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IMMINGHAM EASTERN RO-RO TERMINAL

Navigational Study of Enhanced Control Measures (Dec 2023 Sims Report)

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Immingham Eastern Ro-Ro Terminal

Short navigation study of enhanced control measures and revised flows

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Summary

Associated British Ports (ABP) Humber is considering the development of additional Ro-Ro berth capacity to the east of the Immingham dock, which will be known as the Immingham East Ro-Ro Terminal (IERRT).

ABP commissioned HR Wallingford to undertake a series of desk studies and real time navigation simulation studies to assist in assessing the feasibility of the design for the IERRT.

The new facility is currently being subjected to a Development Consent Order (DCO) process. As part of that process, the Examining Authority encouraged ABP and Stakeholders to consider whether or not further simulation work would enable them to reach a closer level of agreement on some of the navigational issues.

The work described in this report was used to consider the following aspects:

- The effectiveness of tugs when used as enhanced control measures at IERRT Berth 1;
- The effect of the proposed vessel impact protection (VIP) on operations at IERRT and for coastal tankers at the IOT finger pier;
- Understand the flow model effects due to the increased size of the southern IERRT pontoon.

The work was facilitated through 2 navigation simulation sessions of over 1.5 days considering:

- Effectiveness of enhanced operational controls;
- Operations at IOT Berth 8 with VIP and revised flows.

This work was largely a repeat of work covered previously in AS-071, which was submitted as part of ABP’s changes application. The original work was completed on 15 November 2023, unfortunately the IOT and their representatives were unable to attend. This study was commissioned by ABP to enable stakeholder engagement, the timing of the study was earliest possible after 15 November based on resource availability at HR Wallingford.

This report should be read in the context of the wider body of work provided to support the DCO process.

The following conclusions and notes were made as a result of the study:

Enhanced operational controls

Context

The work in this study considered enhanced operational controls, which will be applied only as required in the event of an extremely unlikely emergency scenario. So it was not intended to show the level of control and consequent expected outcome in the course of normal operations.

The study considered the effectiveness of the minimum tug provision in the event of a vessel operating at IERRT Berth 1 during an ebb tide, suffering a complete control failure close to the berth. For modern Ro-Ro type vessels this is an extremely unusual event, as normally there is significant redundancy in the control systems, and the engines are designed to operate independently and reversionary modes of operation are normally readily available.

In considering the outcomes described in this study, it is important to appreciate the other controls that will also need to have failed. Specifically, a ship with previously fully operational engine and controls, tested and in pilotage mode, loses all control and no reversionary modes are unavailable.

The study was designed to test the ability of the tug(s) to keep the ship clear of IOT infrastructure in the most challenging conditions in which the vessel might be required to be operating at the berth. Other controls or protections such as: minimising approach speed, use of anchors and limiting environmental conditions were not included within the scope of this study.

The manoeuvres were not intended to be indications of best practice. It should be noted that for the larger vessels, in the conditions simulated, the Ship Master/PEC may have required additional tugs to those requested or decided to delay their approach.

Design vessels

The design vessels considered included:

- Stena Transit (T) class – This ship represents the vessel which will be operating at IERRT on initial commissioning;
- CLdN G9 class Ro-Ro vessel – A specific version of an existing vessel. The vessel was only used as a 'dead' ship or moored throughout the study, so the ships propulsion or other manoeuvring characteristics were not important. The original model, normally considered for operations on the Humber, has a draught of 7.5 m draught, with a displacement of 47,000 t. At the request of interested parties this was modified to reflect the maximum draught specified in the design envelope of 8 m, so increasing the displacement to 50,600 t.

It should be noted that, at the time of writing, there is no intention of operating a vessel as large as the CLdN G9 vessel at IERRT. Should there be a need for such a large displacement vessel to operate at IERRT, and it is considered necessary to mitigate a full controls failure, additional work will need to be undertaken to agree the requirements and limits for safe operations, to ensure appropriate towage is always in place.

It should also be noted that, due to the limited time available, additional runs with more than one tug supporting with the Stena T class ship were not completed. However, the study is considered to be sufficient to conclude that a single 50 tBP ASD tug is sufficient to provide enhanced operational controls to protect the IOT during operations by a such a vessel at IERRT Berth 1 in the event of a complete control failure in extreme conditions, notwithstanding other tugs will most likely be available.

Conclusions

The following key conclusions were discussed and agreed:

- A 50 tBP ASD tug is sufficient to arrest or control a Stena T class vessel avoiding hazarding the IOT structure.
- In the situation with a mean 27.5 knot (speed at 10 m above mean sea level) north-west wind aligned with peak spring flows, the outcome of the simulations was a contact with the IERRT infrastructure, at velocities of up to 1 knot. It should be noted that the Jacobs basis of design report indicates that IERRT infrastructure is designed to withstand contact of T class vessels at speeds of up to 2.5 knots and 48,000 t displacement vessels at speeds up to 1.8 knots.
- The simulation system is not designed to provide an assessment of contact between a ship and a fixed object at speeds in excess of about 0.6 knots in detail, except in particular circumstances. Therefore it was not possible to determine the outcome after a vessel makes contact with port infrastructure at speeds of up to 1.5 knots. However, experience suggests that at such a speed, a significant part of the energy would be absorbed through deformation of the vessel's hull and the infrastructure, and so the vessel is likely to be brought to stop or could be brought under control quickly afterwards.
- Subsequent runs, conducted after the main study, showed that if the effect of contact with the IERRT infrastructure is ignored, the proposed tug is sufficient to arrest the Stena T class vessel before it could make contact with the IOT infrastructure.
- If it is intended to operate a larger vessel than the Stena T class, then similar studies will be necessary to establish the safe minimum towage requirements to protect IOT infrastructure from any risk of a vessel operating at IERRT 1, which suffers a complete control failure.
- Considering the 50,600 t displacement CLdN G9 class vessel (which meets the maximum design envelope criteria) in a peak spring tide and with a mean wind speed of 27.5 knots:
  - 2 x 70 tBP ASD tugs are sufficient to arrest or control the vessel, avoiding hazarding the IOT structure, except where exceptional north-west winds and strong tides are combined;

  - Additional controls will need to be in place to restrict such a vessel's operation in strong north-west winds and peak spring tides. Noting that these combined conditions would be extremely rare, no significant restriction on operations would be envisaged;
  - Further study would enable more discrete levels of operational control to be agreed for lower environmental conditions, if this size of vessel was to be operated at IERRT.
- The work reinforced the need for emergency scenarios with a full control failure to be included in pilot and PEC training and validations for IERRT.

Operations at IOT Berth 8 with VIP and revised flows

Context

The approach and departure manoeuvres to IOT 8 described in this study should be considered alongside the significant work previously conducted considering operations at IOT 8. In particular:

- Simulation study carried out in July 2022 – Specifically Runs 28 to 43, and Runs 52 and 65 to 70 (see Reference 5);
- Simulation study carried out in November 2022 – Specifically Runs 16 to 22 (see Reference 7).

These were all conducted in similar conditions and it was previously demonstrated, agreed and reported that, considering IOT, based on the additional runs using a modified flow model, the new infrastructure orientation and a 104 m long tanker (with a deadweight of 6,535 t), the following were concluded in July 2022:

- Navigation to and from the IOT 6 and 8 jetties will not be adversely affected by the proposed size and location of the new Ro-Ro infrastructure at an orientation of 300°T;
- Existing manoeuvring practices will need to be updated, taking into account the new infrastructure and reduced sea room to the south of the IOT finger jetty. However, safe manoeuvring was demonstrated in peak spring flows and winds up to 30 to 35 knots;
- Arrivals by vessels in their ballast state during strong south westerly winds will need to be restricted to a limit of 25 knots gusting to 30 knots. Arrivals above this limit may result in a hard landing. At low water there is potential for the new infrastructure to obstruct the flow which can create unusual flow patterns towards IOT8. Pilots and masters will need to be made aware of this effect;
- This is a well understood effect and is experienced and managed by pilots elsewhere on the Humber.

This new work was specifically used to consider the potential effect of the additional blockage created by larger pontoons at IERRT. The pontoons result in a short period of increased acceleration and deviation of flow towards IOT, at between 30 minutes and 60 minutes after LW Immingham. The effect and associated modelling is fully reported in Reference 11. All runs were conducted using the modified flow modelling taking into account the additional blockage.

Also ABP and IOT have been considering the potential provision of vessel impact protection (VIP) structures. The proposed VIP was included in the layout to ensure that the modification did not impede the navigational geometry on approach and departure.

APT restrict approaches to the IOT finger pier in conditions when the mean wind is forecast to be above 26 knots (30 mph) setting on to the berth. Occasionally at the operators discretion if the wind increases above the limit in the 2 hours prior to arrival the approach may be continued. This precaution is in place because the small products tankers operating at the terminal are challenging to control in such conditions, particularly controlling the bow. It is therefore unsurprising that similar challenges were found when approaching the berth in these strong winds, particularly when controlling the lateral set in the final moments of the manoeuvre. Consequently, it can be considered that the difficulty is not due to the IERRT structure.

Design vessel

The design vessel for these runs was the Wisby Teak, which was used throughout, and had been identified by APT as an appropriate design vessel for IOT 8 in November 2022.

Conclusions

The following key conclusions were discussed and agreed:

- Approaches to IOT 8 were considered in peak and mean spring tides, including 1 hour after LW and LW +3 hour flows.
- There were 9 runs undertaken which were all completed successfully.
- Run 22 was assessed as marginal, which was in 27.5 knot winds, simulating the exceptional case where the wind increases above 30 mph (26 knots) during the final 2 hours of the approach to the berth. The ability to control the vessel in the final part of this approach was due to the environment in relation to IOT 8 and is unchanged from the situation at present with the existing port layout.
- The flows (as modelled) and modified by the additional pontoon, did not adversely change the ability of vessels to operate safely at IOT 8 compared with previous studies, noting that an adaptation of the piloting strategy will be required.
- The wind limit, where operations approaching IOT 8 were noted to be challenging, aligns with the levels expected with existing operations and the present advisory operating limit of 30 mph imposed on the berth by APT.
- The modified berthing geometry due to the VIP does not affect the approach or departure manoeuvring strategies for vessels operating at IOT 8, compared with previous studies, noting that some adaptation of the manoeuvring strategy might be required.

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1 Introduction

Associated British Ports (ABP) Humber is considering the development of additional Ro-Ro berth capacity to the east of the Immingham dock, which will be known as the Immingham East Ro-Ro Terminal (IERRT).

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The work was facilitated through 2 navigation simulation sessions of over 1.5 days considering:

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2 Simulation configuration

2.1 General

The simulation configuration for this study was undertaken in accordance with HR Wallingford's normal procedures, with the layout, environmental models and ship manoeuvring models being tested before the simulation session.

The following sections outline the specification configuration for this work.

2.2 Environment

2.2.1 Wind

All Wind speed in this report refer to wind at 10 m above mean sea level (AMSL).

IOT operates a policy that vessels arriving at IOT 6 and 8 are limited to 30 mph when the wind sets onto the berth. This is equivalent to 26 knots.

During previous work, it was determined that with the wind varying between 25 and 30 knots, based on a mean speed of 27.5 knots, vessels can still operate at the IOT6/8, noting that this exceeds the existing operational limit.

Since undertaking the previous simulation studies, HR Wallingford completed a further analysis of the wind parameters at the site. This showed that the original assumptions were conservative and appropriate. This work was undertaken to support the mooring analysis for the IERRT and is summarised in this section.

Wind conditions at the site were derived from measured wind data provided by ABP Humber, collected from the Immingham Maritime Control Centre (at an elevation of 24 m) between August 2020 and August 2021. The data included wind speeds for a gust duration of 3 seconds and 10 minute mean speeds.

The data was post processed to provide wind speeds at an elevation of 10 m and for a 1 minute mean duration. Noting that 10 m above mean sea level is the Metrological standard and therefore that which is normally used in the simulation.

HR Wallingford routinely applies a 1 minute gust value in simulations as it is approximately the minimum gust duration required for a large ship to show a measurable response.

The data was also analysed to determine the return period conditions in 30° sectors, which is presented as follows:

- 1 minute mean wind speeds at 10 m in Table 2.1;
- 10 minute means at 10 m in Table 2.2;
- 30 second mean speeds at 10 m in Table 2.3.

Table 2.1: Return period wind conditions at site, 1 minute mean in knots

Return period (years)	**Wind speed (1 minute mean, knots) by sector (°N)**											
	0	**30**	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**	**330**
0.1	23	20	12	14	12	9	19	20	16	15	15	16
1	38	29	27	22	20	16	25	30	24	22	24	30
2	43	32	32	25	22	17	27	33	26	24	27	34
5	48	35	39	28	25	19	28	37	29	28	31	40

Table 2.2: Return period wind conditions at site, 10 minute mean in knots

Return period (years)	**Wind speed (10 minute mean, knots) by sector (°N)**											
	0	**30**	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**	**330**
0.1	20	17	10	10	8	5	14	17	14	12	13	14
1	33	26	23	14	12	9	19	26	20	17	21	26
2	37	28	28	16	14	10	20	29	22	18	23	30
5	42	31	34	18	16	11	22	32	24	20	26	35

Table 2.3: Return period wind conditions at site, 30 second mean in knots

Return period (years)	**Wind speed (30 second mean, knots) by sector (°N)**											
	0	**30**	**60**	**90**	**120**	**150**	**180**	**210**	**240**	**270**	**300**	**330**
0.1	24	21	13	15	13	10	20	21	17	16	16	17
1	40	31	29	23	21	17	27	32	25	23	25	32
2	46	34	34	27	23	18	29	35	28	25	29	36
5	51	37	41	30	27	20	30	39	31	30	33	42

This analysis indicates that, for a 0.1 year return period (10 times per year), a mean wind speed of 20 knots with a 1 minute gust of 23 knots, would be representative of the routine operating conditions at the site. This supports HR Wallingford's advice that for the north-easterly wind conditions (which are the most challenging for navigation) a mean wind speed of 27.5 ±5 knots at 10 metre elevation, as used in the previous simulations, is equivalent to a 1 in 1 year return period 1 minute mean wind speed, and therefore appropriate for the feasibility study.

The data shows that:

- Mean winds above 25 knots with 30 second gusts up to 30 knots from a north west direction would be a relatively rare event, perhaps once a twice a year on average;
- Mean winds above 25 knots with 30 second gusts up to 30 knots from the south west direction would also be relatively rare, occurring once or twice a year;
- Mean winds above 25 knots with 30 second gusts up to 30 knots from the north east direction would also be relatively rare, occurring once or twice a year.

Based on this data, it is appropriate to assume these conditions as extreme wind conditions for operations. Furthermore, if this is, in due course, deemed the limit for operations, the significance of restricting operations for these wind speeds would not have a significant impact on the overall viability of the facility.

2.2.2 Waves

As with the previous studies, no significant wave action is expected in normal operating conditions, such that it would lead to any significant effects on ship navigation or the assisting tugs.

2.2.3 Flows

As described previously, the flow modelling at IERRT has been revised to account for additional blockage created by larger pontoons included in the design.

The run plan was briefed on 12 December 2023 ahead of the simulation session at the request of the interested parties, and subsequently HR Wallingford flow modelling experts attended the simulation session on 14 December to discuss changes to the flow modelling. Consequently, some additional text and diagrams were included in the flow modelling report (Reference 11).

The new modelling and effect of the increased pontoons is described fully in Reference 11. To aid understanding the relevant chapter is reproduced in Appendix A. The revised flows were used throughout this study.

There were 2 flow models made available as follows:

- Mean spring model with a 1 in 14 day occurrence;
- Peak spring model with a 1 in 28 day occurrence.

In the simulation runs, the time in the tidal cycle to be considered was selected to coincide with either the strongest ebb or flood tide, or at 1 hour after high water Immingham, which is the earliest point in the cycle when IOT starts operations.

The flows as modelled, around the time when maximum divergence is expected, are shown in Figure 2.1 to Figure 2.4.

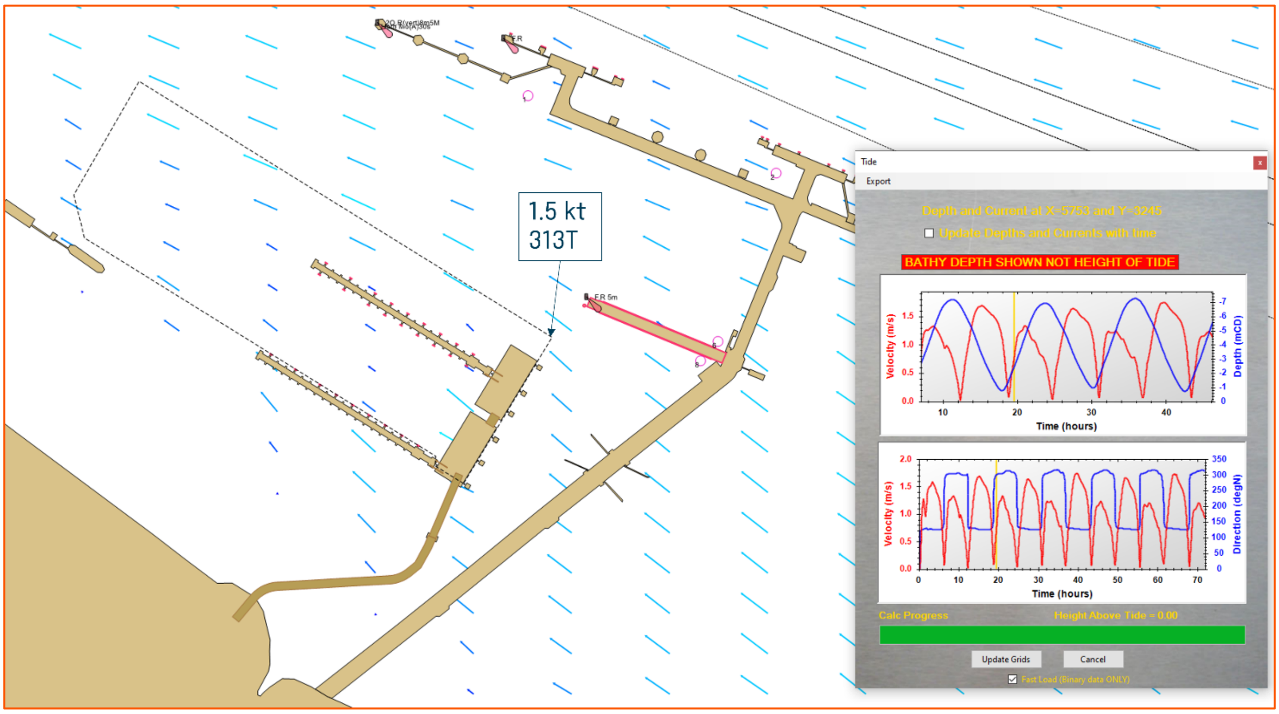


Figure 2.1: Mean spring flow 0.5 hour after LW Immingham

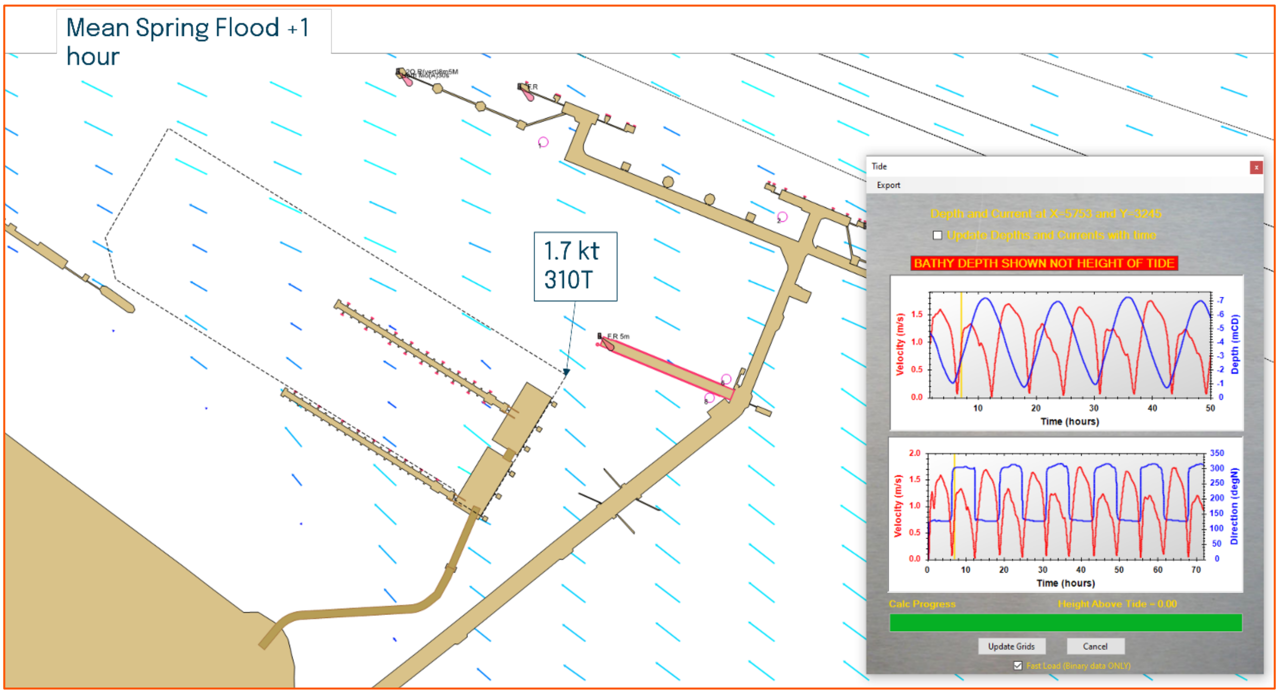
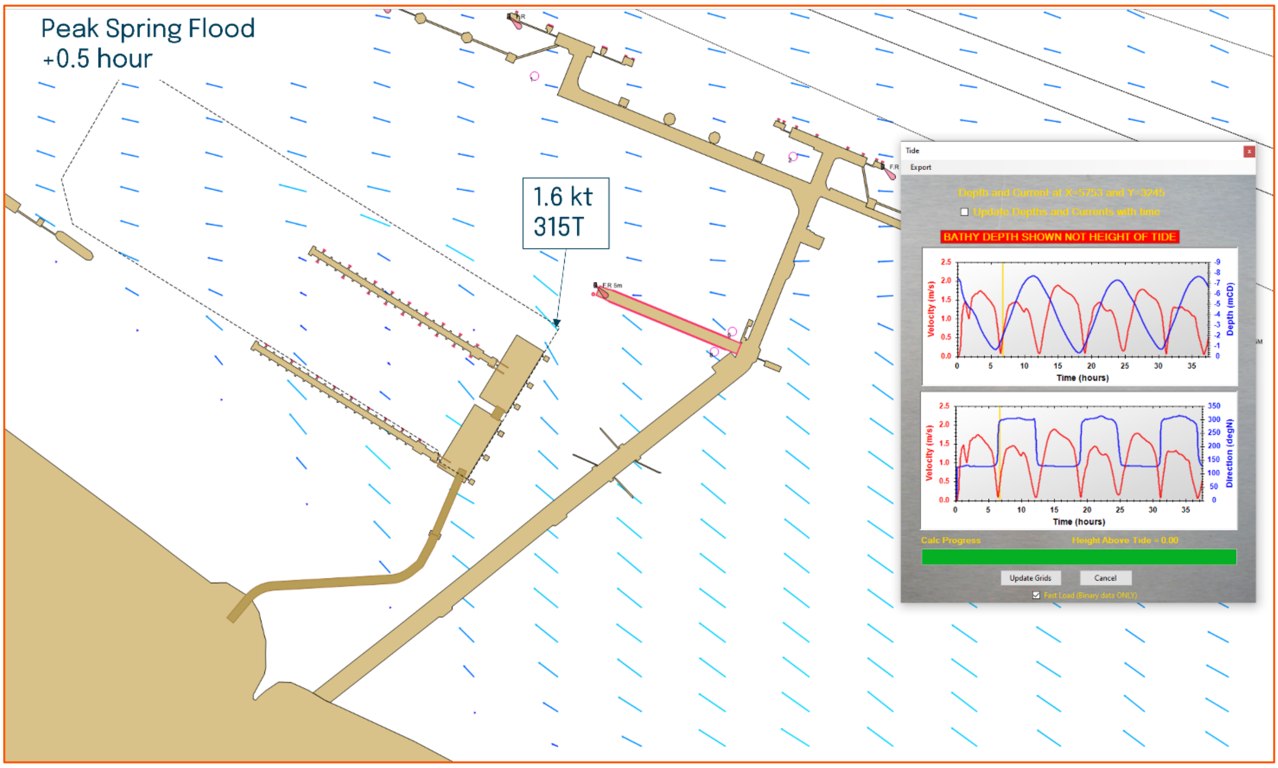


Figure 2.2: Mean spring flow 1 hour after LW Immingham



Depth and Current at X=5753 and Y=3245

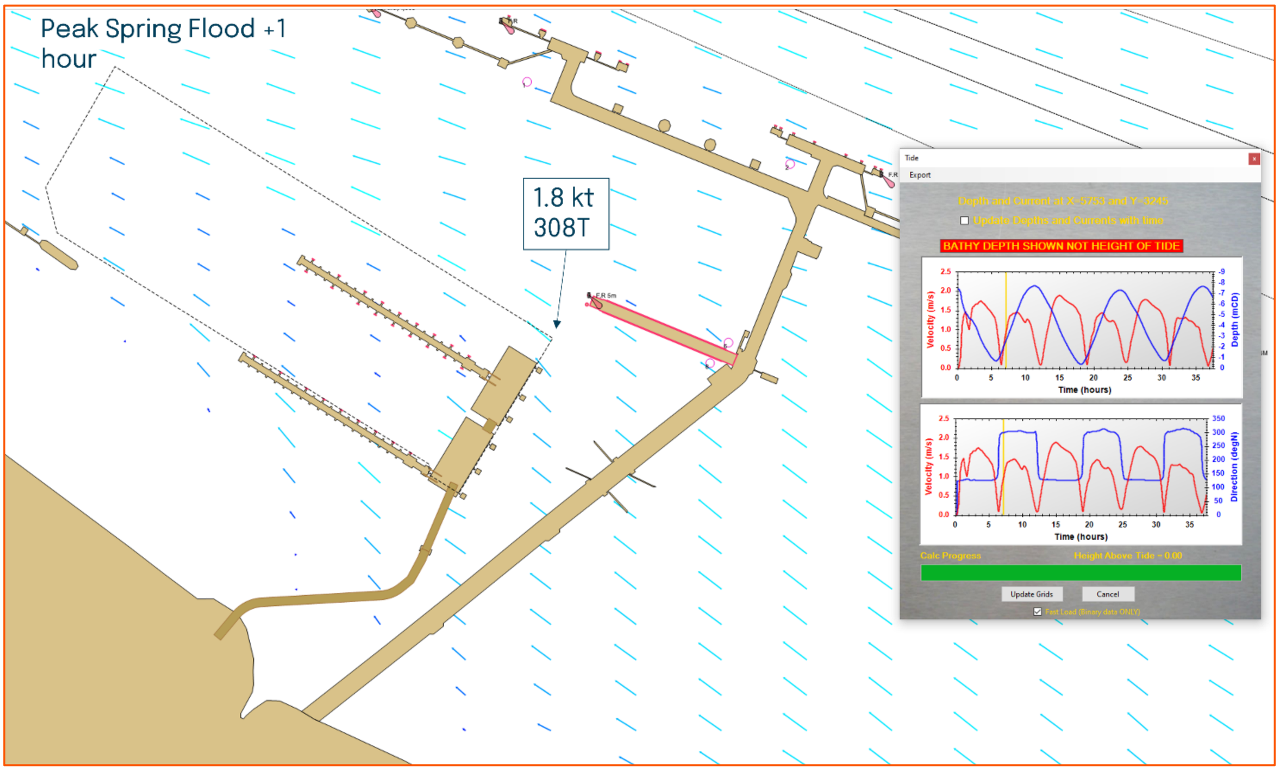
☐ Update Depths and Currents with time

BATHY DEPTH SHOWN NOT HEIGHT OF TIDE

Height Above Tide = 0.00

☑ Fast Load (Binary data ONLY)

Figure 2.3: Peak spring flow 0.5 hour after LW Immingham



Depth and Current at X=5753 and Y=3245

☐ Update Depths and Currents with time

BATHY DEPTH SHOWN NOT HEIGHT OF TIDE

Height Above Tide = 0.00

☑ Fast Load (Binary data ONLY)

Figure 2.4: Peak spring flow 1 hour after LW Immingham

2.3 Port layout

There were 2 port layouts considered as part of this study, as follows:

- Layout A Figure 2.5 – which represents the port layout without any additional vessel impact protection (VIP). This layout was used for the runs considering enhanced control measures;
- Layout B Figure 2.6 – which represents the port layout with the proposed additional VIP. This layout was used for the runs considering operations at IOT8.

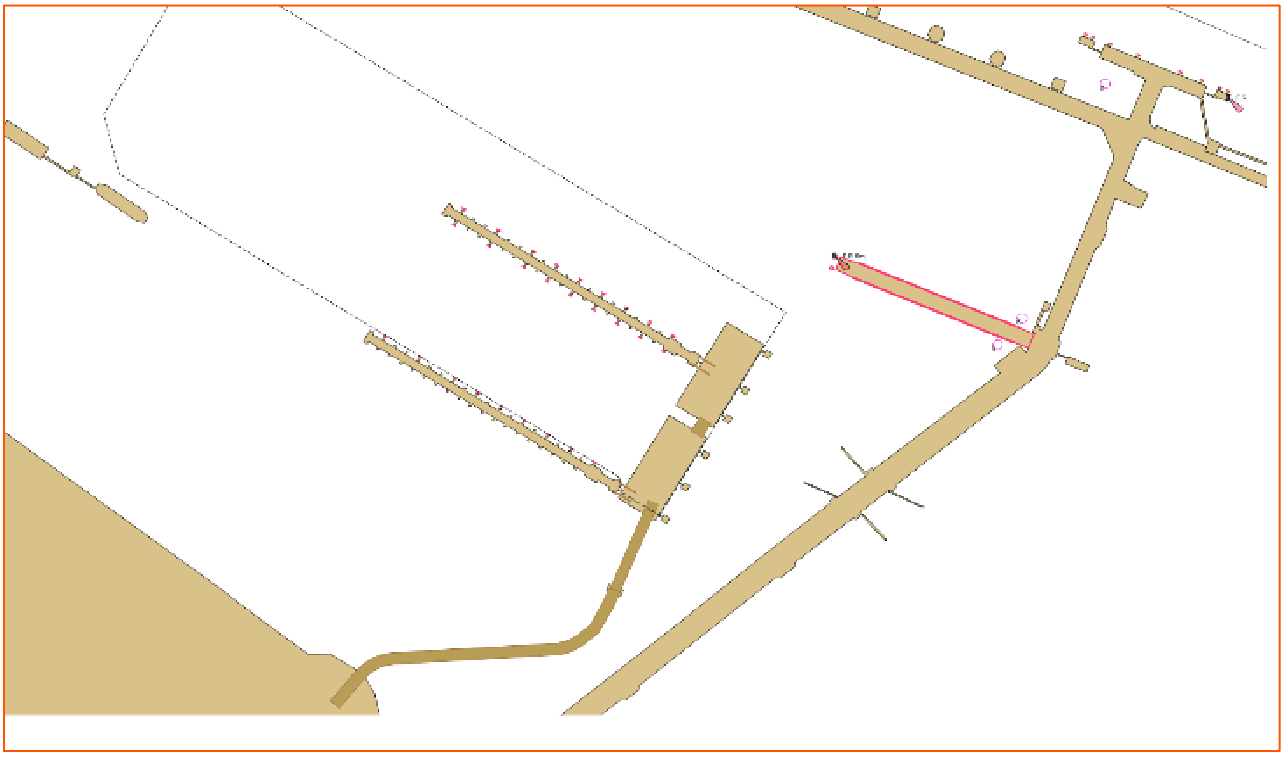


Figure 2.5: Layout A

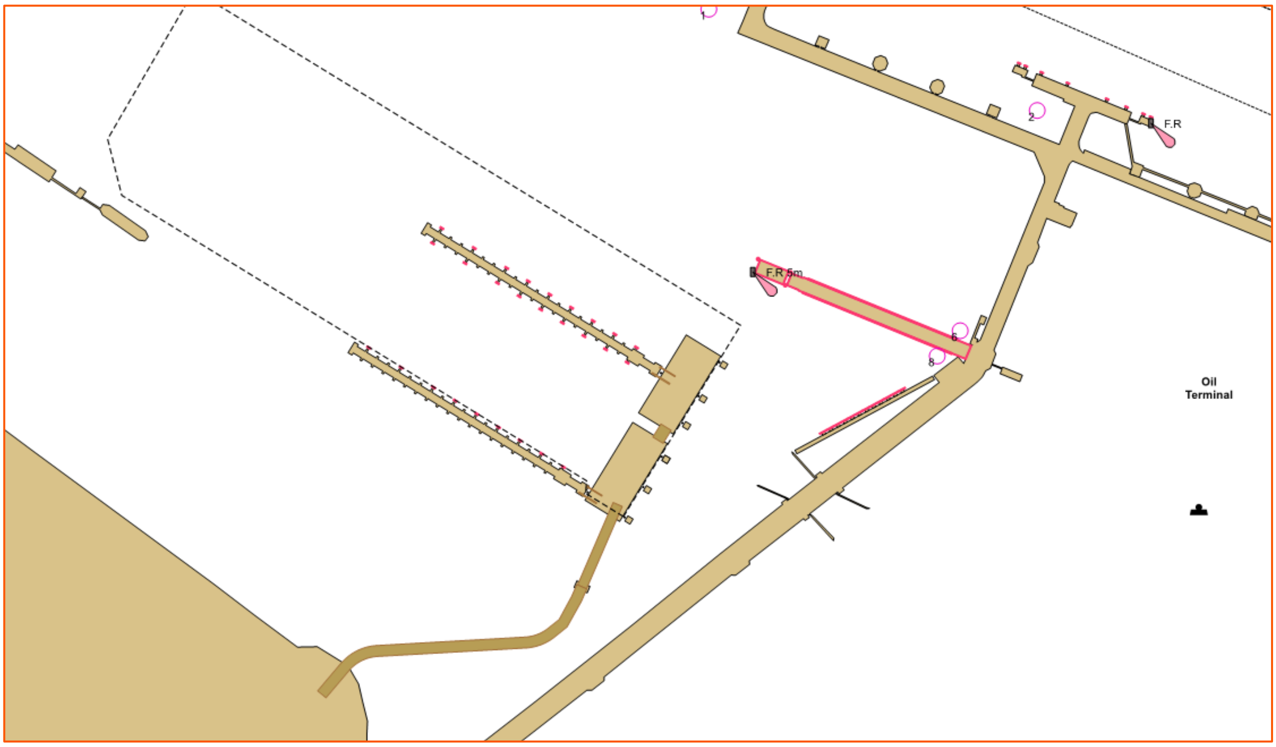


Figure 2.6: Layout B

A further layout (Figure 2.7), with the IERRT infrastructure removed, was used subsequent to the main study to examine the use of tugs in preventing an errant vessel making contact with IOT infrastructure, following a possible contact with the IERRT.

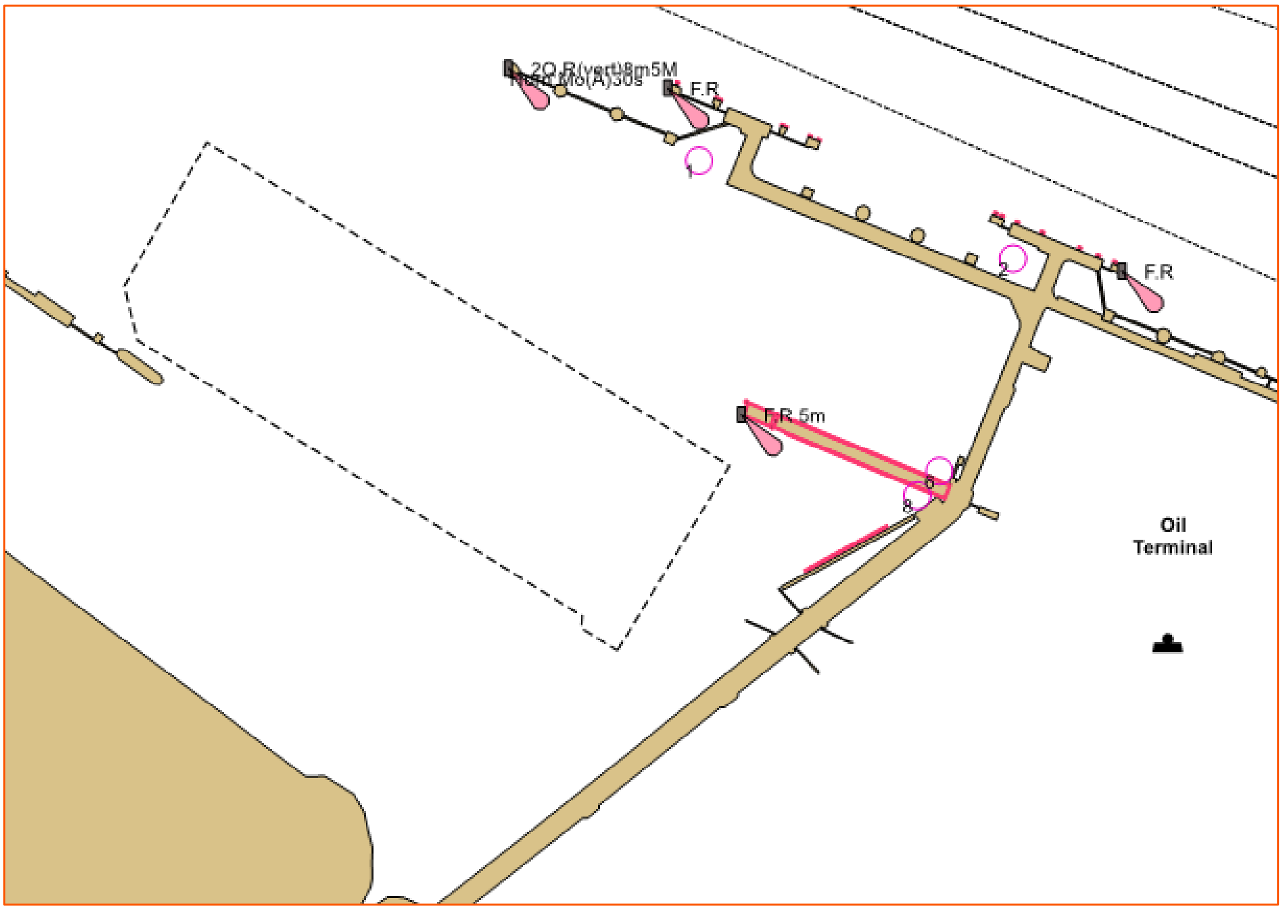


Figure 2.7: Layout C

2.4 Assumptions on approach

The approach tracks to IERRT Berth 1 from previous simulations undertaken in November 2022 where reviewed. From these a general line of approach to the berth was deduced and 3 areas identified, at approximately 1 ship length apart, through which approaching vessels would pass.

The swept paths used for the analysis are shown in Figure 2.8 with the areas identified.

During this study Site A and Site B were used as the start points for emergency scenarios with a total control failure on the ship.

It was agreed that at Site C the vessel was effectively alongside and the combined response of the vessel and tugs could not be reasonably simulated.

The speeds of the vessels approaching the IEERT berth 1 were analysed from previous runs, as shown in the table reproduced in Figure 2.9. The highest speeds observed were used as the initial speed for the emergency scenario.

The Harbour Master Humber (HM) and Stena masters present explained that if it was assumed there was a reasonable risk of a total control failure for a vessel operating at the berth, the approach speed would be reduced, by advice from the HM, and due to good seamanship on the part of the Ship Master. The data shows that slower approach speeds are feasible, noting that the data indicates the vessel's speed over the ground astern, i.e. towards IERRT.

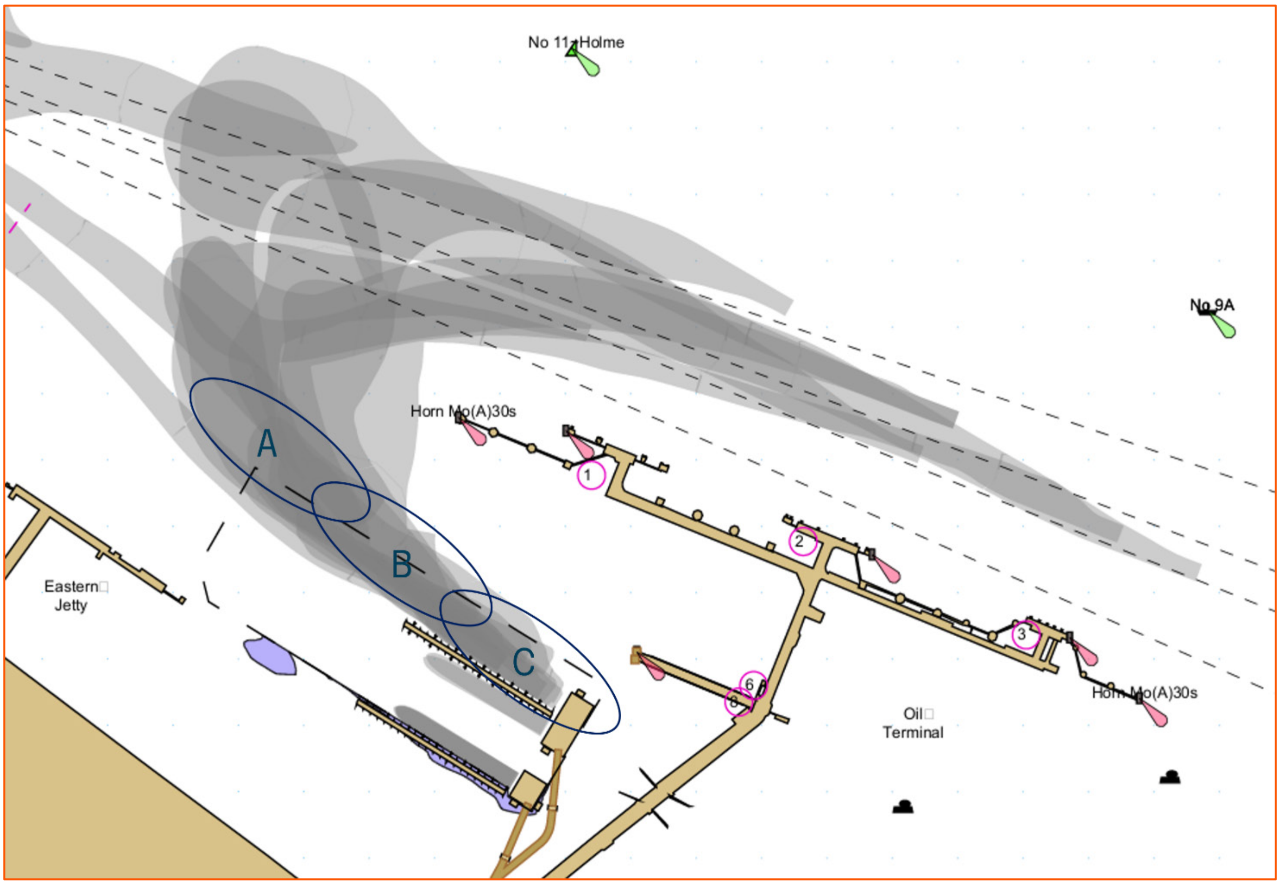
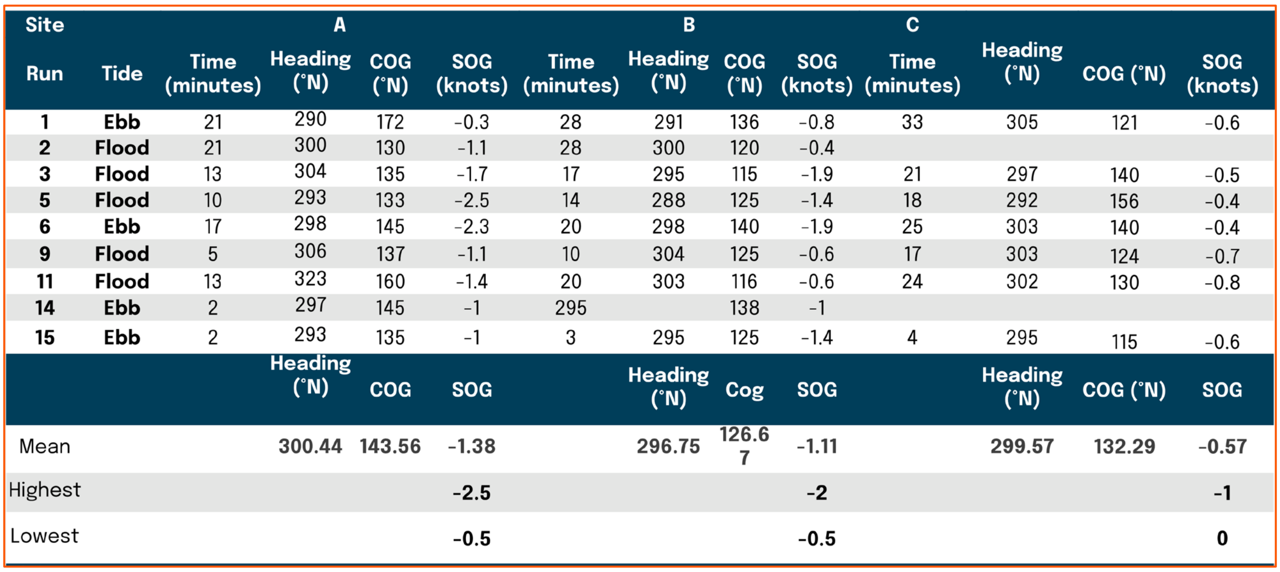


Figure 2.8: Sept path analysis for approaches to IERRT Berth 1



Site		A				B				C			
Run	Tide	Time (minutes)	Heading (°N)	COG (°N)	SOG (knots)	Time (minutes)	Heading (°N)	COG (°N)	SOG (knots)	Time (minutes)	Heading (°N)	COG (°N)	SOG (knots)
1	Ebb	21	290	172	-0.3	28	291	136	-0.8	33	305	121	-0.6
2	Flood	21	300	130	-1.1	28	300	120	-0.4				
3	Flood	13	304	135	-1.7	17	295	115	-1.9	21	297	140	-0.5
5	Flood	10	293	133	-2.5	14	288	125	-1.4	18	292	156	-0.4
6	Ebb	17	298	145	-2.3	20	298	140	-1.9	25	303	140	-0.4
9	Flood	5	306	137	-1.1	10	304	125	-0.6	17	303	124	-0.7
11	Flood	13	323	160	-1.4	20	303	116	-0.6	24	302	130	-0.8
14	Ebb	2	297	145	-1	295		138	-1				
15	Ebb	2	293	135	-1	3	295	125	-1.4	4	295	115	-0.6
			Heading (°N)	COG	SOG		Heading (°N)	Cog	SOG		Heading (°N)	COG (°N)	SOG
Mean			**300.44**	**143.56**	**-1.38**		**296.75**	**126.67**	**-1.11**		**299.57**	**132.29**	**-0.57**
Highest					**-2.5**				**-2**				**-1**
Lowest					**-0.5**				**-0.5**				**0**

Figure 2.9: Analysis of vessel speeds approaching IERRT Berth 1

2.5 Design vessels

2.5.1 Ship manoeuvring models

Ship manoeuvring models for 3 vessels were made available for the study, as follows:

- 100 m long products tanker Wisby Teak – The design vessel for consideration for IERRT manoeuvres by APT In November 2022. Characteristics are laid out in Table 2.4;
- Stena T Class – The vessel intended for use at IERRT for initial operations. Characteristics are laid out in Table 2.5;
- CLdN G9 Ro-Ro ship – This existing ship manoeuvring model was adapted to meet the maximum design envelope for IERRT. It should be noted that the vessel was only used as a 'dead' ship or moored throughout the study, so the ships propulsion or other manoeuvring characteristics were not important. The original model, normally considered for operations on the Humber, has a draught of 7.5 m draught, with a displacement of 47,000 t. At the request of interested parties this was modified to reflect the maximum draught specified in the design envelope of 8 m, so increasing the displacement to 50,600 t. Its characteristics are laid out in Table 2.6.

Table 2.4: Wisby Teak manoeuvring characteristics

Characteristic	Unit	100 m x 18 m Products Tanker Laden		100 m x 18 m Products Tanker Ballast	
Ship type		Products tanker		Products tanker	
Length overall	m	99.9		99.9	
Length between perpendiculars	m	95		95	
Beam overall	m	18.25		18.25	
Distance bridge to stern	m	19.4		19.4	
Modelled conditions					
Draught forward	m	6		3.73	
Draught aft	m	6.1		5.83	
Block coefficient		0.744		0.706	
Displacement	t	8000		6000	
Propulsion					
Main engine type		Wartsila 9L26		Wartsila 9L26	
Engine power (total)	kW	2925		2925	
No. of propellers, type		1 x CPP		1 x CPP	
Bow thrusters	t	7		7	
Stern thrusters	t	none		none	
Rudder type		Spade		Spade	
Max rudder angle	°	70		70	
Manoeuvring engine order		**RPM**	**Speed (knots)**	**RPM**	**Speed (knots)**
Full Ahead		100	13.0	100	13.1
STOP		0	0	0	0
Full Astern		85	- 7.8	85	- 7.8
Windage					
Windage lateral	m^2	1006		1133	
Windage frontal	m^2	315.4		320.3	
Wind speed (knots)		**Beam wind force (t)**		**Beam wind force (t)**	
15		4		4	
20		7		7	
25		10		11	
30		15		17	

Table 2.5: Stena Transporter vessel characteristics

Characteristic	Unit	Stena Transporter	
Ship type		Ferry	
Length overall	m	212	
Length between perpendiculars	m	194.8	
Beam overall	m	26.7	
Distance bridge to stern	m	196	
Modelled conditions			
Draught forward	m	6.3	
Draught aft	m	6.3	
Block coefficient		0.643	
Displacement	t	21600	
Propulsion			
Main engine type		2 x STX MAN 9L48/60B	
Engine power (total)	kW	21600	
No. of propellers, type		2 x CPP	
Bow thrusters	t	55	
Stern thrusters	t	none	
Rudder type		Becker flap	
Max rudder angle	°	35	
Manoeuvring engine order		**RPM**	**Speed (knots)**
Full Ahead		100	21.1
STOP		0	0
Full Astern		100	- 13.7
Windage			
Windage lateral	m²	4050	
Windage frontal	m²	770	
Wind speed (knots)		**Beam wind force (t)**	
15		15	
20		26	
25		41	
30		59	
35		80	

Table 2.6: CLdN G9 ship manoeuvring characteristics

Characteristic	**Unit**	**CLdN G9 8 mT**	
Ship type		Ro-Ro	
Length overall	m	234.06	
Length between perpendiculars	m	226	
Beam overall	m	35	
Distance bridge to stern	m	216	
Modelled conditions			
Draught forward	m	8	
Draught aft	m	8	
Block coefficient		0.780	
Displacement	t	50600	
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	m²	6682	
Windage frontal	m²	1197	
Wind speed (knots)		**Beam wind force (t)**	
15		24	
20		43	
25		68	
30		97	

2.5.2 Limitations regarding contact with structures

The simulation of the effect of contact between a ship and a solid object is a complex and specific science. The outcome will rely on many factors including:

- Velocity including the relative motion and rotation of the moving objects;
- Nature of materials at the point of contact;
- The composite nature of the structure;
- Precise angle and point of impact;
- Energy absorption during the contact due to the deformation of the ship's hull or structure.

Ship and tug simulation at HR Wallingford is not configured to resolve the outcome after a contact between a ship and a solid object, except in the simplest of cases, for example when a ship is sliding on a fender in other very precise circumstances.

Consequently any simulated subsequent movement of a vessel after contact with IERRT infrastructure is not considered reliable. Also the simulator is unable to resolve the nature and level of any damage to a vessel of infrastructure during a simulation.

However, the speed at the point of contact can be provided to engineers for them to assess the survivability of a contact scenario, if required.

Because of these factors, during the enhanced operational controls study, when the vessel made contact with IERRT, the run was stopped, as any further outcome could not be determined reliably.

At the request of the interested parties, after the main study, additional simulation runs were undertaken to consider whether or not the tug(s) would be sufficient to arrest the vessel prior to it hazarding IOT, not considering any restriction to its movement due to contact with the IERRT infrastructure.

These runs were undertaken using the situation just before contact as a start point and continuing the run with a layout with the IERRT infrastructure removed.

In all cases the tug(s) were sufficient to arrest the vessel without it hazarding the IOT infrastructure.

2.6 Tugs

2.6.1 Tug models

HR Wallingford provided 50 t and 70 tBP ASD tug manoeuvring models, along with a 16 m workboat used in previous studies to represent the 'Spurn Sands,' which supports operations at IOT.

The tugs were used either as centrally controlled or independently controlled as 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 2.7, and tug performance curves as shown in Figure 2.10 and Figure 2.11.

Table 2.7: 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

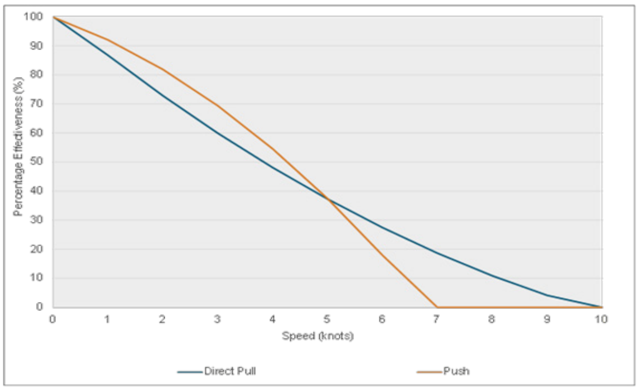


Figure 2.10: Effectiveness of centrally controlled tugs with water speed

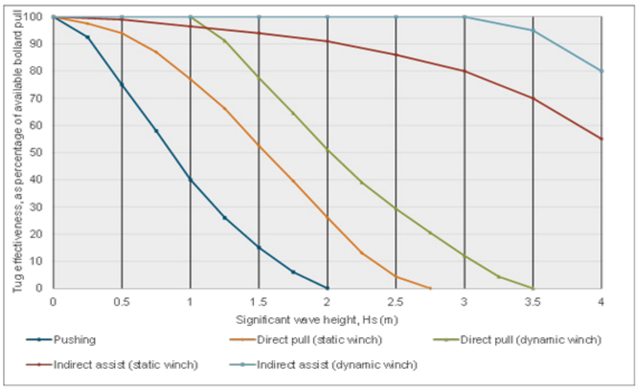


Figure 2.11: Effectiveness of centrally controlled tugs with wave height

2.6.2 Assumptions on use of tug power in an emergency

It is know to be inadvisable to use full power on a tug for extended periods of time. In some cases, it is common practice for some tug masters to ‘keep a little power in reserve’ when full power is ordered by a pilot.

The practical aspect of this was discussed with the tug master present during the study, when considering enhanced control measures. The tug master stated that in an emergency he would provide full power if requested, and manage his engine resources by feathering the power, if required, in consultation with the pilot. It was agreed that he should operate the simulated tug as he would normally in an emergency scenario.

Where centrally controlled tugs were used and full power was requested, full power was delivered by the operator. It was considered that:

- It is reasonable to expect full power to be provided by a tug in an emergency;
- The modelled degradation of effectiveness of centrally controlled tugs was sufficient to ensure the simulation was appropriate and conservative.

3 Navigation simulation

3.1 Simulation session

The real time navigation simulation session was conducted at HR Wallingford's UK Ship Simulation Centre in Wallingford, UK on 13 and 14 December 2023 using a full mission ship bridge simulator and a linked full mission tug bridge simulator.

These demonstration runs were facilitated by HR Wallingford staff with significant input from all stakeholders. Suitably qualified pilots and masters controlled the ship manoeuvring models.

The attendees, who formed the Simulation Team for this work, are detailed in Table 3.1.

Table 3.1: Attendance list and Simulation Team

Name	Role	Organisation
Mike Parr	Project Lead	HR Wallingford
Liam Monahan-Smith	Simulator Operator	HR Wallingford
Andrew “Fred” Firman	Harbour Master Humber	ABP SCNA
Joseph Smith	Pilotage Operations Manager	ABP
Mark Collier	Dock Master	ABP
Jason Melles-Sawyers	VLS Pilot	ABP
Josh Bush (Day 2)	Project Development Manager	ABP
Sophie Young (Day 1)	Consents Lead	ABP
Daniel Landi	Project Development Manager	ABP
Brian Greenwood	Lawyer, Clyde and Co	ABP
Scott Arrowsmith	Tug Master	SMS
Olly Smith	Marine Superintendent	APT
Nigel Bassett	Master Mariner - Nash Maritime	APT
Brocque Preece	Consultant Nash Maritime	DFDS
Ally Temple	Lawyer, BDB Pitman's	DFDS
Marcel van der Vlugt	Project Manager Stena Line	Stena
Laas van der Zee	Master Stena Line	Stena
Geert-Jan Feringa	Master Stena Line	Stena

Before the start of the session the aims, assumptions and simulation configuration were discussed and agreed. Follow this discussion, the interested parties requested:

- A ship manoeuvring model of a CLdN G9m class Ro-Ro ship with a draught of 8 m should be used, as it was considered the most conservative. So this was provided.
- Additional details regarding the flow modelling. These were addressed formally in a reissue of the original HR Wallingford report (Reference 11). For convenience, an extract of Reference 11 is included in Appendix A of this report.

On completion of each run the outcome was discussed and the grading agreed.

DFDS representatives were required to make no formal comment or observation during the process. However, throughout the session they were engaged and participated asking the HR Wallingford team questions regarding the details of the simulation. These were addressed at the time or in subsequent email exchanges.

At the request of the interested parties, after the main study simulation runs, HR Wallingford completed additional simulation runs to consider those were the vessel had made contact with IERRT. The aim of the continuation runs was to assess if tug(s) would be sufficient to arrest the vessel prior to it hazarding IOT, not considering any restriction to its movement due to contact with IERRT.

These runs were undertaken using the situation just before collision as a start point and continuing the run with a layout with the IERRT infrastructure removed.

In all cases the tug(s) were sufficient to arrest the vessel without it hazarding the IOT infrastructure.

3.2 Grading of results

3.2.1 Considering enhanced control measures

The work in this study considering enhanced operational controls, in the event of an extremely unlikely emergency and is not intended to show the level of control and consequent expected outcome in the course of normal operations.

The grading of the results was discussed during the initial briefing:

- Success – Vessel is arrested without contacting with IOT infrastructure;
- Fail – Vessel is not arrested or contacts with IOT infrastructure such that significant damage or hazard would be caused.

It was not possible to agree a marginal description. So within this report, success or failure was based on the protection of IOT infrastructure. A marginal outcome was specified to account for the situation where the vessel contacts with IERRT, but IOT infrastructure was not hazarded.

When considering the outcome of these runs the reader should be fully aware that the situation in which a modern Ro-Ro type vessel loses all control for any extended period of time (more than 1 to 2 minutes) is highly unusual, and the subsequent manoeuvring in extreme environmental conditions will be challenging. This study was used to demonstrate, where applicable, that tugs can be an effective mitigation against such failures, should it be deemed plausible.

The emergency scenario tested was considered to be a severe and extreme case, in conditions that were also challenging. The outcomes must be viewed in this context.

3.2.2 Considering operations at IOT 8

For the work considering operations at IOT 8 the criteria described below were applied

Each simulation run was graded by the simulation participants as Successful, Marginal or Fail, according to the following evaluation criteria:

Successful Standard manoeuvres:

- The ship remains under full control at all times without resorting to aggressive manoeuvring techniques;
- The ship stays within safe water areas with acceptable clearances to all port and other structures, and other berthed ships;
- Tugs are operating safely and within sustainable limits;
- For berthing manoeuvres, the ship ends the run alongside, or in such a position that lines would be ashore without appreciable difficulty, at zero speed, with an acceptable sway velocity and no appreciable yaw rate;
- For departure manoeuvres the ship exits smoothly, without risk of drifting onto port structures or other ships.

Emergency/failure situations:

- The ship is brought back under full control without encountering significant hazards, with the risk of only minor damage;
- The ship may leave the designated manoeuvring area boundaries, but still has acceptable under keel clearance and maintains acceptable clearances to other ships/structures throughout the recovery;

	● Tugs are neither endangered nor asked to operate in an unsafe manner; ● The ship can be moved into safe, deep water or to a position suitable to anchor safely, where the equipment failure can be investigated/resolved.
Marginal	Standard manoeuvres: ● The Pilot considers the ship is at the limit of control during standard manoeuvres; ● The ship stays within the safe water area boundaries, but with unacceptable clearances; ● The ship clears all port structures, and other berthed ships, but with unacceptable clearances; ● Tugs are operating safely, but approaching their sustainable operating limits (e.g. being used at 100% power for more than 15 minutes); ● For approach manoeuvres, the ship ends up alongside, but may have a high approach velocity. The manoeuvre can be concluded, but minor damage may occur; ● On departure, the ship is manoeuvred off the berth but with some difficulty. The manoeuvre is completed with the potential for minor damage only. Emergency/failure situations: ● The ship is at the limits of control during the recovery from the failure; ● The ship has marginal under keel clearance or marginal clearances to other ships/structures during the recovery; ● Tugs operate at the limits of safety; ● The ship is at the limits of controllability as it is moved into safe, deep water or to a position suitable to anchor safely, where the equipment failure can be investigated/resolved.
Fail	Standard manoeuvres: ● The Pilot loses control of the ship; ● The ship strays outside the safe water area boundaries and/or grounds; ● The ship either contacts, or has a near-miss with port structures and/or other berth ships; ● Tugs are required to operate in an unsafe manner, or exceed sustainable operating limits (e.g. being used at 100% power for more than 30 minutes); ● For approach manoeuvres, the ship cannot get alongside at all, or contacts the berth with sufficient force that severe damage may have occurred; ● On departure, the ship either cannot be manoeuvred off the berth, or encounters significant difficulty in manoeuvring, such that severe damage may have occurred. Emergency/failure situations: ● The Pilot cannot regain control of the ship before the ship is endangered; ● The ship cannot be prevented from entering dangerously shallow water and/or grounds; ● The ship either contacts or has a near-miss with a known hazard, port structures, and/or other berth ships; ● Tugs are endangered or are asked to operate in an unsafe manner; ● The ship cannot be moved into safe, deep water or to a position suitable to anchor safely.
Aborted	The run was aborted for efficiency reasons, to save wasting any time, due to either: ● The initial manoeuvring strategy or approach/departure manoeuvre was deemed to be inappropriate right at the start, so the run would be bound to fail if continued; or ● Because of the need to test aspects of the ship manoeuvring model.

3.3 Simulation results

A summary of the simulation runs that were undertaken is presented in Table 3.2.

The run plan was determined prior to the study, and shared with interested parties to support their preparations.

Representatives of APT were invited to a meeting on 1 December 2023 to discuss the proposal and context of the scenarios, although they did not attend. The run plan was further briefed on 12 December ahead of the simulation session at the request of interested parties.

Due to time constraints and the requirement to include additional runs, not all of the originally proposed runs were undertaken.

The original run numbering system was maintained to assist the interested parties in identifying pertinent data against their notes.

As previously noted, the outcome of any ship contact with the IERRT infrastructure cannot be confidently precited, nevertheless, the speed and nature of any contact between the vessel and IERRT infrastructure during the enhanced controls element of this study is recorded in Table 3.3.

At the request of the interested parties, after the main part of the study, HR Wallingford completed additional simulation runs to consider those were the vessel had contacted with IERRT. Specifically, these runs examined whether or not supporting tug(s) would have been sufficient to arrest the vessel prior to it hazarding IOT, although this did not consider any restriction to its movement due to any contact.

These runs were undertaken using the situation just before the contact as a starting point and continuing the run in a layout with the IERRT infrastructure removed.

In all cases the tug(s) were sufficient to arrest the vessel without it hazarding the IOT infrastructure. The results from these runs are detailed in Table 3.4.

Table 3.2: Simulation run summary – Main study

Run ID	Pilot/ PEC	Manoeuvre	Vessel	Tugs	Tide	Wind (dirn, speed)	Start speed	Assessment	Aim	Outcome
1	JMS/ GJF	Layout A New Position Start position A	Stena T Class	Tug 1: 50 tBP ASD CLF	Peak spring ebb	NE(045°) 27.5 knots ± 5.0 knots	2.5 knots towards IERRT	Successful	Demonstrate that 1 x 50 t tug is sufficient to arrest the vessel in peak ebb conditions and extreme NE wind conditions	The vessel was arrested and began moving ahead after 4:45 mins at 90 m from the IERRT infrastructure and 385 m from nearest IOT infrastructure.
2	JMS/ LVDZ	Layout A Start position A	Stena T Class	Tug 1: 50 tBP ASD CLF	Peak spring ebb	SW(225°) 27.5 knots ± 5.0 knots	2.5 knots	Successful	Demonstrate that 1 x 50 t tug is sufficient to arrest the vessel in peak ebb conditions and extreme SW wind conditions	The vessel was arrested after 12 mins and was then moving away from the nearest point of danger the IOT berthing piles associated with IOT Berth 1. The vessel was arrested 232 m from the IERRT infrastructure and 100 m from nearest IOT infrastructure. Comment: the vessel picked up leeway towards IOT Berth 1 more quickly in the simulator than would normally be expected.
3	JMS/ GJF	Layout A Start position A	Stena T Class	Tug 1: 50 tBP ASD CLF	Peak spring ebb	NW(315°) 27.5 knots ± 5.0 knots	2.5 knots	Marginal – due to contact with IERRT infrastructure. Success – in avoiding contact with IOT infrastructure	Demonstrate that 1 x 50 t tug is sufficient to arrest the vessel in peak ebb conditions and extreme NW wind conditions	The vessel was controlled for the first 3 mins of the run. The vessel was moving at 0.83 knots when it contacted IERRT. The vessel was brought under control 190 m from IOT infrastructure. The run was continued in Run 03 cont. without IERRT infrastructure.
4	JMS/ LVDZ	Layout A Start position B	Stena T Class	Tug 1: 50 tBP ASD CLF	Peak spring ebb	NE(045°) 27.5 knots ± 5.0 knots	1.9 knots	Marginal – due to contact with IERRT infrastructure. Success – in avoiding contact with IOT infrastructure	Demonstrate that 1 x 50 t tug is sufficient to arrest the vessel in peak ebb conditions and extreme NE wind conditions	The vessel was arrested within 5 mins of the failure and was moving away from IOT at the time of contact. The vessel was moving at 0.56 knots on contact with IERRT and was brought under control 270m from IOT infrastructure. Comment: in these conditions an additional tug would be expected. The run was continued in Run 04 cont. without IERRT infrastructure.
5	JMS/ GJF	Layout A Start position B	Stena T Class	Tug 1: 50 tBP ASD CLF	Peak spring ebb	SW(225°) 27.5 knots ± 5.0 knots	1.9 knots	Successful	Demonstrate that 1 x 50 t tug is sufficient to arrest the vessel in peak ebb conditions and extreme SW wind conditions	Vessel was arrested within 12 mins and was being manoeuvred away from IOT and IERRT infrastructure at the end of the run. The vessel was arrested 110 m from the IERRT infrastructure and 120 m from nearest IOT infrastructure.
6a	JMS/ LVDZ	Layout A Start position B	Stena T Class	Tug 1: 50 tBP ASD CLF	Peak spring ebb	NW(315°) 27.5 knots ± 5.0 knots	1.9 knots	Fail	Demonstrate that 1 x 50 t tug is sufficient to arrest the vessel in peak ebb conditions and extreme NW wind conditions	The vessel contacted the IERRT after 3 mins at 0.6 knots. The run was initially paused and then allowed to continue, although the realism of the simulation after initial contact may be reliable. The vessel was still setting astern towards IOT after 7 mins. The pilots noted that the initial acceleration of the vessel due to leeway appeared unrealistic. In these conditions 2 tugs would be required, It was also noted by the HM that he would prescribe a slower speed to approach, which was applied in Run 6b. The run was continued in Run 06a cont. without IERRT infrastructure.
6b	JMS/ LVDZ	Layout A Start position B	Stena T Class	Tug 1: 50 tBP ASD CLF	Peak spring ebb	NW(315°) 27.5 knots ± 5.0 knots	1.0 knot	Run aborted – as the initial acceleration due to leeway was considered unreasonable	Rerun of Run 6 a with reduced approach speed 1.9 knots to 1.0 knots	The pilots noted that the initial acceleration of the vessel due to leeway appeared unrealistic. Decision taken to run the approach as part of a dynamic manoeuvre. The run was continued in Run 06b cont. without IERRT infrastructure.

Run ID	Pilot/ PEC	Manoeuvre	Vessel	Tugs	Tide	Wind (dirn, speed)	Start speed	Assessment	Aim	Outcome
6c	JMS/ GJF	Layout A Start position (West of site A)	Stena T Class	Tug 1: 50 tBP ASD CLF	Peak spring ebb	NW(315°) 27.5 knots ± 5.0 knots	1.0 knot	Marginal – due to contact with IERRT infrastructure. Success – in avoiding contact with IOT infrastructure	Dynamic approach with pilot controlling the vessel through point B. Controls failure initiated at minute 9	The vessel contacted the IERRT after 12 mins at 0.93 knots. The vessel was arrested 170 m from nearest IOT infrastructure. The run was continued in Run 06c cont. without IERRT infrastructure.
6d	JMS/ GJF	Layout A Start position between a and b	Stena T Class	Tug 1: 50 tBP ASD CLF	Peak spring ebb	NW(315°) 25.0 knots	0.8 knots	Marginal – due to contact with IERRT infrastructure. Success – in avoiding contact with IOT infrastructure	Repeat of Run 6c considering the a slightly reduced wind Controls failure initiated at minute 3	The vessel contacted the IERRT after 8 mins at 0.65 knots. The vessel was arrested 150 m from nearest IOT infrastructure. The run was continued in Run 06d cont. without IERRT infrastructure.
7a	JMS/ GJF	Layout A New Position Start position A (1/2 ships length NW)	G9 Displacement: 50,600 t T: 8 m	Tug 1: 50 tBP ASD CLF Tug 2: 50 tBP ASD SQ	Peak spring ebb	NE(045°) 27.5 knots ± 5.0 knots	2.5 knots	Marginal – due to contact with IERRT infrastructure. Success – in avoiding contact with IOT infrastructure	Demonstrate that 2 x 50 t tug is sufficient to arrest the vessel in peak ebb conditions and extreme NE wind conditions	The vessel contacted the IERRT after 5 mins at 0.8 knots. The vessel was arrested 310 m from nearest IOT infrastructure. The run was continued in (Run 07a cont. without IERRT infrastructure).
7b	JMS/ GJF	Layout A New Position Start position A (1/2 ships length NW)	G9 Displacement: 50,600 t T: 8 m	Tug 1: 70 tBP ASD CLF Tug 2: 50 tBP ASD SQ	Peak spring ebb	NE(045°) 27.5 knots ± 5.0 knots	2.5 knots	Successful	Consider the effect of increasing towage from 50tBP to 70tBP	Vessel was arrested within 12 mins and was being manoeuvred away from IOT and IERRT infrastructure at the end of the run. The vessel was arrested 50 m from the IERRT infrastructure and 360 m from nearest IOT infrastructure.
8a	JMS/ LVDZ	Layout A Start position A (one ship beam south)	G9 Displacement: 50,600 t T: 8 m	Tug 1: 50 tBP ASD CLF Tug 2: 50 tBP ASD SQ	Peak spring ebb	SW(225°) 27.5 knots ± 5.0 knots	2.5 knots	Aborted	Demonstrate that 2 x 50 t tug is sufficient to arrest the vessel in peak ebb conditions and extreme NE wind conditions	Pilot attempted to use flow to assist minimising tug input. Quickly realised this would be an ineffective tactic. Run highlights the need for training and detailed evaluation prior to operating a larger Ro-Ro at the port.
8b	JMS/ LVDZ	Layout A New Position Start position A (1/2 ships length NW)	G9 Displacement: 50,600 t T: 8 m	Tug 1: 50 tBP ASD CLF Tug 2: 50 tBP ASD SQ	Peak spring ebb	SW(225°) 27.5 knots ± 5.0 knots	2.5 knots	Fail	Demonstrate that 2 x 50 t tug is sufficient to arrest the vessel in peak ebb conditions and extreme NE wind conditions	In peak flow and extreme wind 2 x 50 tBP tugs are insufficient to arrest a 50,600 t displacement large Ro-Ro. When the run was stopped the vessel was still being set towards IOT Berth 1.
8c	JMS/ LVDZ	Layout A New Position Start position A (1/2 ships length NW)	G9 Displacement: 50,600 t T: 8 m	Tug 1: 70 tBP ASD CLF Tug 2: 50 tBP ASD SQ	Peak spring ebb	SW(225°) 27.5 knots ± 5.0 knots	2.5 knots	Fail	Consider the effect of increasing towage from 50 tBP to 70 tBP	In peak flow and extreme wind 1 x 70 t and 1 x 50 tBP tugs are insufficient to arrest a 50,600 t displacement large Ro-Ro vessel. When the run was stopped the vessel was still being set towards IOT Berth 1.
8d	JMS/ GJF	Layout A New Position Start position A (1/2 ships length NW)	G9 Displacement: 50,600 t T: 8 m	Tug 1: 70 tBP ASD CLF Tug 2: 70 tBP ASD SQ	Peak spring ebb	SW(225°) 27.5 knots ± 5.0 knots	2.5 knots	Successful	Consider the effect of increasing towage to 2 x 70 tBP tugs	Vessel was arrested within 12 mins and was being manoeuvred away from IOT and IERRT infrastructure at the end of the run. The vessel was arrested 180 m from the IERRT infrastructure and 360 m from nearest IOT infrastructure.
9a	JMS/ GJF	Layout A Start position B	G9 Displacement: 50,600 t T: 8 m	Tug 1: 70 tBP ASD CLF Tug 2: 70 tBP ASD SQ	Peak spring ebb	NE(045°) 27.5 knots ± 5.0 knots	1.9 knots	Marginal – due to contact with IERRT infrastructure. Success – in avoiding contact with IOT infrastructure	Demonstrate that 2 x 70 t tug is sufficient to arrest the vessel in peak ebb conditions and extreme NE wind conditions	The vessel contacted the IERRT after 4 mins at 0.71 knots. The vessel was arrested 170 m from nearest IOT infrastructure. The run was continued in (Run 09a cont. without IERRT infrastructure).

Run ID	Pilot/ PEC	Manoeuvre	Vessel	Tugs	Tide	Wind (dirn, speed)	Start speed	Assessment	Aim	Outcome
9b	JMS/ GJF	Layout A Start position A	G9 Displacement: 50,600 t T: 8 m	Tug 1: 70 tBP ASD CLF Tug 2: 70 tBP ASD SQ	Peak spring ebb	NW(315°) 27.5 knots ± 5.0 knots	2.5 knots	Fail – due to the vessel coming beam onto the current and being set out of control towards IERRT	Demonstrate that 2 x 70 t tug is sufficient to arrest the vessel in peak ebb conditions and extreme NW wind conditions	The run was stopped after 5 mins with the vessel not in control setting towards the IERRT at 2 knots. The run was continued in Run 09b cont. without IERRT infrastructure.
10	-	Layout A Start position A	G9 Displacement: 50,600 t T: 8 m	Tug 1: 70 tBP ASD CLF Tug 2: 70 tBP ASD SQ	Peak spring ebb	SW(225°) 27.5 knots ± 5.0 knots	1.9 knots	De-prioritised by Simulation Team	-	-
11	-	Layout A Start position B	G9 Displacement: 50,600 t T: 8 m	Tug 1: 70 tBP ASD CLF Tug 2: 50 tBP ASD SQ	Peak spring ebb	NE(045°) 27.5 knots ± 5.0 knots	2.5 knots	De-prioritised by Simulation Team	-	-
12	JMS/ LVDZ	Layout B Arrival Vessel on IERRT Berth 1 Vessel on IOT 9	Whisby Teak Laden	1 x 10 tBP workboat	Peak spring (LW +1hr)	SW(225°) 20.0 knots	N/A	Successful	Initial familiarisation run considering Vessel Impact Protection (VIP) and revised flows	The approach was assessed as straightforward and no issues noted.
13	-	Layout B Arrival	Whisby Teak	1 x 10 tBP workboat 1 x 50 tBP ASD	Peak spring (LW +1hr)	SW(225°) 22.5 knots ± 5.0 knots	N/A	De-prioritised by Simulation Team	-	-
14	-	Layout B Arrival	Whisby Teak	1 x 10 tBP workboat 1 x 50 tBP ASD	Peak spring (LW +1hr)	SW(225°) 27.5 knots ± 5.0 knots	N/A	De-prioritised by Simulation Team	-	-
15	JMS/ GJF	Layout B Arrival	Whisby Teak Laden	1 x 10 tBP workboat	Peak spring (LW +1hr)	SW(225°) 27.5 knots ± 5.0 knots Sheltering	N/A	Successful	To consider the approach to IOT 8 in full flood and extreme SW wind conditions	Pilot allowed approaching vessel to come within 10 m of the Ro-Ro ship berthed on IERRT 1. This was due to not fully anticipating the effect of the wind sheltering. It was agreed that a more northerly line would have been more appropriate and achievable. Once clear of the stern of the berthed Ro-Ro ship the pilot was able to demonstrate full control of the vessel during the approach to IOT. Discussion within the Simulation Team acknowledged the pilot's comments and noted that the conditions were setting away from the berthed Ro-Ro ship. It was agreed not to re-run, but consider the conditions for Run 22.
16a	JMS/ GJF	Layout B Arrival	Whisby Teak Laden	1 x 10 tBP workboat	Peak spring	NE(045°) 27.5 knots ± 5.0 knots Sheltering	N/A	Marginal – dur to distance vessel passes to berthed Ro-Ro (less than 1 beam)	To consider the approach to IOT 8 in full flood and strong NE wind conditions	Poor initial start position as pilot and Simulation Team had not communicated intention to change wind direction. In normal operation the pilot would have been monitoring the wind and set up as for Run 16b.
16b	JMS/ GJF	Layout B Arrival	Whisby Teak Laden	1 x 10 tBP workboat 1 x 50 tBP ASD	Peak spring	NE(045°) 35.0 knots ± 5.0 knots Sheltering	N/A	Successful	Repeat of run 16a with wind increased	The pilot reported no issues and a straightforward approach. Despite the stronger wind the pilot was able to control the vessel on a better line and avoid passing too close to the berthed Ro-Ro ship.
16c	JMS/ LVDZ	Layout B Arrival	Whisby Teak Laden	1 x 10 tBP workboat 1 x 50 tBP ASD	Mean spring	NE(045°) 35.0 knots ± 5.0 knots Sheltering	N/A	Successful	Repeat of run 16b with mean spring flow	Straightforward run.

Run ID	Pilot/ PEC	Manoeuvre	Vessel	Tugs	Tide	Wind (dirn, speed)	Start speed	Assessment	Aim	Outcome
17	JMS/ LVDZ	Layout B Departure	Whisby Teak Ballast	1 x 10 tBP workboat 1 x 50 tBP ASD	Peak spring Flood	SW(225°) 27.5 knots ± 2.5 knots Sheltering	N/A	Successful	Consider the departure from IOT 8	The vessel is able to safely depart swinging clear of the new VIP and moored Ro-Ro ship. Discussions with pilot regarding the decision to swing so early revealed an alternative strategy to open more to the NE before commencing the swing would be equally feasible and would have resulted in greater space between the berthed Ro-Ro ship and the bow of the departing product tanker.
18	-	Layout B Departure	Whisby Teak	1 x 10 tBP workboat	Mean spring (LW +1hr)	SW(225°) 27.5 knots ± 2.5 knots Sheltering	N/A	De-prioritised by Simulation Team	-	-
19	-	Layout B Departure	Whisby Teak	1 x 10 tBP workboat	Mean spring (LW +1hr)	SW(225°) 27.5 knots ± 2.5 knots	N/A	De-prioritised by Simulation Team	-	-
20	-	Layout B Departure	Whisby Teak	1 x 10 tBP workboat	Mean spring (LW +1hr)	SW(225°) 27.5 knots ± 2.5 knots	N/A	De-prioritised by Simulation Team	-	-
21	-	Layout B Departure	Whisby Teak	1 x 10 tBP workboat	Mean spring (LW +1hr)	SW(225°) 27.5 knots ± 2.5 knots Sheltering	N/A	De-prioritised by Simulation Team	-	-
22	JMS	Layout B Arrival	Whisby Teak Laden	1 x 10 tBP workboat	Mean spring (LW +1hr)	SW(225°) 27.5 knots ± 5.0 knots Sheltering	N/A	Marginal (0.6 knot landing speed)	To consider the approach to IOT 8 in mean spring flood and extreme SW wind conditions To reexamine the line of approach taken in Run 15	The pilot was able to demonstrate a better approach line taking into account the effect of sheltering. Considering the combined effect of the wind and flow setting onto the berth, the pilot was able to manage the approach speed in these wind conditions (outside of normal IOT operating limits of 26 knots) such that the lateral speed on landing was 0.6 knots. Whilst undesirable, this would be expected given the strength of the wind, as reflected in IOT operating guidance.
23	JMS	Layout B Arrival	Whisby Teak Laden	1 x 10 tBP workboat 1 x 50 tBP ASD	Peak spring flood	SW(225°) 27.5 knots ± 5.0 knots Sheltering		Successful	To consider the approach to IOT 8 in full flood and extreme SW wind conditions	Straightforward approach with no issues.
24	JMS	Layout B Departure	Whisby Teak Ballast	1 x 10 tBP workboat 1 x 50 tBP ASD	Peak spring flood	NE(045°) 27.5 knots ± 5.0 knots Sheltering		Successful	To consider the approach to IOT 8 in full flood and extreme NE wind conditions	Straightforward approach with no issues.

Note: Tug positions: CLF = Centre lead forward and SQ = Starboard quarter

Table 3.3: Table detailing nature of contact with IERRT during enhanced controls study

Run	Vessel	Wind (From)	Starting site	Speed over ground (knots)	Course over ground (°N)	Drift angle (°N)	Rate of turn (°/min)	Time to contact (s)	Distance to IOT (m)
03	Stena Transporter	NW (315°) 27.5 knots ± 5 knots	A	**-1.0**	157°N	-129°	2.7°	381	187 m
04	Stena Transporter	NE (045°) 27.5 knots ± 5 knots	A	**-0.7**	262.5°N	-040°	1.8 °	221	260 m
06a	Stena Transporter	NW (315°) 27.5 knots ± 5 knots	B	**-1.4**	139.4°N	-140.8°	-6.7°	157	54 m
06b	Stena Transporter	NW (315°) 27.5 knots ± 5 knots	B	**-1.0**	145.4°N	-135.2°	-9.0°	133	168 m
06c	Stena Transporter	NW (315°) 27.5 knots ± 5 knots	A	**-1.2**	154.3°N	-126.7°	-1.4°	731	170 m
06d	Stena Transporter	NW (315°) 25 knots ± 5 knots	B	**-0.8**	156.5°N	-129.4°	0.1°	444	160 m
07a	G9	NE (045°) 27.5 knots ± 5 knots	B	**-0.9**	174.0°N	-124.3°	1.5°	262	300 m
09a	G9	NW (315°) 27.5 knots ± 5 knots	B	**-0.9**	243.2°N	-050.1°	0.2°	205	180 m
09b	G9	NW (315°) 27.5 knots ± 5 knots	B	**-2.0**	167.6°N	-095.5°	0.8°	248	130 m

Table 3.4: Simulation run summary - Continuation runs with IERRT infrastructure removed

Run	Vessel	Wind (from)	Site	Starting speed (knots)	Outcome	Distance when vessel was arrested and moving away from IOT (m)
03 Continued	Stena Transporter	NW (315°) 27.5 knots ± 5 knots	A	2.5	Successful	200 m
04 Continued	Stena Transporter	NE (045°) 27.5 knots ± 5 knots	A	2.5	Successful	275 m
06a Continued	Stena Transporter	NW (045°) 27.5 knots ± 5 knots	B	1.9	Successful	80 m
06b Continued	Stena Transporter	NW (045°) 27.5 knots ± 5 knots	B	1	Successful	185 m
06c Continued	Stena Transporter	NW (315°) 27.5 knots ± 5 knots	A	1	Successful	185 m
06d Continued	Stena Transporter	NE (315°) 25 knots ± 2 knots	B	1	Successful	150 m
07a Continued	G9	NE (045°) 27.5 knots ± 5 knots	B	1	Successful	310 m
09a Continued	G9	NE (045°) 27.5 knots ± 5 knots	B	1	Successful	175 m
09b Continued	G9	NW (315°) 27.5 knots ± 5 knots	B	1	Successful	138 m

3.4 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 and C.

The vessel data and track plots show:

- The position of the ship and the tugs at one minute intervals is 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;
- A scale bar;

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;
- 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 (%);
- Number of ship's engine restarts.

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.

4 Conclusions

The following sections provide the conclusions and notes that were made as a result of the study.

The following conclusions and notes were made as a result of the study:

4.1 Enhanced operational controls

4.1.1 Context

The work in this study considered enhanced operational controls, which will be applied only as required in the event of an extremely unlikely emergency scenario. So it was not intended to show the level of control and consequent expected outcome in the course of normal operations.

The study considered the effectiveness of the minimum tug provision in the event of a vessel operating at IERRT Berth 1 during an ebb tide, suffering a complete control failure close to the berth. For modern Ro-Ro type vessels this is an extremely unusual event, as normally there is significant redundancy in the control systems, and the engines are designed to operate independently and reversionary modes of operation are normally readily available.

In considering the outcomes described in this study, it is important to appreciate the other controls that will also need to have failed. Specifically, a ship with previously fully operational engine and controls, tested and in pilotage mode, loses all control and no reversionary modes are unavailable.

The study was designed to test the ability of the tug(s) to keep the ship clear of IOT infrastructure in the most challenging conditions in which the vessel might be required to be operating at the berth. Other controls or protections such as: minimising approach speed, use of anchors and limiting environmental conditions were not included within the scope of this study.

The manoeuvres were not intended to be indications of best practice. It should be noted that for the larger vessels, in the conditions simulated, the Ship Master/PEC may have required additional tugs to those requested or decided to delay their approach.

