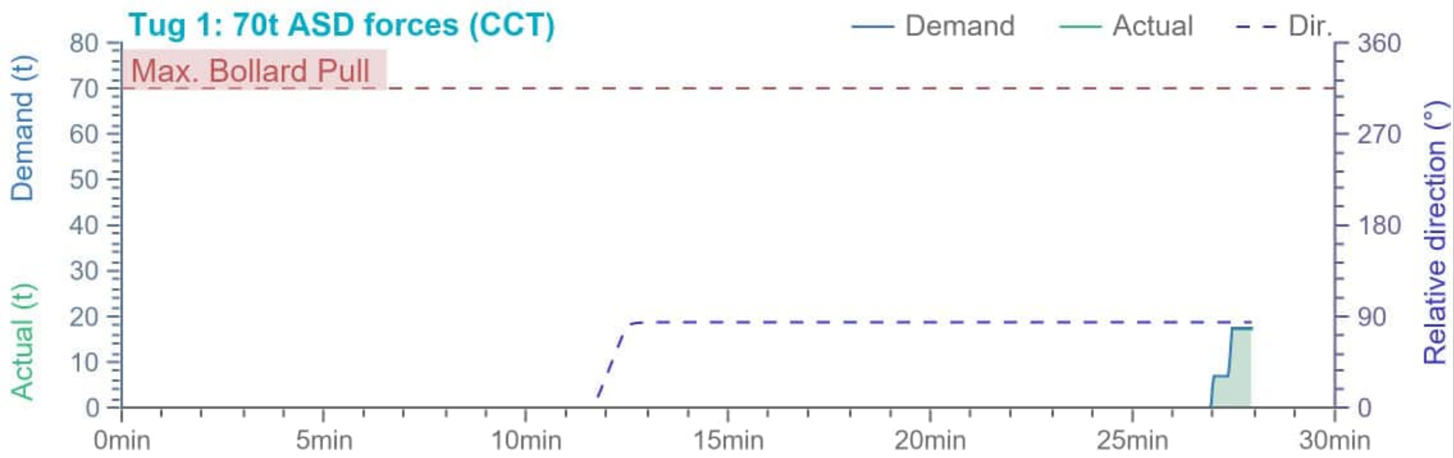

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min

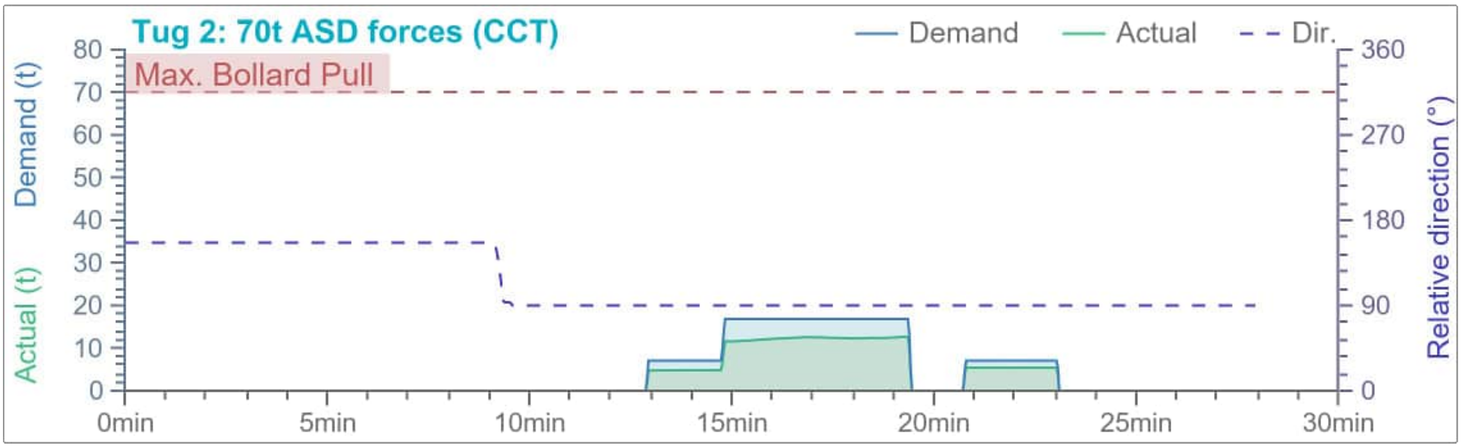

Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min

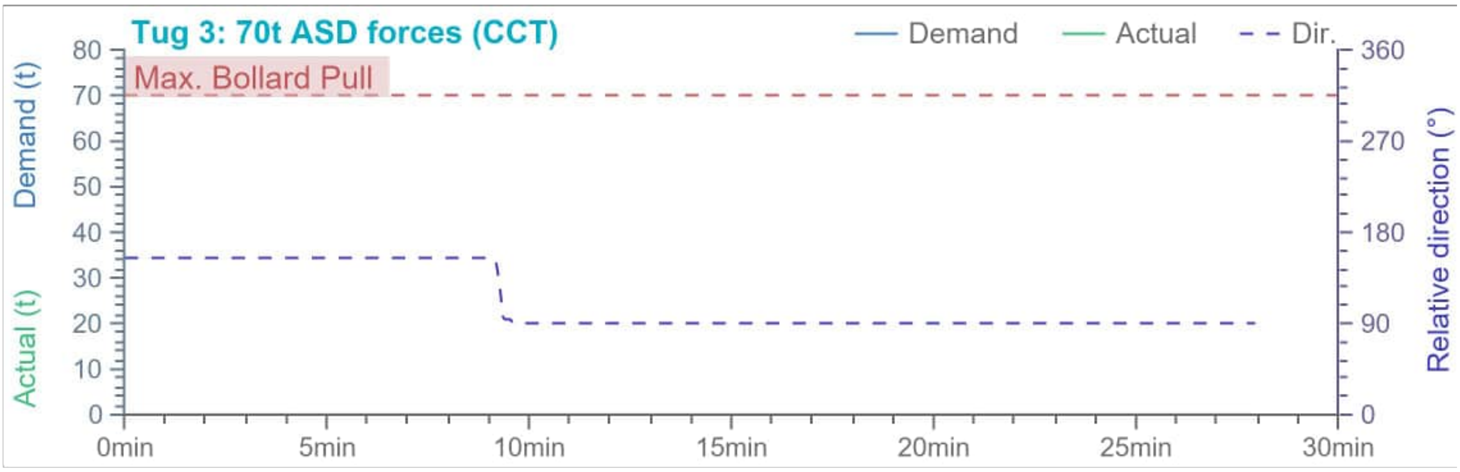

Underkeel Clearance
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min

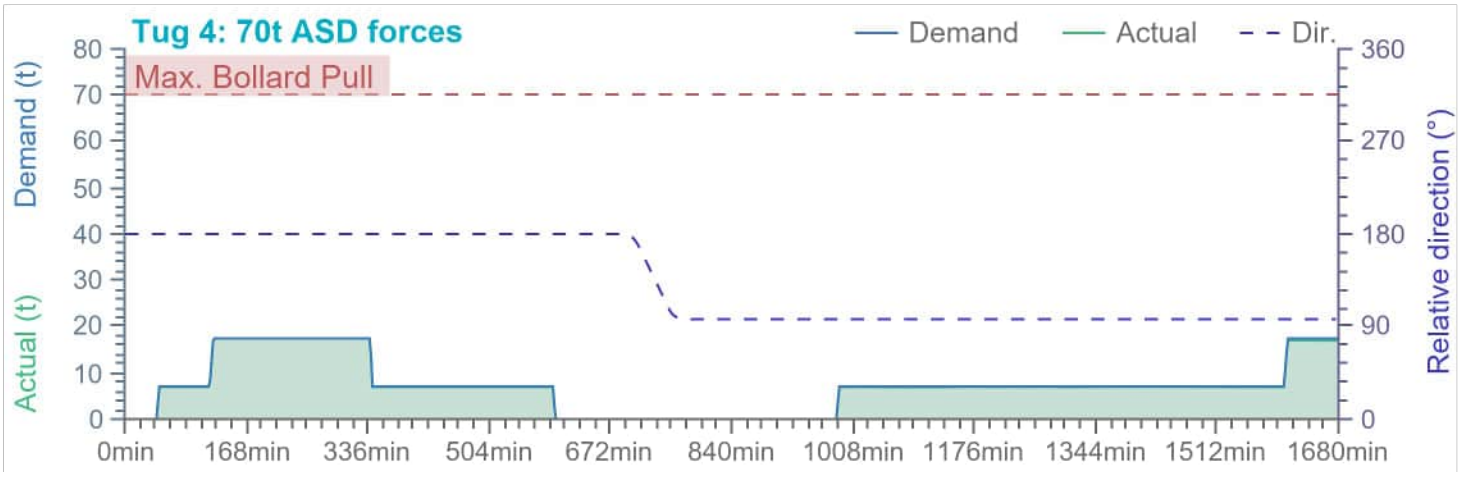

Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min
30min

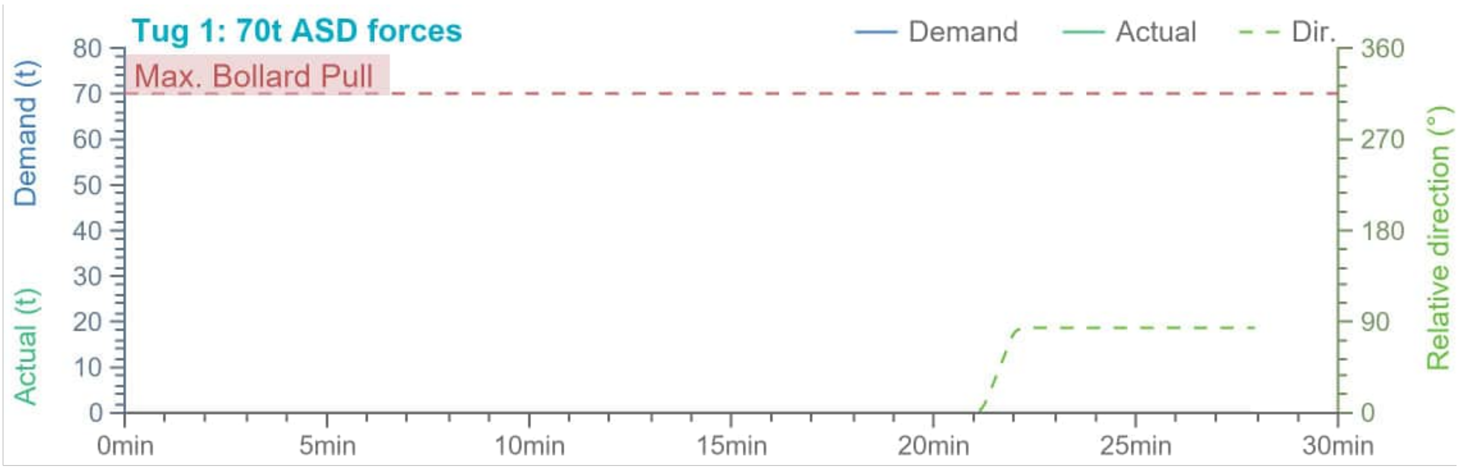

Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min
30min

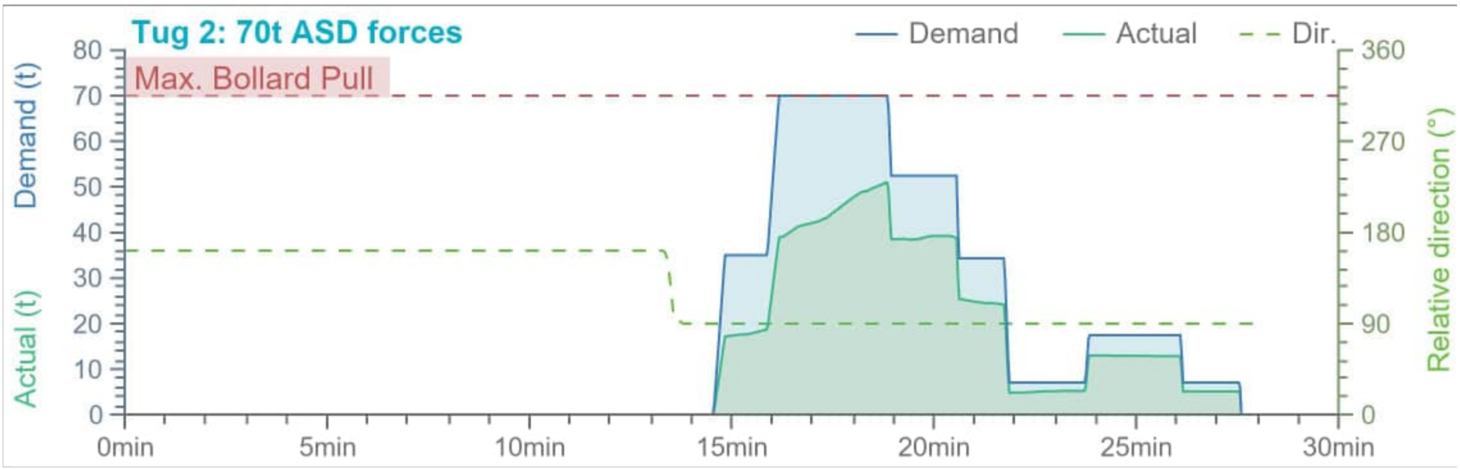

Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min

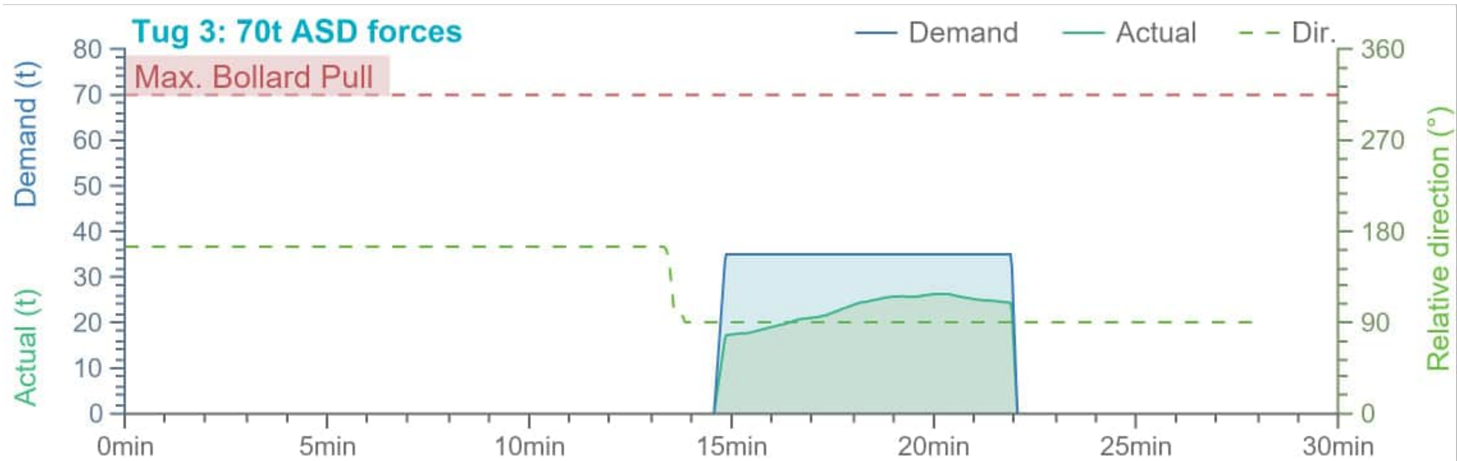

Tug 2: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min

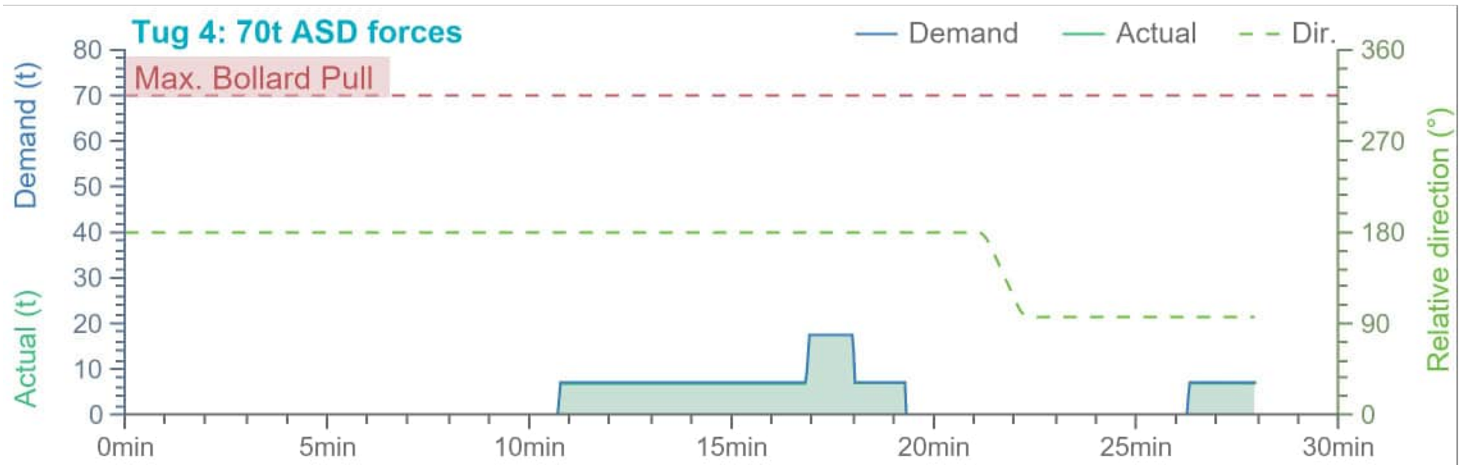

Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min


Tug 4: 70t ASD forces
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
168min
336min
504min
672min
840min
1008min
1176min
1344min
1512min
1680min

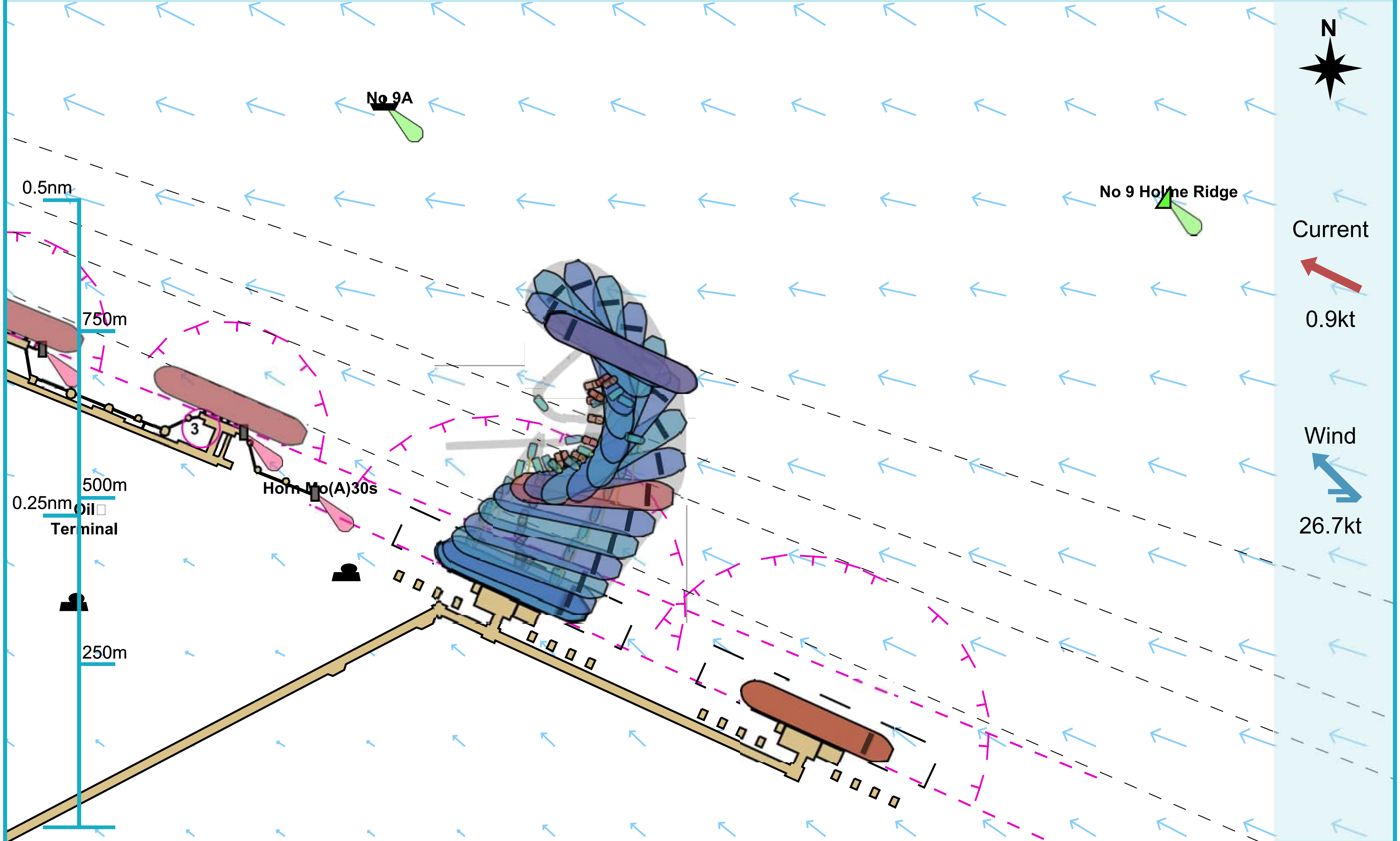

Tug 1: 70t ASD forces
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
80
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min
20min
25min
30min


Tug 2: 70t ASD forces
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
80
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min
20min
25min
30min

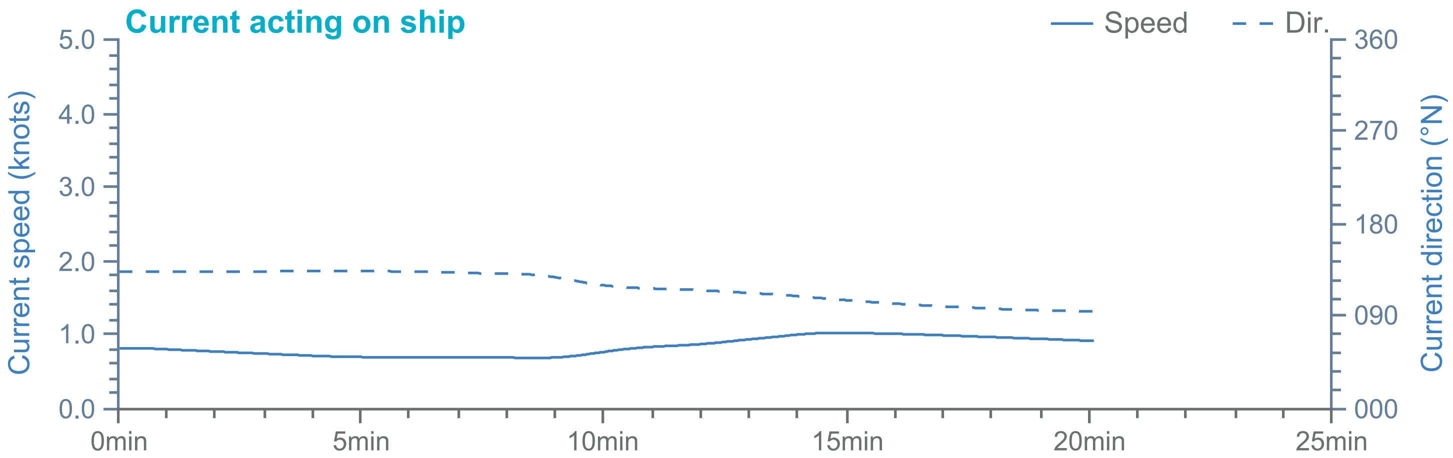

Tug 3: 70t ASD forces
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
80
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min
20min
25min
30min

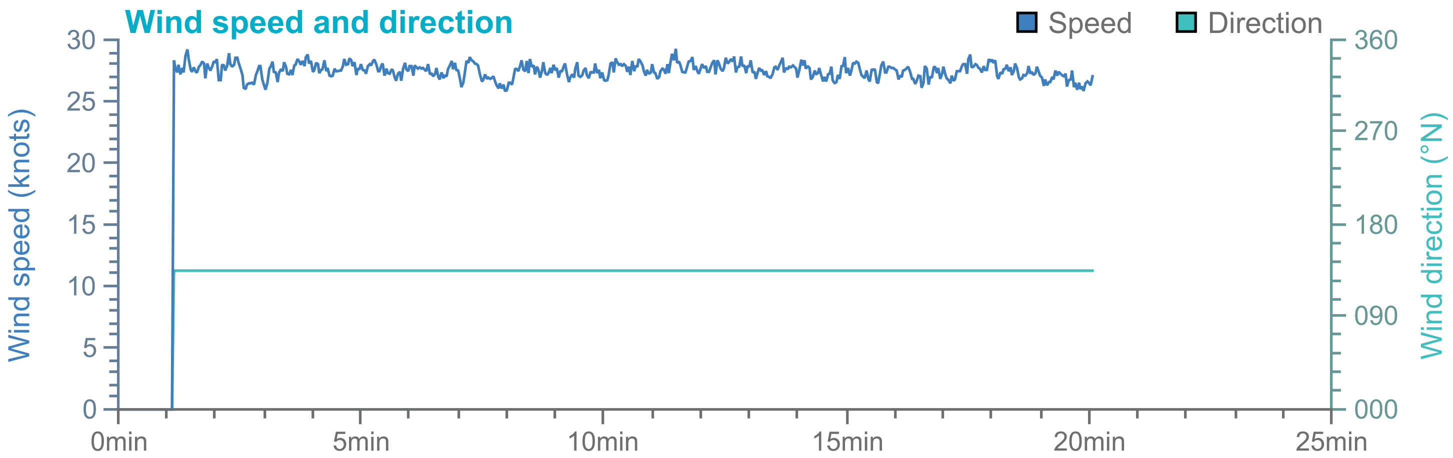

Tug 4: 70t ASD forces
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
80
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min
20min
25min
30min