4.1.2 Design vessels

The design vessels considered included:

- Stena Transit (T) class – This ship represents the vessel which will be operating at IERRT on initial commissioning;
- CLdN G9 class Ro-Ro vessel – A specific version of an existing vessel. The vessel was only used as a 'dead' ship or moored throughout the study, so the ships propulsion or other manoeuvring characteristics were not important. The original model, normally considered for operations on the Humber, has a draught of 7.5 m draught, with a displacement of 47,000 t. At the request of interested parties this was modified to reflect the maximum draught specified in the design envelope of 8 m, so increasing the displacement to 50,600 t.

It should be noted that, at the time of writing, there is no intention of operating a vessel as large as the CLdN G9 vessel at IERRT. Should there be a need for such a large displacement vessel to operate at IERRT, and it is considered necessary to mitigate a full controls failure, additional work will need to be undertaken to agree the requirements and limits for safe operations, to ensure appropriate towage is always in place.

It should also be noted that, due to the limited time available, additional runs with more than one tug supporting with the Stena T class ship were not completed. However, the study is considered to be sufficient to conclude that a single 50tBP ASD tug is sufficient to provide enhanced operational controls to protect the IOT during operations by a such a vessel at IERRT Berth 1 in the event of a complete control failure in extreme conditions, notwithstanding other tugs will most likely be available.

4.1.3 Conclusions

The following key conclusions were discussed and agreed:

- A 50tBP ASD tug is sufficient to arrest or control a Stena T class vessel avoiding hazarding the IOT structure.
- In the situation with a mean 27.5 knot (speed at 10 m above mean sea level) north-west wind aligned with peak spring flows, the outcome of the simulations was a contact with the IERRT infrastructure, at velocities of up to 1 knot. It should be noted that the Jacobs basis of design report indicates that IERRT infrastructure is designed to withstand contact of T class vessels at speeds of up to 2.5 knots and 48,000 t displacement vessels at speeds up to 1.8 knots.
- The simulation system is not designed to provide an assessment of contact between a ship and a fixed object at speeds in excess of about 0.6 knots in detail, except in particular circumstances. Therefore it was not possible to determine the outcome after a vessel makes contact with port infrastructure at speeds of up to 1.5 knots. However, experience suggests that at such a speed, a significant part of the energy would be absorbed through deformation of the vessel's hull and the infrastructure, and so the vessel is likely to be brought to stop or could be brought under control quickly afterwards.
- Subsequent runs, conducted after the main study, showed that if the effect of contact with the IERRT infrastructure is ignored, the proposed tug is sufficient to arrest the Stena T class vessel before it could make contact with the IOT infrastructure.
- If it is intended to operate a larger vessel than the Stena T class, then similar studies will be necessary to establish the safe minimum towage requirements to protect IOT infrastructure from any risk of a vessel operating at IERRT 1, which suffers a complete control failure.
- Considering the 50,600 t displacement CLdN G9 class vessel (which meets the maximum design envelope criteria) in a peak spring tide and with a mean wind speed of 27.5 knots:
  - 2 x 70 tBP ASD tugs are sufficient to arrest or control the vessel, avoiding hazarding the IOT structure, except where exceptional north-west winds and strong tides are combined;
  - Additional controls will need to be in place to restrict such a vessel's operation in strong north-west winds and peak spring tides. Noting that these combined conditions would be extremely rare, no significant restriction on operations would be envisaged;
  - Further study would enable more discrete levels of operational control to be agreed for lower environmental conditions, if this size of vessel was to be operated at IERRT.
- The work reinforced the need for emergency scenarios with a full control failure to be included in pilot and PEC training and validations for IERRT.

4.2 Operations at IOT Berth 8 with VIP and revised flows

4.2.1 Context

The approach and departure manoeuvres to IOT 8 described in this study should be considered alongside the significant work previously conducted considering operations at IOT 8. In particular:

- Simulation study carried out in July 2022 – Specifically Runs 28 to 43, and Runs 52 and 65 to 70 (see Reference 5);
- Simulation study carried out in November 2022 – Specifically Runs 16 to 22 (see Reference 7).

These were all conducted in similar conditions and it was previously demonstrated, agreed and reported that, considering IOT, based on the additional runs using a modified flow model, the new infrastructure orientation and a 104 m long tanker (with a deadweight of 6,535 t), the following were concluded in July 2022:

- Navigation to and from the IOT 6 and 8 jetties will not be adversely affected by the proposed size and location of the new Ro-Ro infrastructure at an orientation of 300°T;
- Existing manoeuvring practices will need to be updated, taking into account the new infrastructure and reduced sea room to the south of the IOT finger jetty. However, safe manoeuvring was demonstrated in peak spring flows and winds up to 30 to 35 knots;
- Arrivals by vessels in their ballast state during strong south westerly winds will need to be restricted to a limit of 25 knots gusting to 30 knots. Arrivals above this limit may result in a hard landing. At low water there is potential for the new infrastructure to obstruct the flow which can create unusual flow patterns towards IOT8. Pilots and masters will need to be made aware of this effect;
- This is a well understood effect and is experienced and managed by pilots elsewhere on the Humber.

This new work was specifically used to consider the potential effect of the additional blockage created by larger pontoons at IERRT. The pontoons result in a short period of increased acceleration and deviation of flow towards IOT, at between 30 minutes and 60 minutes after LW Immingham. The effect and associated modelling is fully reported in Reference 11. All runs were conducted using the modified flow modelling taking into account the additional blockage.

Also ABP and IOT have been considering the potential provision of vessel impact protection (VIP) structures. The proposed VIP was included in the layout to ensure that the modification did not impede the navigational geometry on approach and departure.

APT restrict approaches to the IOT finger pier in conditions when the mean wind is forecast to be above 26 knots (30 mph) setting on to the berth. Occasionally at the operators discretion if the wind increases above the limit in the 2 hours prior to arrival the approach may be continued. This precaution is in place because the small products tankers operating at the terminal are challenging to control in such conditions, particularly controlling the bow. It is therefore unsurprising that similar challenges were found when approaching the berth in these strong winds, particularly when controlling the lateral set in the final moments of the manoeuvre. Consequently, it can be considered that the difficulty is not due to the IERRT structure.

4.2.2 Design vessel

The design vessel for these runs was the Wisby Teak, which was used throughout, and had been identified by APT as an appropriate design vessel for IOT 8 in November 2022.

4.2.3 Conclusions

The following key conclusions were discussed and agreed:

- Approaches to IOT 8 were considered in peak and mean spring tides, including 1 hour after LW and LW +3 hour flows.
- There were 9 runs undertaken which were all completed successfully.
- Run 22 was assessed as marginal, which was in 27.5 knot winds, simulating the exceptional case where the wind increases above 30mph (26 knots) during the final 2 hours of the approach to the berth. The ability to control the vessel in the final part of this approach was due to the environment in relation to IOT 8 and is unchanged from the situation at present with the existing port layout.
- The flows (as modelled) and modified by the additional pontoon, did not adversely change the ability of vessels to operate safely at IOT 8 compared with previous studies, noting that an adaptation of the piloting strategy will be required.

- The wind limit, where operations approaching IOT 8 were noted to be challenging, aligns with the levels expected with existing operations and the present advisory operating limit of 30 mph imposed on the berth by APT.
- The modified berthing geometry due to the VIP does not affect the approach or departure manoeuvring strategies for vessels operating at IOT 8, compared with previous studies, noting that some adaptation of the manoeuvring strategy might be required.

5 References

1. HR Wallingford, “Project Sugar – ABP Humber – Immingham East Development – Design review and navigation studies” , Report no. DJR6612-RT001-00-04,10 Dec 2021.
2. HR Wallingford, “Project Sugar – ABP Humber – Immingham East Development – Navigation simulation study Dec 2021”, Report no. DJR6612-RT002-03-00, 04 Aug 2022.
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4. HR Wallingford, “Project Sugar – ABP Humber – Immingham East Development – Quasi-static force assessment”, Report no. DJR6612-RT0004-01-00, 08 Jul 22.
5. HR Wallingford, “Project Sugar – ABP Humber – Immingham East Development – Navigation Simulation Study - July 2022”, Report no. DJR6612-RT0005-01-00, 04 Aug 22.
6. 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.
7. HR Wallingford, “Project-Sugar_Stakeholder-demonstrations-Nov2022-SECURED”, Report no. DJR6612-RT008-R03-00, 11 Aug 2023.
8. HR Wallingford, “Project Sugar – ABP Humber – Immingham East Development – Simulated Flows Summary”, Report no. DJR6612-RT0009-02-00, 10 Nov 23.
9. HR Wallingford “Project Sugar – ABP Humber – Immingham East Development – Additional short navigation simulation study”, Report no. DJR6612-RT00012-01-00, 08 Nov 23.
10. HR Wallingford “Project Sugar – ABP Humber – Immingham East Development – considering revise flows and impact protection”, Report no. DJR6612-RT00013-02-00, 29 Nov 23.
11. HR Wallingford “Project Sugar – ABP Humber – Immingham East Development – 3D modelling of revised layouts”, Report no. DJR6612-RT00015-02-00, 21 Dec 23.

Appendices

A Revised flow model results

This is an extract from Reference 11, but not all figures have been reproduced.

A.1 Comparison with baseline conditions

The above results show the incremental effect of the revised IERRT pontoon. For nearby navigation the anticipated change in currents between the present day and those with the revised IERRT are also of importance. Examples of the change in current speed at times of approximate mid ebb and flood tides are provided for the peak spring tide simulation in Figure A.1 and Figure A.2. Equivalent results for mean spring tide case are shown in Figure A.3 and Figure A.4. Hourly results covering the whole of each tide are included in Appendix A (not included in this extract). For these figures the minimum threshold for plotting changes is 0.1 m/s, which is more than the 0.05 m/s used for the comparison of the original and revised IERRT schemes. A threshold of 0.1 m/s (<0.25 knots) is a more typical choice to show changes to estuarine flows. The more refined choice of 0.05 was used to provide evidence for all the changes between the two IERRT schemes.

The main effects of the project are predicted to be current reductions to either side of the pontoon due to the blockage of the structure and local acceleration under the pontoon. Some transient patches of speed increase of the order of 0.1 m/s are seen at times to the side of the development during the flood tide and similar magnitude patches of speed decreases are seen occasionally to the sides of the development during the ebb tide.

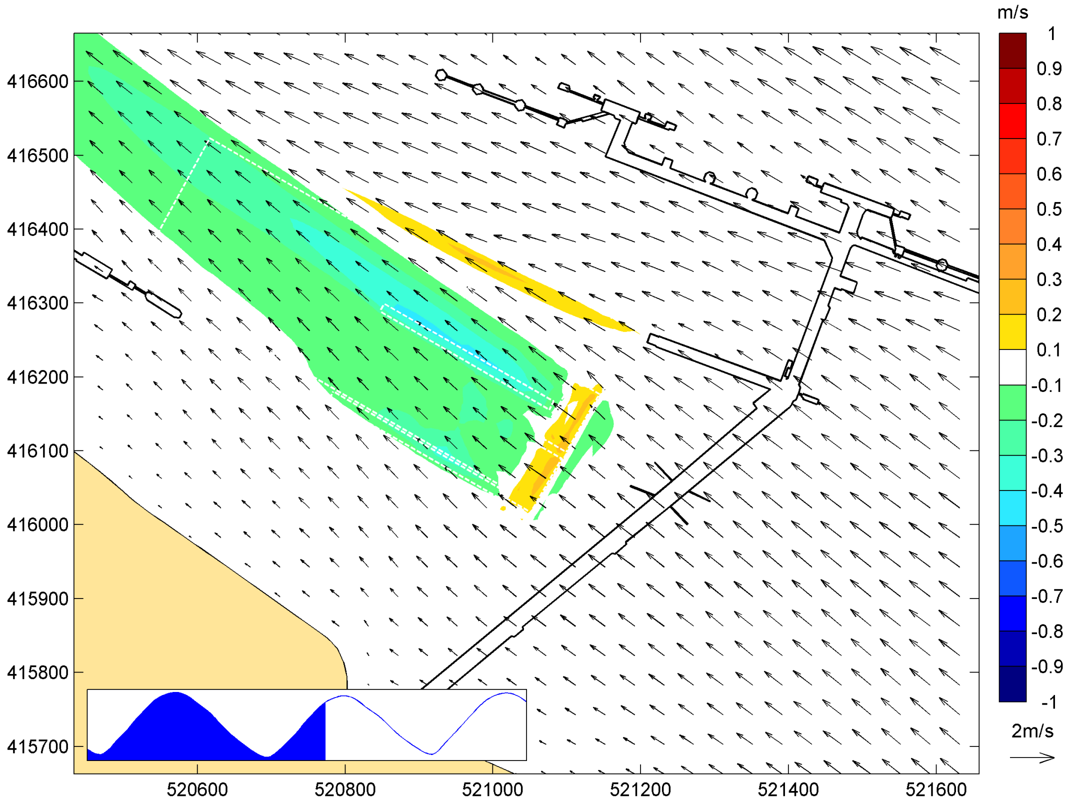


Figure A.1: Difference in current speed between revised IERRT and baseline conditions, mid flood tide, peak spring tide

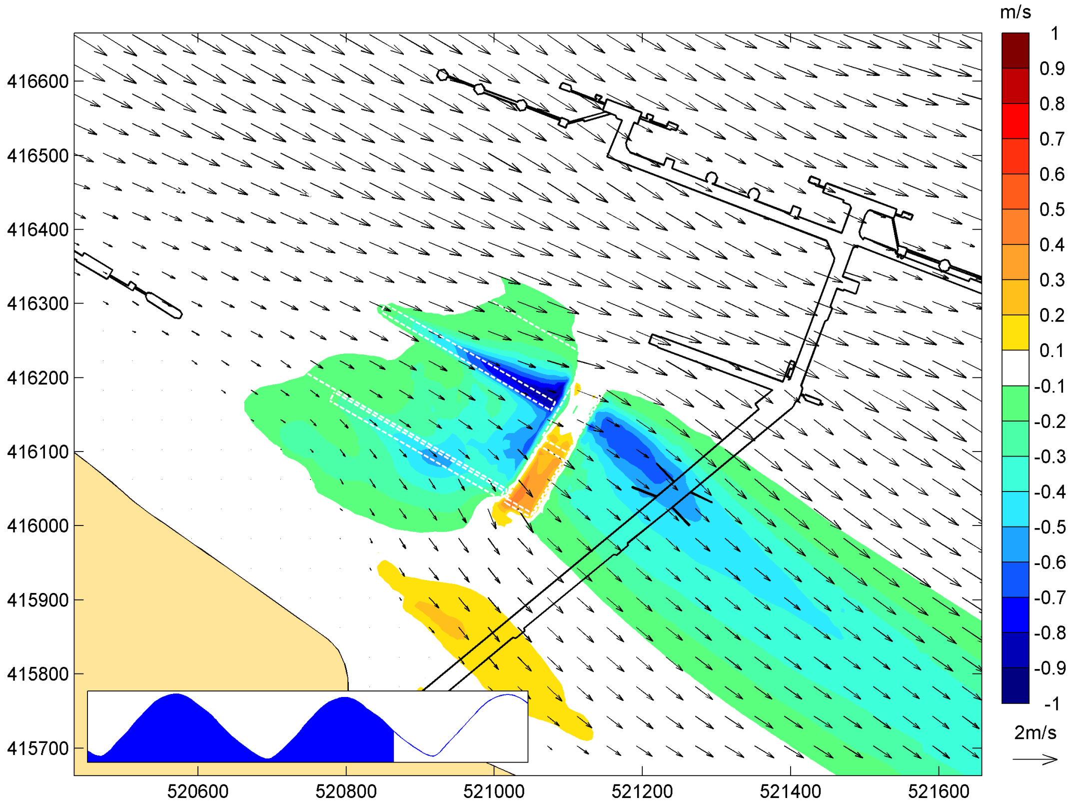


Figure A.2: Difference in current speed between revised IERRT and baseline conditions, mid ebb tide, peak spring tide

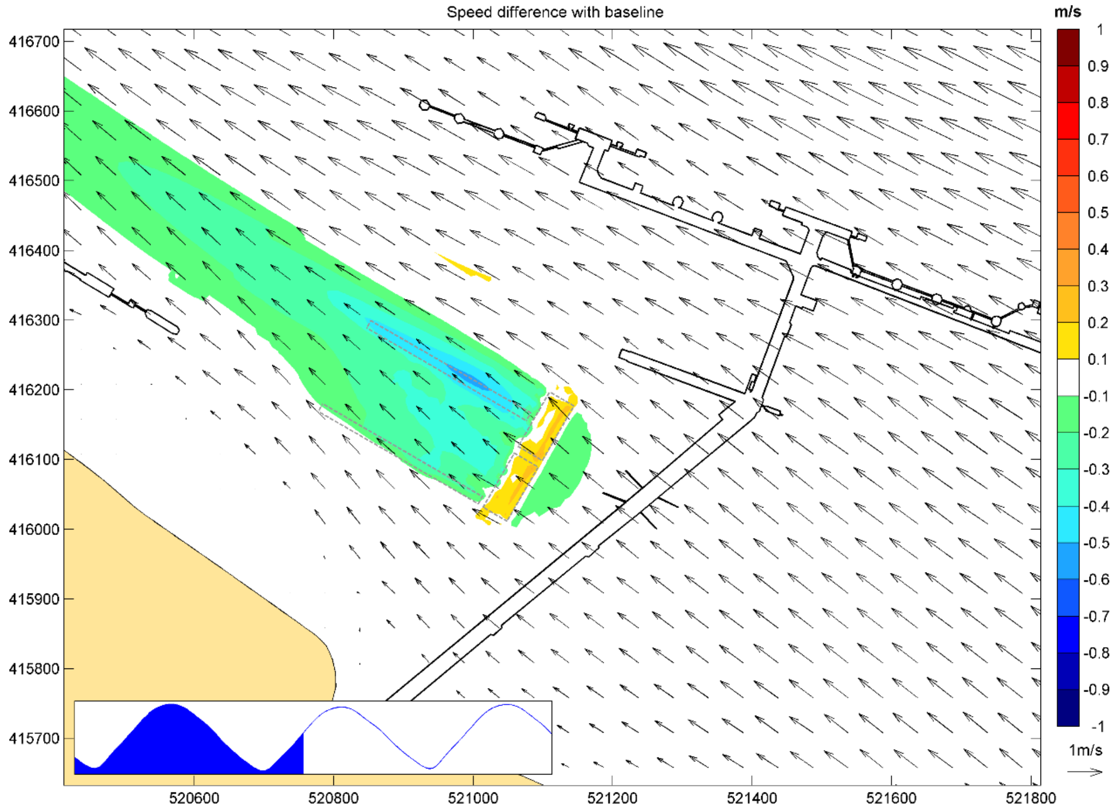


Figure A.3: Difference in current speed between revised IERRT and baseline conditions, mid flood tide, mean spring tide

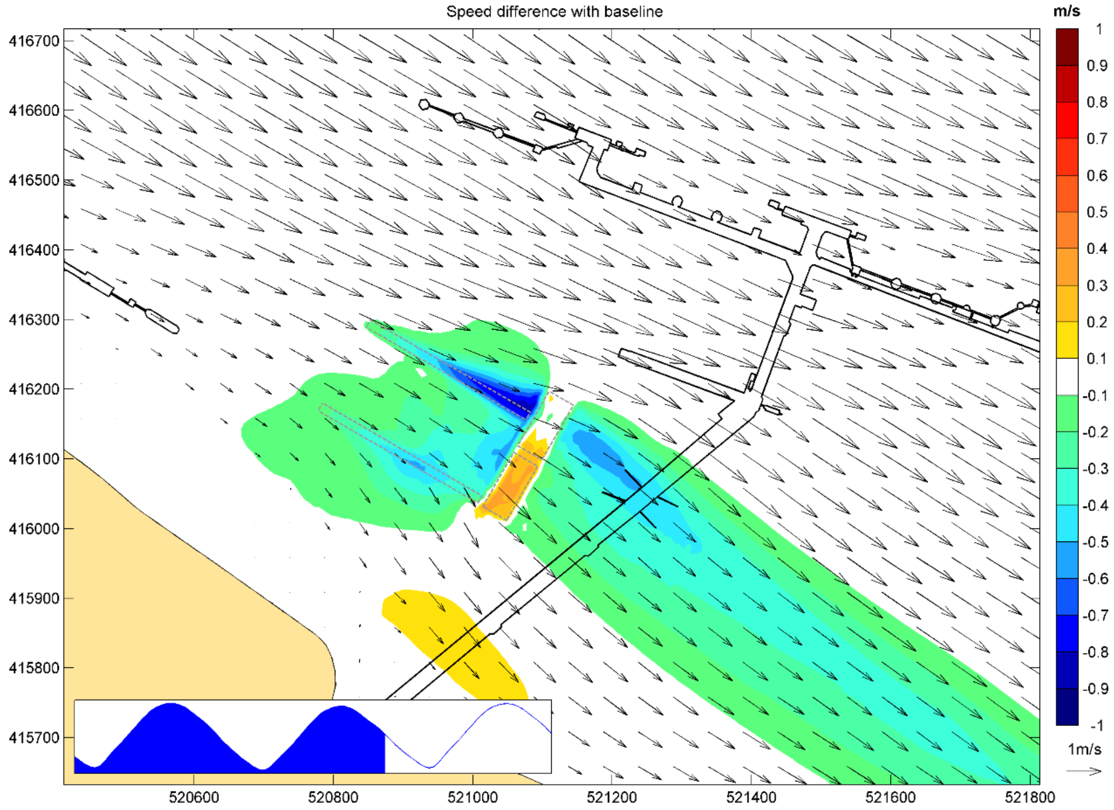


Figure A.4: Difference in current speed between revised IERRT and baseline conditions, mid ebb tide, mean spring tide

A.2 Flow conditions between IERRT and IOT

The above results shows the current pattern with the revised IERRT in place interpolated onto a 30 m square grid. To remove any potential effect of the interpolation and to provide further details of the current pattern in the gap between IERRT and the IOT finger jetty current vectors of every model node were plotted provide additional details of the simulation results. The times of mid ebb and flood currents are plotted in Figure A.5 and Figure A.6, and the hourly results are included in Appendix A (Not Included).

These results confirm that whilst some deflection of the currents around the pontoon does occur, no large scale eddies which might influence vessels are seen. Smaller eddies, of a few metres diameter, may occur in the immediate vicinity of the pontoon structure as are seen for other marine structures at this site but these are considered too small to significantly effect navigation.

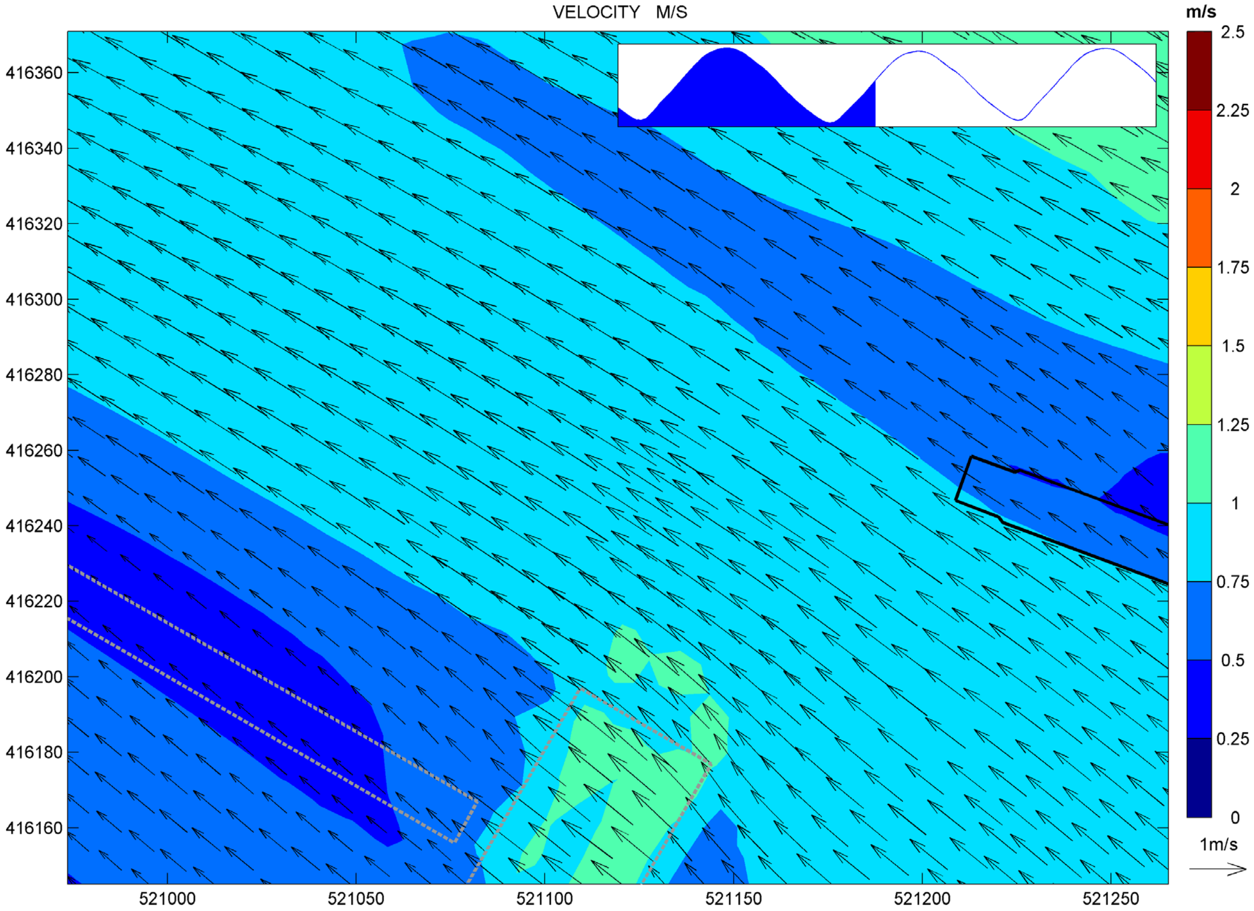


Figure A.5: Distribution of current speed and direction between IERRT and IOT, mid flood tide, mean spring tide range

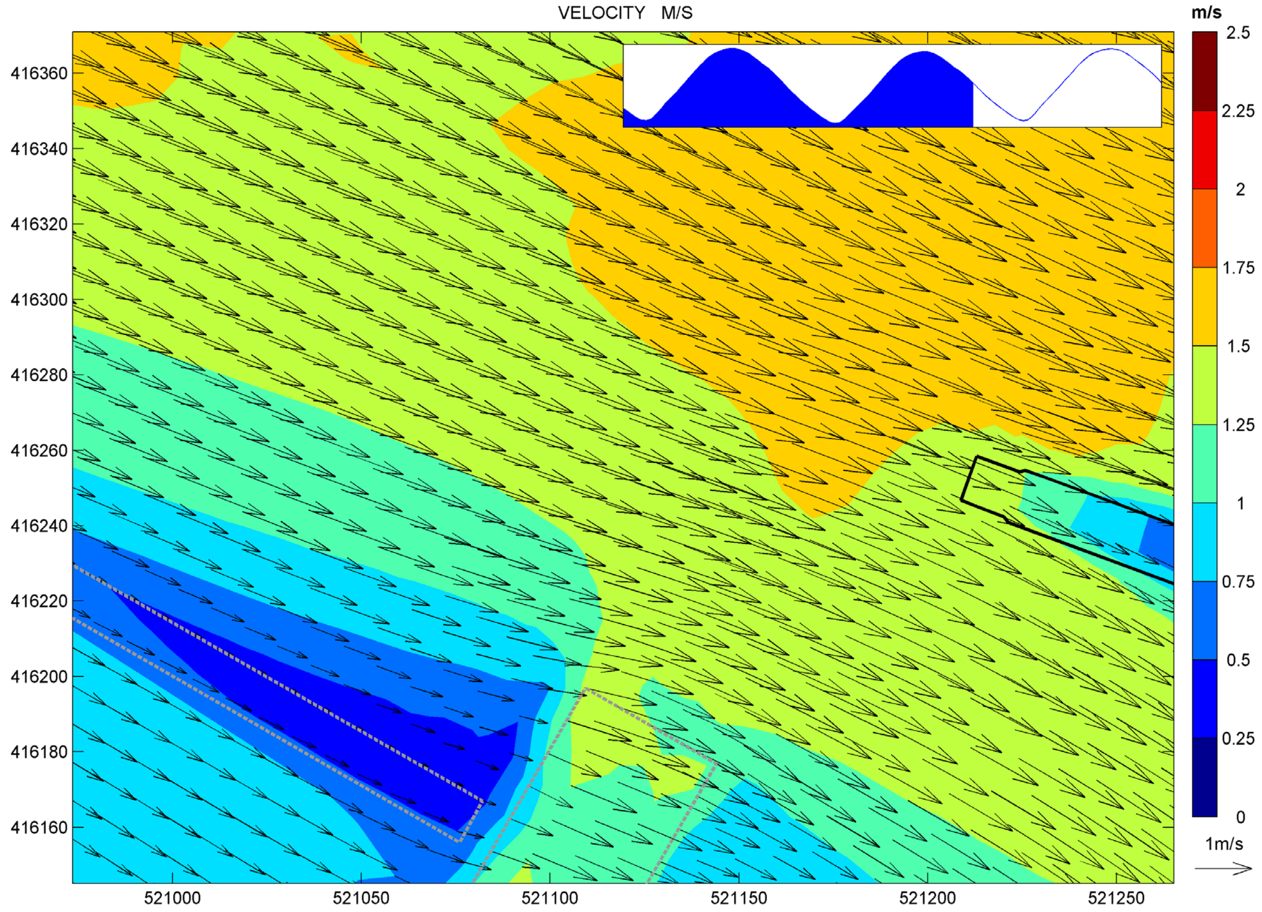


Figure A.6: Distribution of current speed and direction between IERRT and IOT, mid ebb tide, mean spring tide range

A.3 Sensitivity to moored vessels at IERRT

All the modelling has included the permanent parts of the IERRT project, in particular the pontoon. It is noted that vessels which are to use the IERRT may have a greater draught than the pontoon. The situation is described in Figure A.7 and Figure A.8.

The spatial view indicates the relatively large width across the flow of the pontoon compared to the vessel, which will also be moored in the area of low currents associated with the blockage of the pontoon (see Appendix A Not reproduced). The likely proximity of the moored vessel to the pontoon is illustrated by Figure A.8. Assuming a typical 1:10 expansion of the flow, the flood tide flow will not have recovered from the effect of the pontoon before reaching the vessel. That means any effect is likely to be only from the lower part of the vessel's hull. The additional blockage of the vessel will also be acting on the lower part of the water column where currents are lower.

Most likely the moored vessels will extend the flow effect of the project along the flow stream direction. No additional effect beyond that predicted for the pontoon is anticipated for the across stream direction.

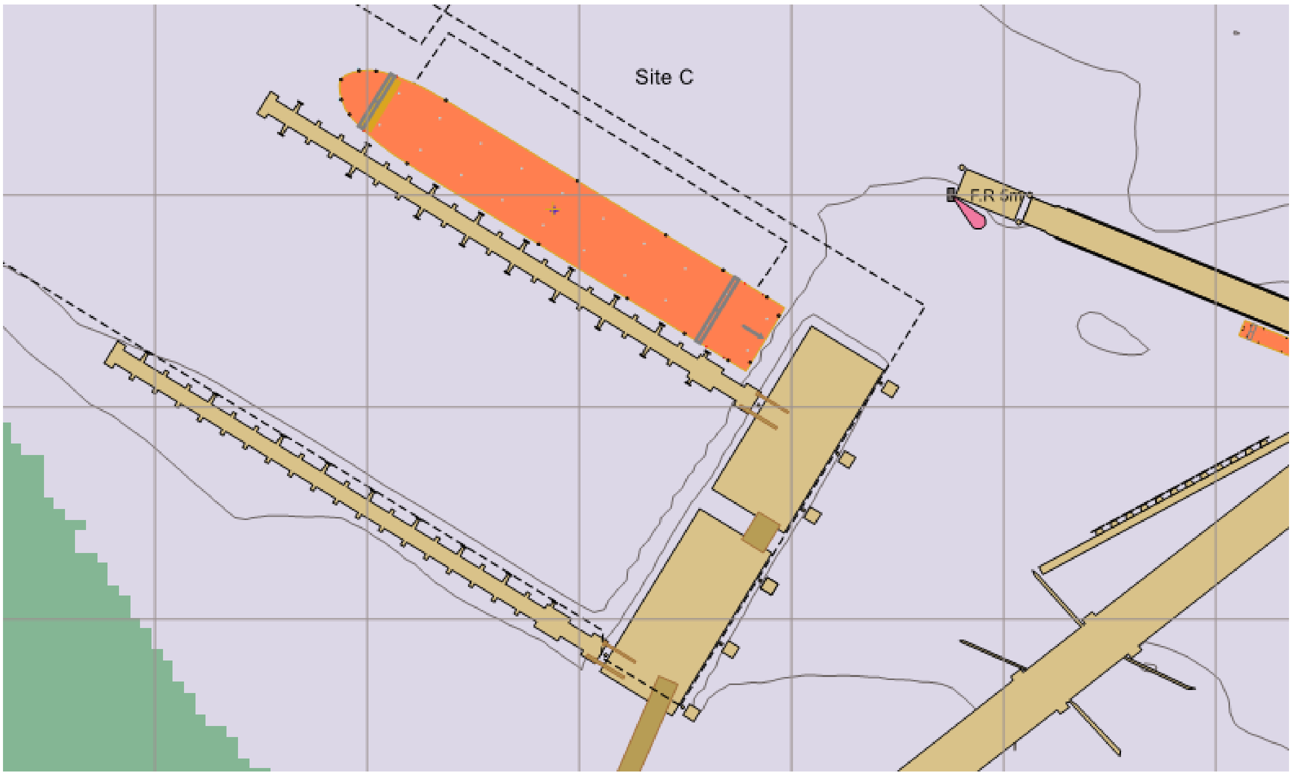


Figure A.7: Spatial view of moored vessel at IERRT

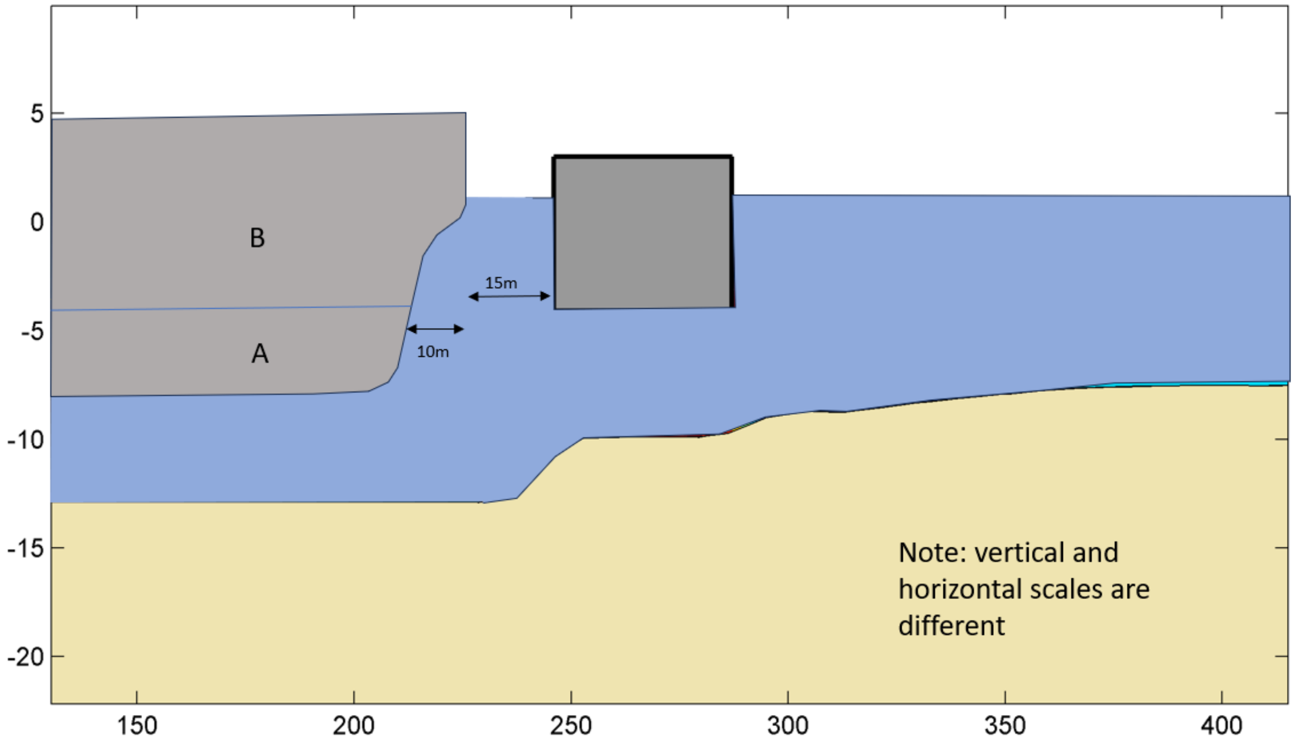
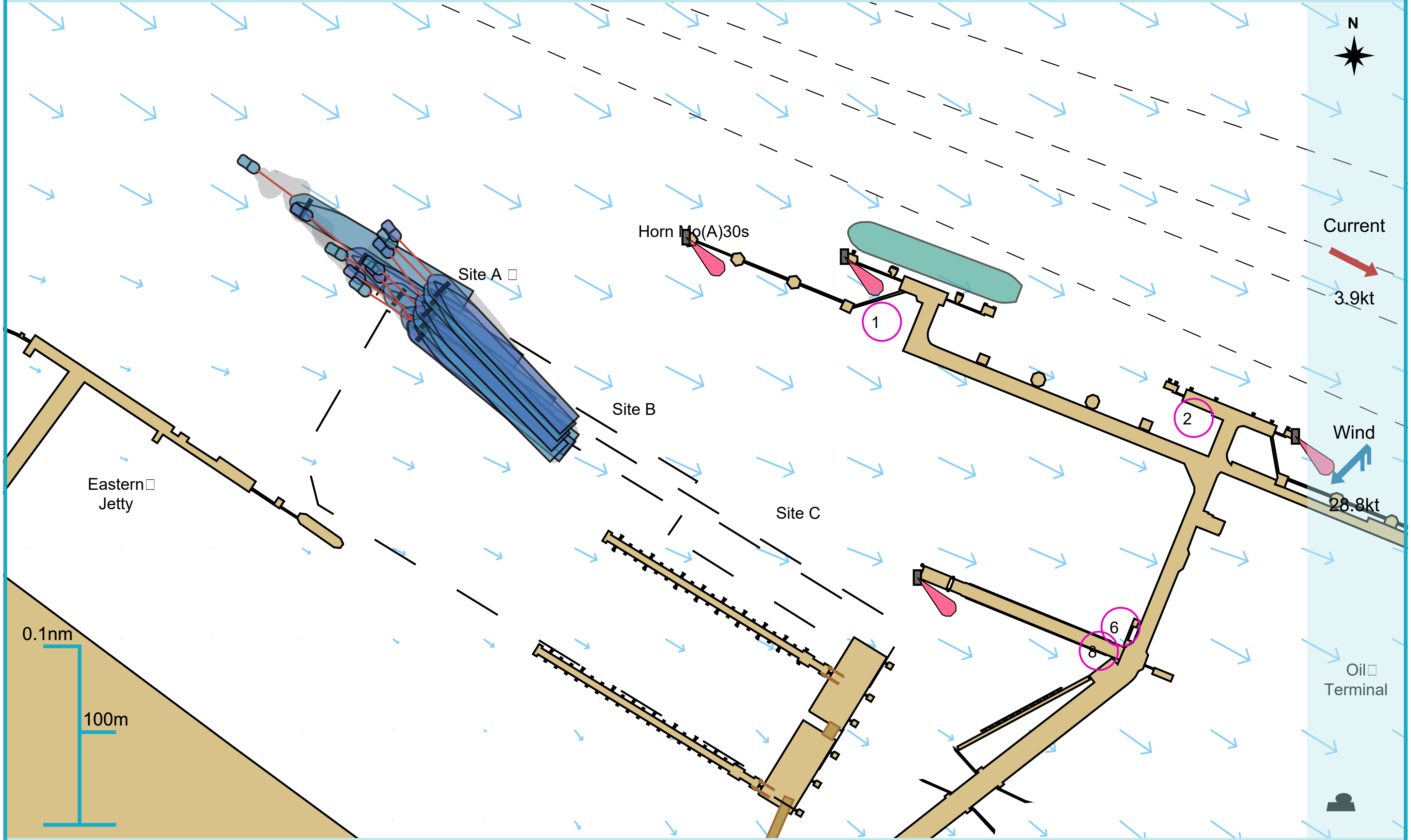


Figure A.8: Schematic section of moored vessel and IERRT pontoon

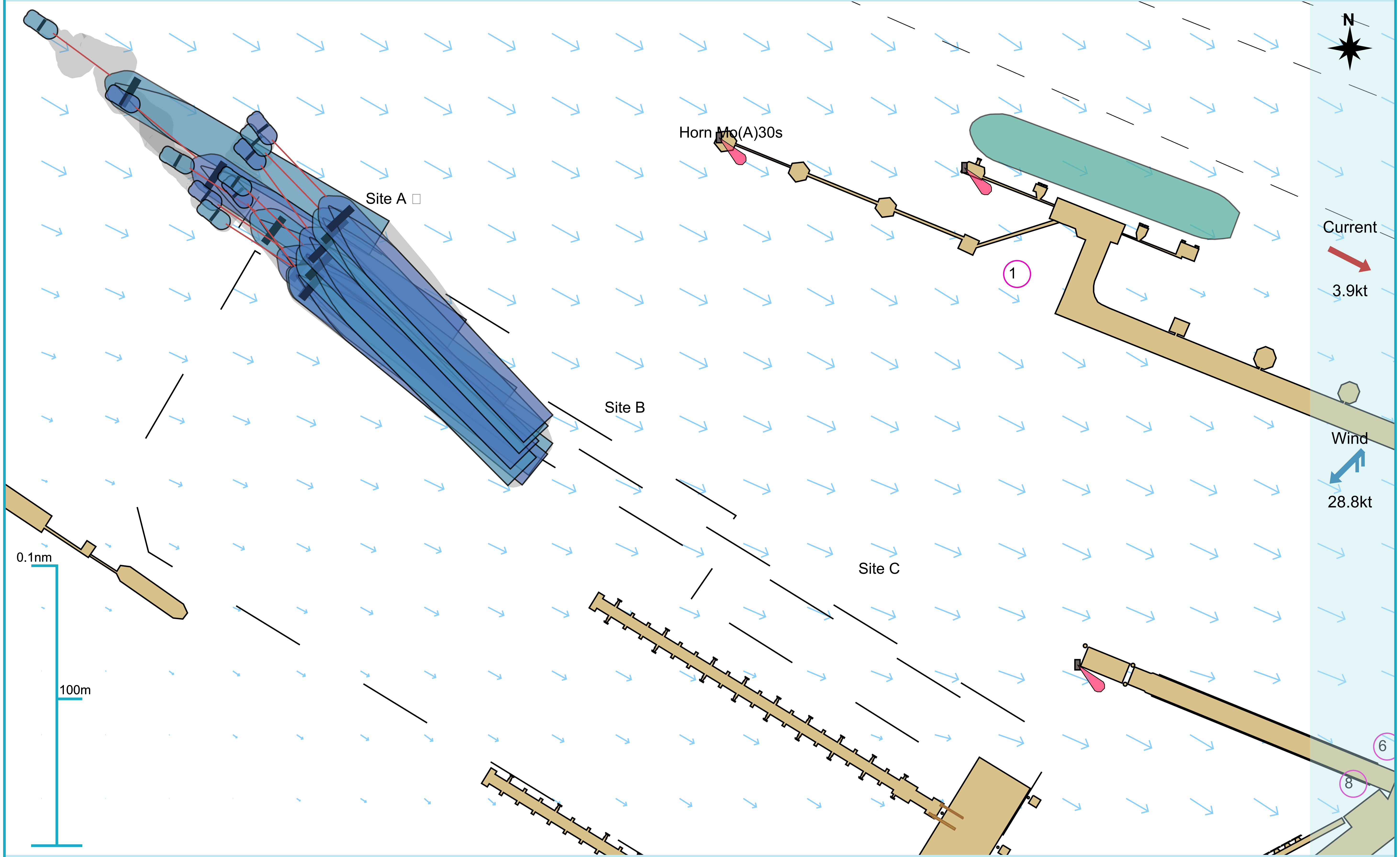
B Simulation track and data plots – Main study

Manoeuvre track plot



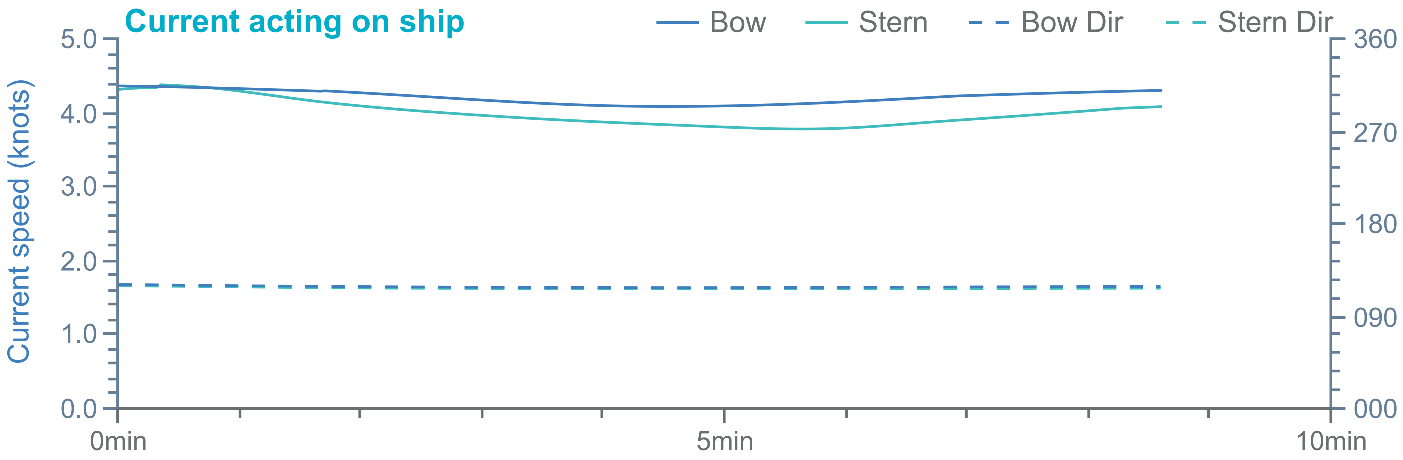
Ships plotted every 1 mins, highlight every 10 mins

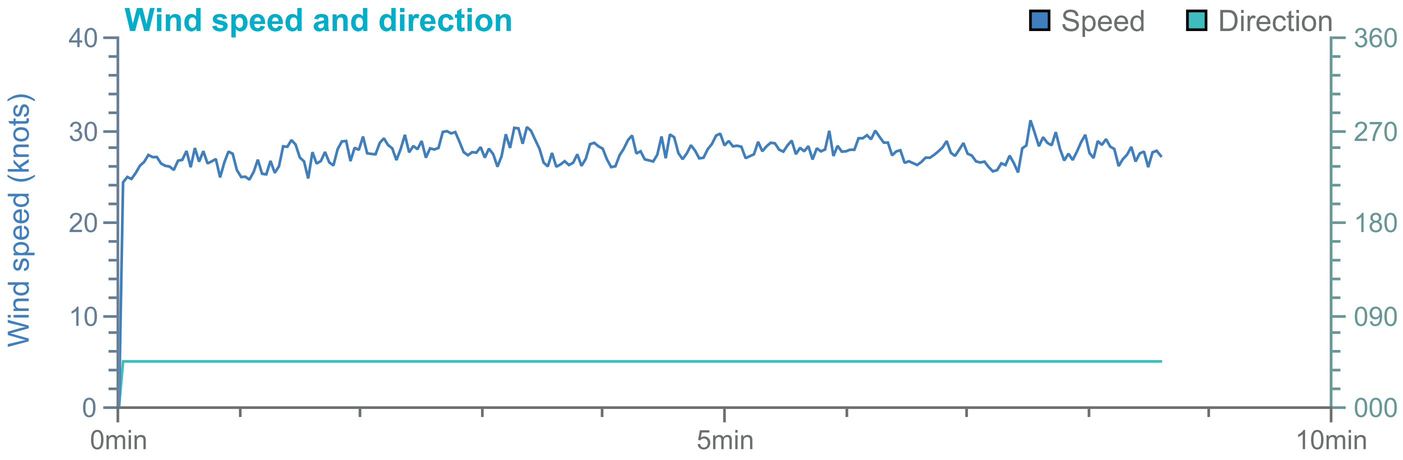
Manoeuvre track plot

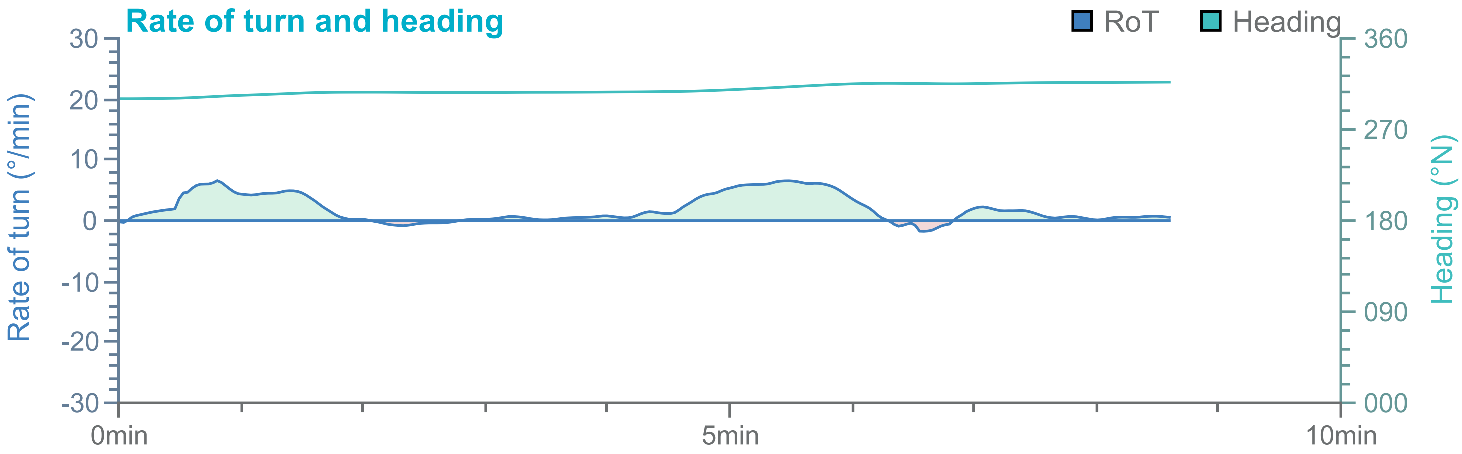


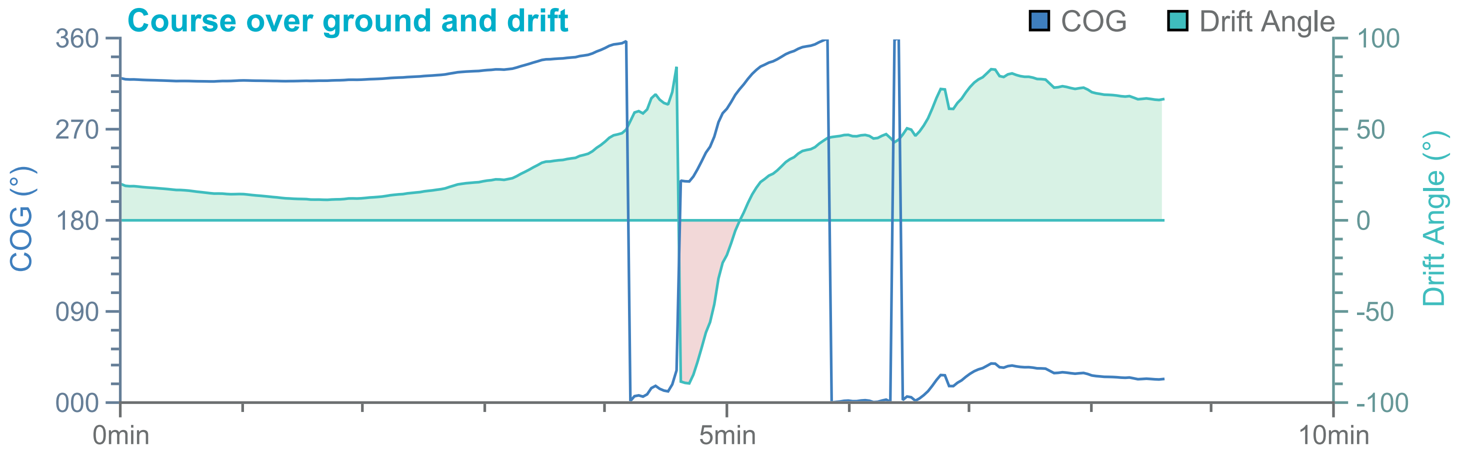
3.71 kts

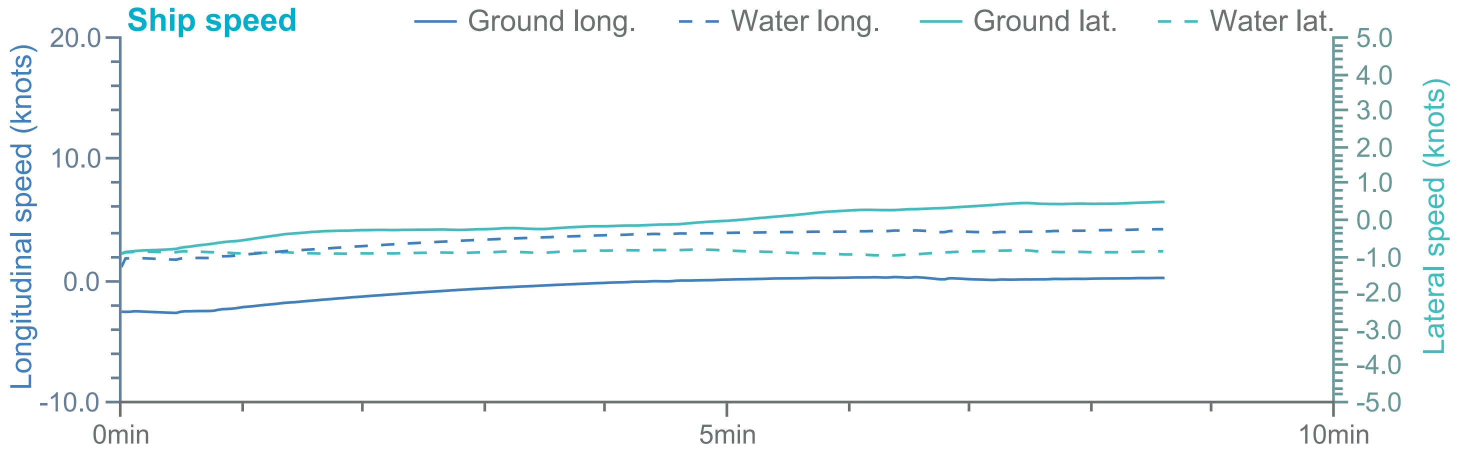
Ships plotted every 1 mins, highlight every 10 mins

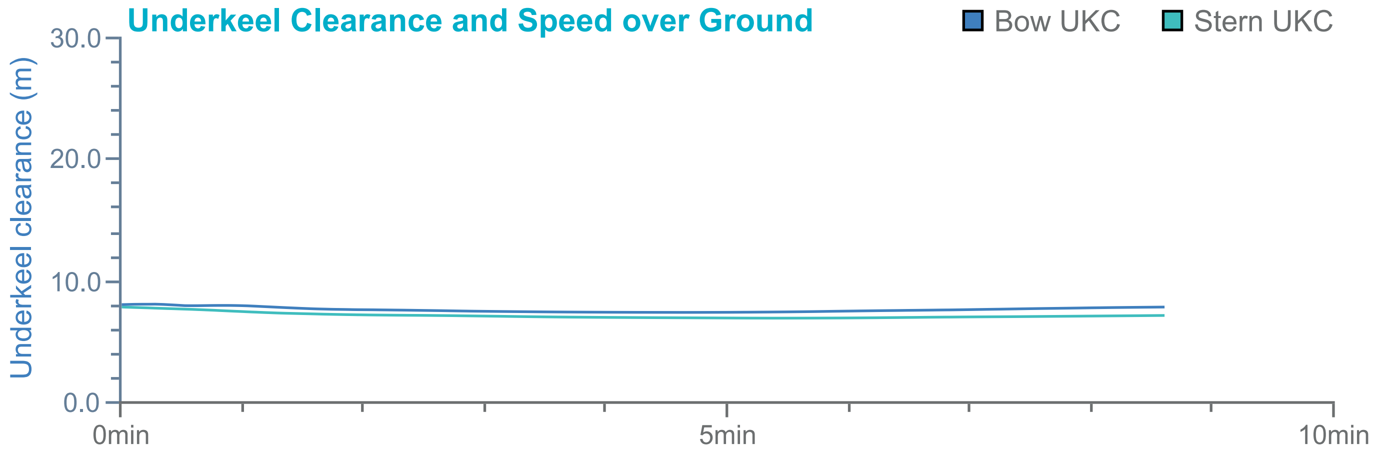

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
Current direction (°N)
360
270
180
090
000
0min
5min
10min

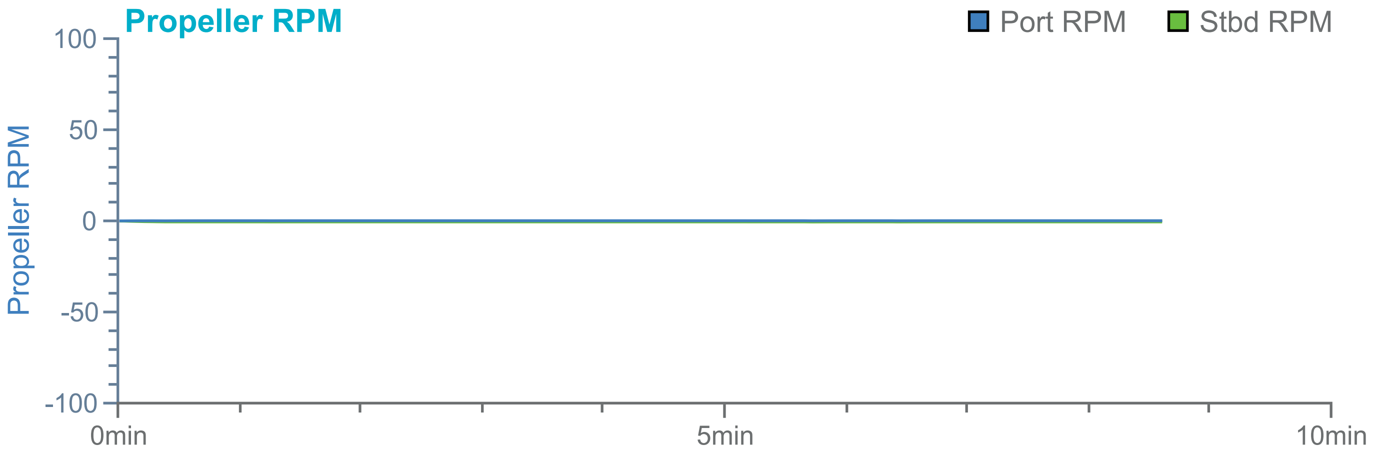

Wind speed and direction
Speed
Direction
Wind speed (knots)
40
30
20
10
0
Wind direction (°N)
360
270
180
090
000
0min
5min
10min

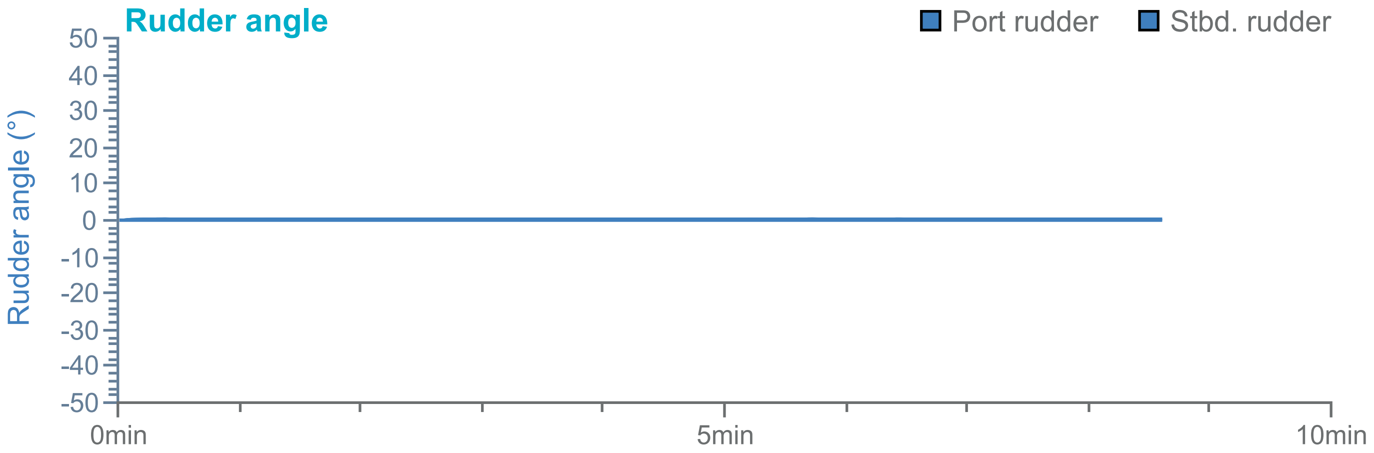

Rate of turn and heading

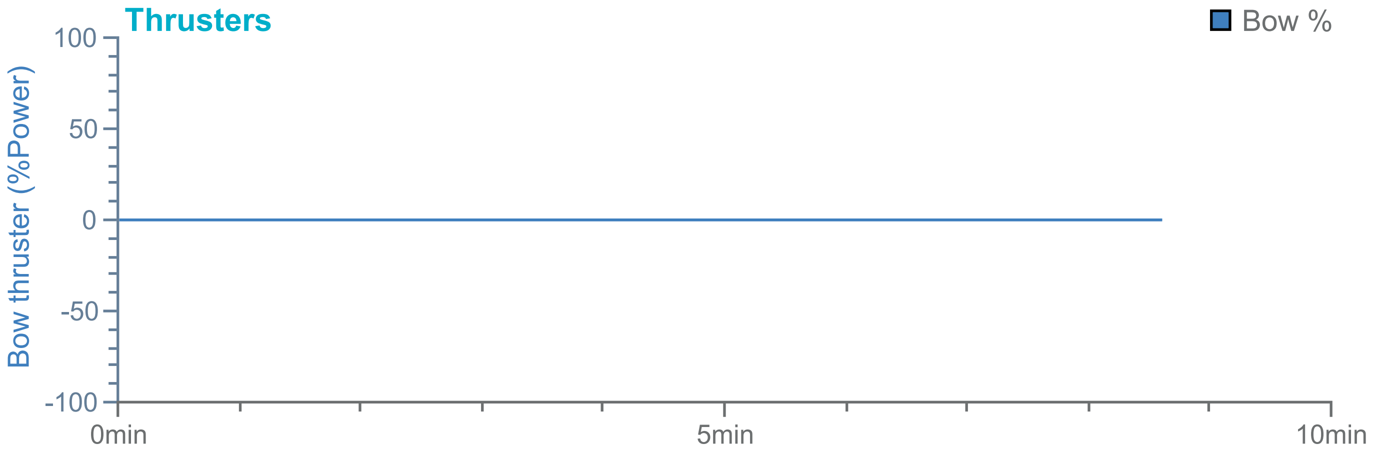

Course over ground and drift

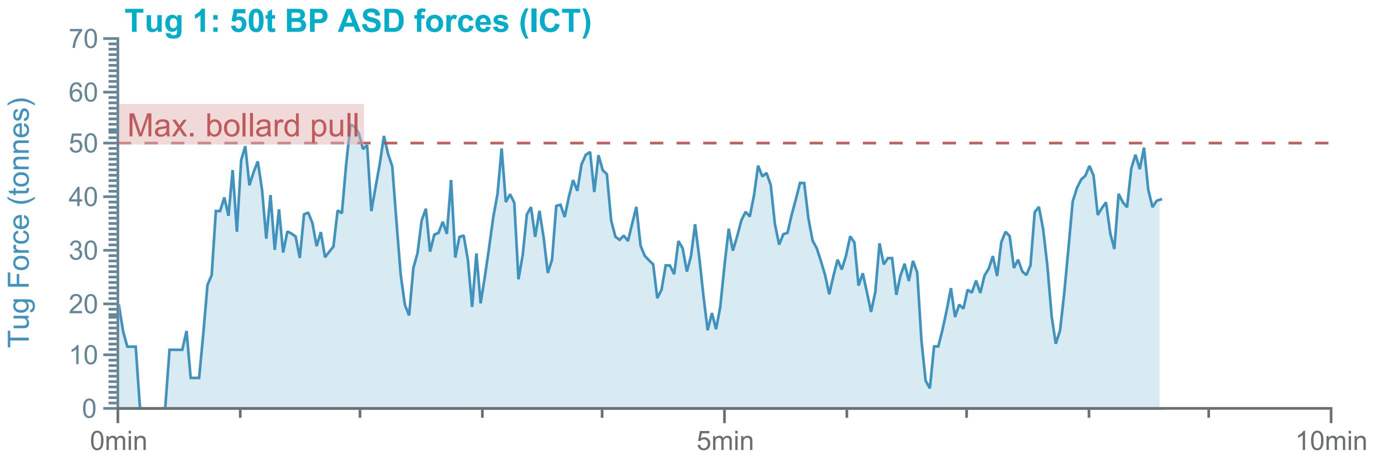

Ship speed


Underkeel Clearance and Speed over Ground

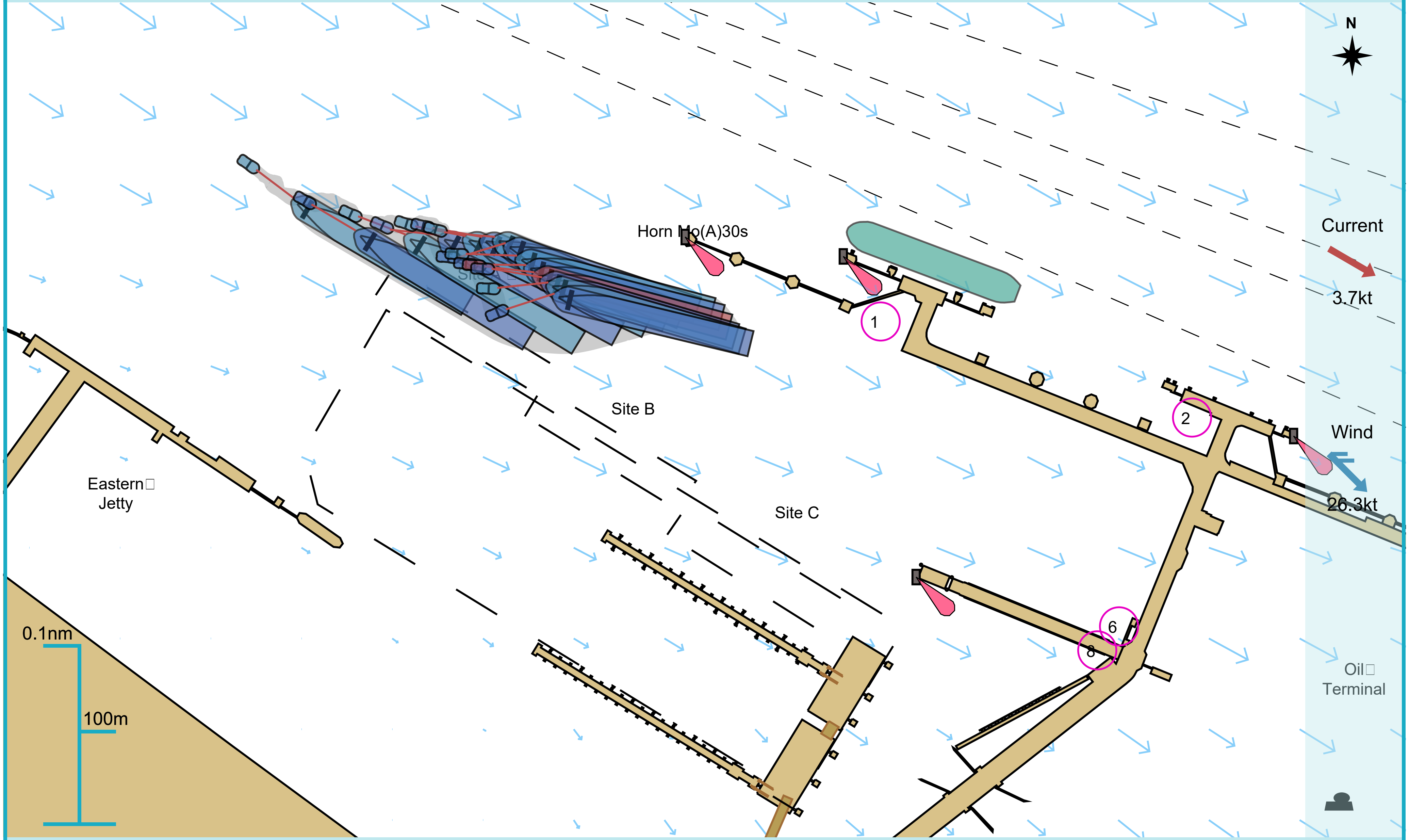

Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min


Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
5min
10min


Thrusters
Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min

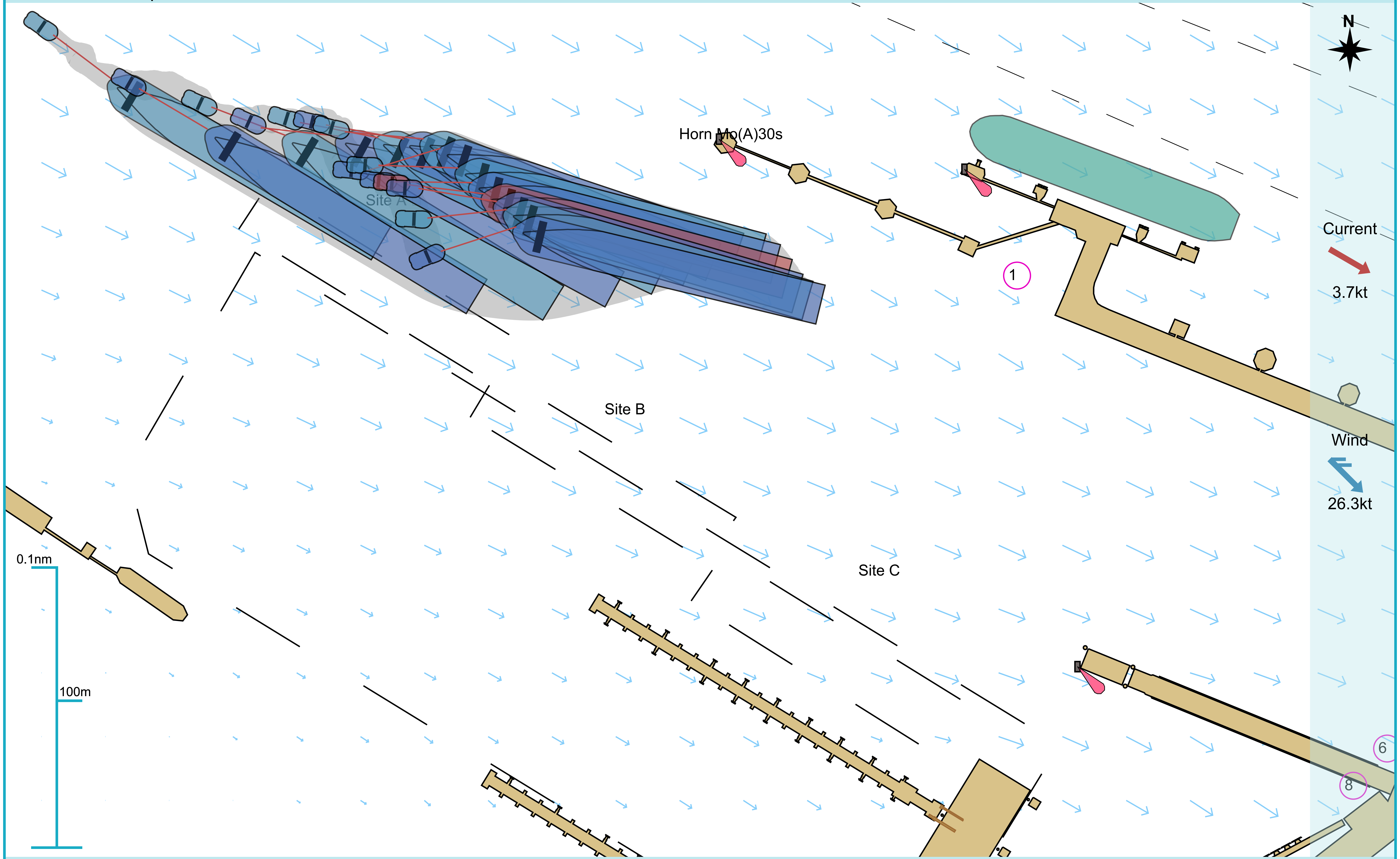

Tug 1: 50t BP ASD forces (ICT)
Tug Force (tonnes)
70
60
50
40
30
20
10
0
Max. bollard pull
0min
5min
10min

Manoeuvre track plot



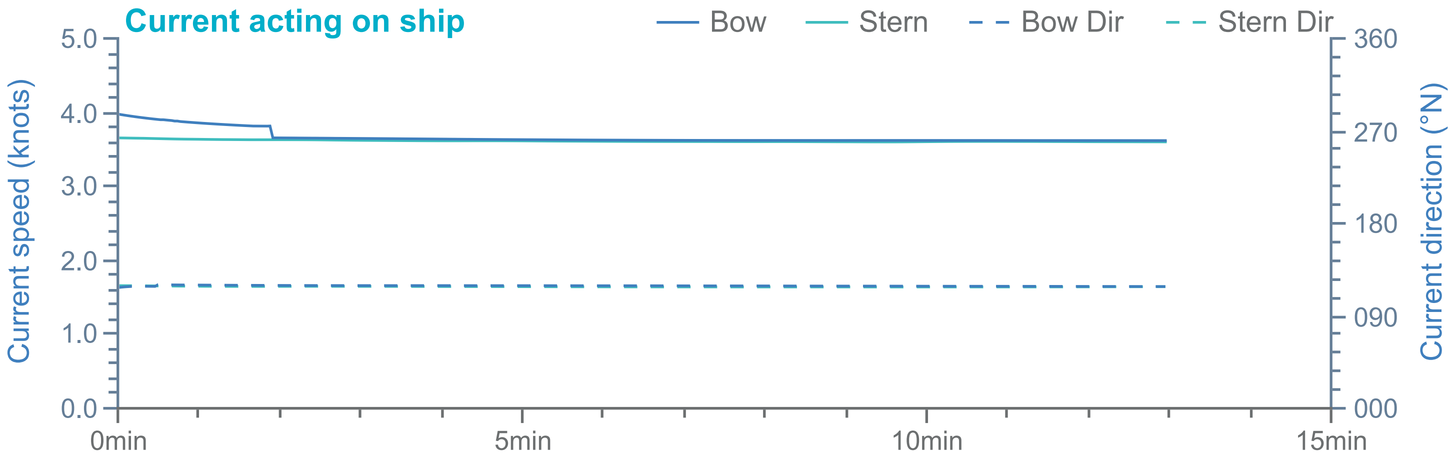
Ships plotted every 1 mins, highlight every 10 mins

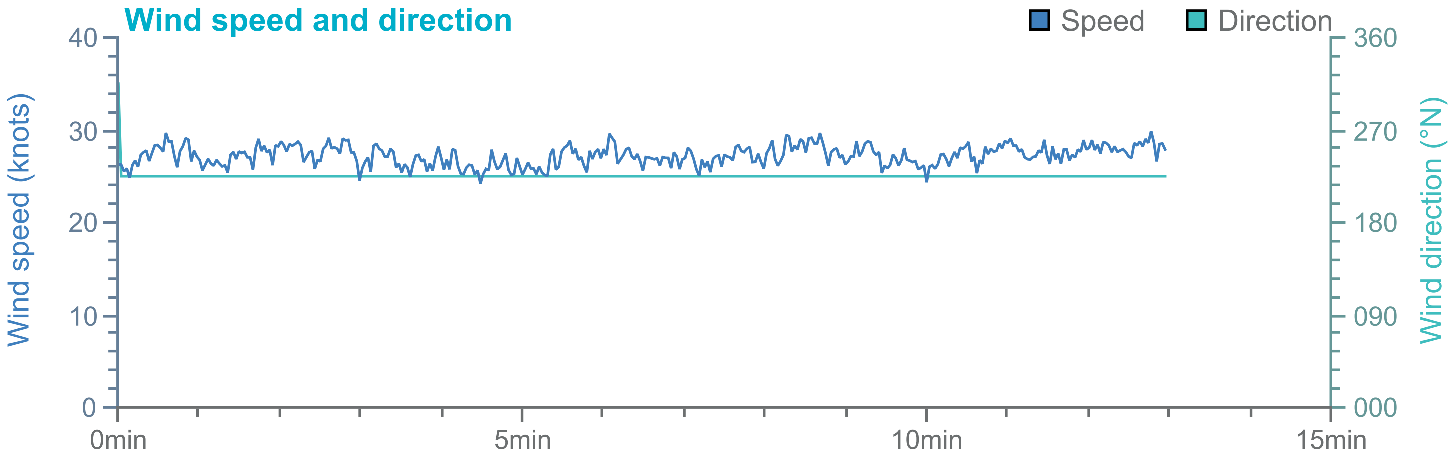
Manoeuvre track plot

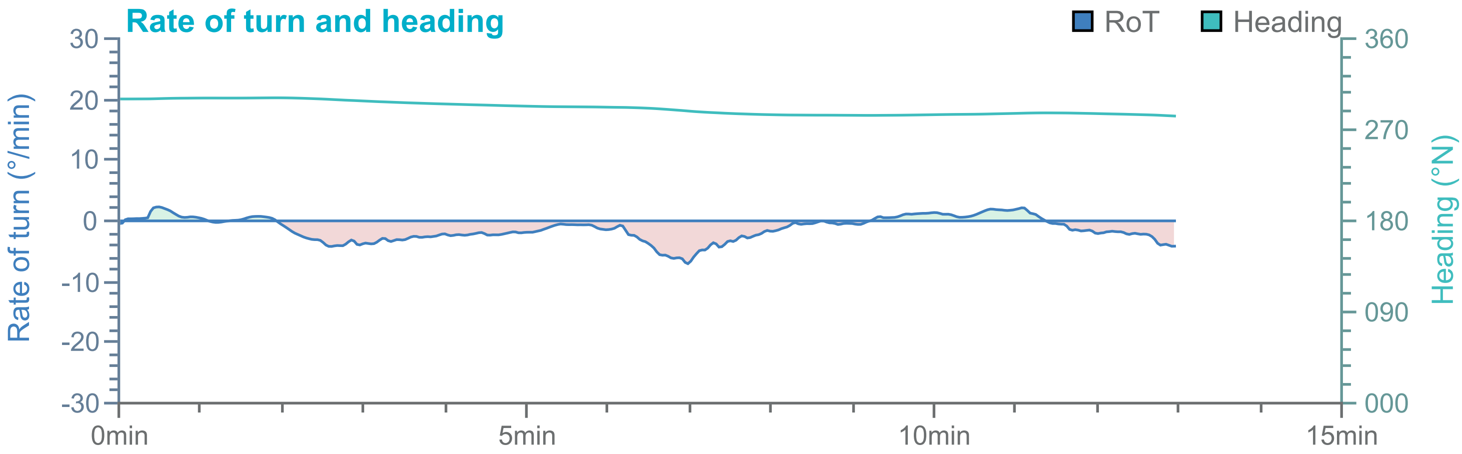


→ 3.71 kts

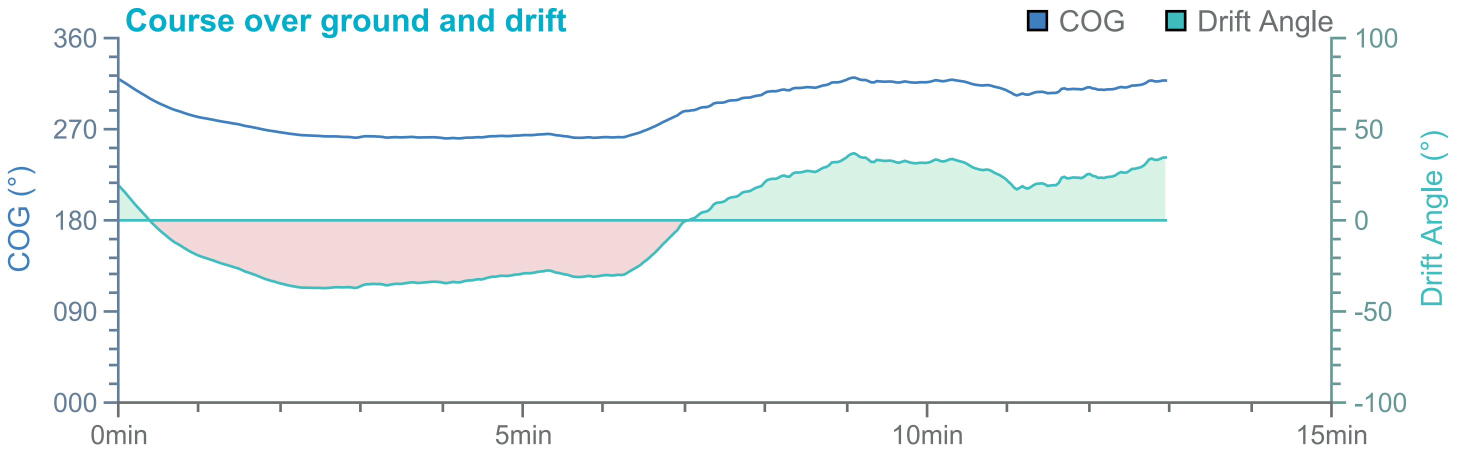
Ships plotted every 1 mins, highlight every 10 mins


Current acting on ship
Bow
Stern
Bow Dir
Stern 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

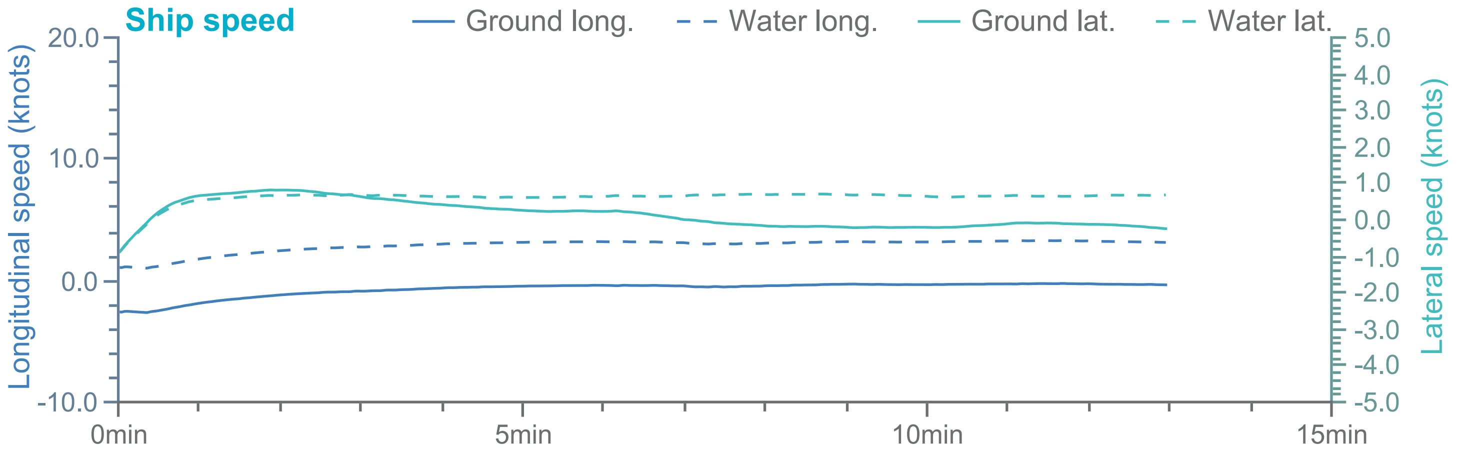

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
40
30
20
10
0
360
270
180
090
000
0min
5min
10min
15min



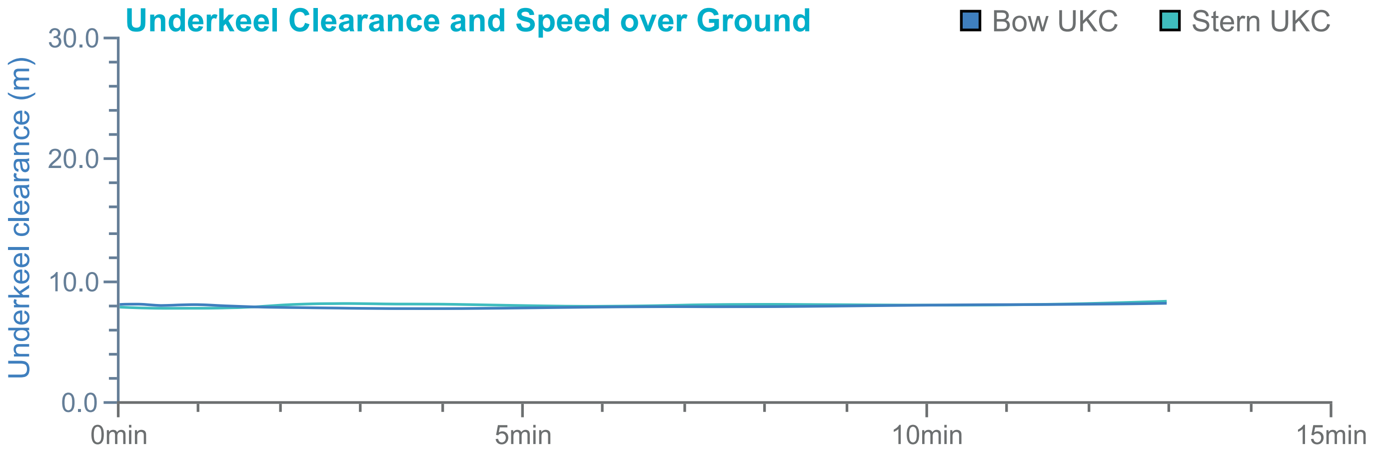
Rate of turn and heading



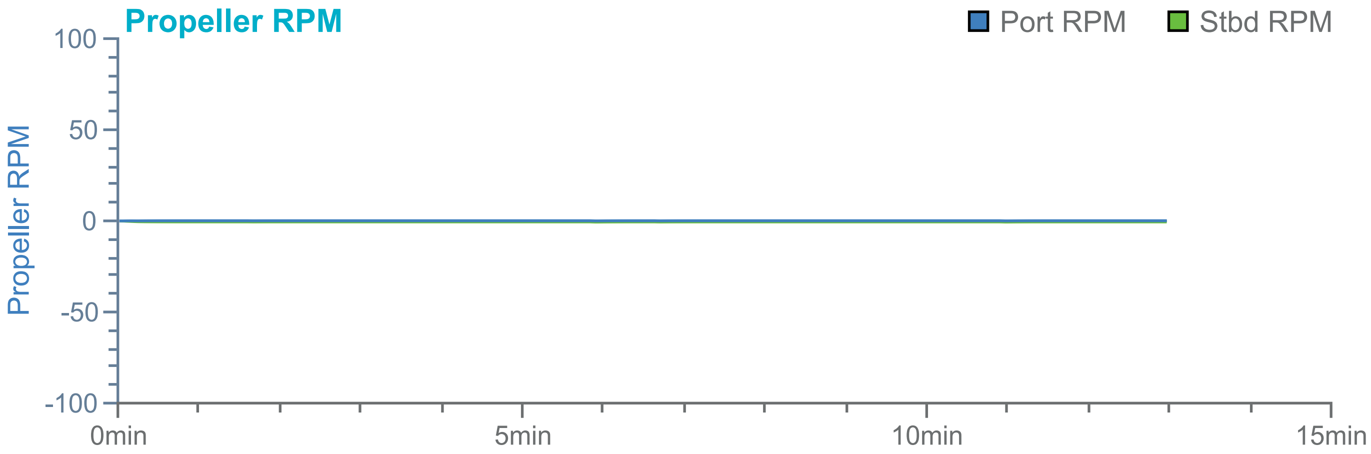
Course over ground and drift

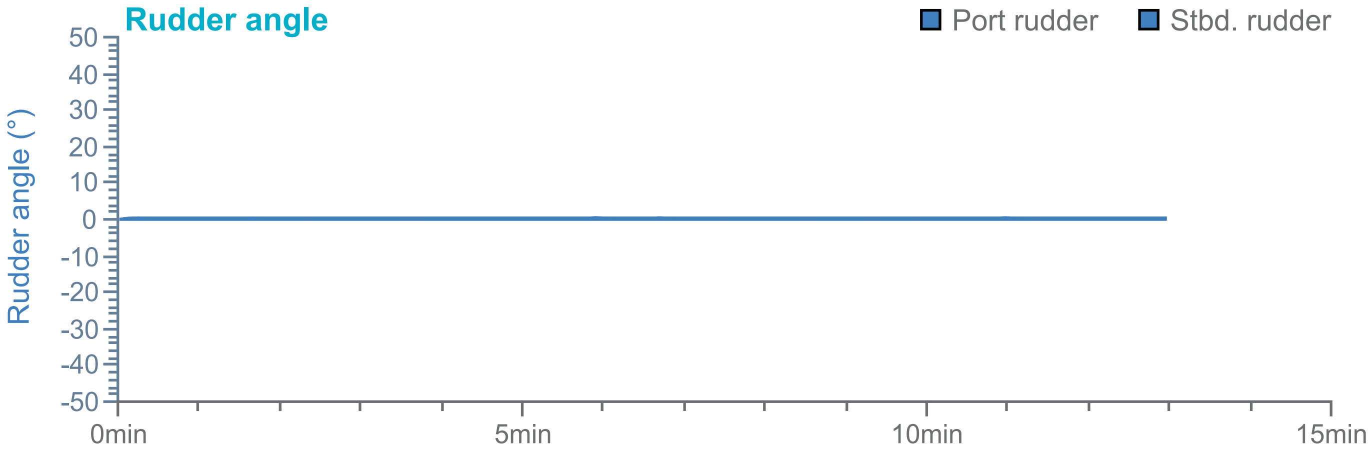


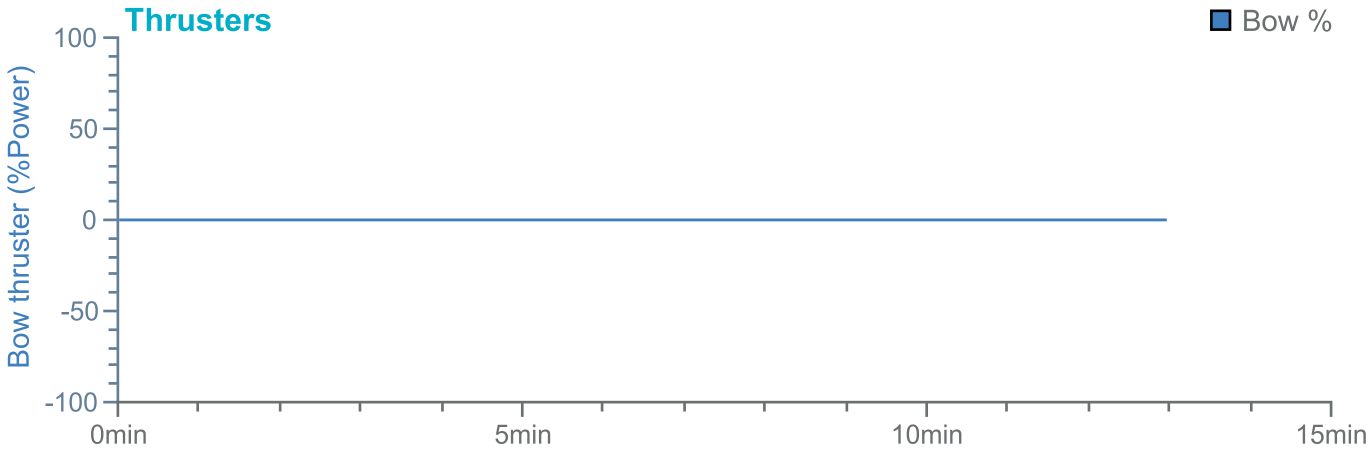
Ship speed

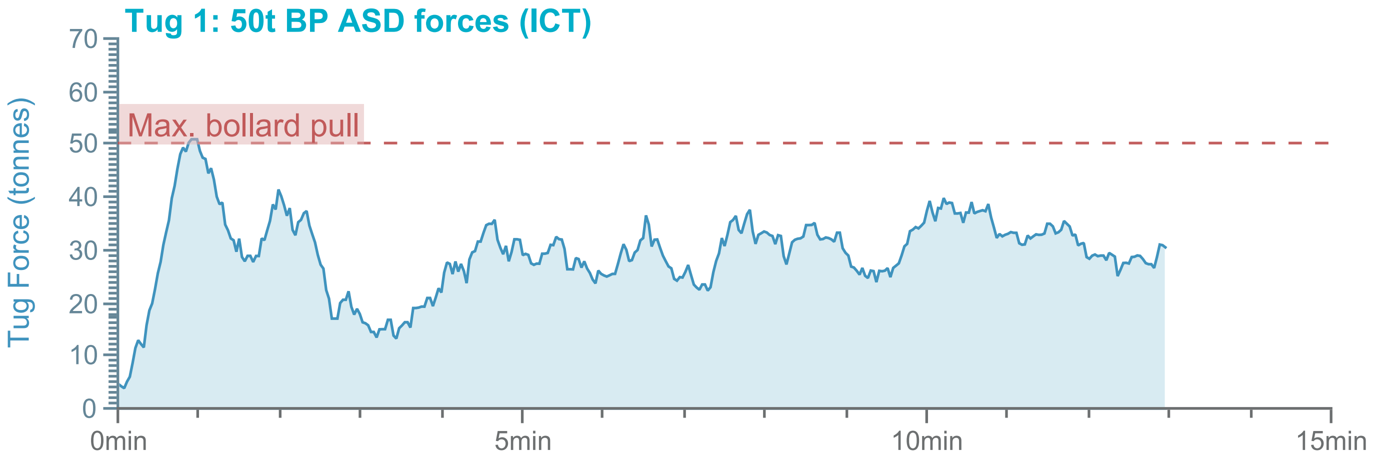


Underkeel Clearance and Speed over Ground

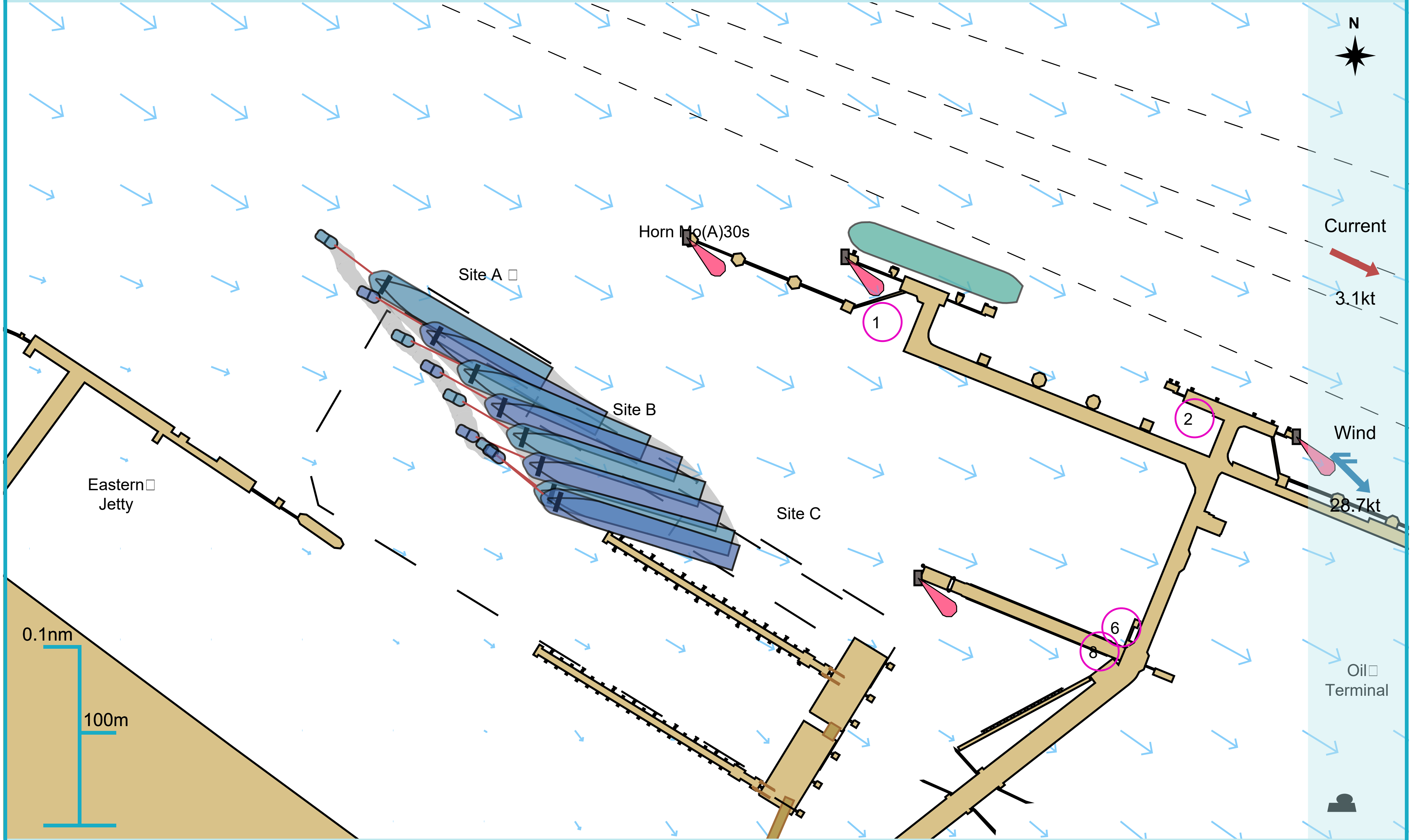

Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min


Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
5min
10min
15min


Thrusters
Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min

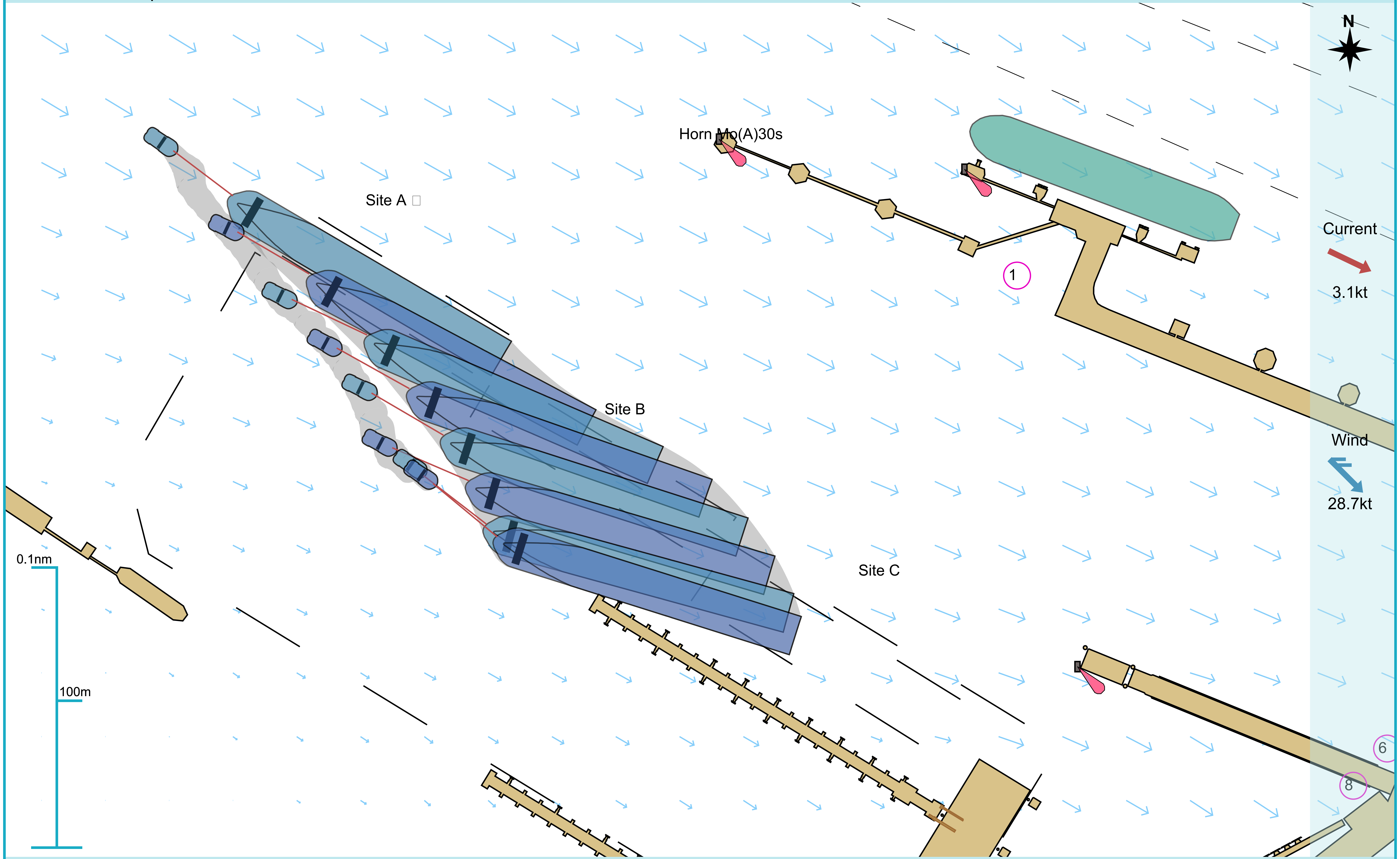

Tug 1: 50t BP ASD forces (ICT)
Tug Force (tonnes)
70
60
50
40
30
20
10
0
Max. bollard pull
0min
5min
10min
15min

Manoeuvre track plot



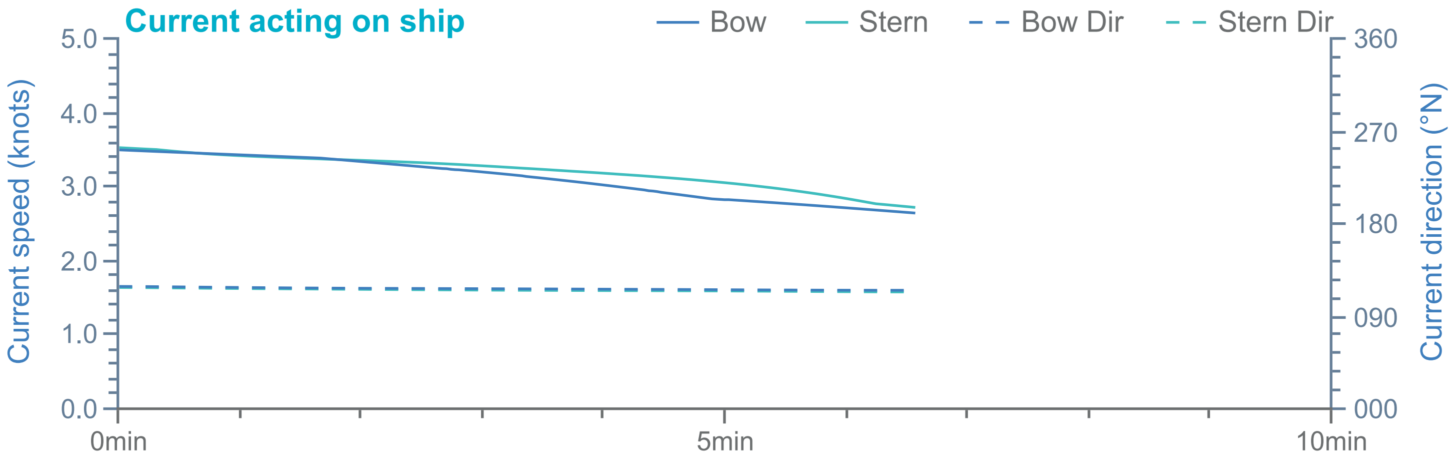
Ships plotted every 1 mins, highlight every 10 mins

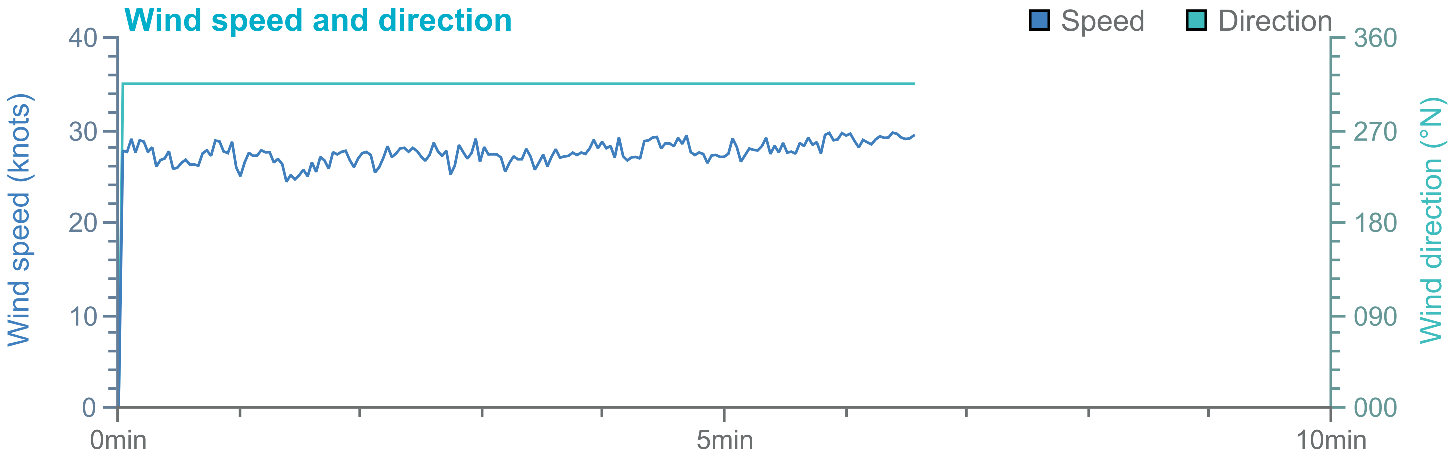
Manoeuvre track plot

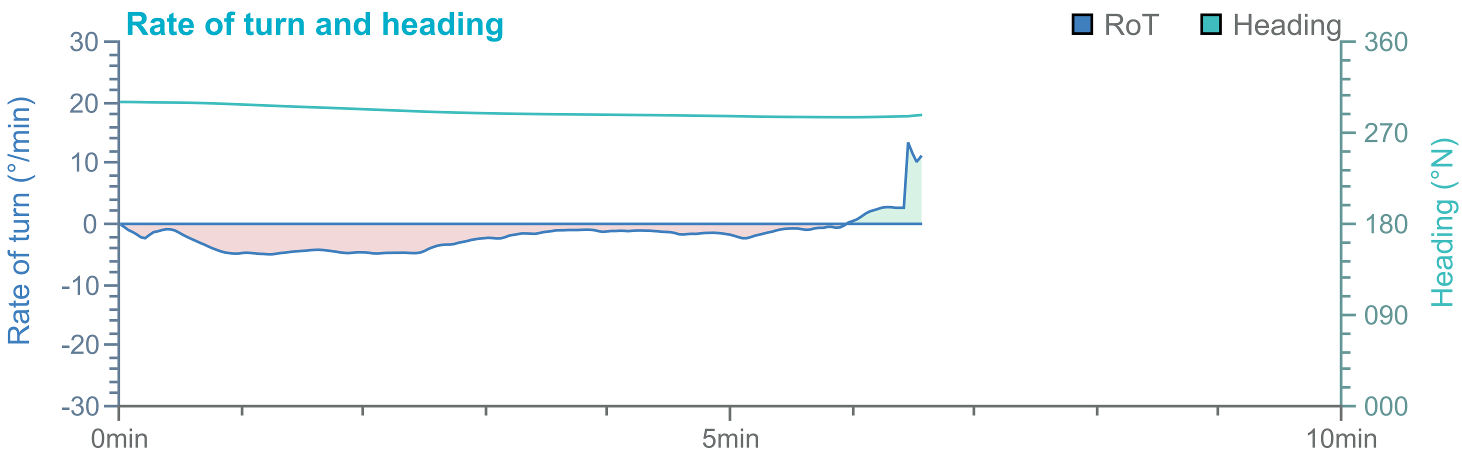


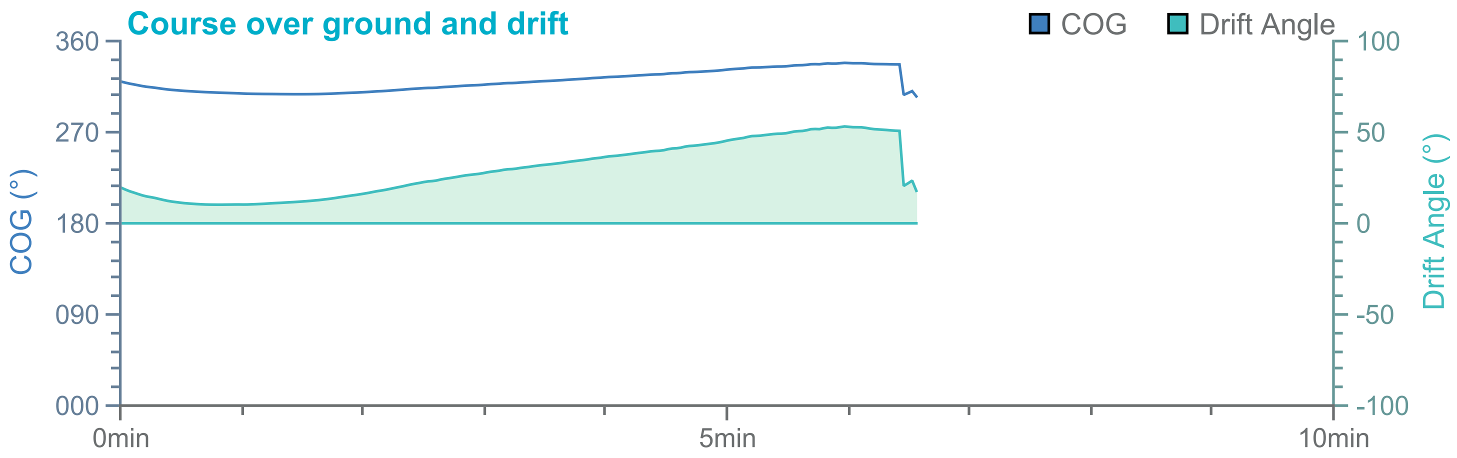
3.71 kts

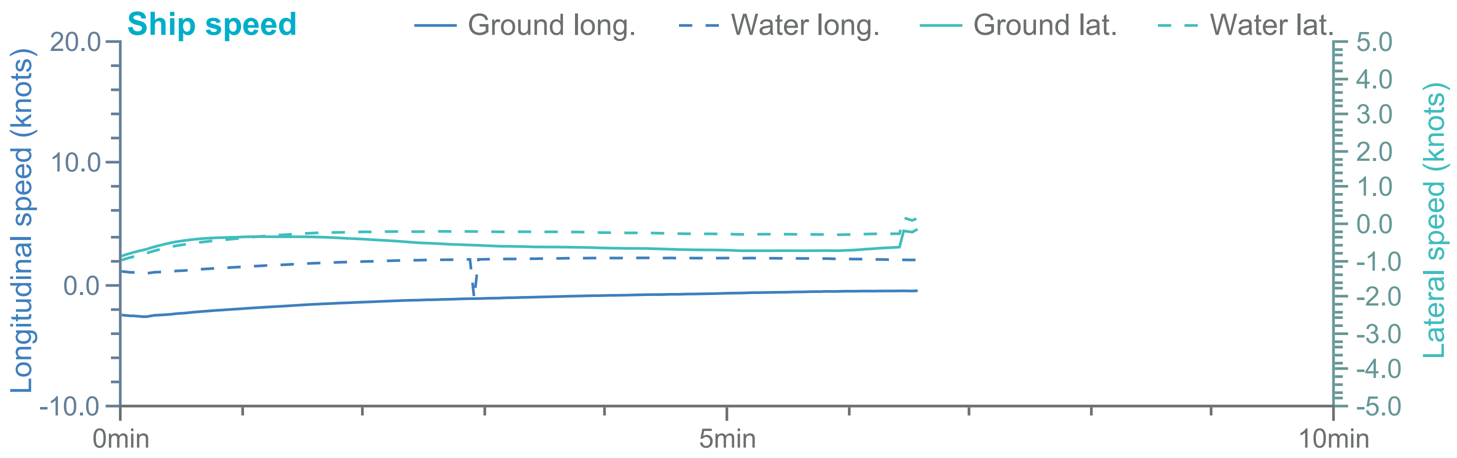
Ships plotted every 1 mins, highlight every 10 mins

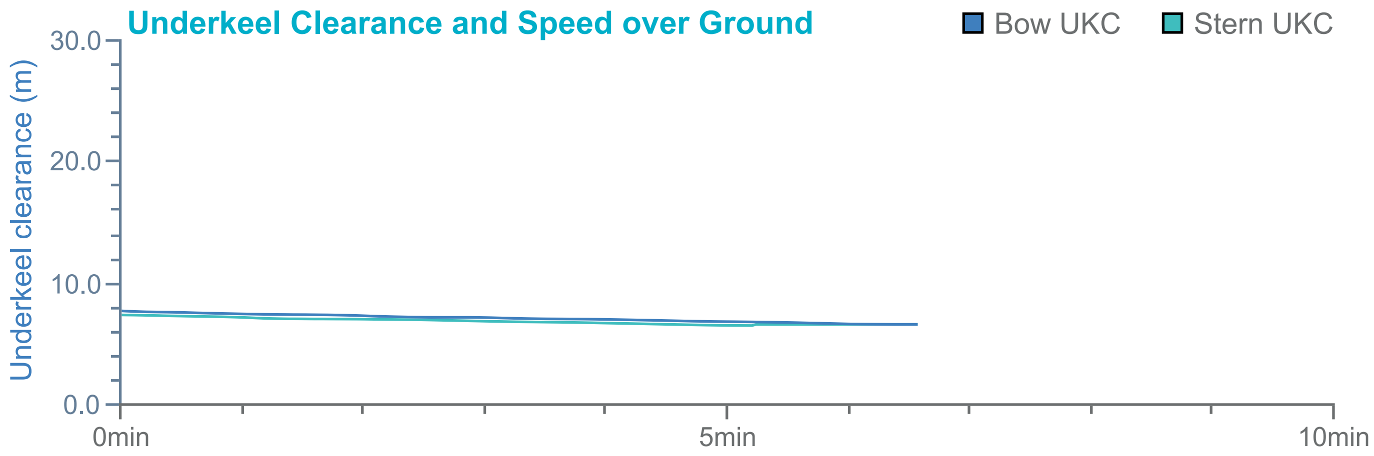

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
Current direction (°N)
360
270
180
090
000
0min
5min
10min

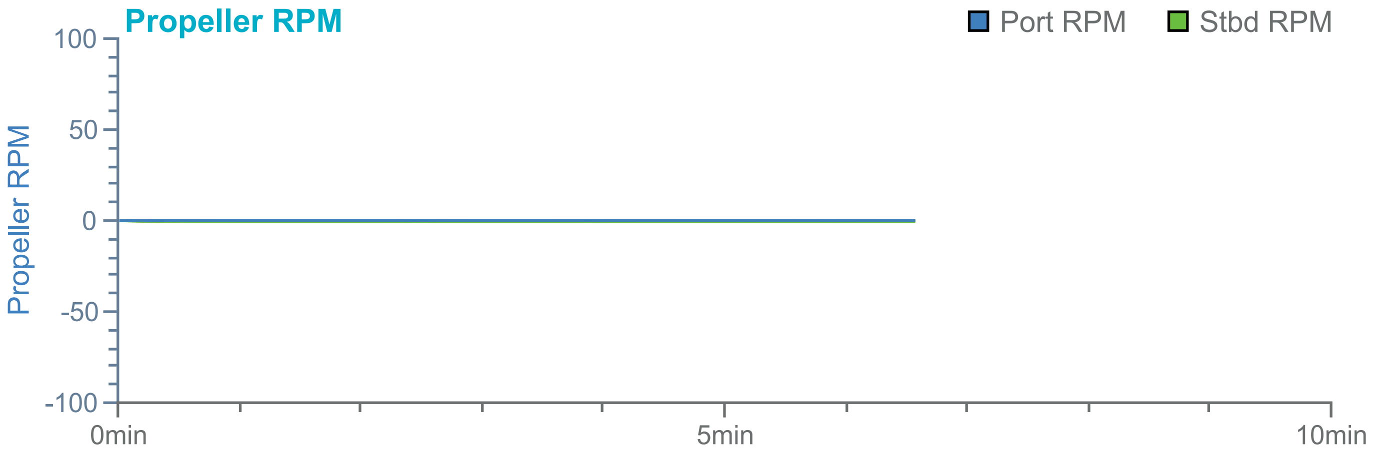

Wind speed and direction
Speed
Direction
Wind speed (knots)
40
30
20
10
0
Wind direction (°N)
360
270
180
090
000
0min
5min
10min

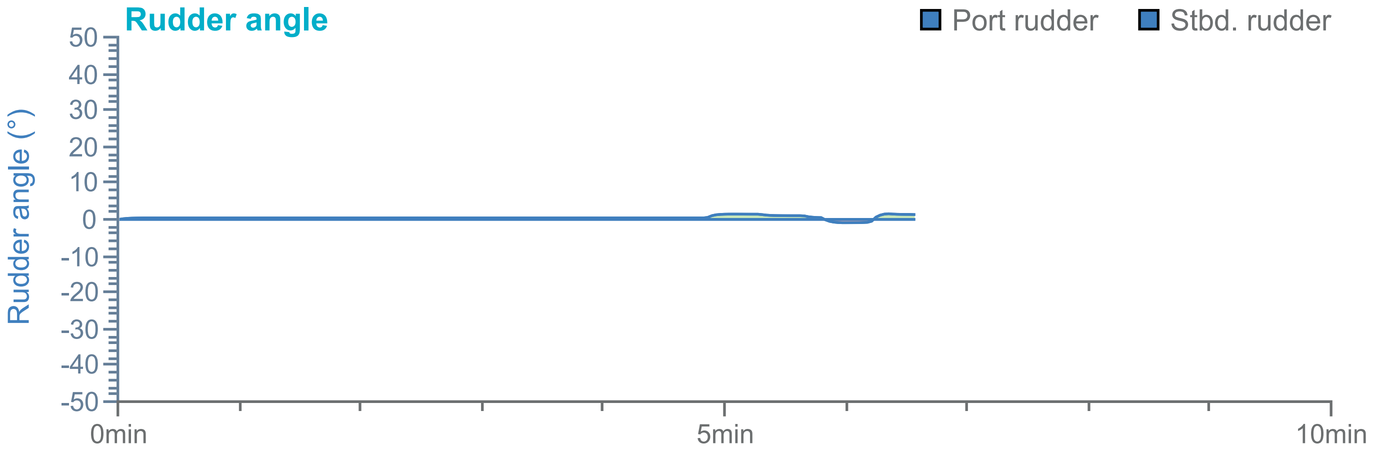

Rate of turn and heading

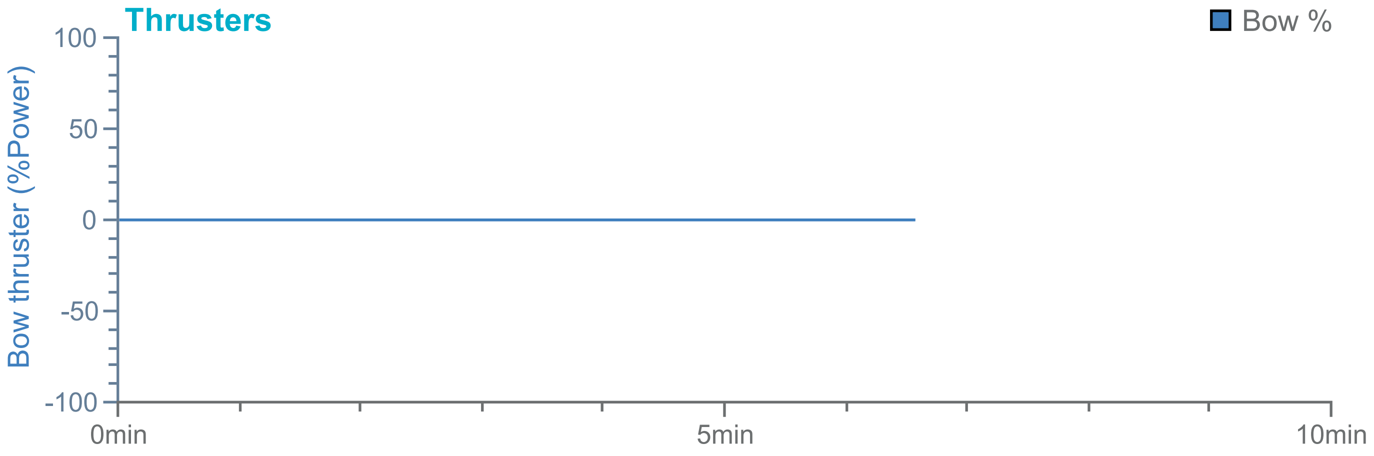

Course over ground and drift

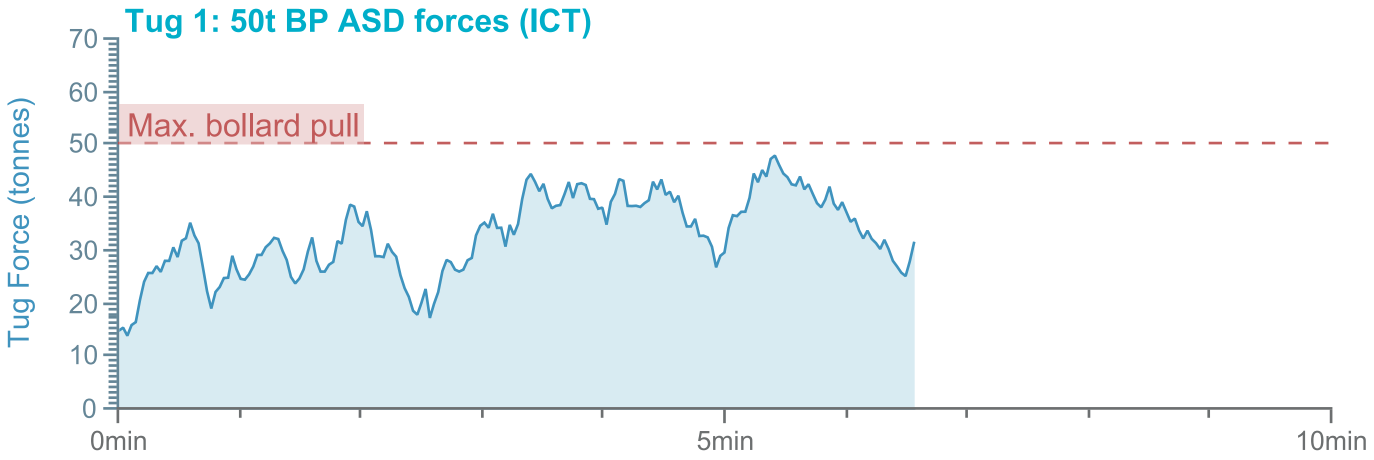

Ship speed


Underkeel Clearance and Speed over Ground

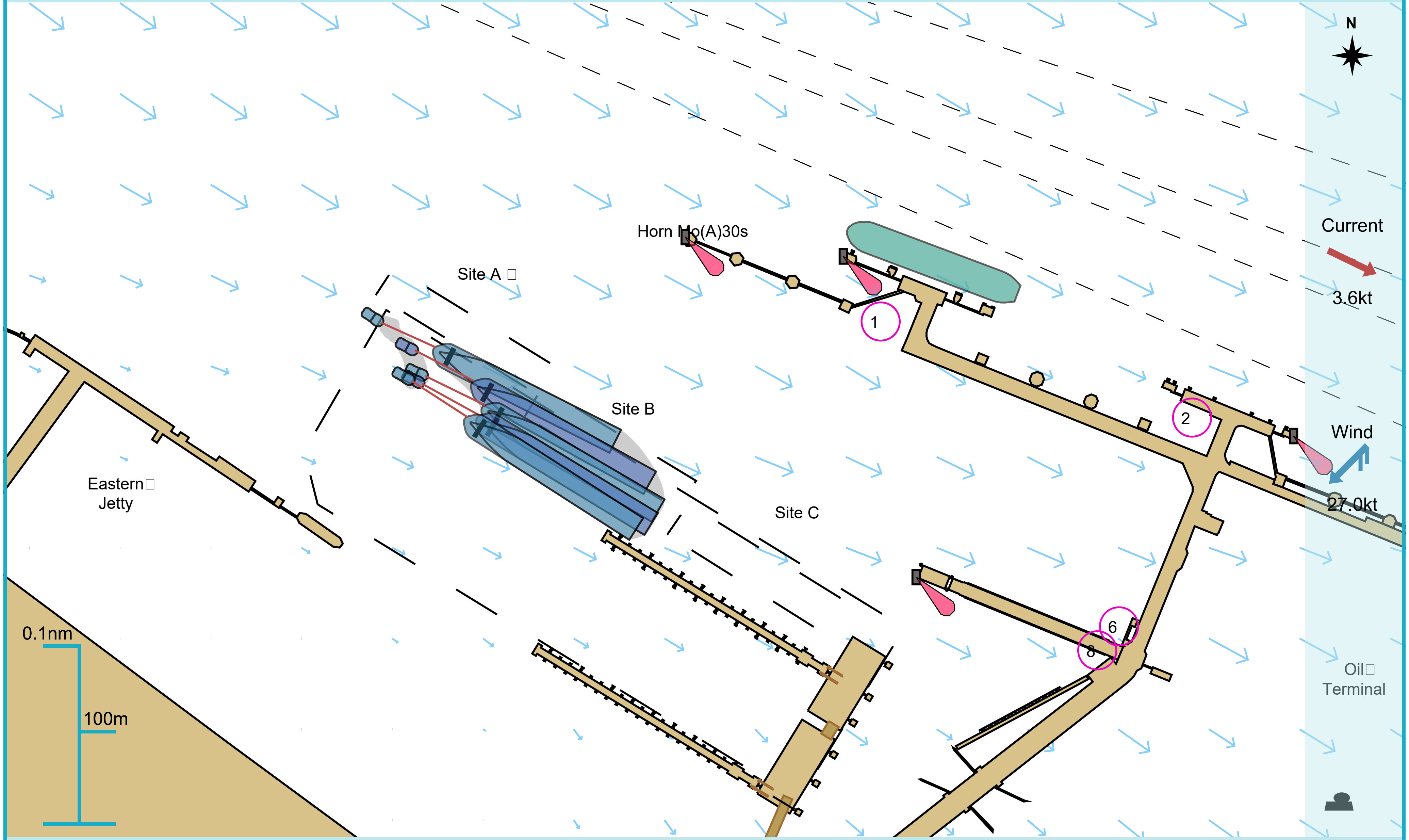

Propeller RPM
🟦 Port RPM
🟩 Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min


Rudder angle
🟦 Port rudder
🟦 Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
5min
10min


Thrusters
🟦 Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min

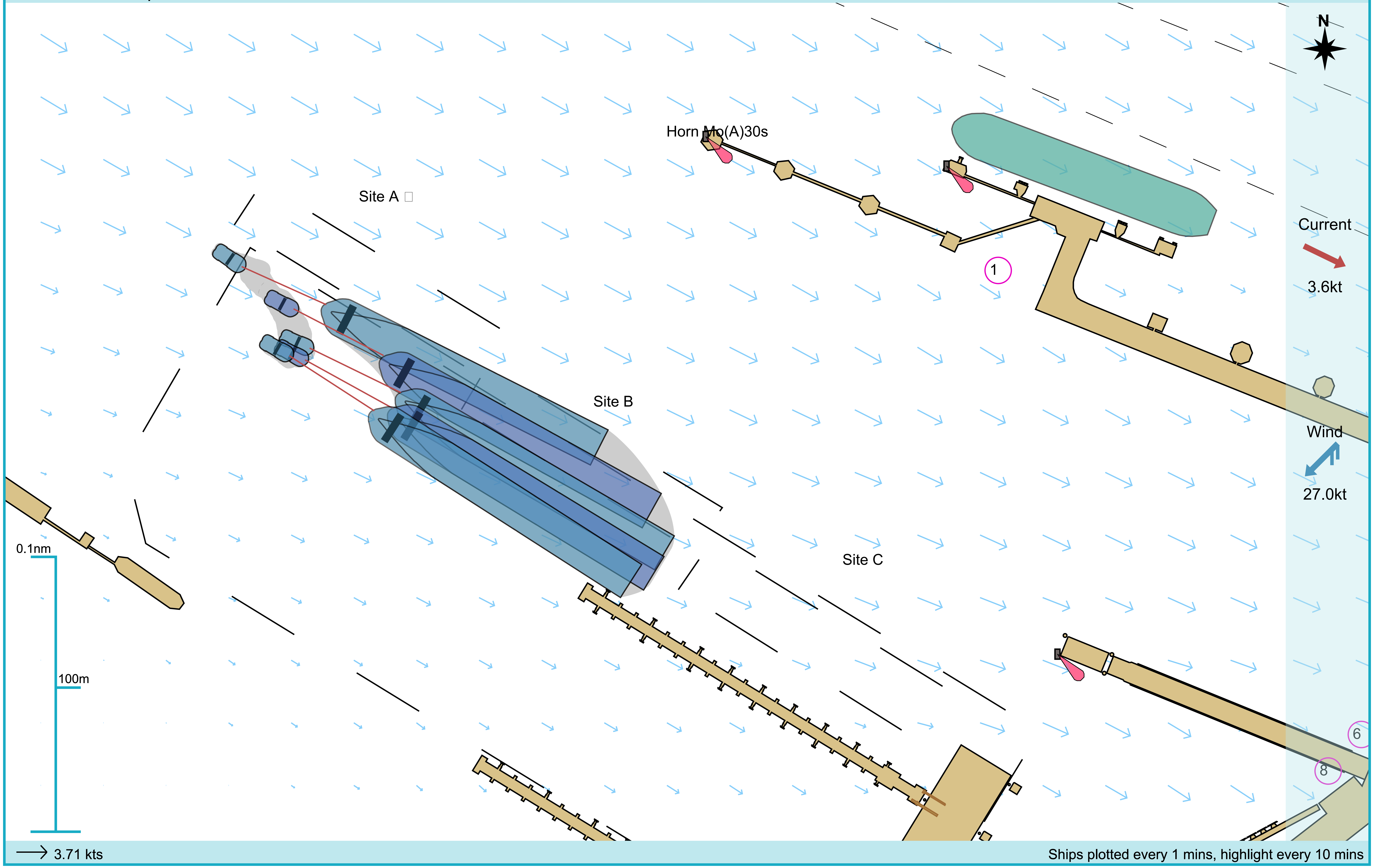

Tug 1: 50t BP ASD forces (ICT)
Tug Force (tonnes)
70
60
50
40
30
20
10
0
Max. bollard pull
0min
5min
10min

Manoeuvre track plot

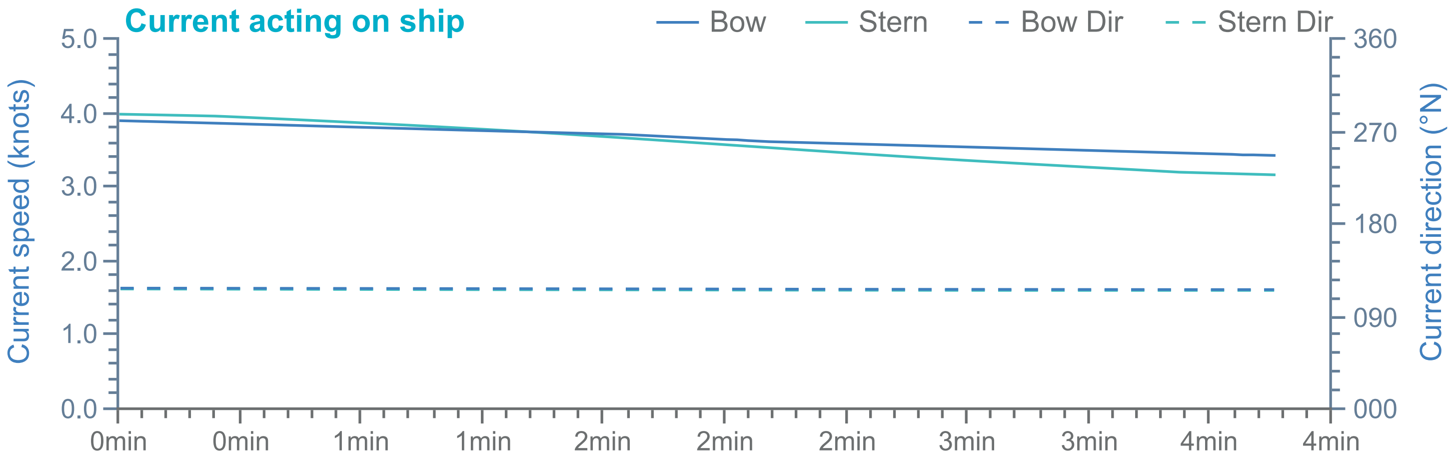


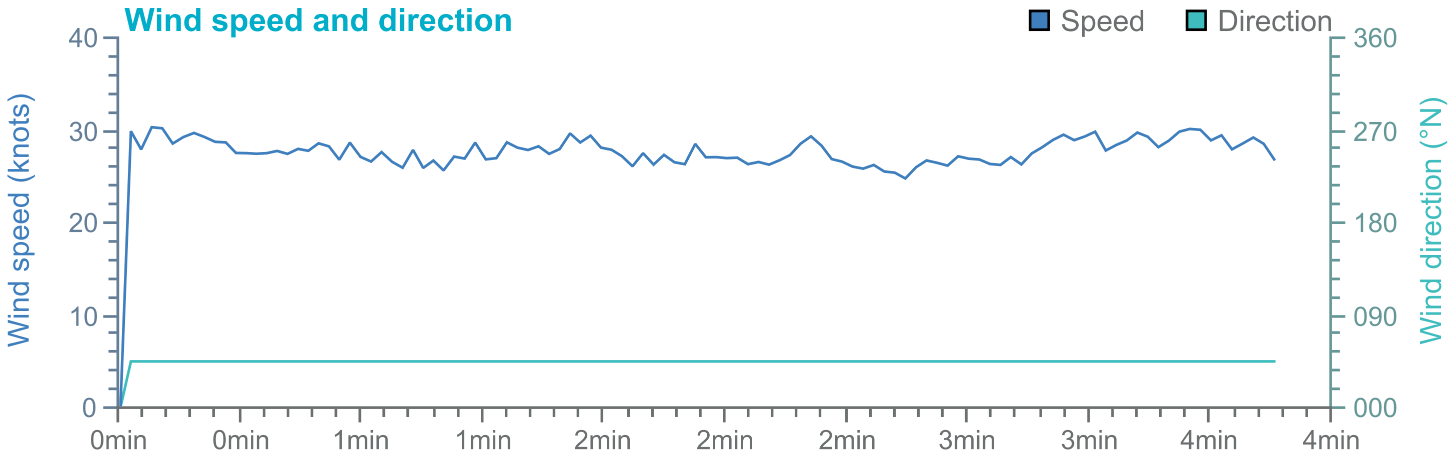
Ships plotted every 1 mins, highlight every 10 mins

Manoeuvre track plot

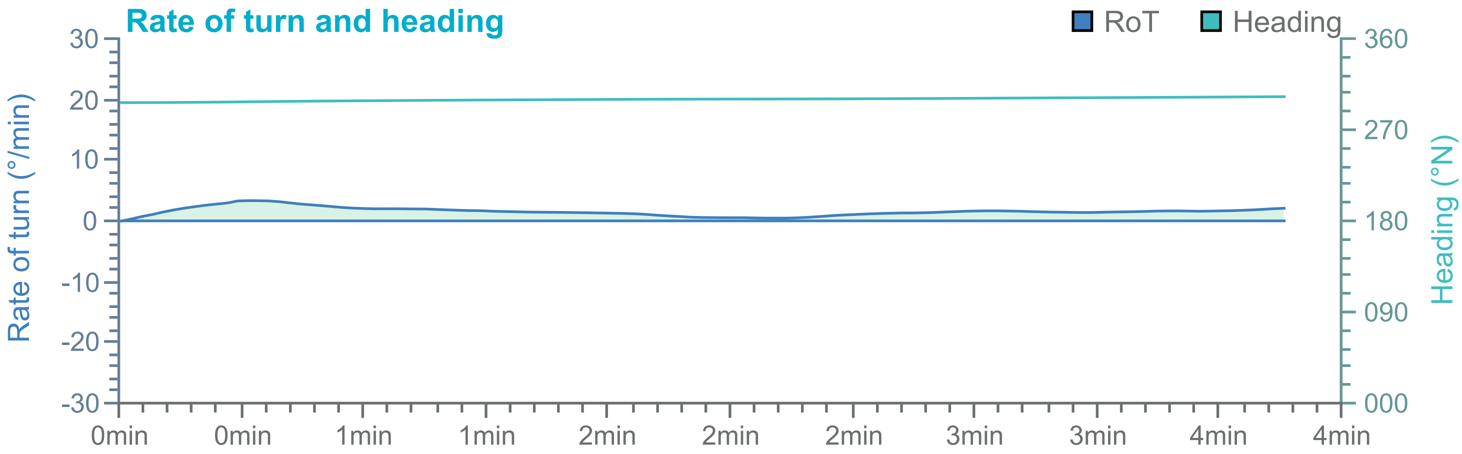


Ships plotted every 1 mins, highlight every 10 mins

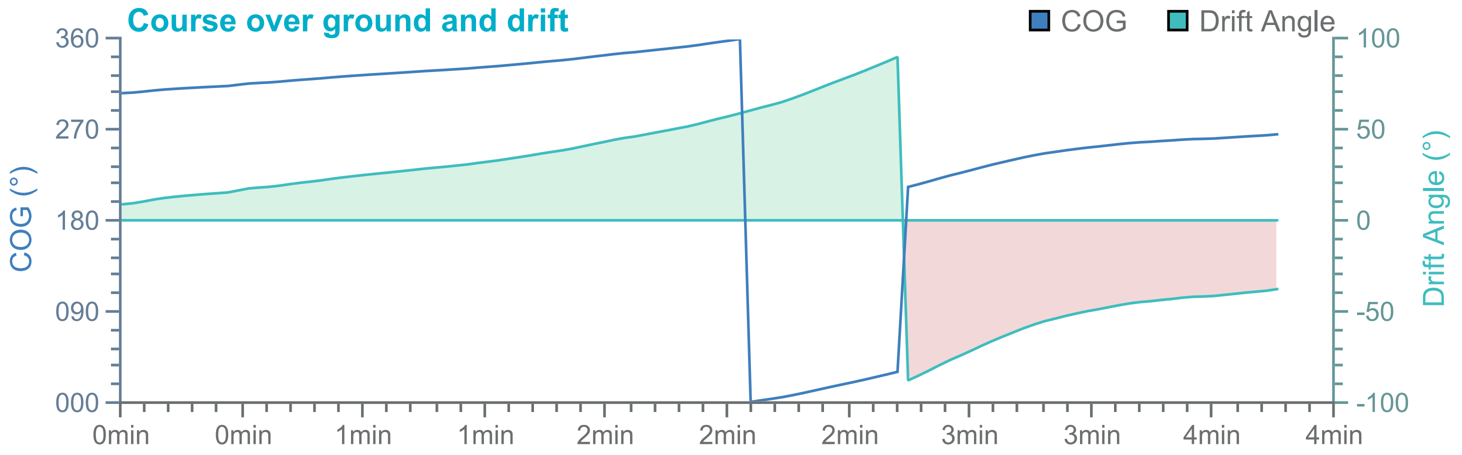

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
Current direction (°N)
360
270
180
090
000
0min
0min
1min
1min
2min
2min
2min
3min
3min
4min
4min


Wind speed and direction
Speed
Direction
Wind speed (knots)
40
30
20
10
0
Wind direction (°N)
360
270
180
090
000
0min
0min
1min
1min
2min
2min
2min
3min
3min
4min
4min

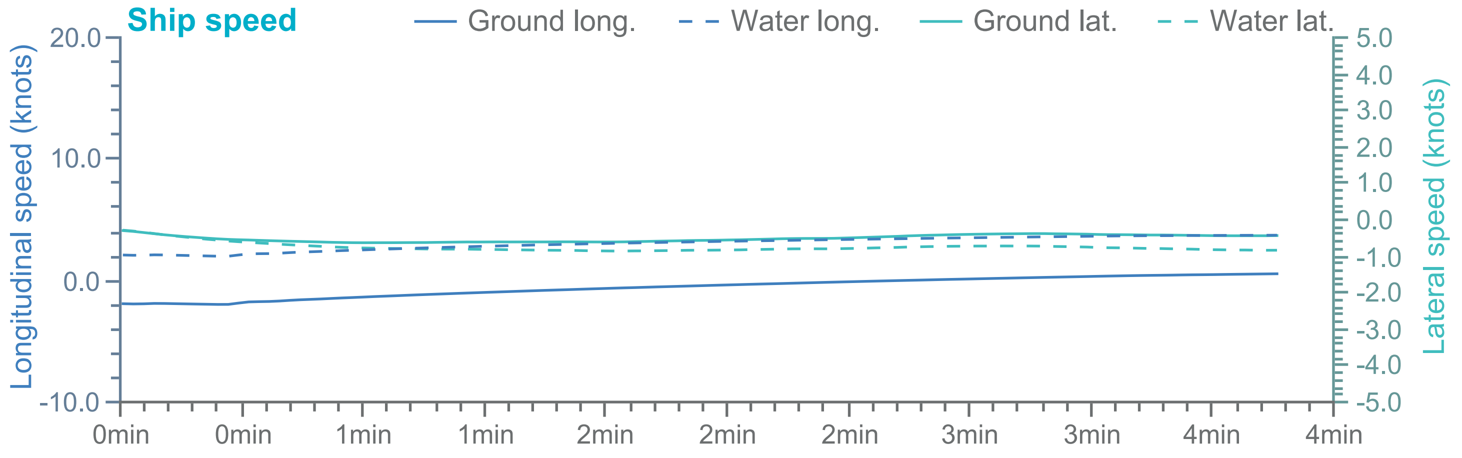
Rate of turn and heading



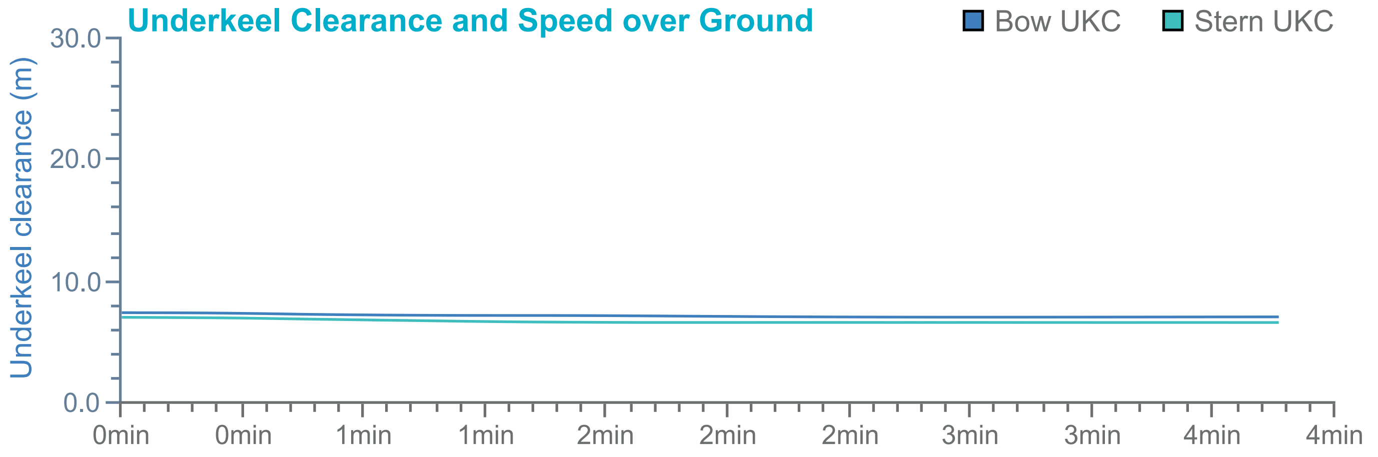
Course over ground and drift

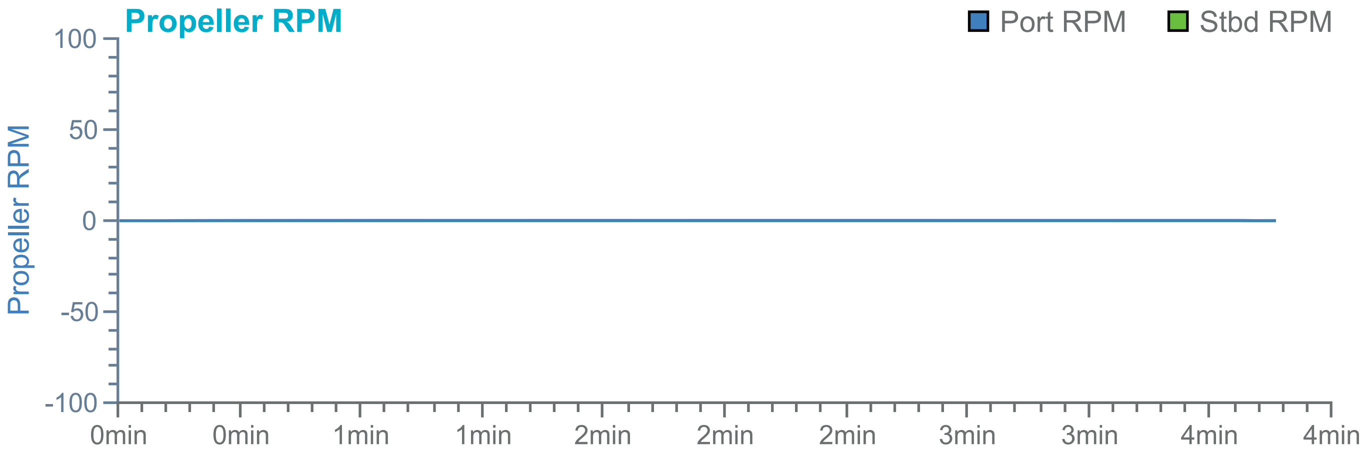


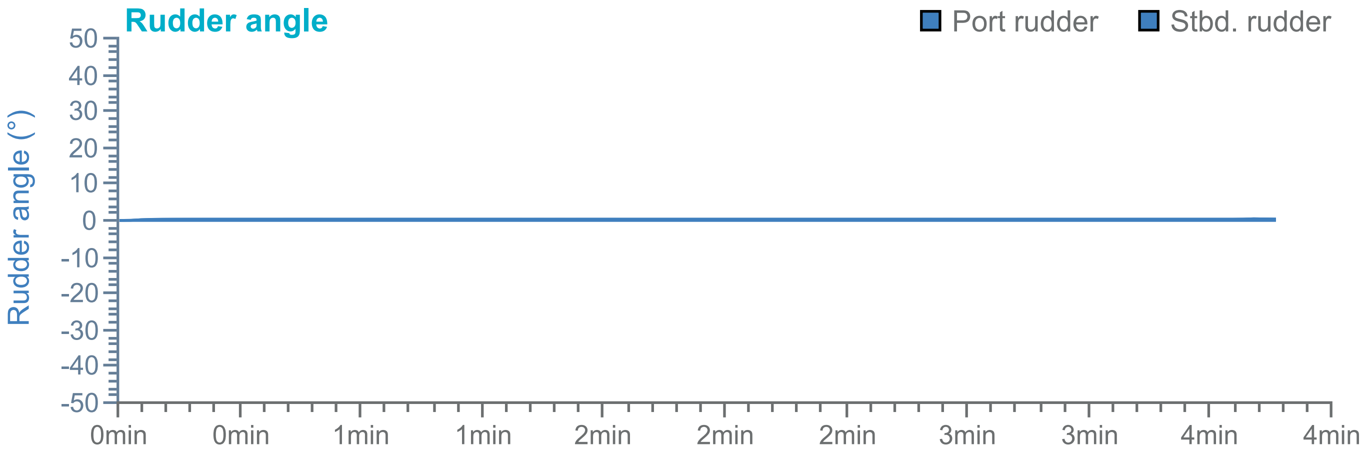
Ship speed

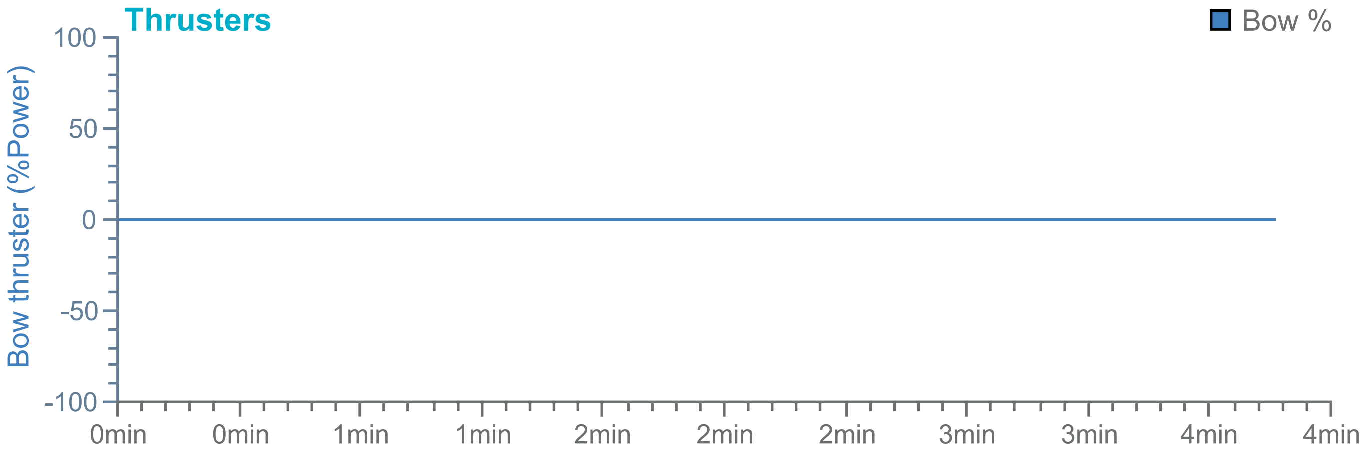


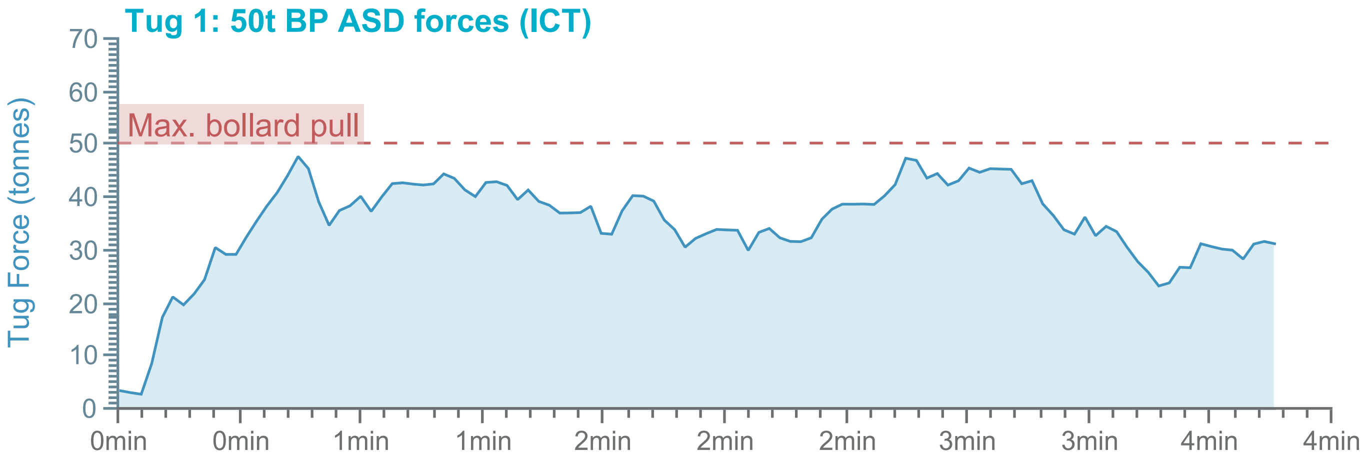
Underkeel Clearance and Speed over Ground



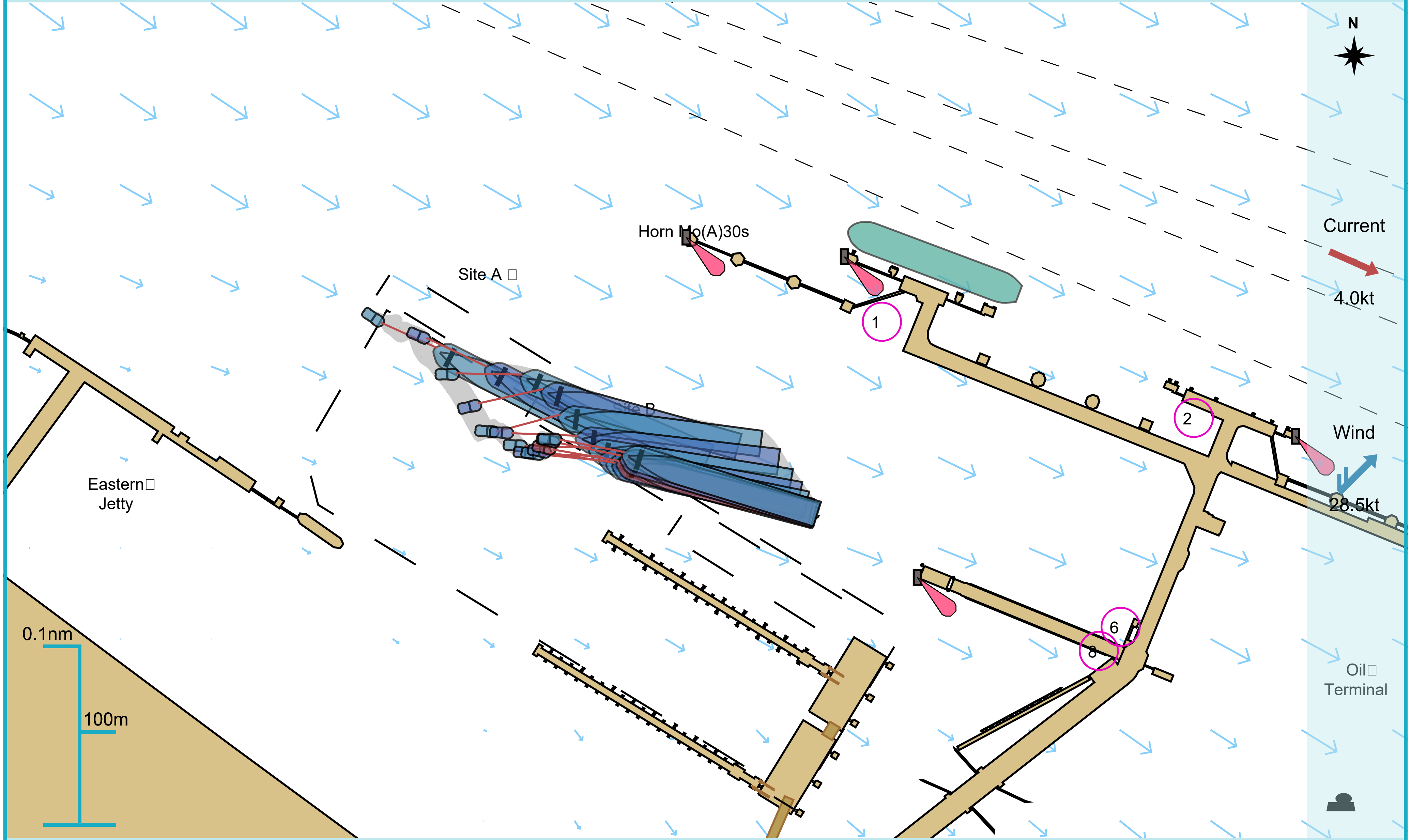

Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
0min
1min
1min
2min
2min
2min
3min
3min
4min
4min


Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
0min
1min
1min
2min
2min
2min
3min
3min
4min
4min


Thrusters
Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0min
0min
1min
1min
2min
2min
2min
3min
3min
4min
4min

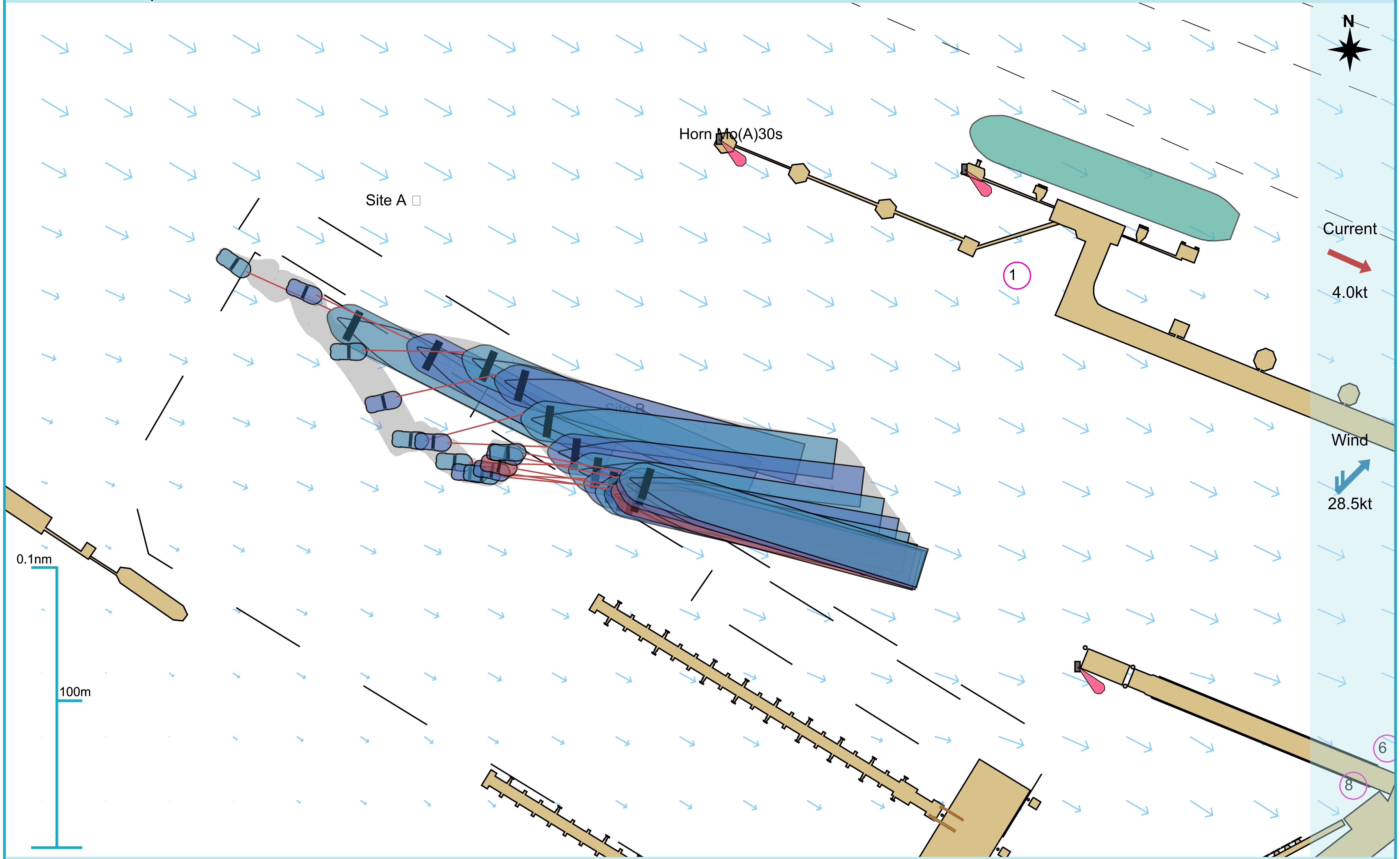

Tug 1: 50t BP ASD forces (ICT)
Tug Force (tonnes)
Max. bollard pull
70
60
50
40
30
20
10
0
0min
0min
1min
1min
2min
2min
2min
3min
3min
4min
4min

Manoeuvre track plot



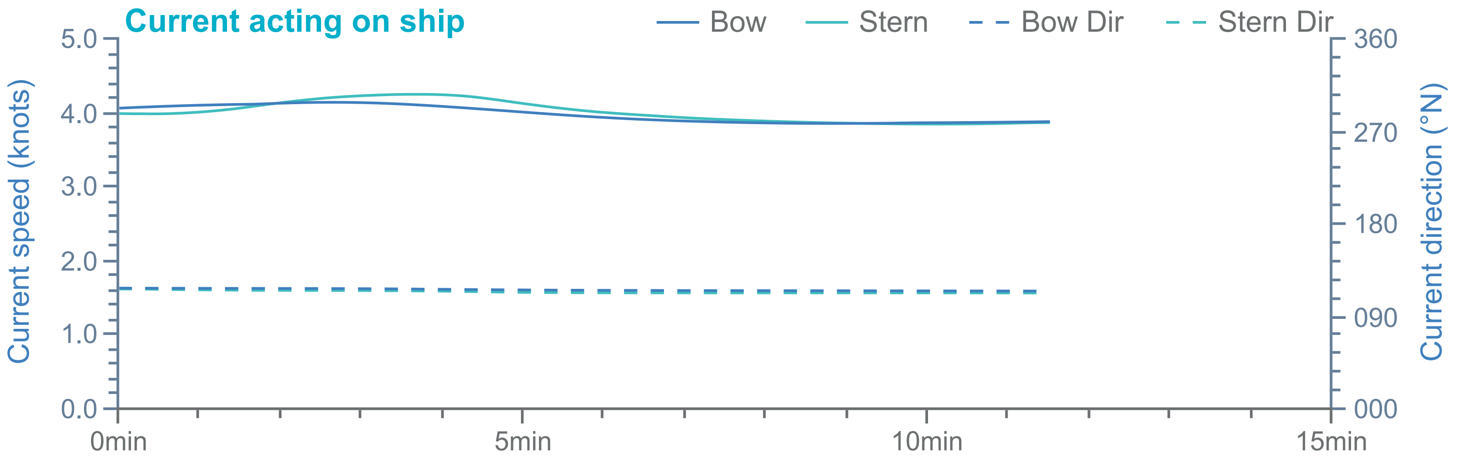
Ships plotted every 1 mins, highlight every 10 mins

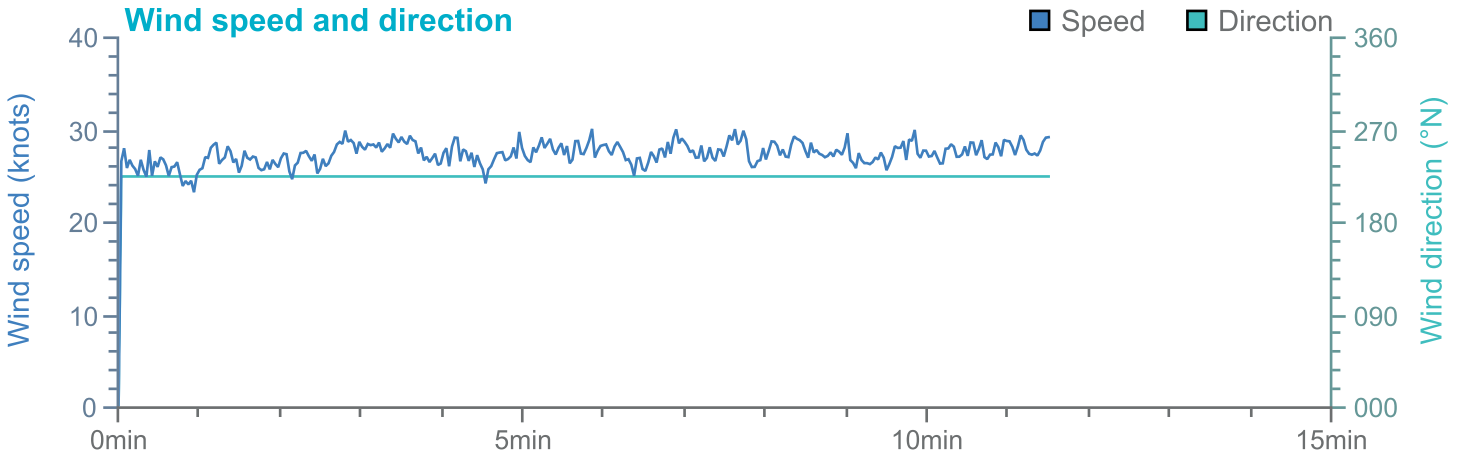
Manoeuvre track plot

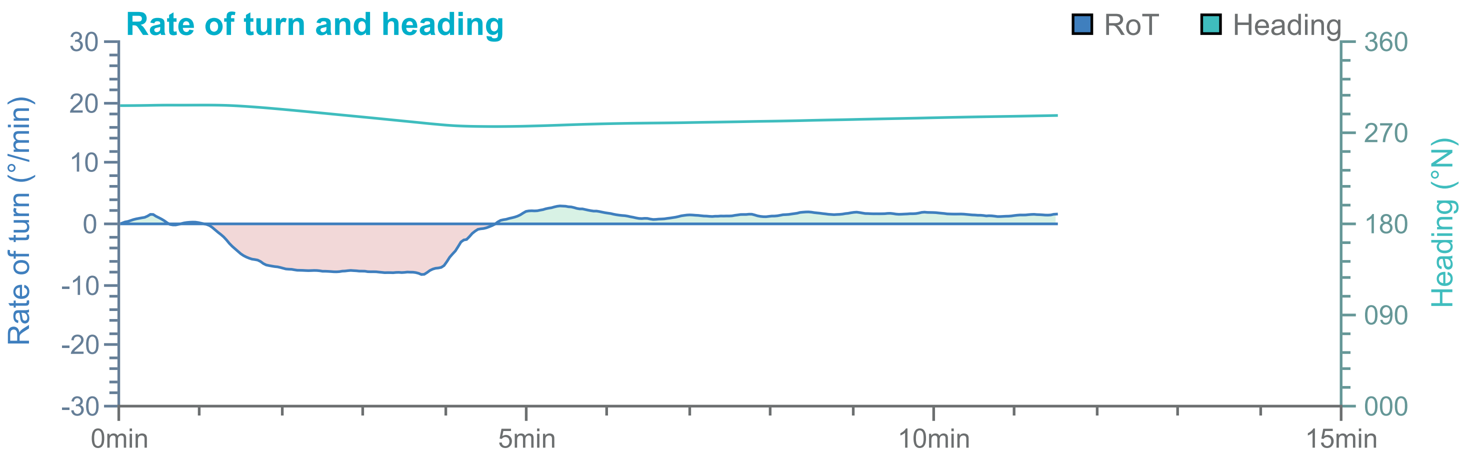


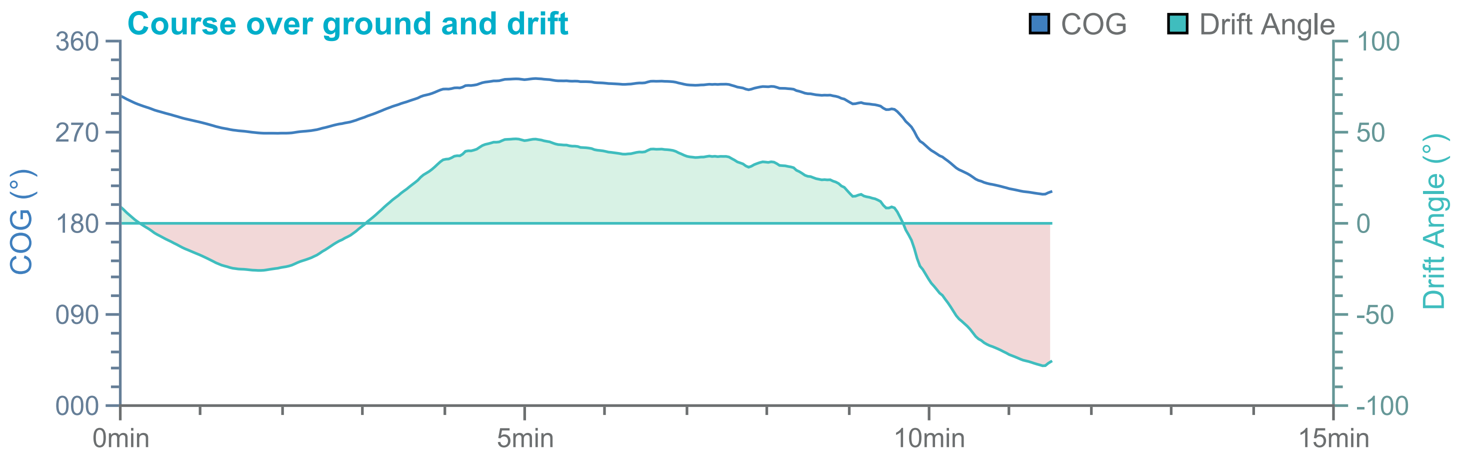
→ 3.71 kts

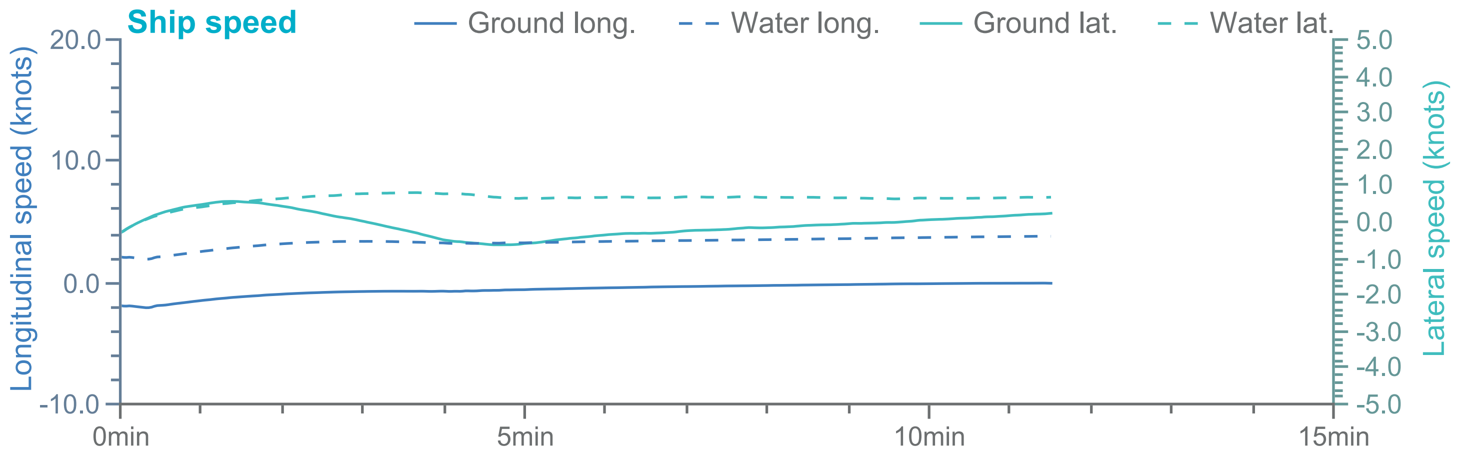
Ships plotted every 1 mins, highlight every 10 mins