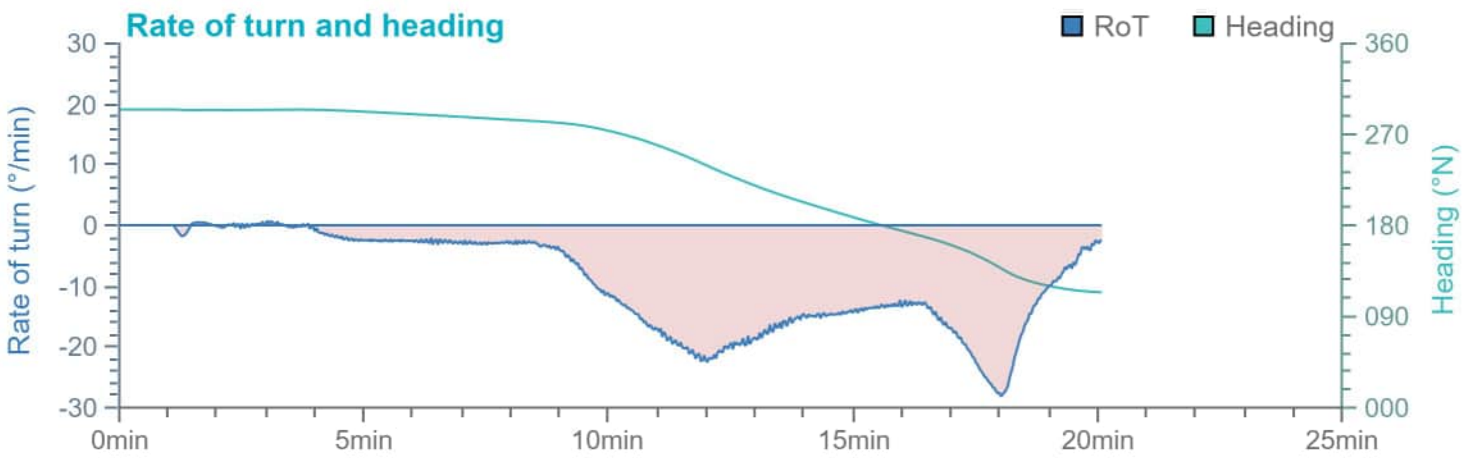
Manoeuvre track plot

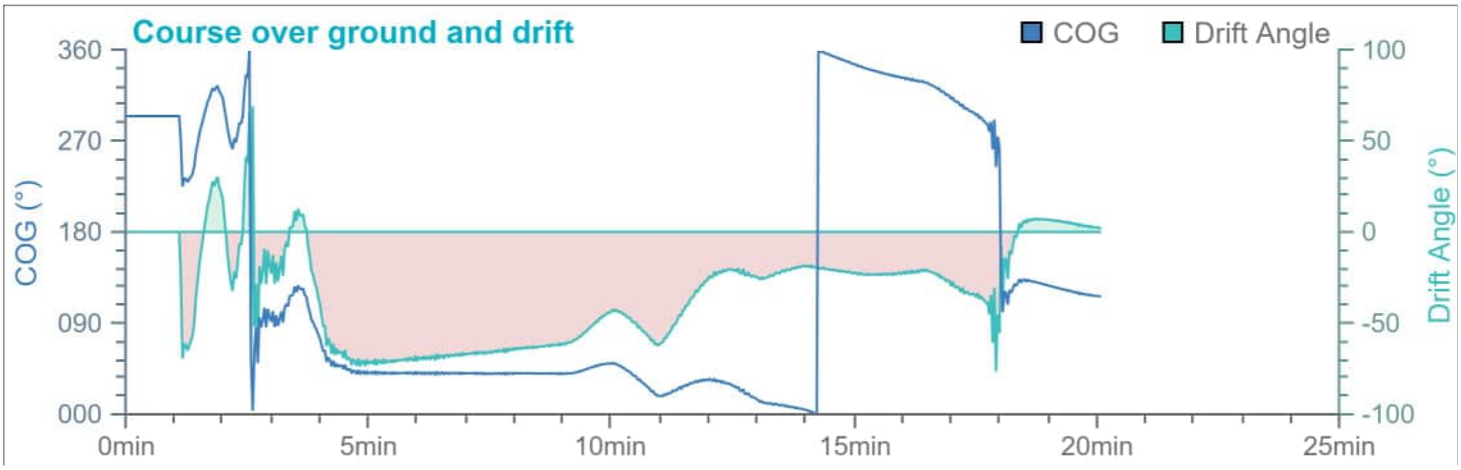


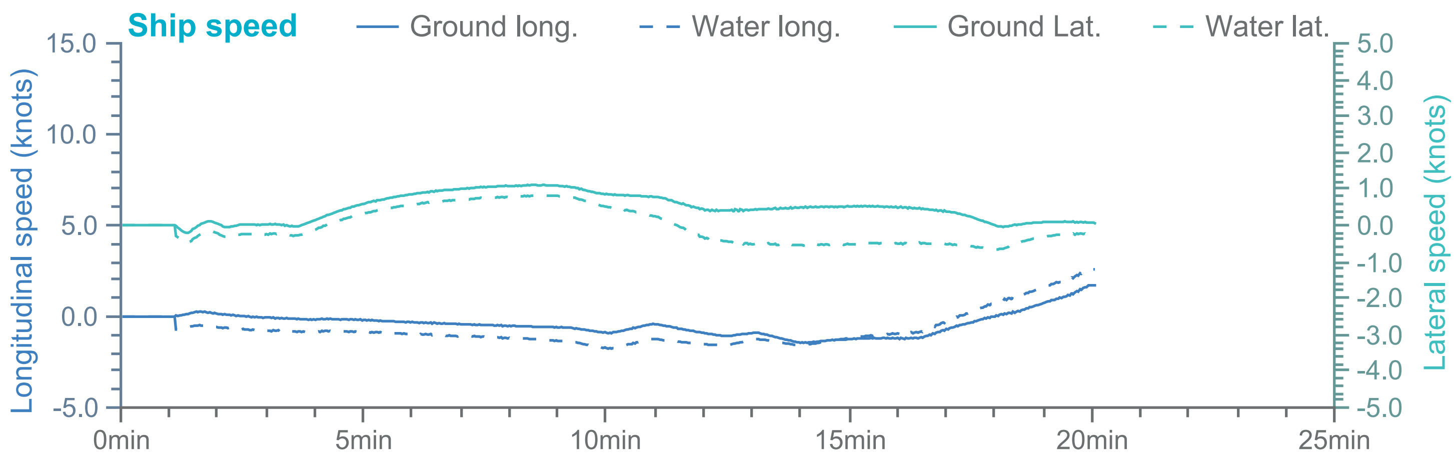
Ships plotted every 1 mins, highlight every 10 mins

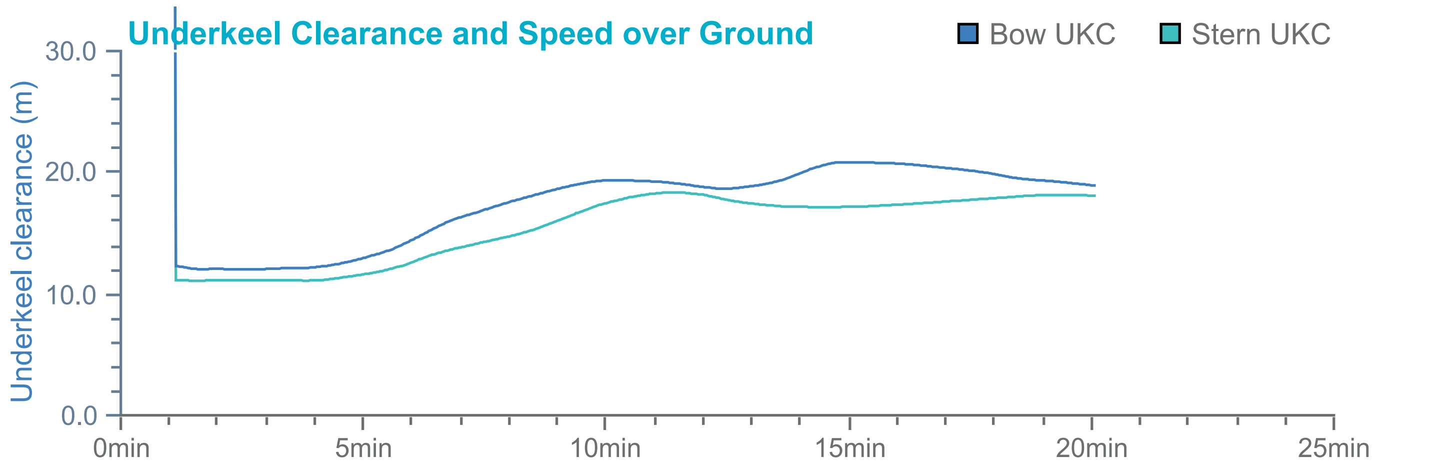

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min

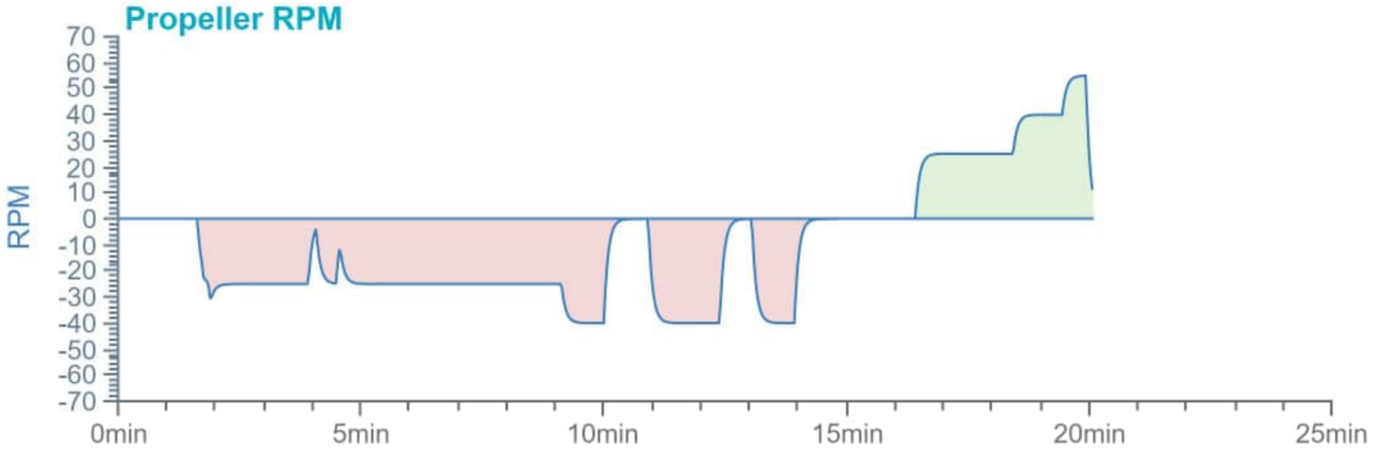

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min

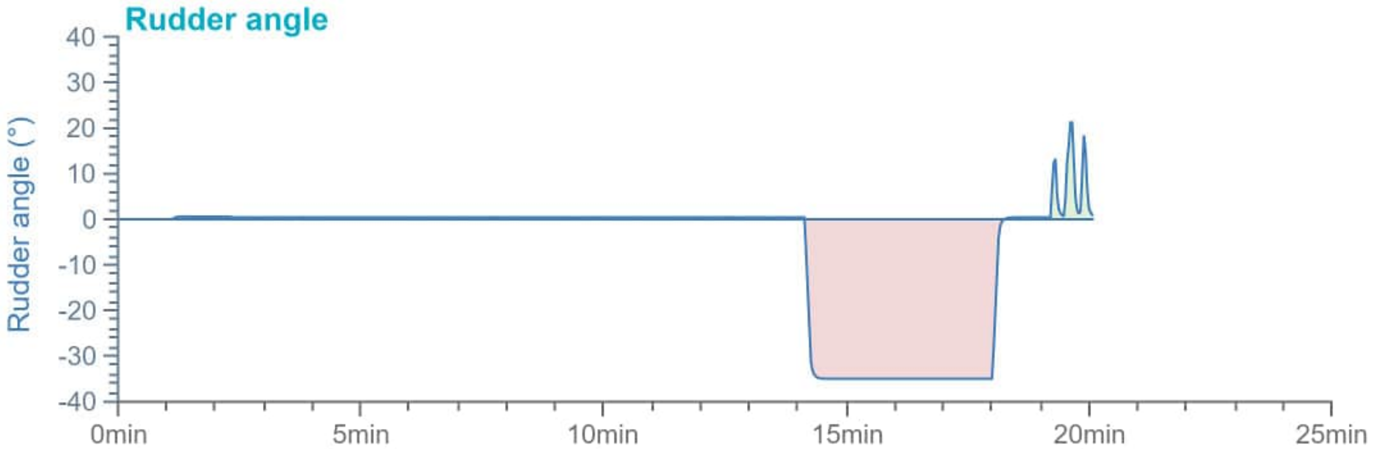

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min
15min
20min
25min

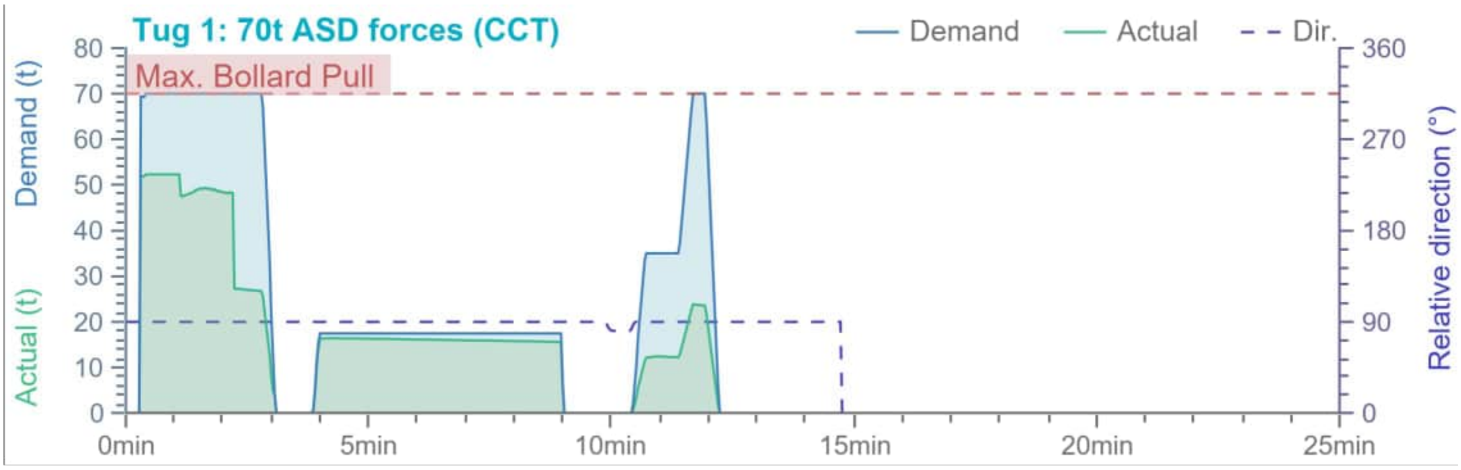

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min

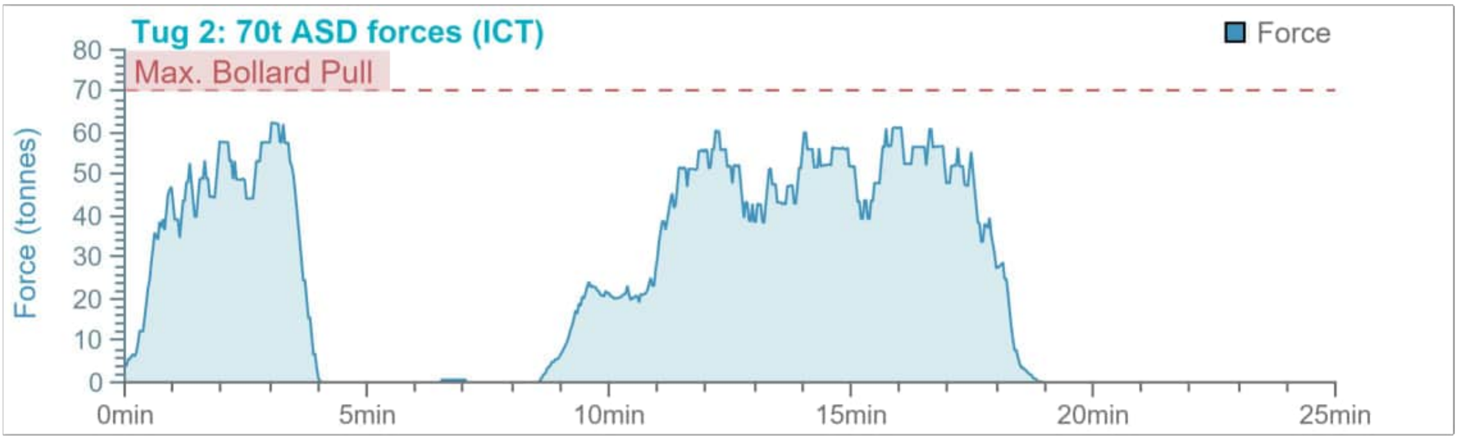

Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min

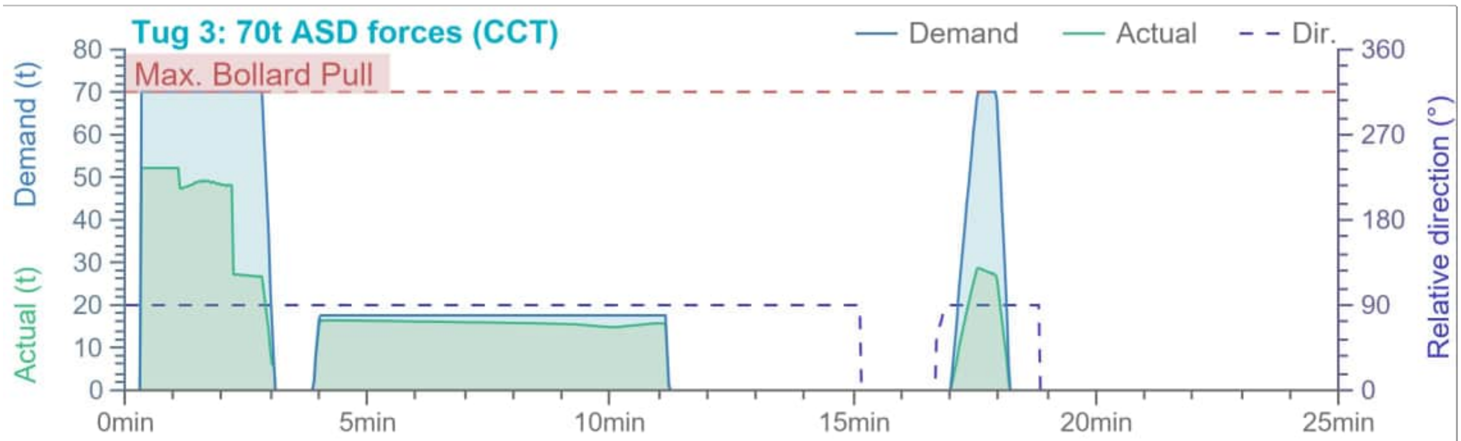

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min


Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min

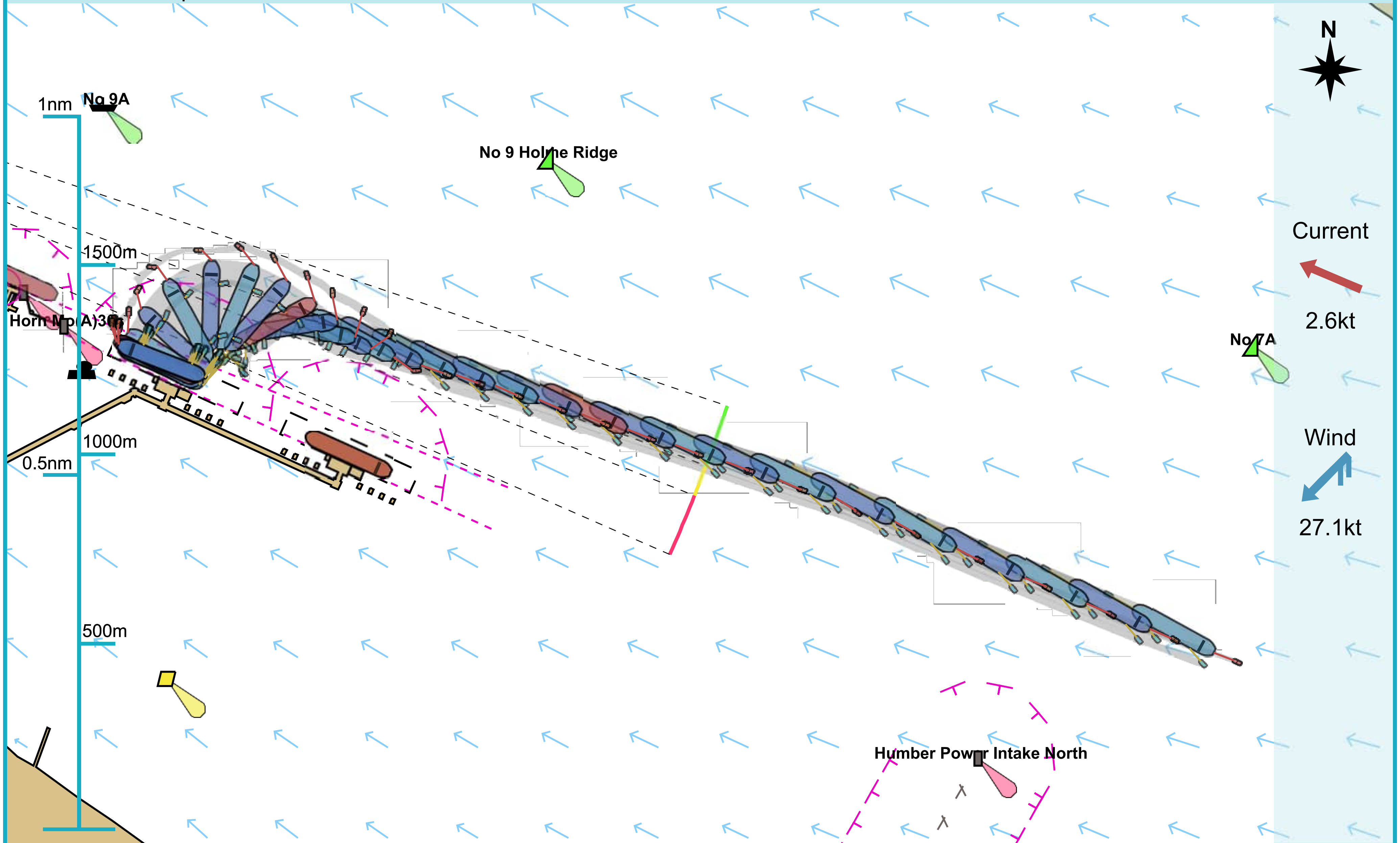

Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min


Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min


Tug 2: 70t ASD forces (ICT)
Force
Max. Bollard Pull
Force (tonnes)
0min
5min
10min
15min
20min
25min


Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min

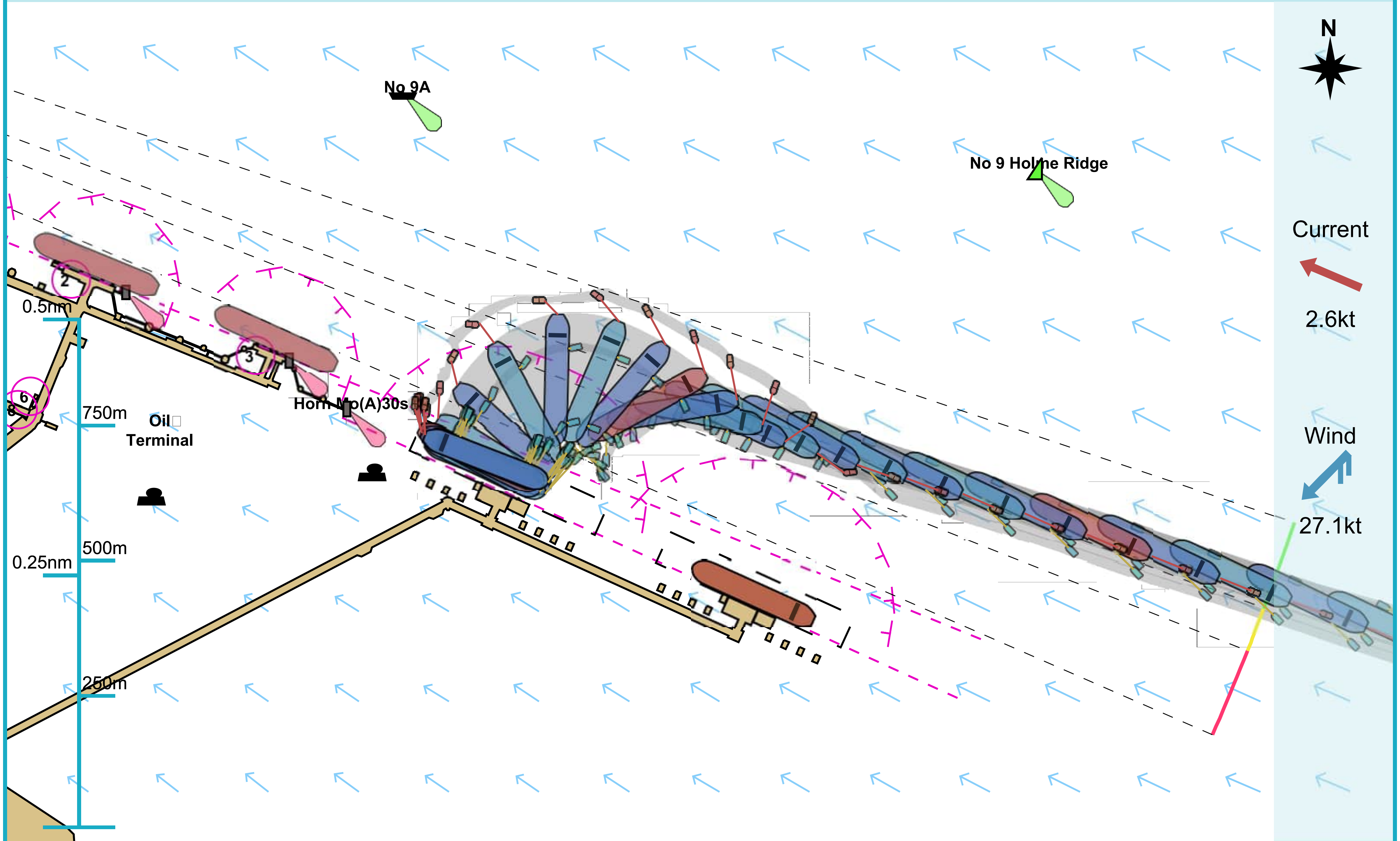
Manoeuvre track plot



3.28 kts

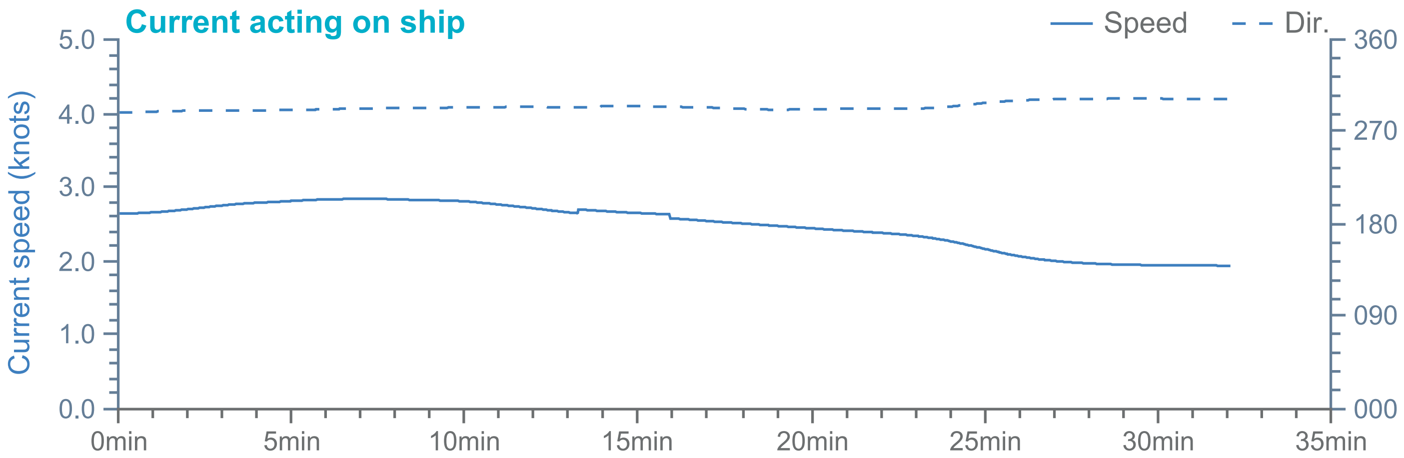
Ships plotted every 1 mins, highlight every 10 mins

Manoeuvre track plot

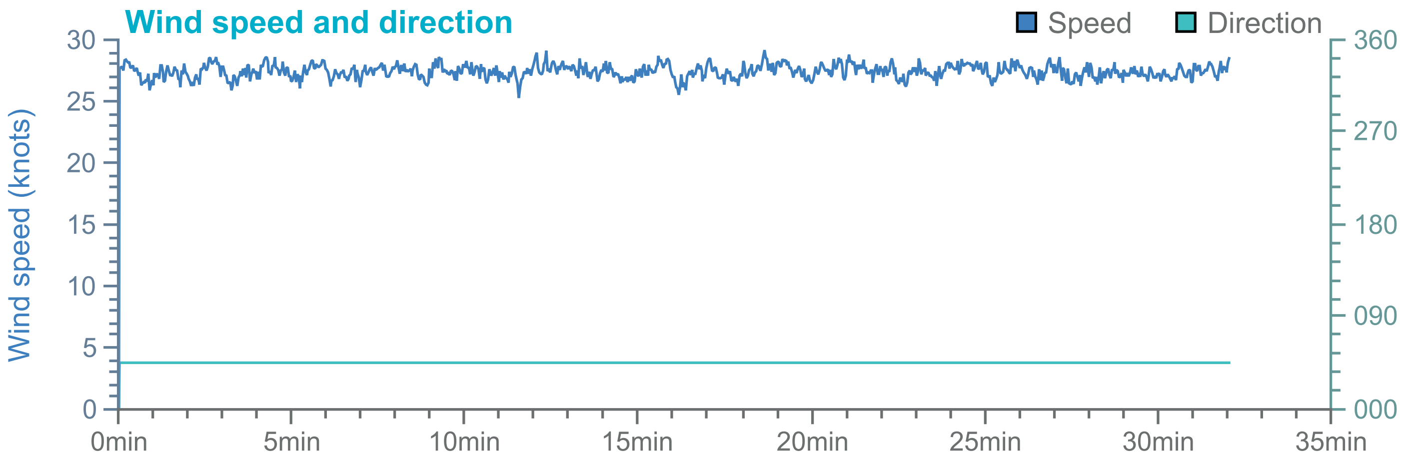


3.28 kts

Ships plotted every 1 mins, highlight every 10 mins

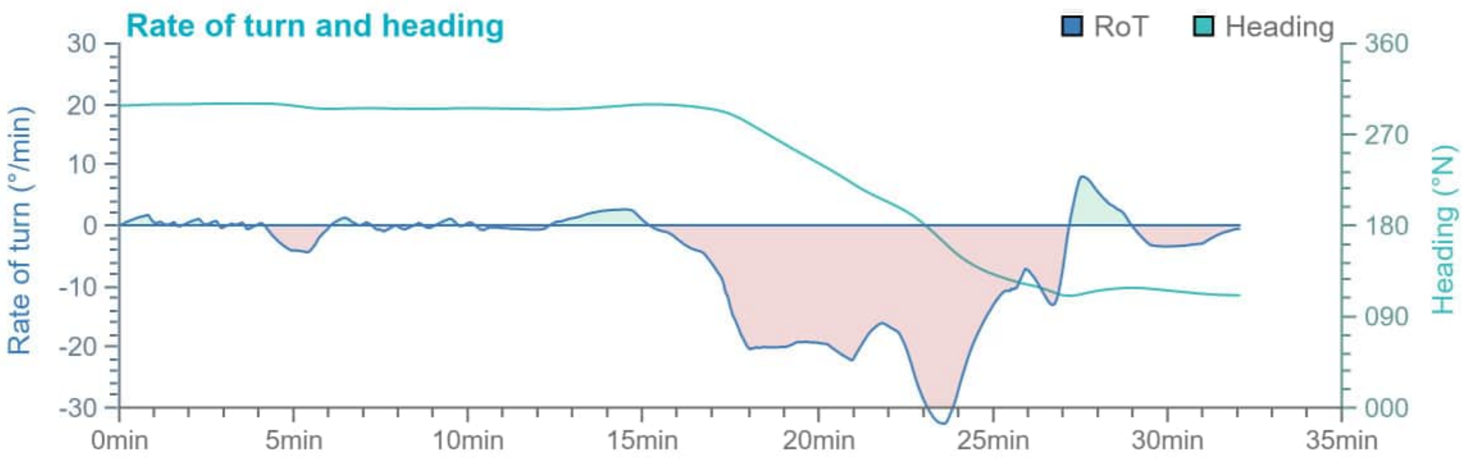


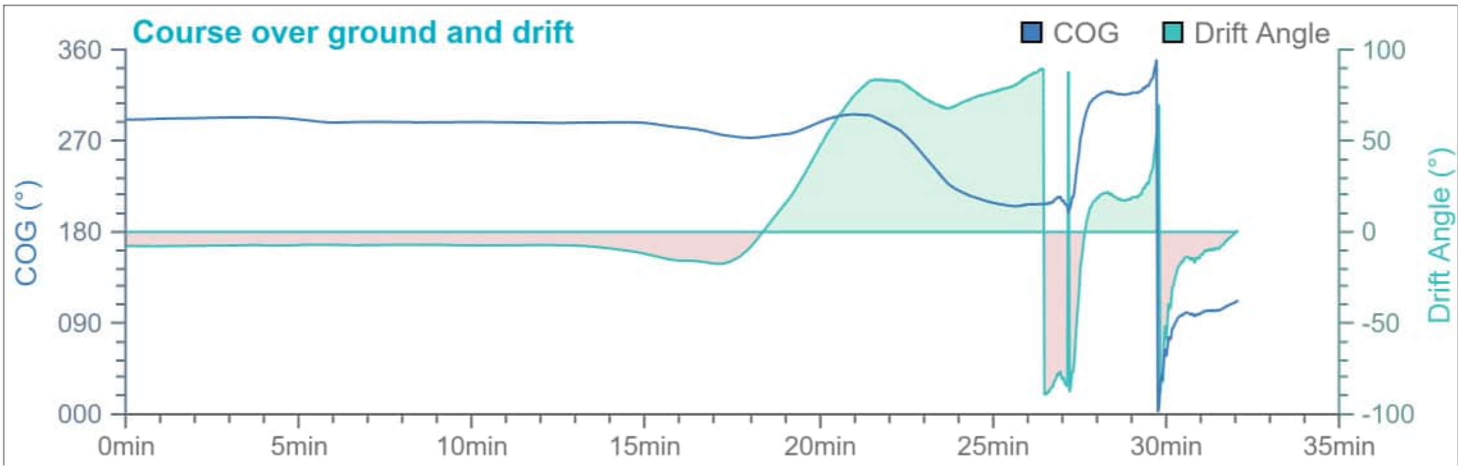
Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

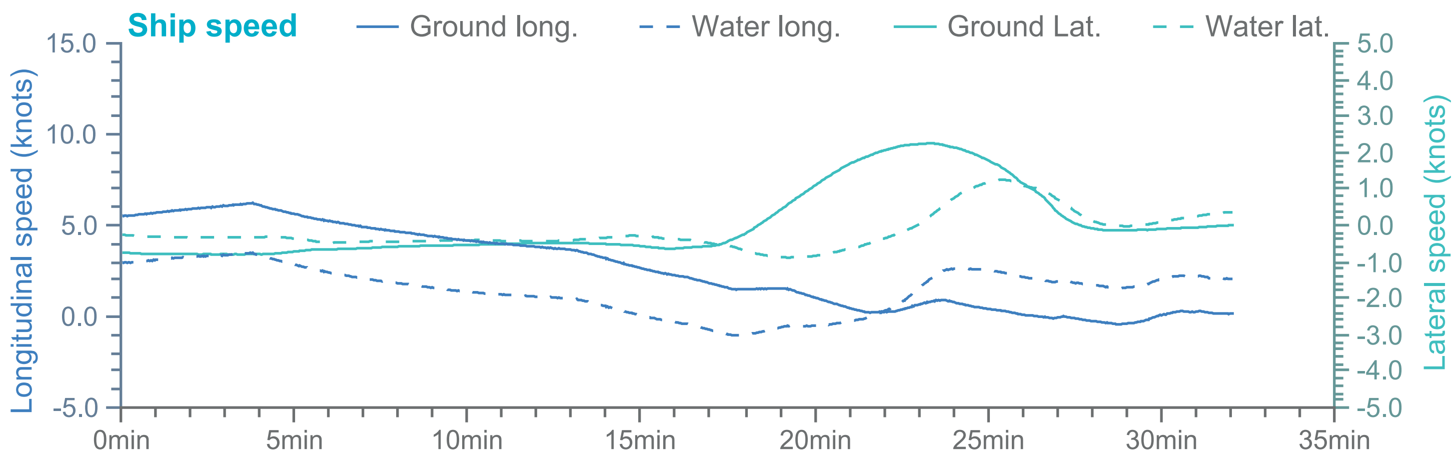


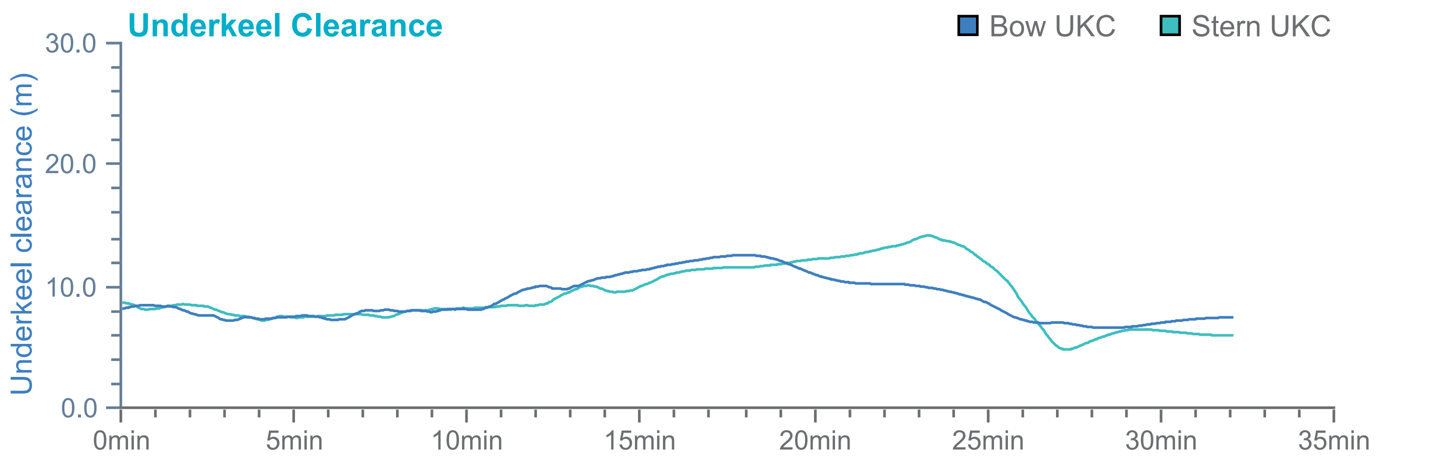
Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

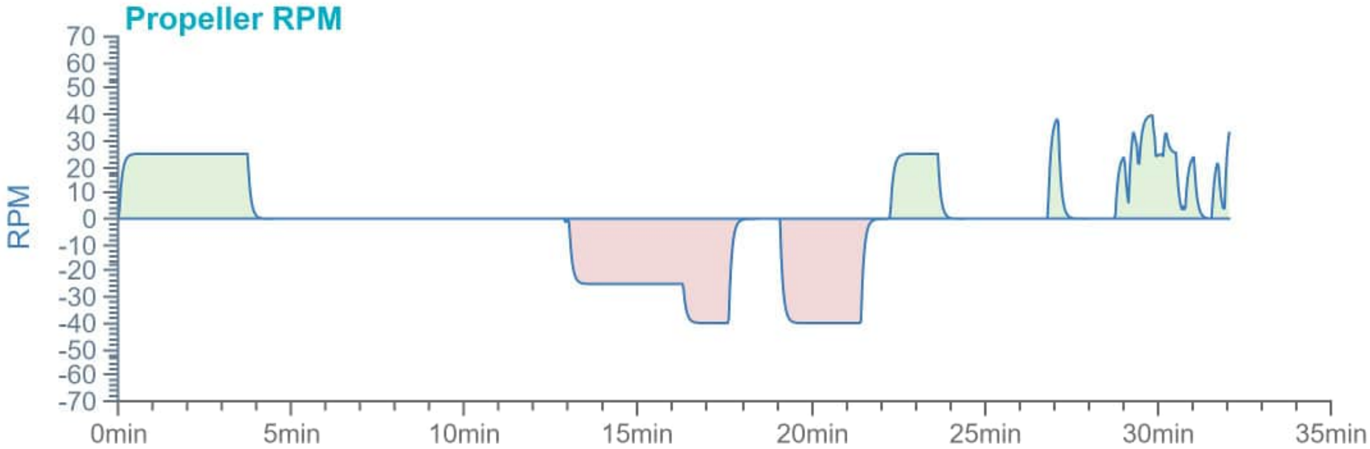
Overview | Environment | 243m Product Tanker | Tugs