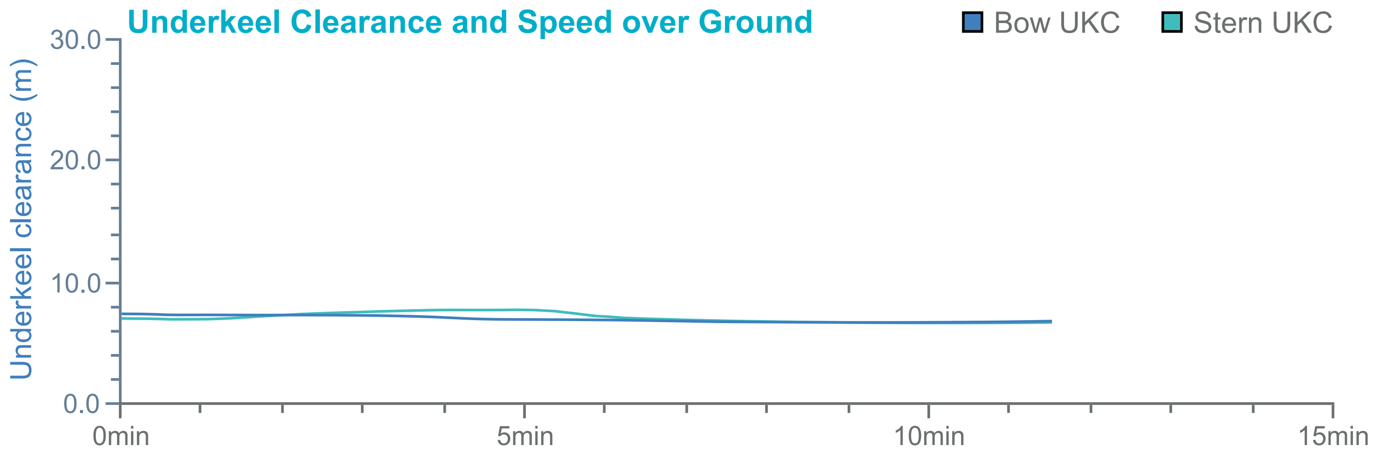

Current acting on ship

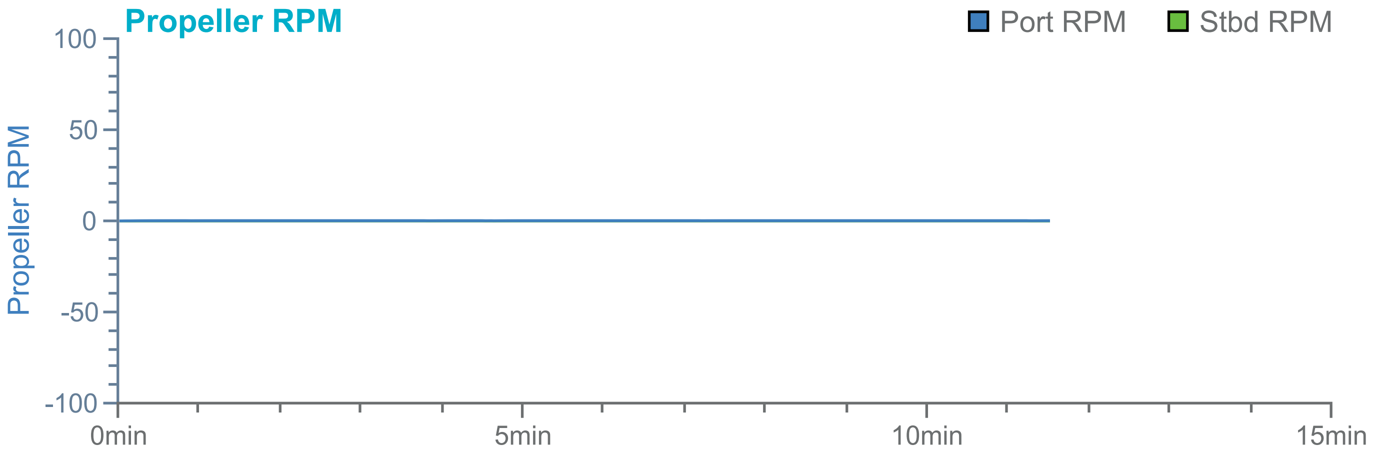

Wind speed and direction

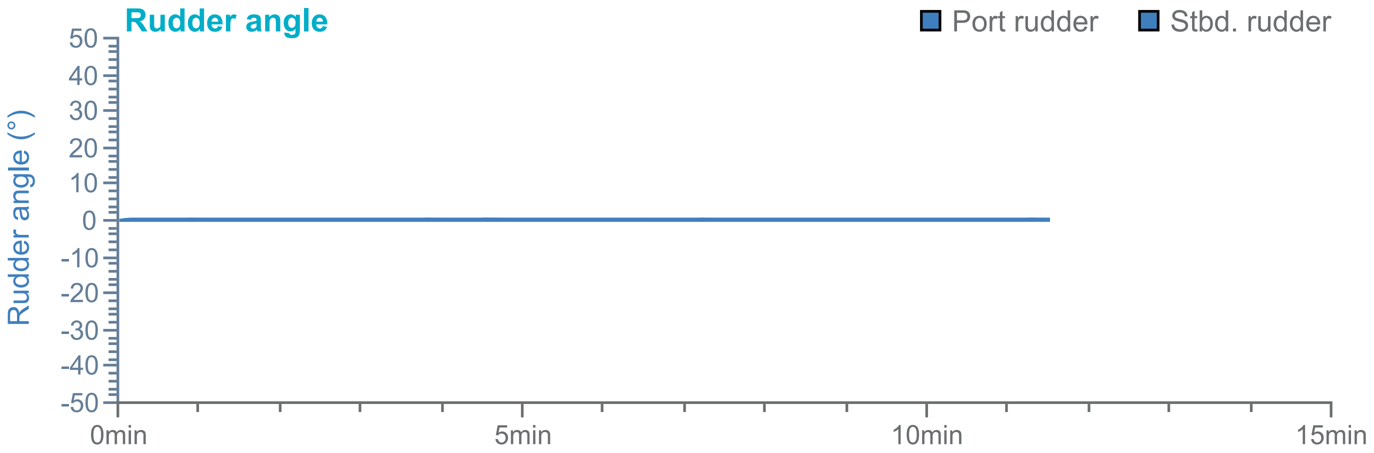

Rate of turn and heading

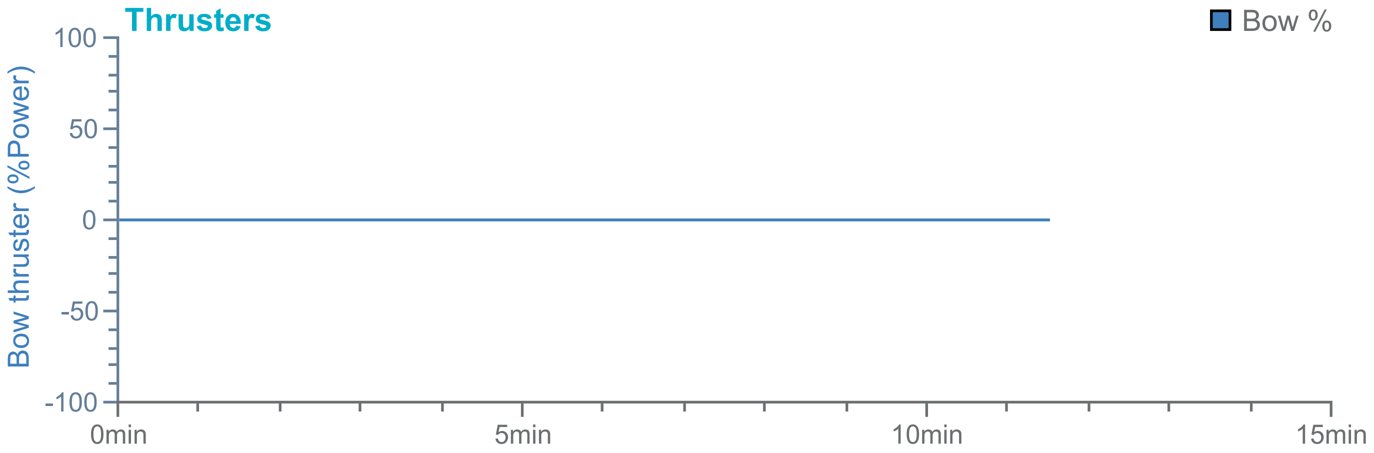

Course over ground and drift


Ship speed


Underkeel Clearance and Speed over Ground

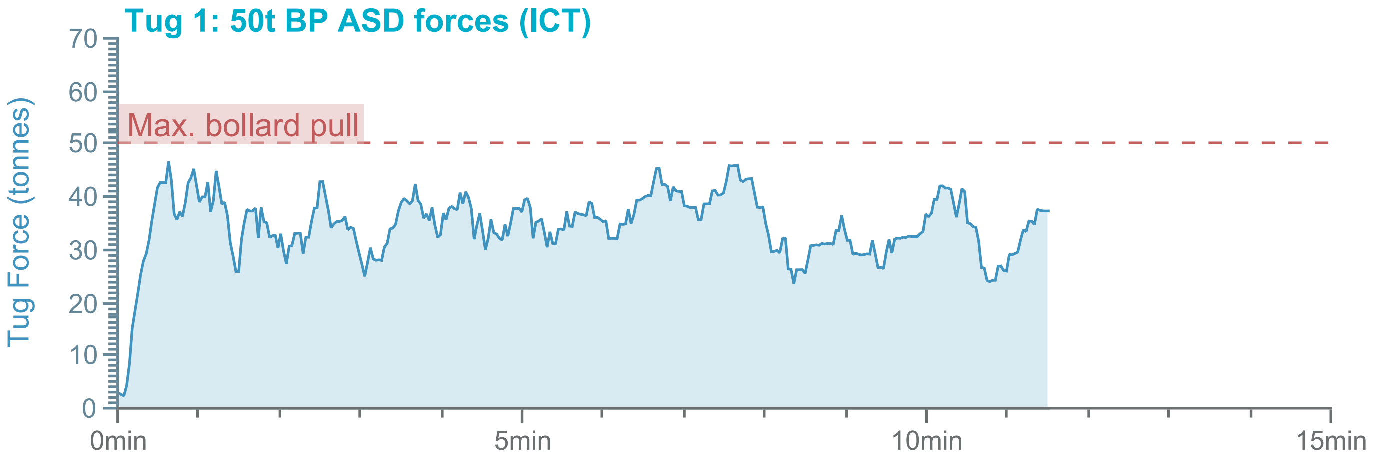






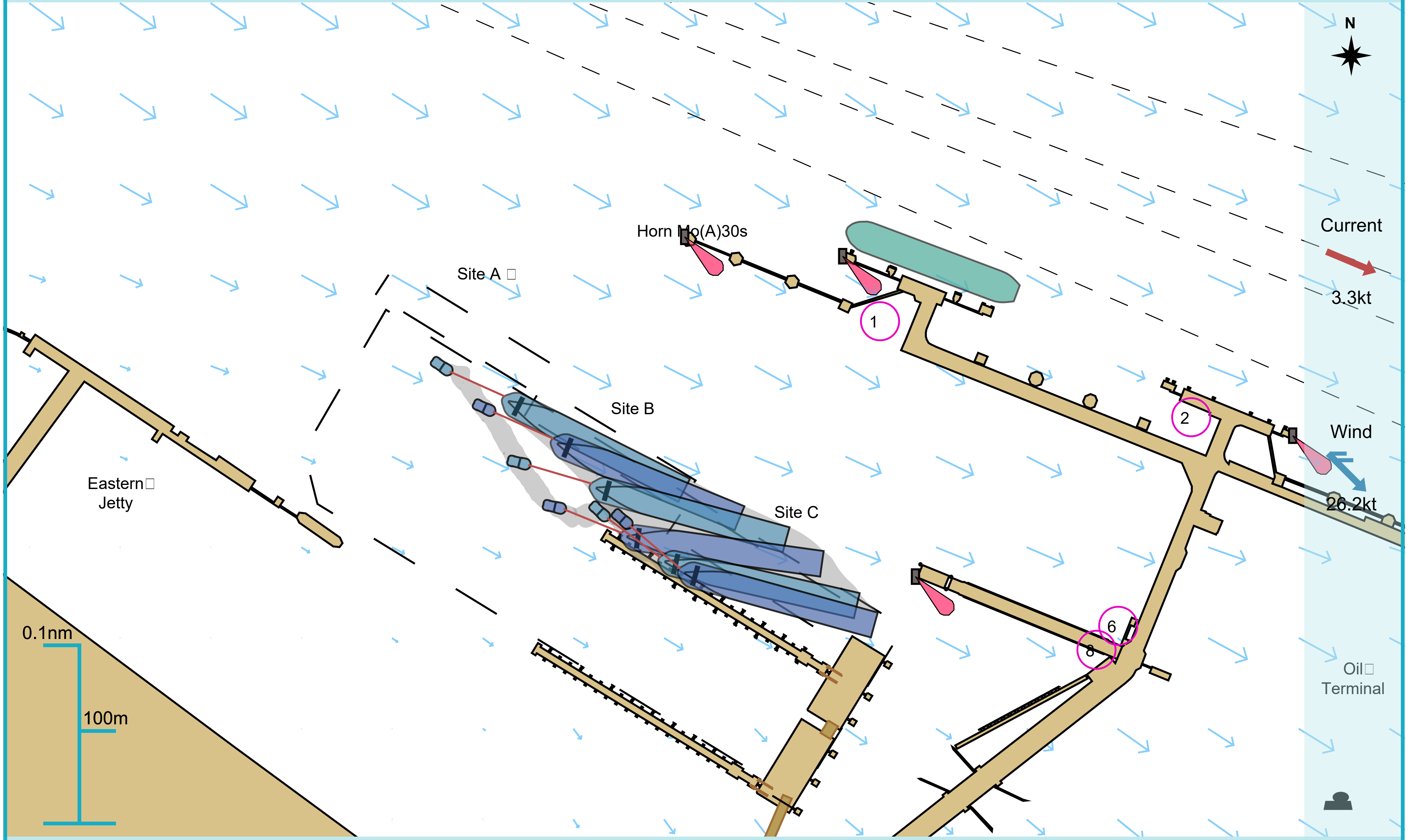
Pilot: JMS
Manoeuvre: Other

Ship: Stena Transporter


Tug 1: 50t BP ASD forces (ICT)
Tug Force (tonnes)
70
60
50
40
30
20
10
0
Max. bollard pull
0min
5min
10min
15min

Project: Humber
Session: DJR6612_13-14_December 2023
Configuration: Peak_Spring - no piles
Run: 06a

Manoeuvre track plot

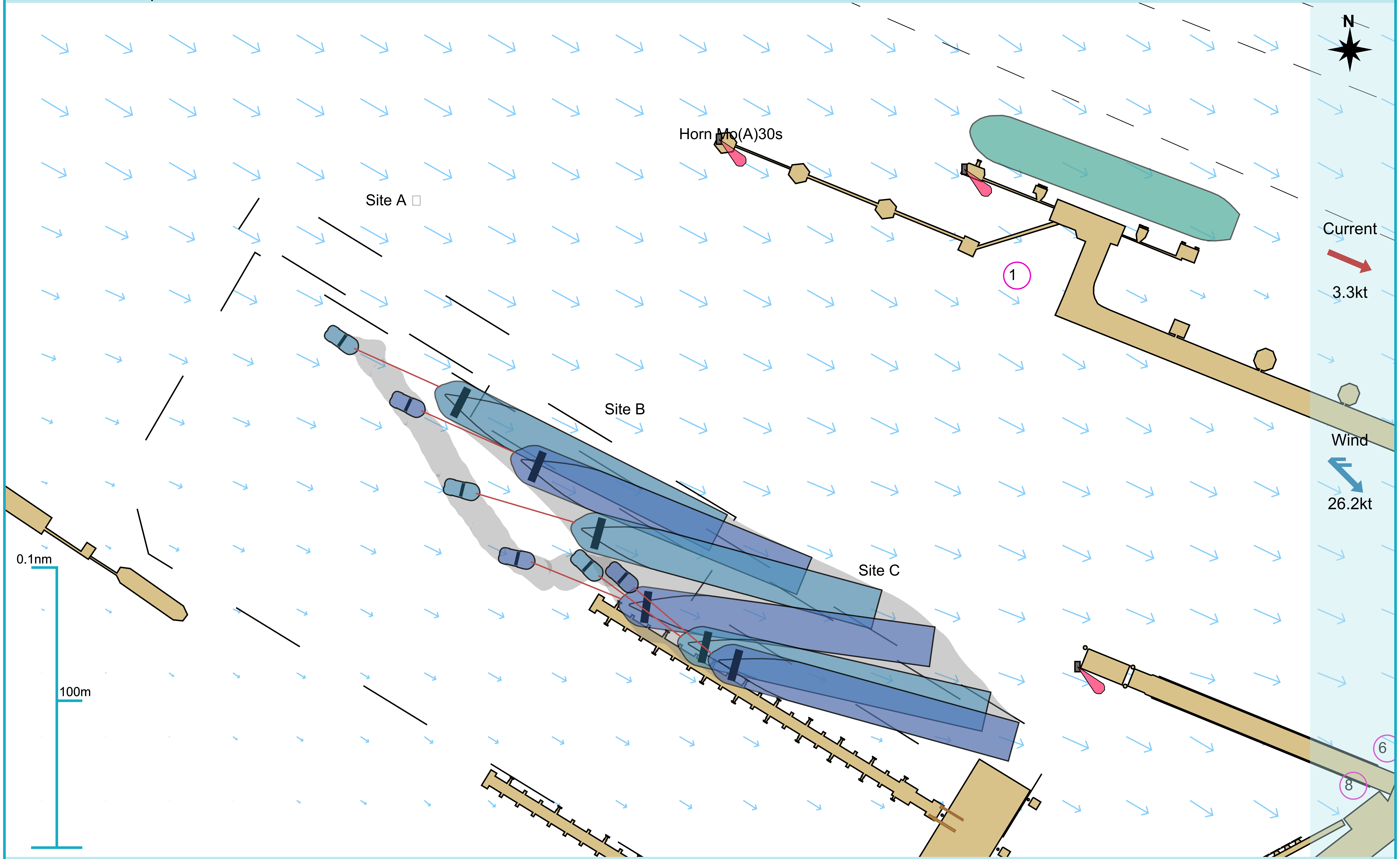


Ships plotted every 1 mins, highlight every 10 mins

Pilot: JMS
Manoeuvre: Other

Overview | Environment | Stena Transporter | Tugs

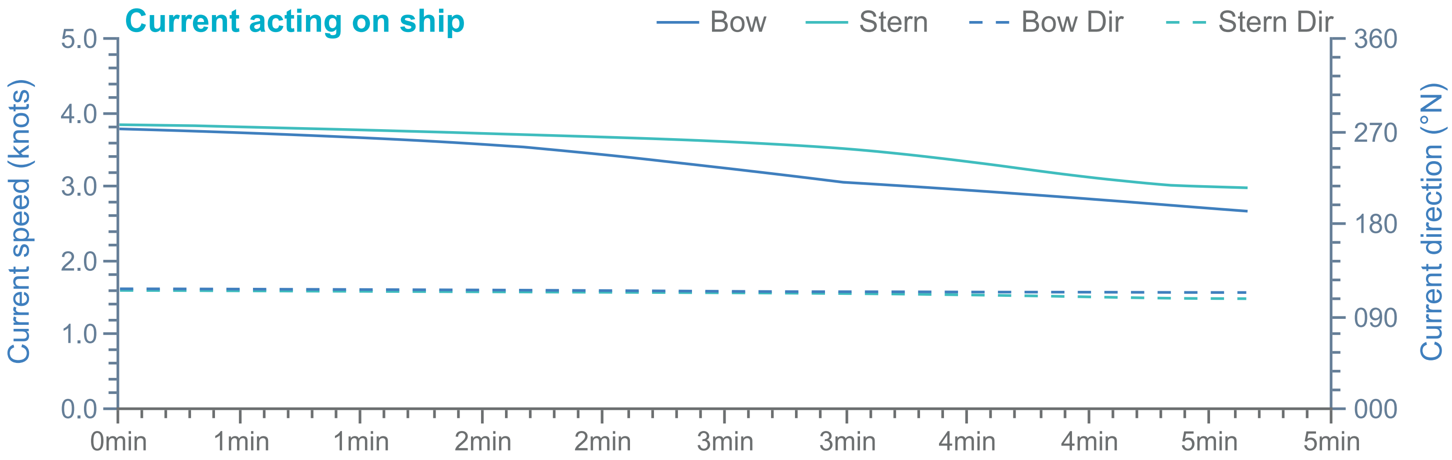
Manoeuvre track plot



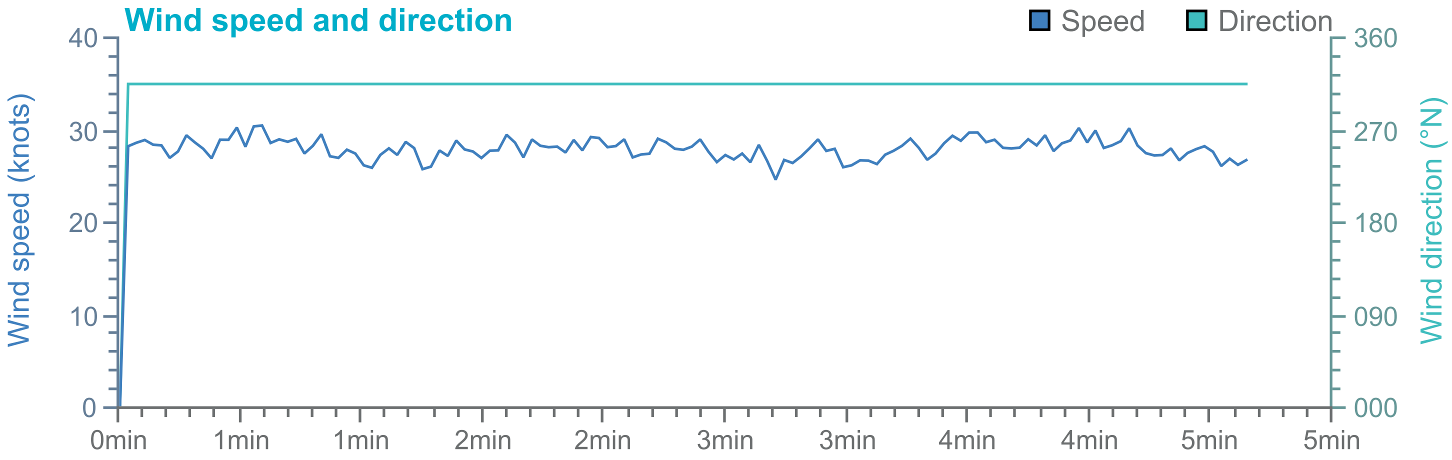
→ 3.71 kts

Ships plotted every 1 mins, highlight every 10 mins

Current acting on ship

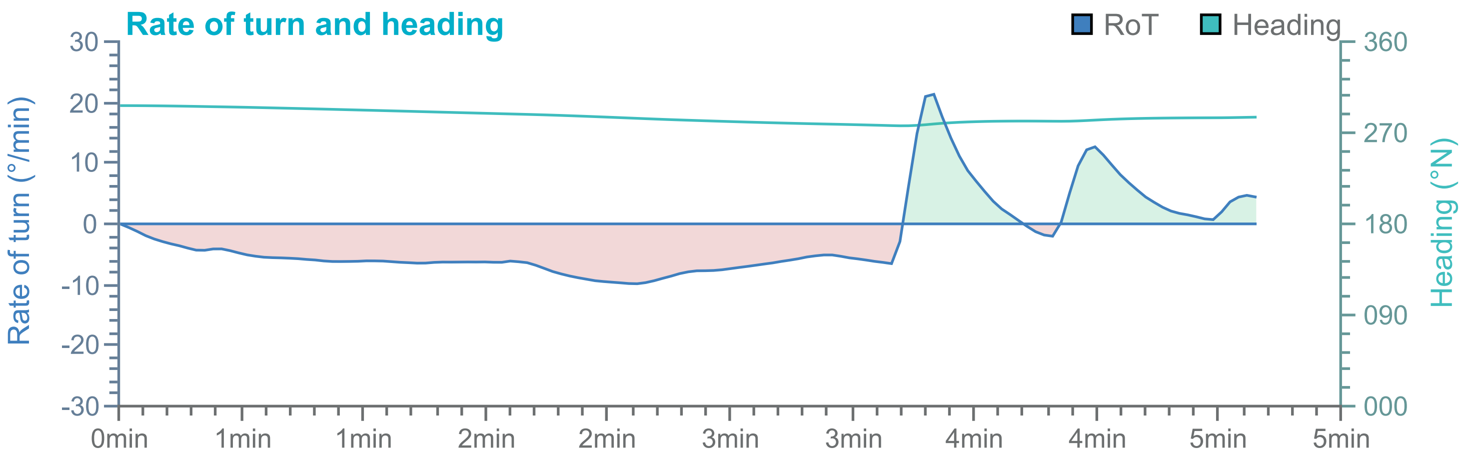


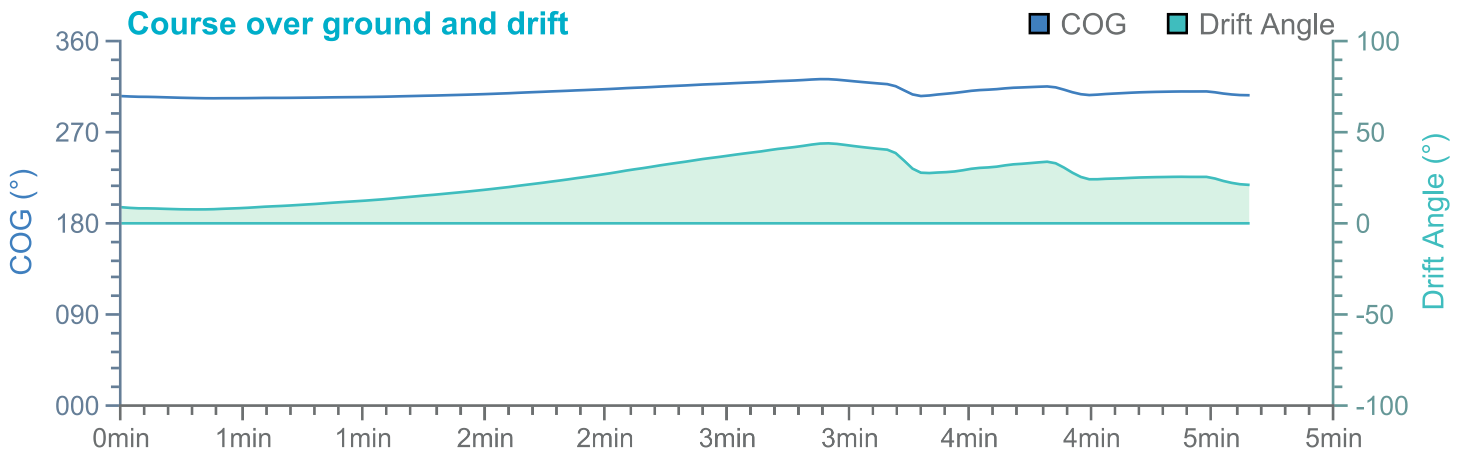
Wind speed and direction

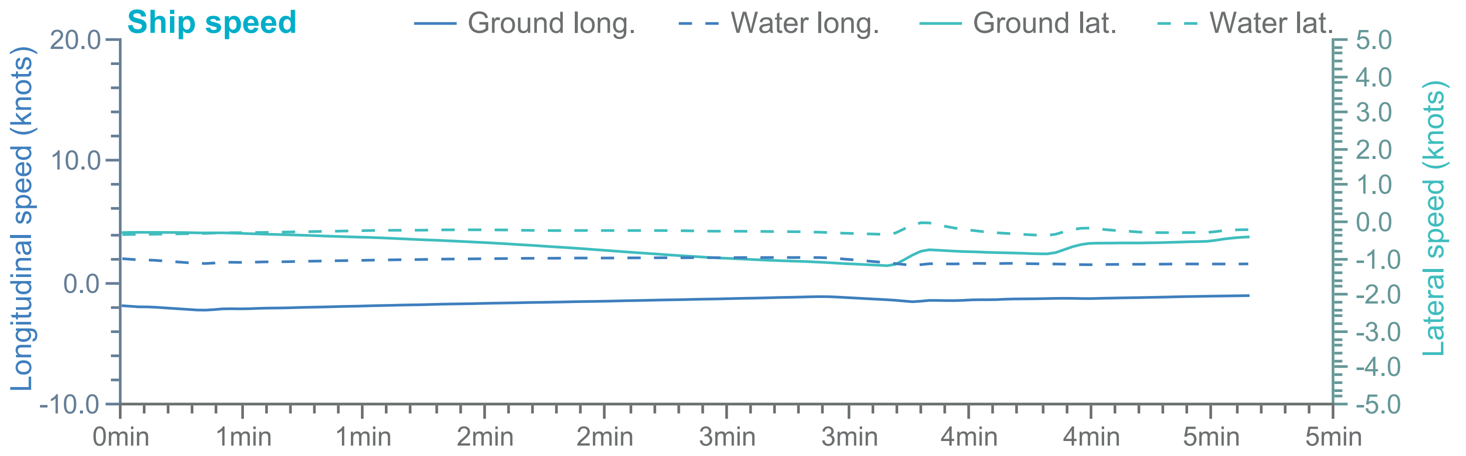


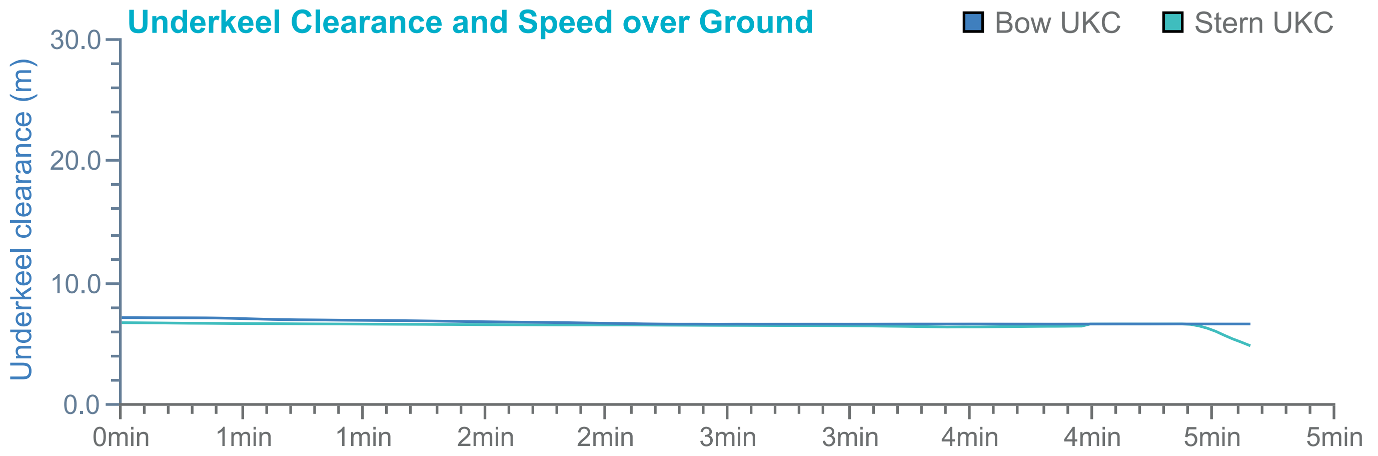
Project: Humber
Session: DJR6612_13-14_December 2023
Configuration: Peak_Spring - no piles
Run: 06a

Overview | Environment | **Stena Transporter** | Tugs



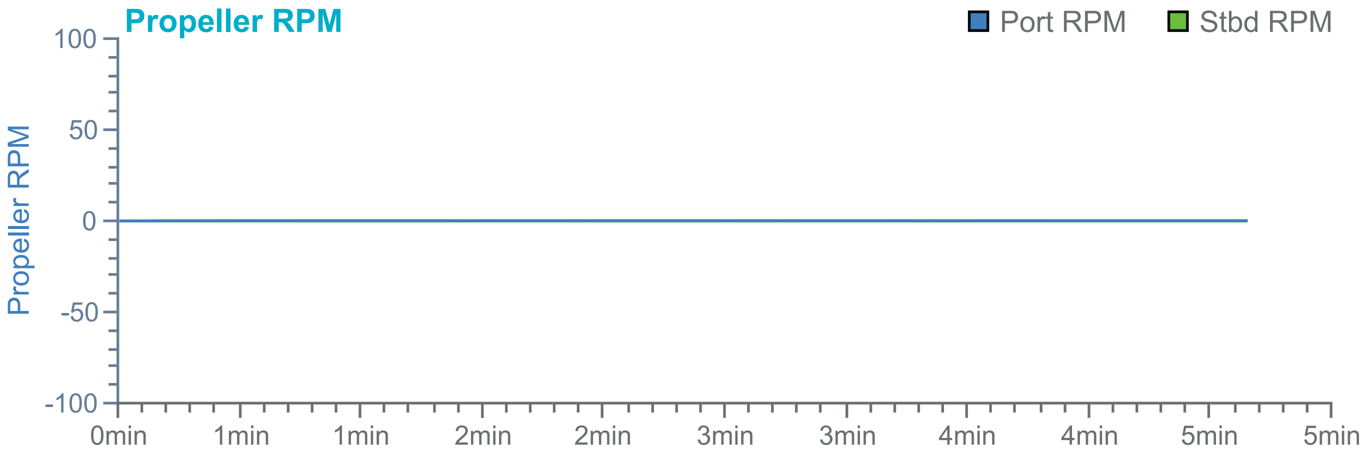


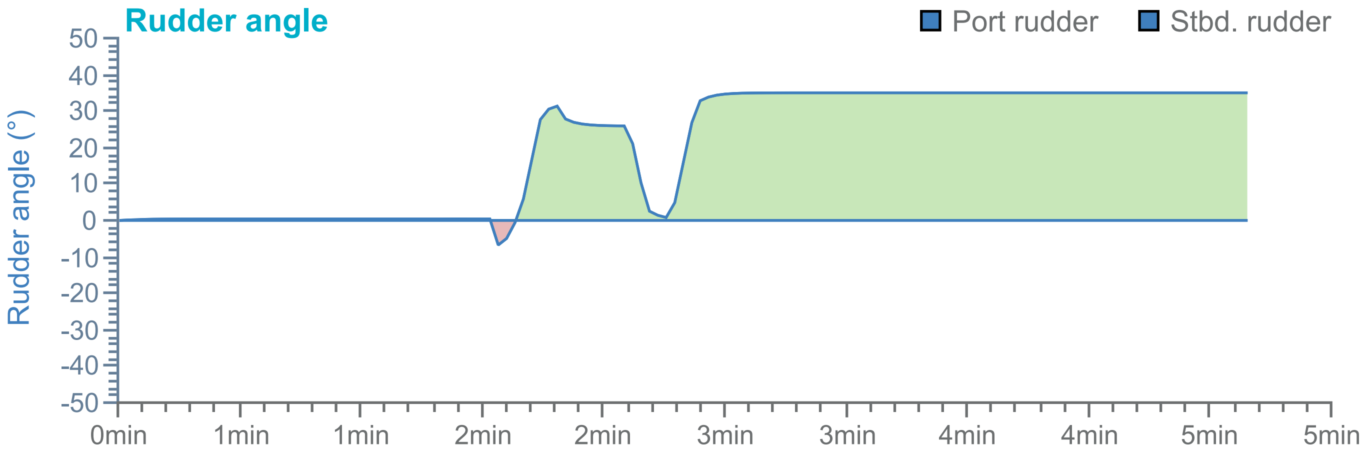


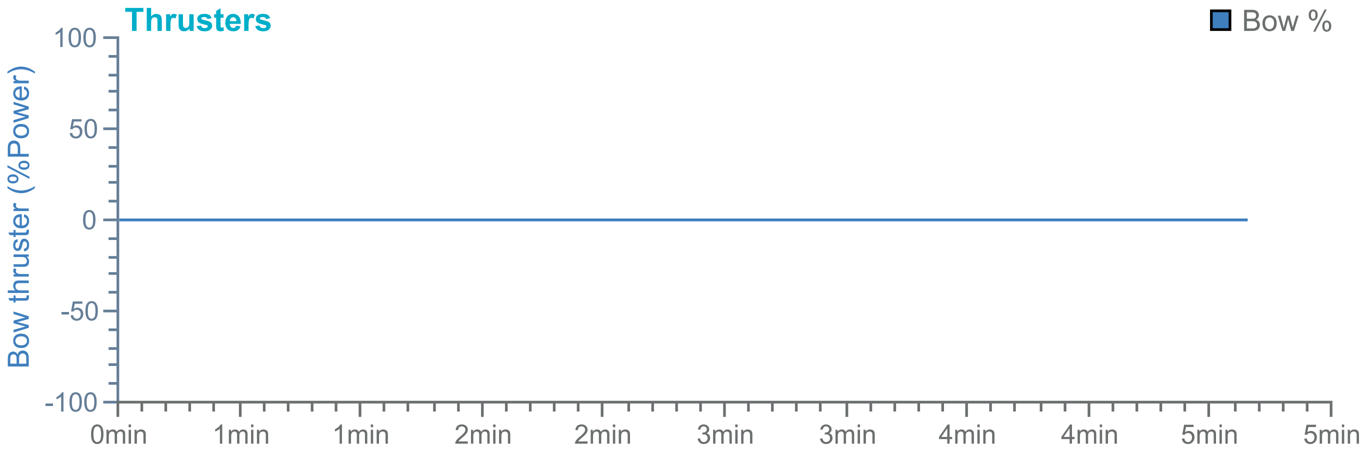


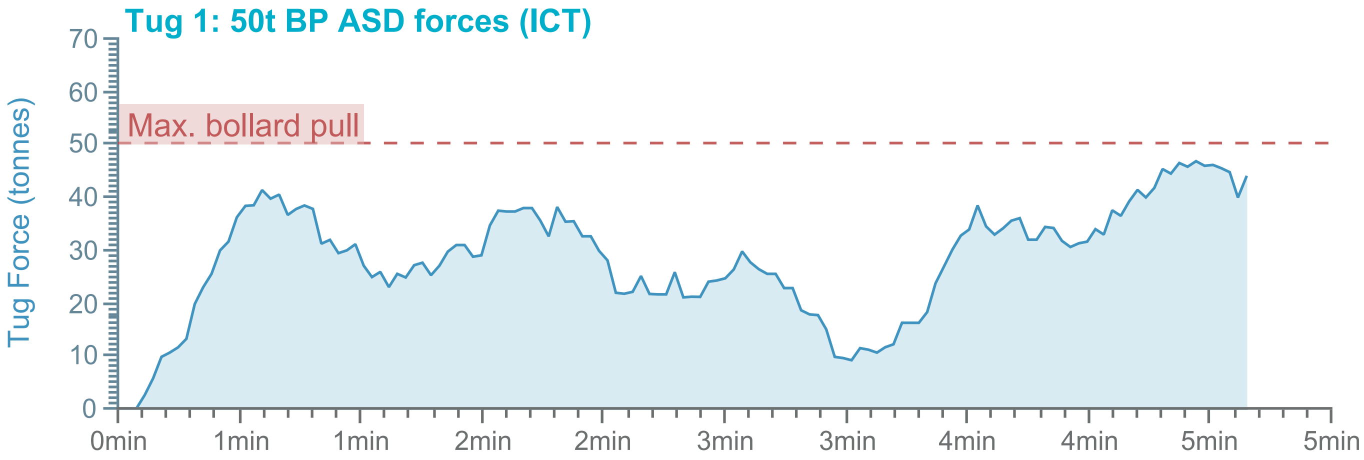
Pilot: JMS
Manoeuvre: Other

Ship: Stena Transporter

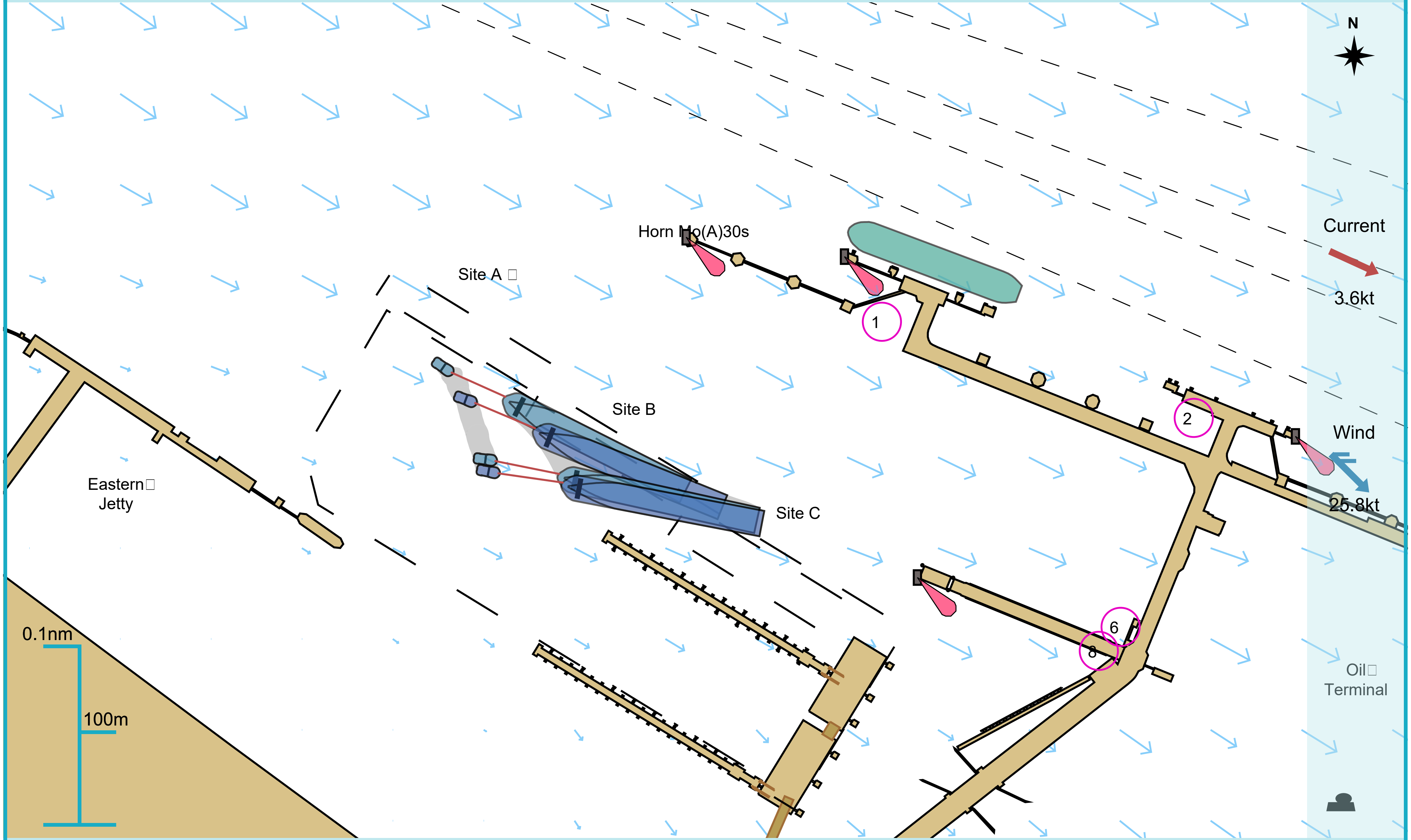

Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min
5min


Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min
5min


Thrusters
Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min
5min

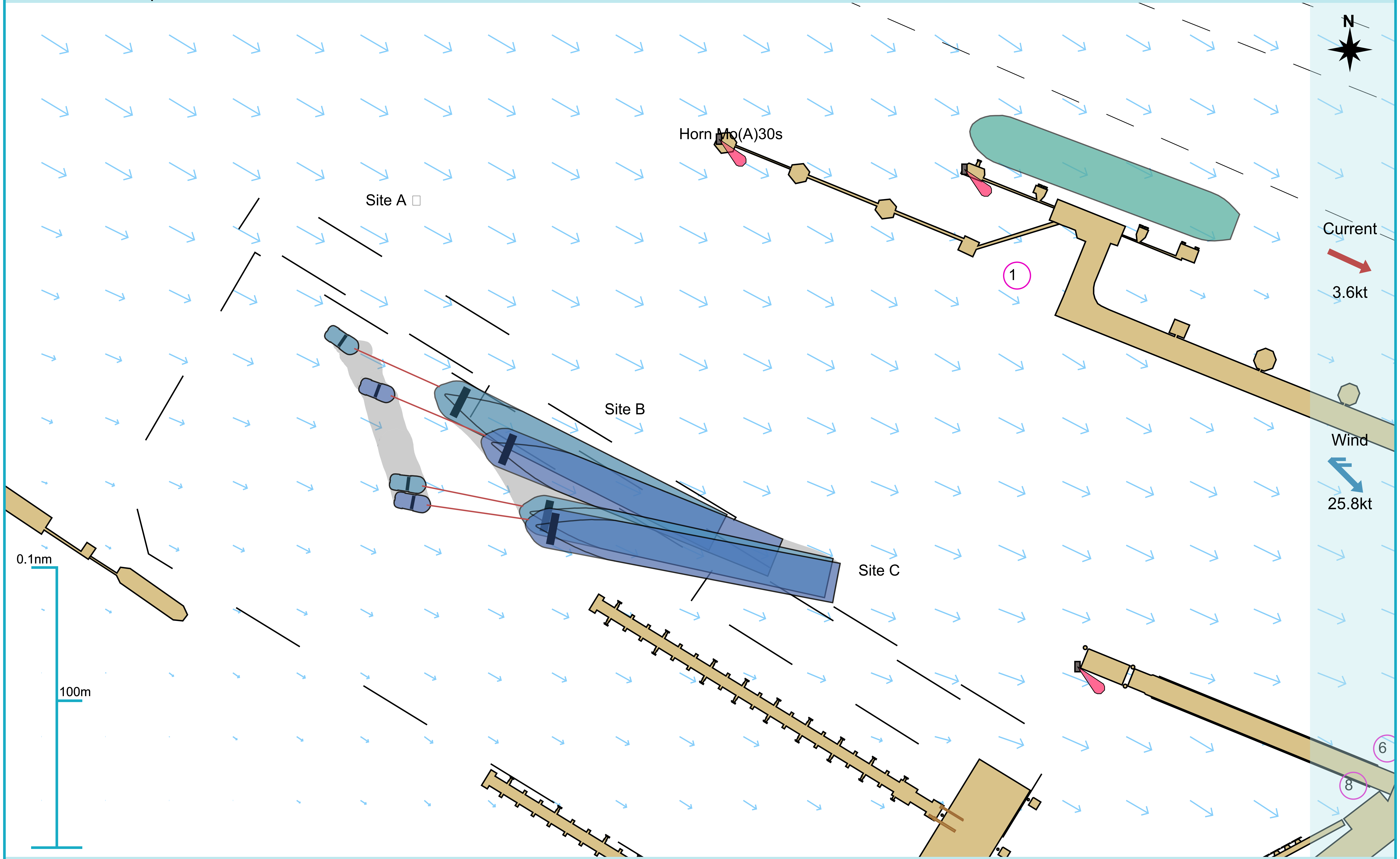

Tug 1: 50t BP ASD forces (ICT)
Tug Force (tonnes)
70
60
50
40
30
20
10
0
Max. bollard pull
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min
5min

Manoeuvre track plot



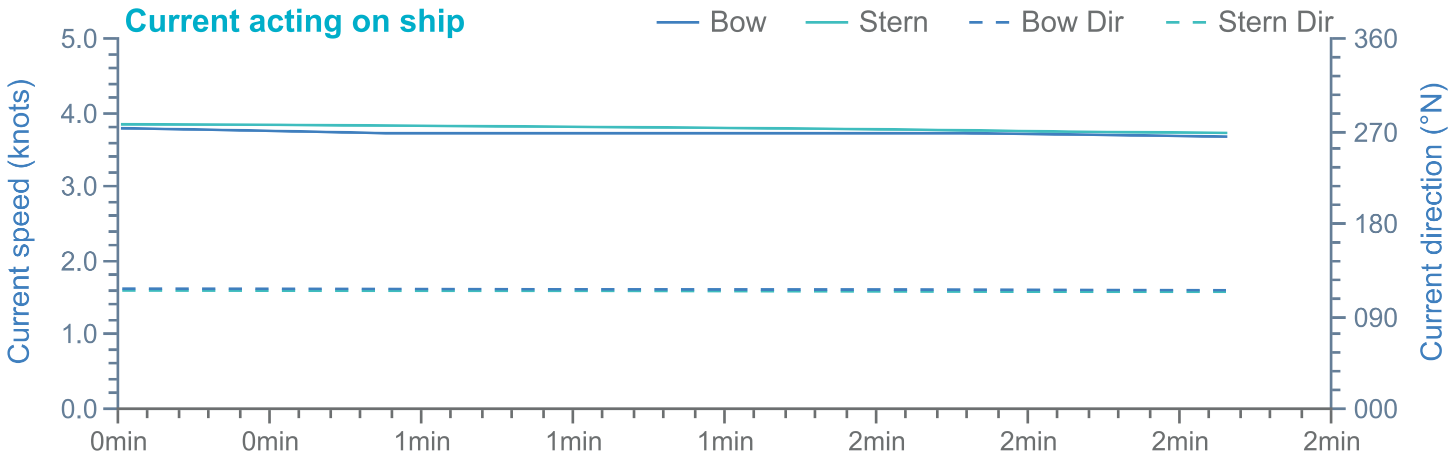
Ships plotted every 1 mins, highlight every 10 mins

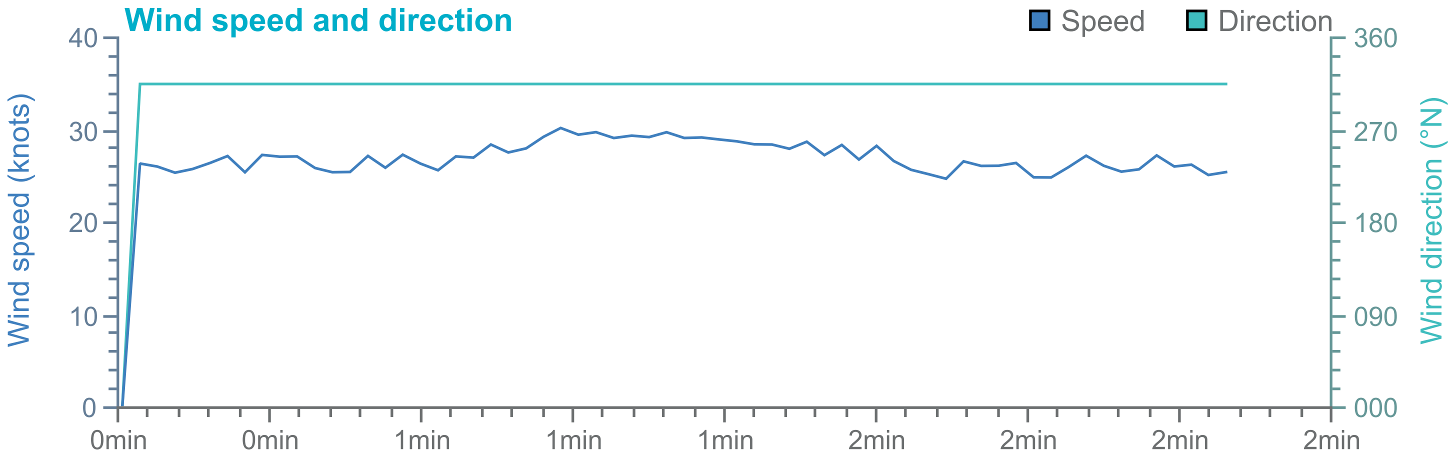
Manoeuvre track plot



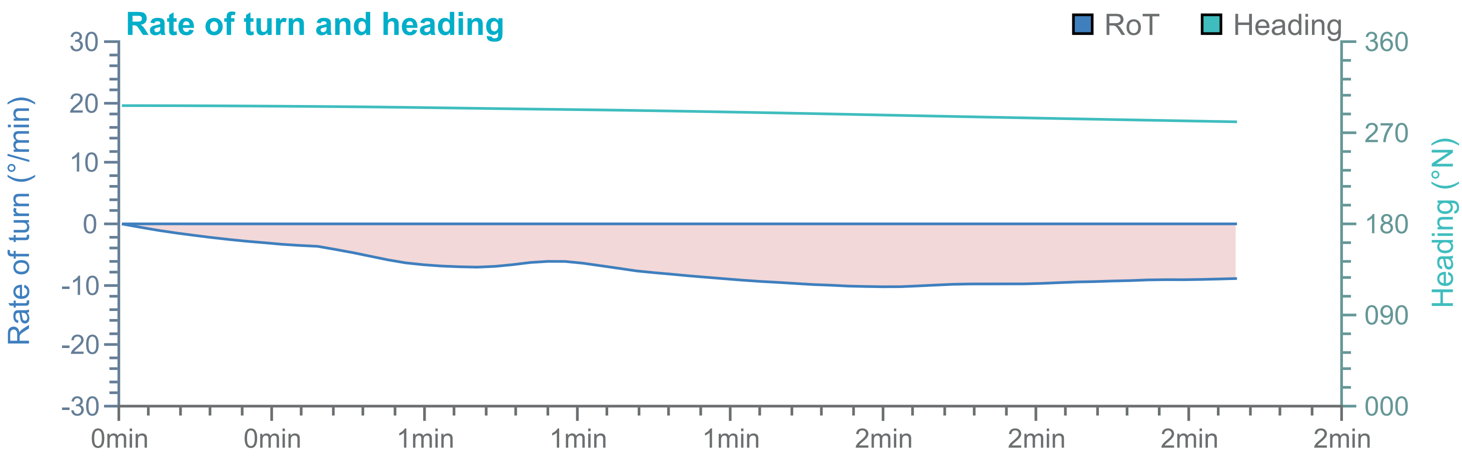
→ 3.71 kts

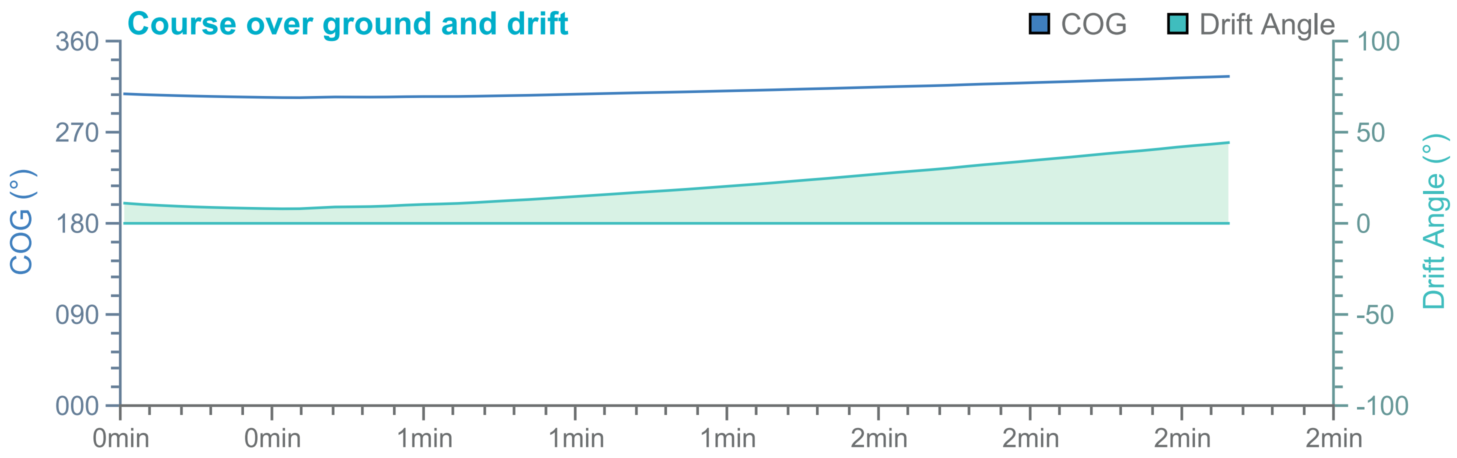
Ships plotted every 1 mins, highlight every 10 mins

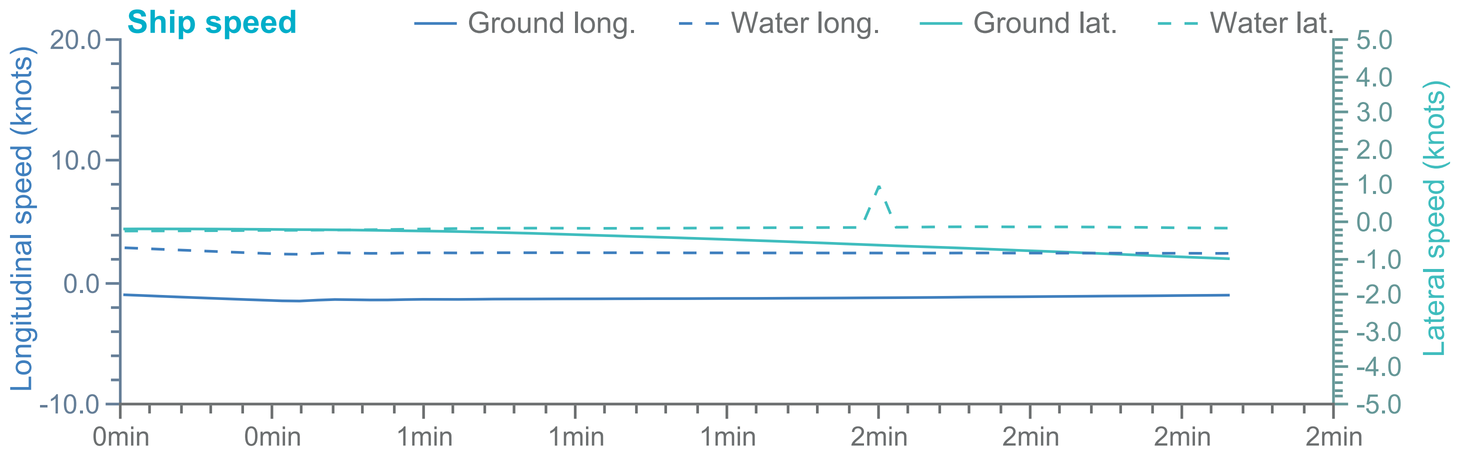

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
Current direction (°N)
360
270
180
090
000
0min
0min
1min
1min
1min
2min
2min
2min
2min

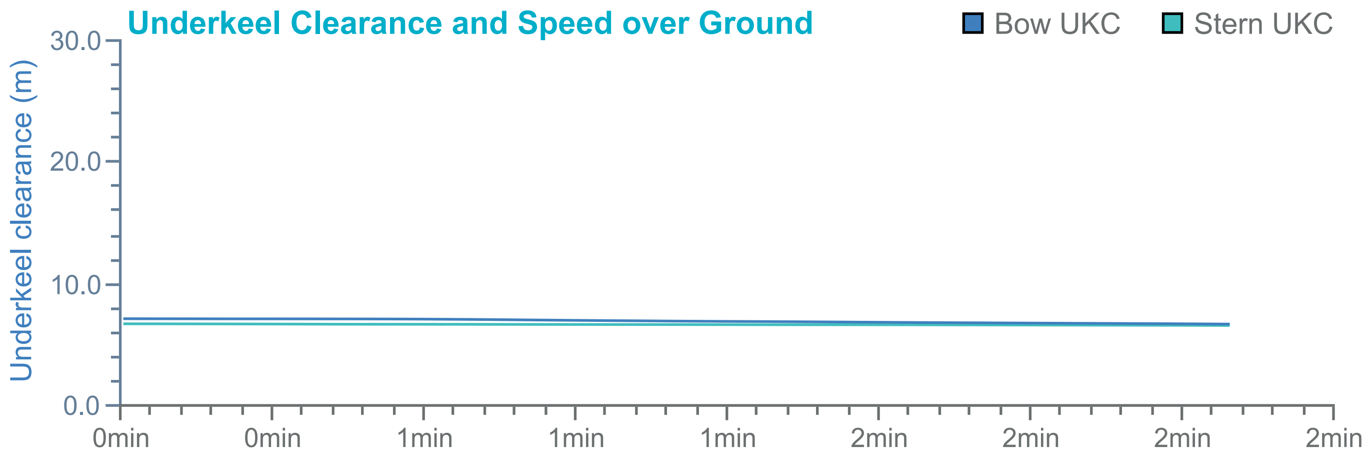

Wind speed and direction
Speed
Direction
Wind speed (knots)
40
30
20
10
0
Wind direction (°N)
360
270
180
090
000
0min
0min
1min
1min
1min
2min
2min
2min
2min

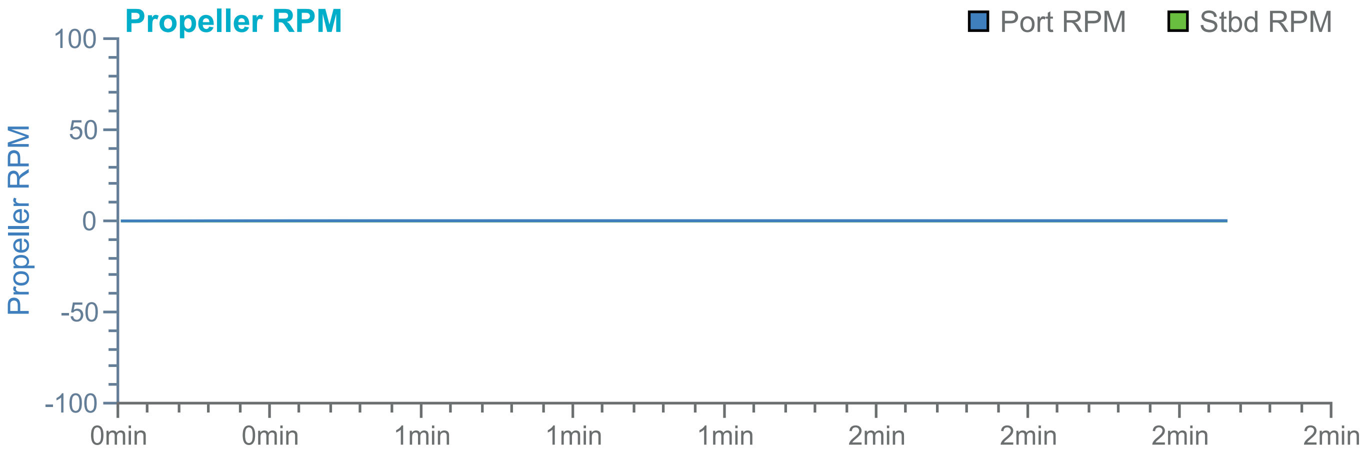
Overview | Environment | Stena Transporter | Tugs

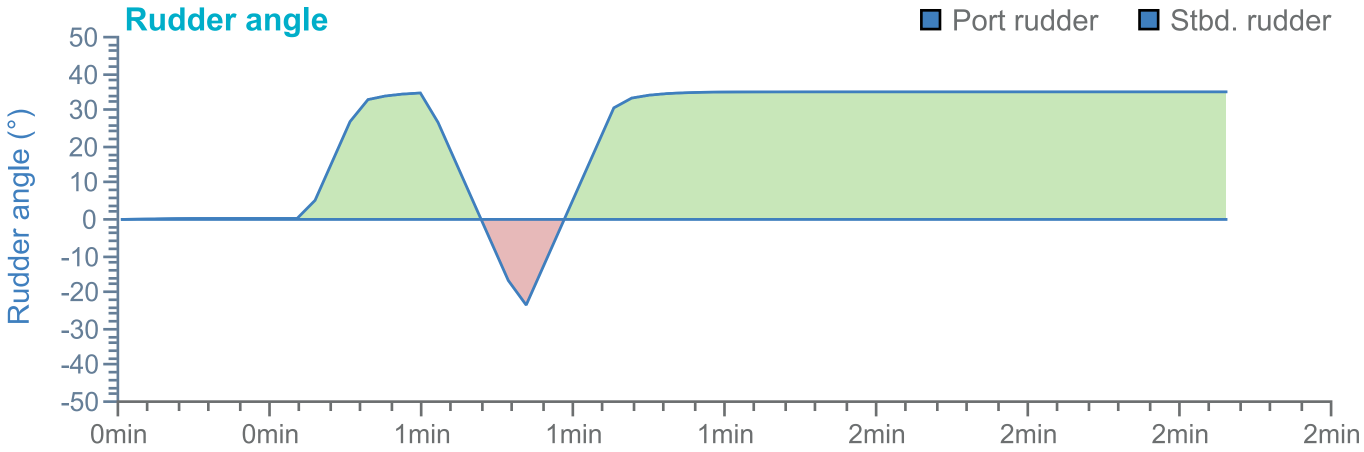

Rate of turn and heading

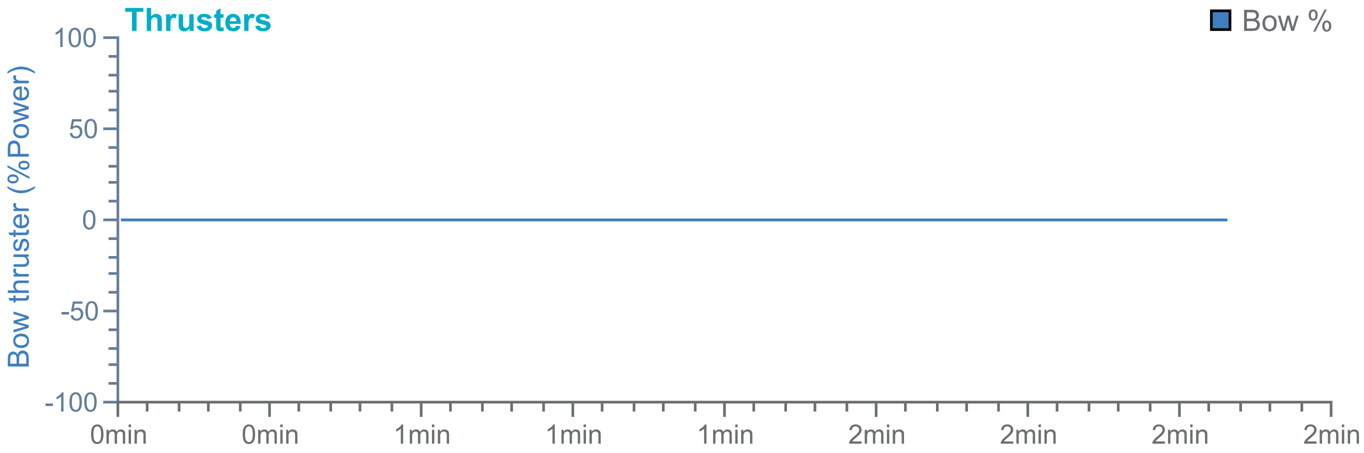

Course over ground and drift


Ship speed

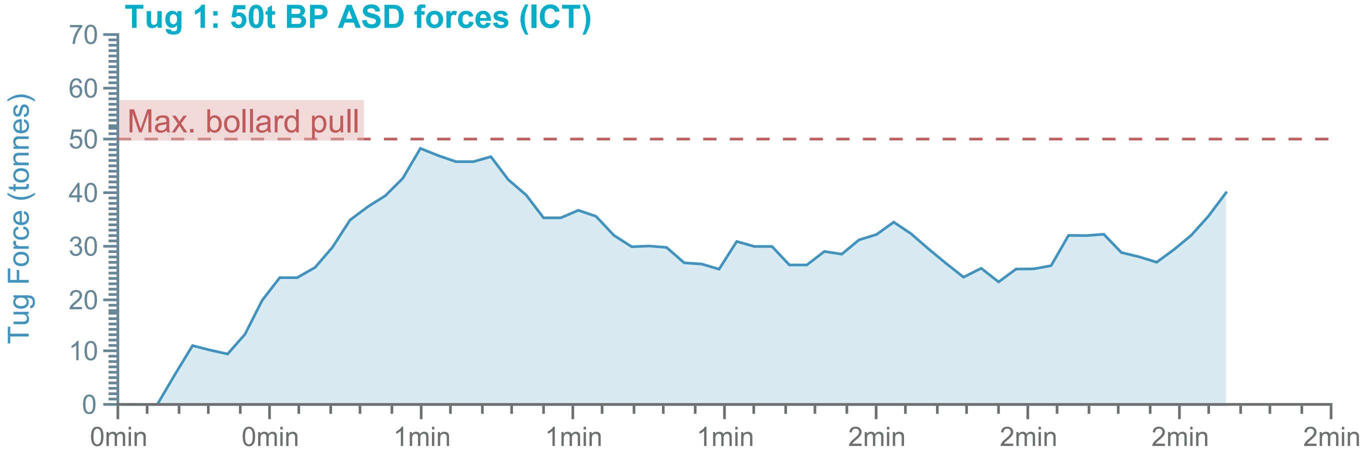

Underkeel Clearance and Speed over Ground


Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
0min
1min
1min
1min
2min
2min
2min
2min

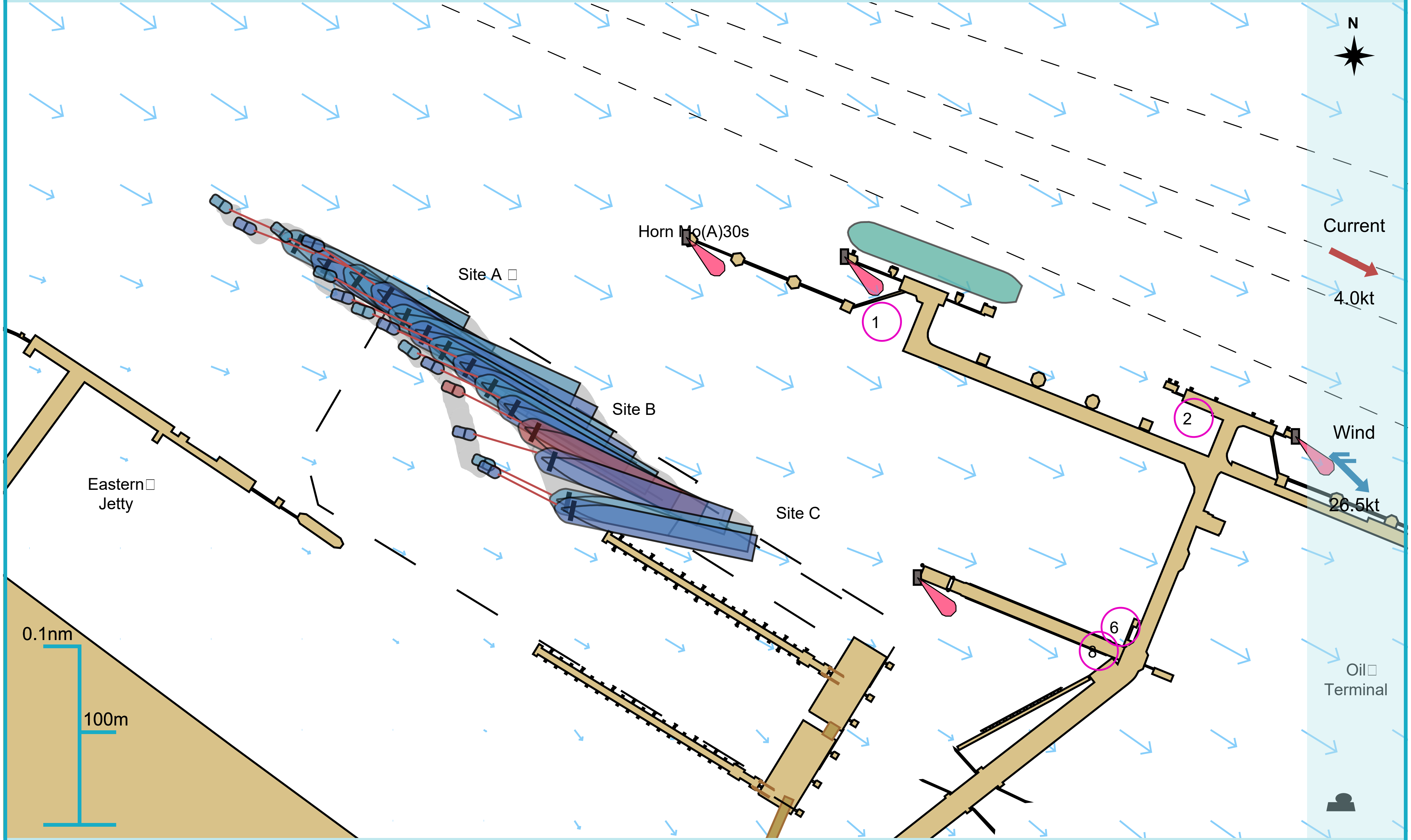

Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
0min
1min
1min
1min
2min
2min
2min
2min


Thrusters
Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0min
0min
1min
1min
1min
2min
2min
2min
2min

Tug 1: 50t BP ASD forces (ICT)

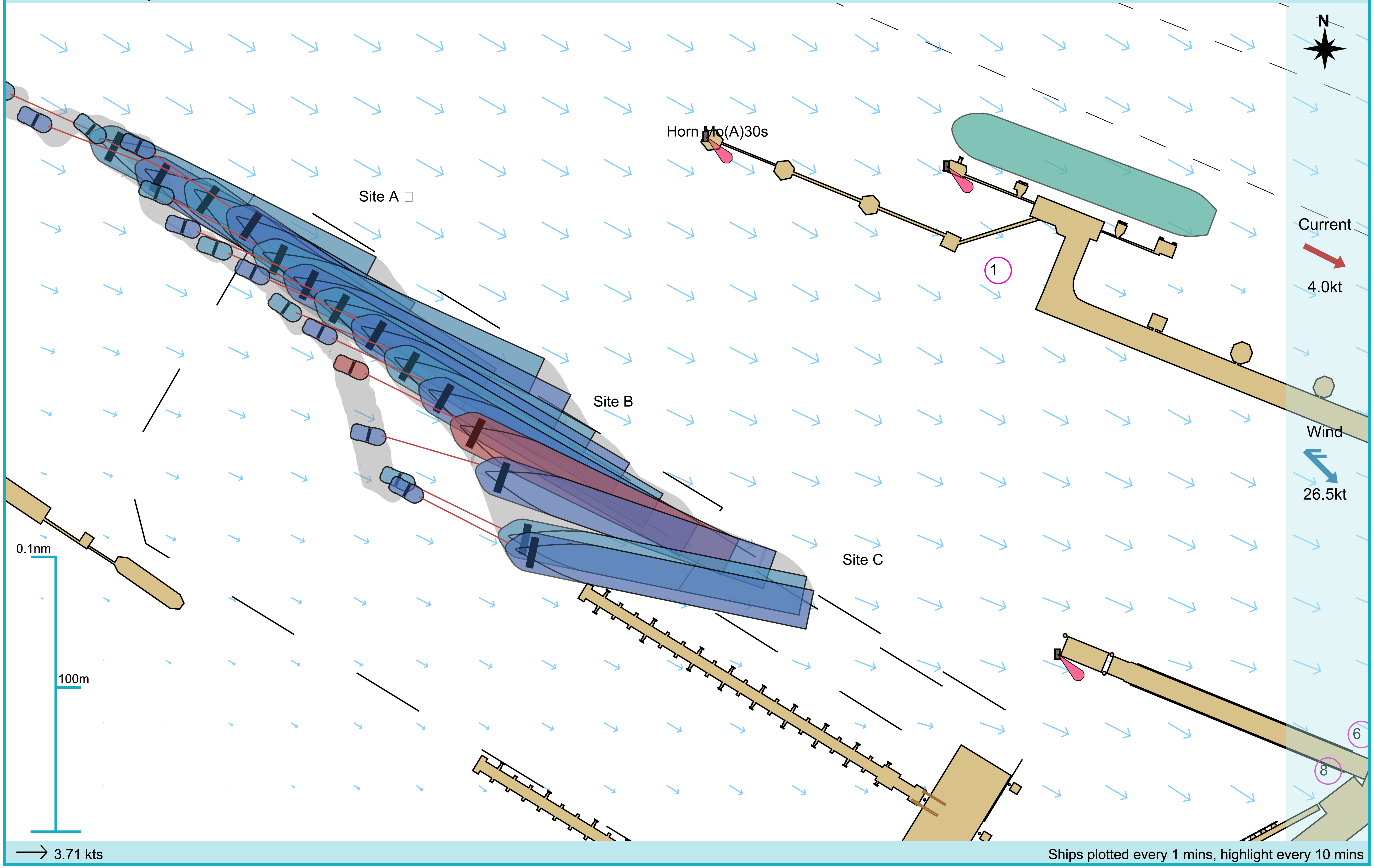


Manoeuvre track plot

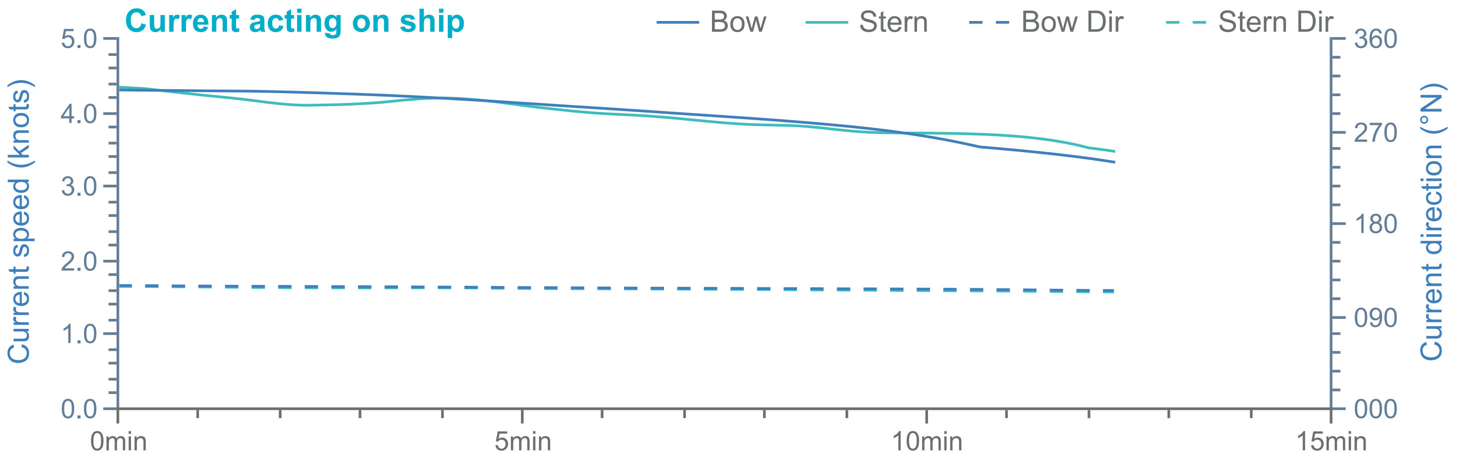


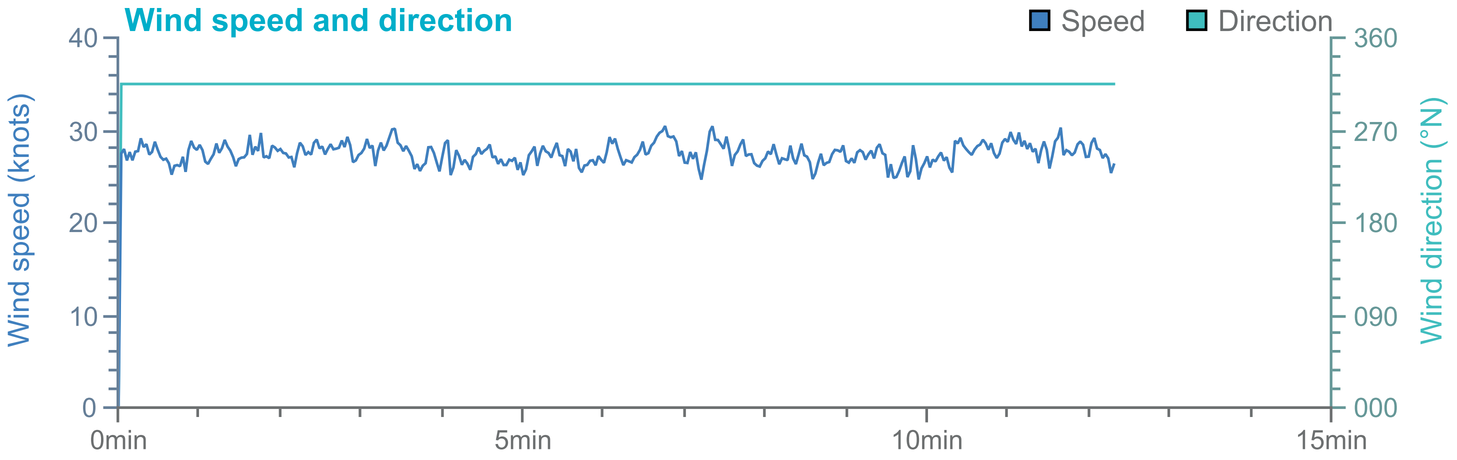
Ships plotted every 1 mins, highlight every 10 mins

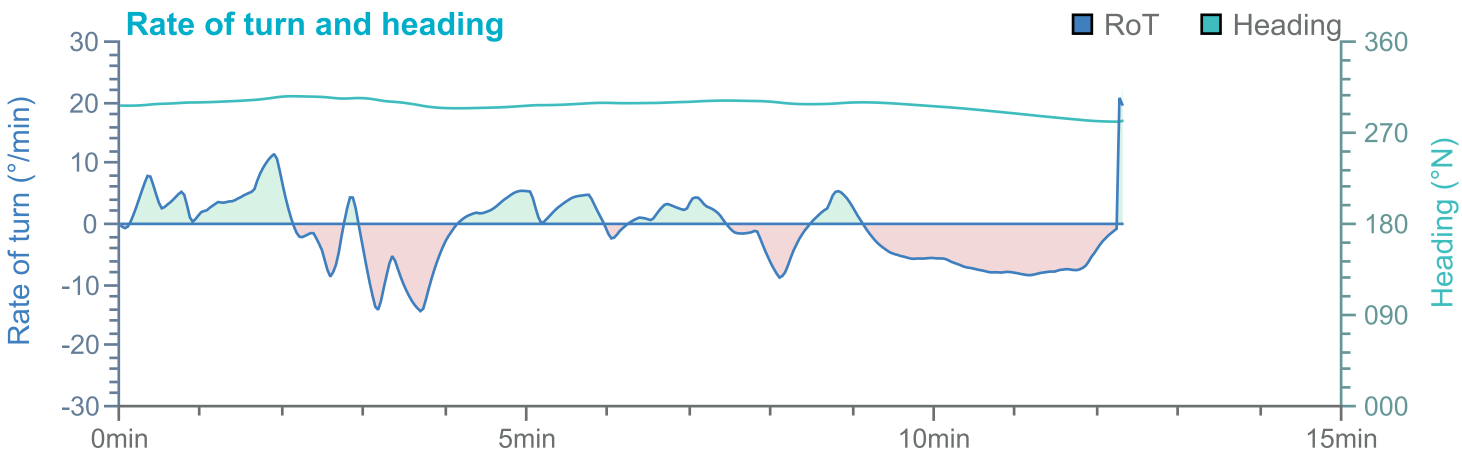
Manoeuvre track plot

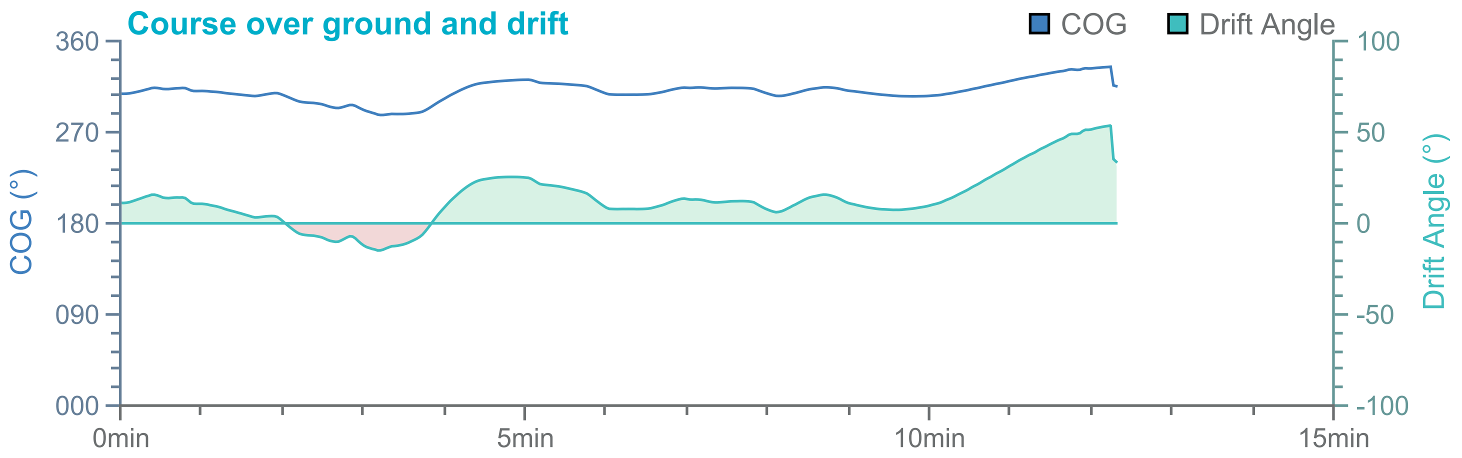


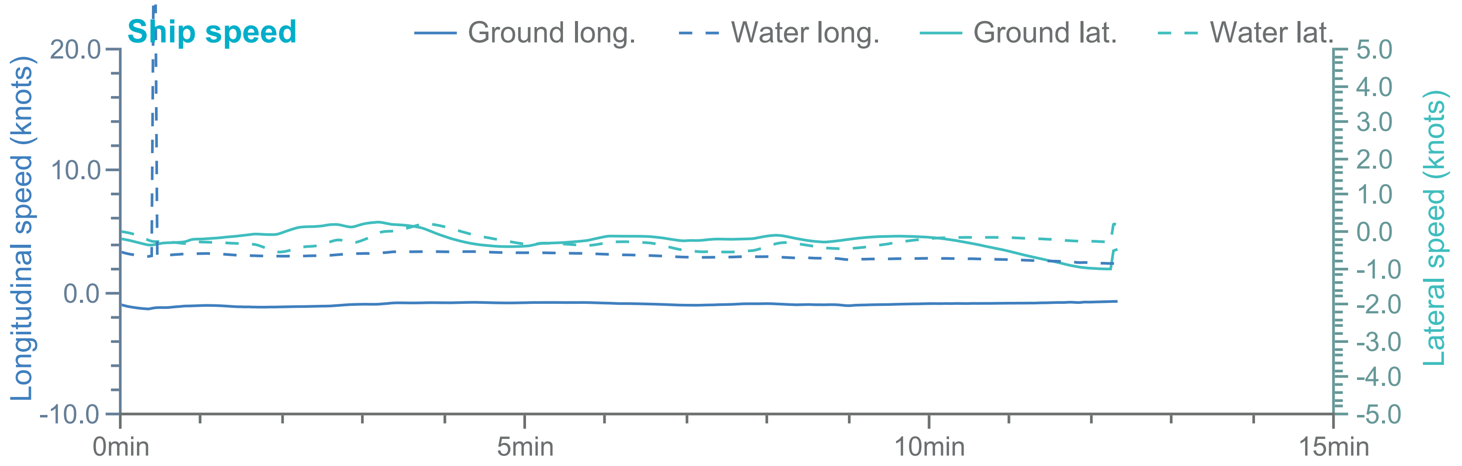
Ships plotted every 1 mins, highlight every 10 mins

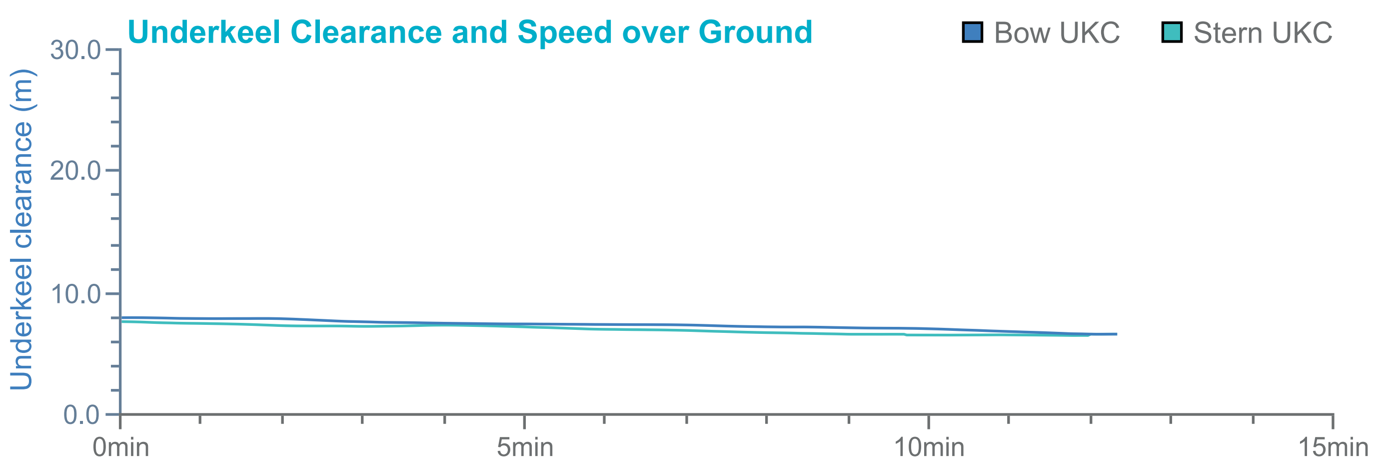

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
Current direction (°N)
360
270
180
090
000
0min
5min
10min
15min

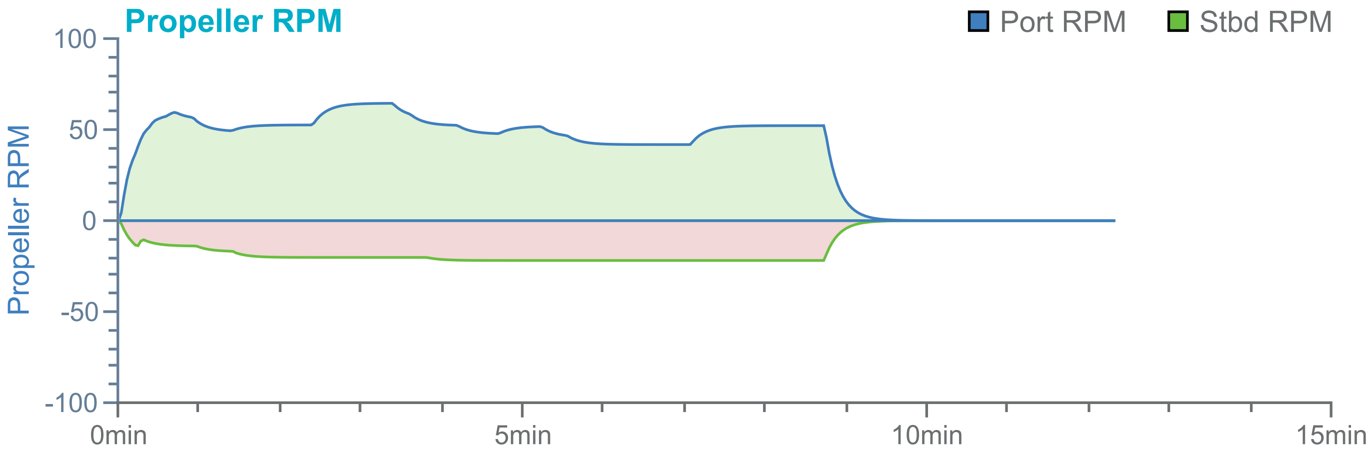

Wind speed and direction
Speed
Direction
Wind speed (knots)
40
30
20
10
0
Wind direction (°N)
360
270
180
090
000
0min
5min
10min
15min

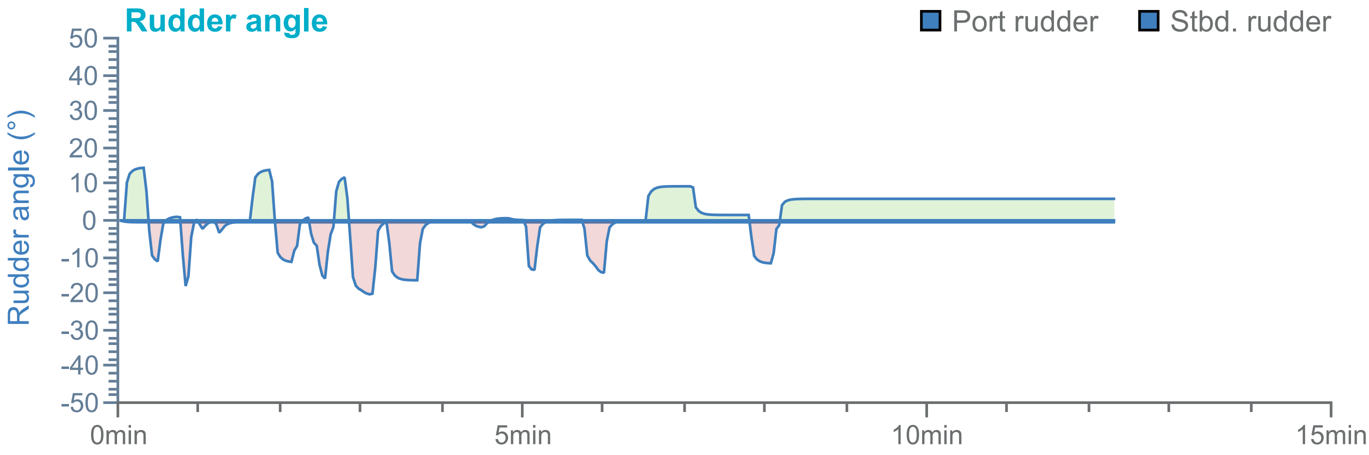

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min
15min

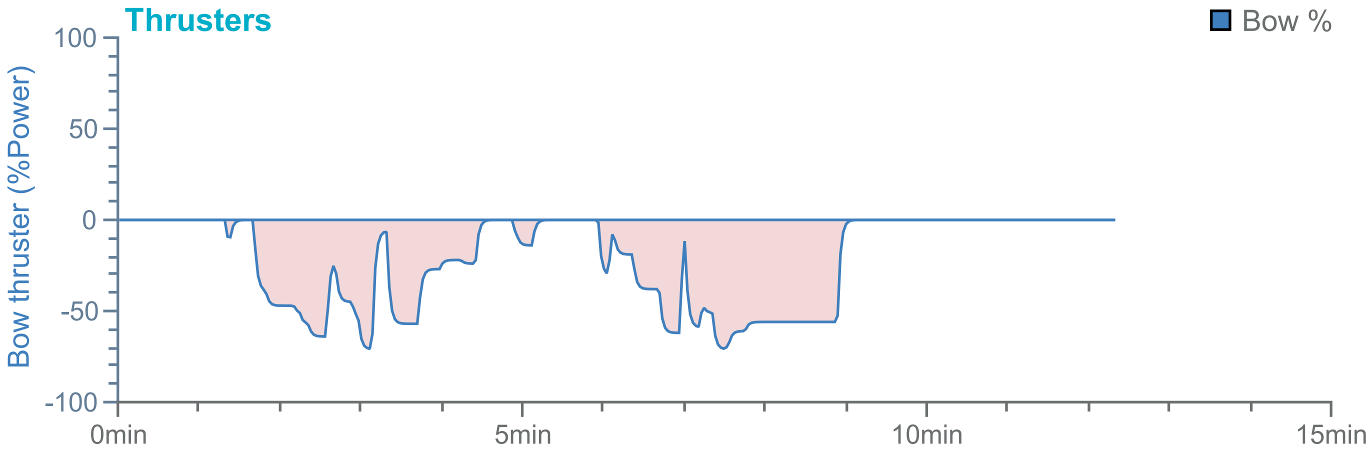

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min

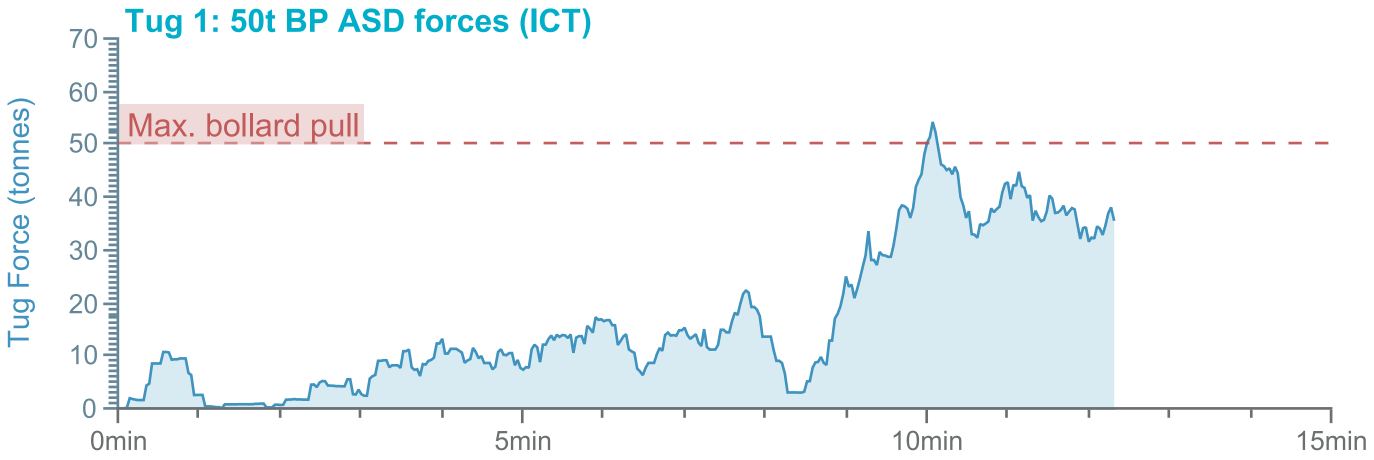

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
20.0
10.0
0.0
-10.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min


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

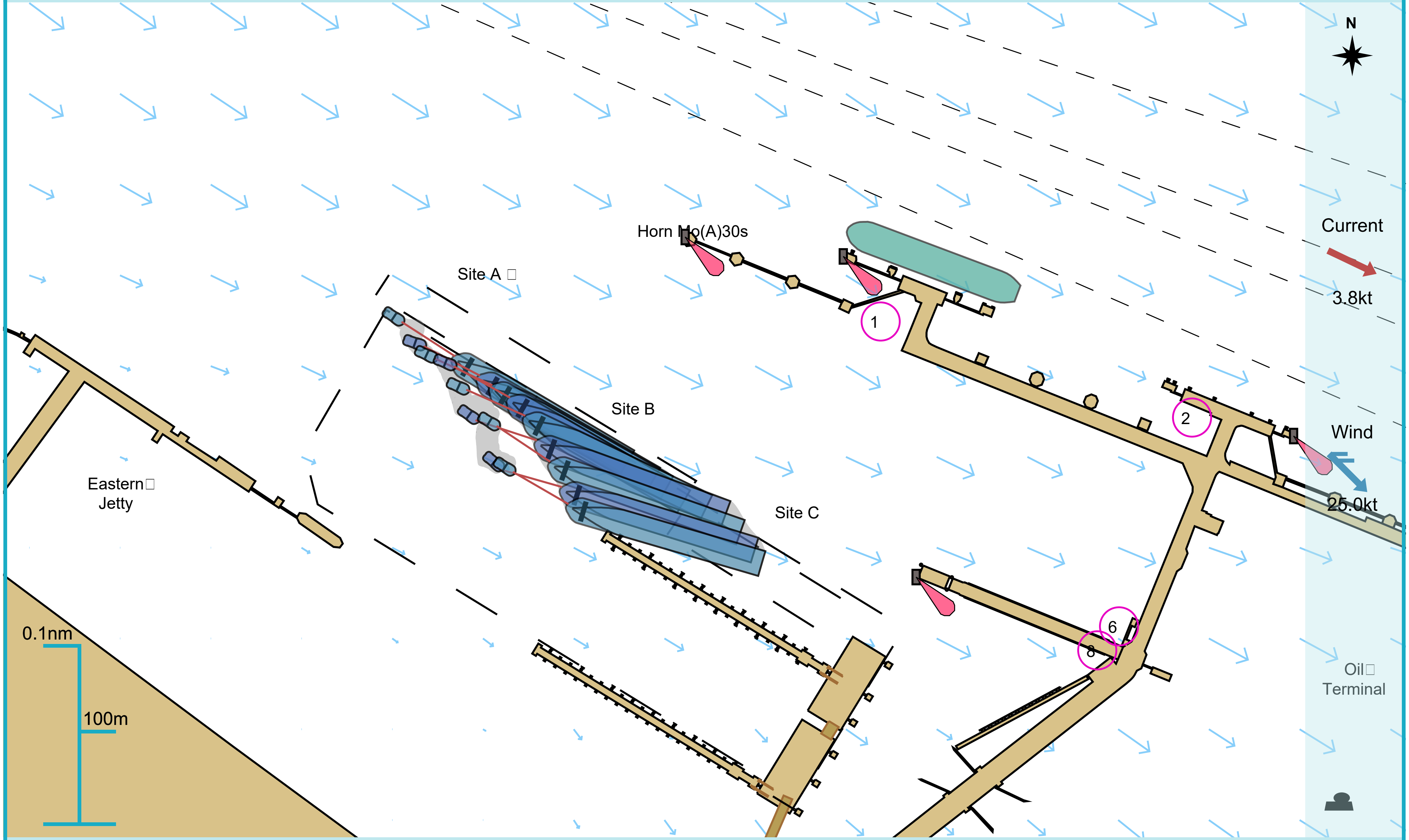

Propeller RPM
🟦 Port RPM
🟩 Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min


Rudder angle
🟦 Port rudder
🟦 Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
5min
10min
15min


Thrusters
🟦 Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min

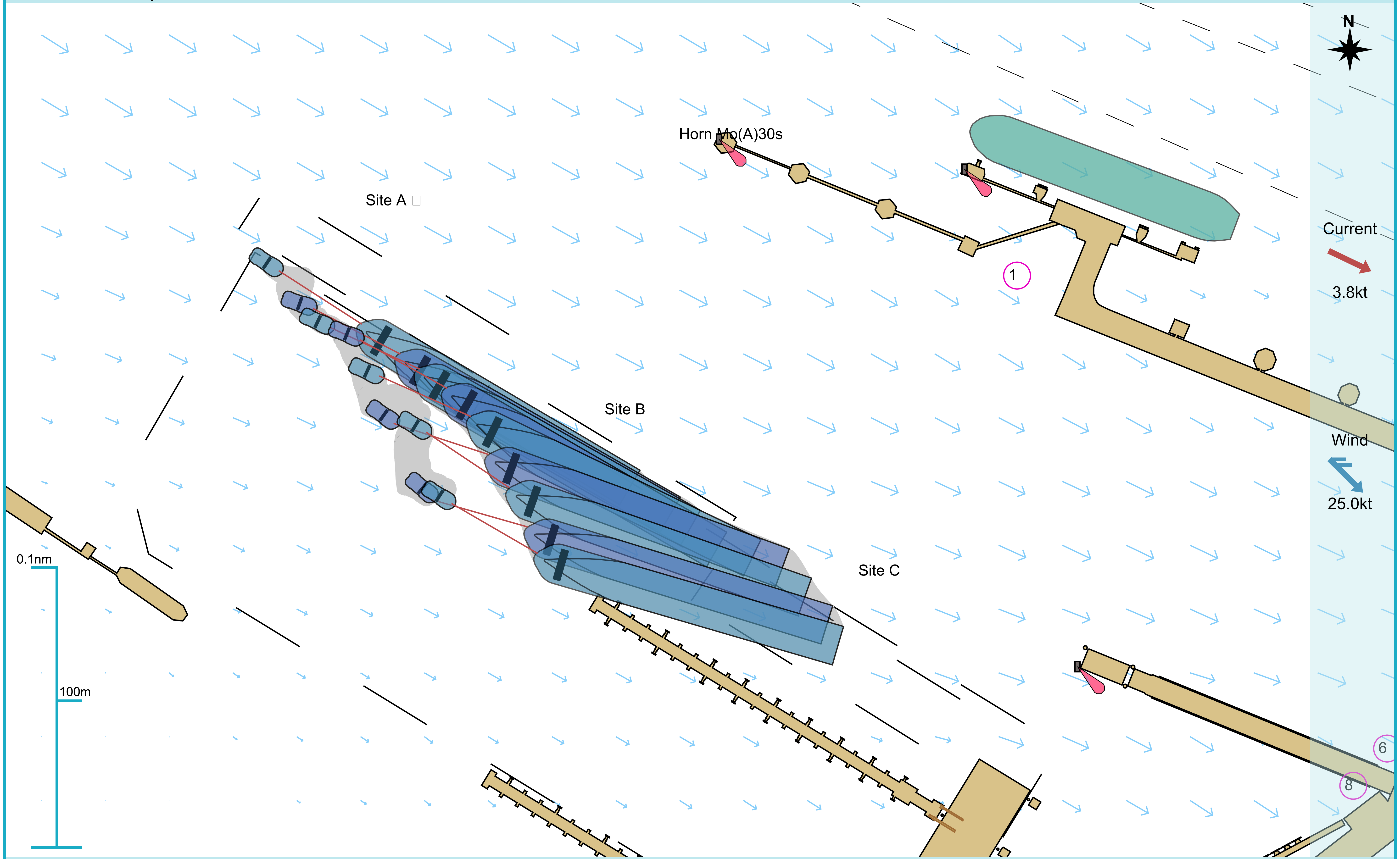

Tug 1: 50t BP ASD forces (ICT)
Tug Force (tonnes)
70
60
50
40
30
20
10
0
Max. bollard pull
0min
5min
10min
15min

Manoeuvre track plot



Ships plotted every 1 mins, highlight every 10 mins

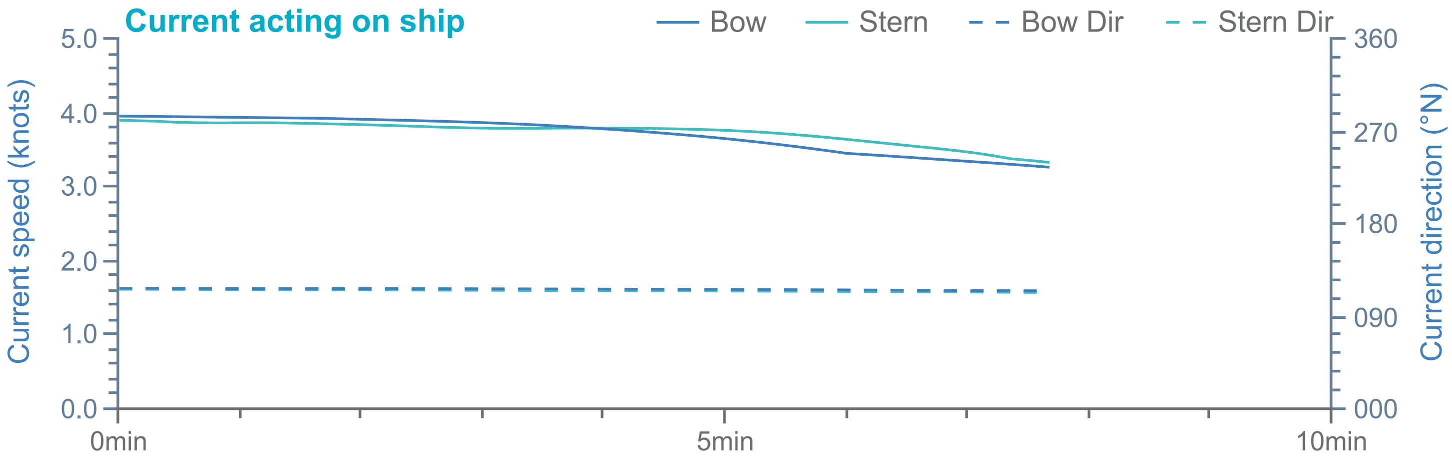
Manoeuvre track plot



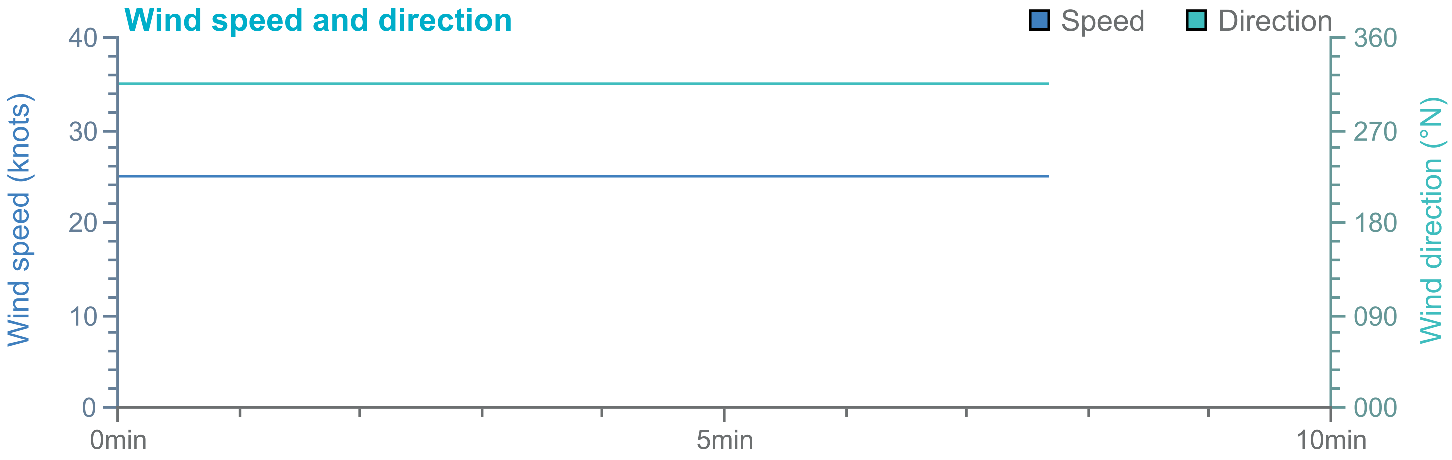
3.71 kts

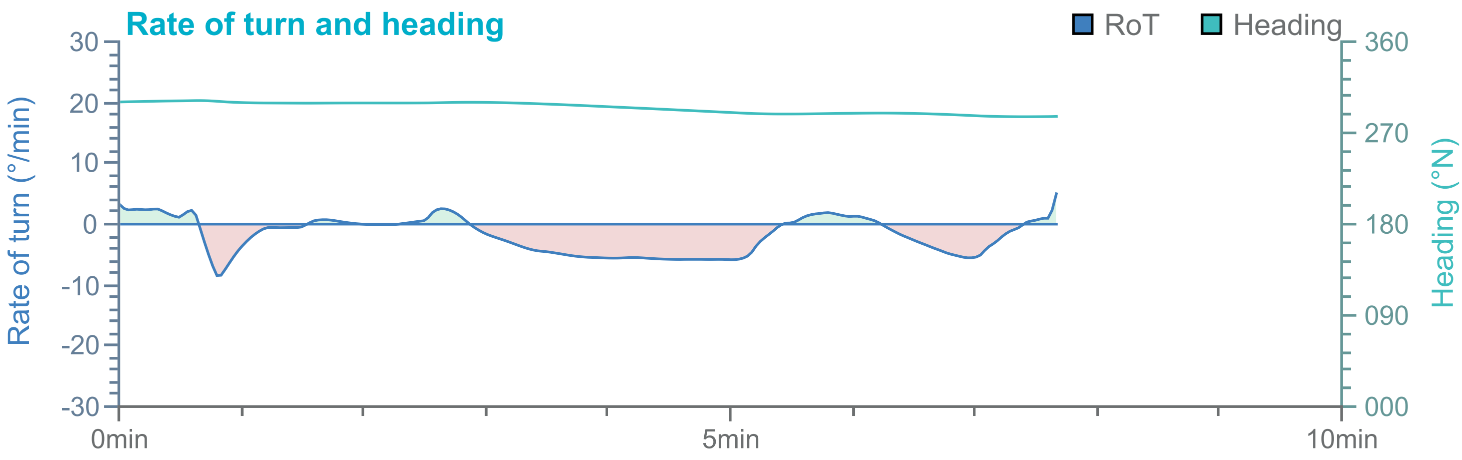
Ships plotted every 1 mins, highlight every 10 mins

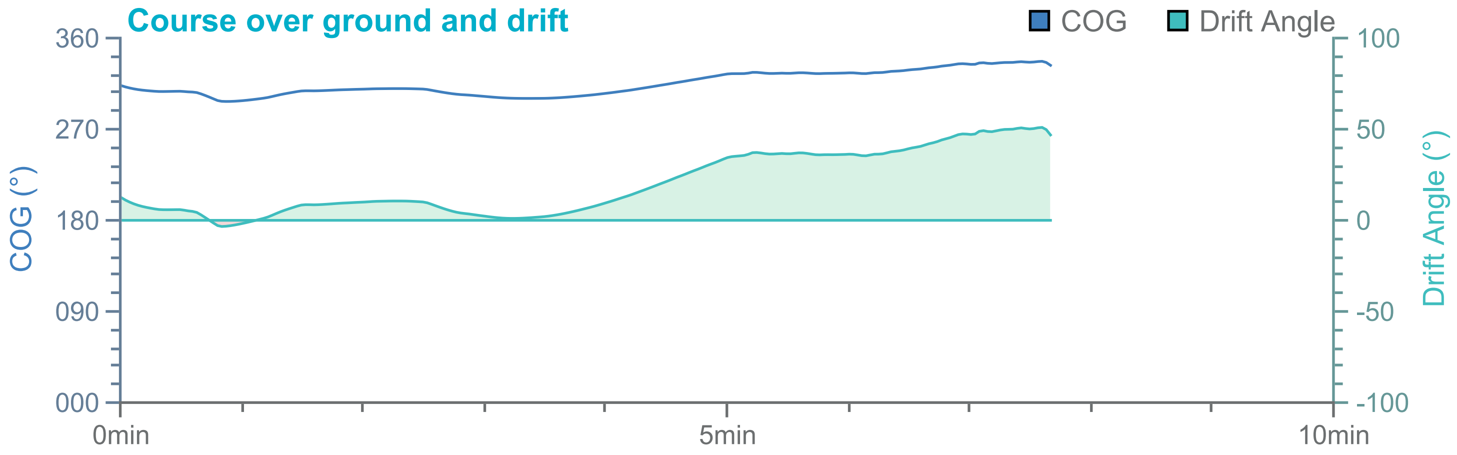
Current acting on ship

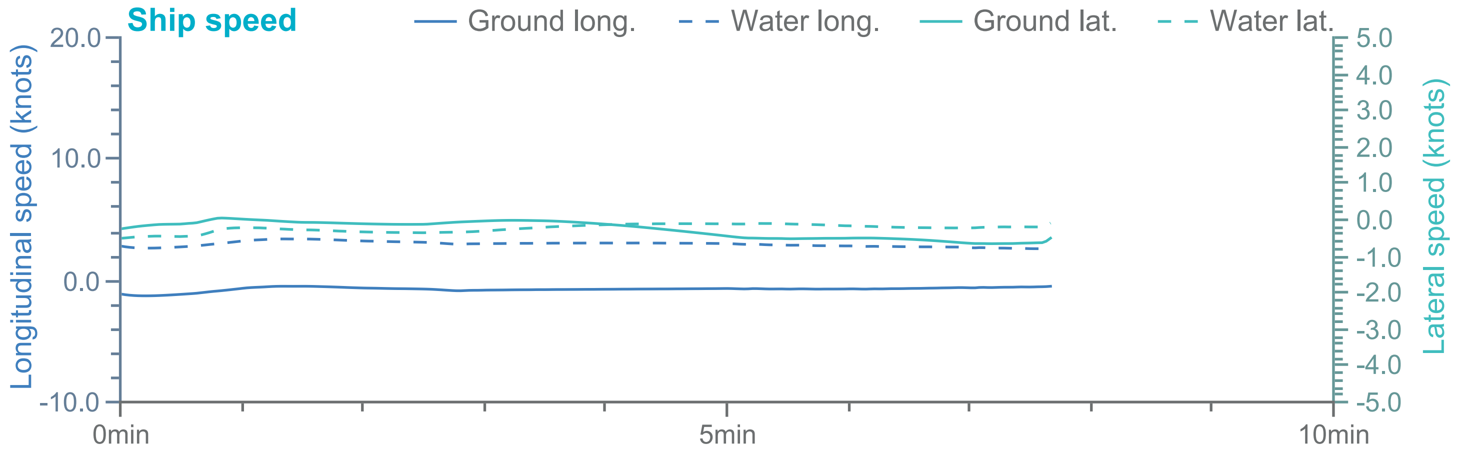


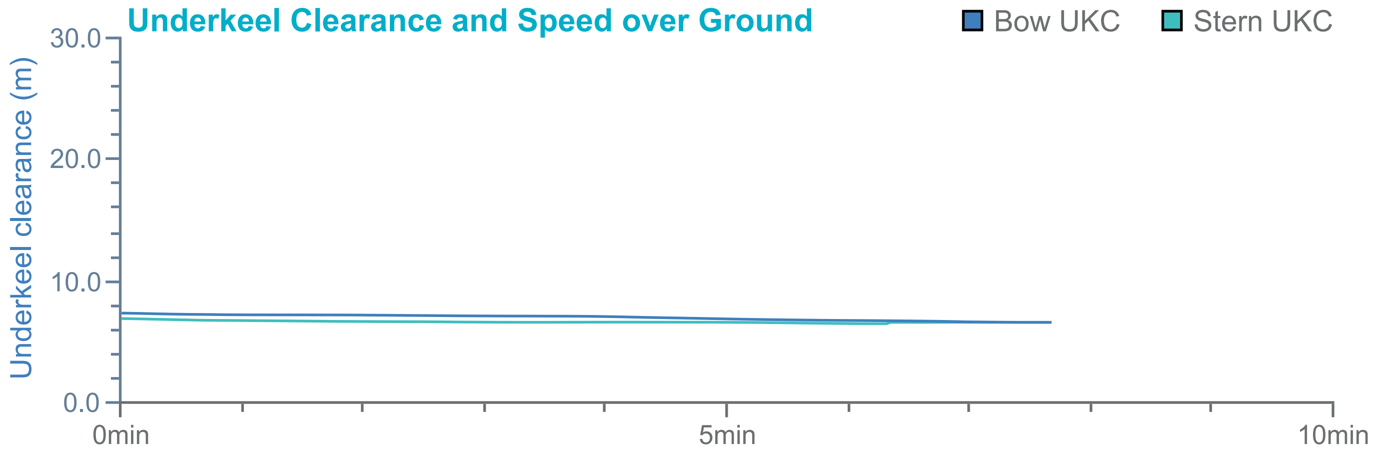
Wind speed and direction



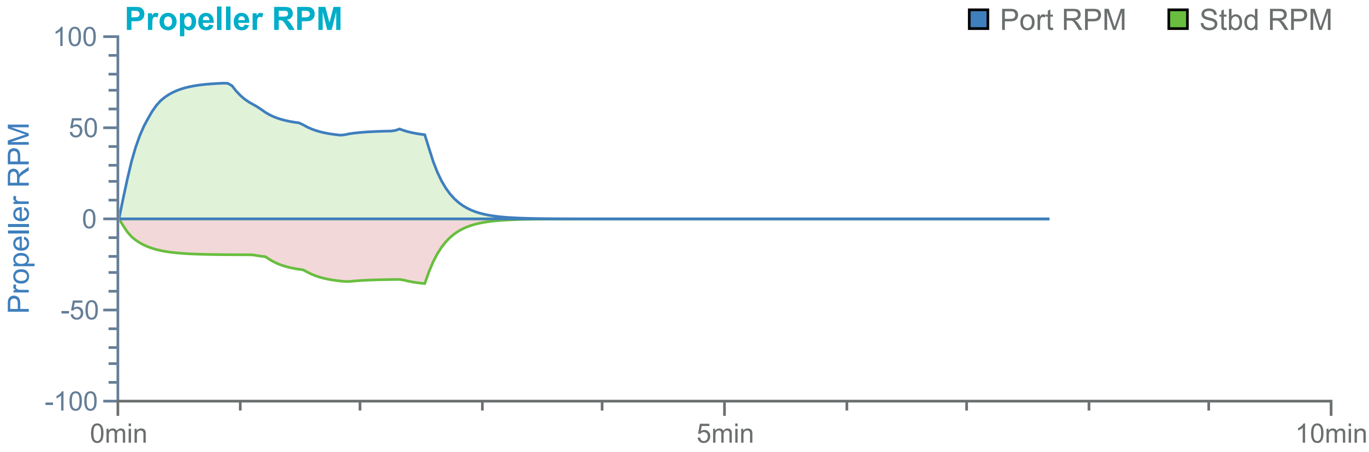

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
30
20
10
0
-10
-20
-30
360
270
180
090
000
0min
5min
10min


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

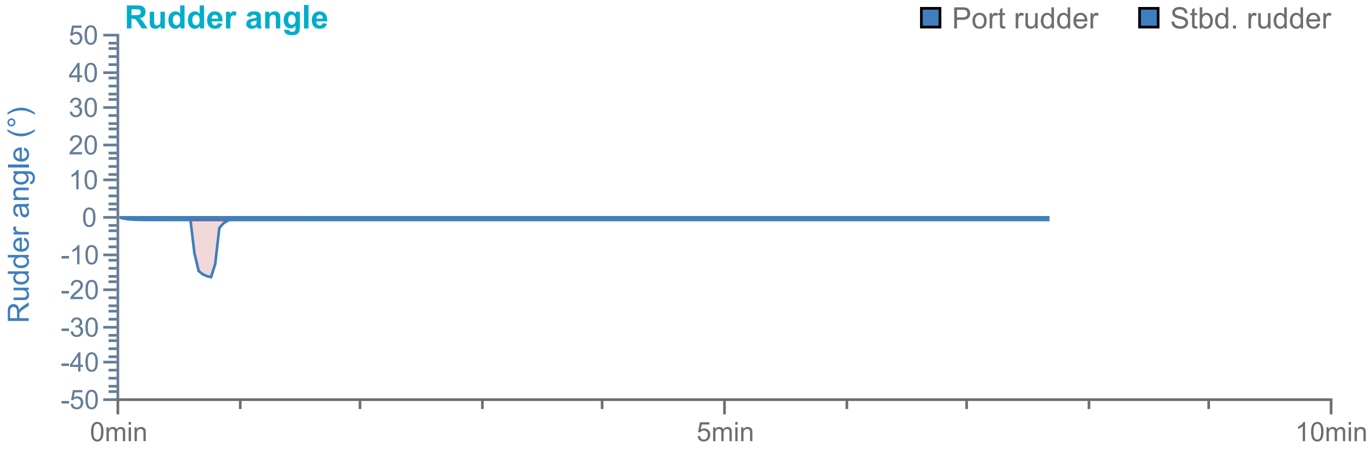

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
20.0
10.0
0.0
-10.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min


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

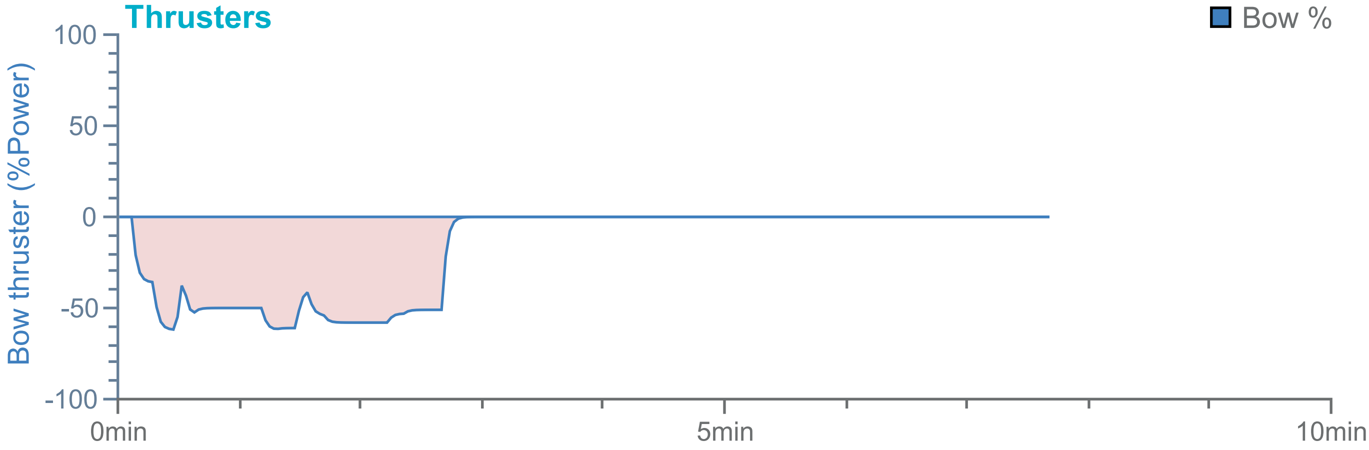
Propeller RPM



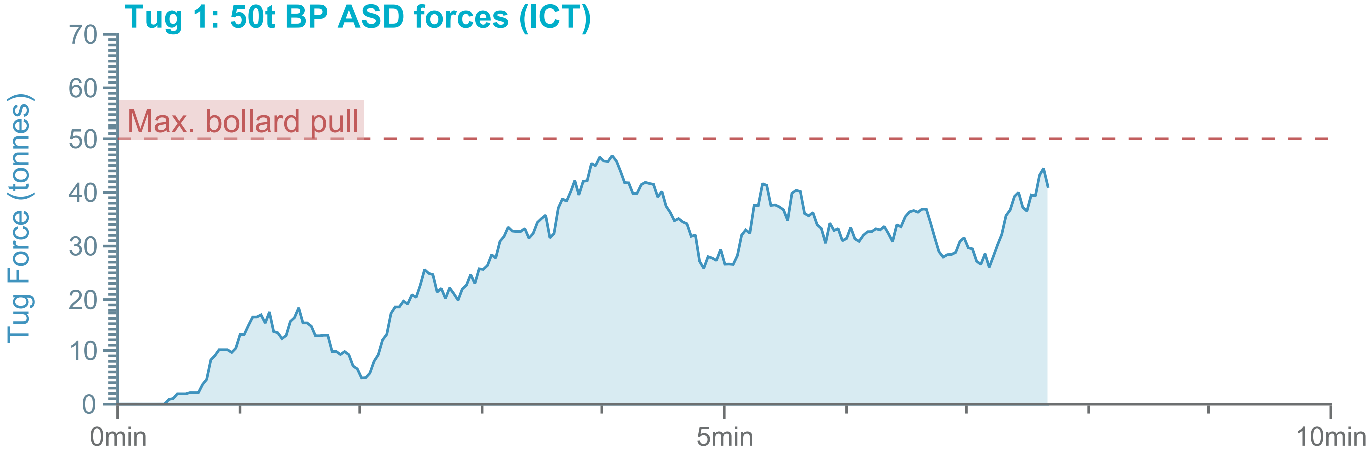
Rudder angle



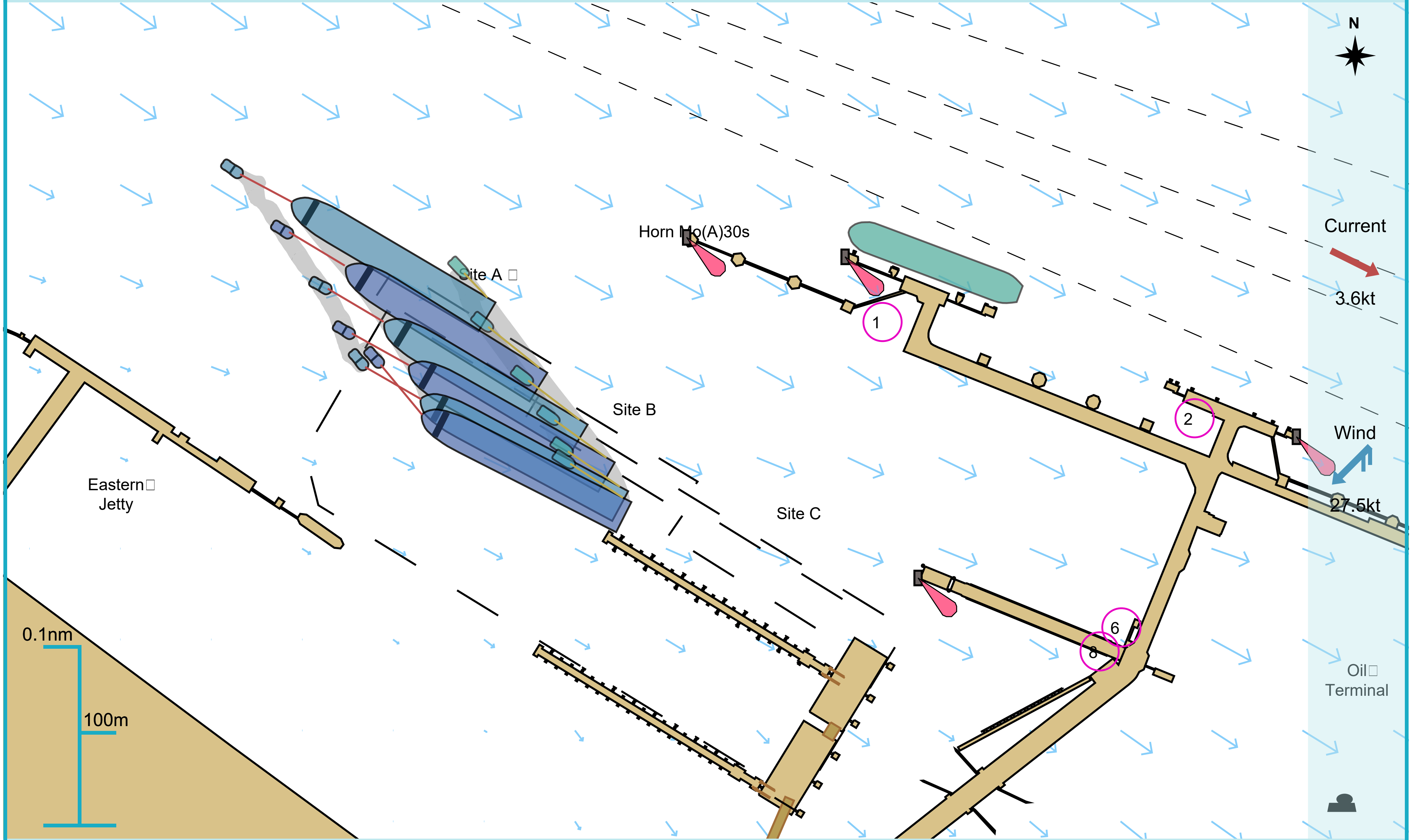
Thrusters



Tug 1: 50t BP ASD forces (ICT)



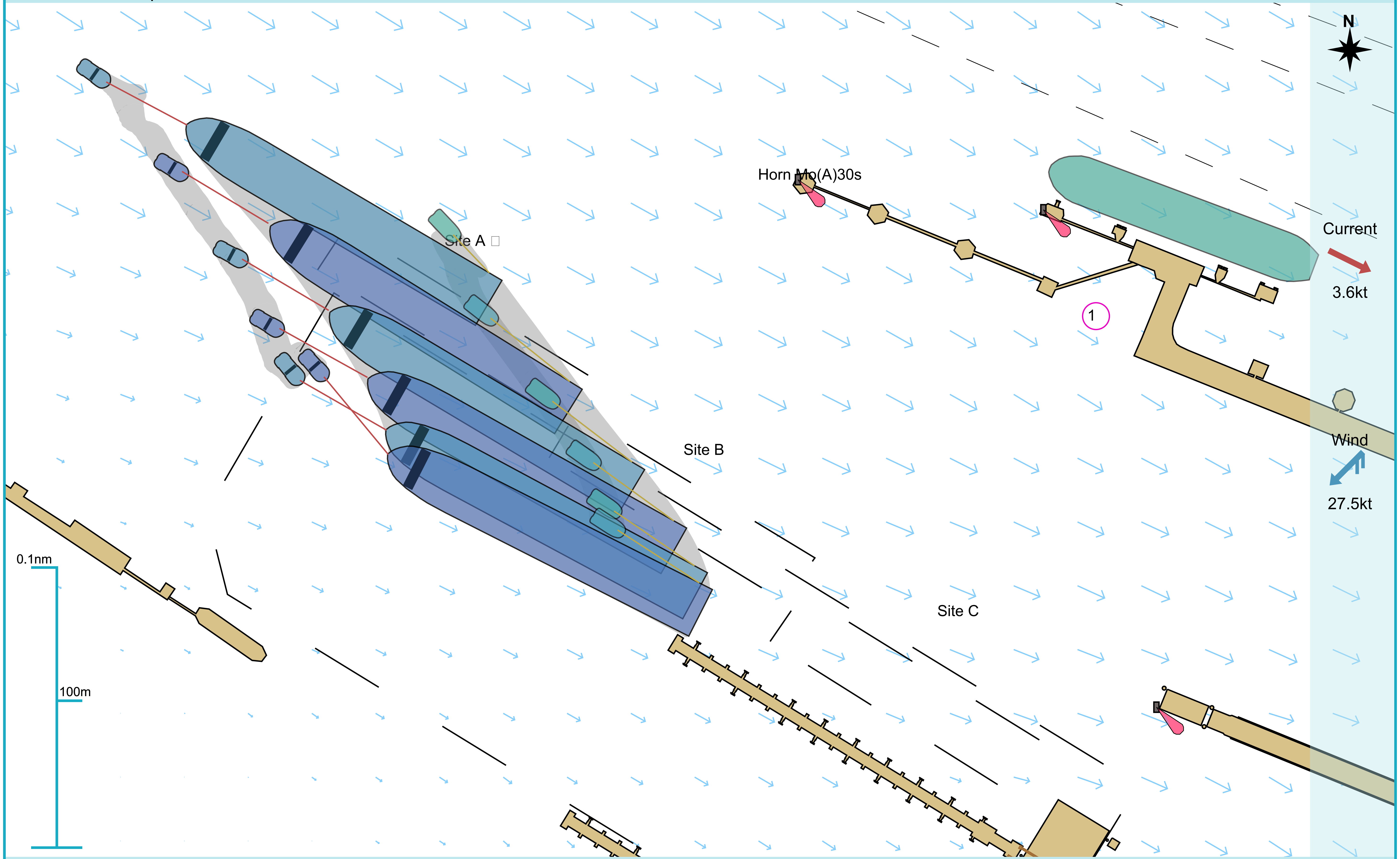
Manoeuvre track plot



Ships plotted every 1 mins, highlight every 10 mins

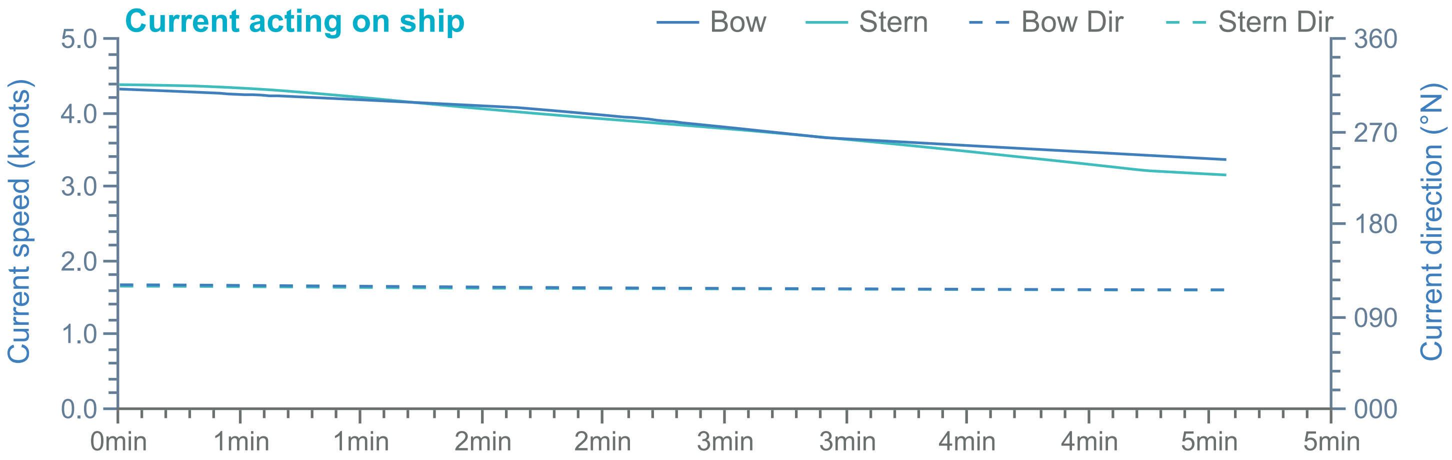
Pilot: JMS
Manoeuvre: Other

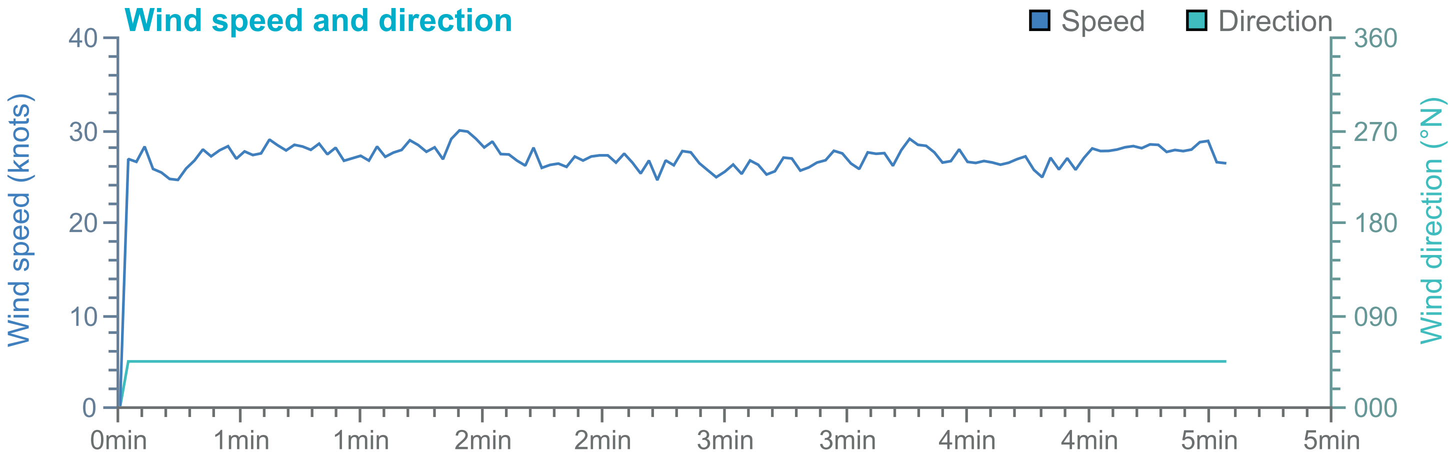
Manoeuvre track plot

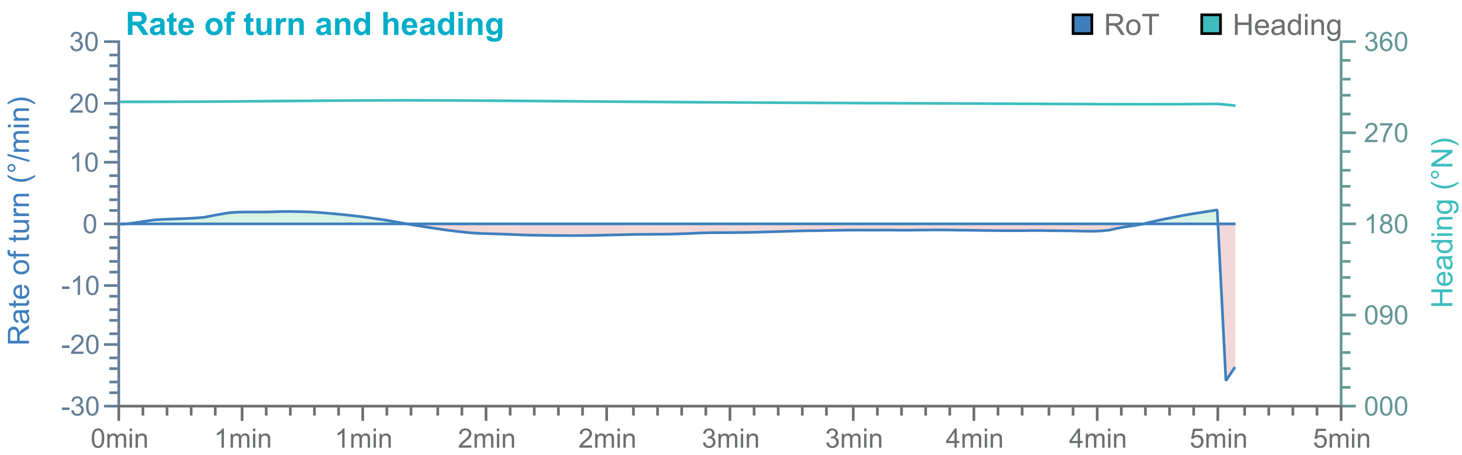


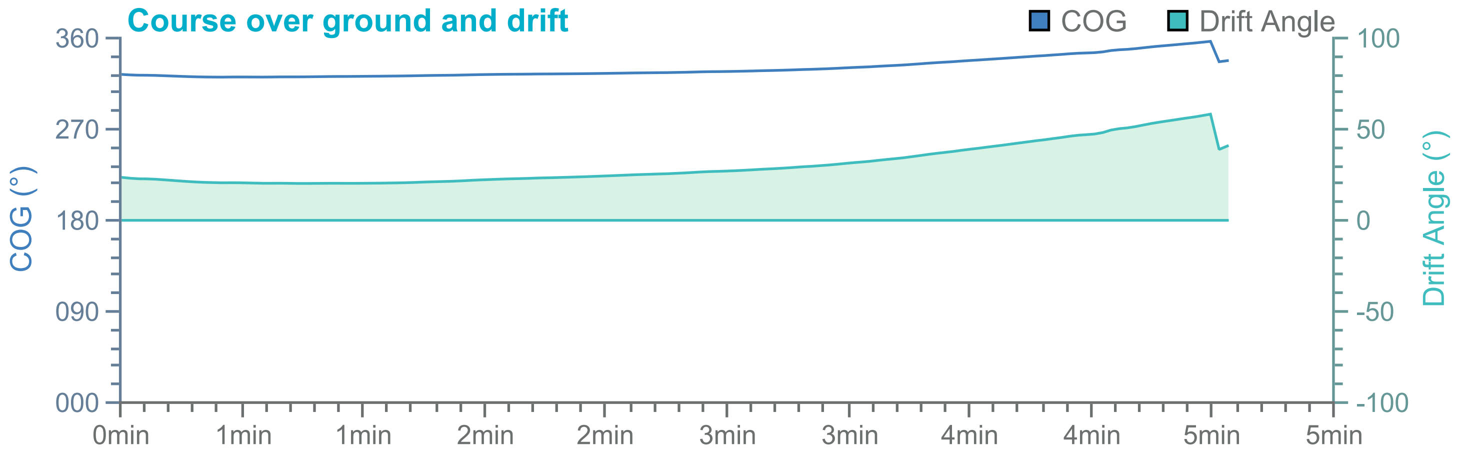
3.72 kts

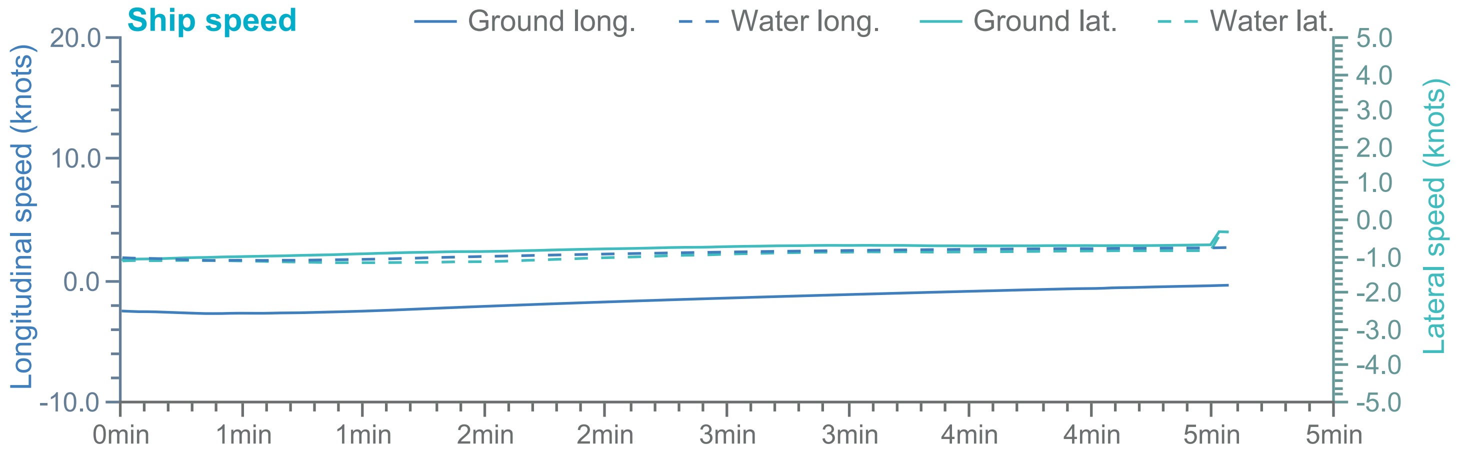
Ships plotted every 1 mins, highlight every 10 mins

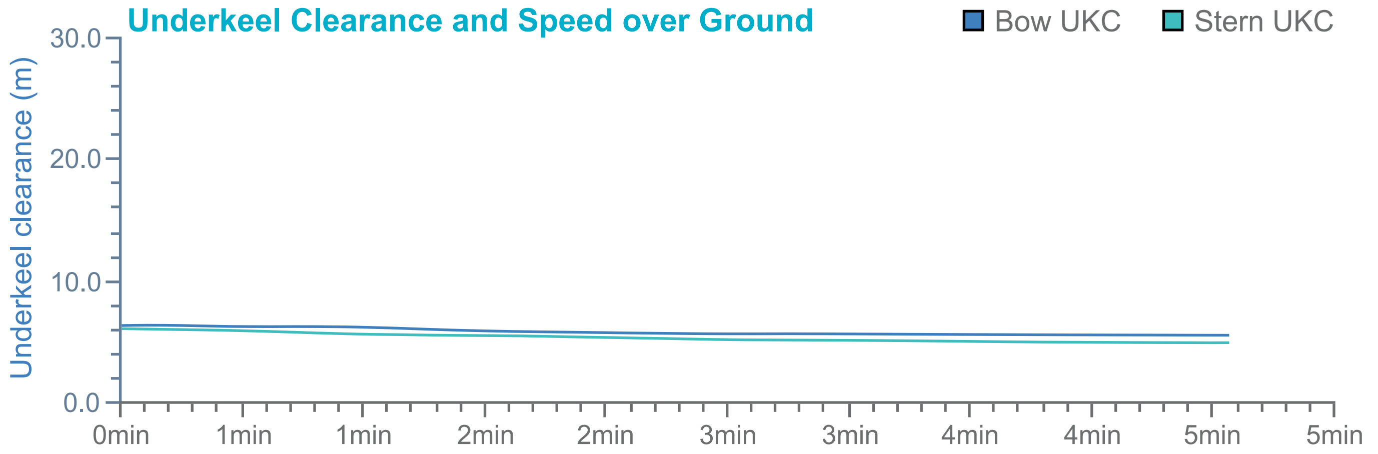

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
Current direction (°N)
5.0
4.0
3.0
2.0
1.0
0.0
360
270
180
090
000
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min
5min

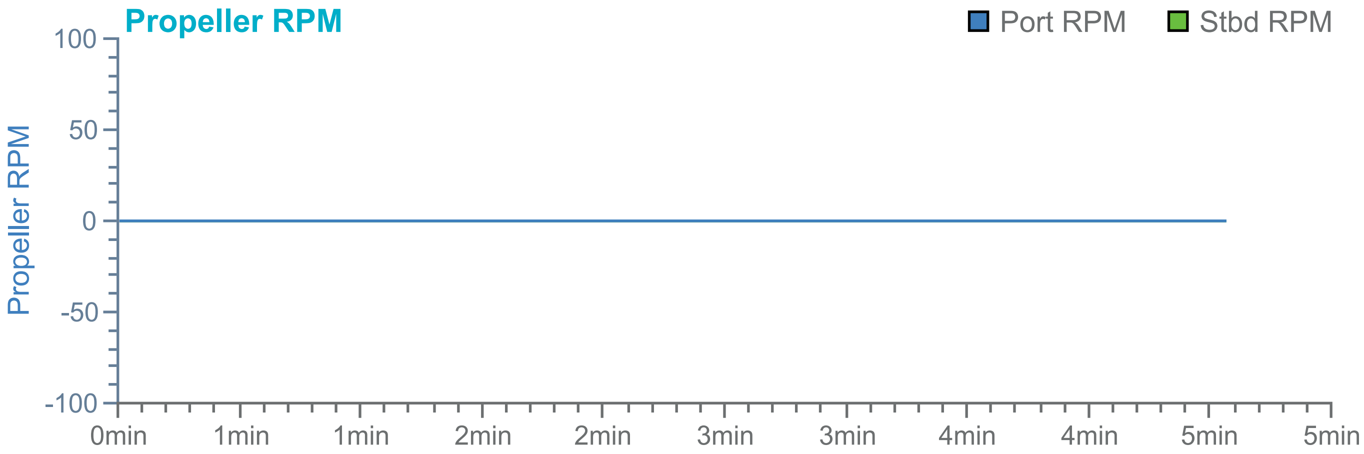

Wind speed and direction
Speed
Direction
Wind speed (knots)
Wind direction (°N)
40
30
20
10
0
360
270
180
090
000
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min
5min

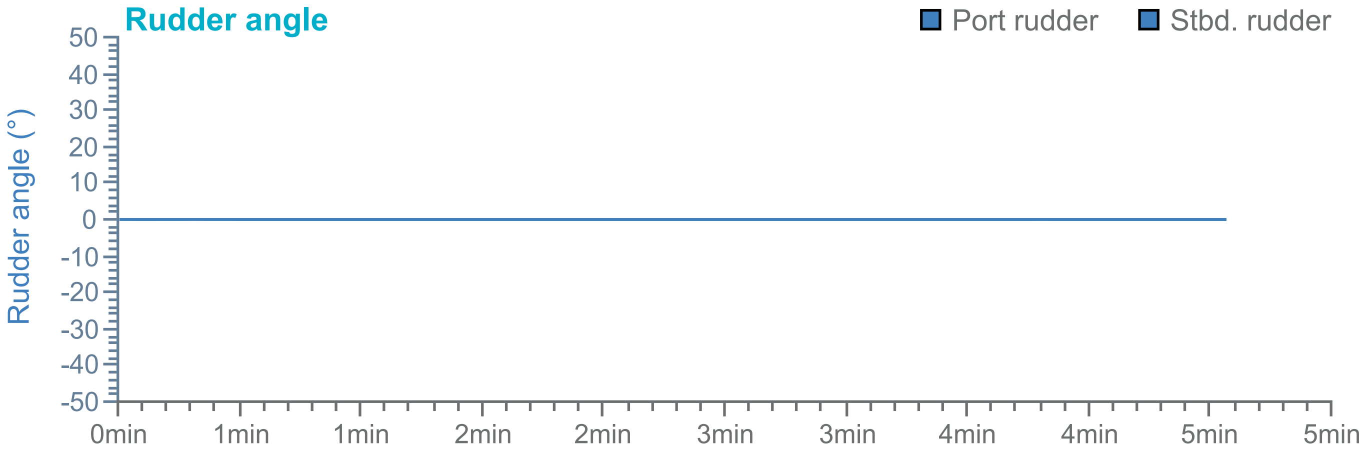

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
30
20
10
0
-10
-20
-30
Heading (°N)
360
270
180
090
000
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min
5min

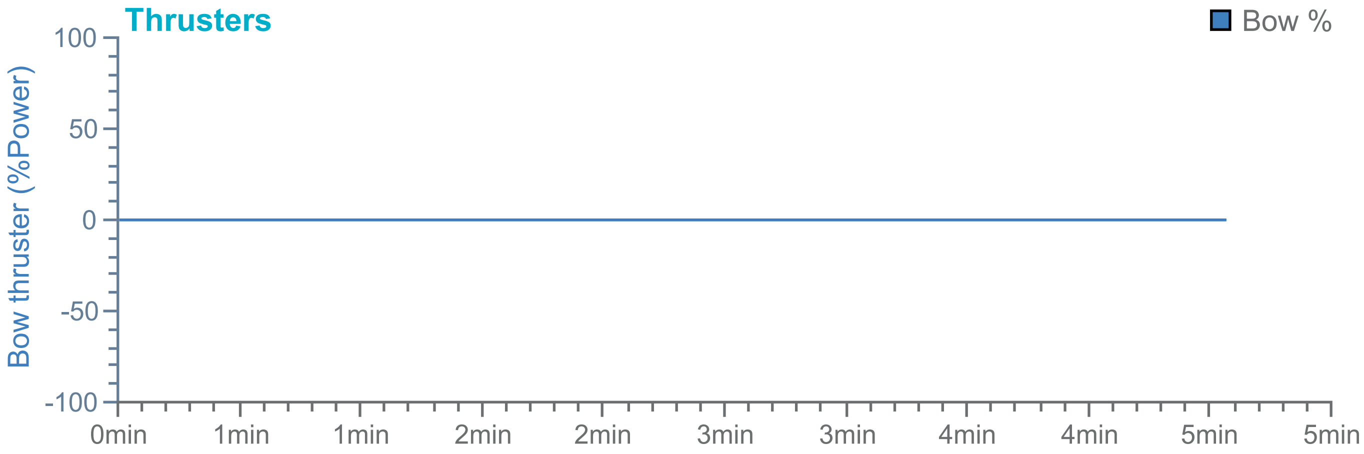

Course over ground and drift
COG
Drift Angle
COG (°)
360
270
180
090
000
Drift Angle (°)
100
50
0
-50
-100
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min
5min

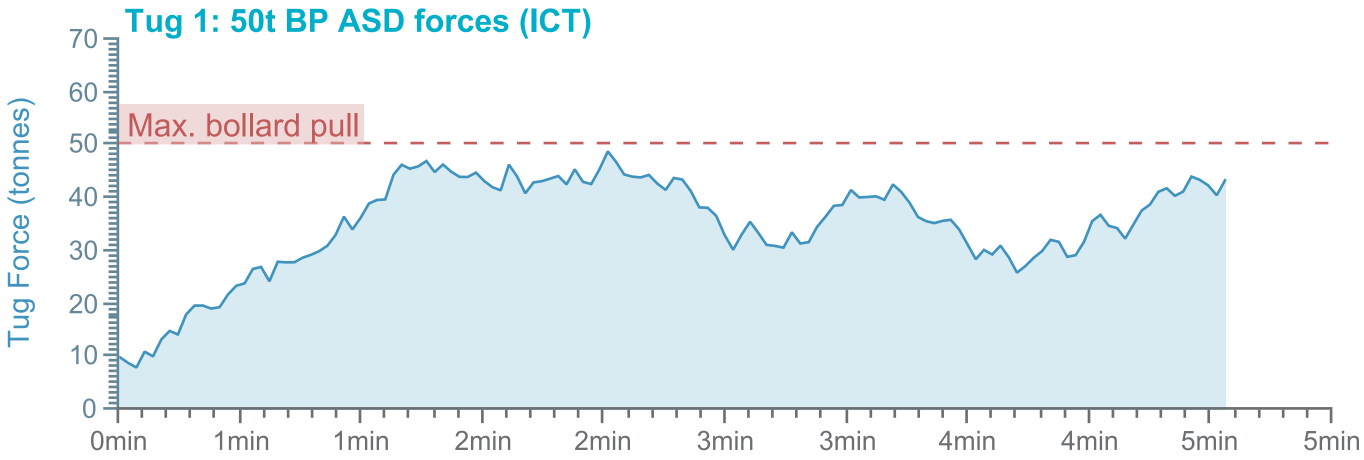

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
20.0
10.0
0.0
-10.0
Lateral speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min
5min

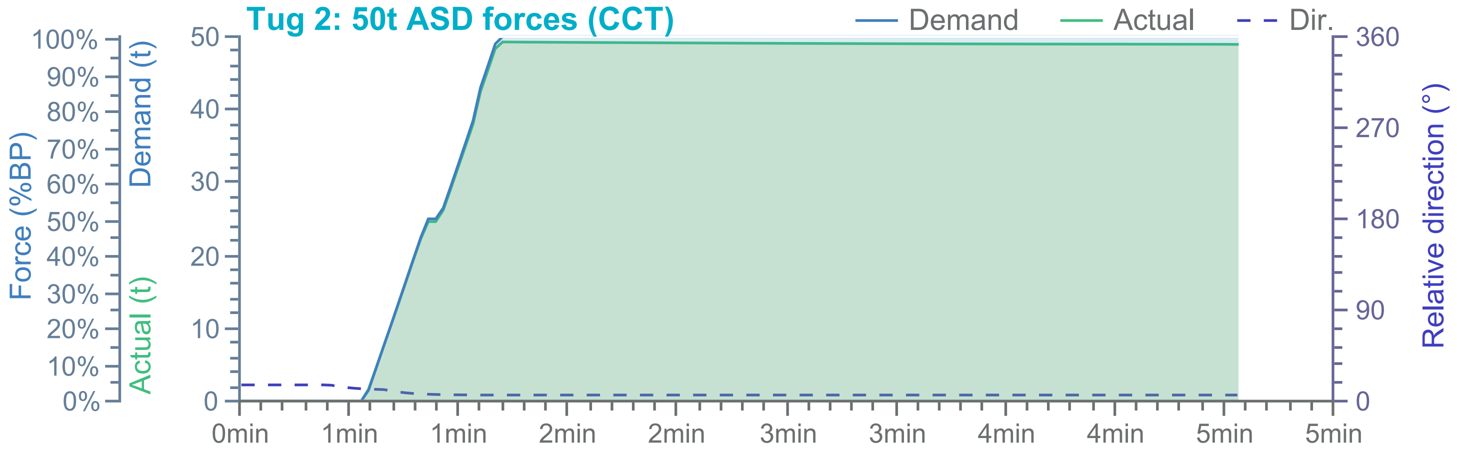

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min
5min


Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min
5min

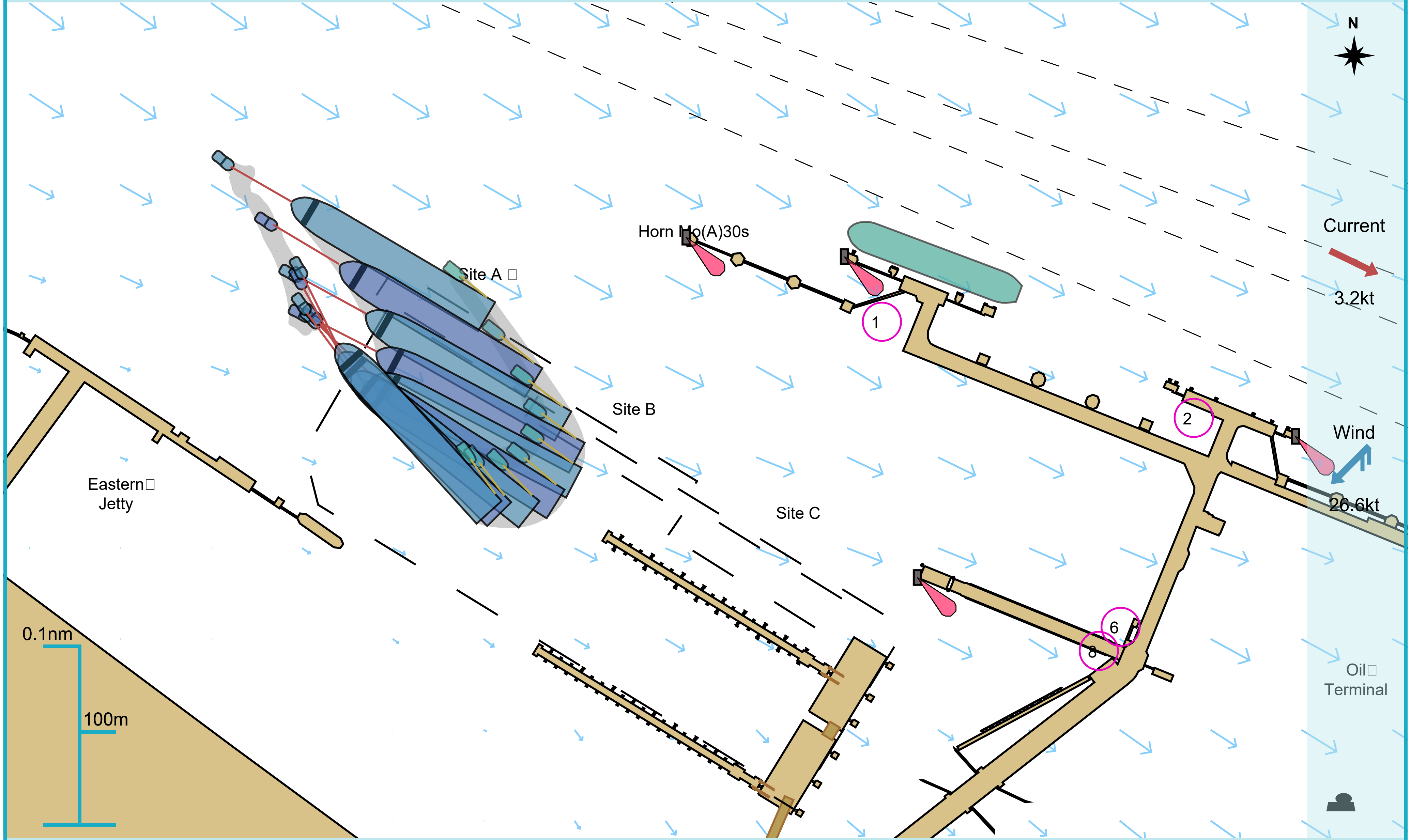

Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min
5min


Thrusters
Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min
5min


Tug 1: 50t BP ASD forces (ICT)
Tug Force (tonnes)
Max. bollard pull
70
60
50
40
30
20
10
0
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min
5min

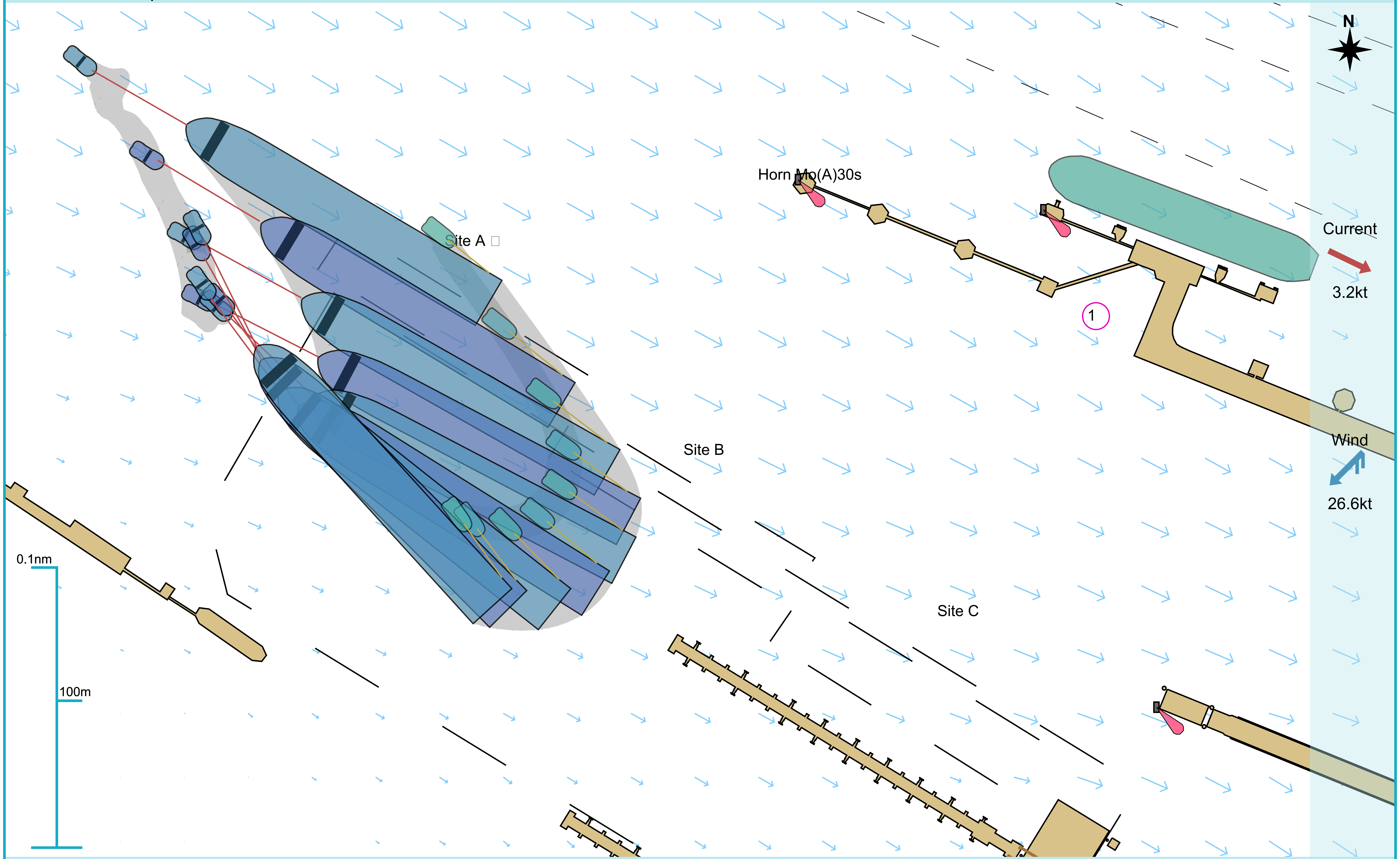

Tug 2: 50t ASD forces (CCT)
Demand
Actual
Dir.
Force (%BP)
Demand (t)
Actual (t)
Relative direction (°)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
50
40
30
20
10
0
360
270
180
90
0
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min
5min

Manoeuvre track plot



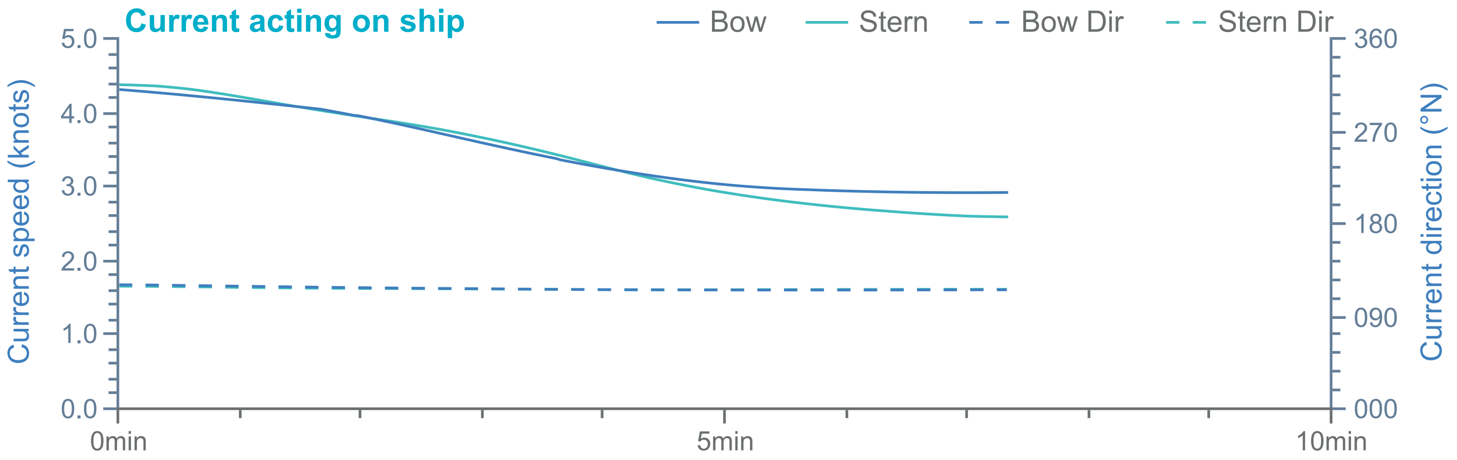
Ships plotted every 1 mins, highlight every 10 mins

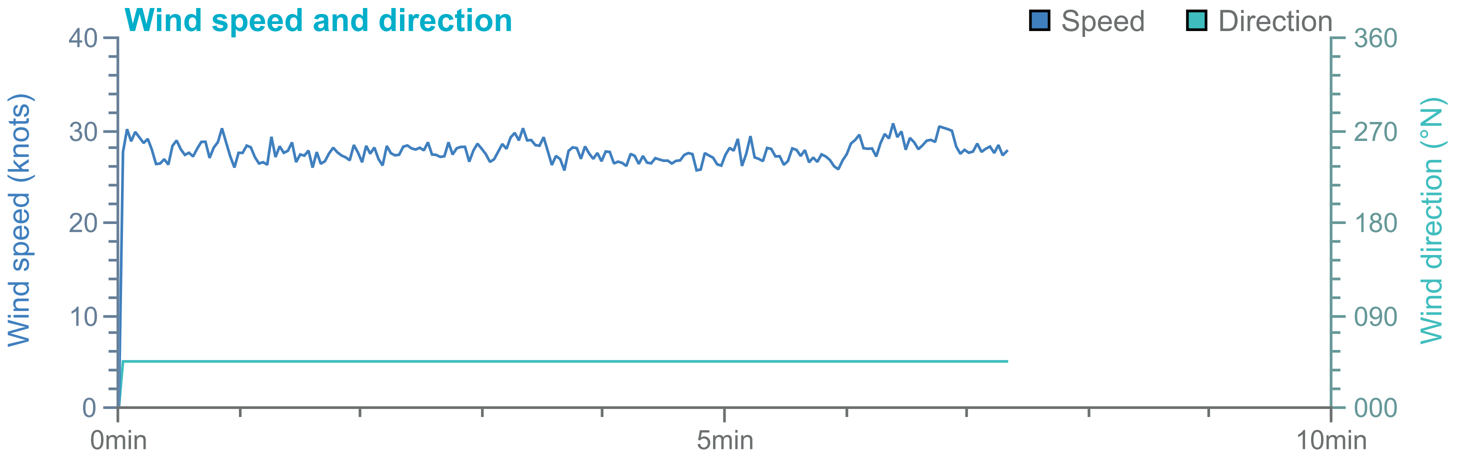
Manoeuvre track plot

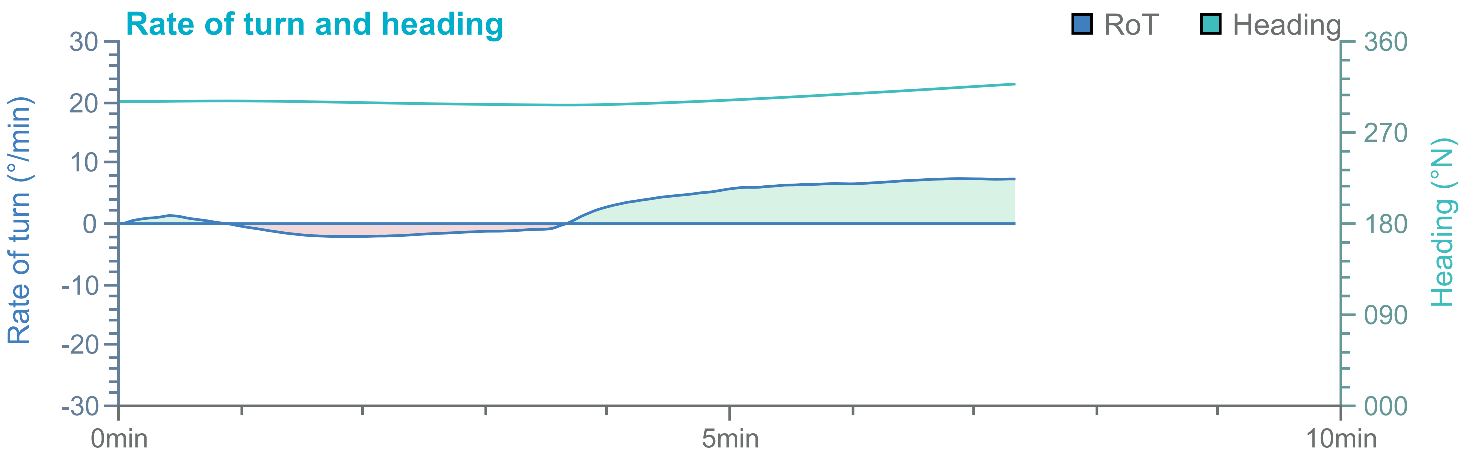


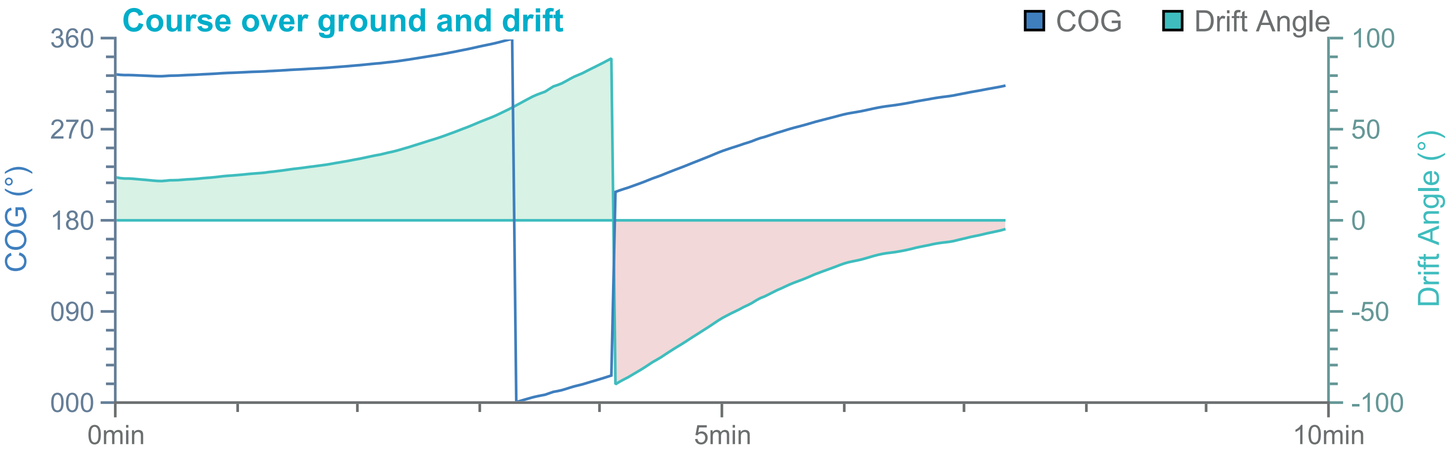
3.72 kts

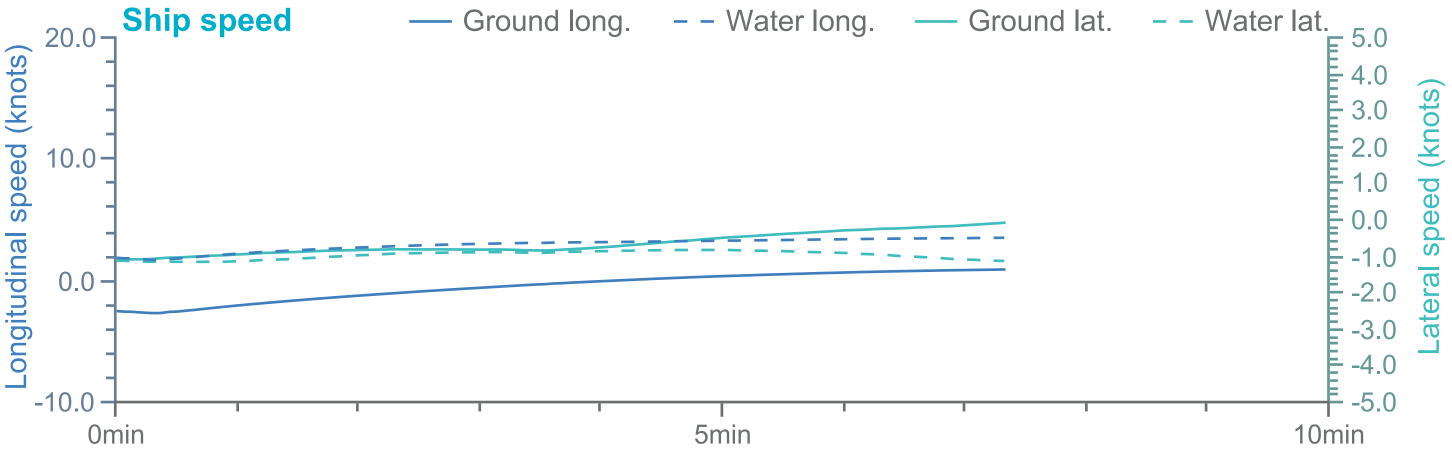
Ships plotted every 1 mins, highlight every 10 mins