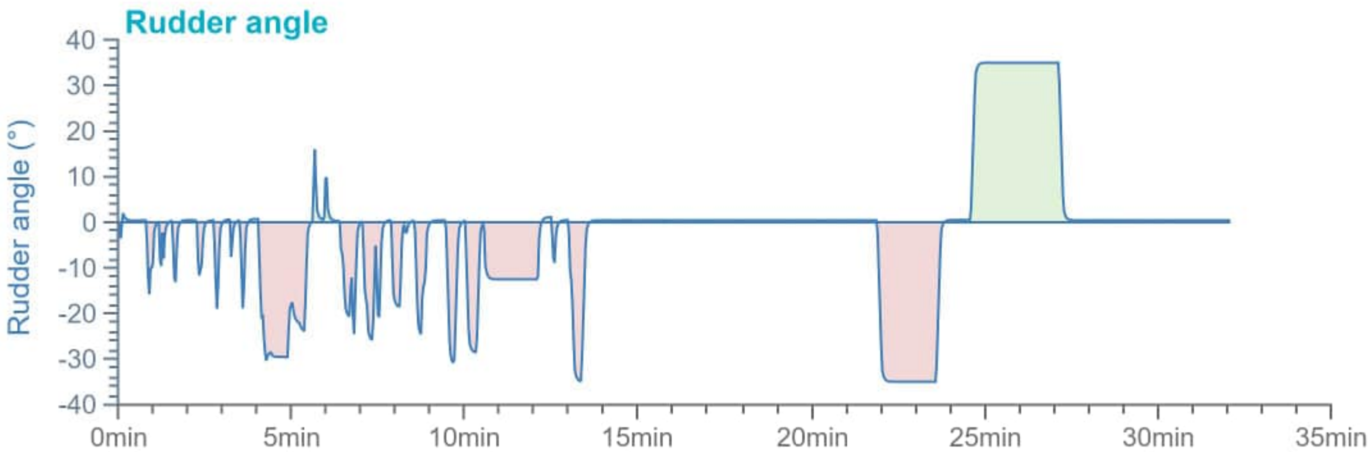


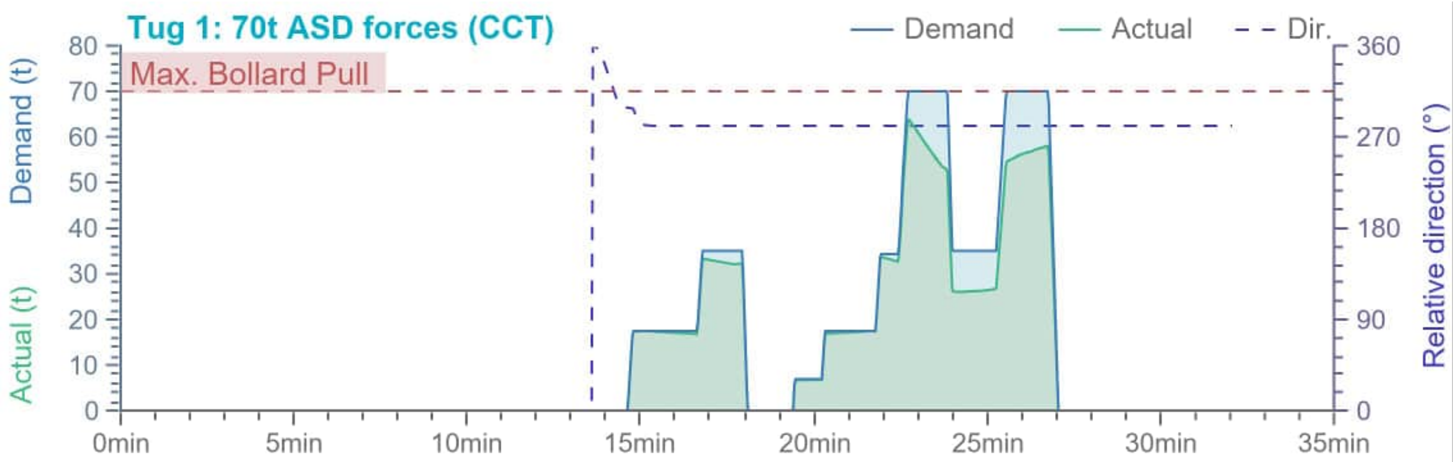


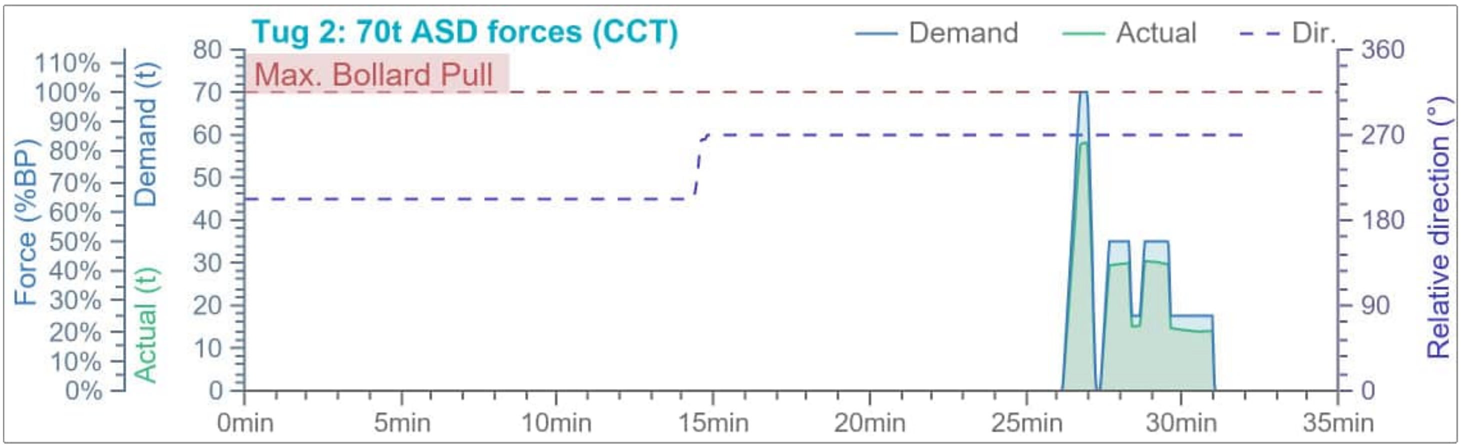


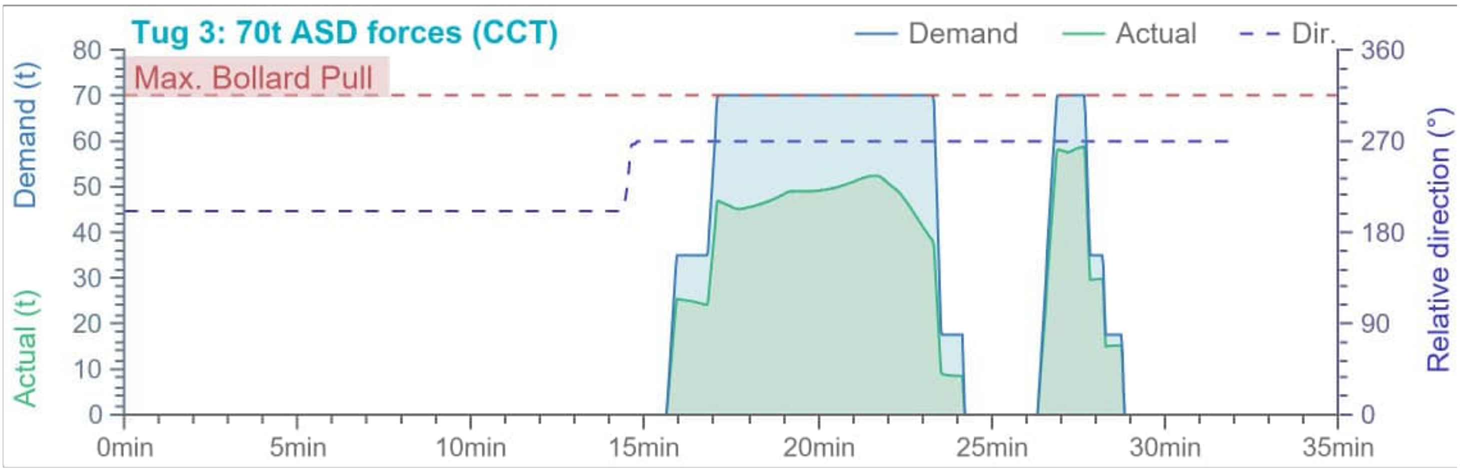


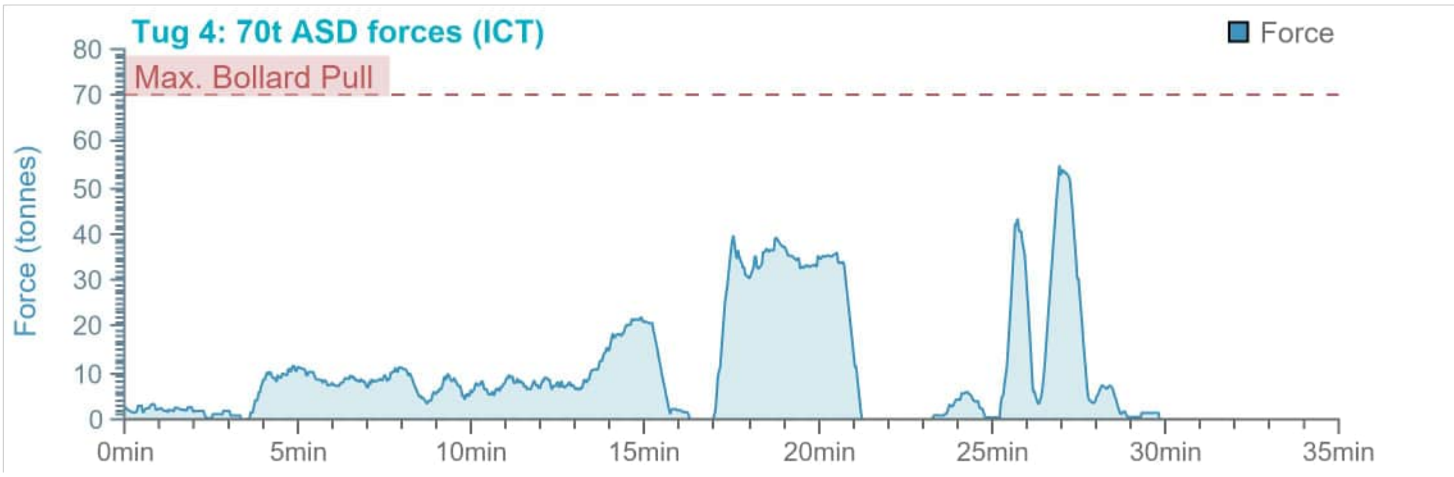

Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min
30min
35min


Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min
30min
35min

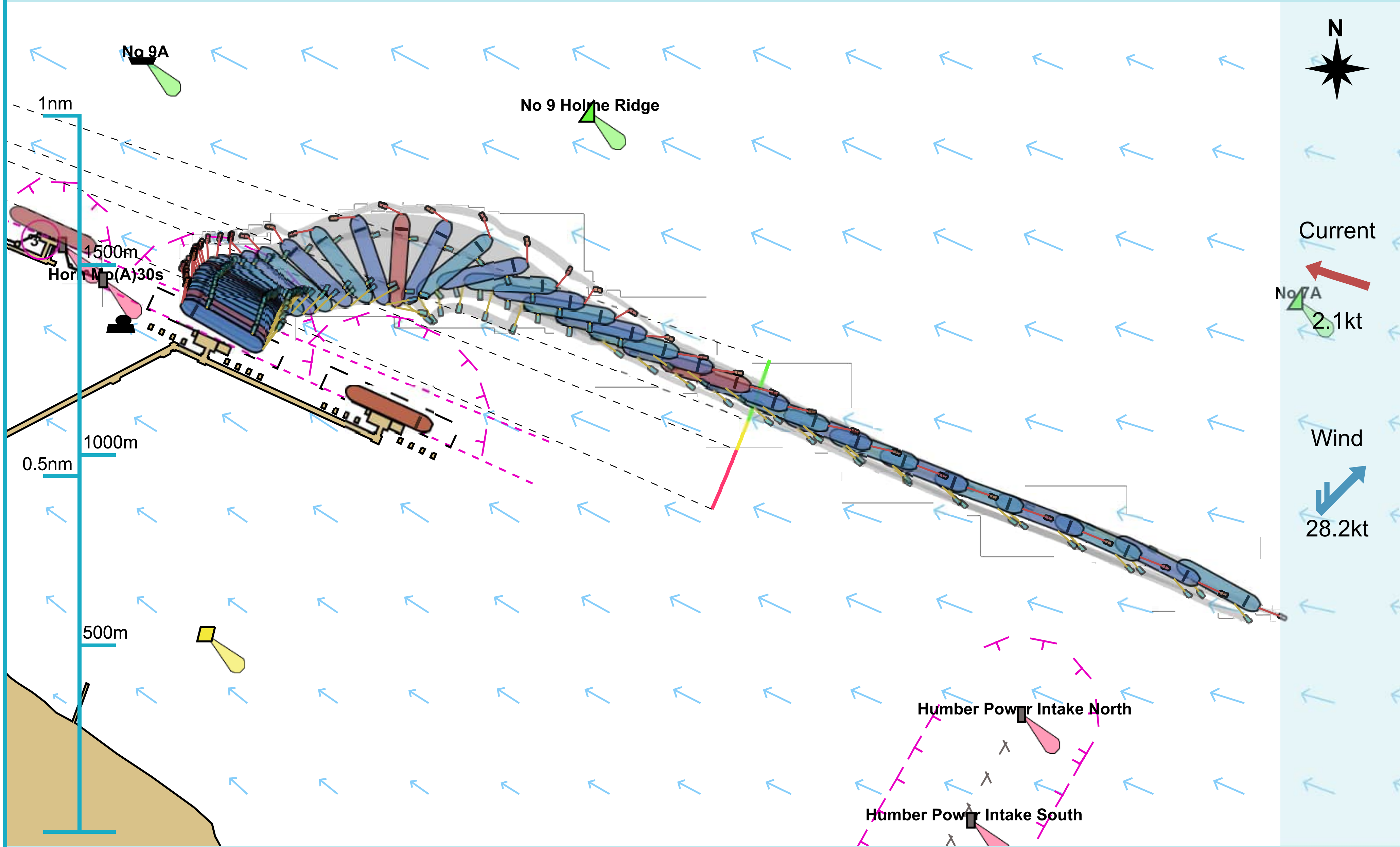

Tug 1: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min
35min


Tug 2: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Force (%BP)
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min
35min


Tug 3: 70t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0min
5min
10min
15min
20min
25min
30min
35min

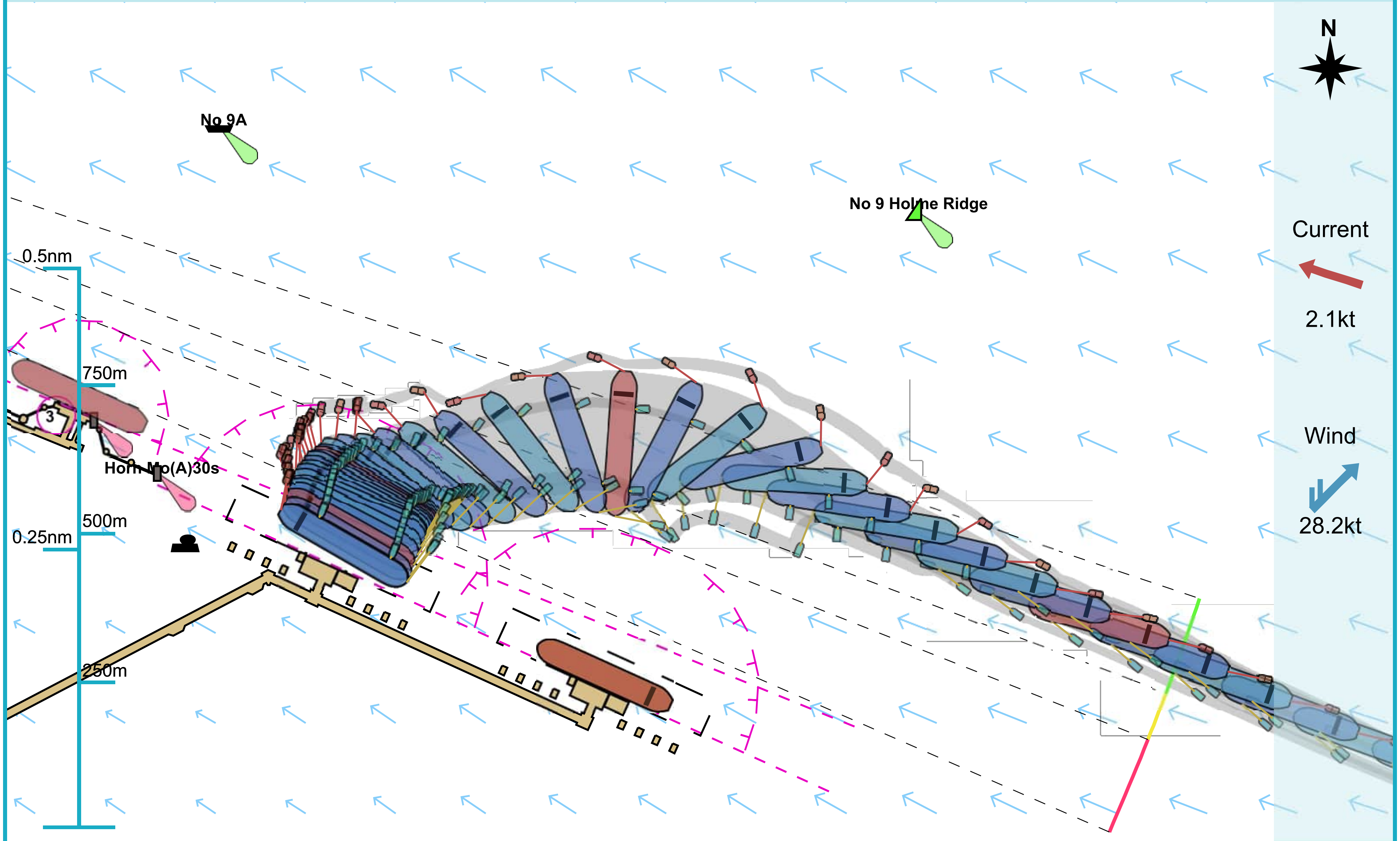

Tug 4: 70t ASD forces (ICT)
Force
Max. Bollard Pull
Force (tonnes)
0min
5min
10min
15min
20min
25min
30min
35min

Manoeuvre track plot



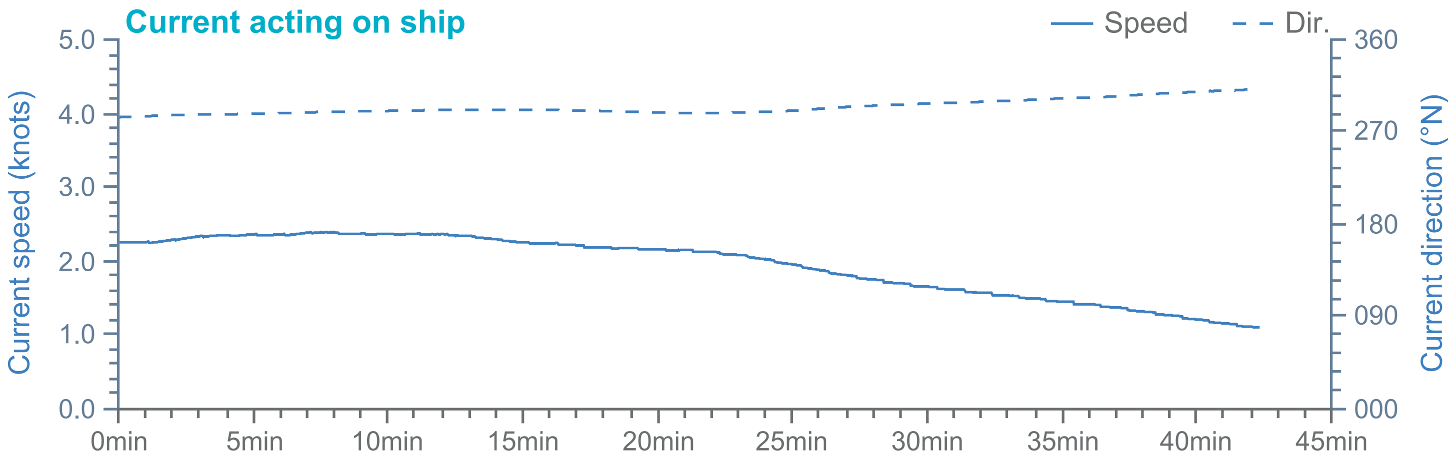
Ships plotted every 1 mins, highlight every 10 mins

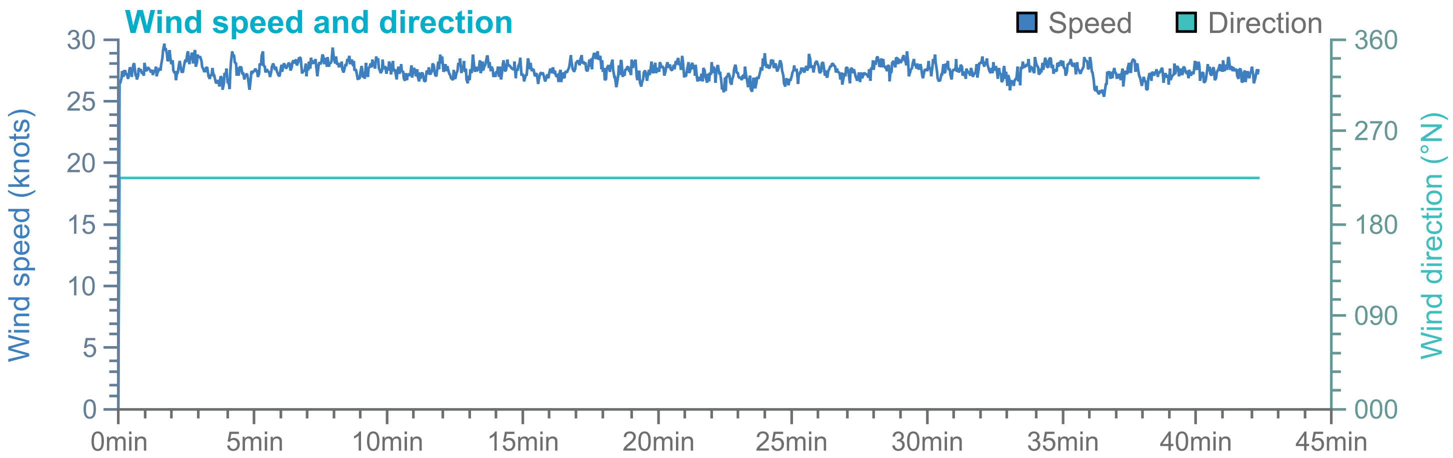
Manoeuvre track plot

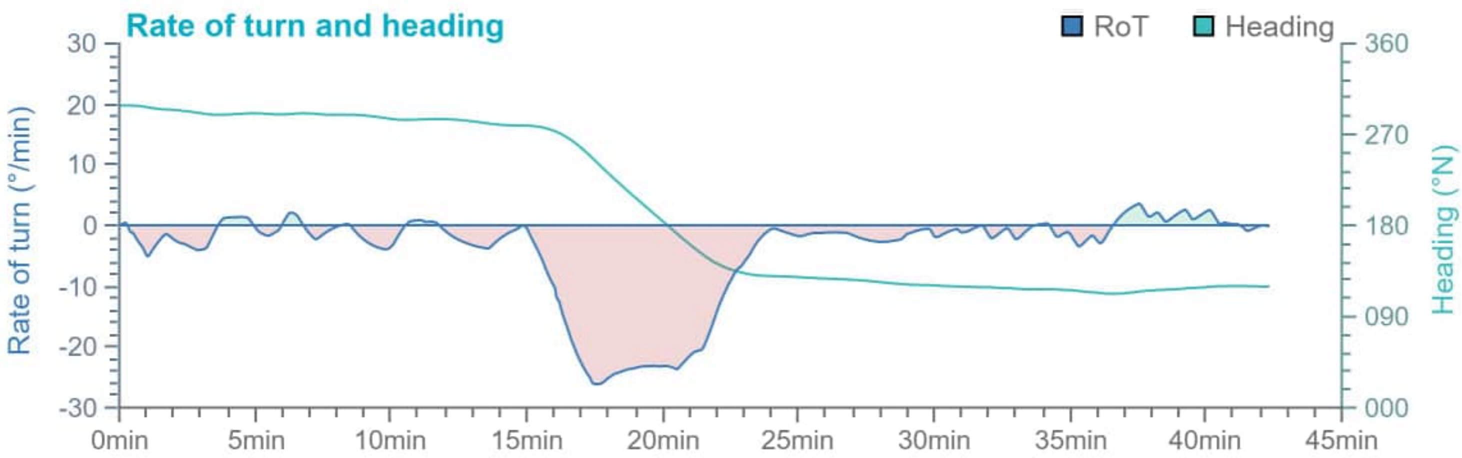


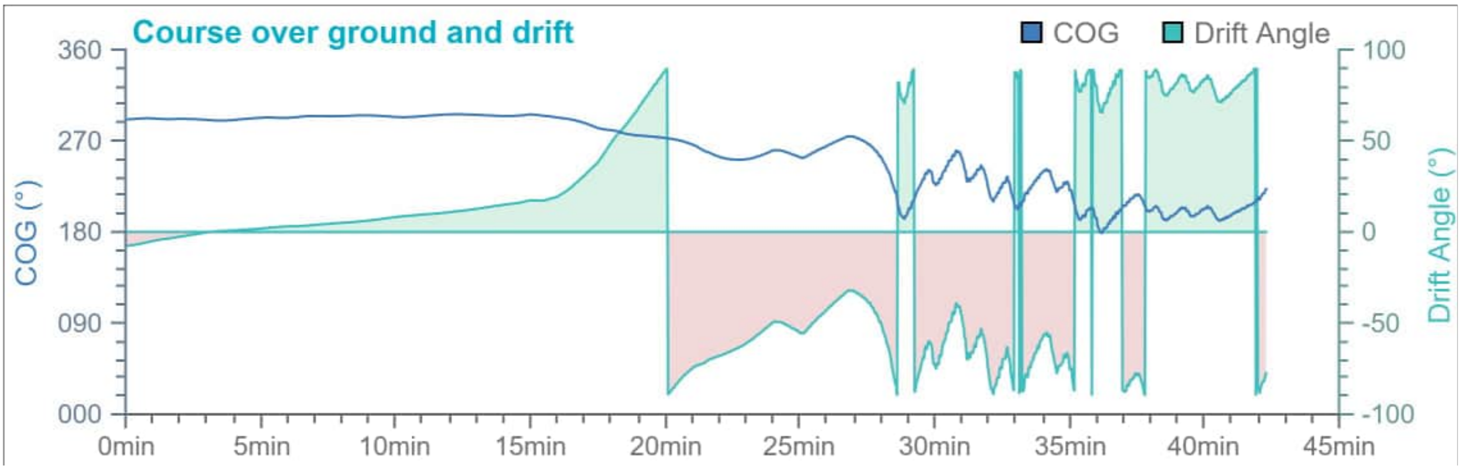
2.73 kts

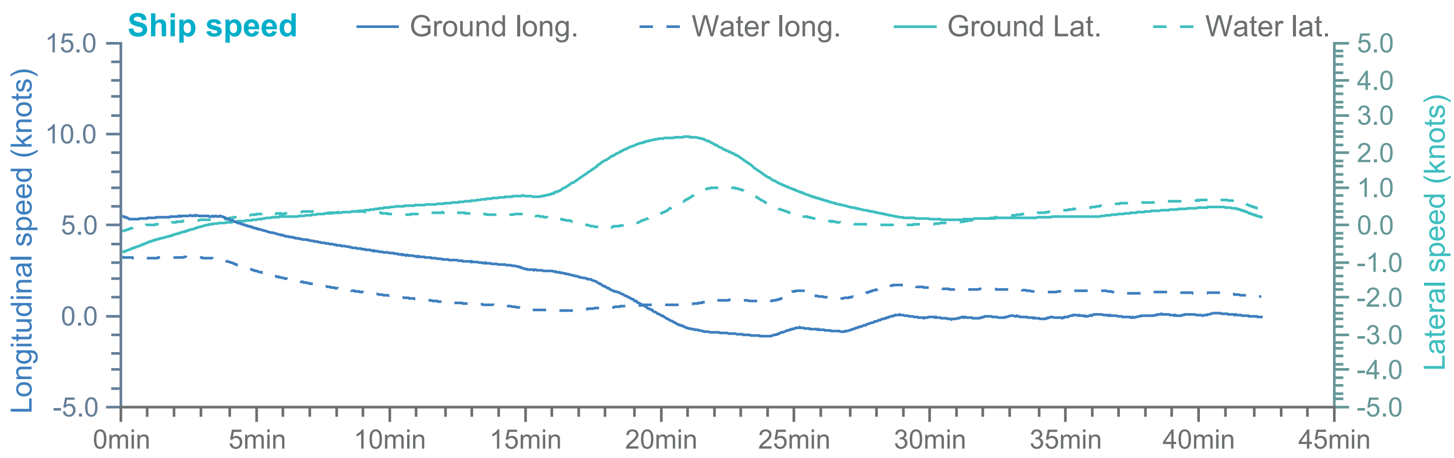
Ships plotted every 1 mins, highlight every 10 mins

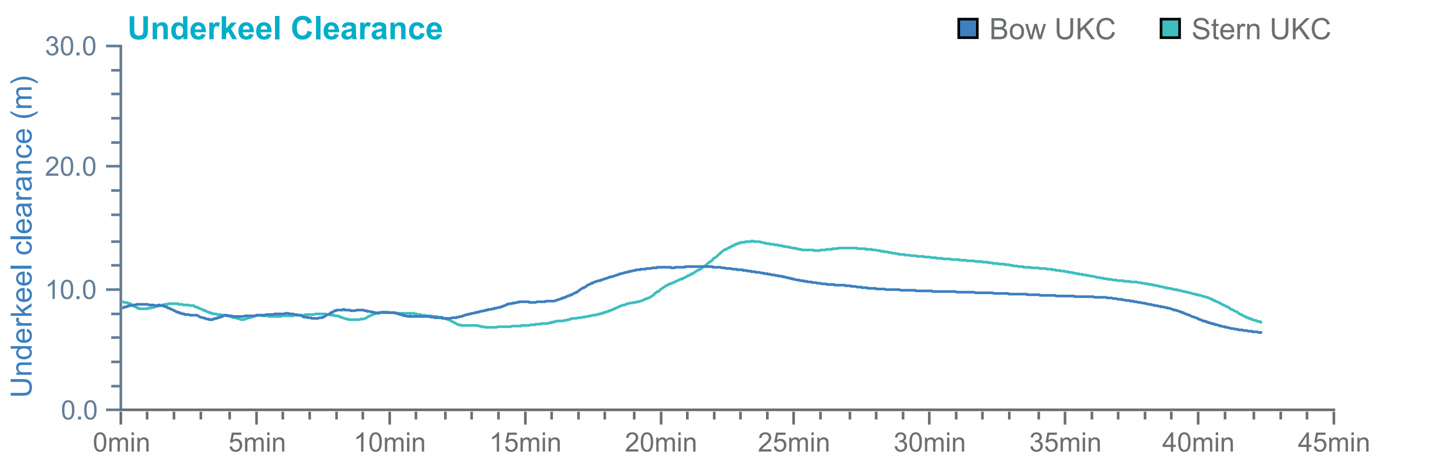

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min


Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min

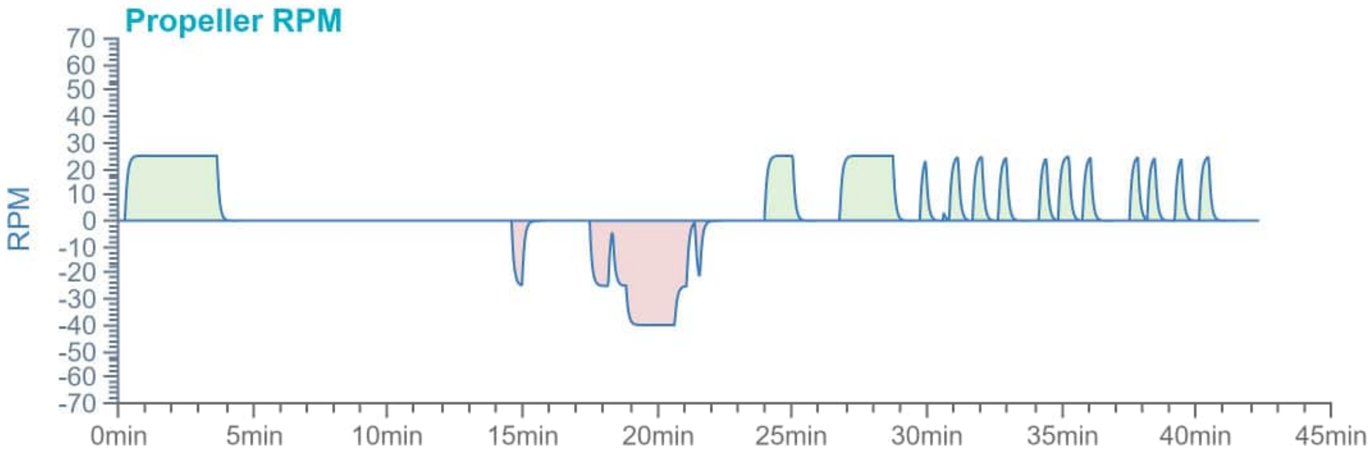

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min

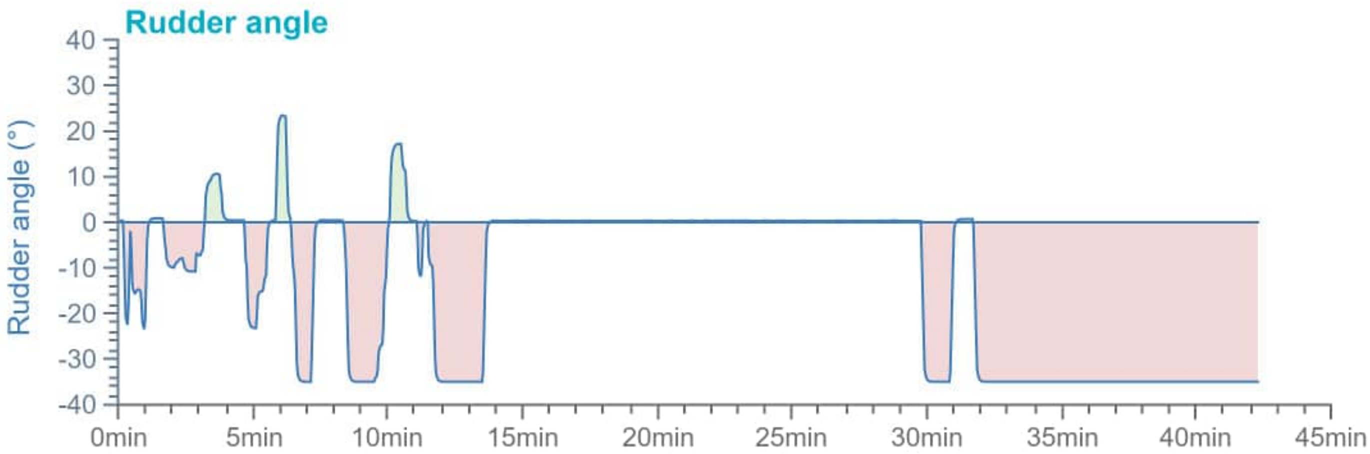

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min


Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min

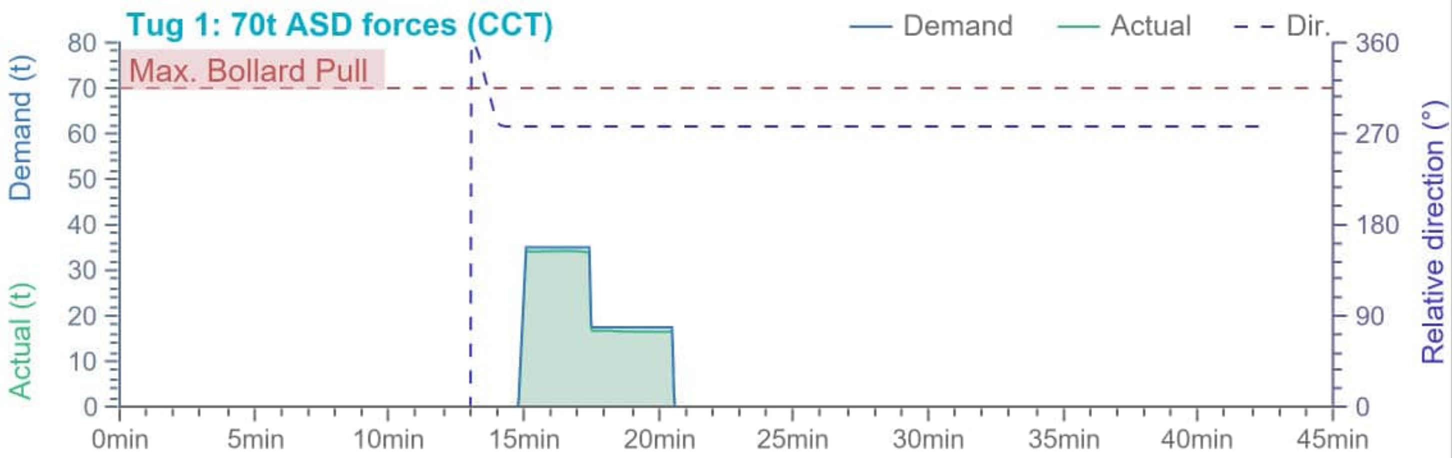

Underkeel Clearance
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min
35min
40min
45min