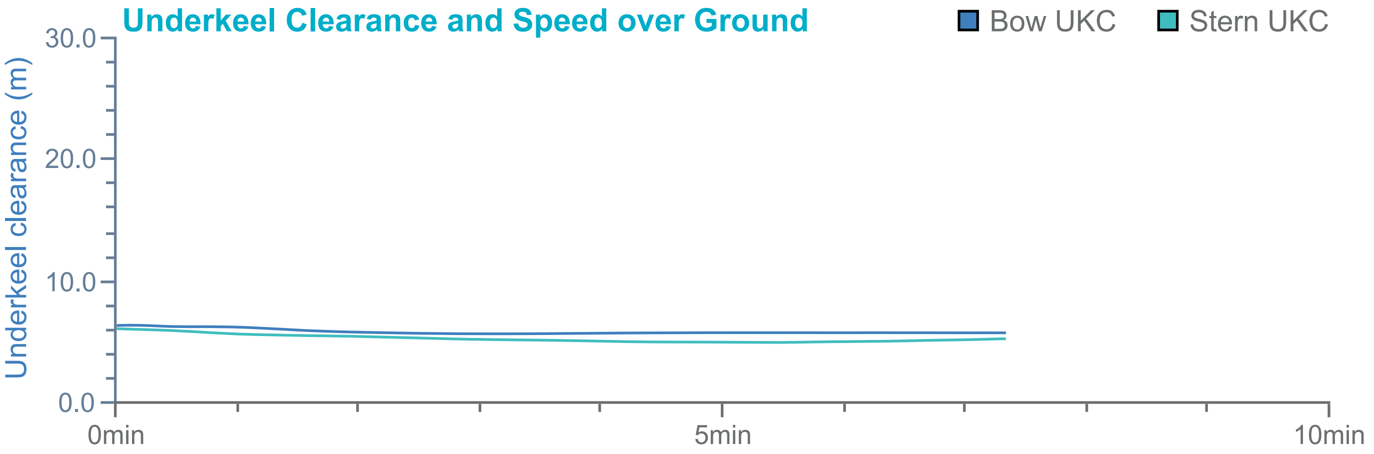

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
Current direction (°N)
360
270
180
090
000
0min
5min
10min


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

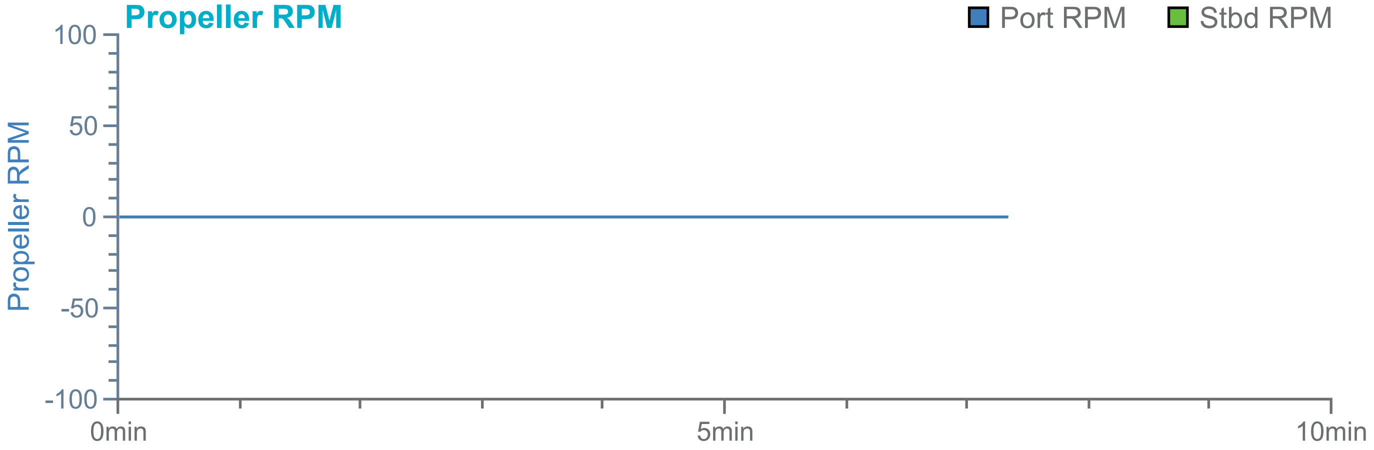

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
30
20
10
0
-10
-20
-30
Heading (°N)
360
270
180
090
000
0min
5min
10min


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

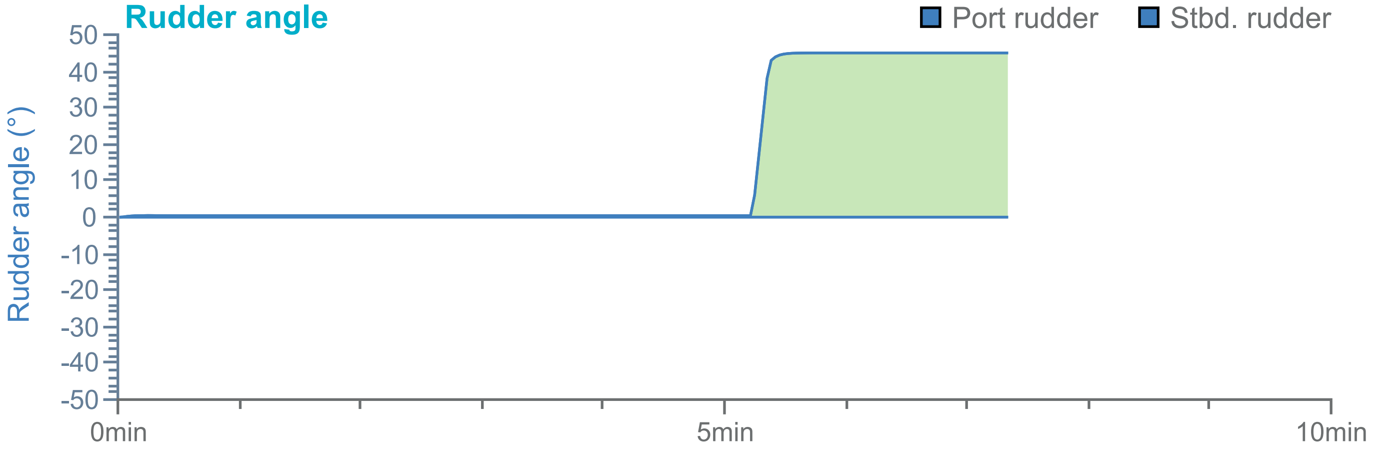

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
20.0
10.0
0.0
-10.0
Lateral speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min


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

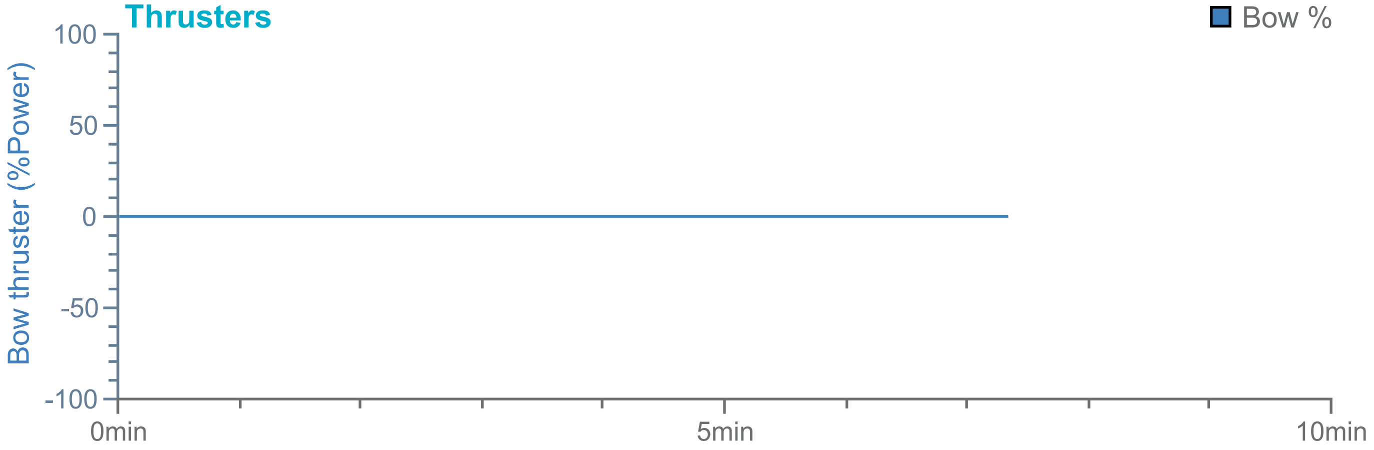
Propeller RPM

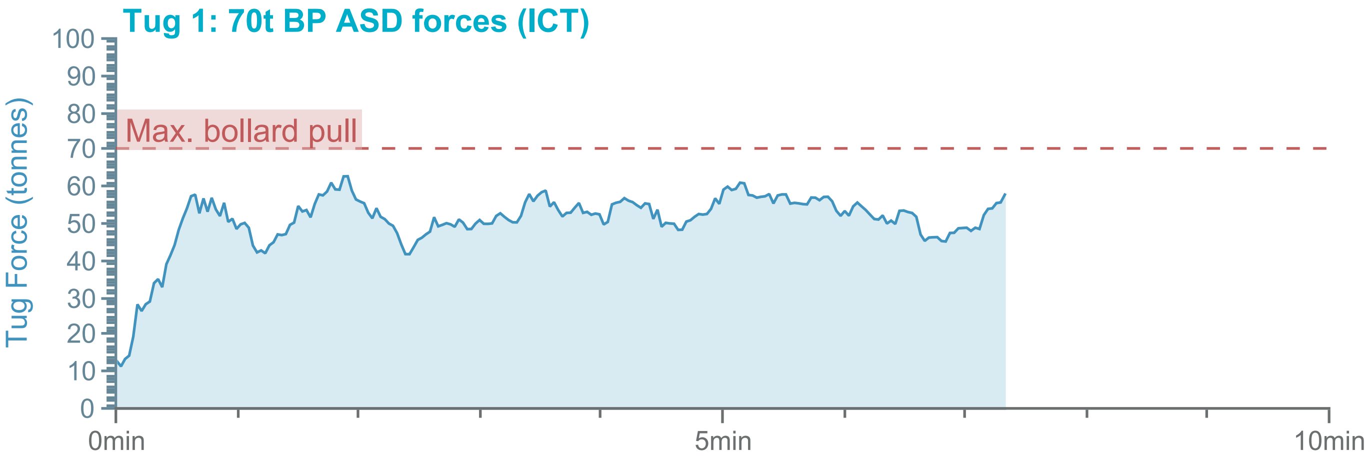


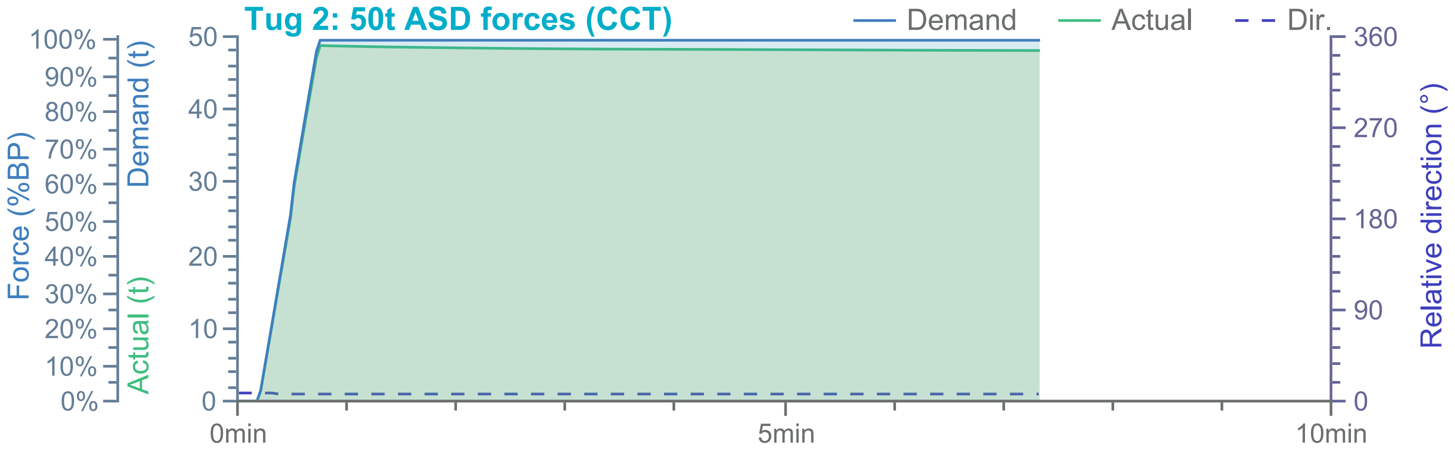
Rudder angle



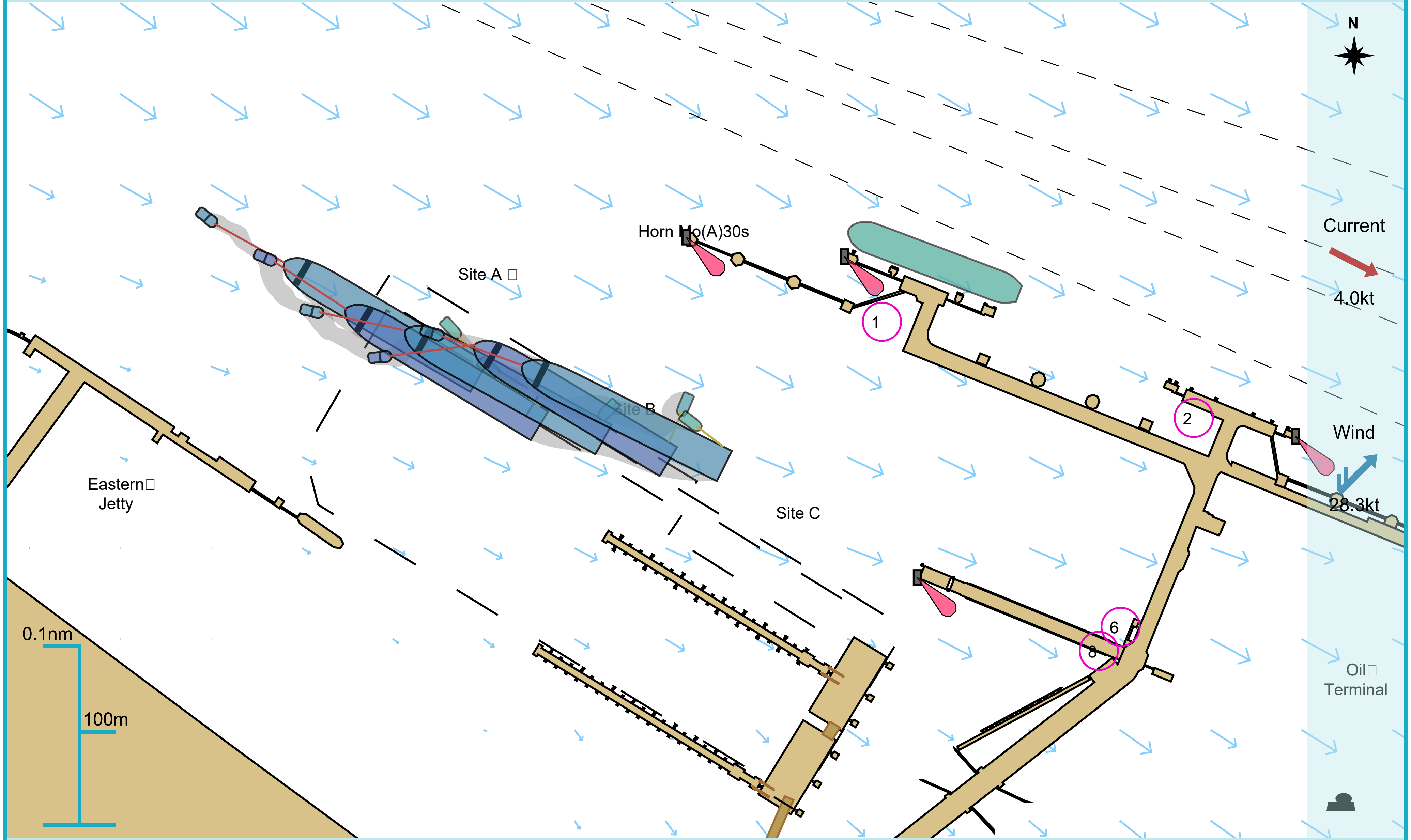
Thrusters




Tug 1: 70t BP ASD forces (ICT)
Tug Force (tonnes)
100
90
80
70
60
50
40
30
20
10
0
Max. bollard pull
0min
5min
10min

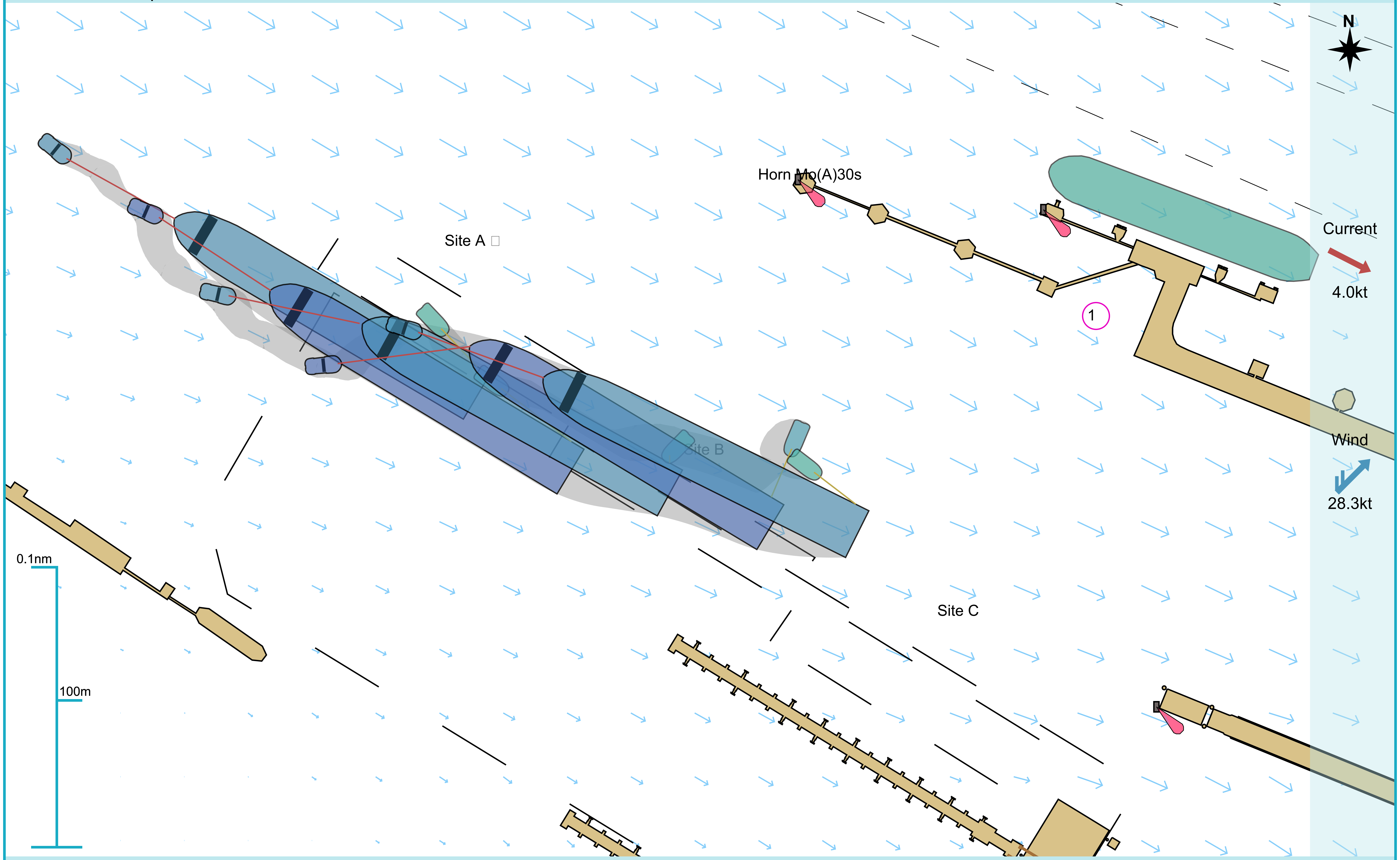

Tug 2: 50t ASD forces (CCT)
Demand
Actual
Dir.
Force (%BP)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Demand (t)
Actual (t)
50
40
30
20
10
0
Relative direction (°)
360
270
180
90
0
0min
5min
10min

Manoeuvre track plot



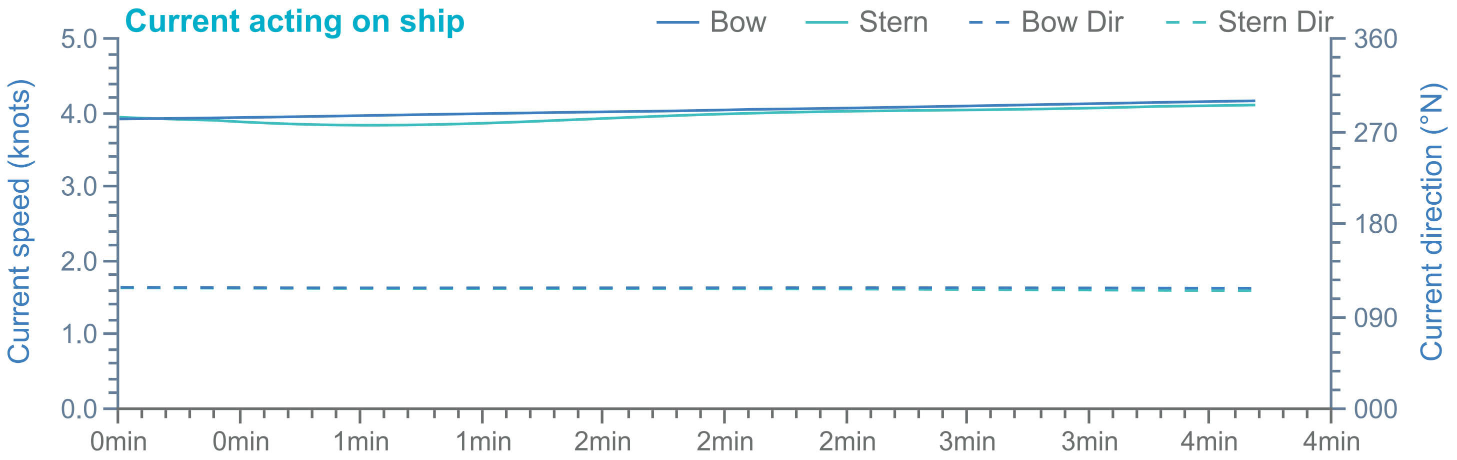
Ships plotted every 1 mins, highlight every 10 mins

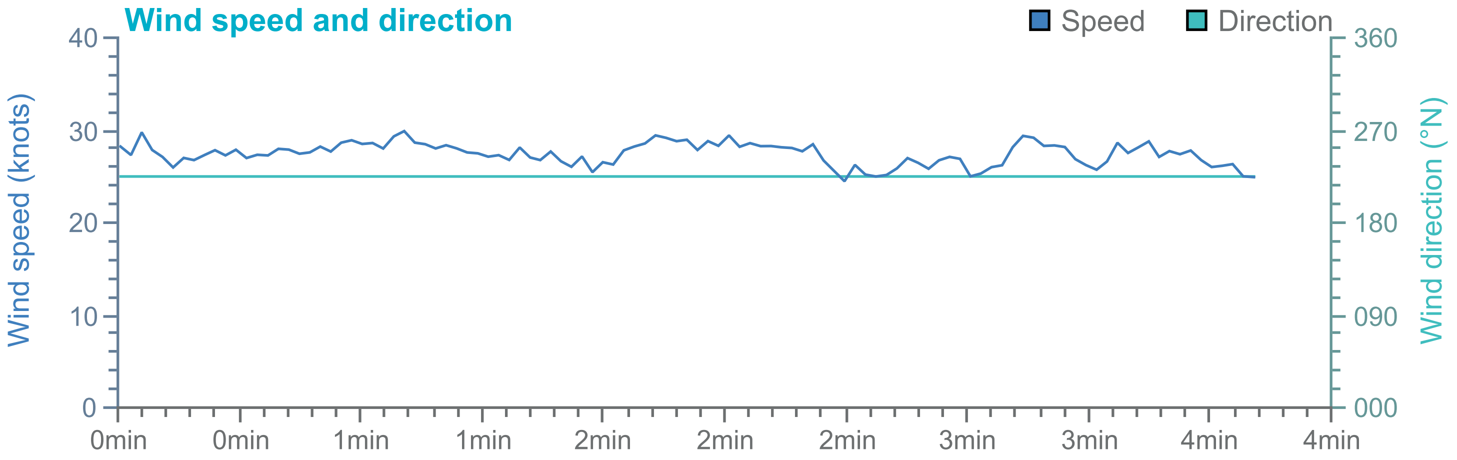
Manoeuvre track plot

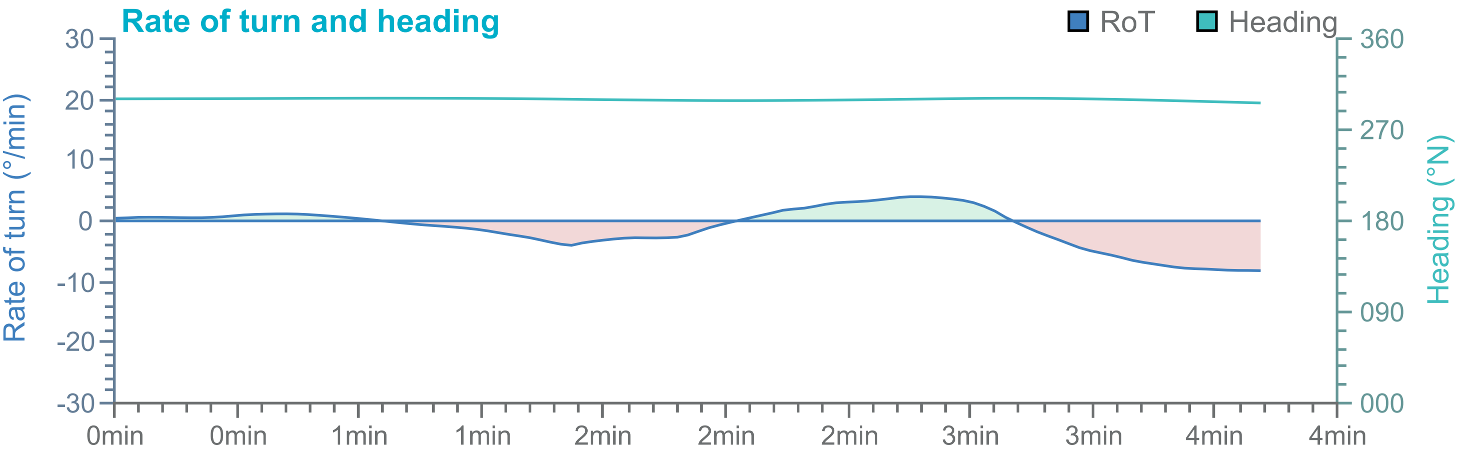


3.72 kts

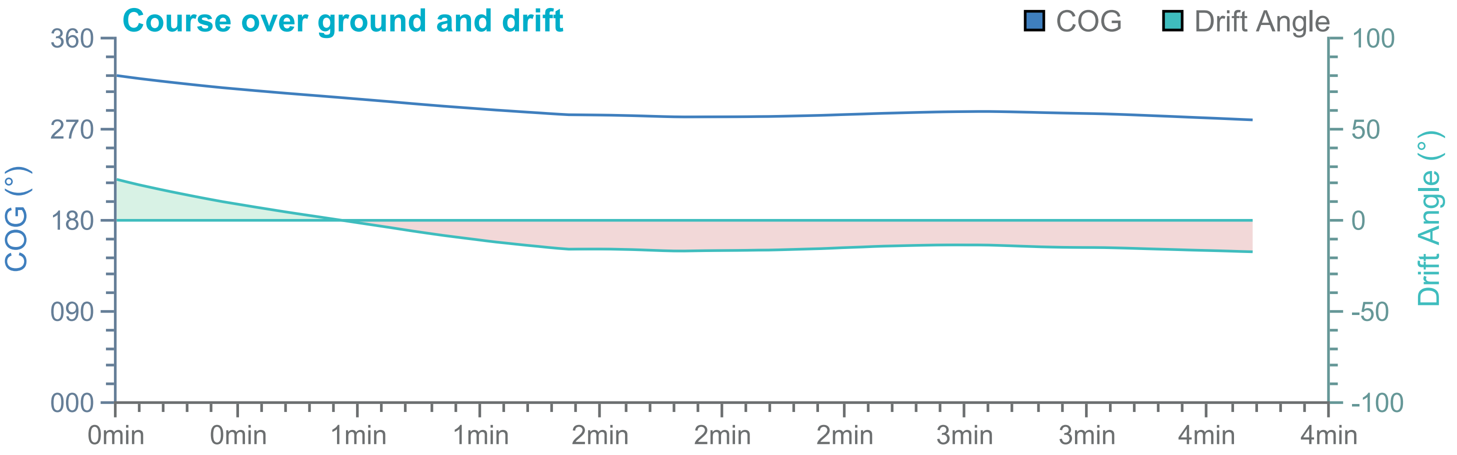
Ships plotted every 1 mins, highlight every 10 mins


Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
Current direction (°N)
360
270
180
090
000
0min
0min
1min
1min
2min
2min
2min
3min
3min
4min
4min

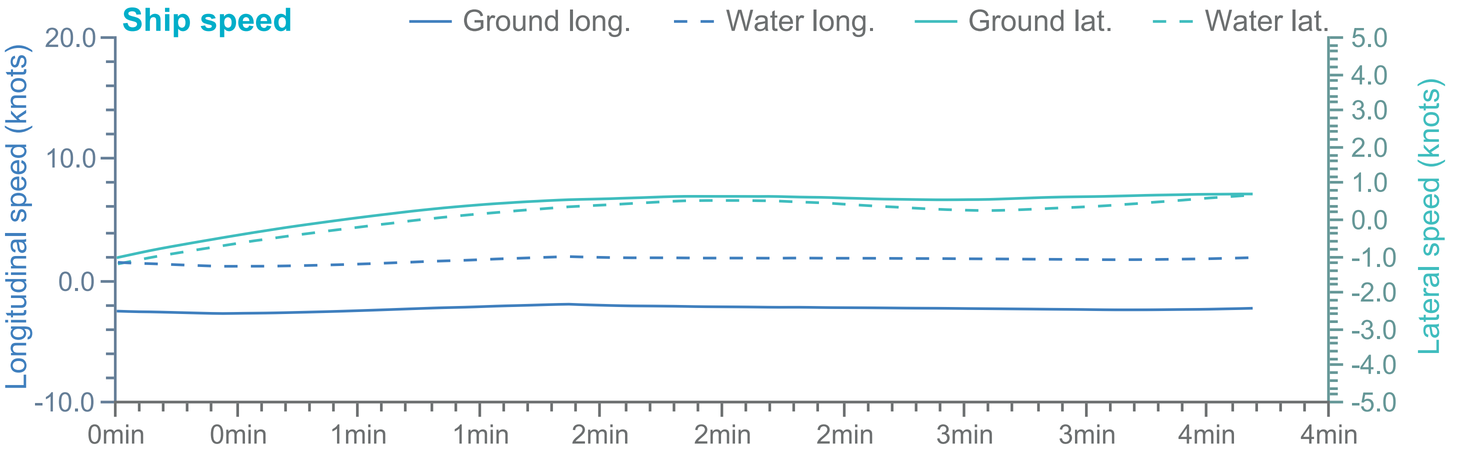

Wind speed and direction
Speed
Direction
Wind speed (knots)
40
30
20
10
0
Wind direction (°N)
360
270
180
090
000
0min
0min
1min
1min
2min
2min
2min
3min
3min
4min
4min



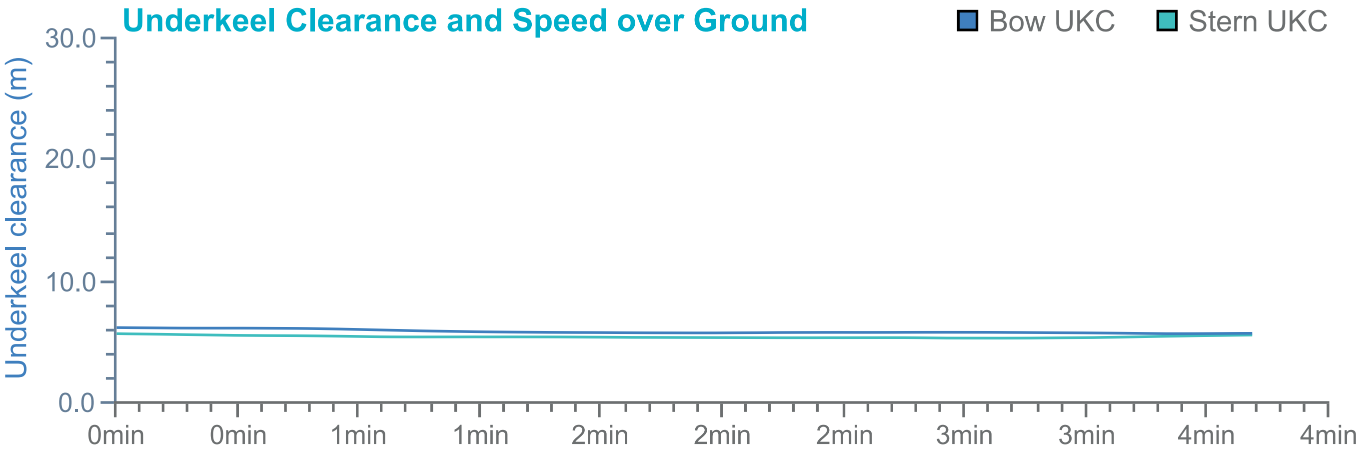
Rate of turn and heading



Course over ground and drift

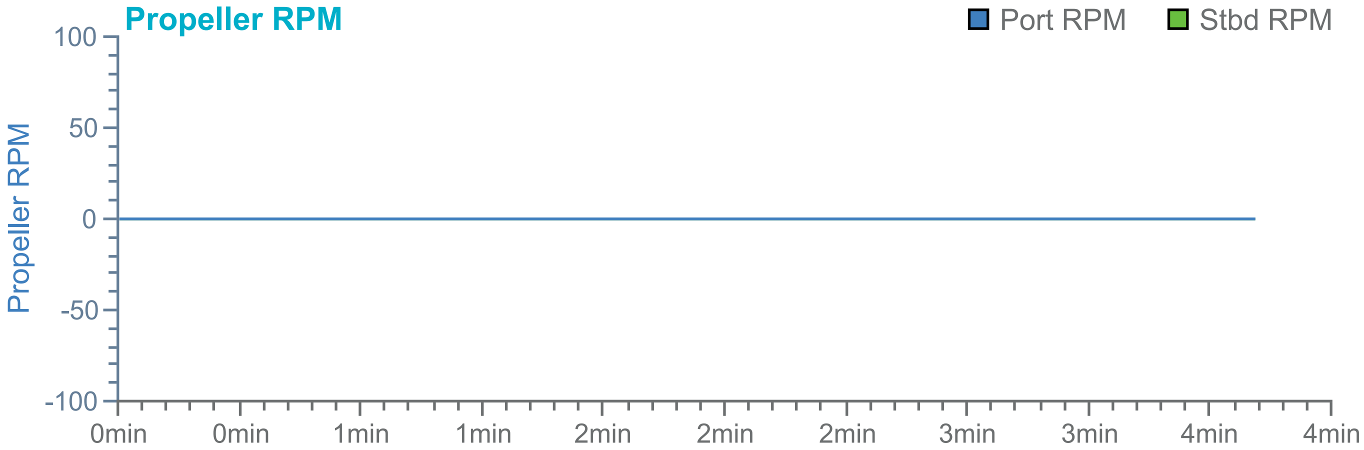


Ship speed

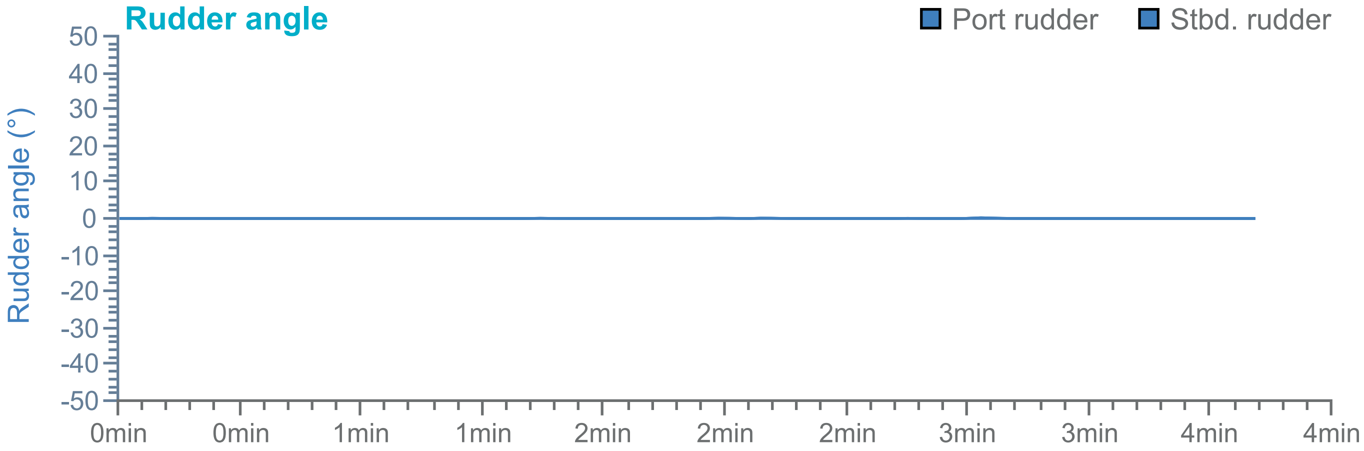


Underkeel Clearance and Speed over Ground

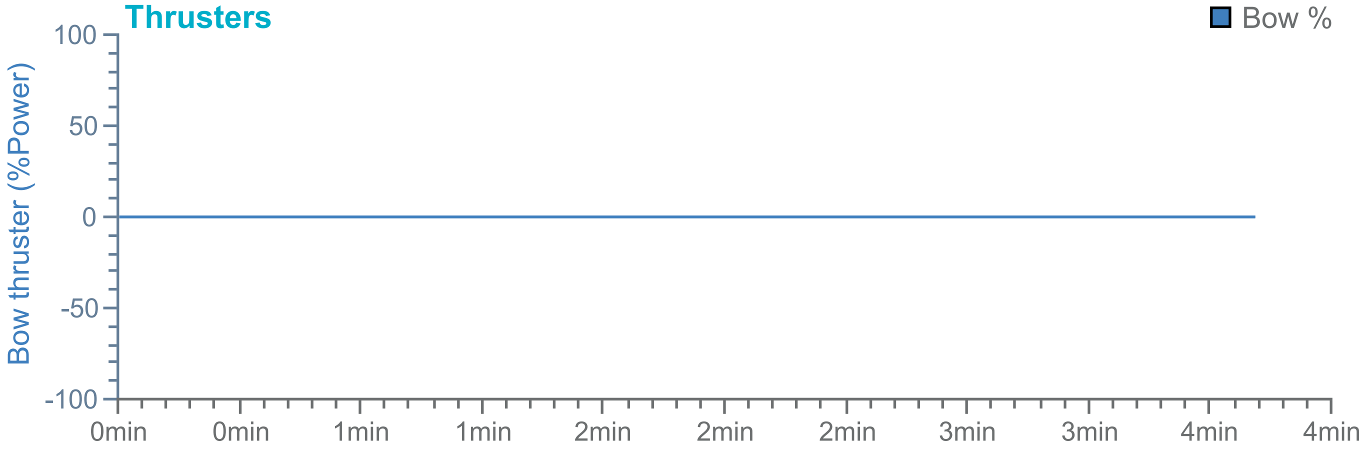
Propeller RPM

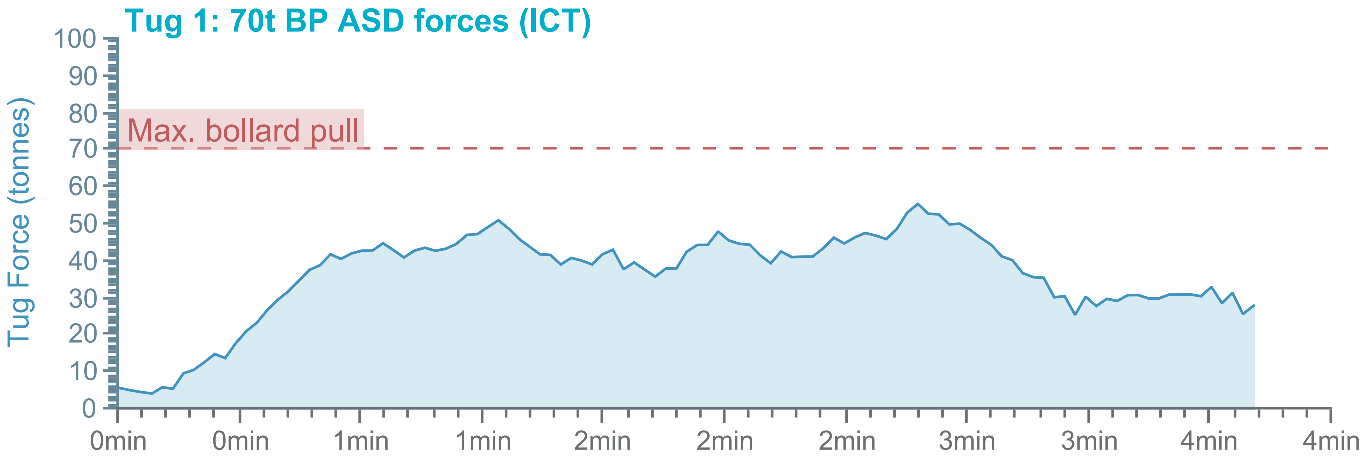


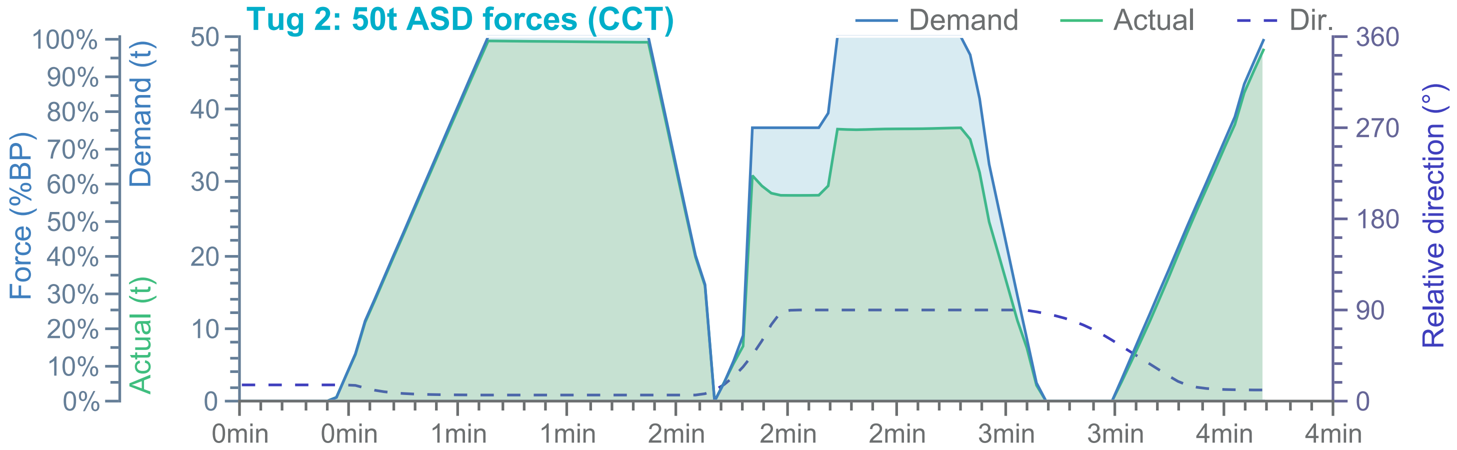
Rudder angle



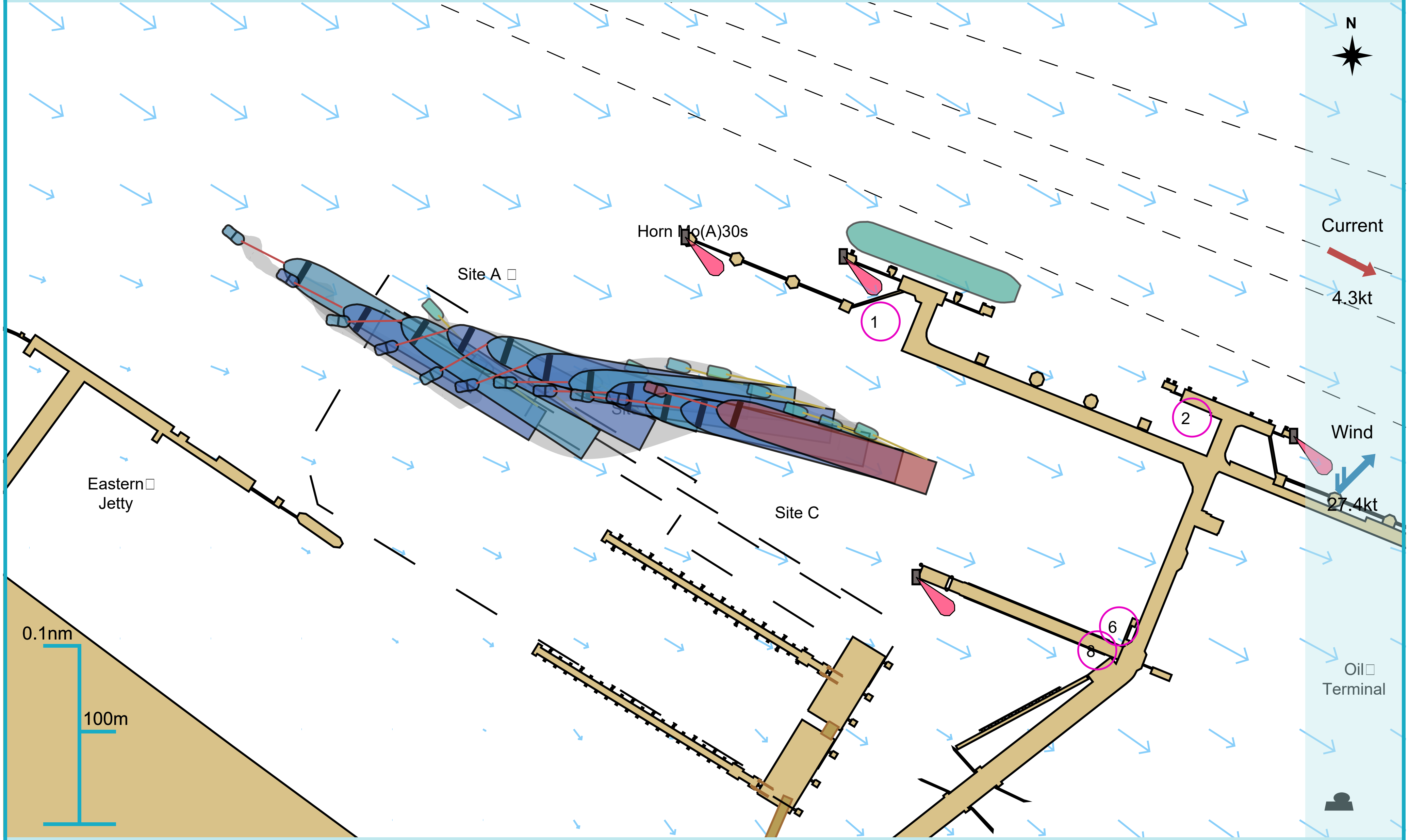
Thrusters




Tug 1: 70t BP ASD forces (ICT)
Tug Force (tonnes)
100
90
80
70
60
50
40
30
20
10
0
Max. bollard pull
0min
0min
1min
1min
2min
2min
2min
3min
3min
4min
4min

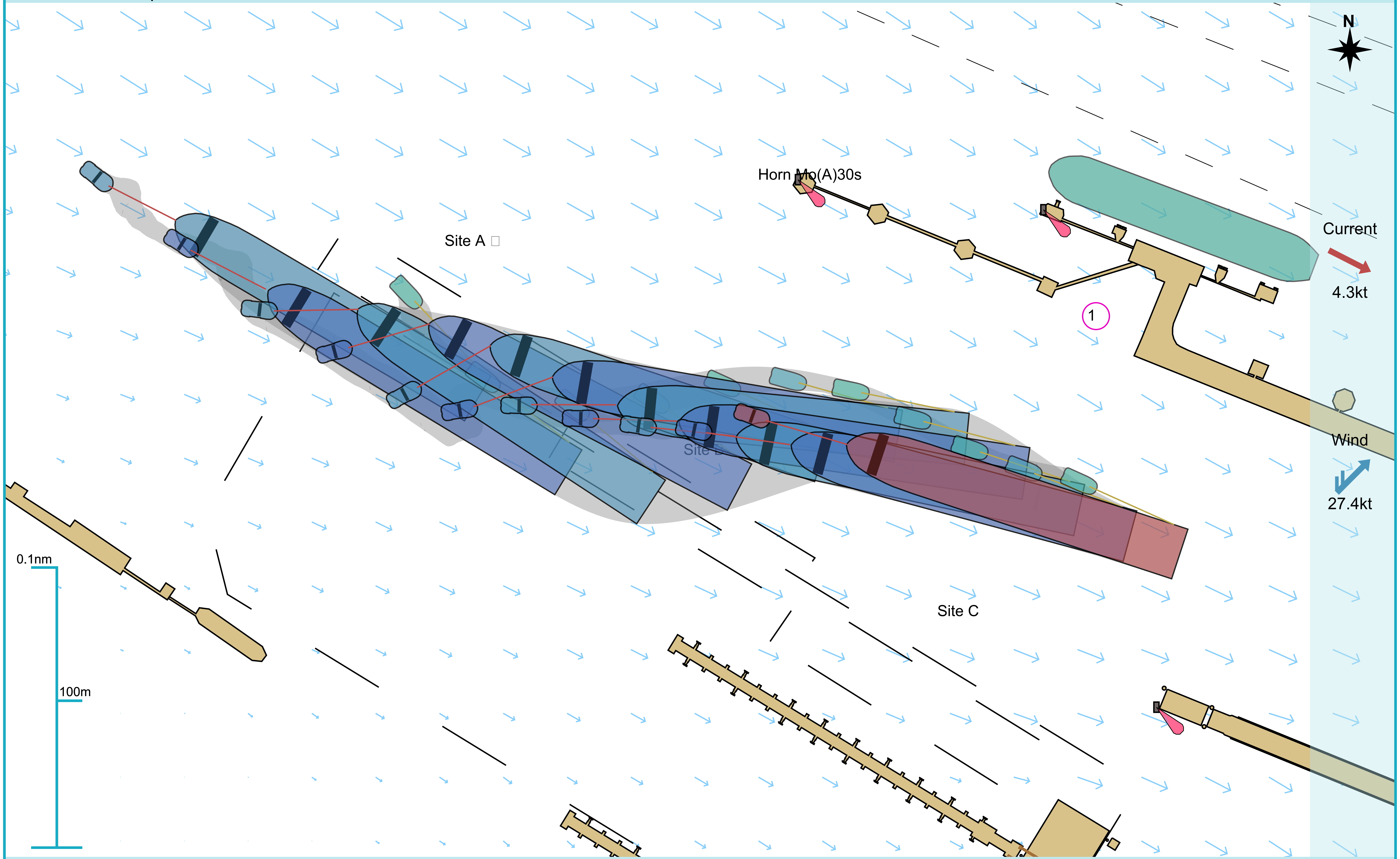

Tug 2: 50t ASD forces (CCT)
Demand
Actual
Dir.
Force (%BP)
Demand (t)
Actual (t)
Relative direction (°)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
50
40
30
20
10
0
360
270
180
90
0
0min
0min
1min
1min
2min
2min
2min
3min
3min
4min
4min

Manoeuvre track plot



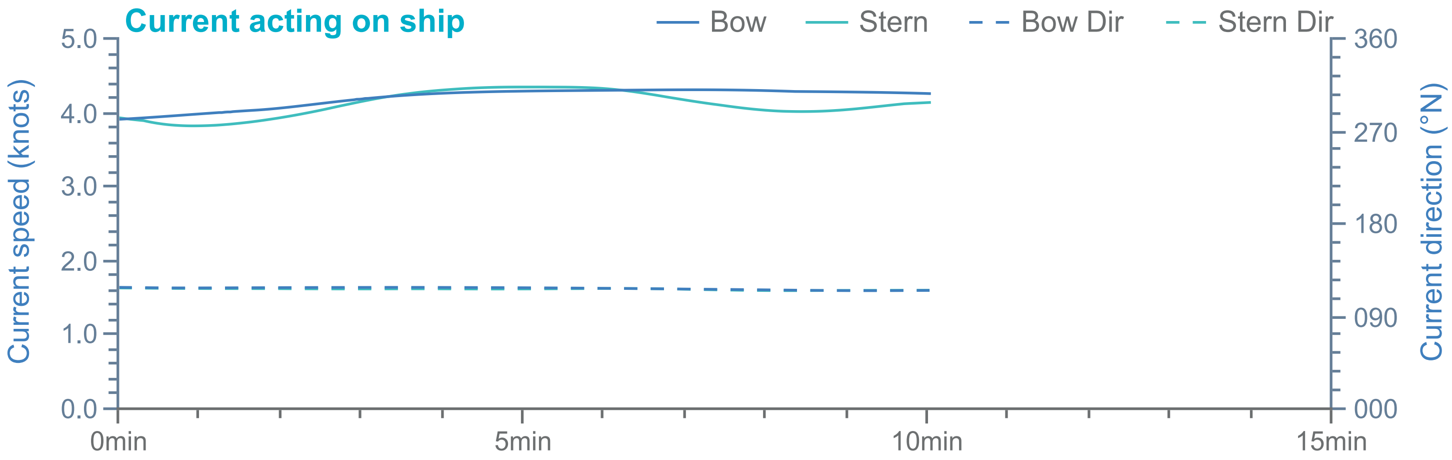
Ships plotted every 1 mins, highlight every 10 mins

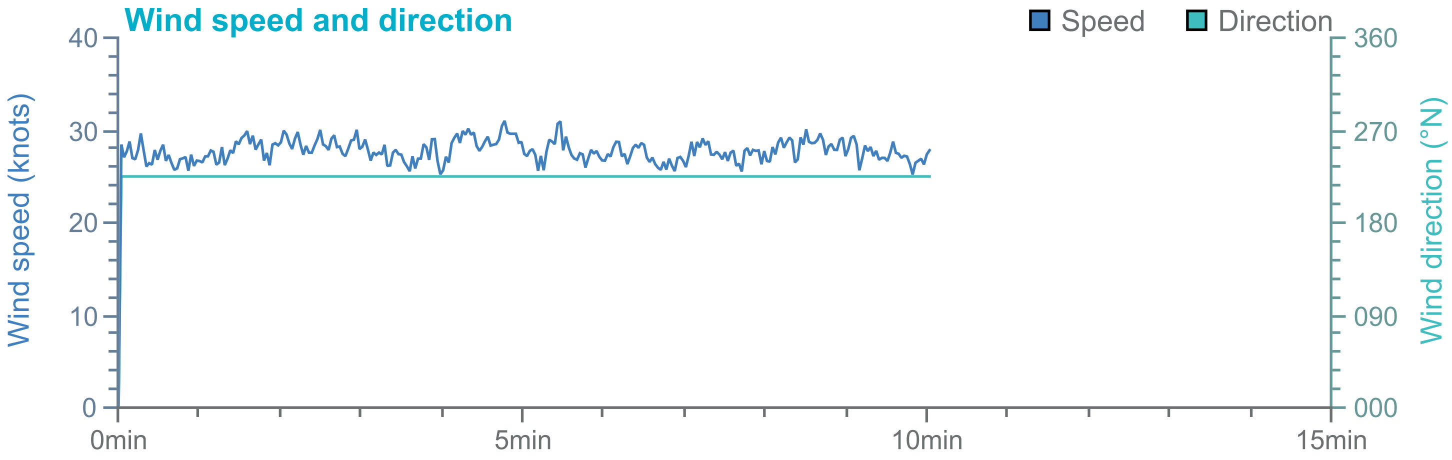
Manoeuvre track plot

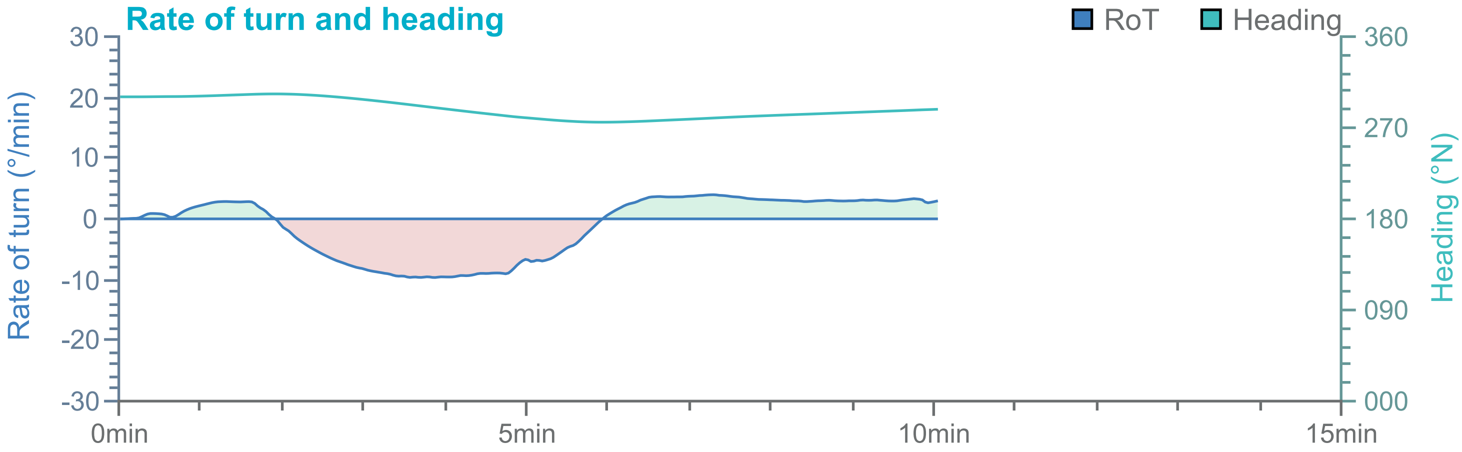


3.72 kts

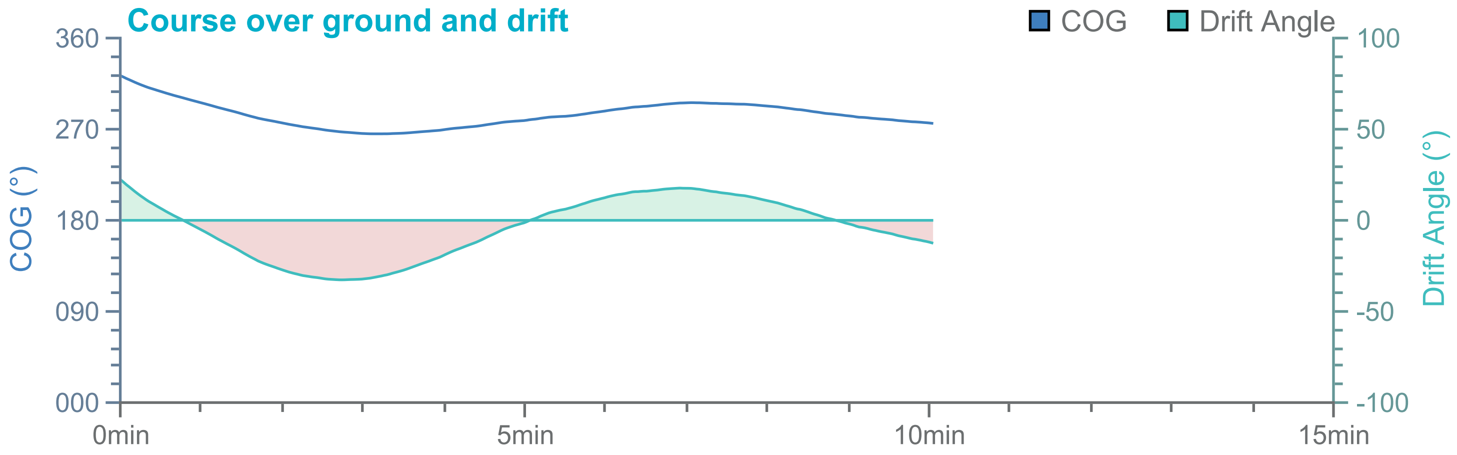
Ships plotted every 1 mins, highlight every 10 mins


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

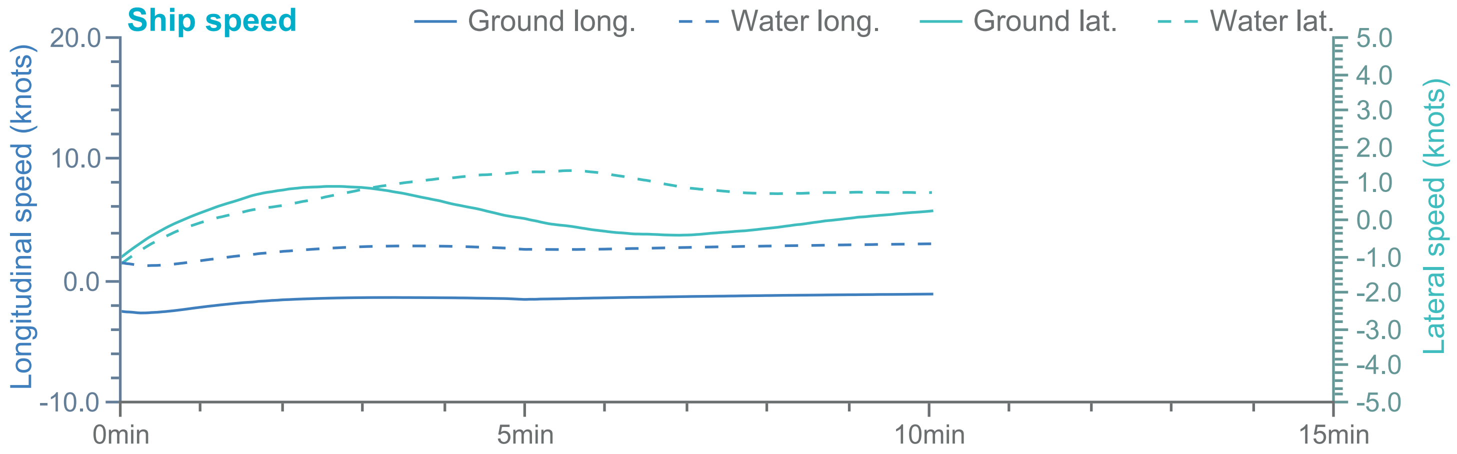

Wind speed and direction
Speed
Direction
Wind speed (knots)
40
30
20
10
0
Wind direction (°N)
360
270
180
090
000
0min
5min
10min
15min



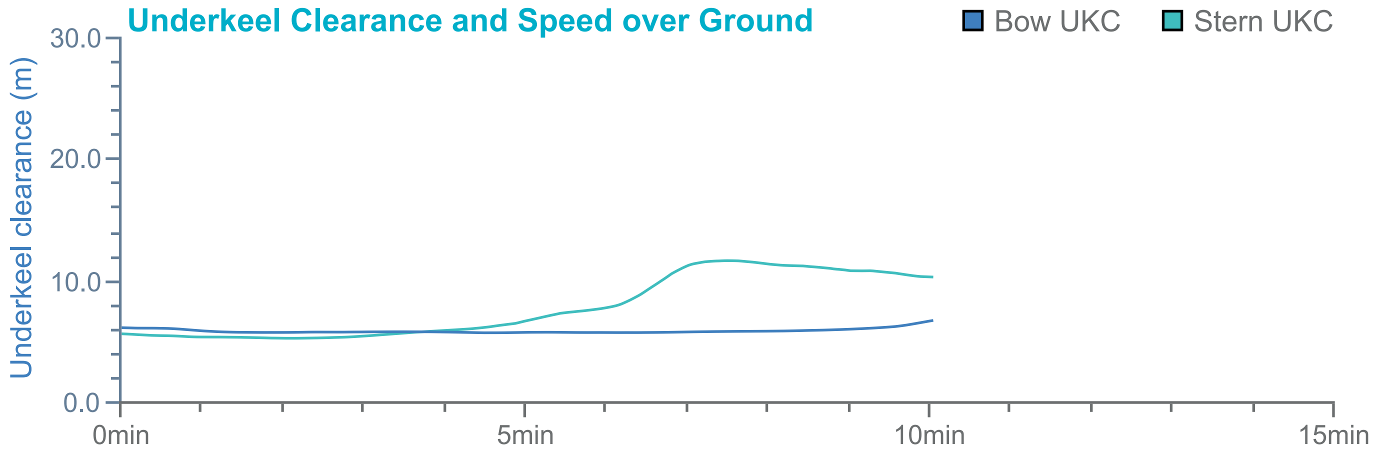
Rate of turn and heading



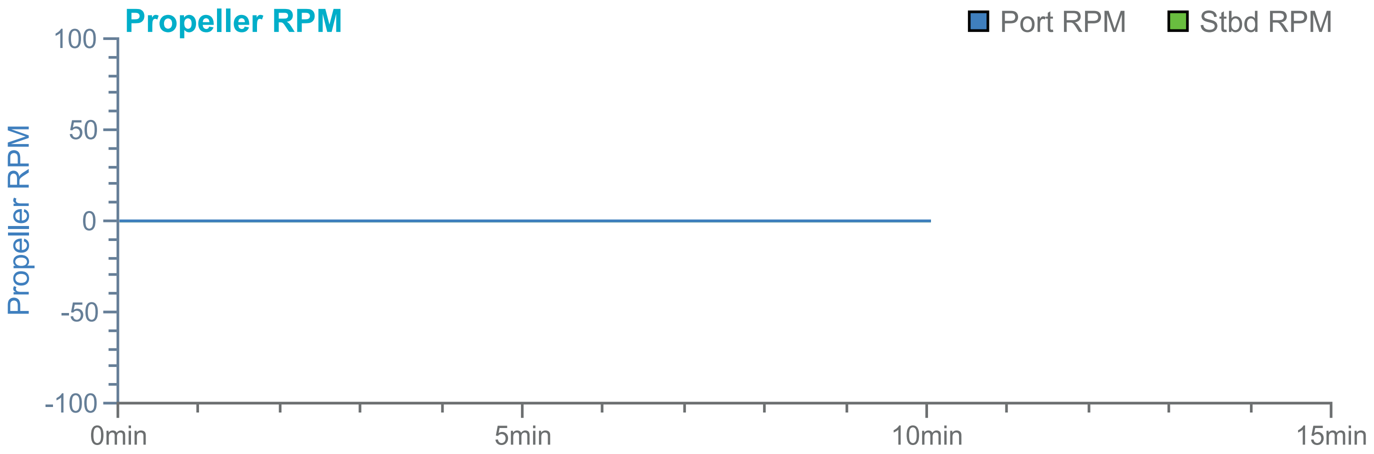
Course over ground and drift

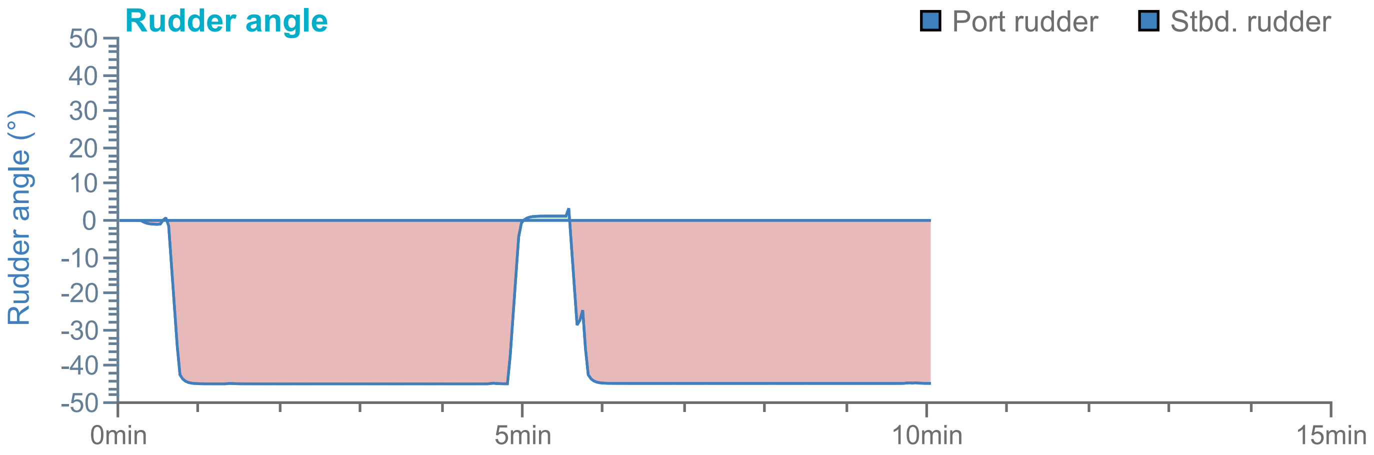


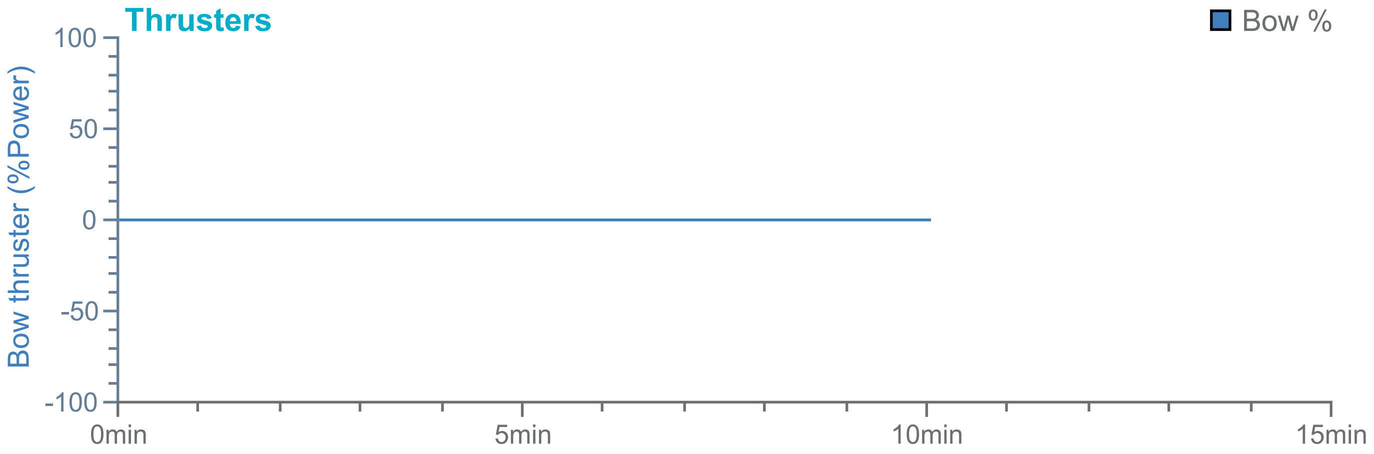
Ship speed

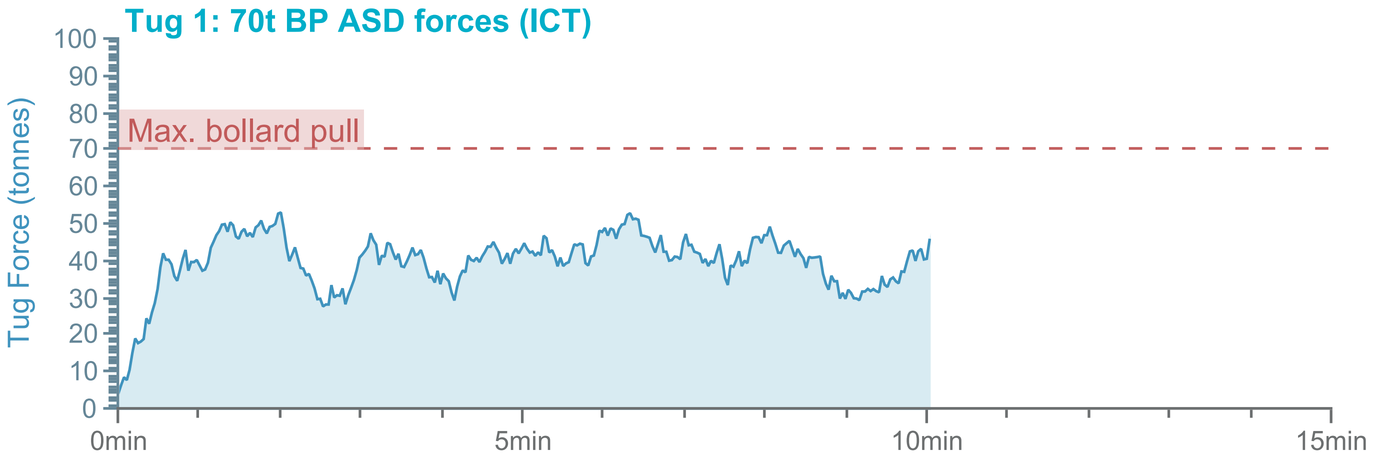


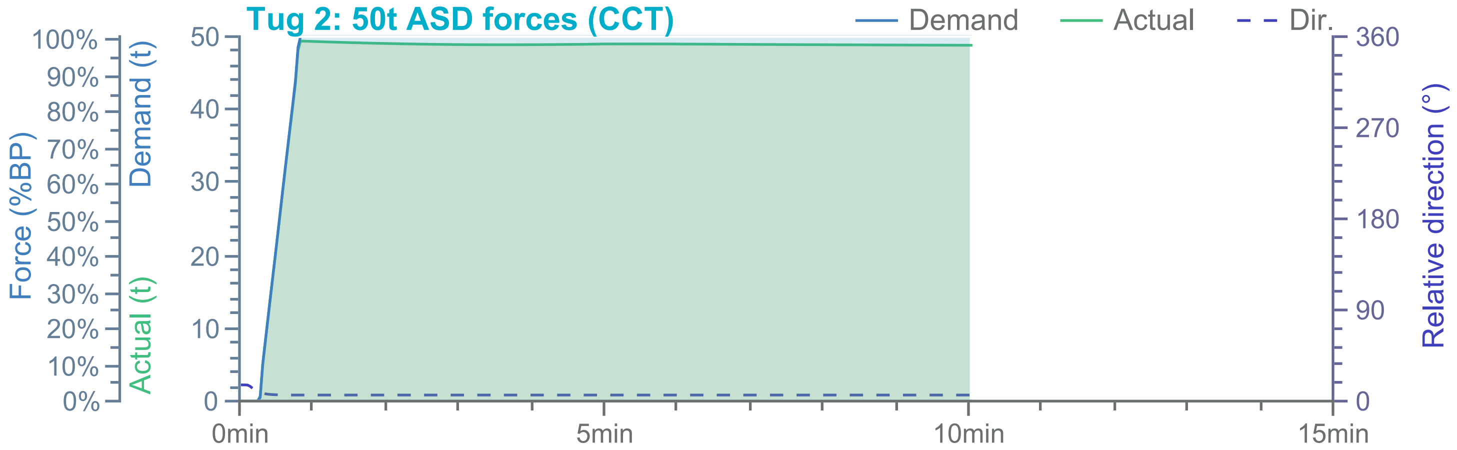
Underkeel Clearance and Speed over Ground


Propeller RPM
🟦 Port RPM
🟩 Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min

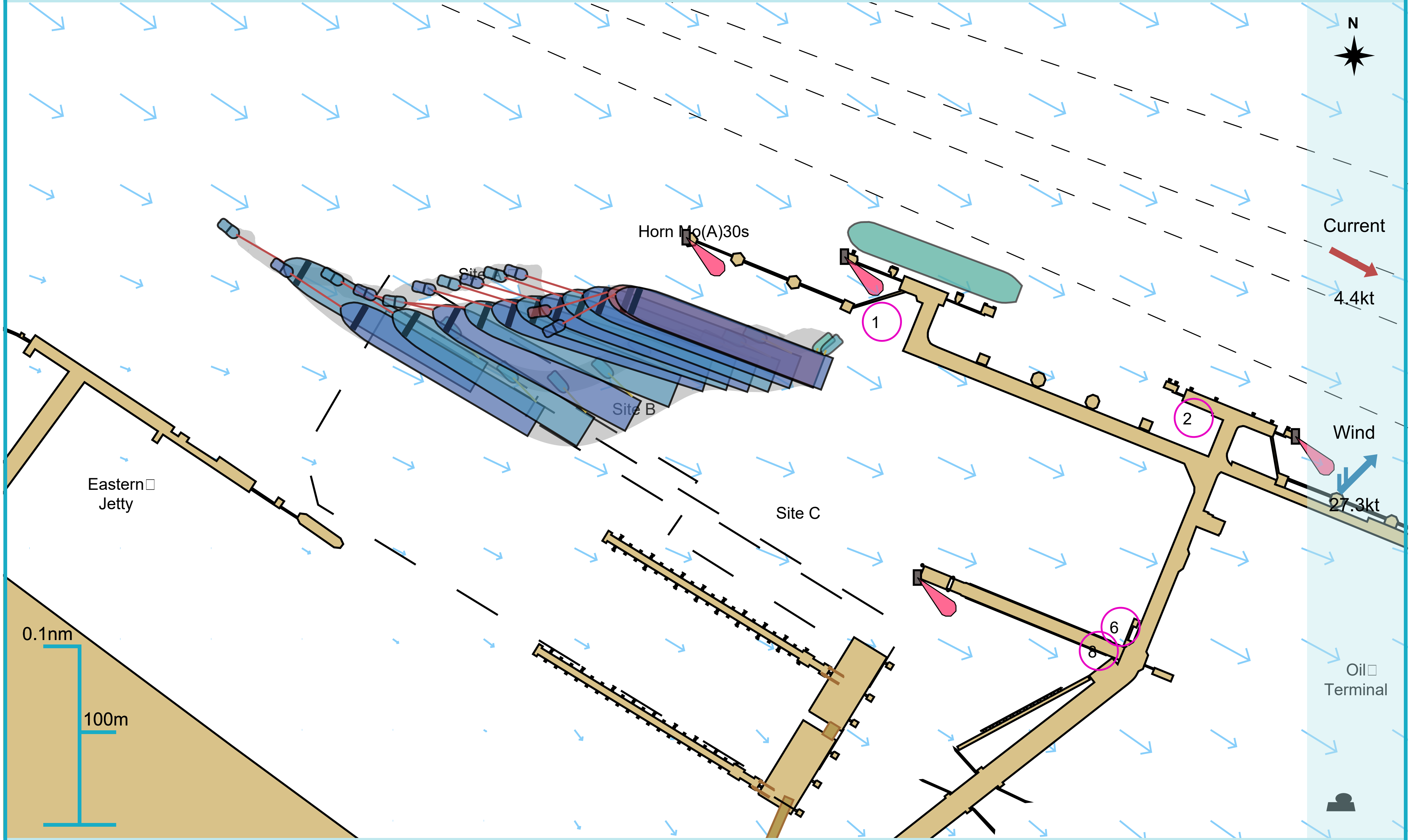

Rudder angle
🟦 Port rudder
🟦 Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
5min
10min
15min


Thrusters
🟦 Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min


Tug 1: 70t BP ASD forces (ICT)
Tug Force (tonnes)
100
90
80
70
60
50
40
30
20
10
0
Max. bollard pull
0min
5min
10min
15min

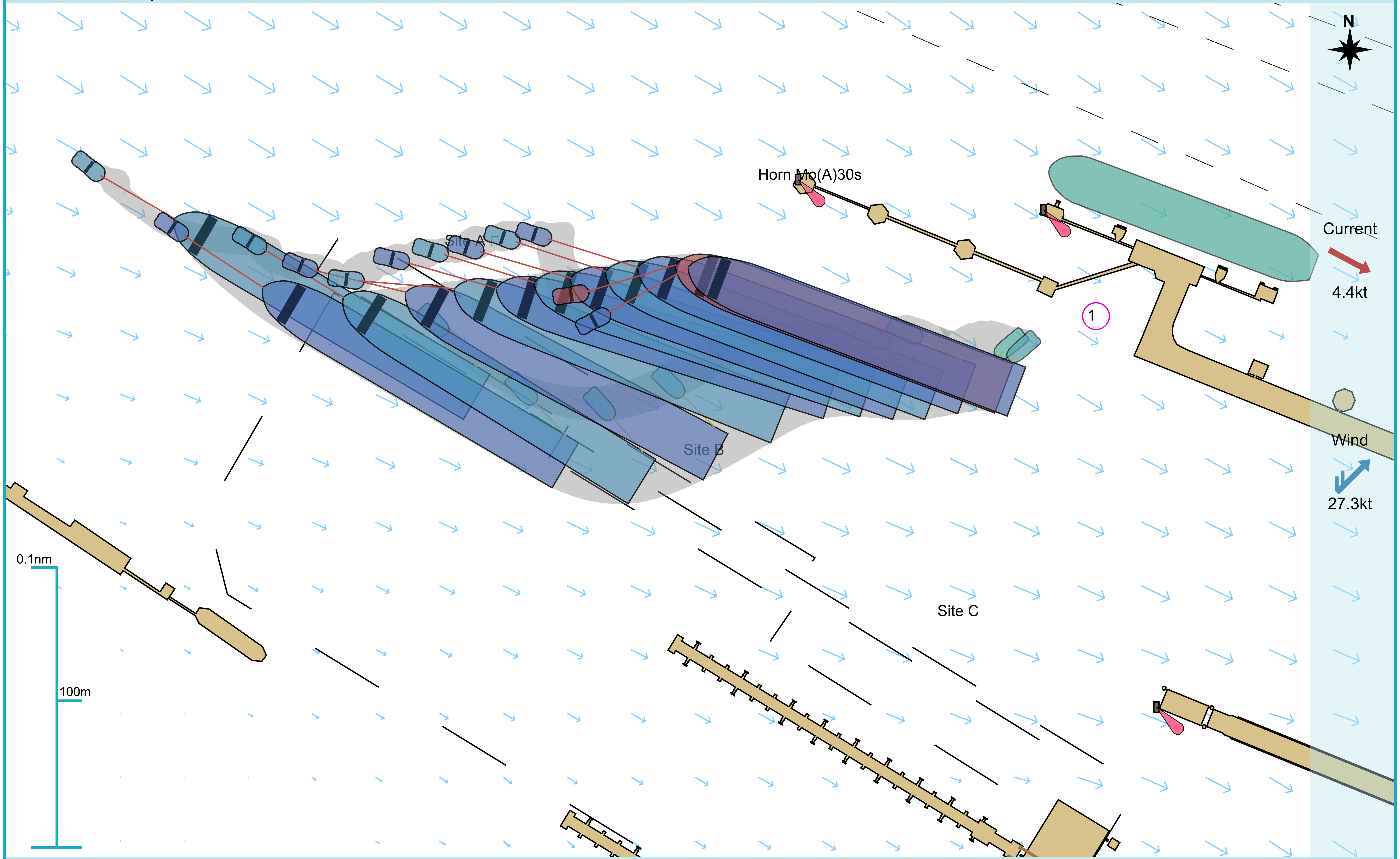

Tug 2: 50t ASD forces (CCT)
Demand
Actual
Dir.
Force (%BP)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Demand (t)
Actual (t)
50
40
30
20
10
0
Relative direction (°)
360
270
180
90
0
0min
5min
10min
15min

Manoeuvre track plot



Ships plotted every 1 mins, highlight every 10 mins

Manoeuvre track plot



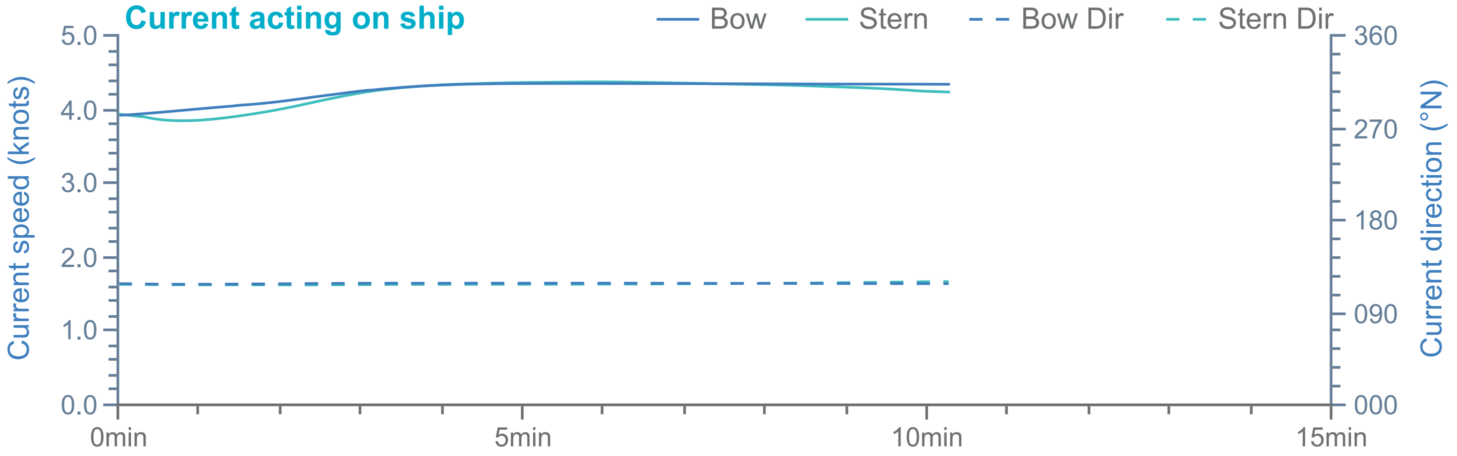
3.72 kts

Ships plotted every 1 mins, highlight every 10 mins

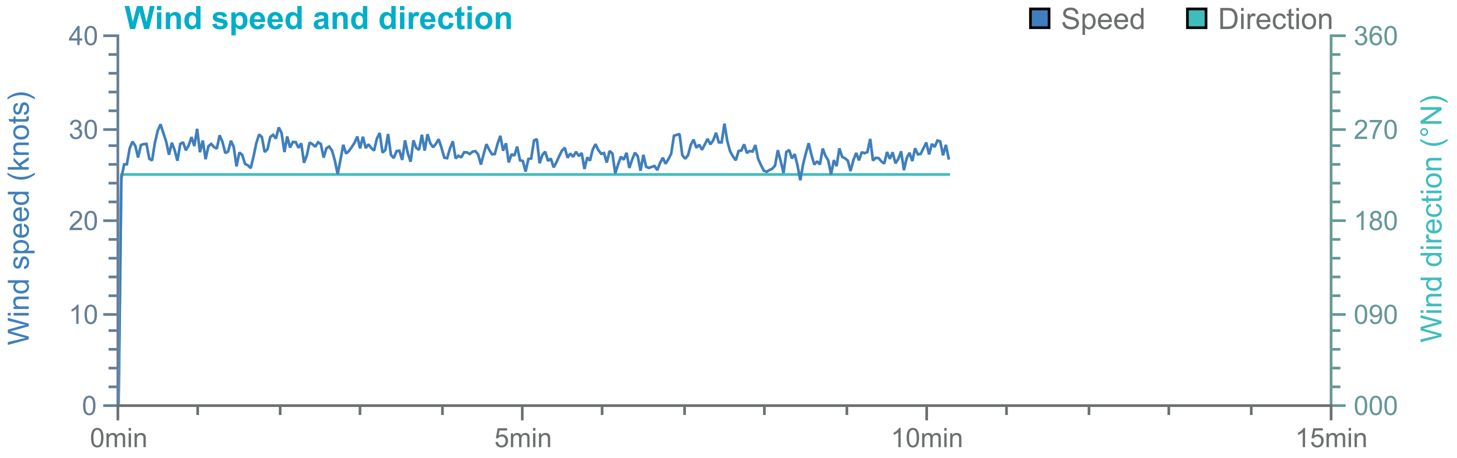
Pilot: JMS
Manoeuvre: Other

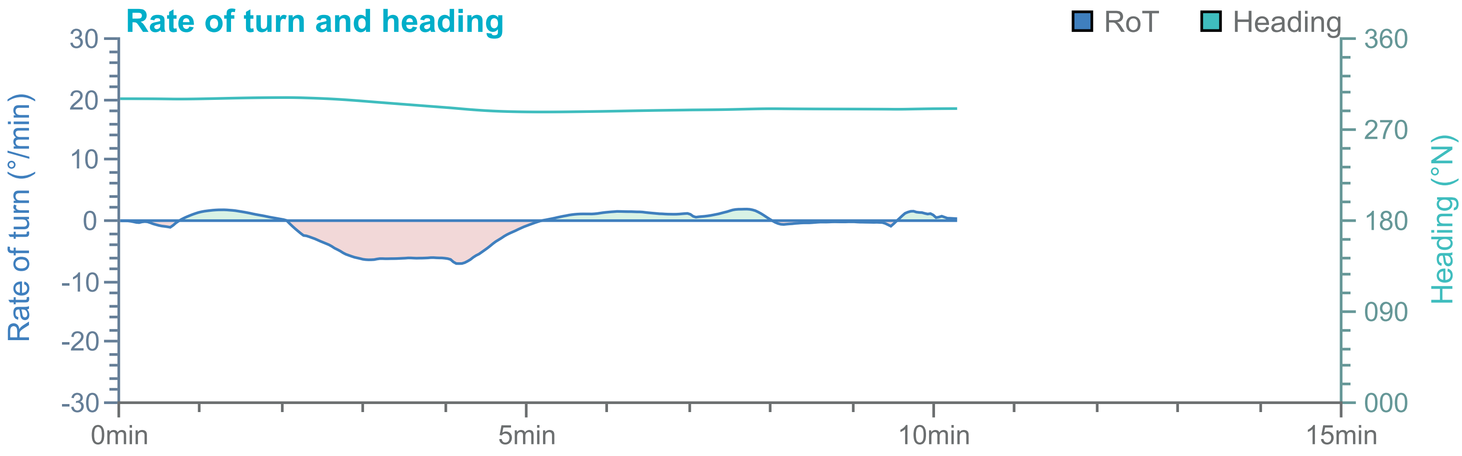
Ship: MV Celine

Current acting on ship

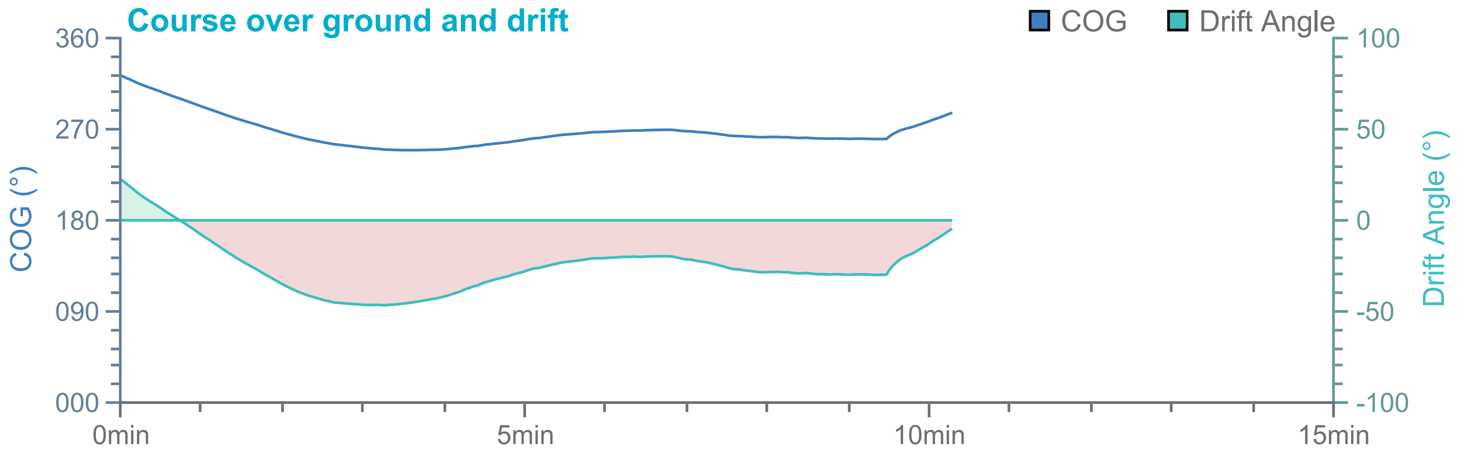


Wind speed and direction

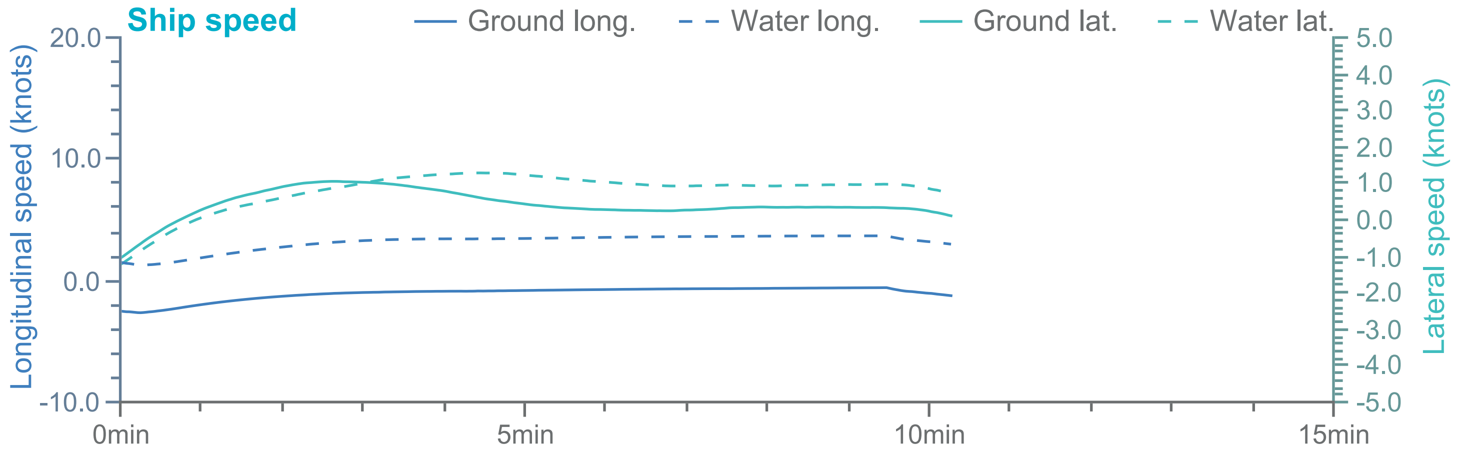




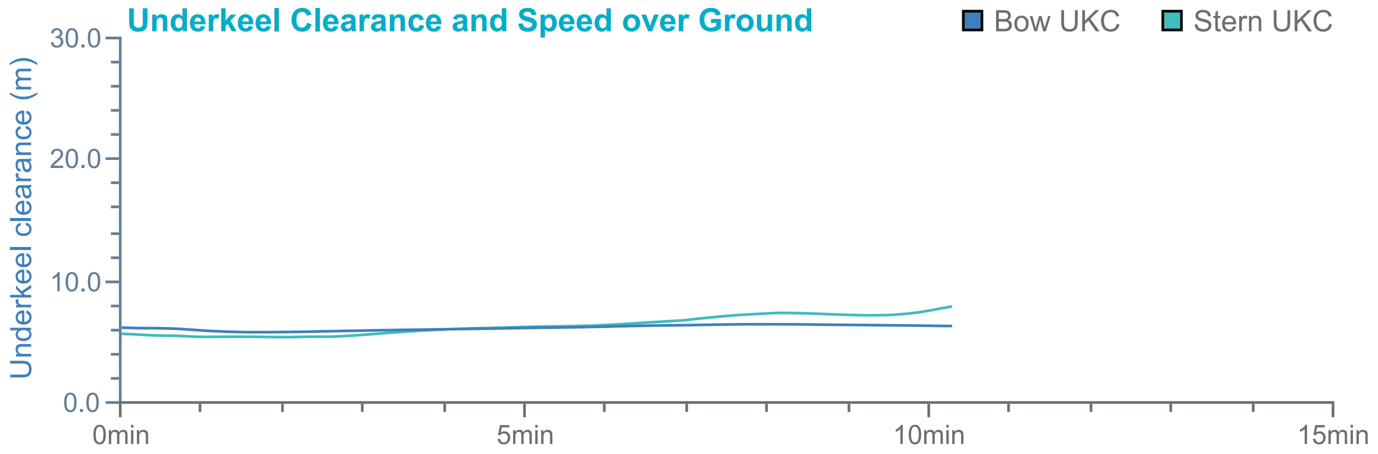
Rate of turn and heading



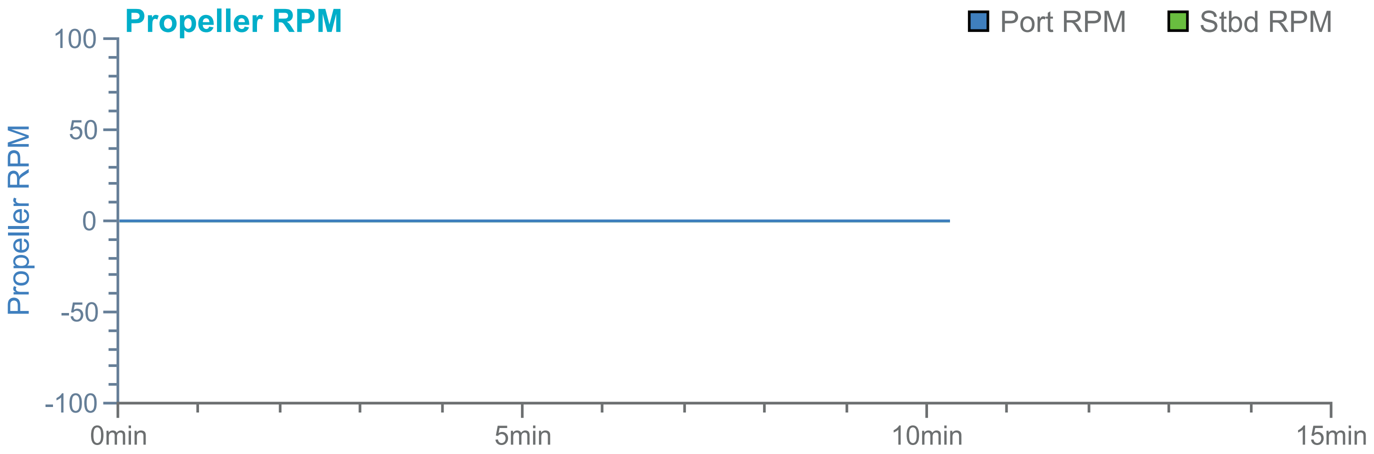
Course over ground and drift

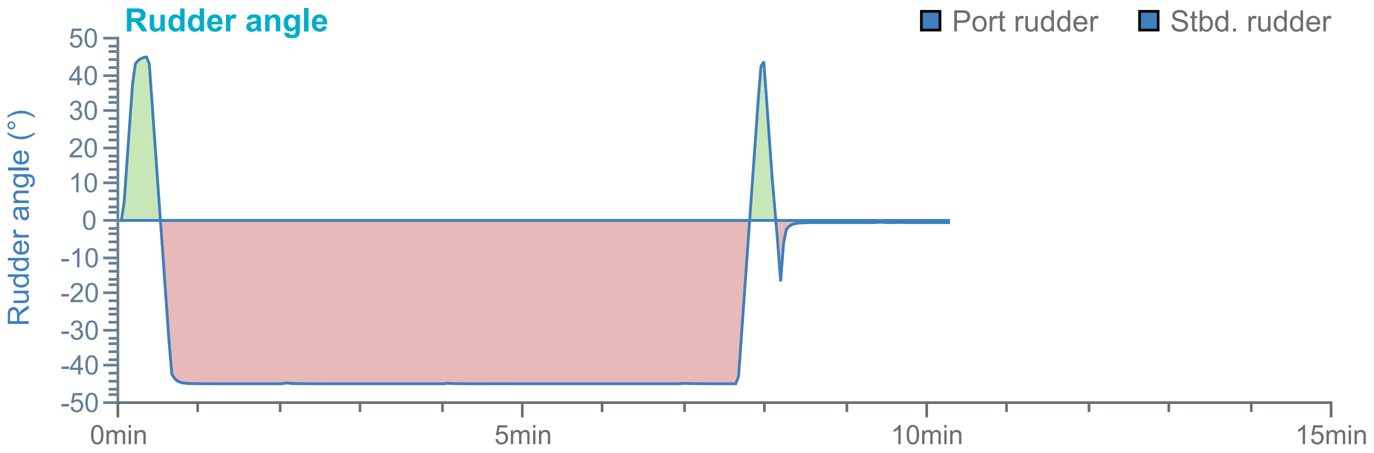


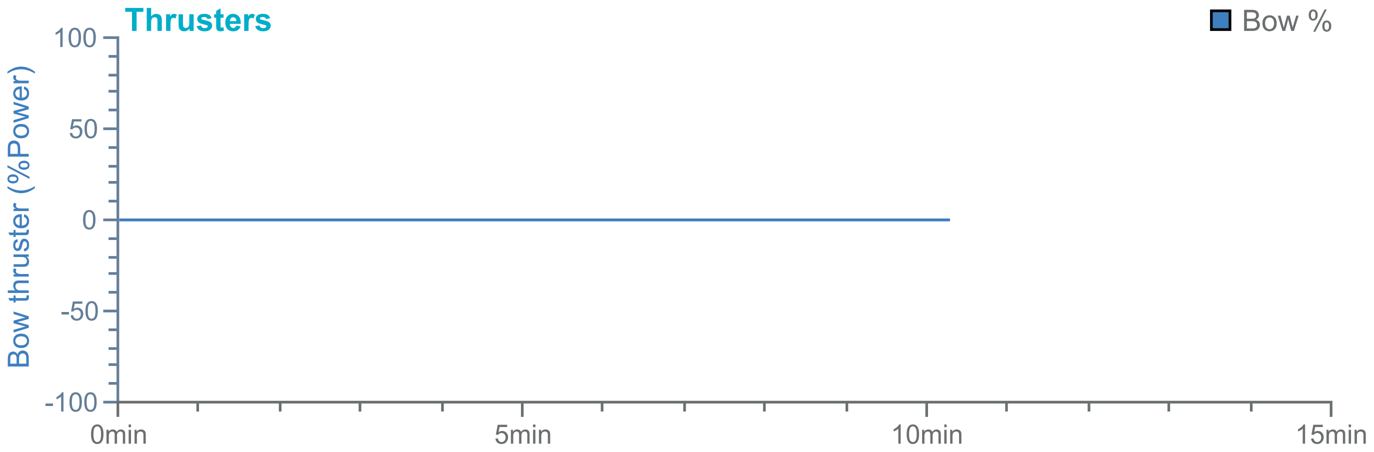
Ship speed

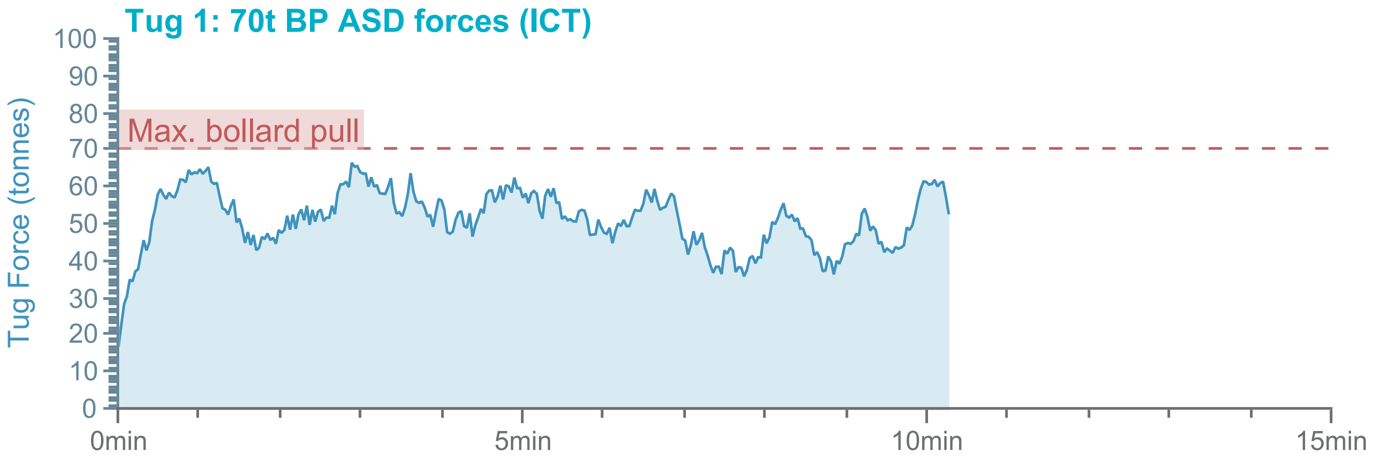


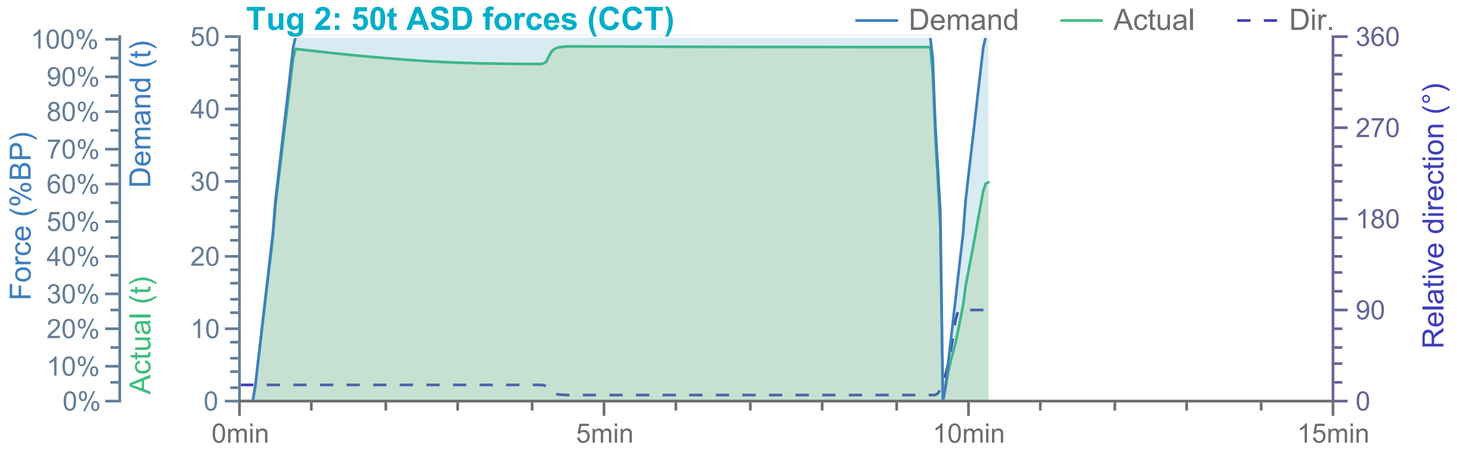
Underkeel Clearance and Speed over Ground


Propeller RPM
🟦 Port RPM
🟩 Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min

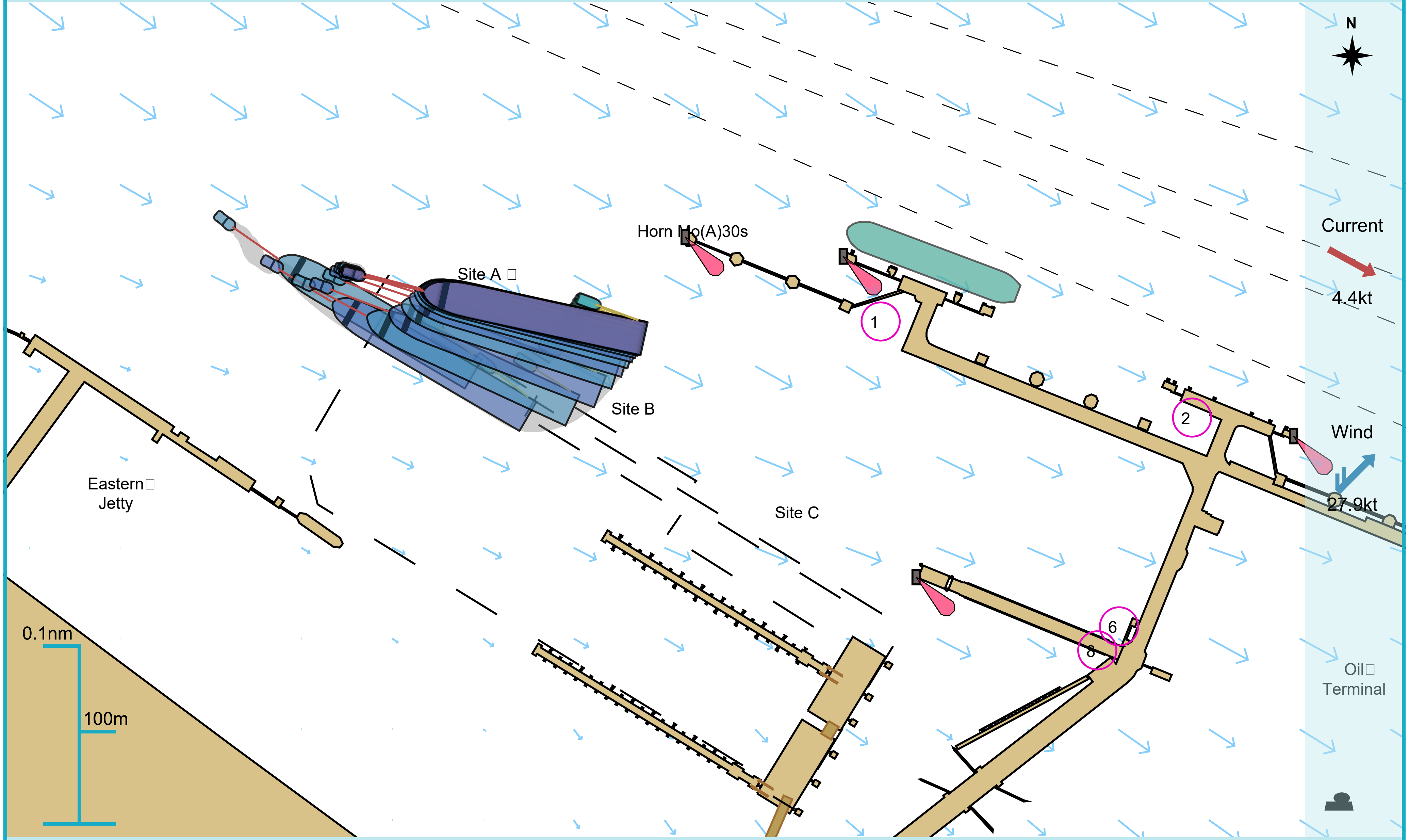

Rudder angle
🟦 Port rudder
🟦 Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
5min
10min
15min


Thrusters
🟦 Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min


Tug 1: 70t BP ASD forces (ICT)
Tug Force (tonnes)
Max. bollard pull
100
90
80
70
60
50
40
30
20
10
0
0min
5min
10min
15min

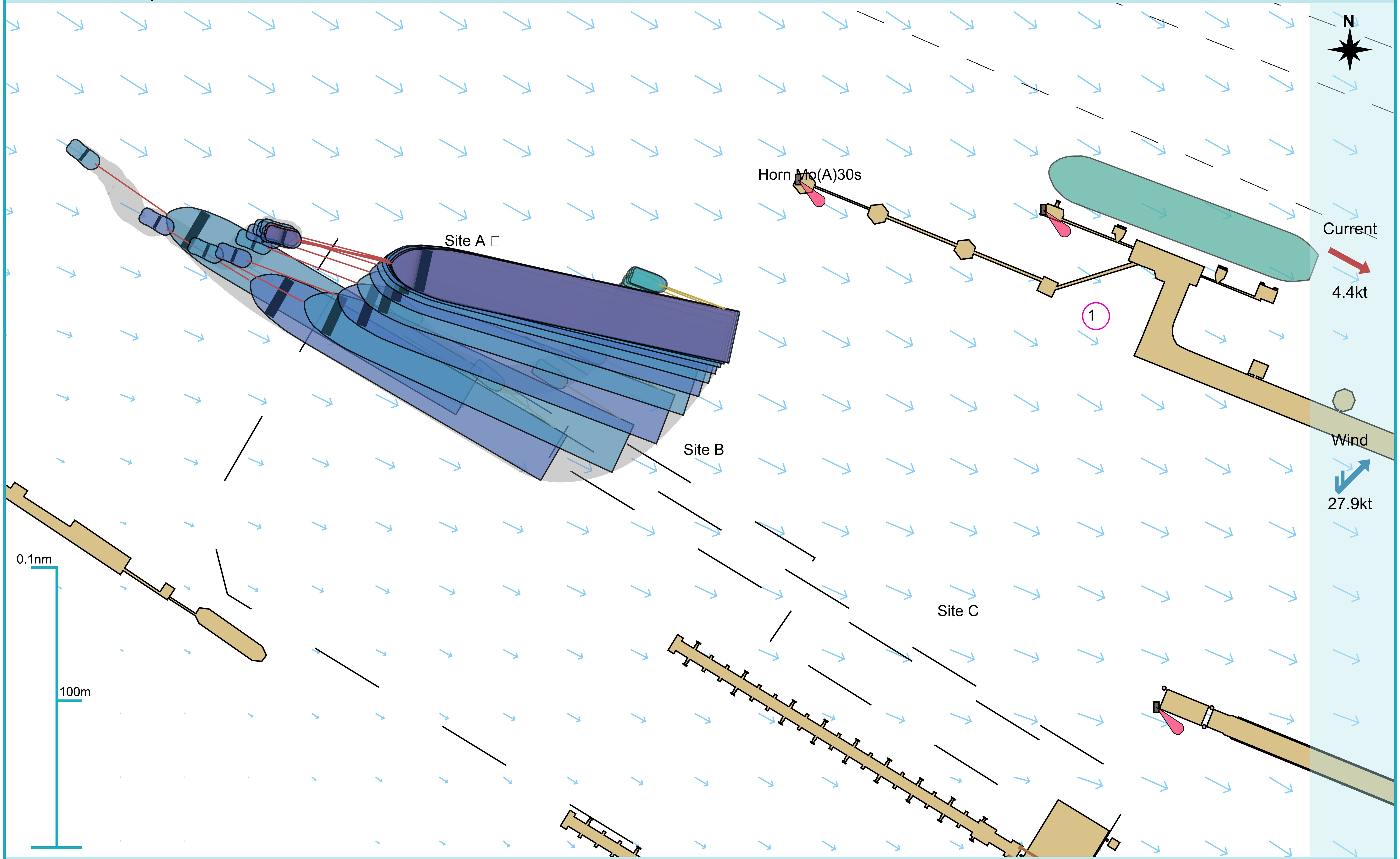

Tug 2: 50t ASD forces (CCT)
Demand
Actual
Dir.
Force (%BP)
Demand (t)
Actual (t)
Relative direction (°)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
50
40
30
20
10
0
360
270
180
90
0
0min
5min
10min
15min

Manoeuvre track plot



Ships plotted every 1 mins, highlight every 10 mins

Manoeuvre track plot

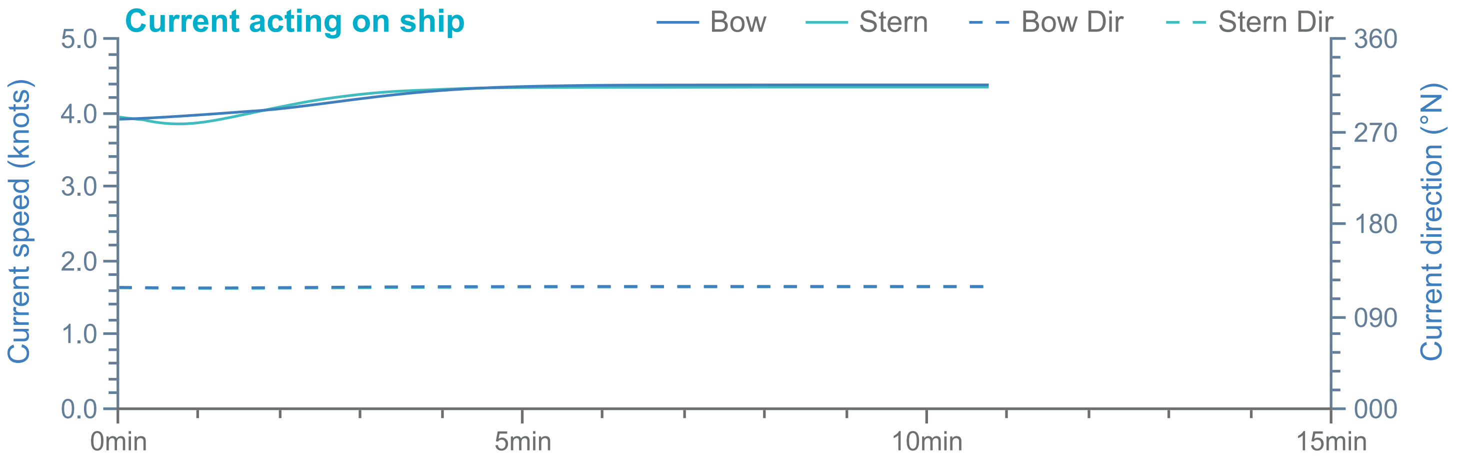


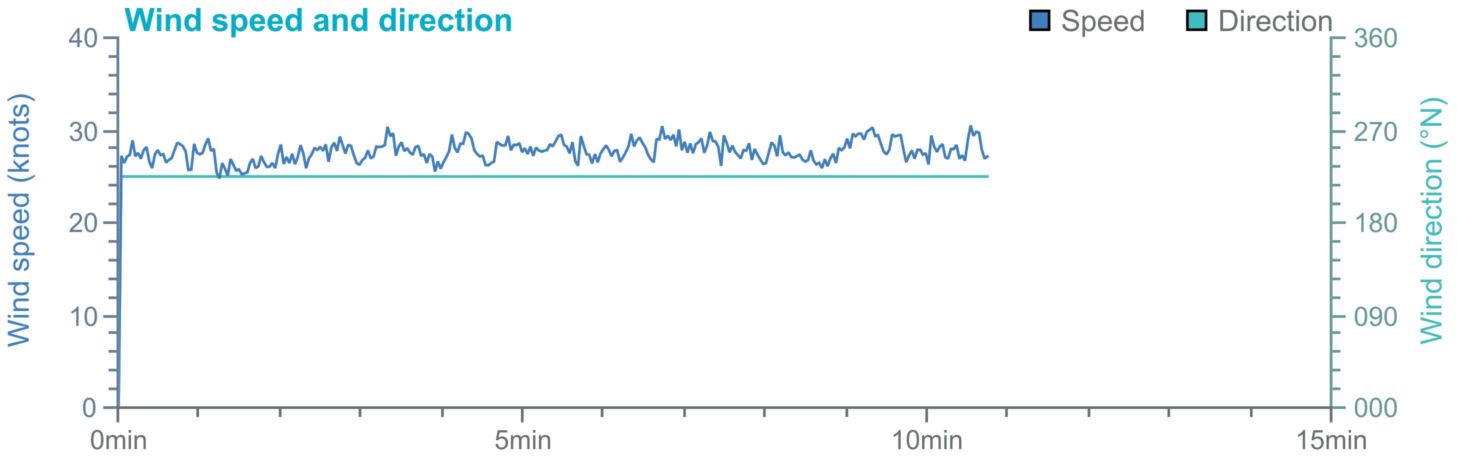
3.72 kts

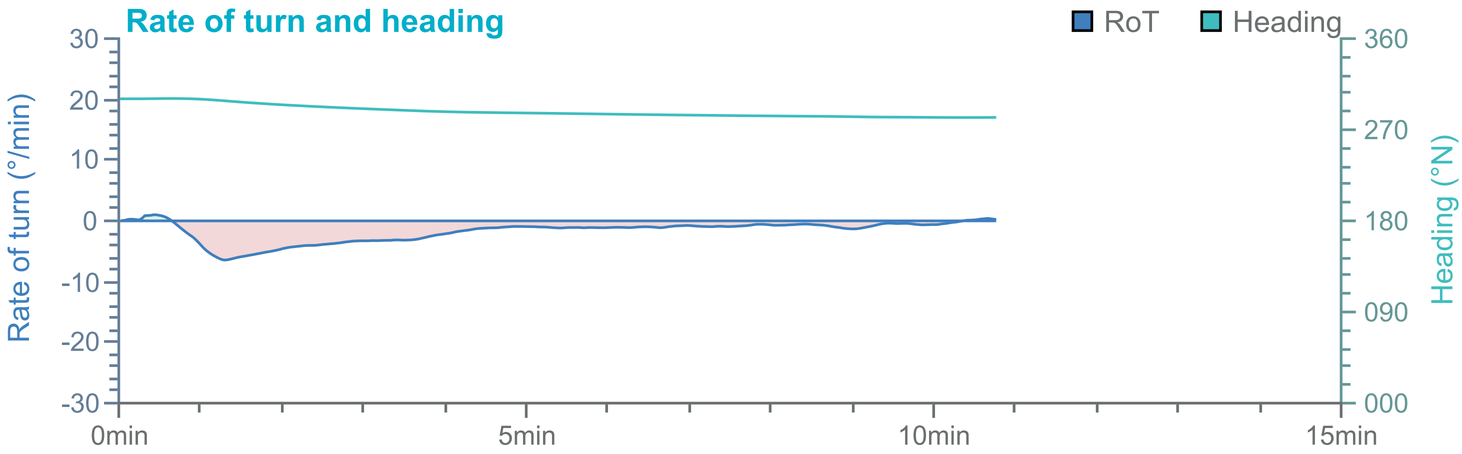
Ships plotted every 1 mins, highlight every 10 mins

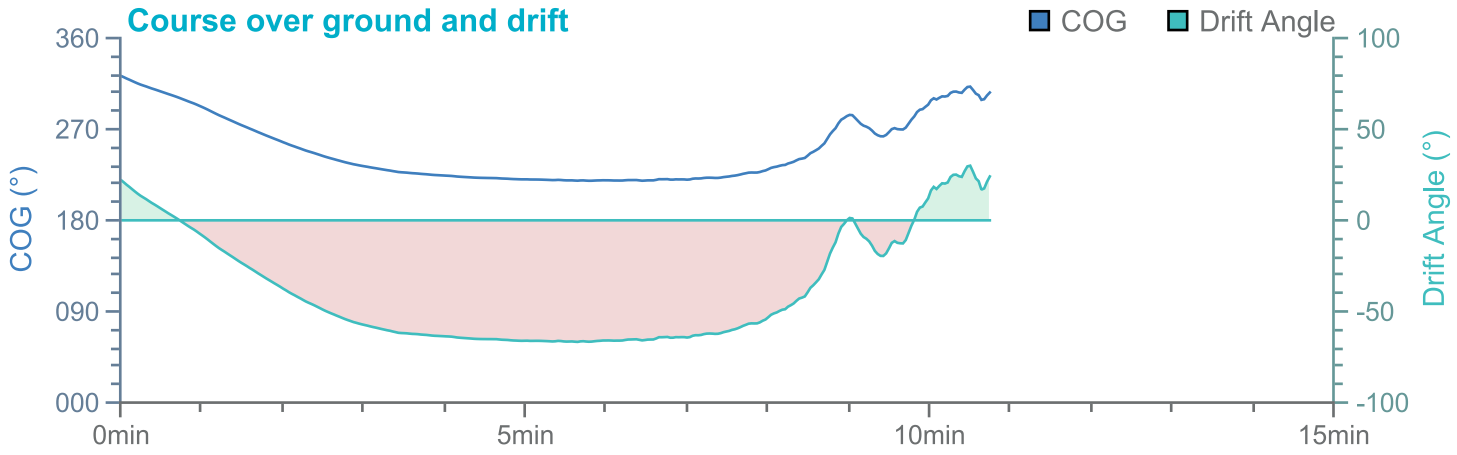
Pilot: JMS
Manoeuvre: Other

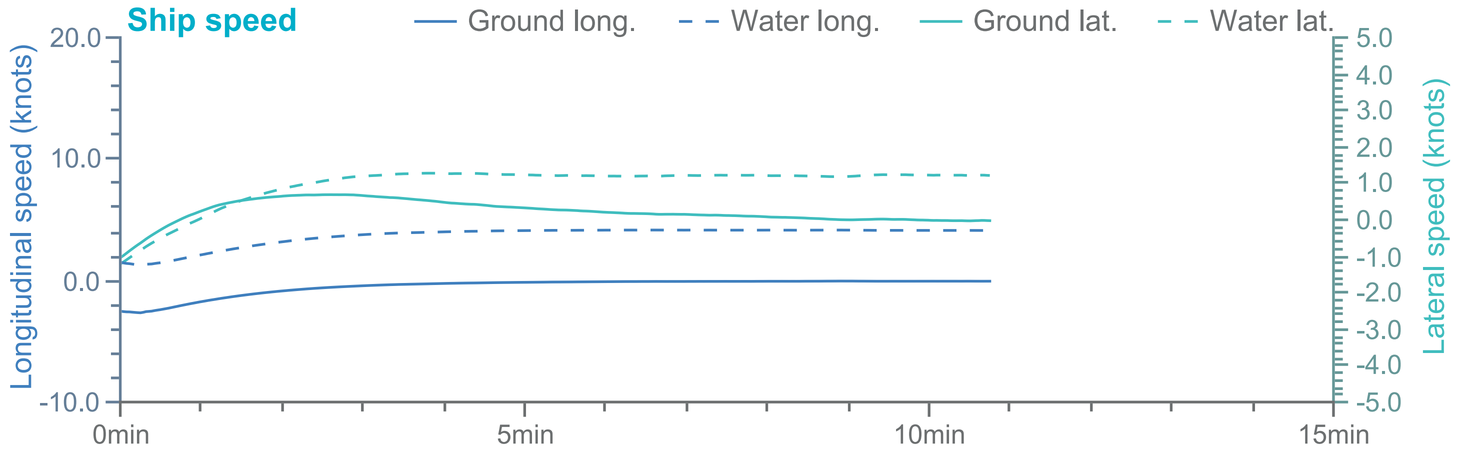
Ship: MV Celine

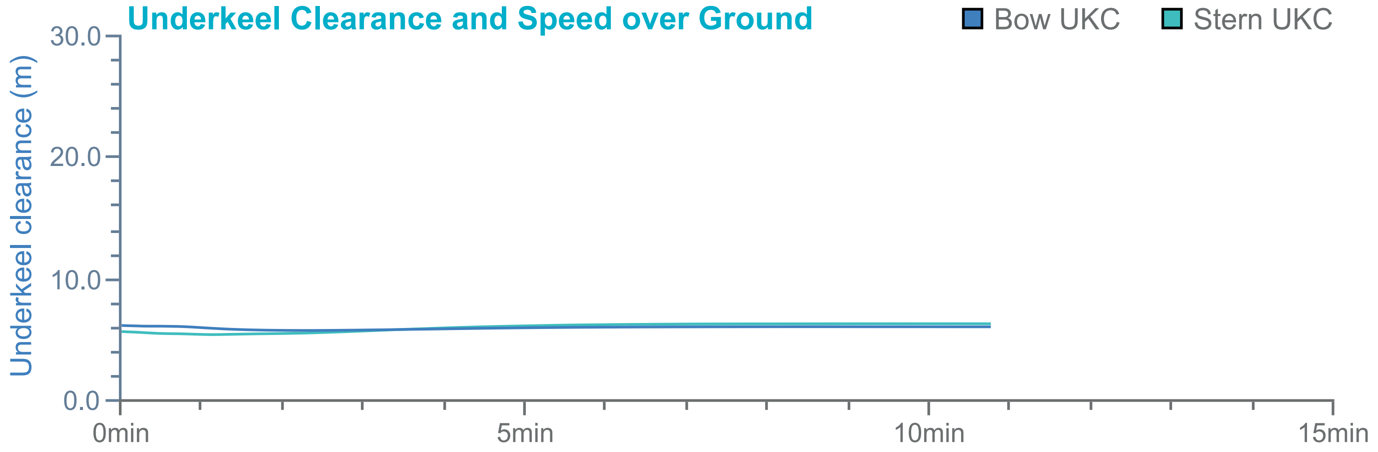

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
Current direction (°N)
360
270
180
090
000
0min
5min
10min
15min

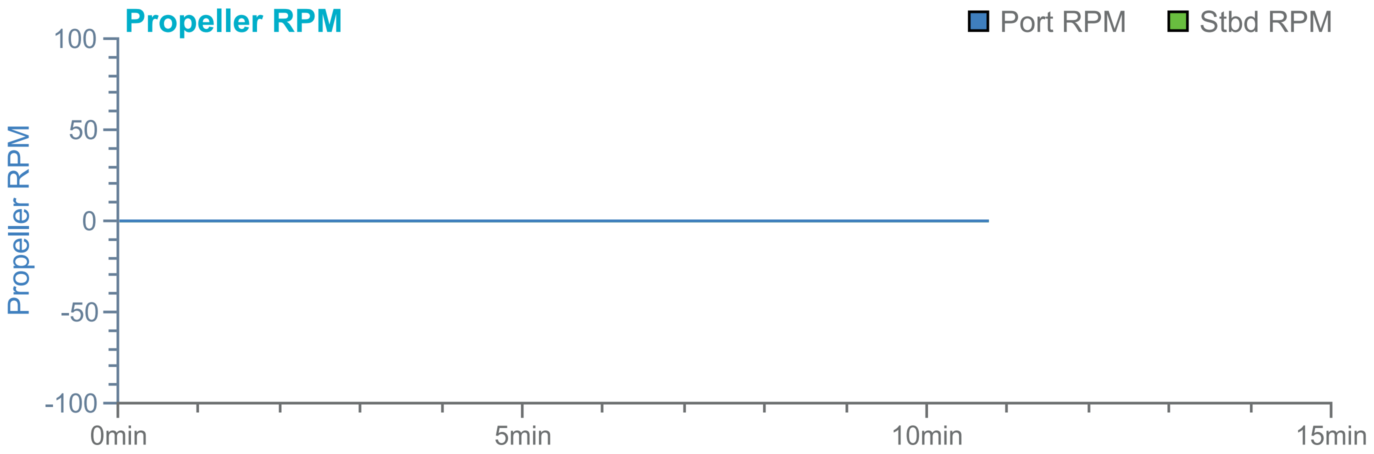

Wind speed and direction
Speed
Direction
Wind speed (knots)
40
30
20
10
0
Wind direction (°N)
360
270
180
090
000
0min
5min
10min
15min

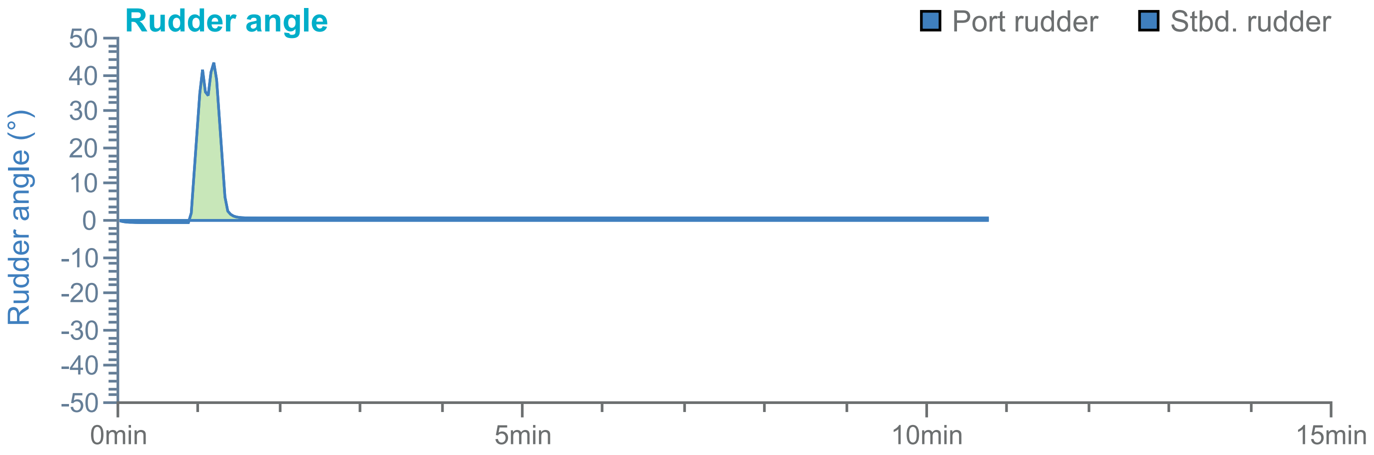

Rate of turn and heading

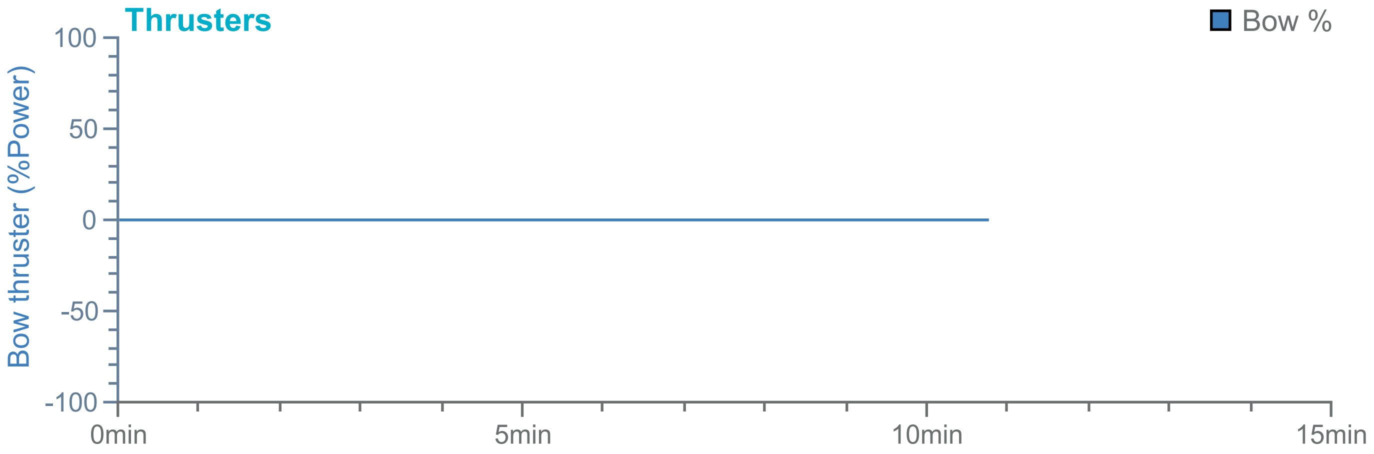

Course over ground and drift

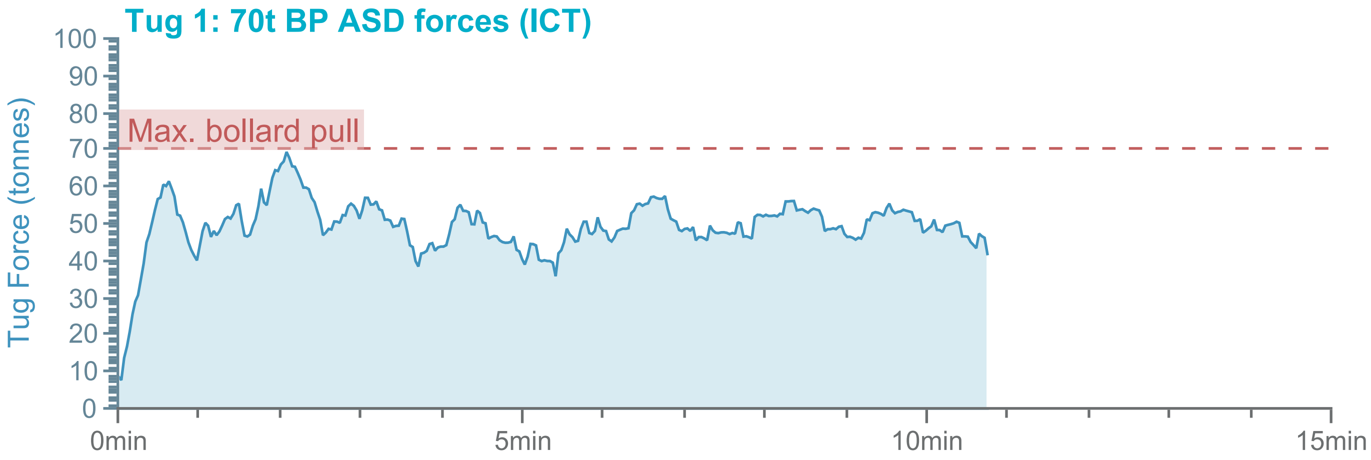

Ship speed

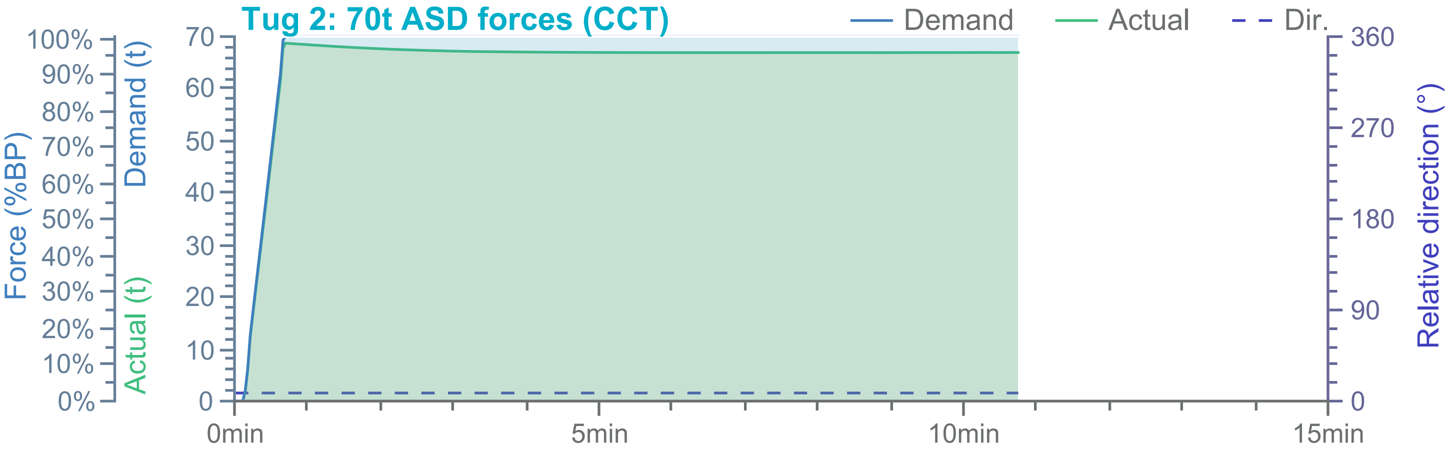

Underkeel Clearance and Speed over Ground


Propeller RPM
🟦 Port RPM
🟩 Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min

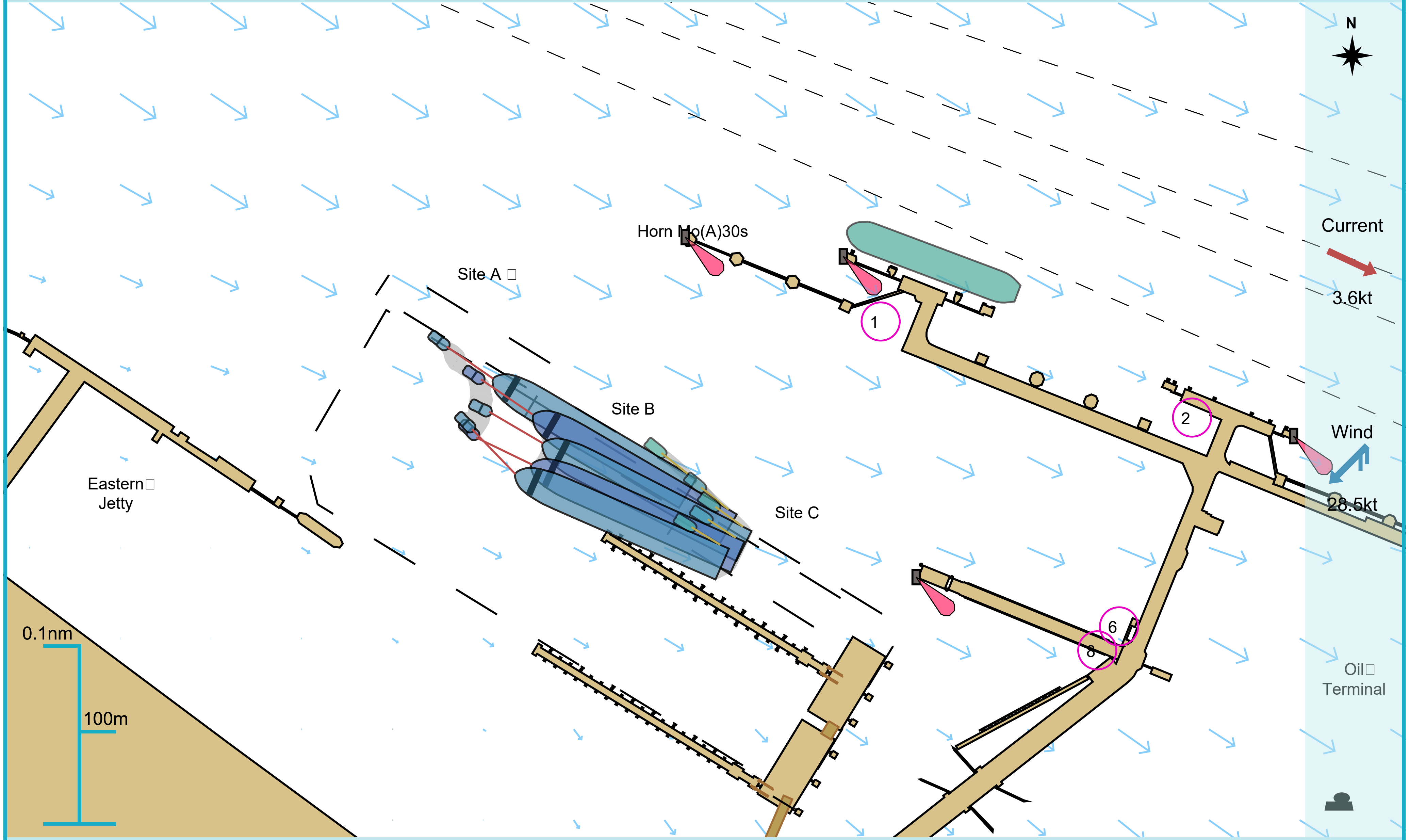

Rudder angle
🟦 Port rudder
🟦 Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
5min
10min
15min


Thrusters
🟦 Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min


Tug 1: 70t BP ASD forces (ICT)

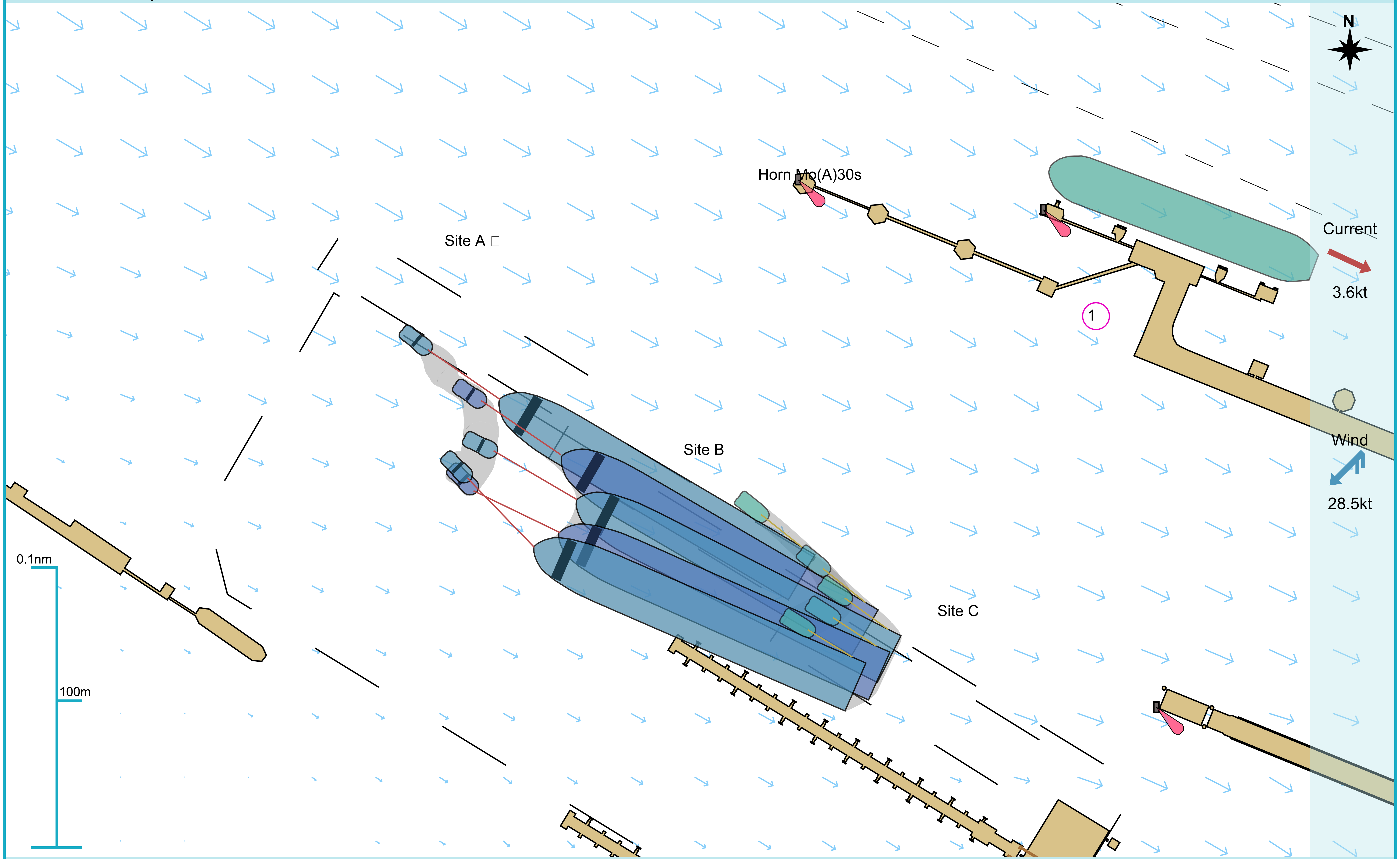

Tug 2: 70t ASD forces (CCT)

Manoeuvre track plot



Ships plotted every 1 mins, highlight every 10 mins

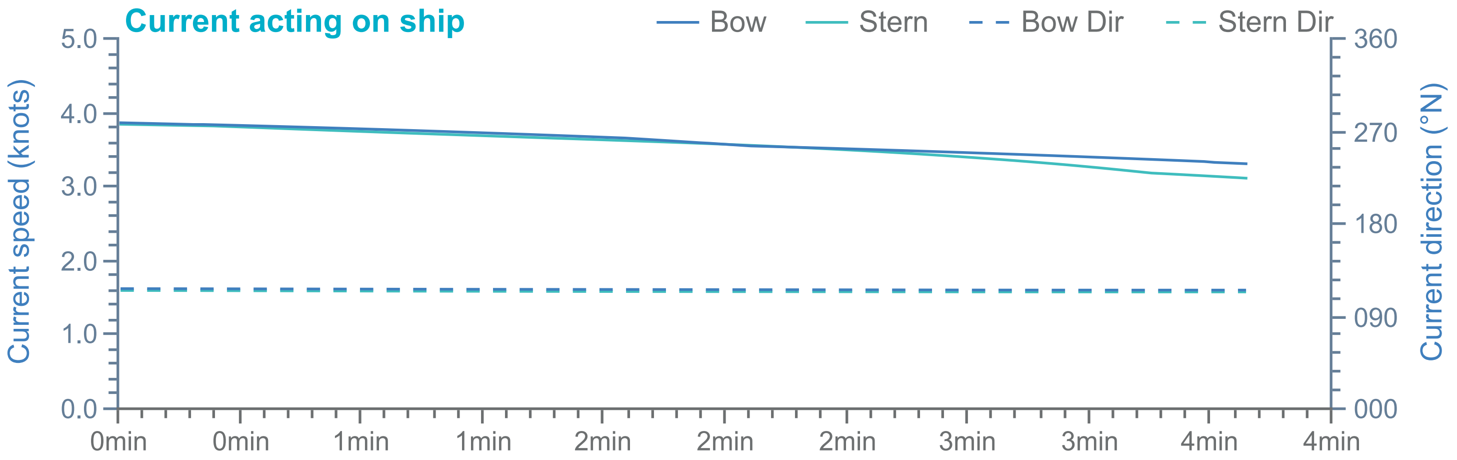
Manoeuvre track plot



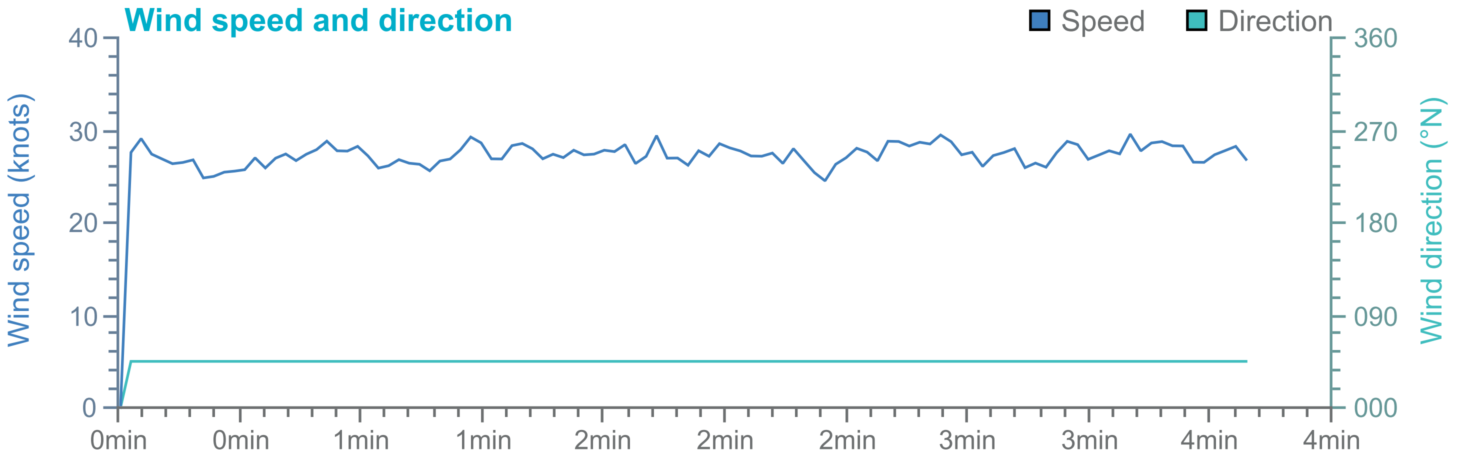
3.72 kts

Ships plotted every 1 mins, highlight every 10 mins

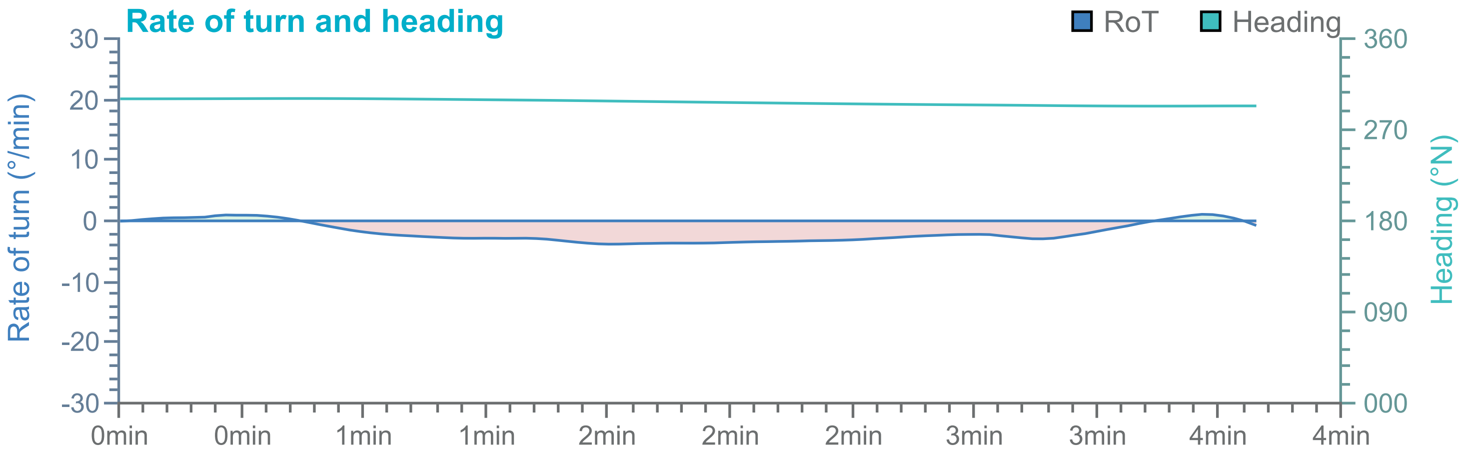
Current acting on ship



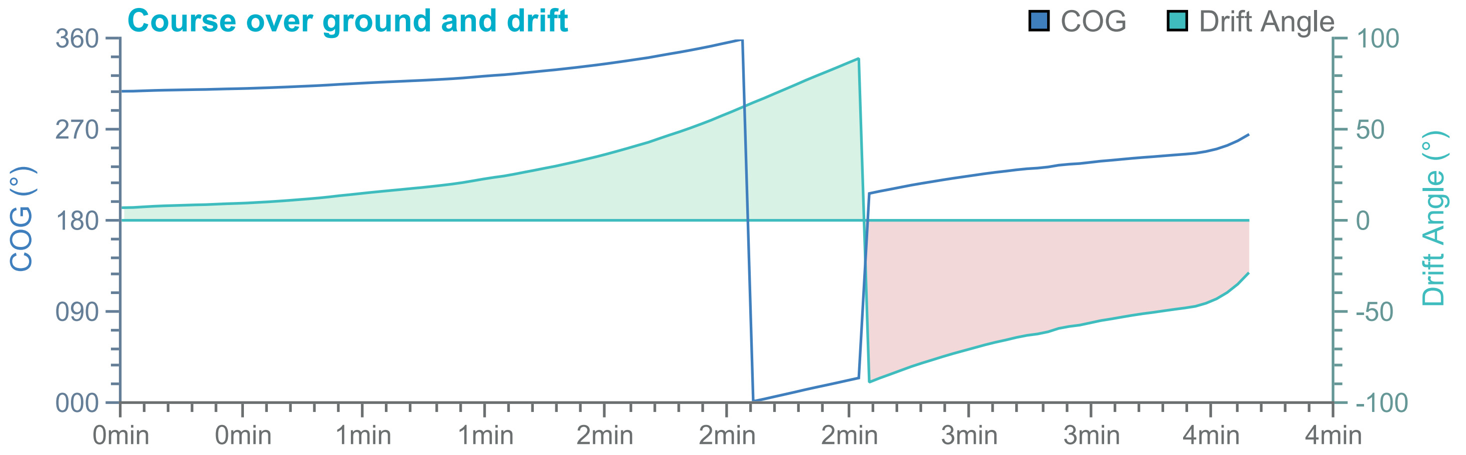
Wind speed and direction



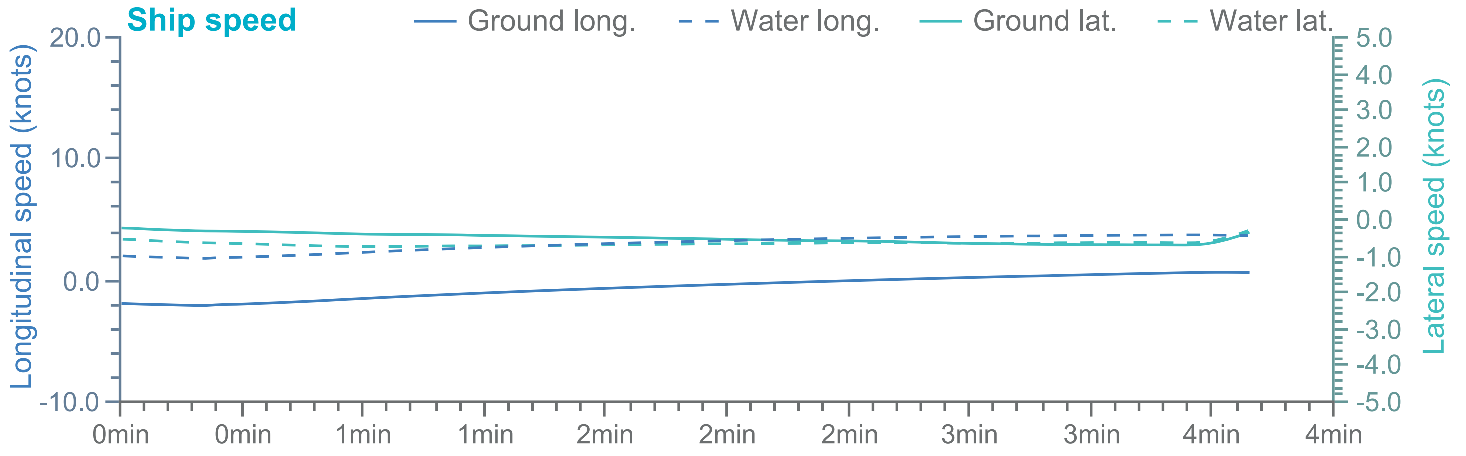
Rate of turn and heading



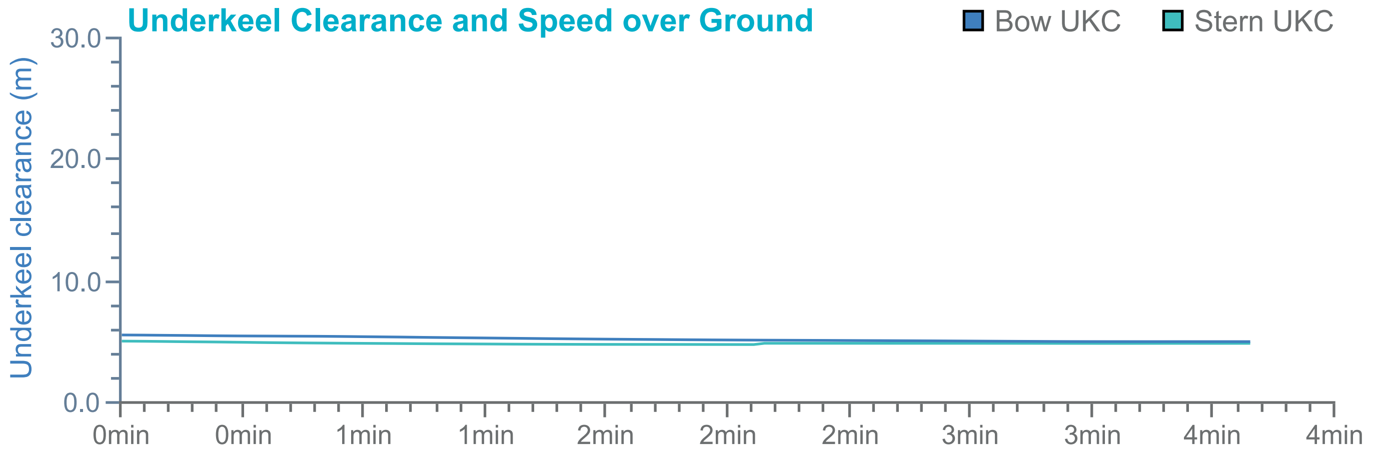
Course over ground and drift

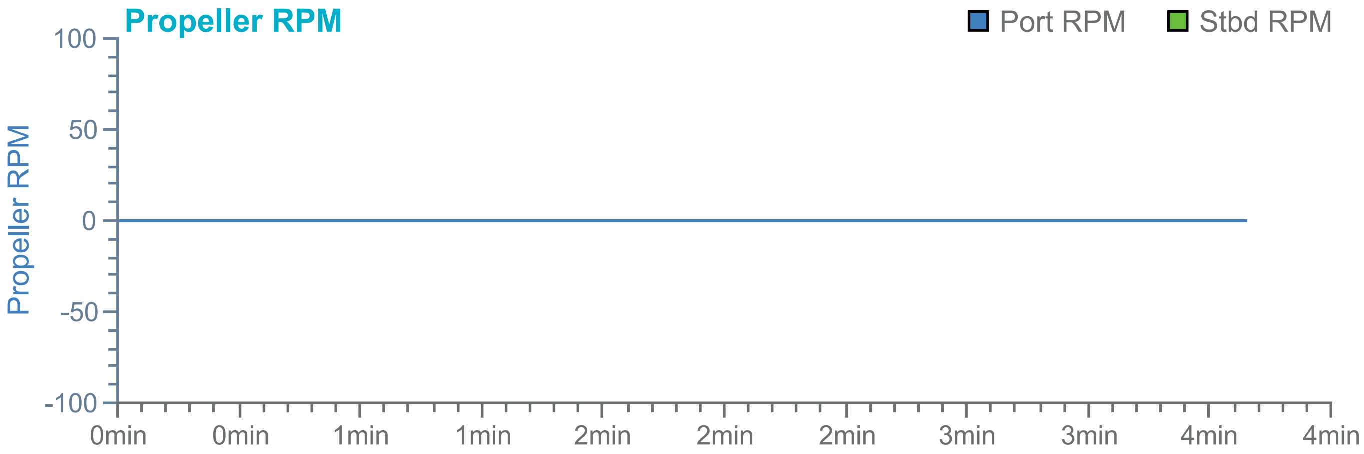


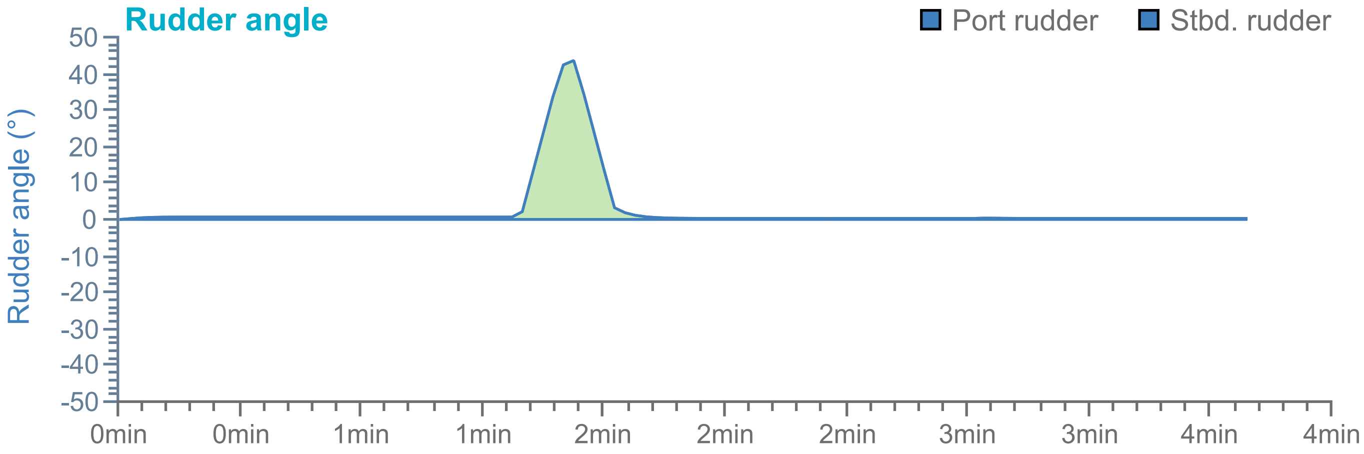
Ship speed

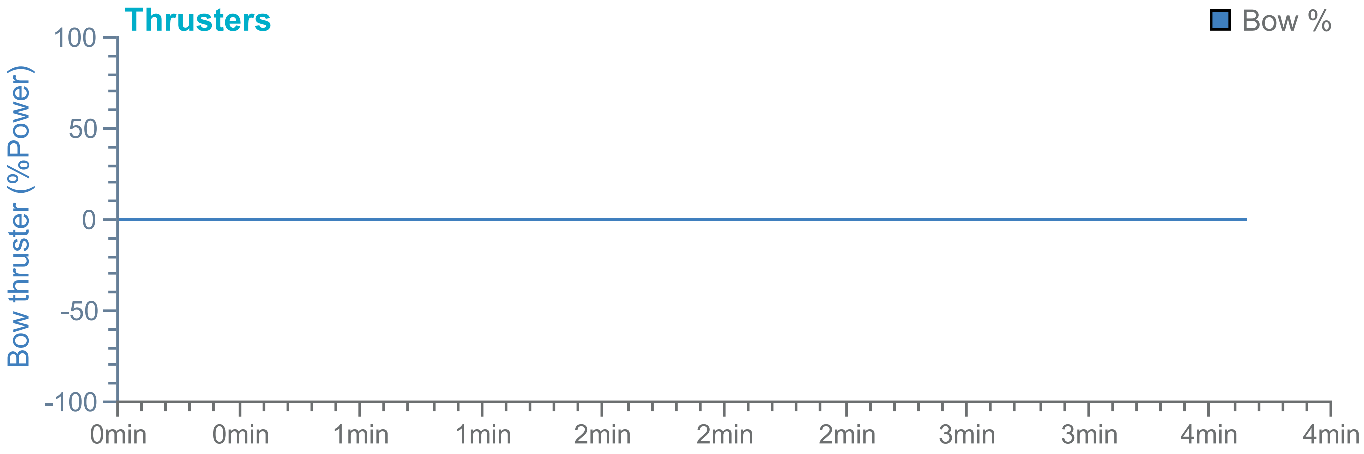


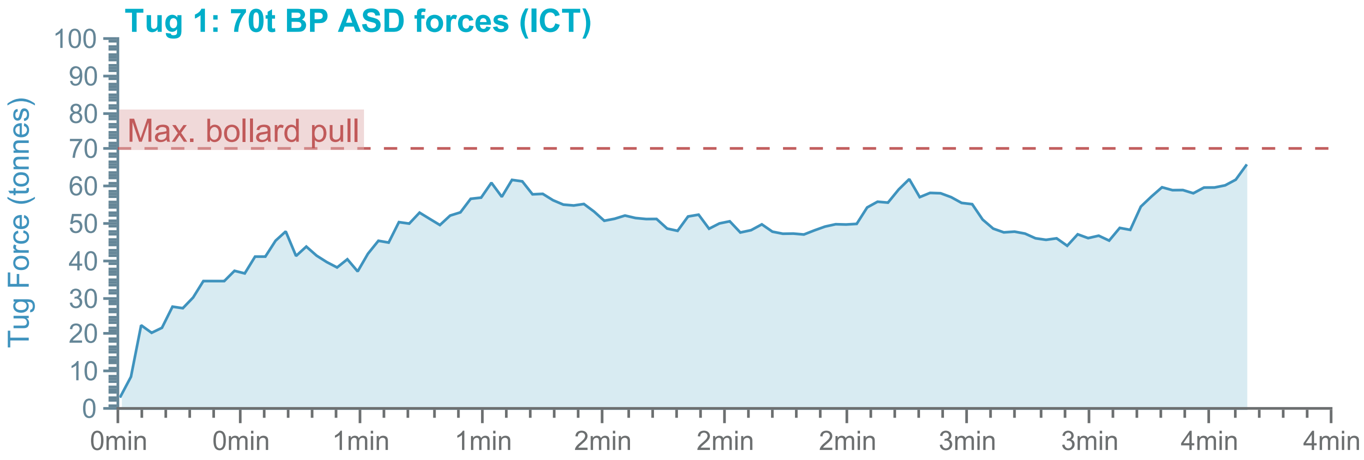
Underkeel Clearance and Speed over Ground