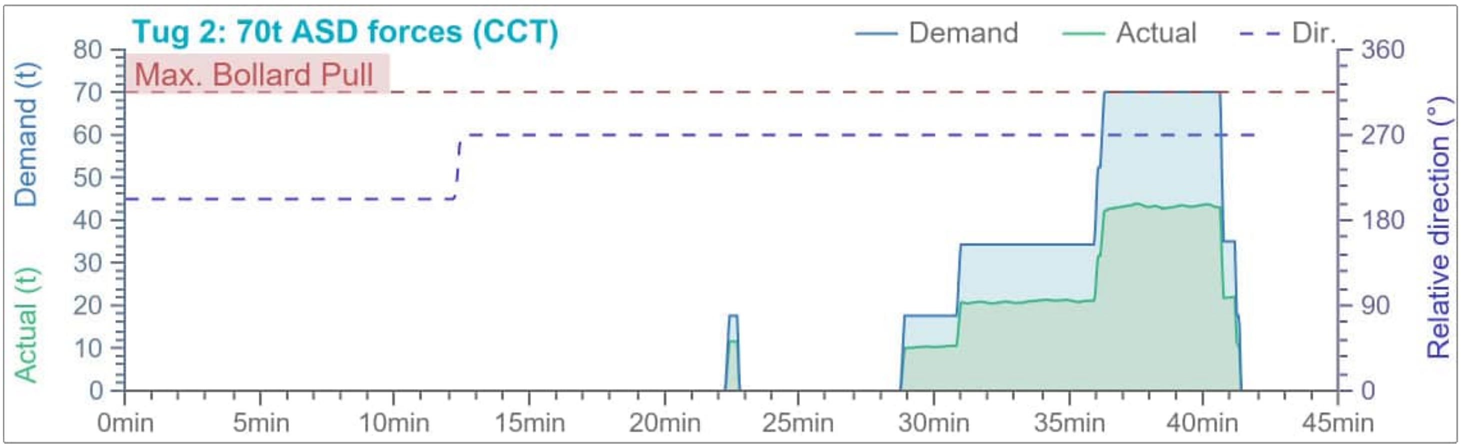
Overview | Environment | 243m Product Tanker | Tugs

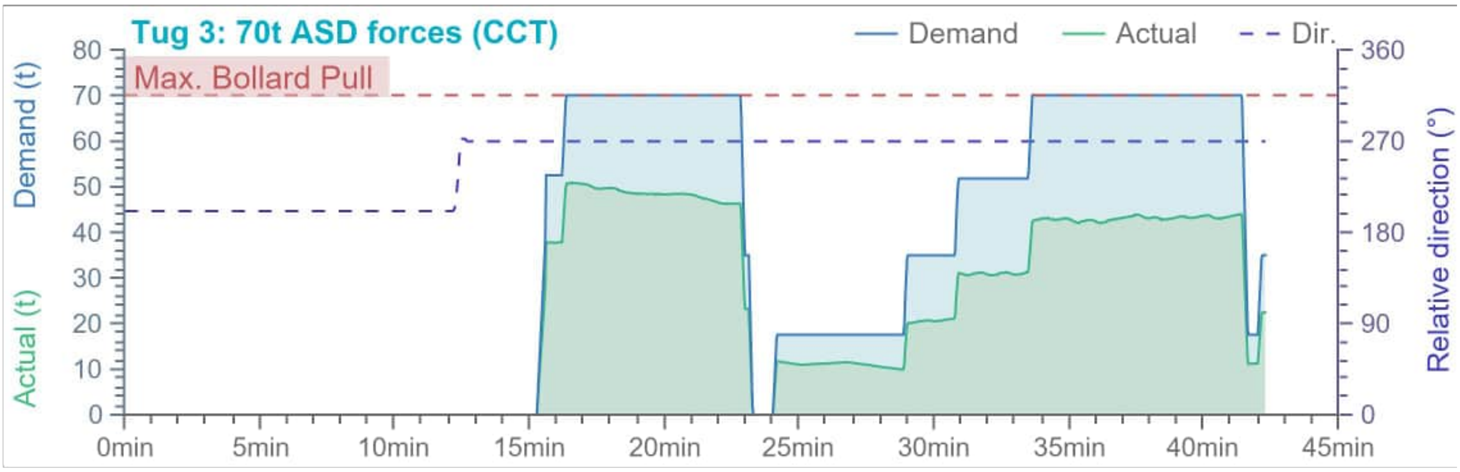


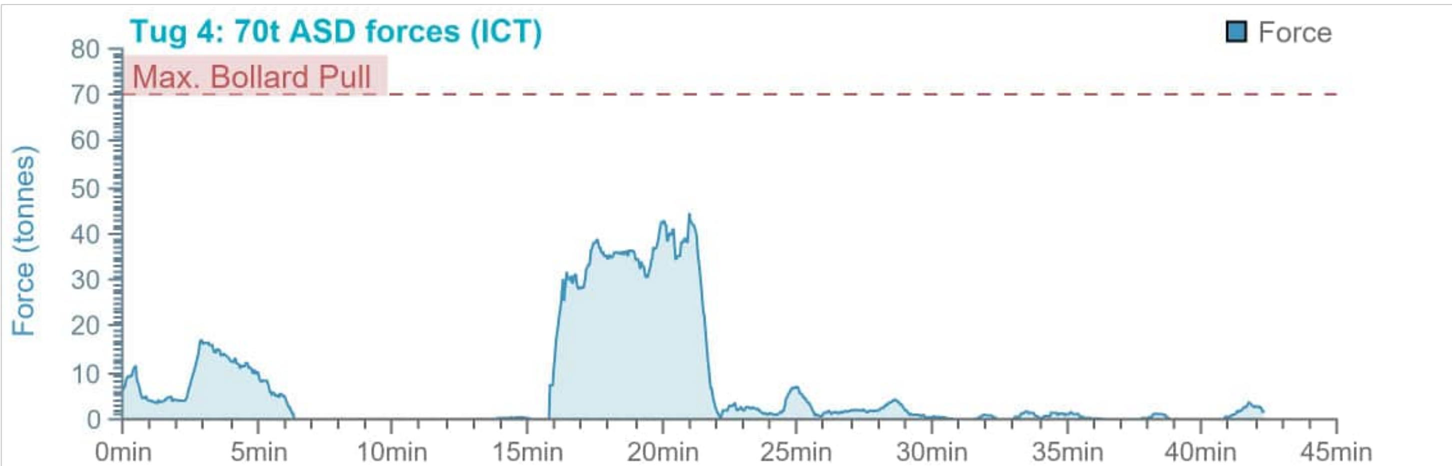


Overview | Environment | 243m Product Tanker | Tugs



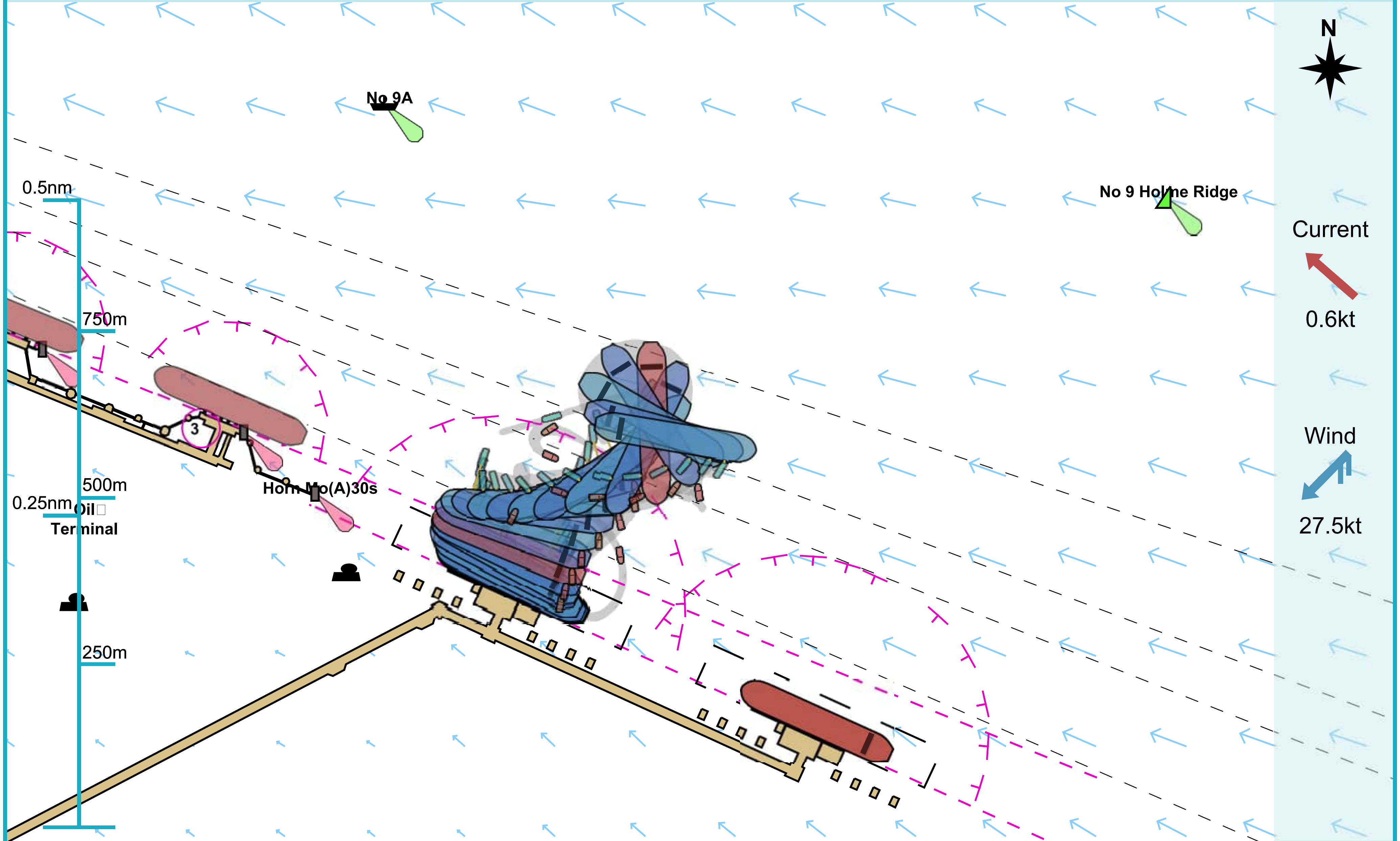




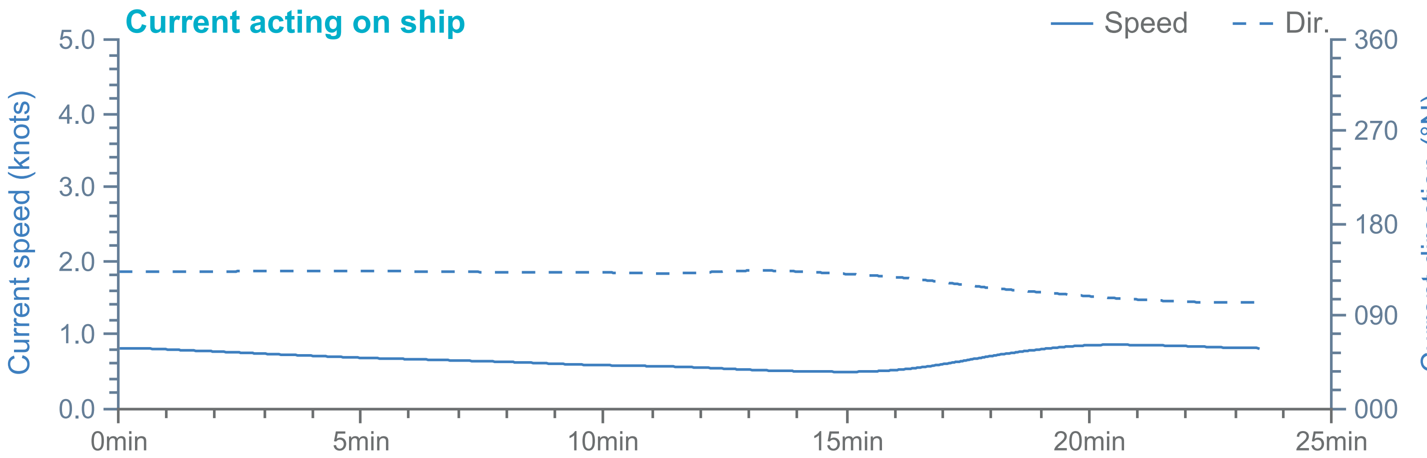


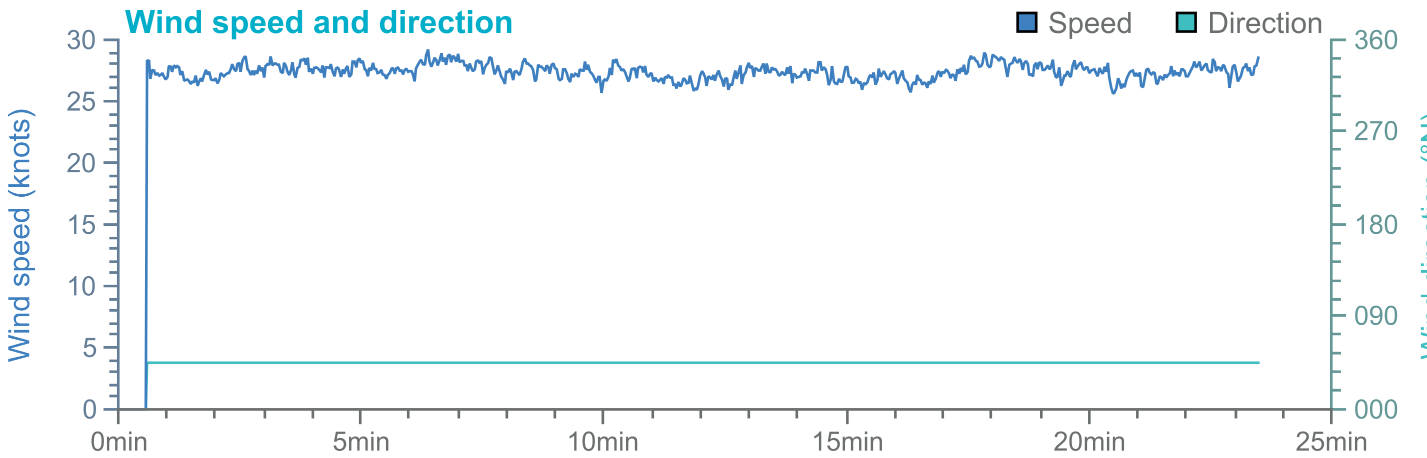
Overview | Environment | 243m Product Tanker | Tugs

Manoeuvre track plot

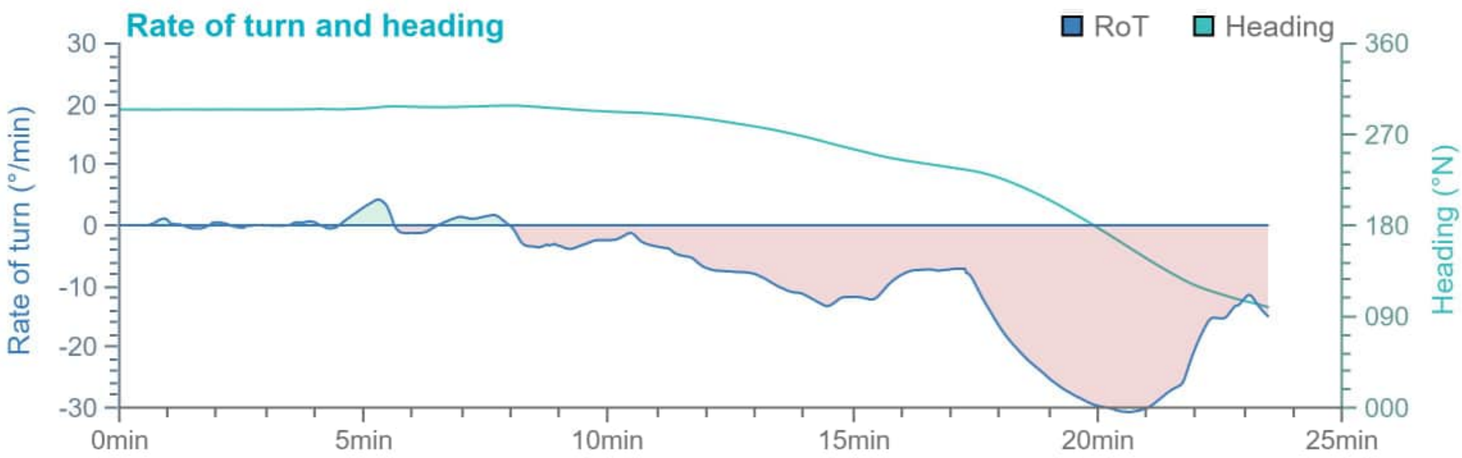


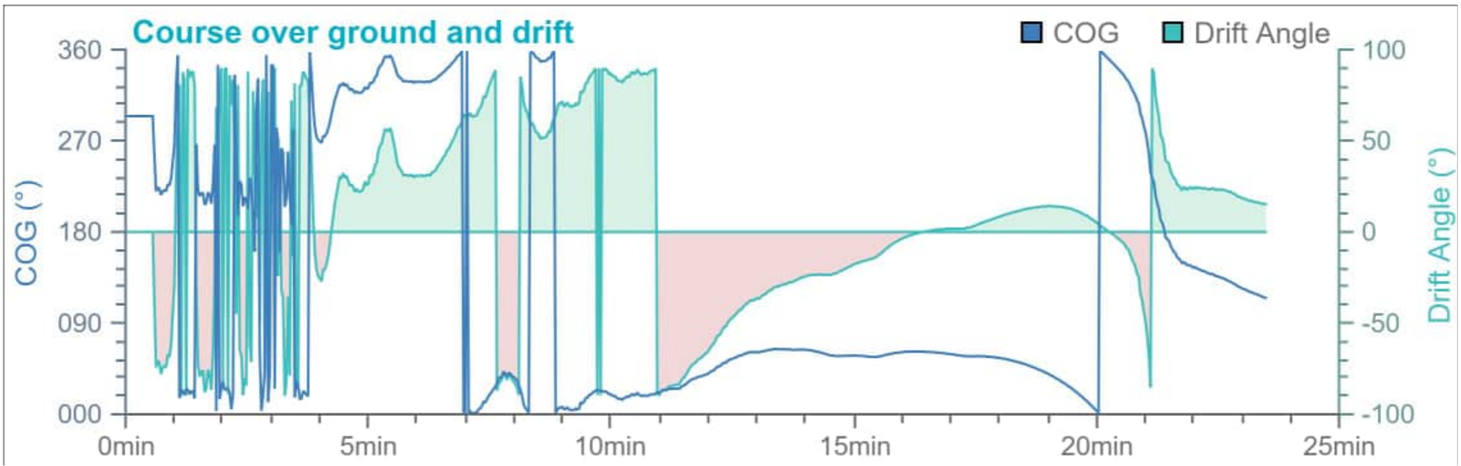
Ships plotted every 1 mins, highlight every 10 mins

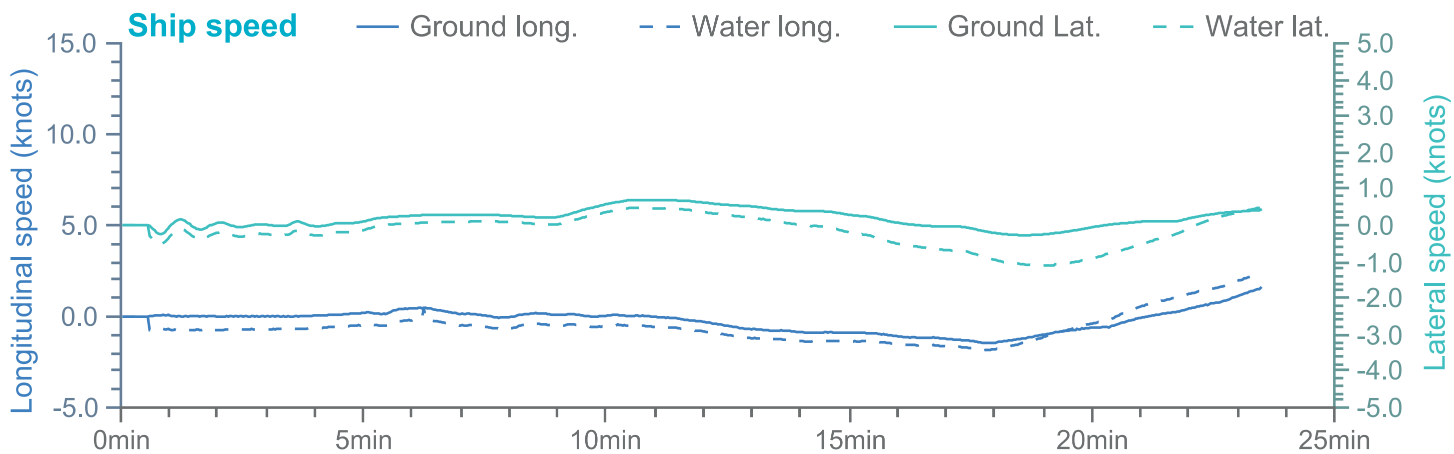

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min

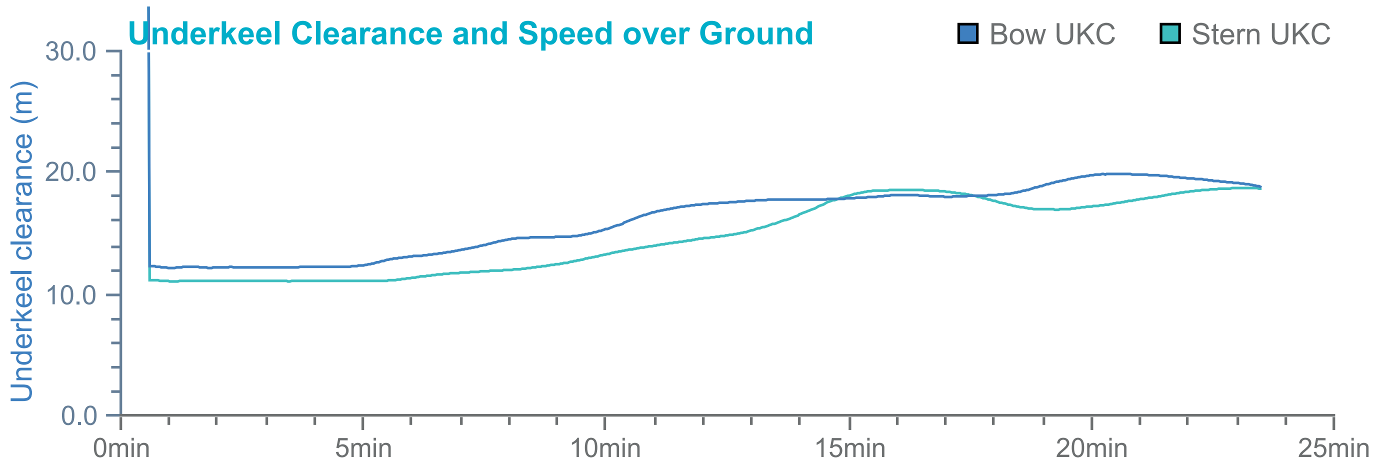

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min

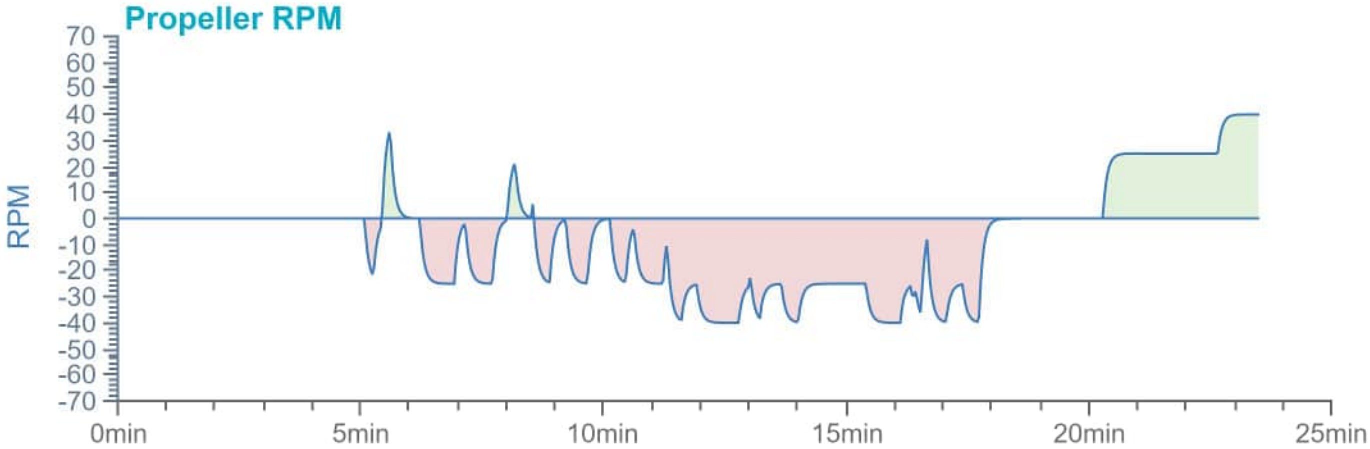
Overview | Environment | 243m Product Tanker | Tugs

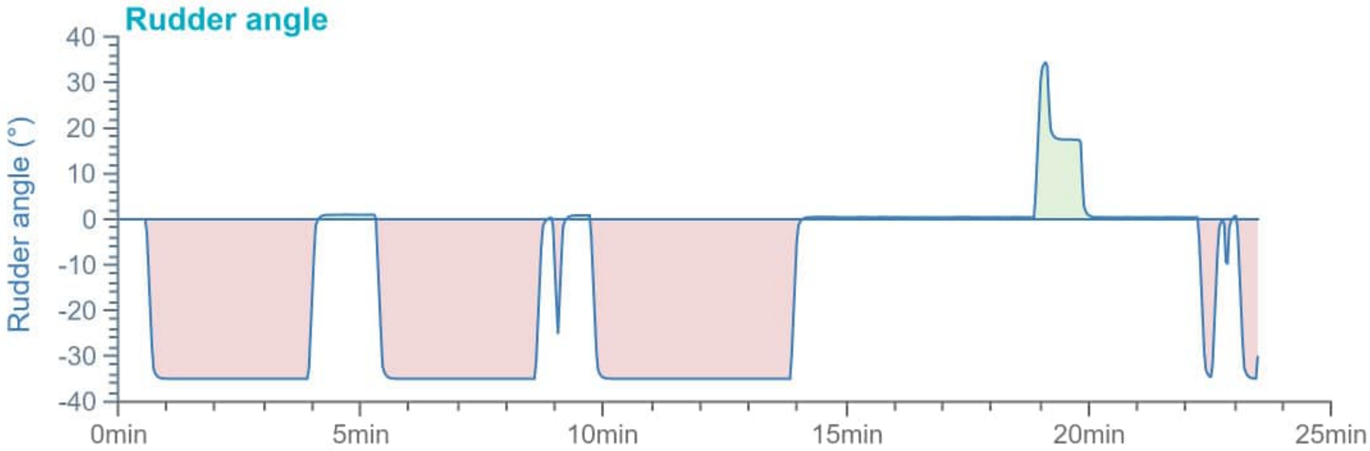


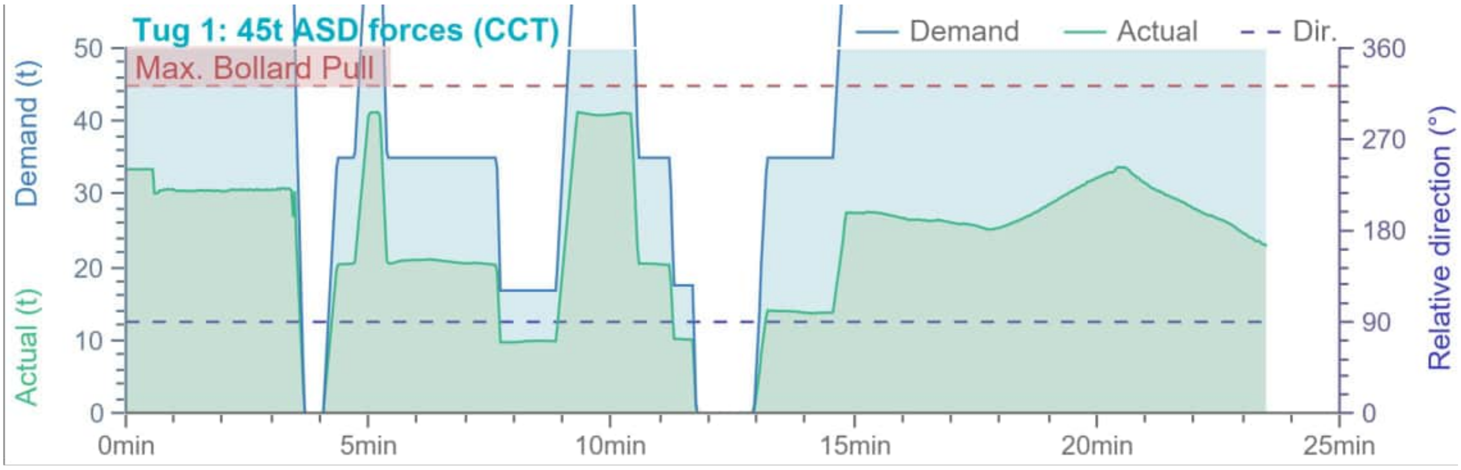


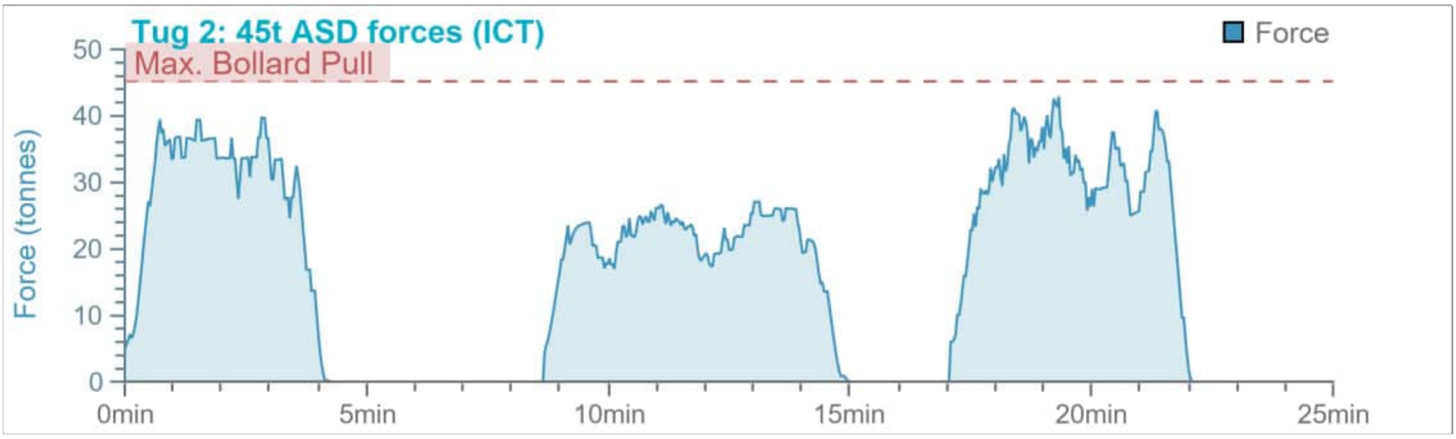


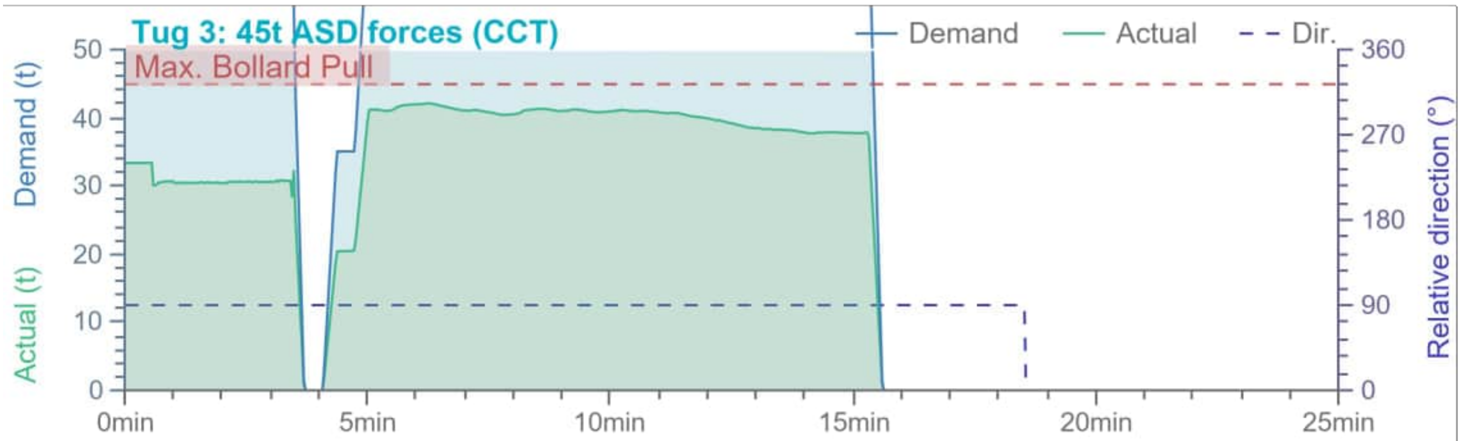



Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min

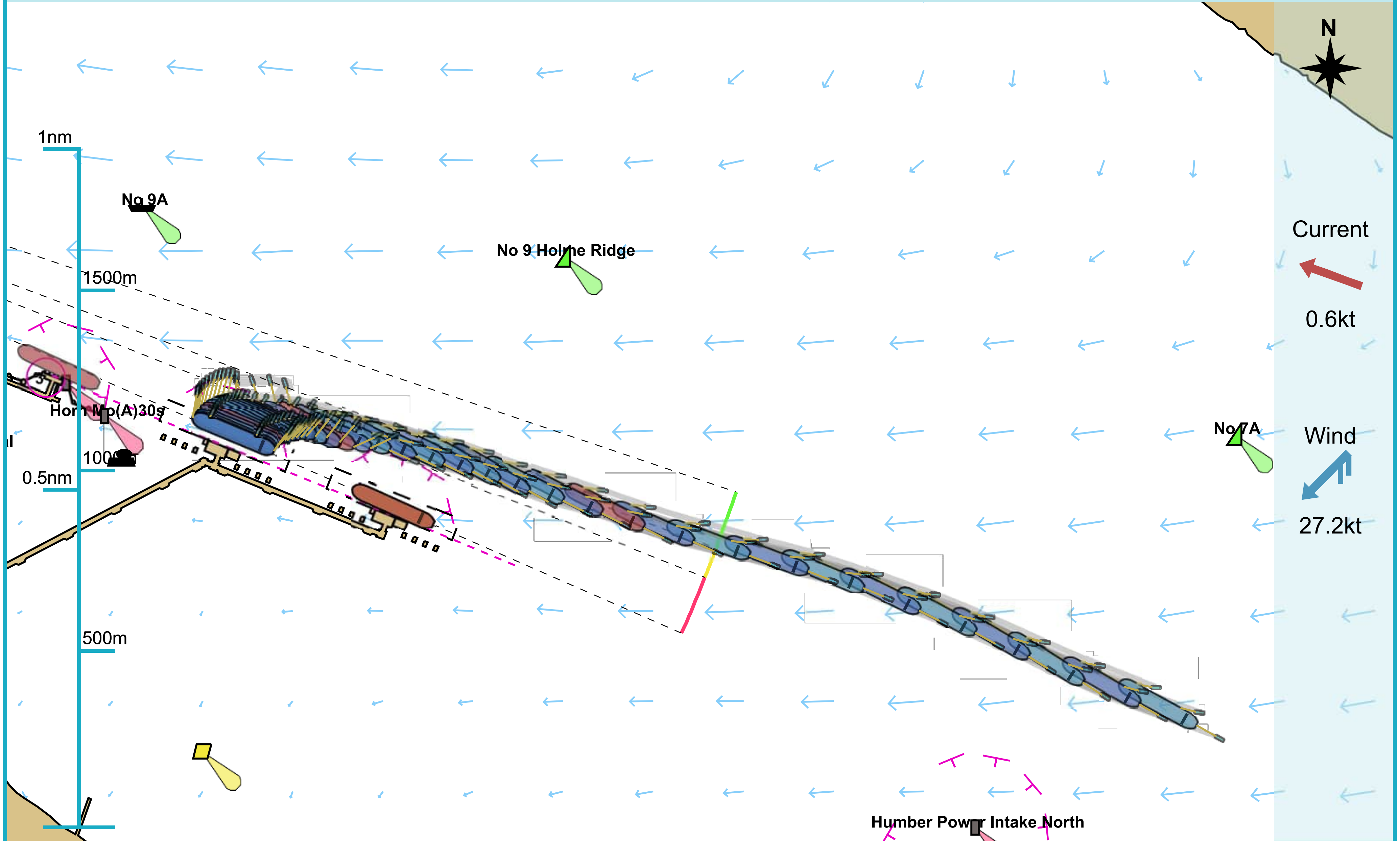

Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min


Tug 1: 45t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
90
180
270
360
0min
5min
10min
15min
20min
25min


Tug 2: 45t ASD forces (ICT)
Force
Max. Bollard Pull
Force (tonnes)
0
10
20
30
40
50
0min
5min
10min
15min
20min
25min


Tug 3: 45t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
90
180
270
360
0min
5min
10min
15min
20min
25min

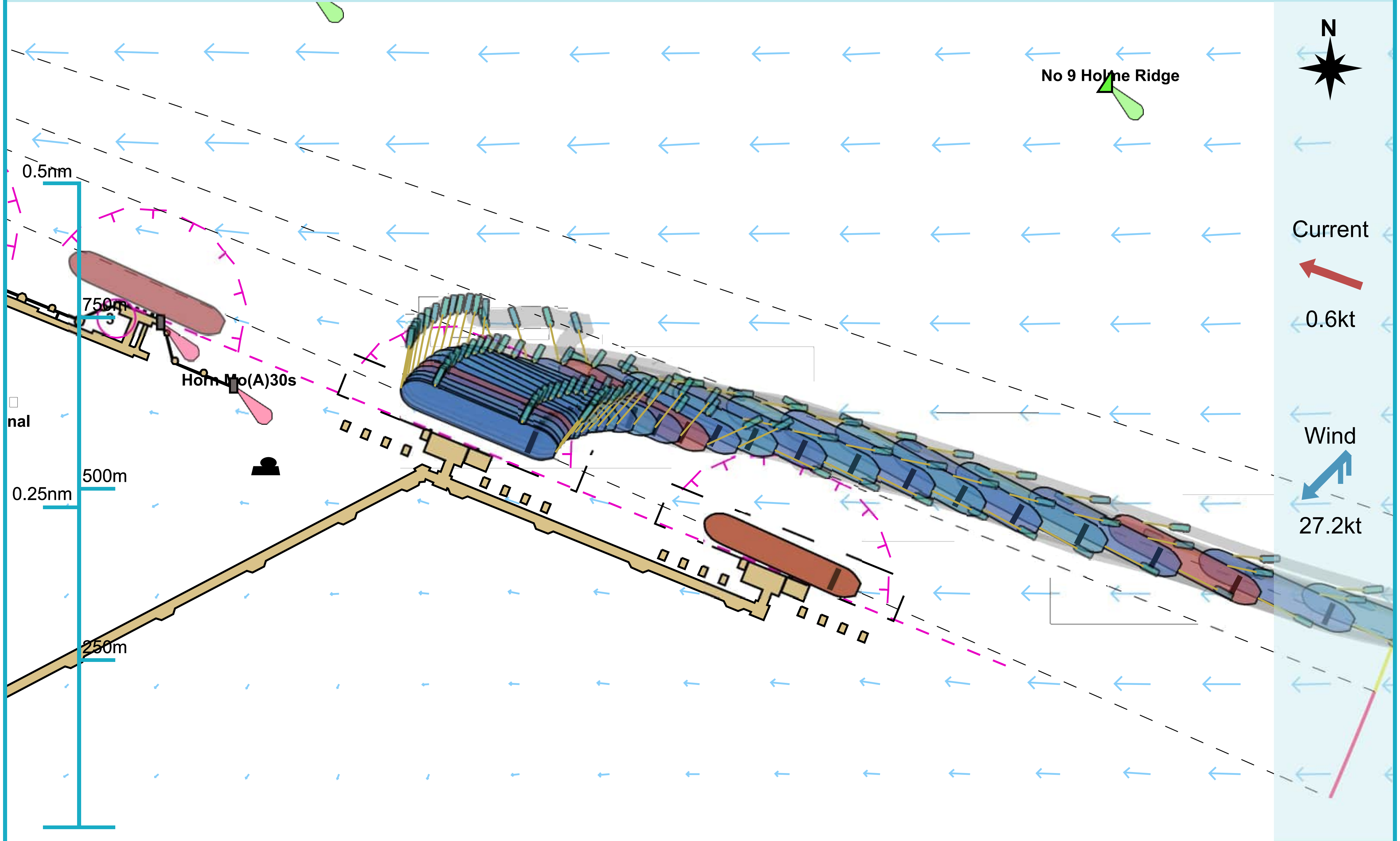
Manoeuvre track plot



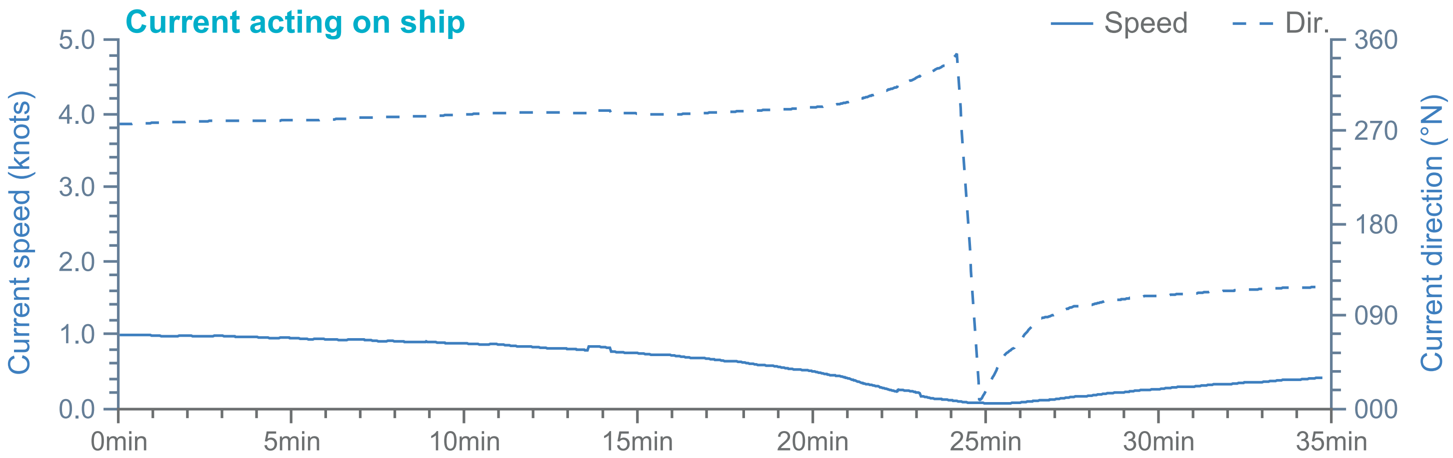
1.23 kts

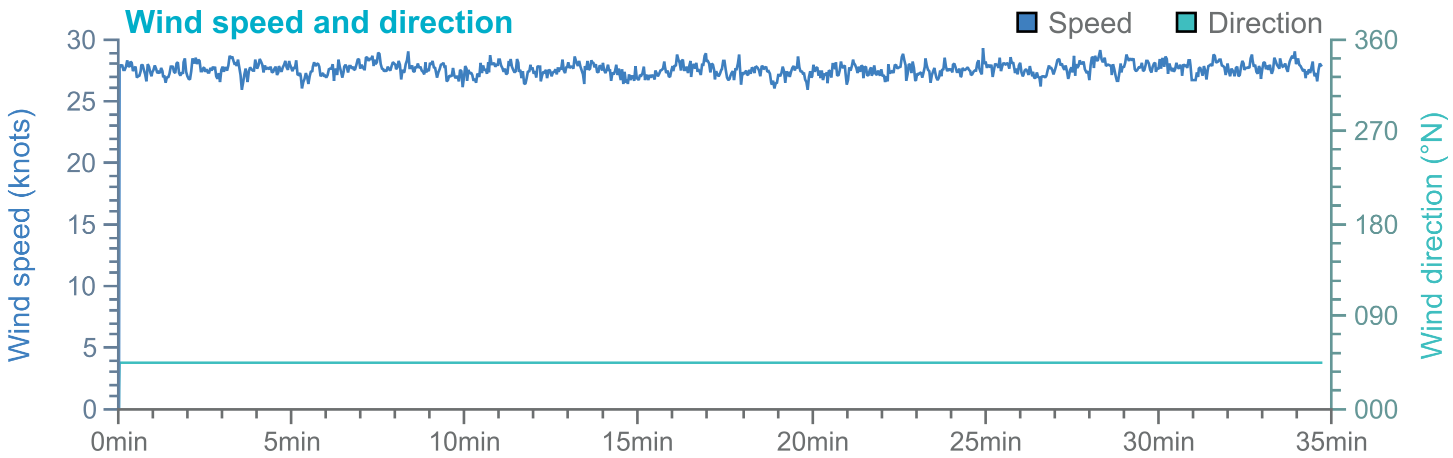
Ships plotted every 1 mins, highlight every 10 mins

Manoeuvre track plot

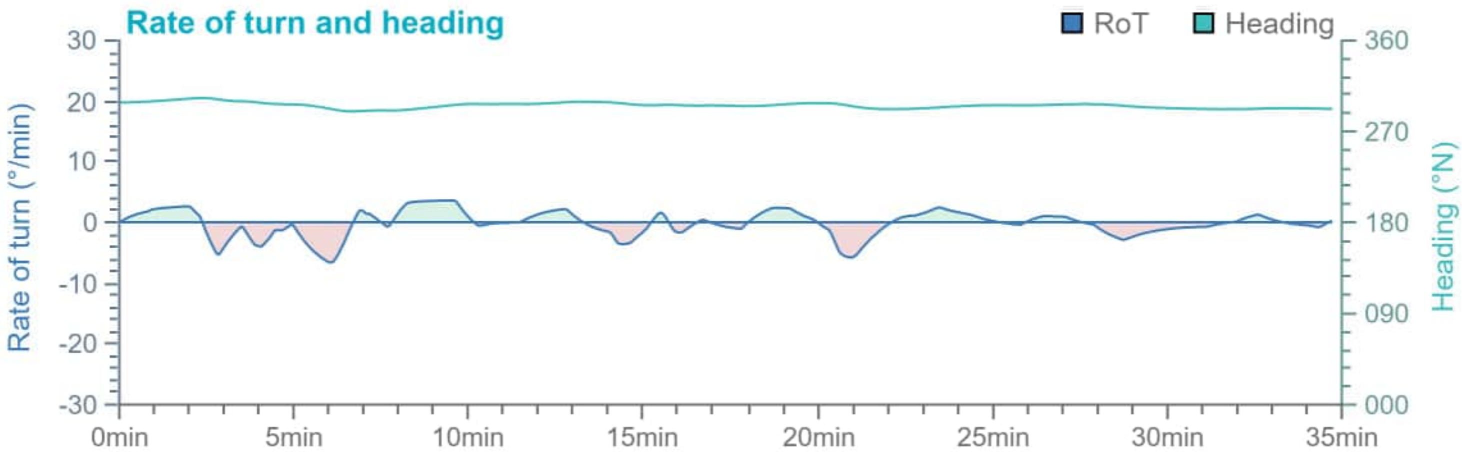


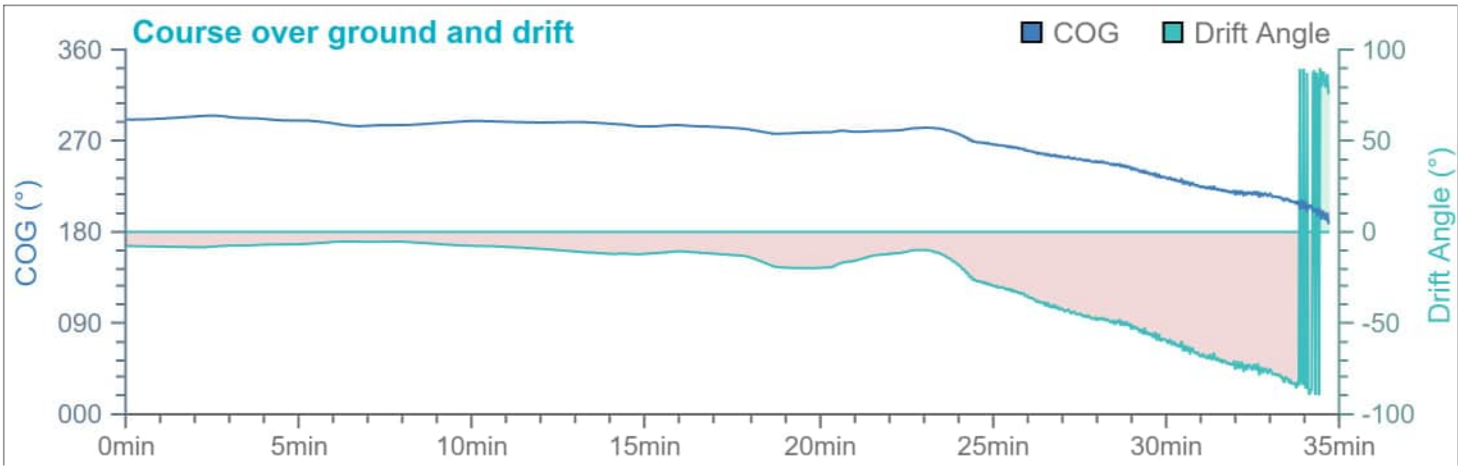
Ships plotted every 1 mins, highlight every 10 mins

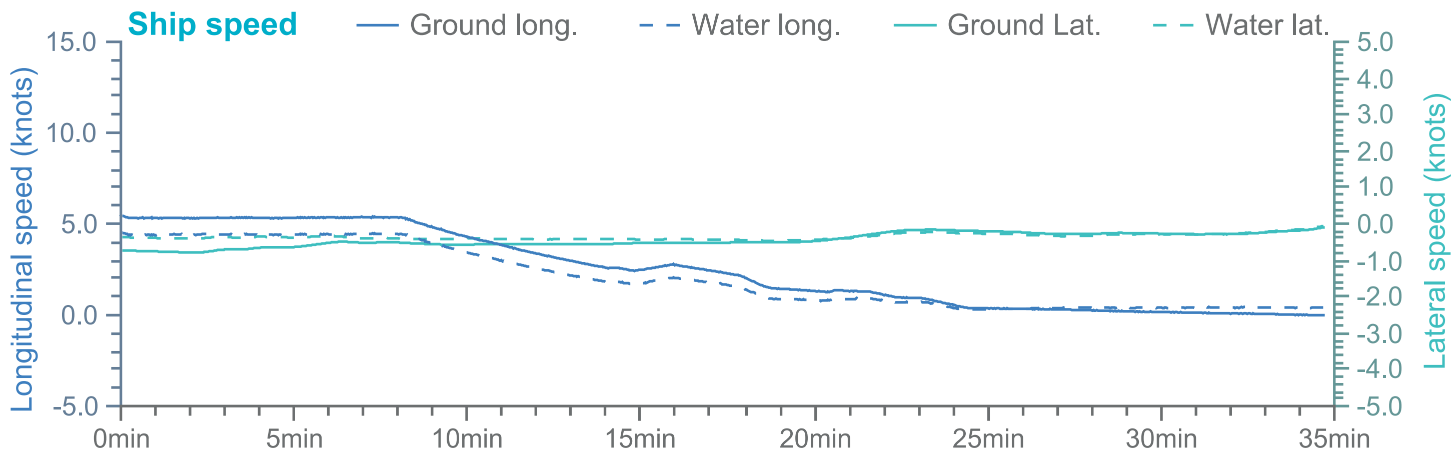

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

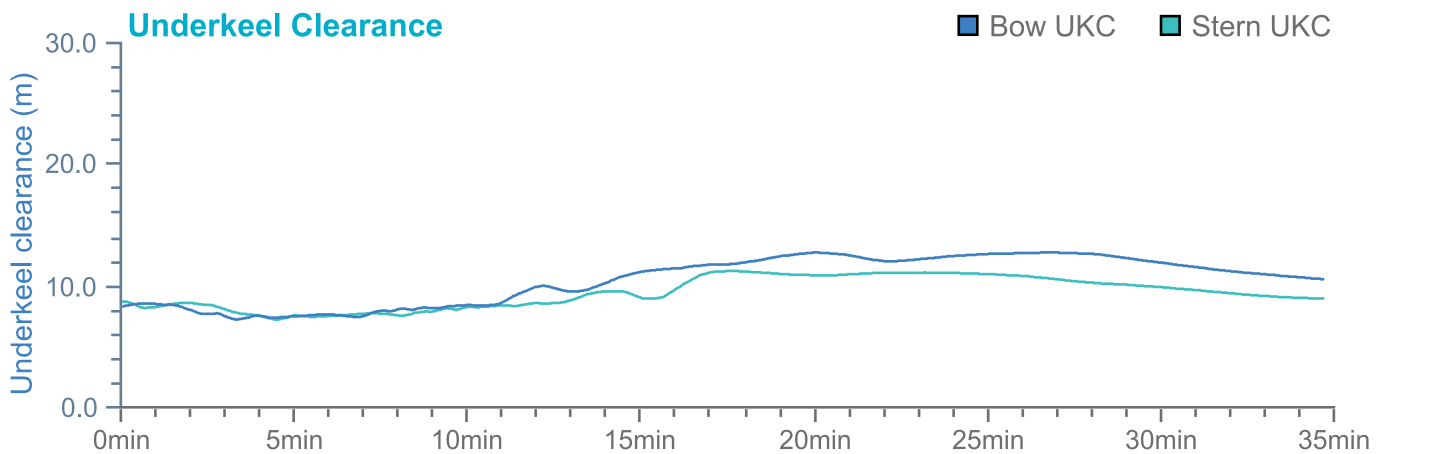

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

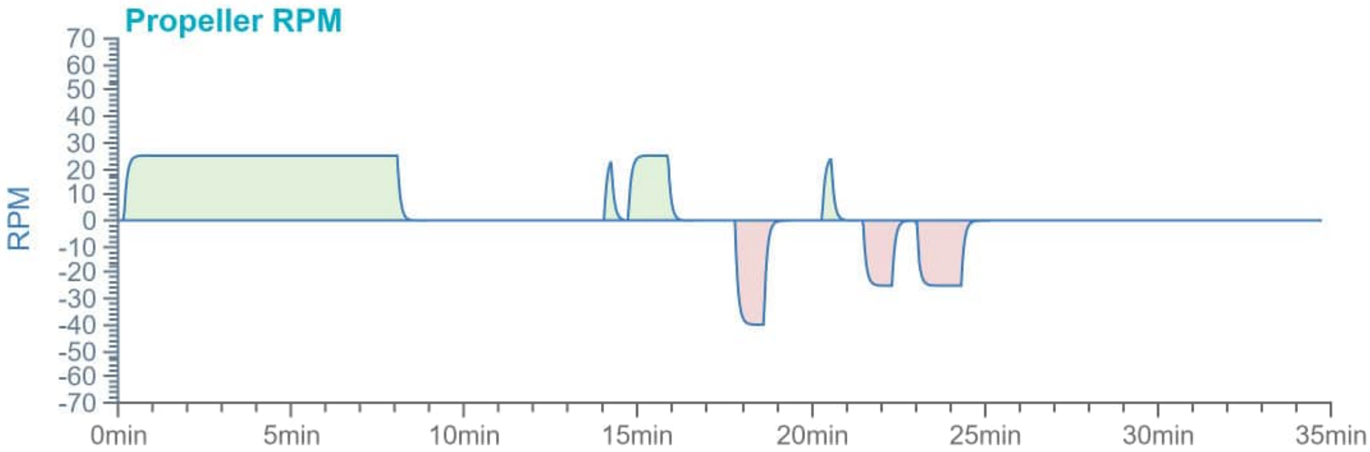
Overview	Environment	243m Product Tanker	Tugs

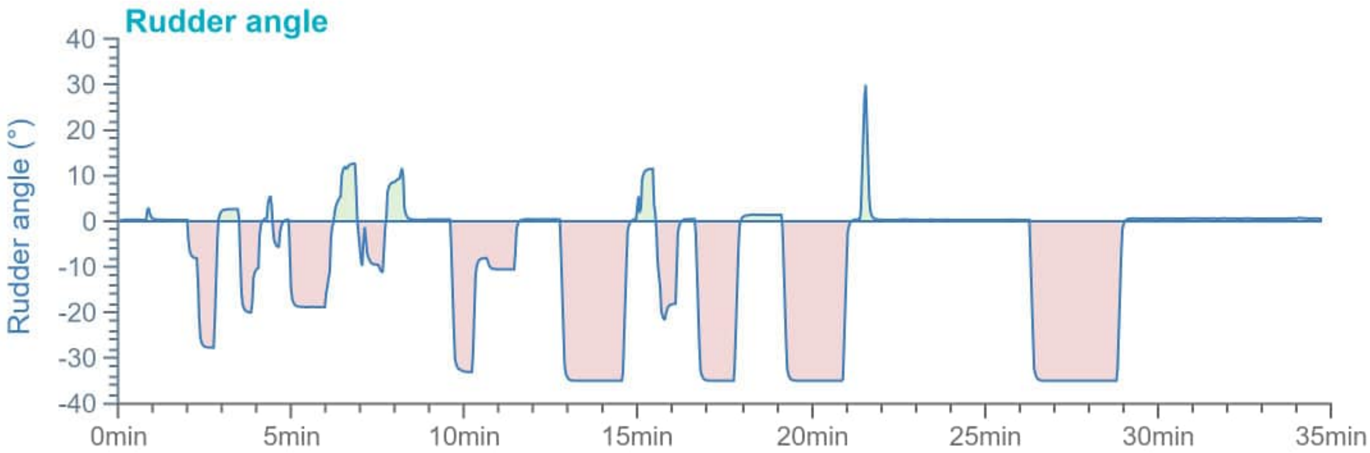


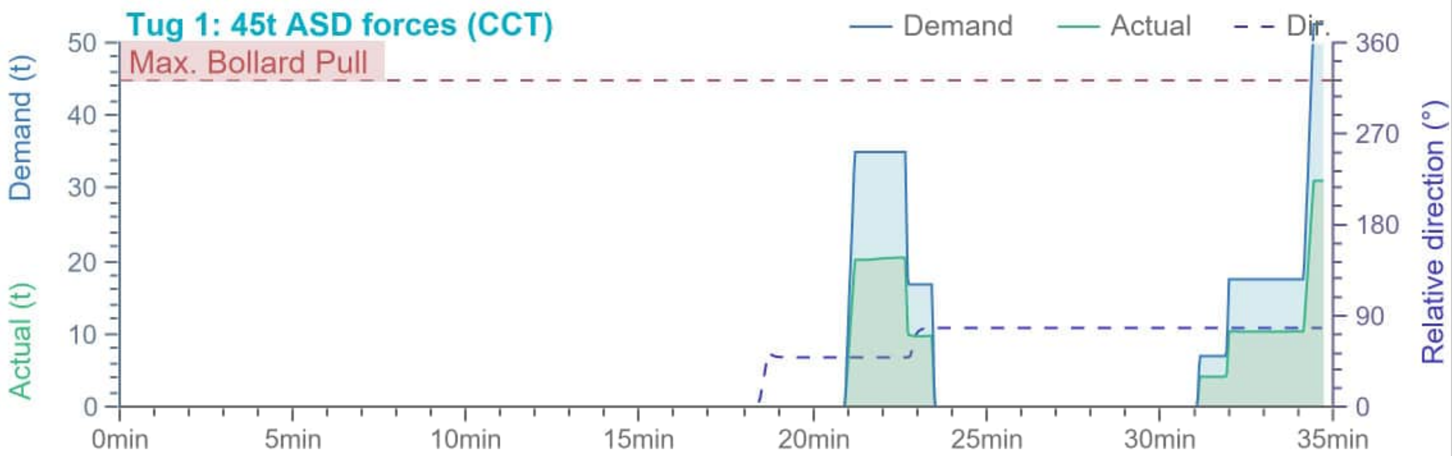




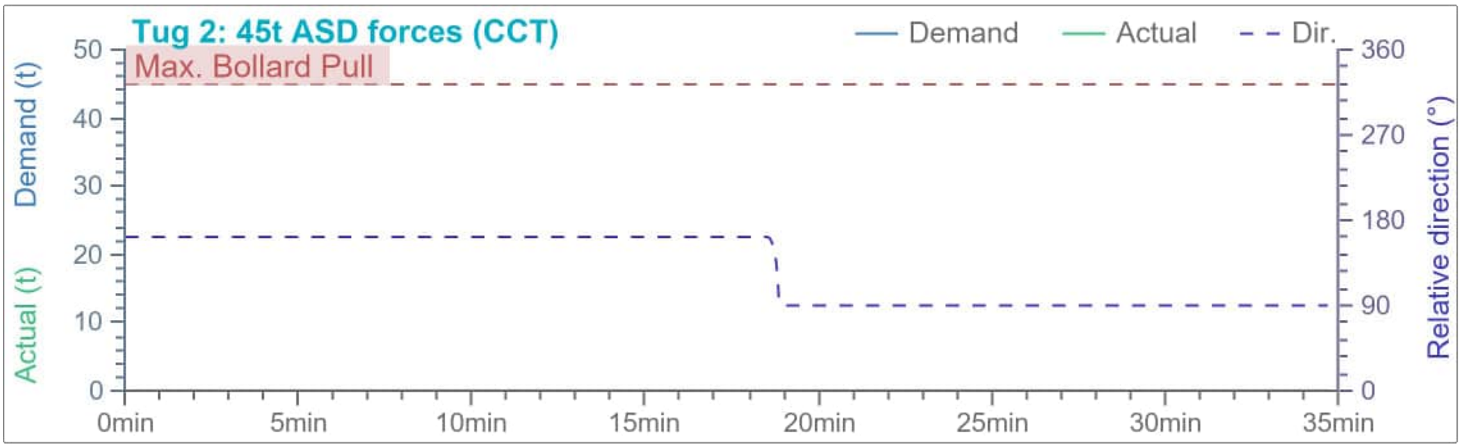



Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min
30min
35min

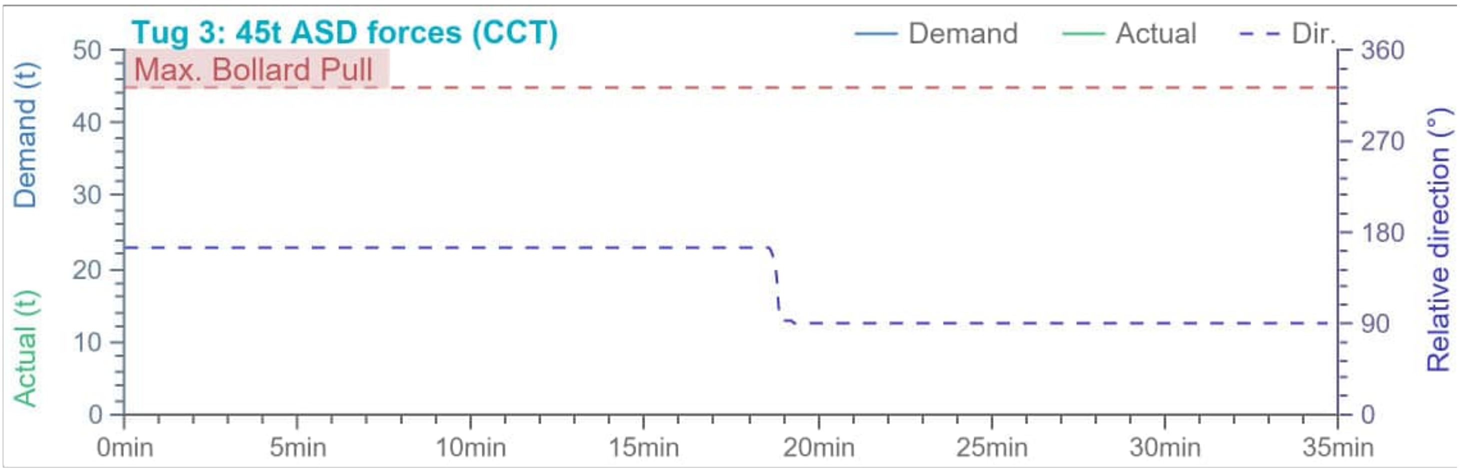

Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min
30min
35min



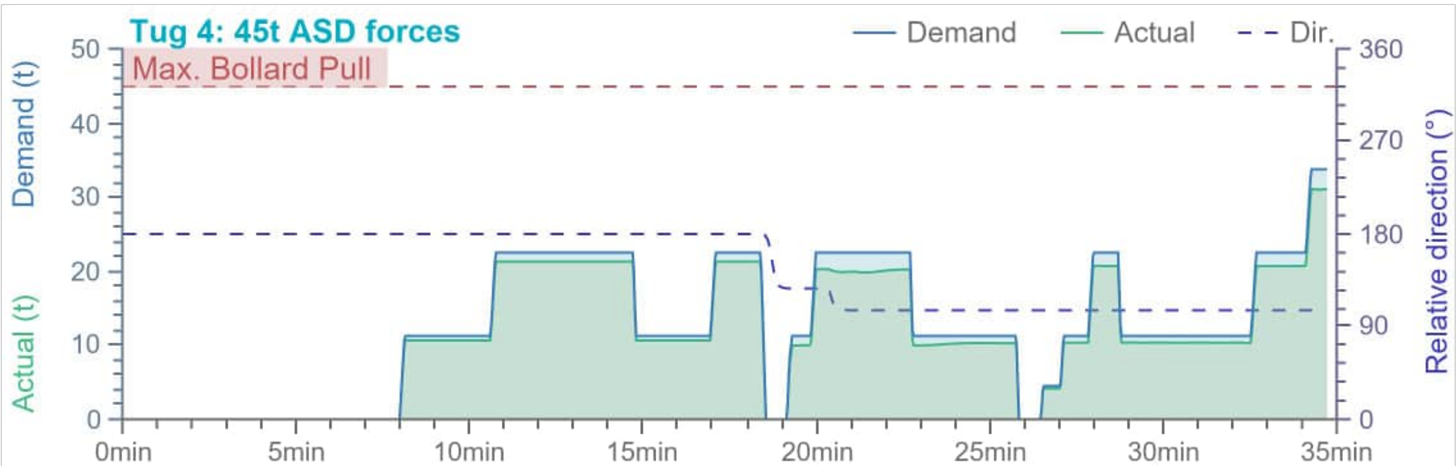
Tug 1: 45t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
0
90
180
270
360
0min
5min
10min
15min
20min
25min
30min
35min



Tug 2: 45t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
0
90
180
270
360
0min
5min
10min
15min
20min
25min
30min
35min



Tug 3: 45t ASD forces (CCT)
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
0
90
180
270
360
0min
5min
10min
15min
20min
25min
30min
35min



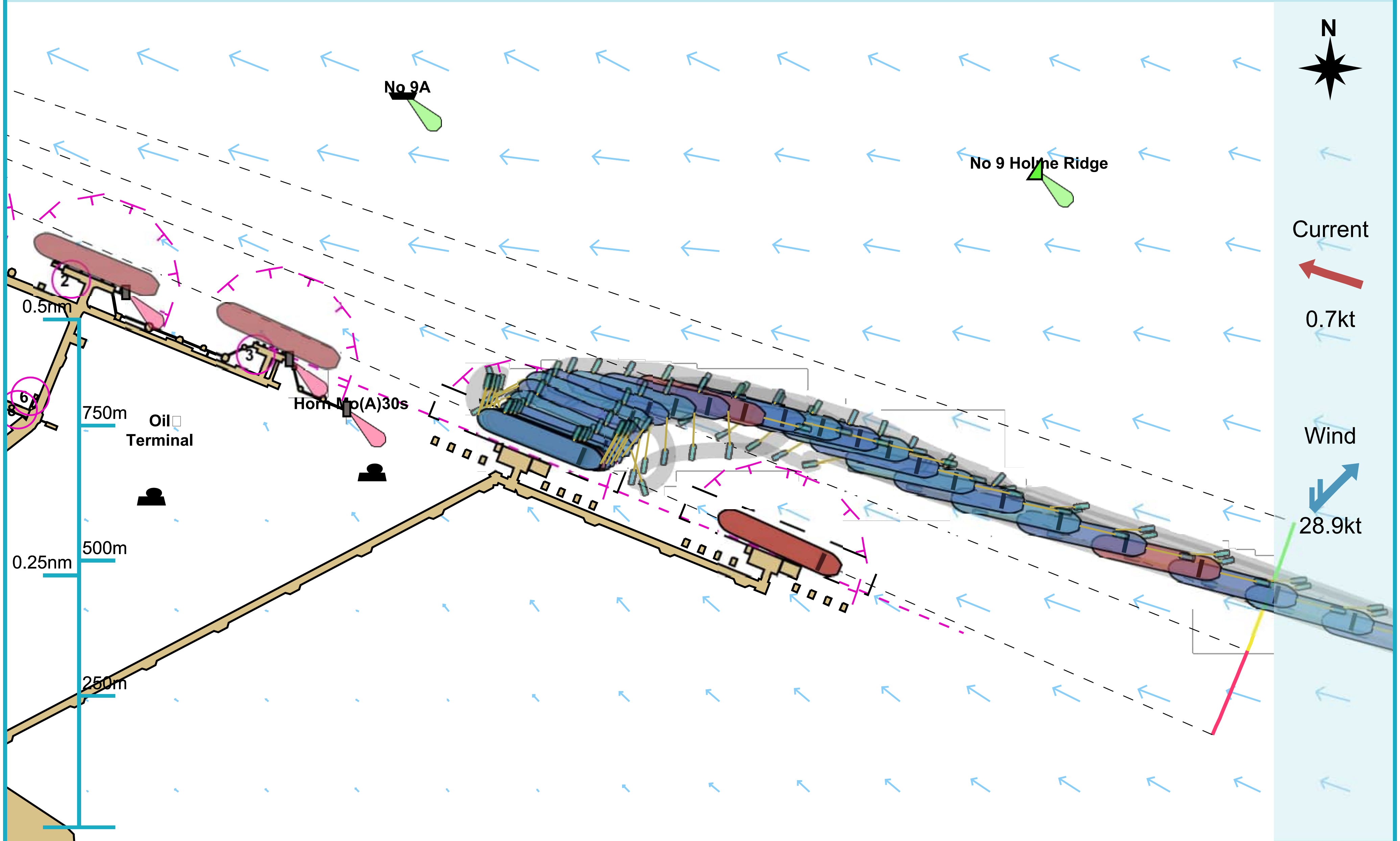
Tug 4: 45t ASD forces
Demand
Actual
Dir.
Max. Bollard Pull
Demand (t)
Actual (t)
Relative direction (°)
0
10
20
30
40
50
0
90
180
270
360
0min
5min
10min
15min
20min
25min
30min
35min

Manoeuvre track plot

1.34 kts

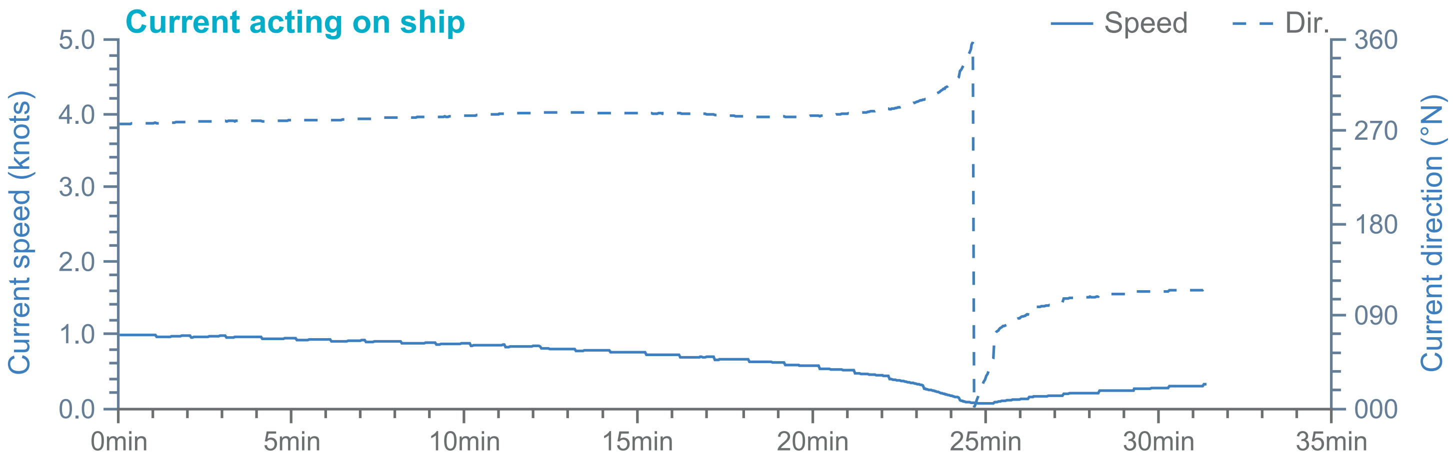
Ships plotted every 1 mins, highlight every 10 mins

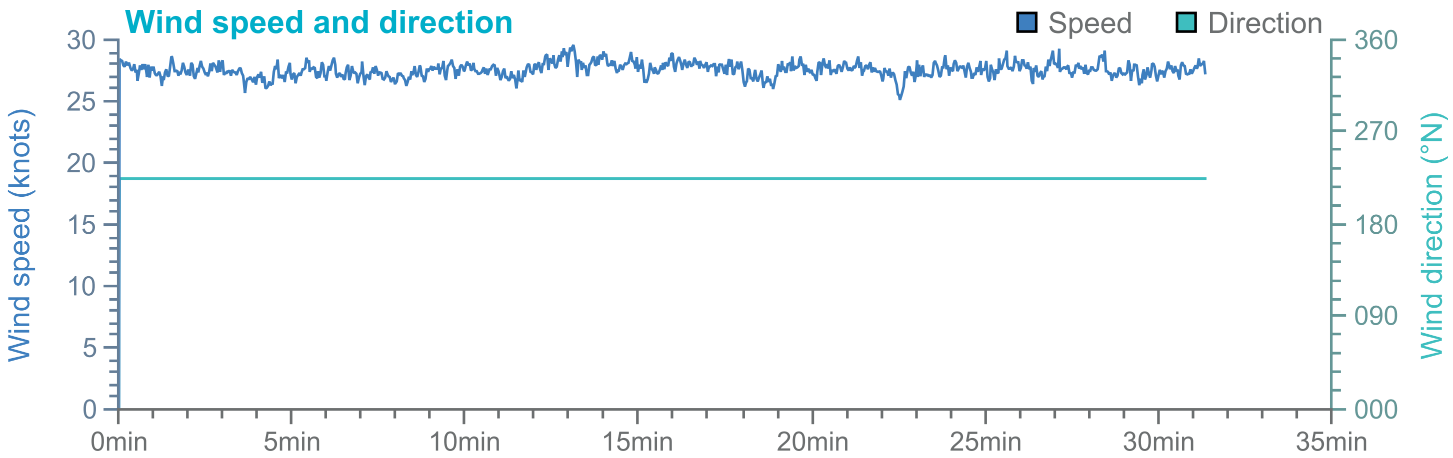
Manoeuvre track plot

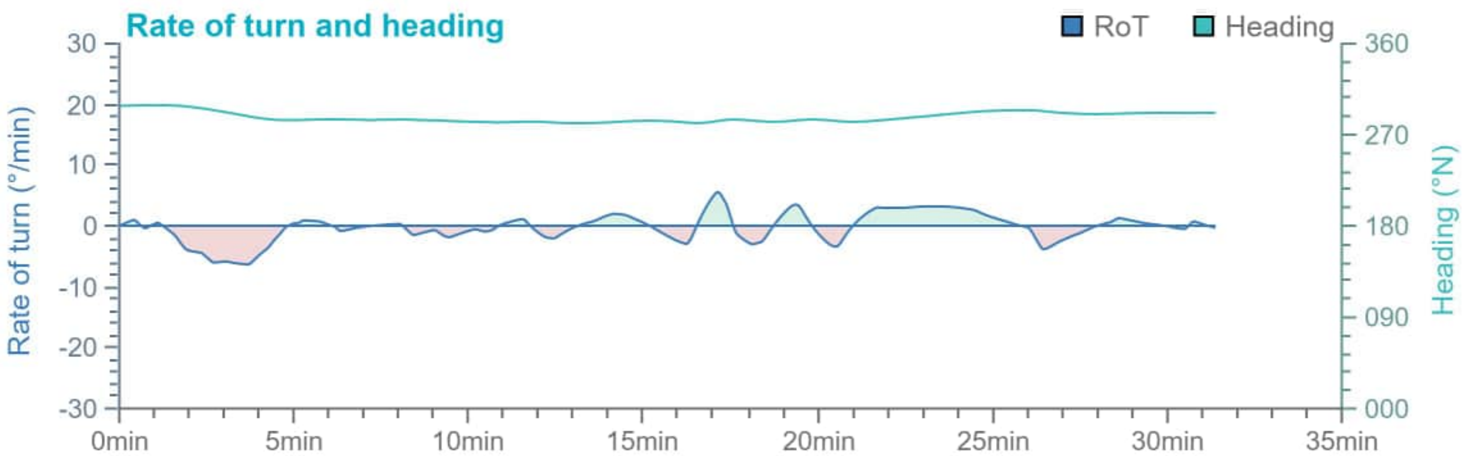


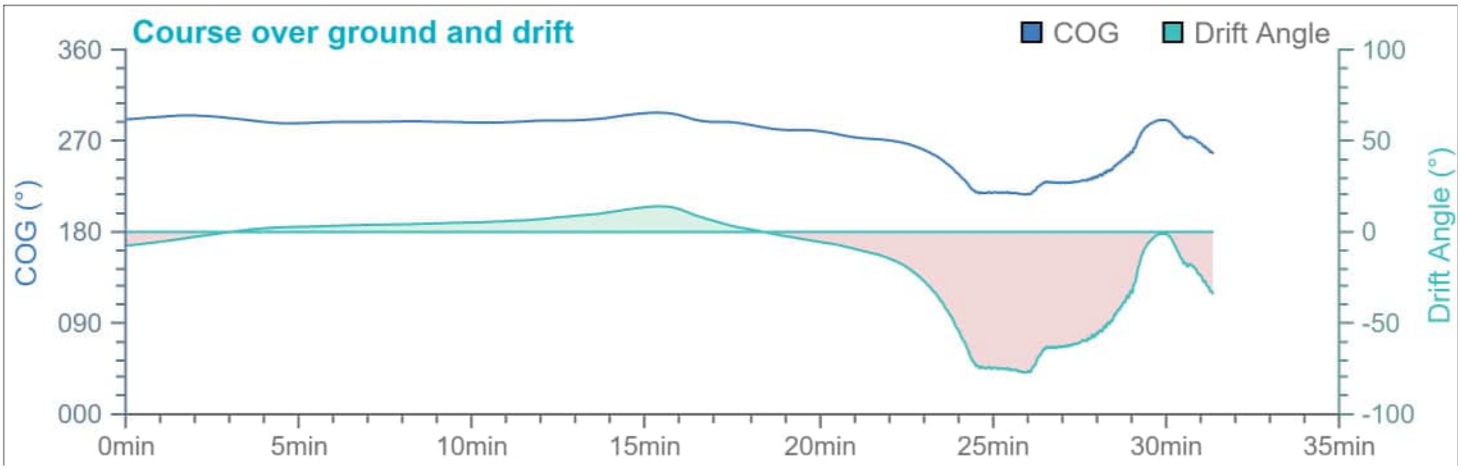
1.35 kts

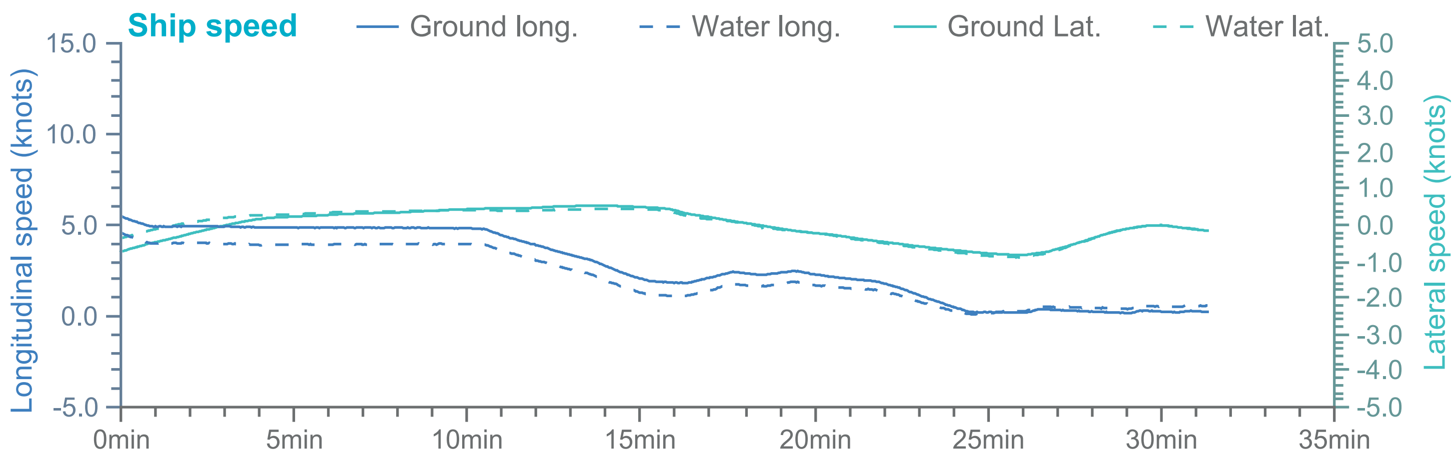
Ships plotted every 1 mins, highlight every 10 mins

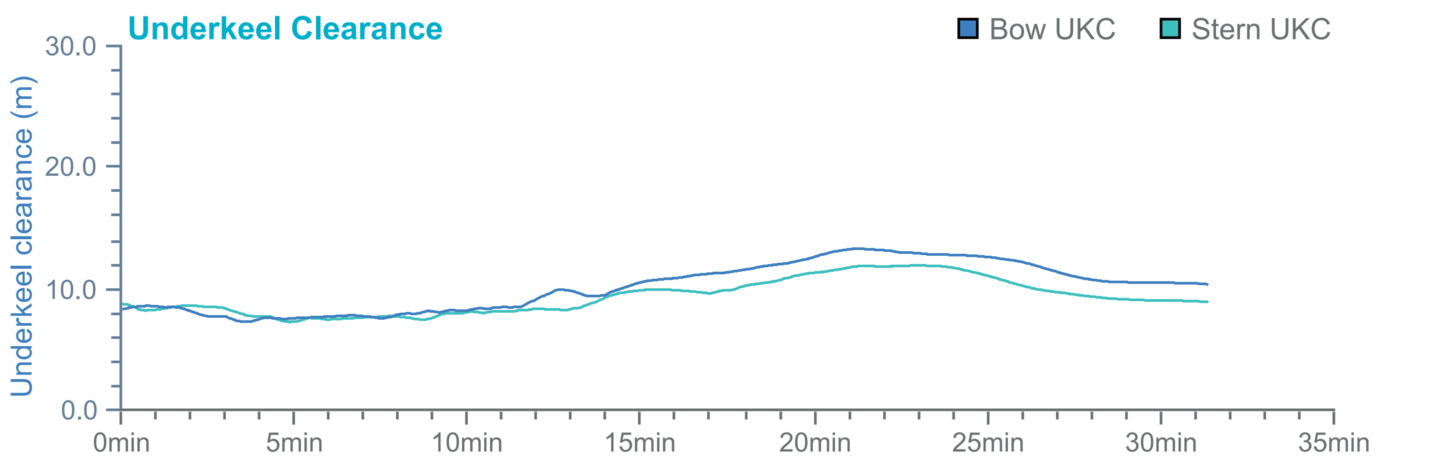

Current acting on ship
Speed
Dir.
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

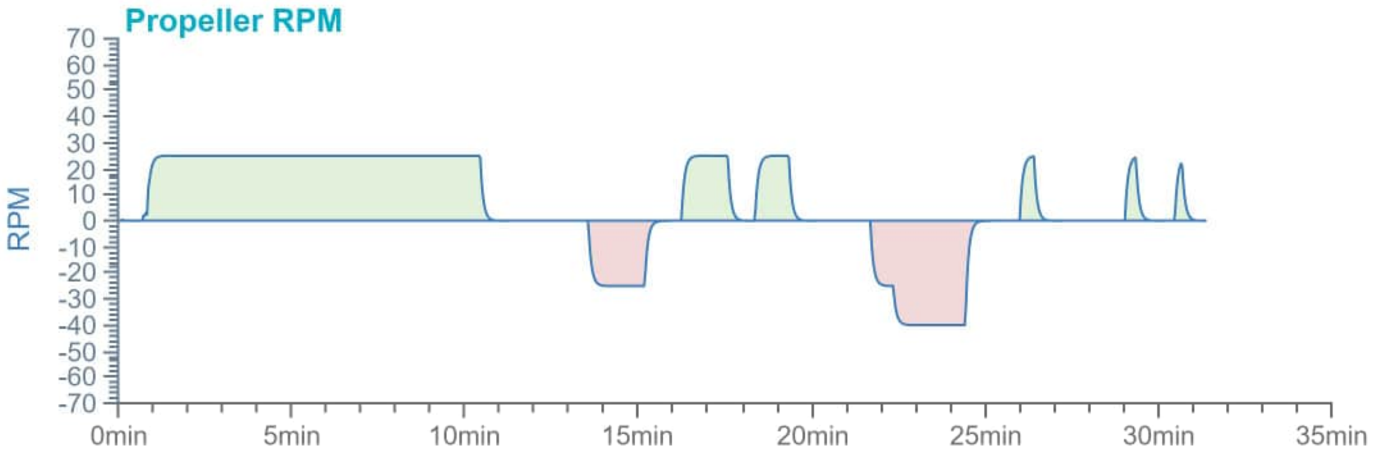

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
30
25
20
15
10
5
0
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

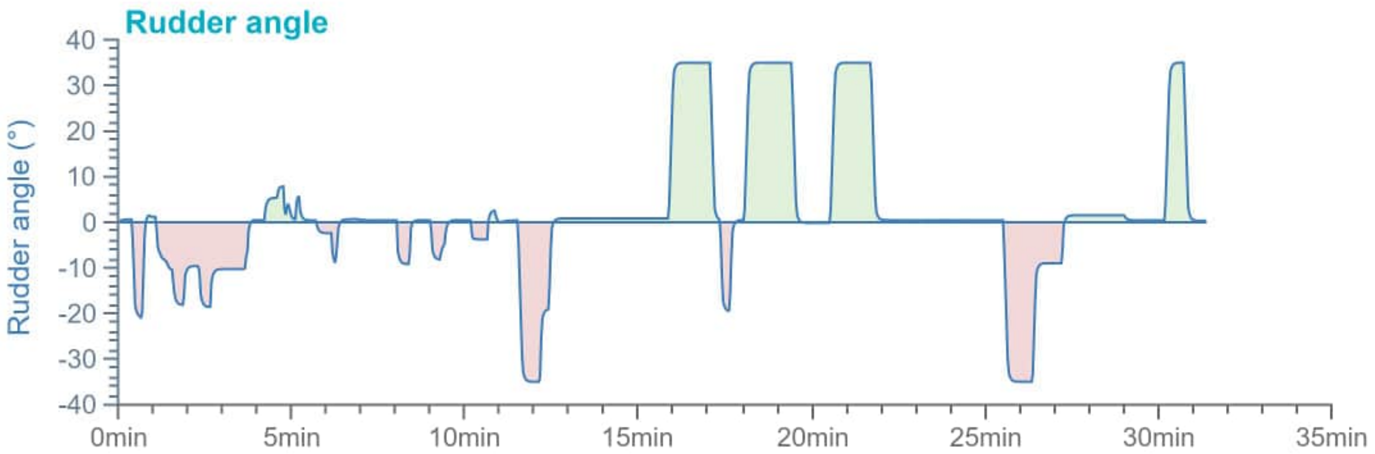

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min
35min

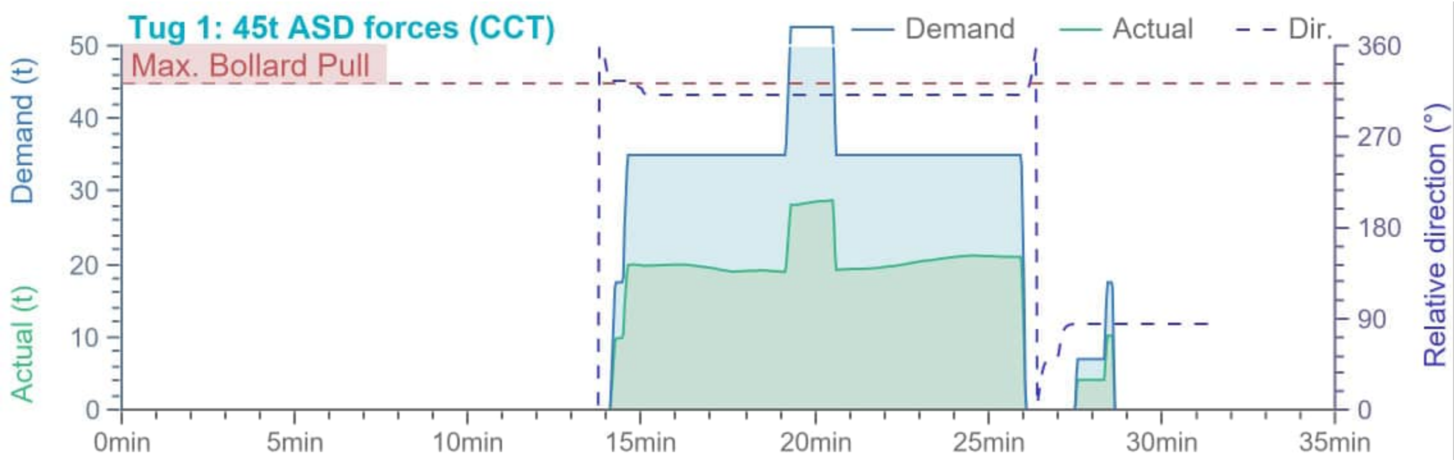

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min
35min

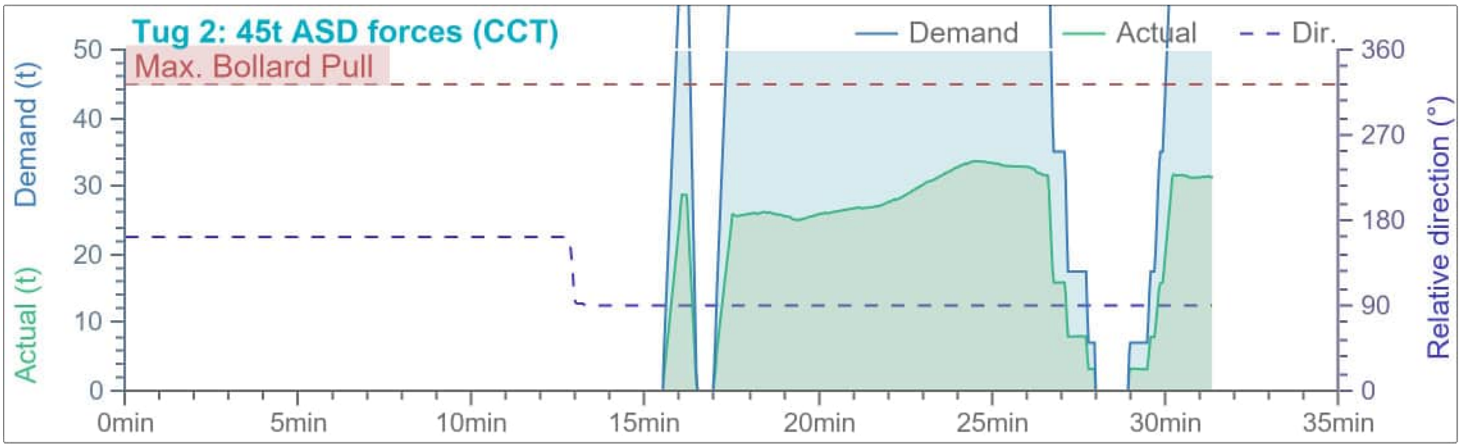

Ship speed
Ground long.
Water long.
Ground Lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
15.0
10.0
5.0
0.0
-5.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min
25min
30min
35min

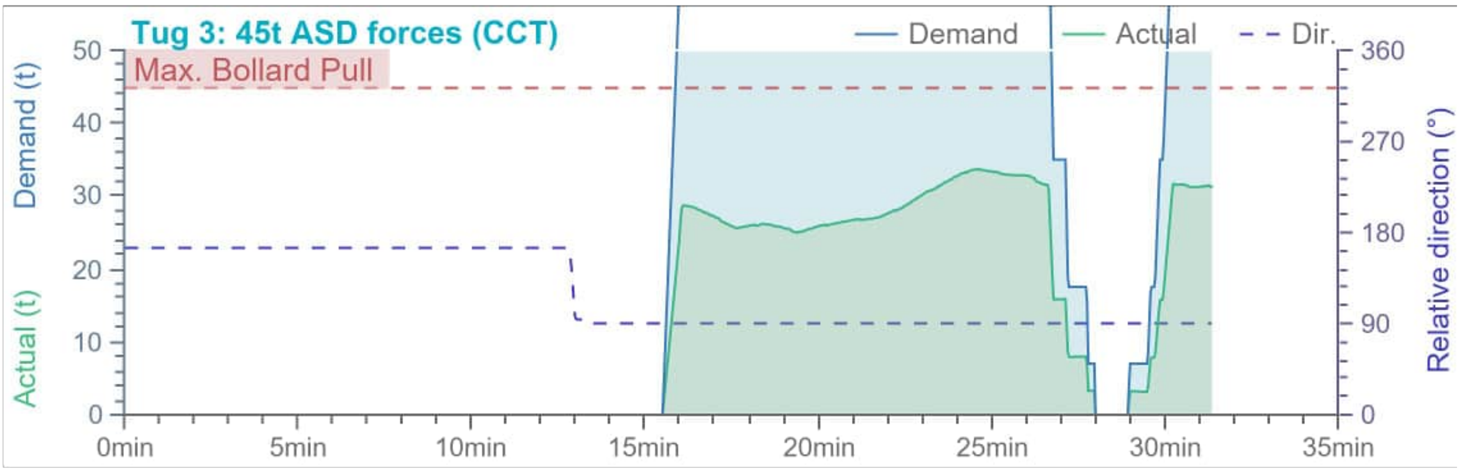

Underkeel Clearance
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min
25min
30min
35min

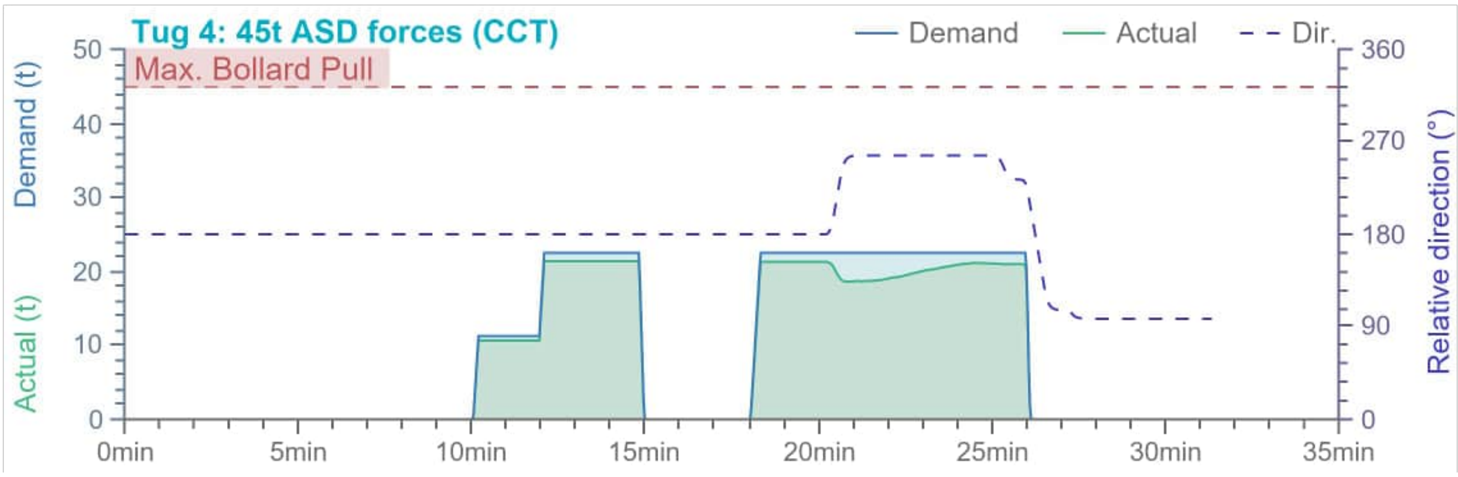

Propeller RPM
RPM
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min
30min
35min


Rudder angle
Rudder angle (°)
40
30
20
10
0
-10
-20
-30
-40
0min
5min
10min
15min
20min
25min
30min
35min


Tug 1: 45t ASD forces (CCT)
Max. Bollard Pull
Demand
Actual
Dir.
Actual (t)
Demand (t)
Relative direction (°)
0
10
20
30
40
50
0
90
180
270
360
0min
5min
10min
15min
20min
25min
30min
35min


Tug 2: 45t ASD forces (CCT)
Max. Bollard Pull
Demand
Actual
Dir.
Actual (t)
Demand (t)
Relative direction (°)
0
10
20
30
40
50
0
90
180
270
360
0min
5min
10min
15min
20min
25min
30min
35min


Tug 3: 45t ASD forces (CCT)
Max. Bollard Pull
Demand
Actual
Dir.
Actual (t)
Demand (t)
Relative direction (°)
0
10
20
30
40
50
0
90
180
270
360
0min
5min
10min
15min
20min
25min
30min
35min


Tug 4: 45t ASD forces (CCT)
Max. Bollard Pull
Demand
Actual
Dir.
Actual (t)
Demand (t)
Relative direction (°)
0
10
20
30
40
50
0
90
180
270
360
0min
5min
10min
15min
20min
25min
30min
35min

C Construction Design and Management Regulations (CDM, 2015)

The Construction (Design and Management) Regulations 2015 (CDM 2015) require a designer to avoid foreseeable risks to those involved in construction and future use of the structure, and in doing so, they should eliminate hazards (so far as is reasonably practicable, taking into account other design considerations) and reduce and control risks associated with those hazards which remain. It is essential that, where required to do so, a principal designer and principal contractor are appointed to fulfil their respective duties under the CDM 2015. It is also essential to highlight and record the impacts of the works on health, safety and welfare which should feed into the Health and Safety File (if required). Further details of the requirements of CDM 2015 can be found on:

http://www.hse.gov.uk/construction/cdm/2015/index.htm

This project consists of desk assessments, numerical and physical modelling work and/or simulation work which may be used by others in the design process. No design work, as defined in the CDM 2015, has been undertaken by HR Wallingford. If during the navigation simulation process we identify any particular issues that should be drawn to the attention of the principal designer and principal contractor in any ultimate construction work which may be undertaken, we will do so in our client discussions and reports. It is assumed that the appointed principal designer will review the information produced in this study when discharging their duties under the CDM 2015.

hr wallingford

We design smarter, more resilient solutions across both the natural and built environment to help everyone live and work more sustainably with water.

HR Wallingford
Howbery Park
Wallingford
Oxfordshire OX10 8BA
United Kingdom

+44 (0)1491 835381

info@hrwallingford.com

www.hrwallingford.com