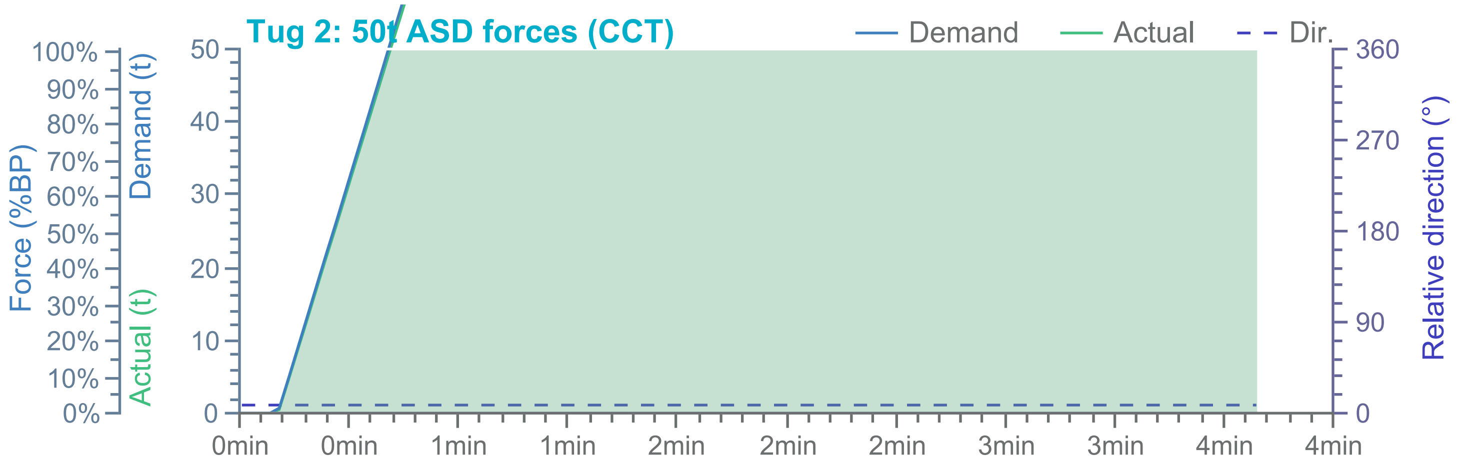



Propeller RPM
🟦 Port RPM
🟩 Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
0min
1min
1min
2min
2min
2min
3min
3min
4min
4min

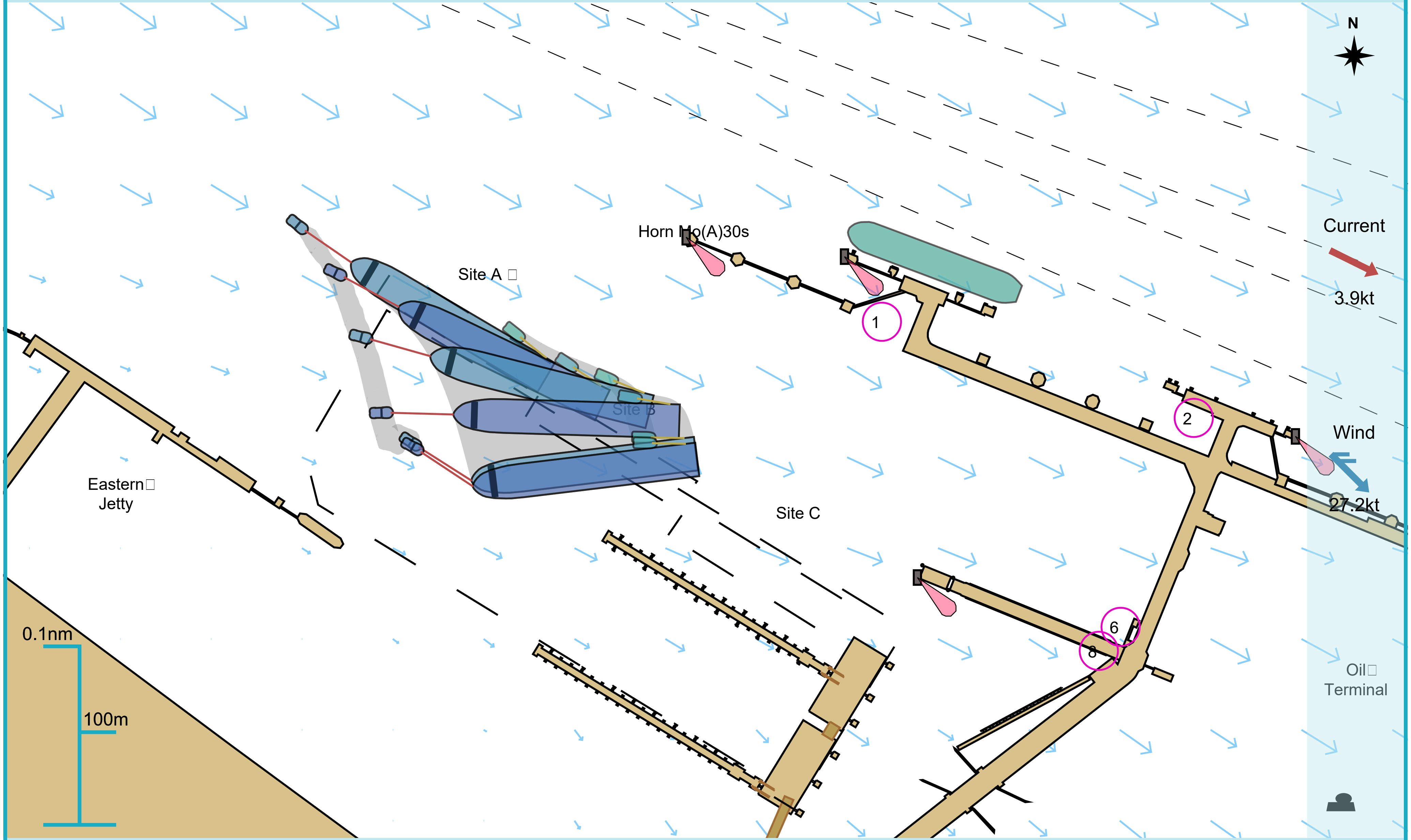

Rudder angle
🟦 Port rudder
🟦 Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
0min
1min
1min
2min
2min
2min
3min
3min
4min
4min


Thrusters
🟦 Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0min
0min
1min
1min
2min
2min
2min
3min
3min
4min
4min


Tug 1: 70t BP ASD forces (ICT)
Tug Force (tonnes)
100
90
80
70
60
50
40
30
20
10
0
Max. bollard pull
0min
0min
1min
1min
2min
2min
2min
3min
3min
4min
4min

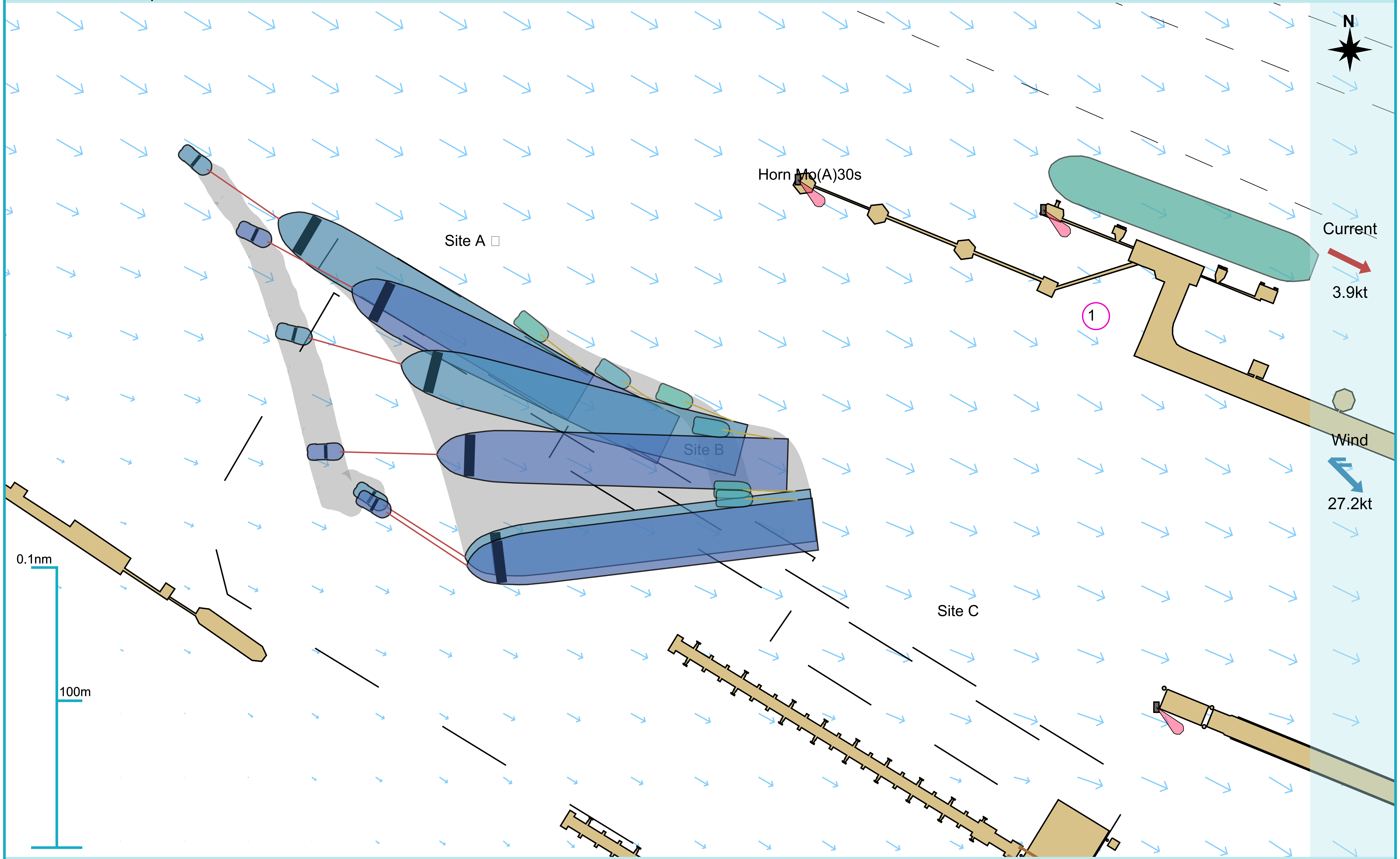

Tug 2: 50t ASD forces (CCT)
Demand
Actual
Dir.
Force (%BP)
Demand (t)
Actual (t)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
50
40
30
20
10
0
360
270
180
90
0
Relative direction (°)
0min
0min
1min
1min
2min
2min
2min
3min
3min
4min
4min

Manoeuvre track plot



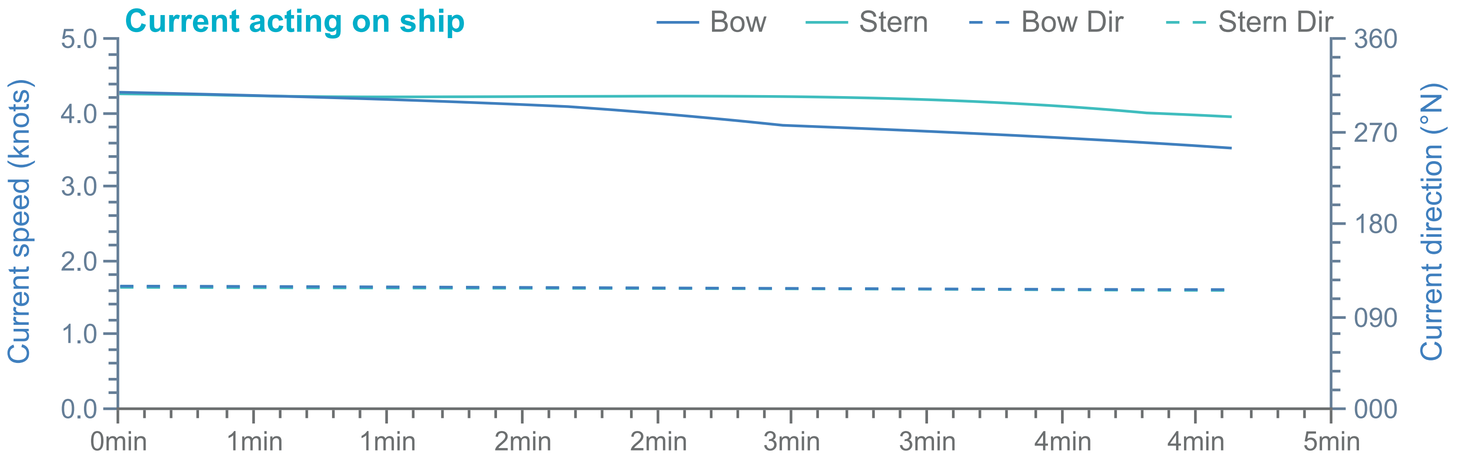
Ships plotted every 1 mins, highlight every 10 mins

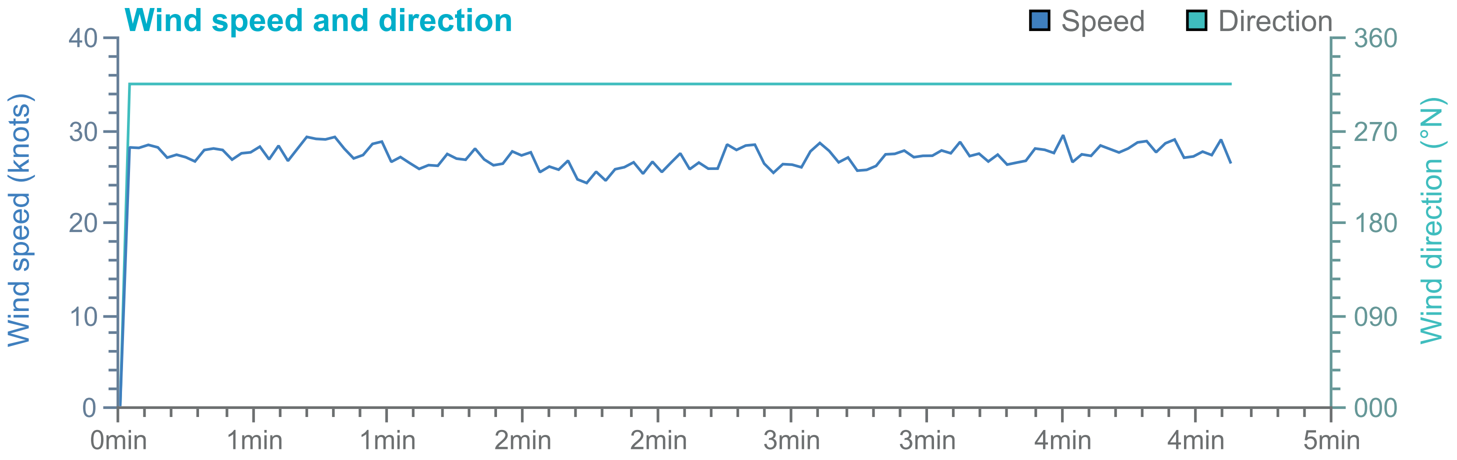
Manoeuvre track plot

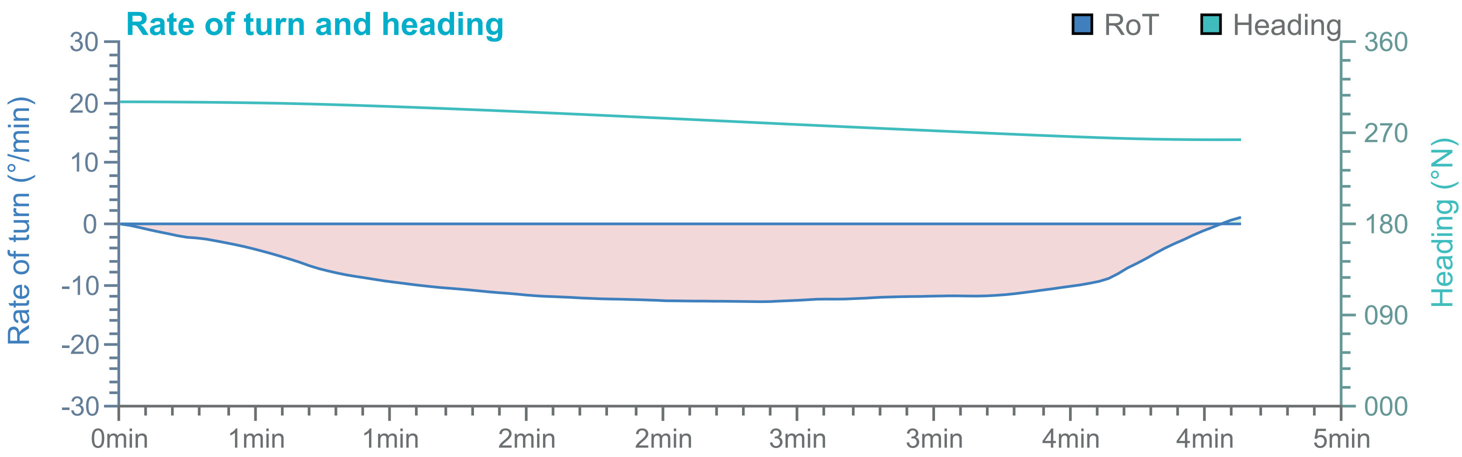


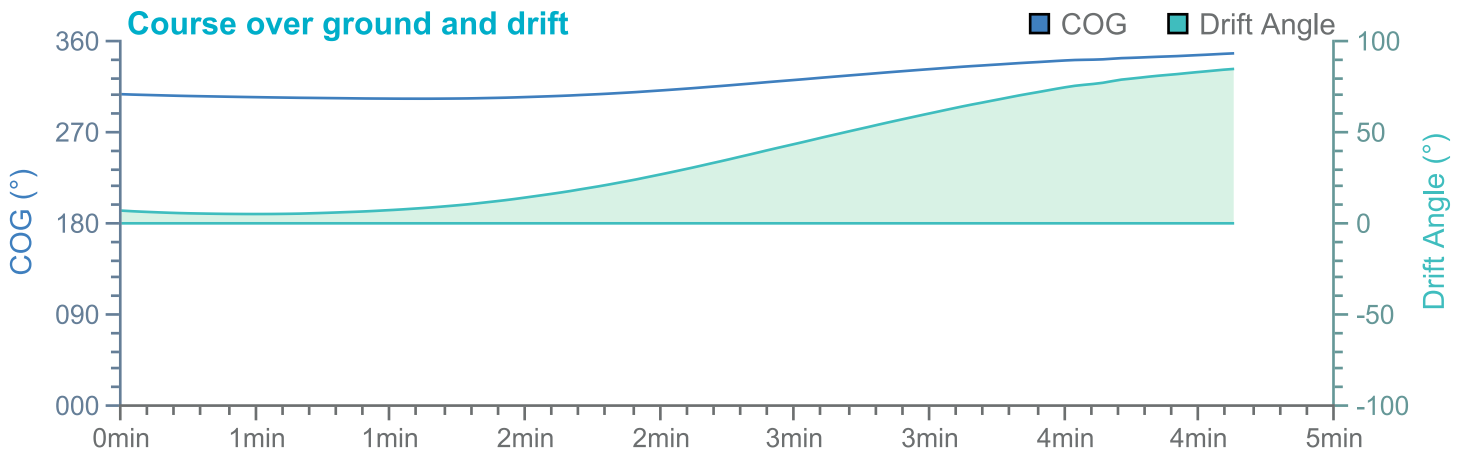
3.72 kts

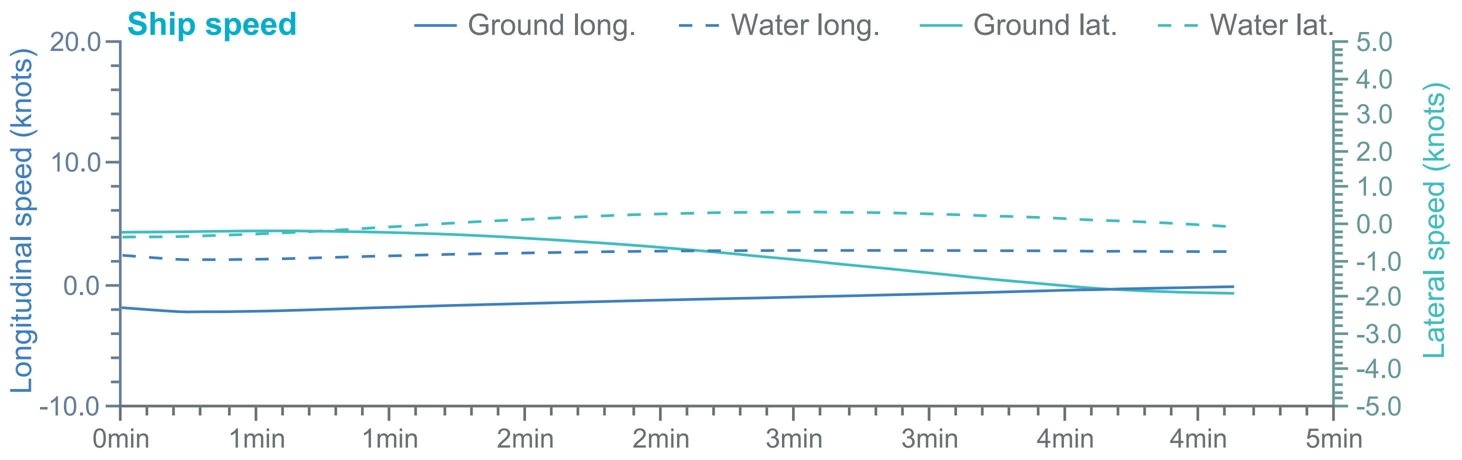
Ships plotted every 1 mins, highlight every 10 mins

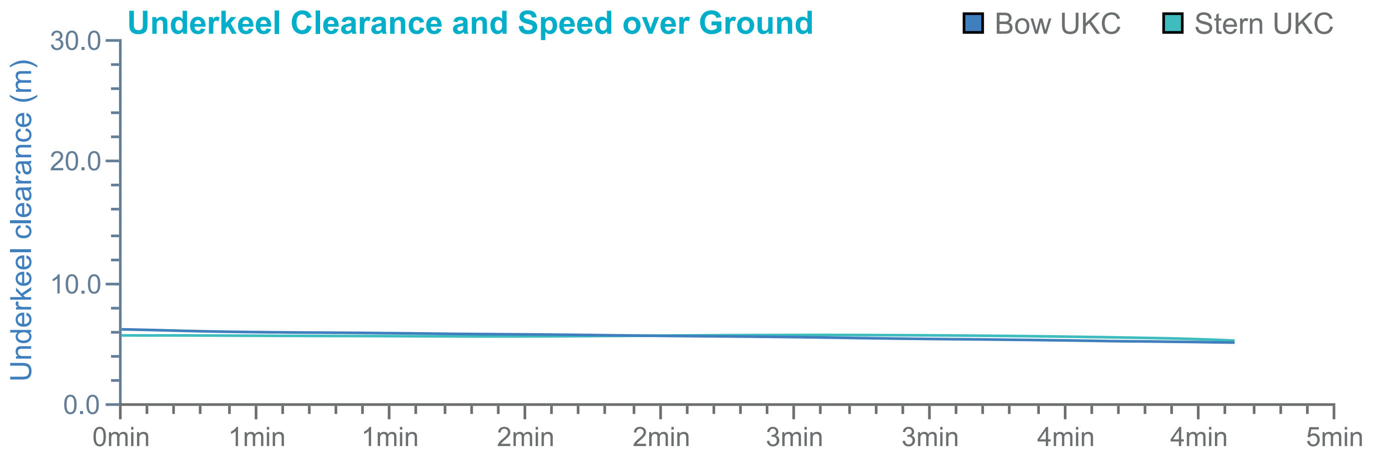

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
Current direction (°N)
360
270
180
090
000
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min

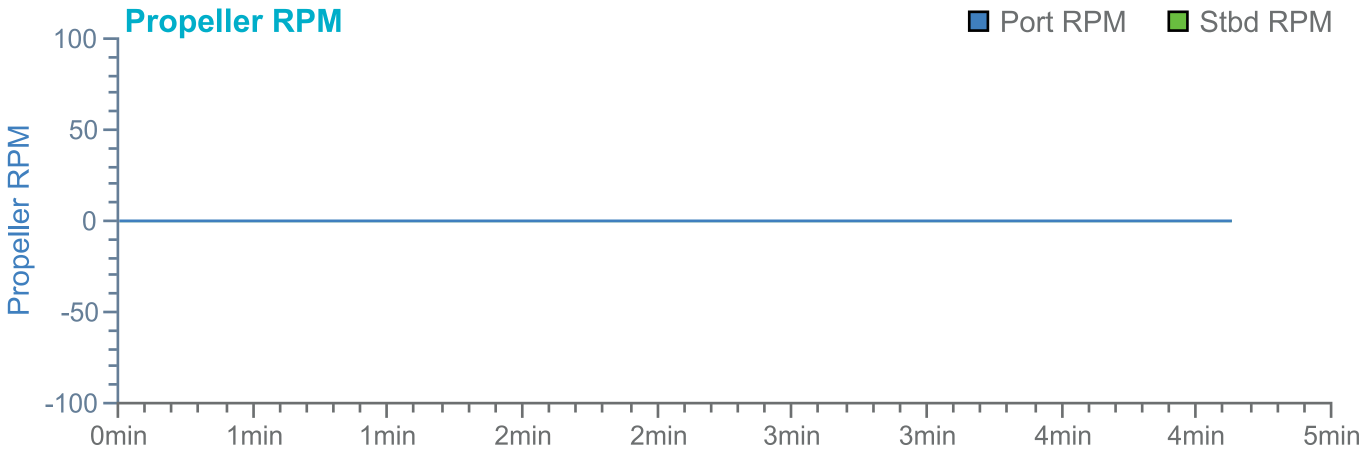

Wind speed and direction
Speed
Direction
Wind speed (knots)
40
30
20
10
0
Wind direction (°N)
360
270
180
090
000
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min

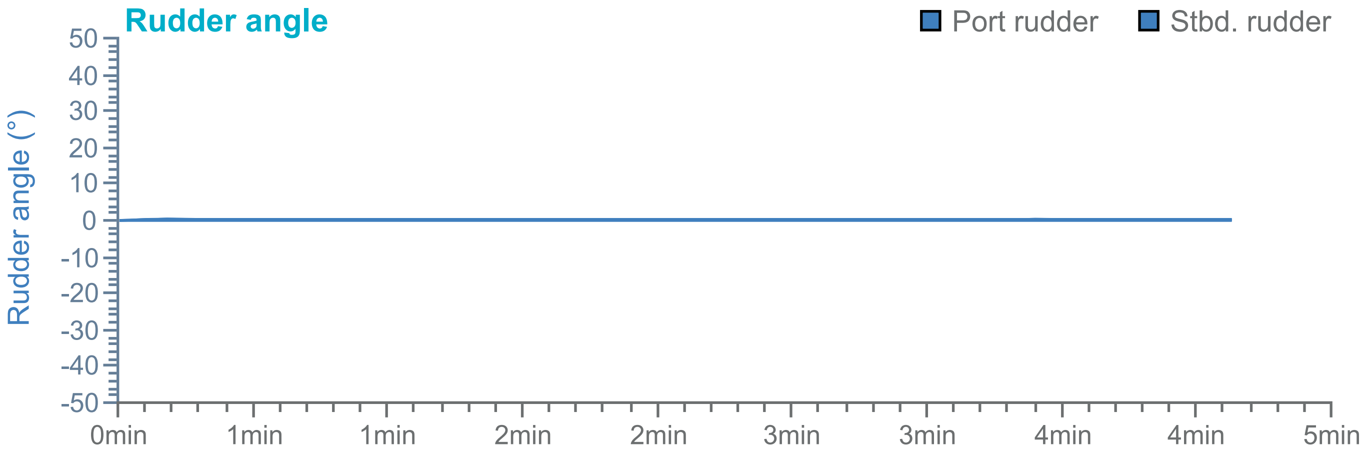

Rate of turn and heading

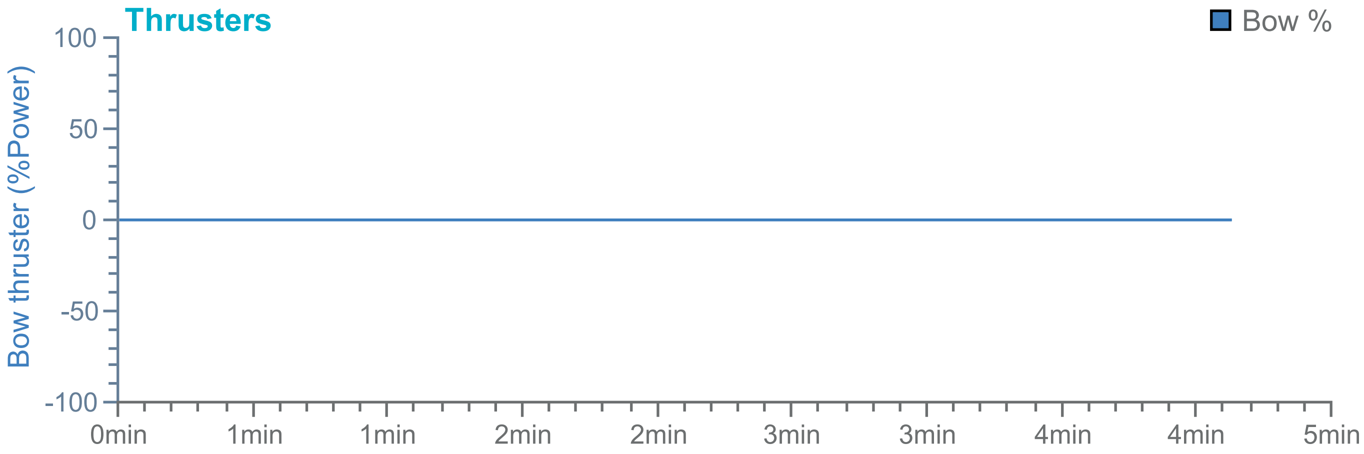

Course over ground and drift

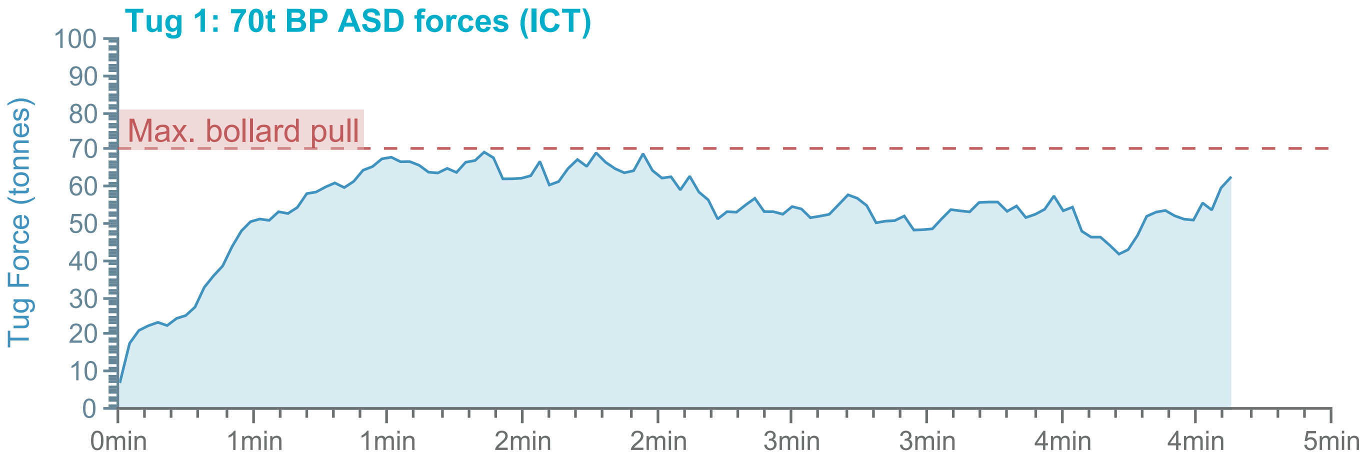

Ship speed

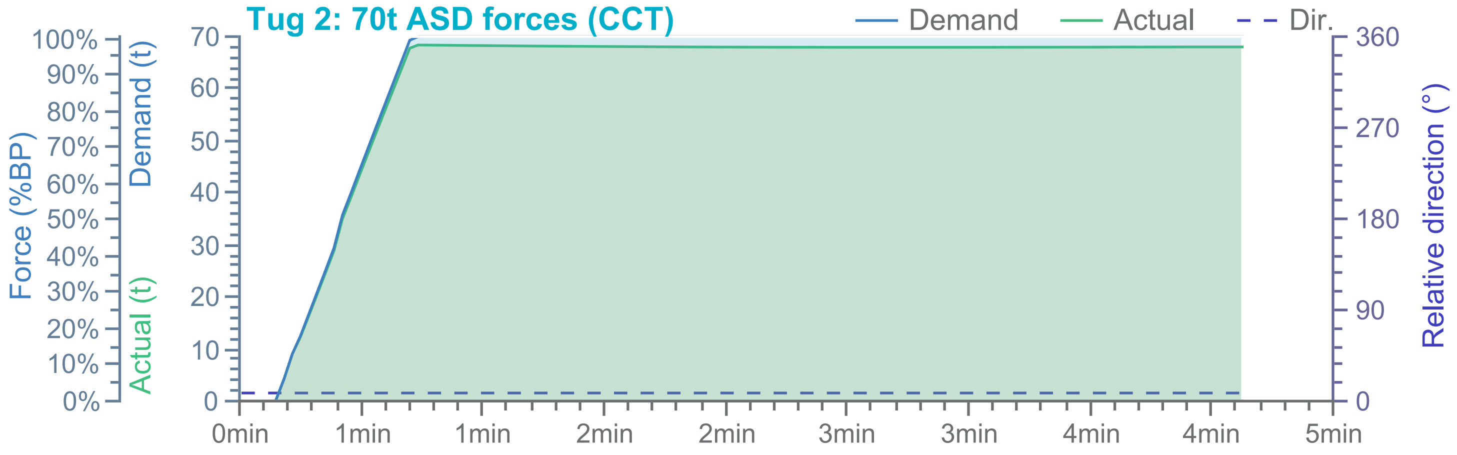

Underkeel Clearance and Speed over Ground


Propeller RPM
Port RPM
Stbd RPM
Propeller RPM
100
50
0
-50
-100
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min


Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
50
40
30
20
10
0
-10
-20
-30
-40
-50
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min


Thrusters
Bow %
Bow thruster (%Power)
100
50
0
-50
-100
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min

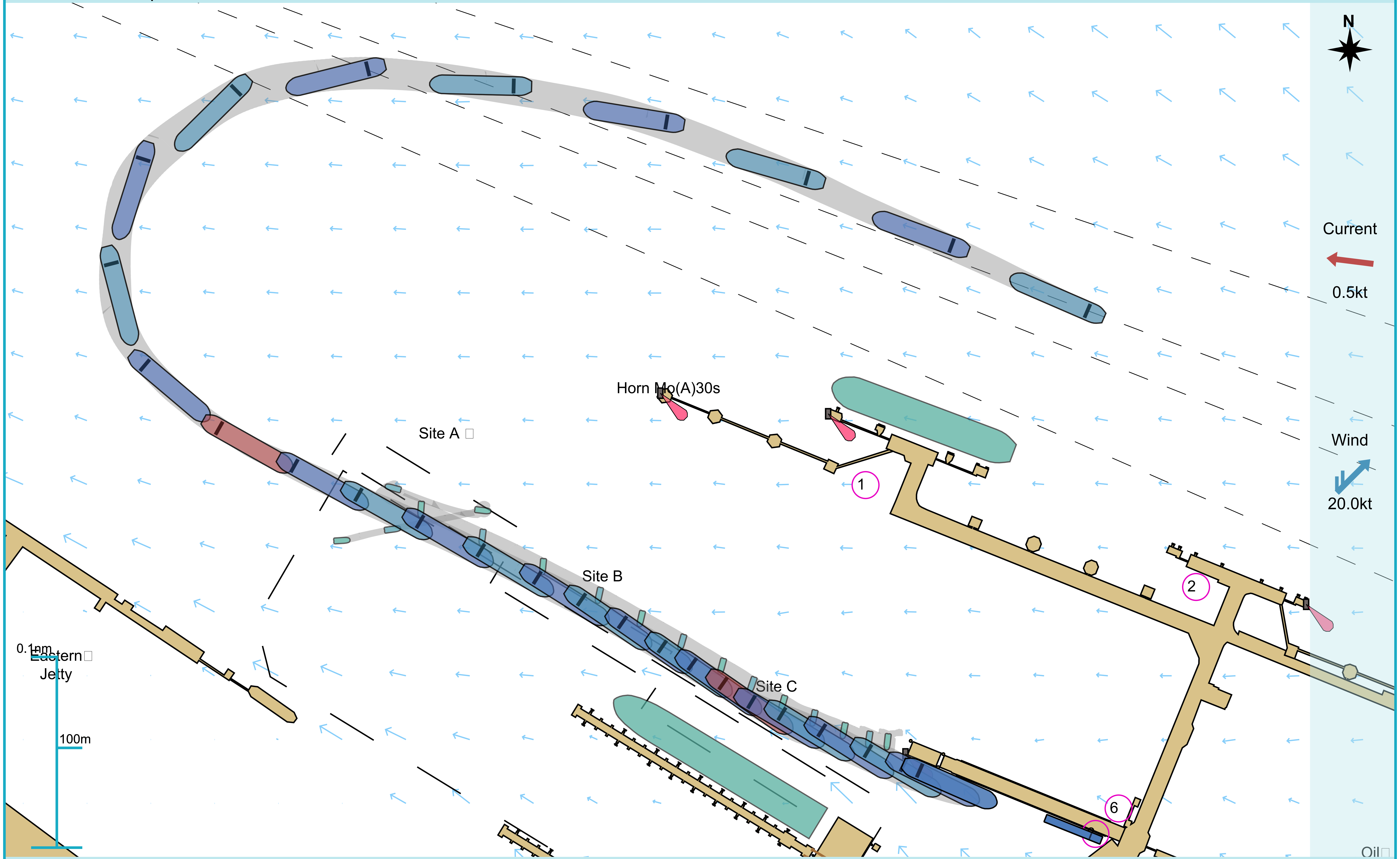

Tug 1: 70t BP ASD forces (ICT)
Tug Force (tonnes)
100
90
80
70
60
50
40
30
20
10
0
Max. bollard pull
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min


Tug 2: 70t ASD forces (CCT)
Demand
Actual
Dir.
Force (%BP)
Demand (t)
Actual (t)
Relative direction (°)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
70
60
50
40
30
20
10
0
360
270
180
90
0
0min
1min
1min
2min
2min
3min
3min
4min
4min
5min

Project: Humber
Session: DJR6612_13-14_December 2023
Configuration: Peak_Spring - no piles
Run: 12

Overview | Environment | 100m x 18m Product Tanker | Tugs

Manoeuvre track plot



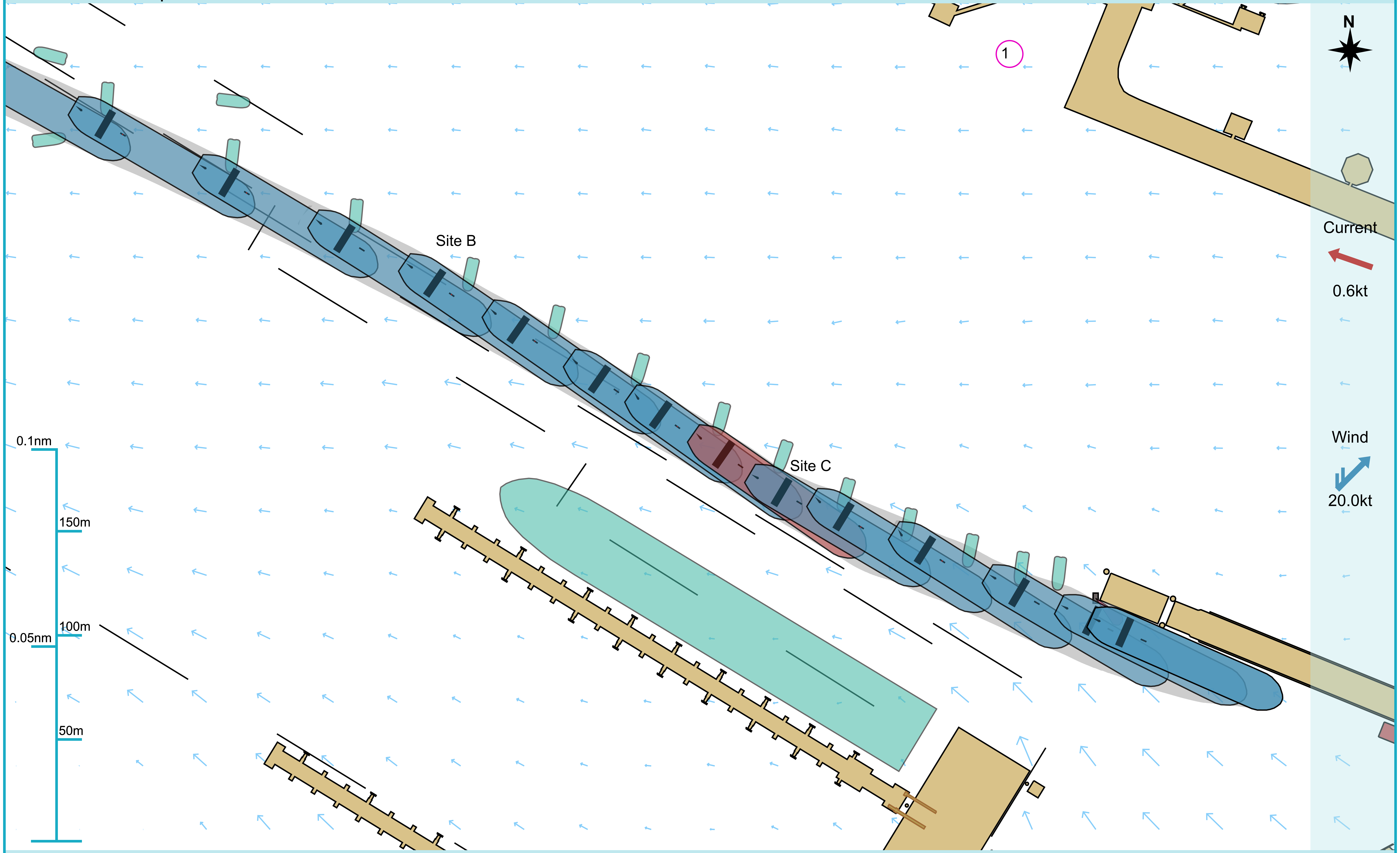
1.39 kts

Ships plotted every 1 mins, highlight every 10 mins

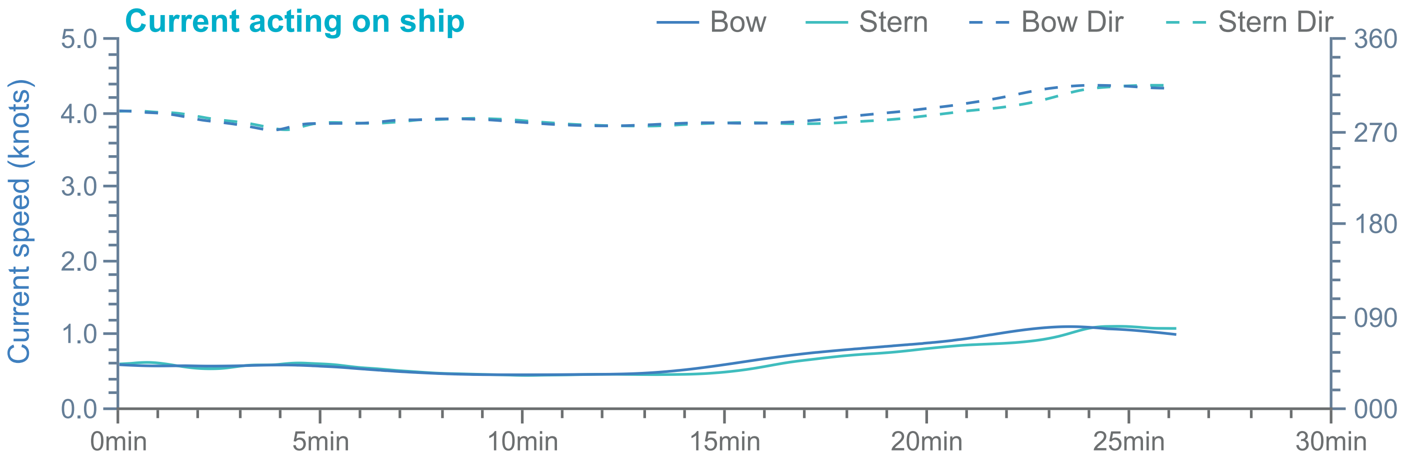
Pilot: JMS
Manoeuvre: Other

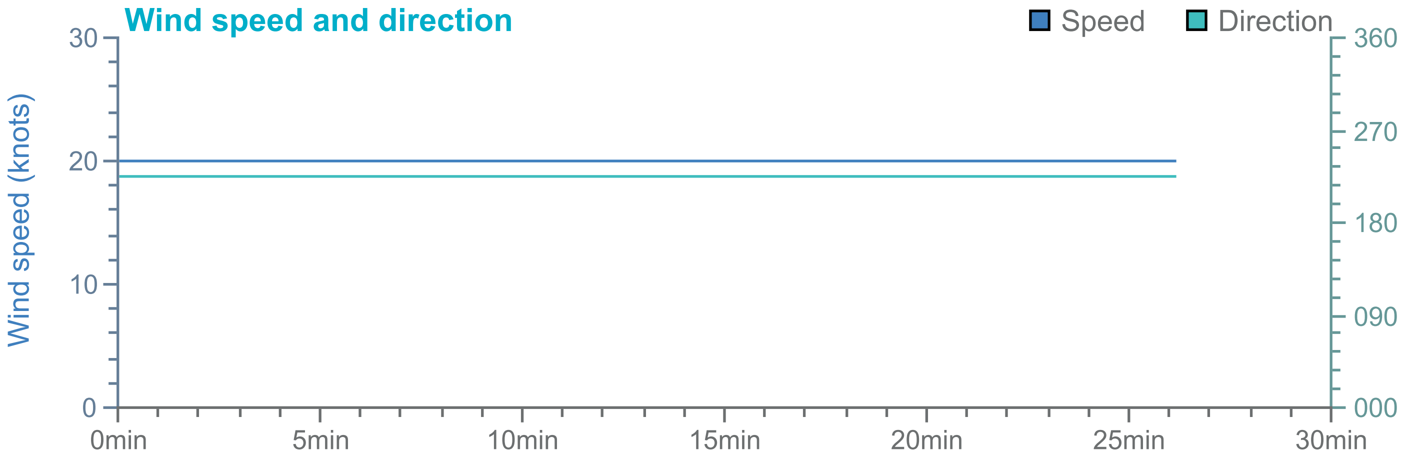
Ship: 100m x 18m Product Tanker

Manoeuvre track plot

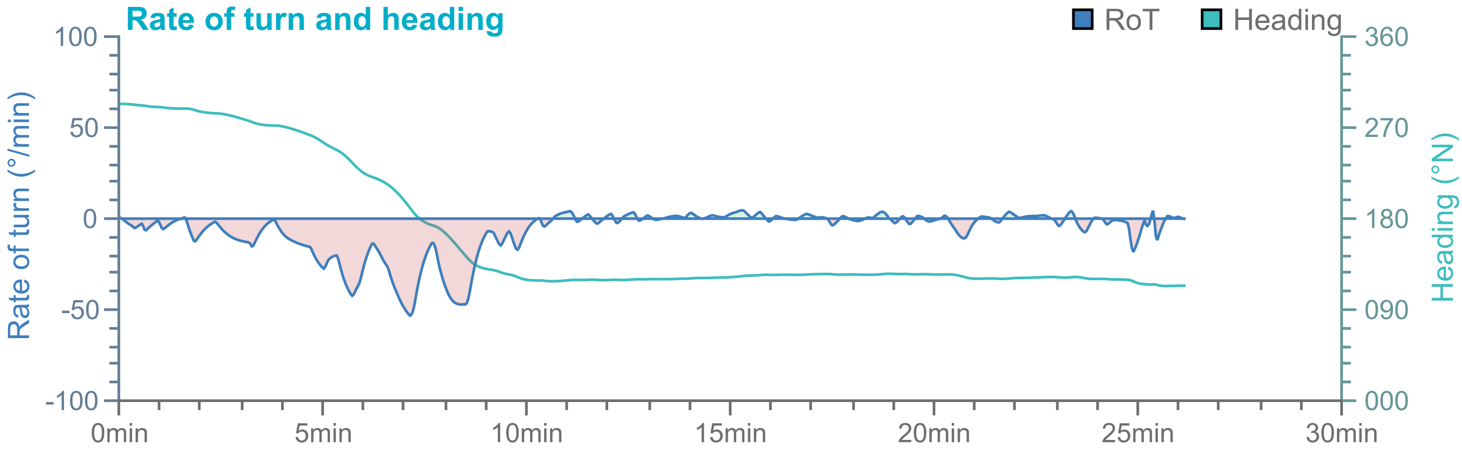


Ships plotted every 1 mins, highlight every 10 mins

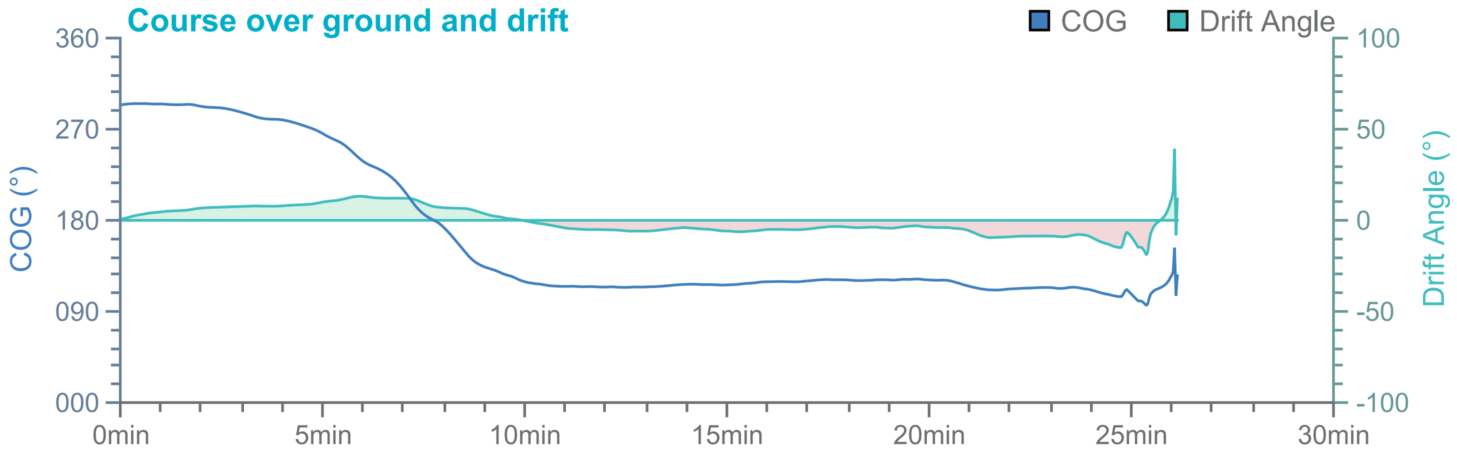

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
Current direction (°N)
360
270
180
090
000
0min
5min
10min
15min
20min
25min
30min


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

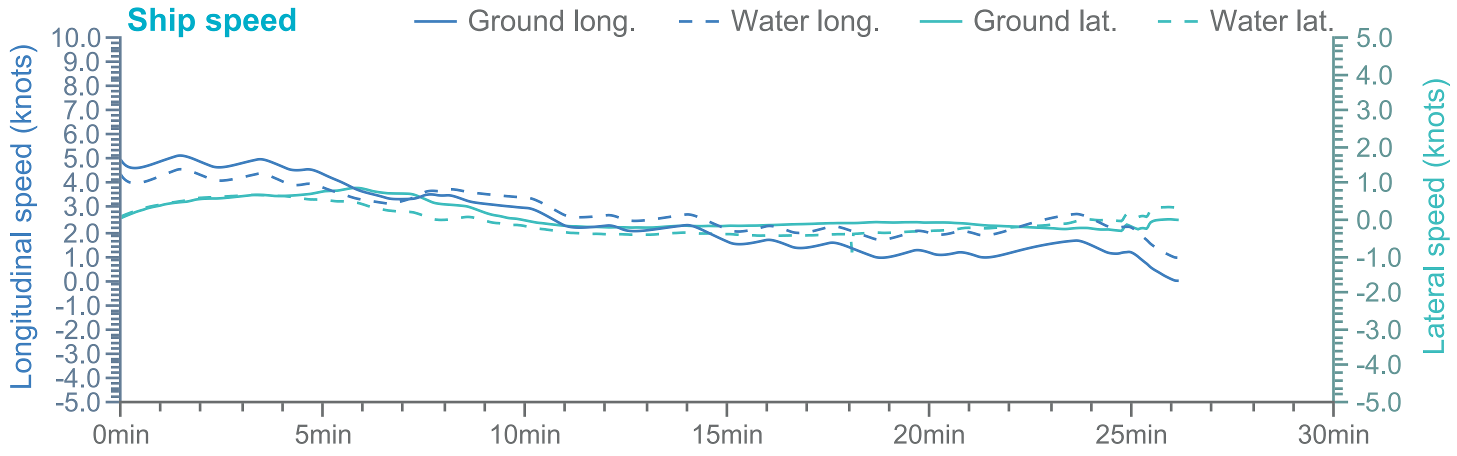
Rate of turn and heading



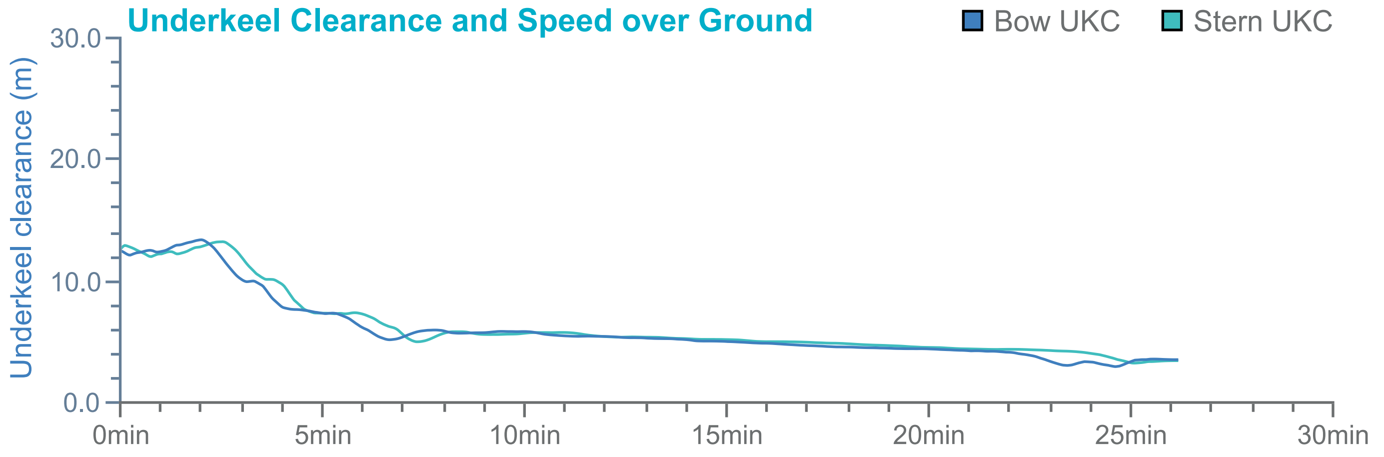
Course over ground and drift

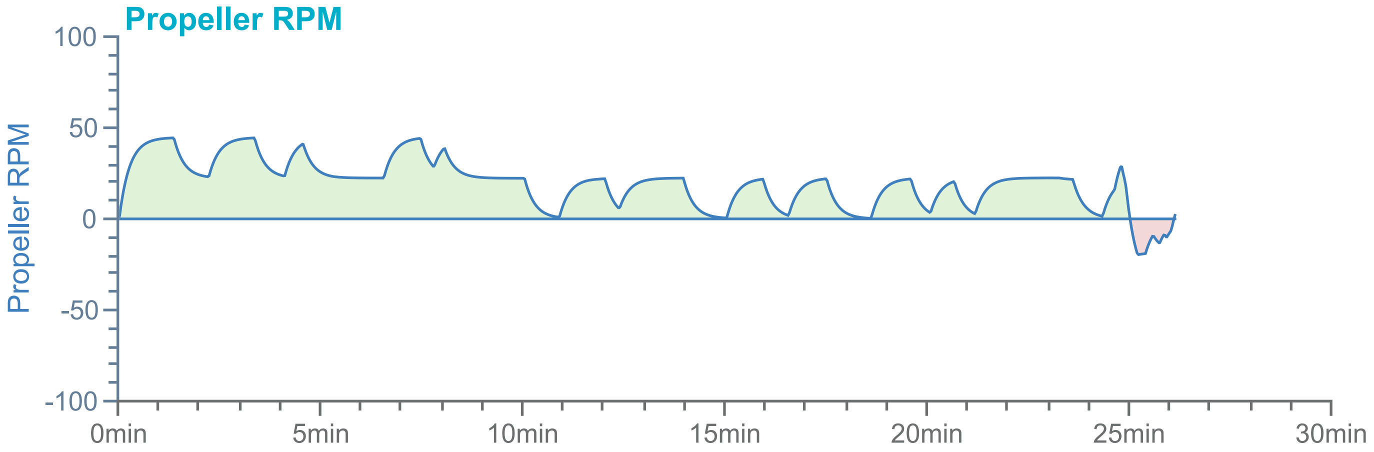


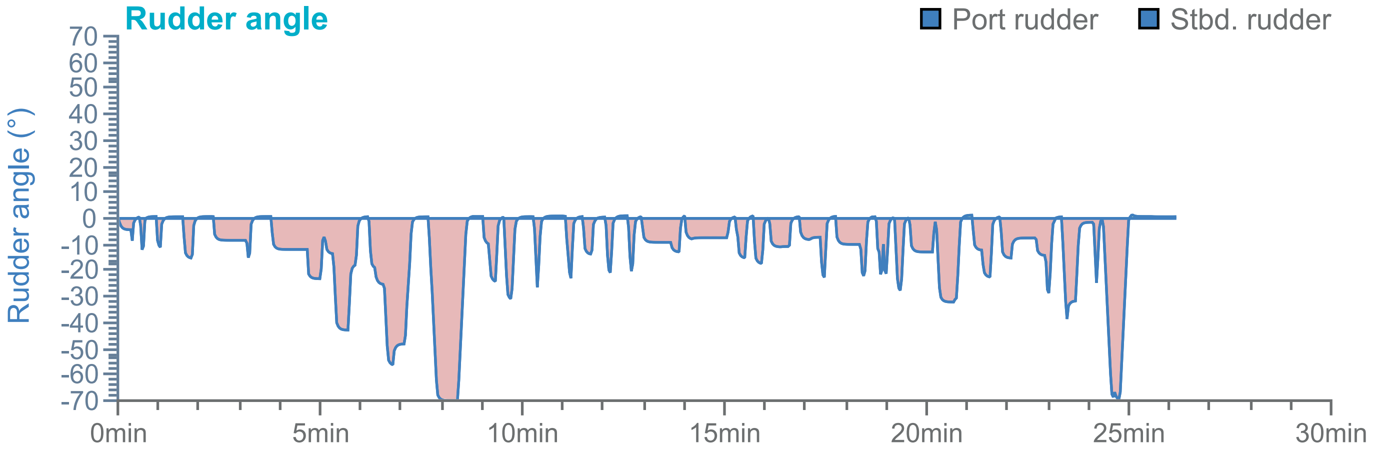
Ship speed

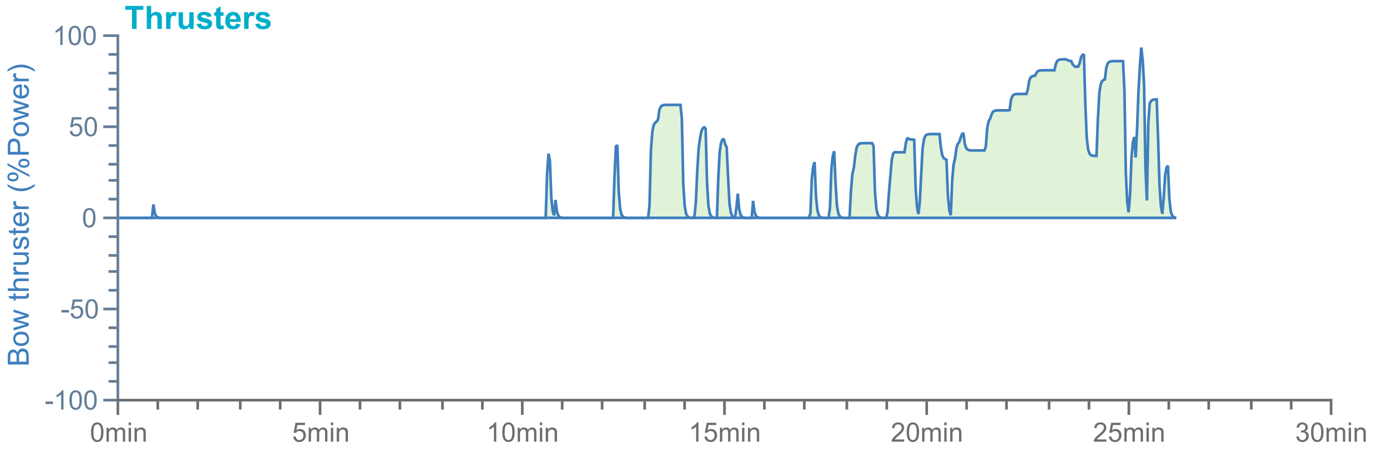


Underkeel Clearance and Speed over Ground

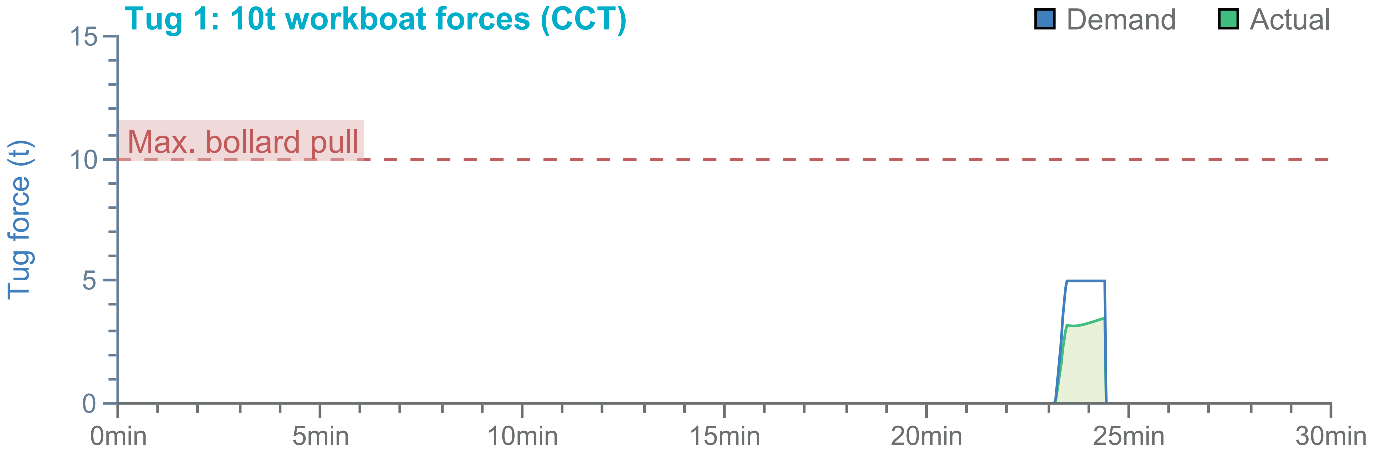



Propeller RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min

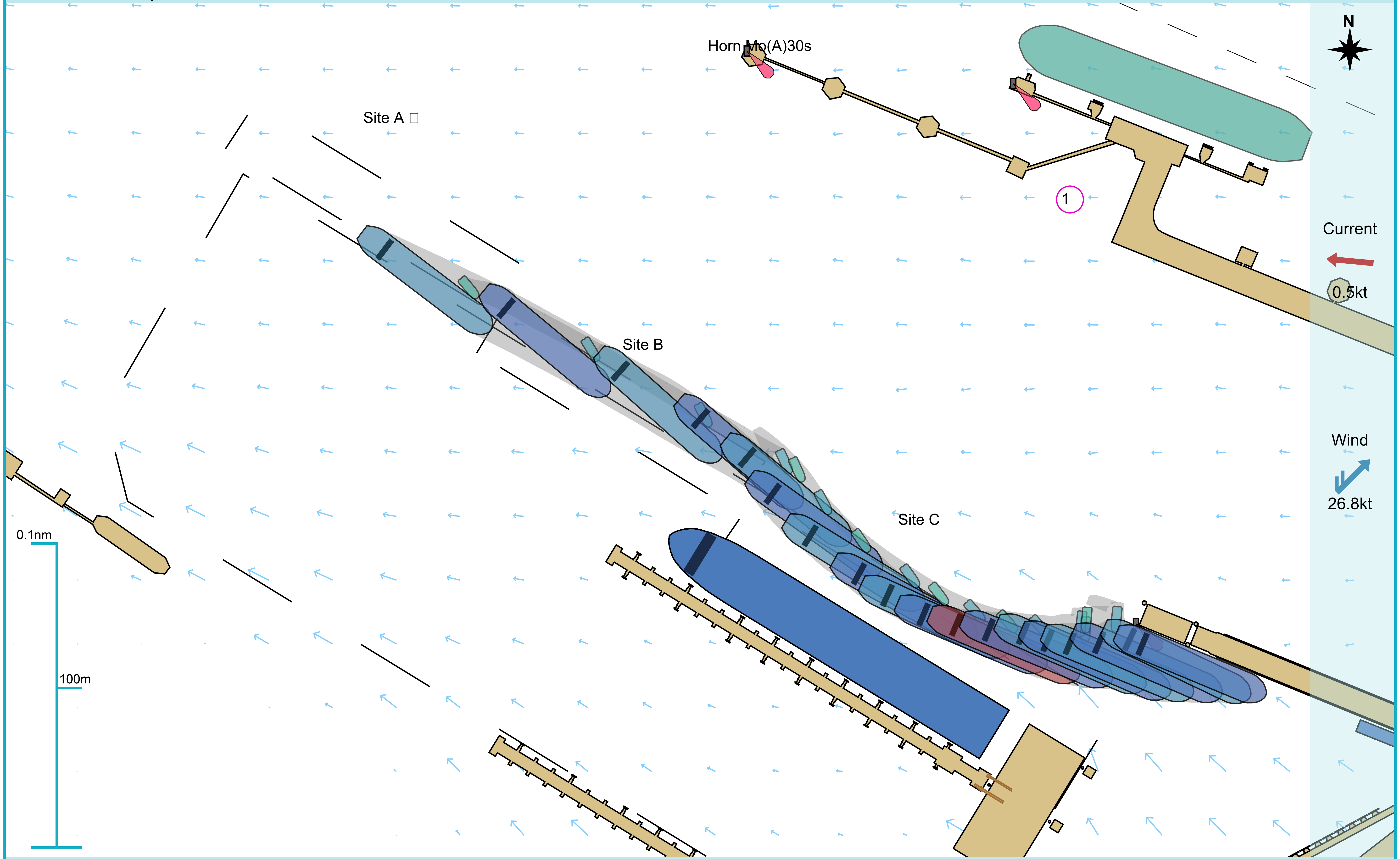

Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min
25min
30min


Thrusters
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min
20min
25min
30min

Tug 1: 10t workboat forces (CCT)

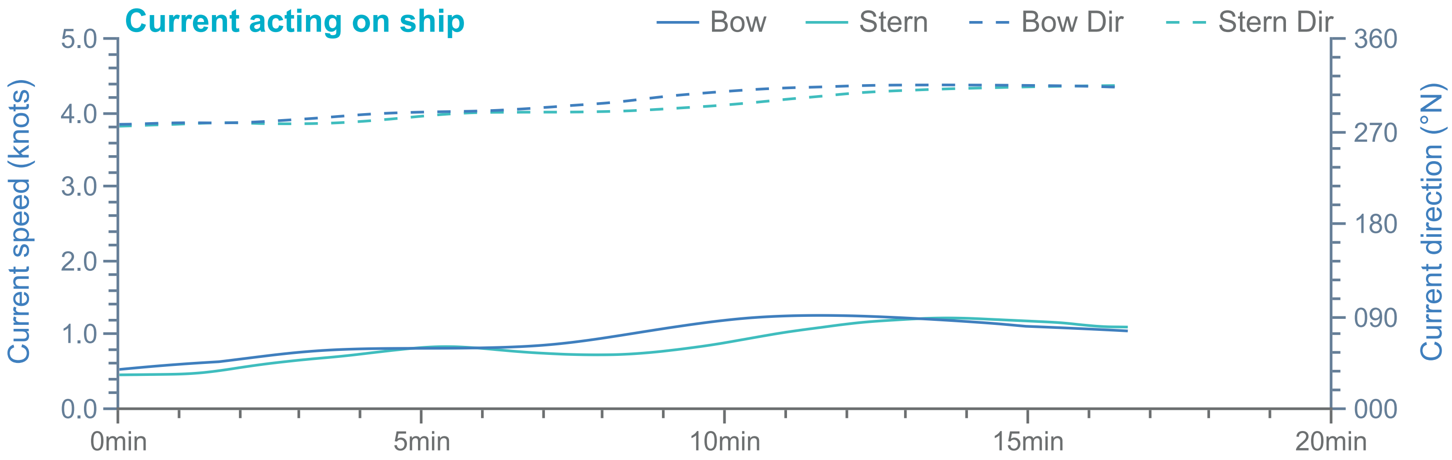


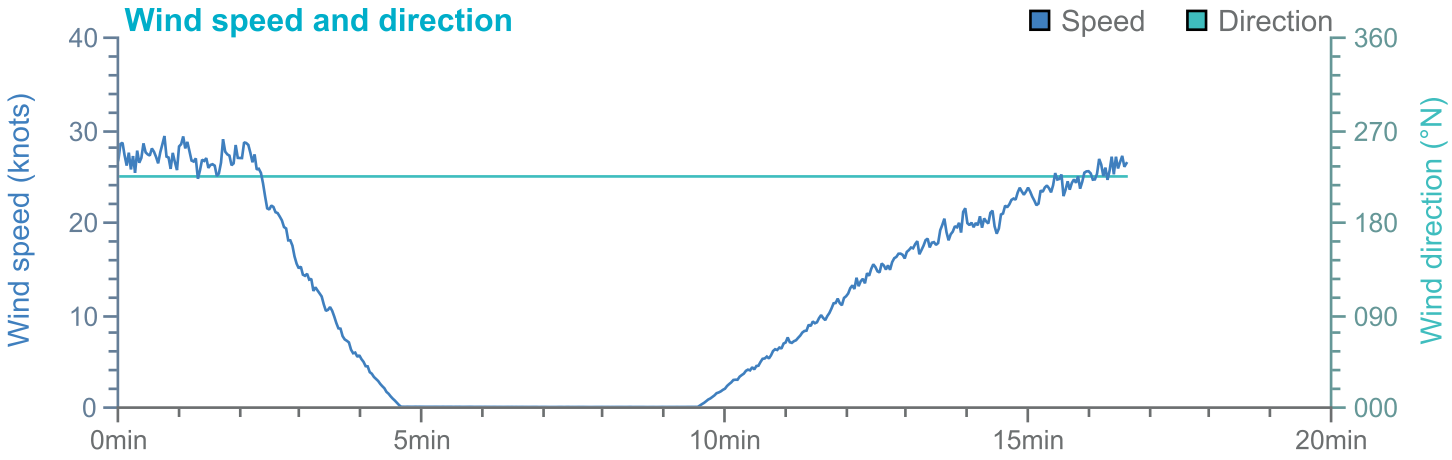
Manoeuvre track plot

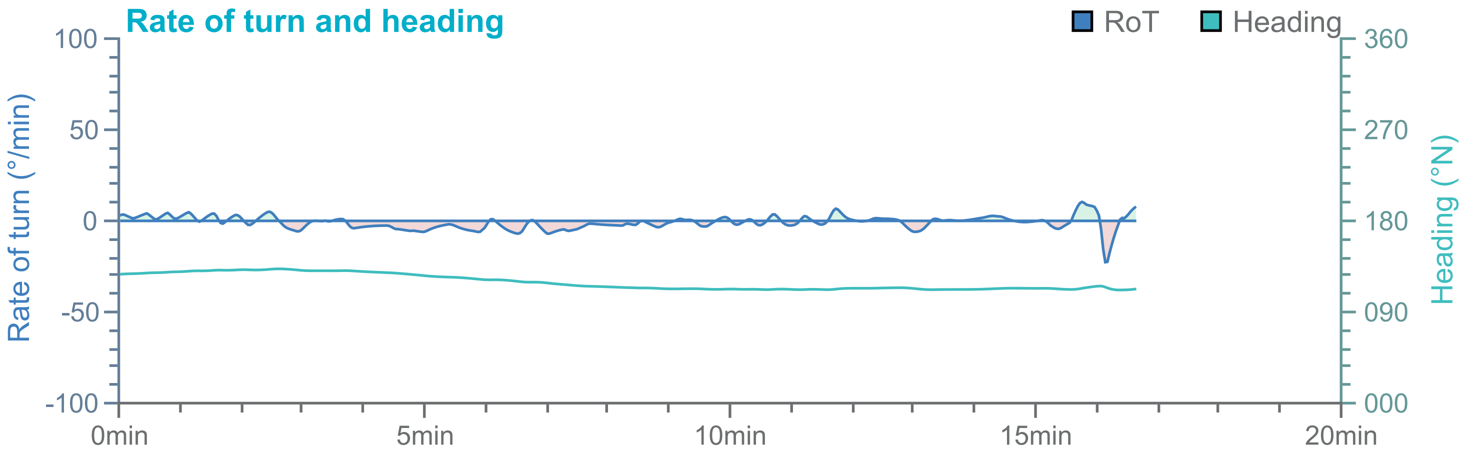


1.61 kts

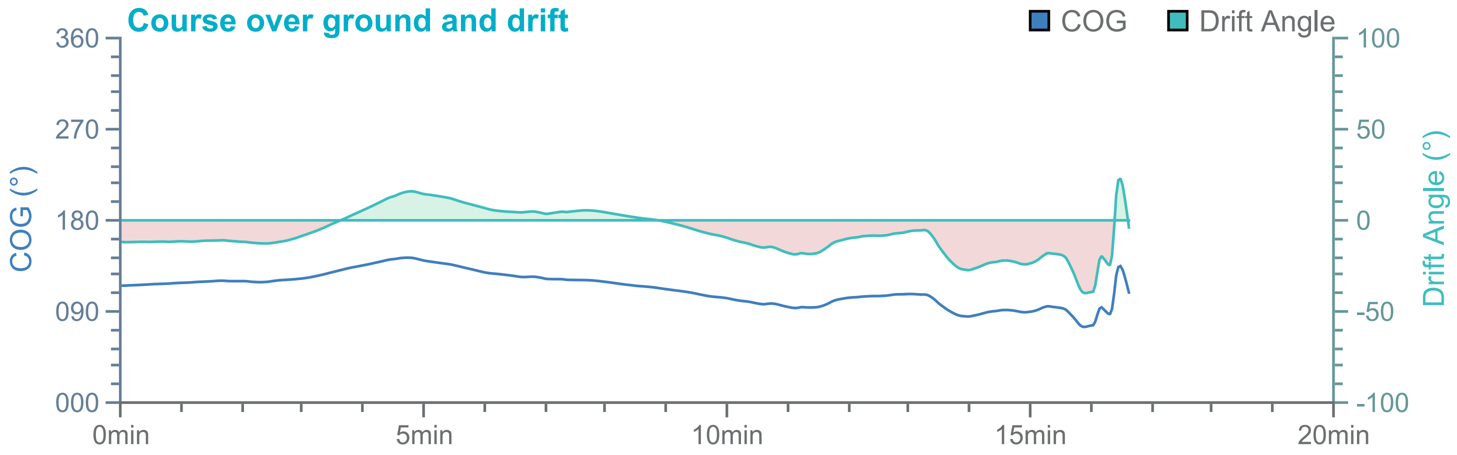
Ships plotted every 1 mins, highlight every 10 mins


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

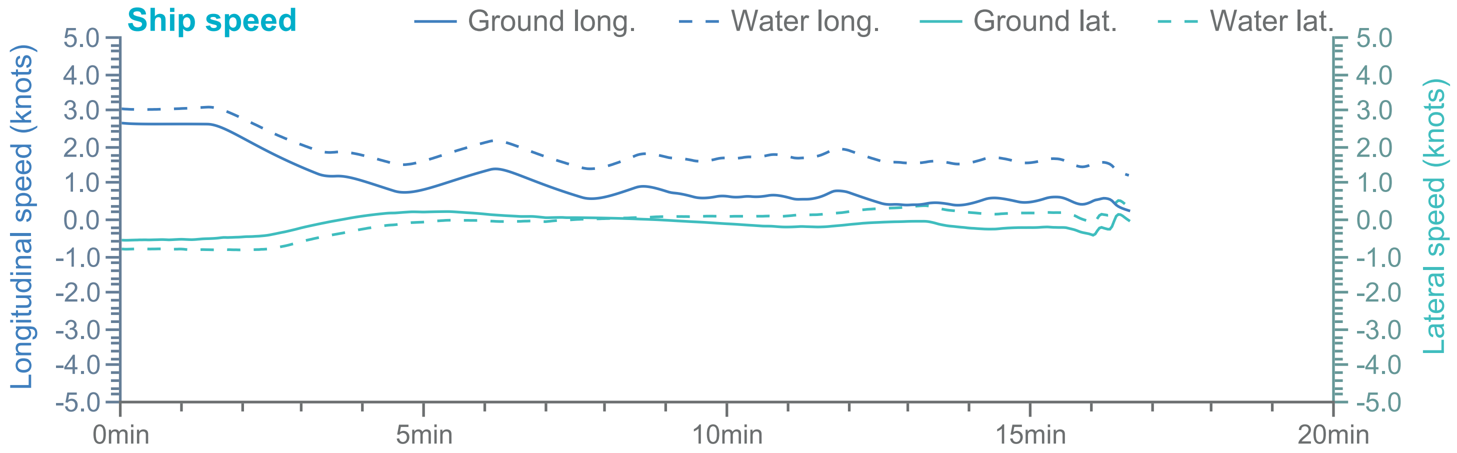

Wind speed and direction
Speed
Direction
Wind speed (knots)
40
30
20
10
0
Wind direction (°N)
360
270
180
090
000
0min
5min
10min
15min
20min



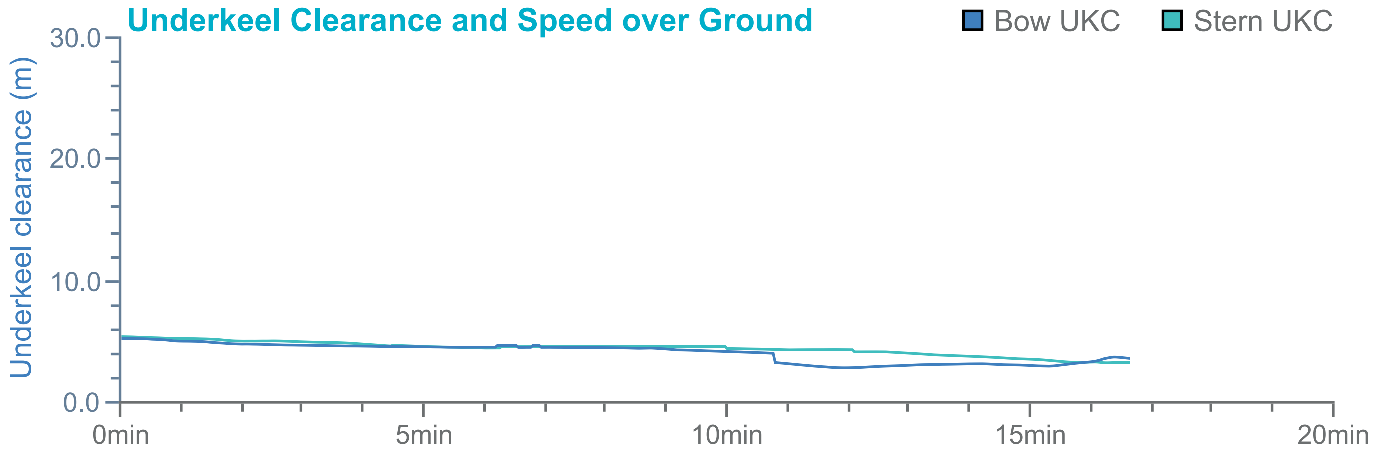
Rate of turn and heading



Course over ground and drift

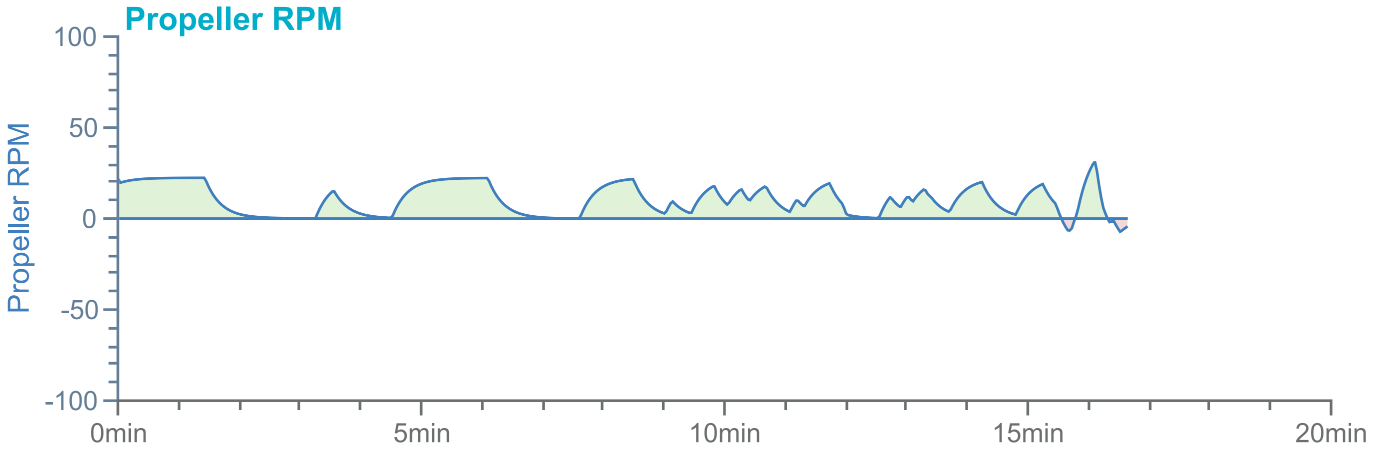


Ship speed

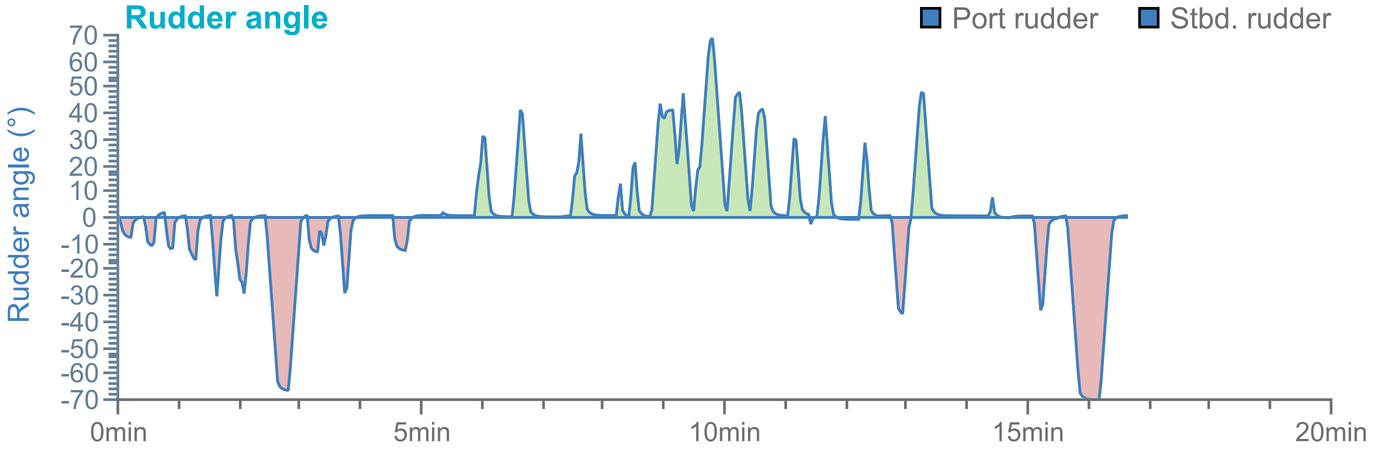


Underkeel Clearance and Speed over Ground

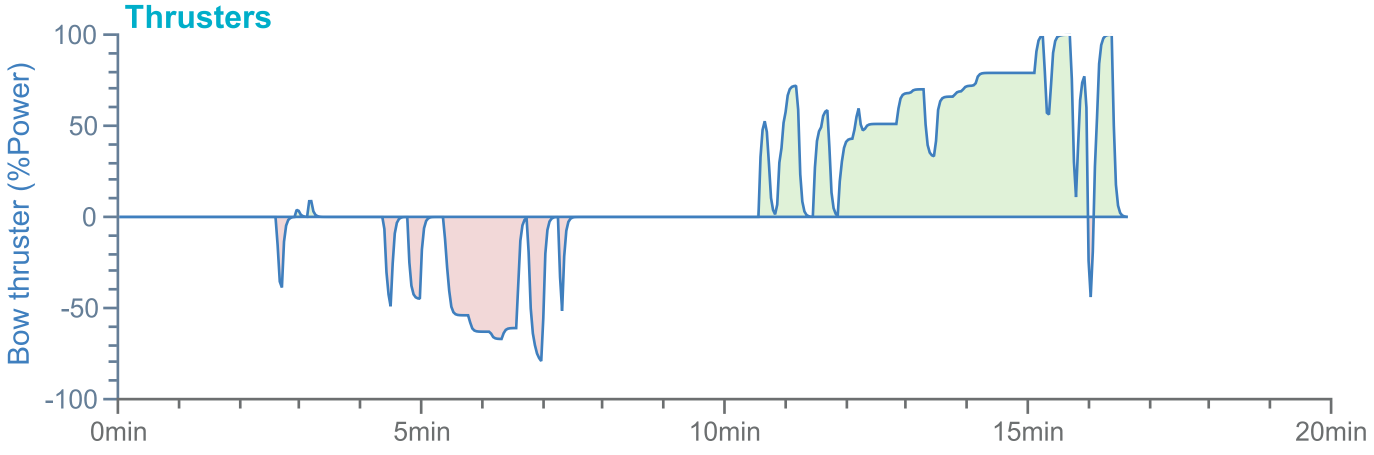
Propeller RPM

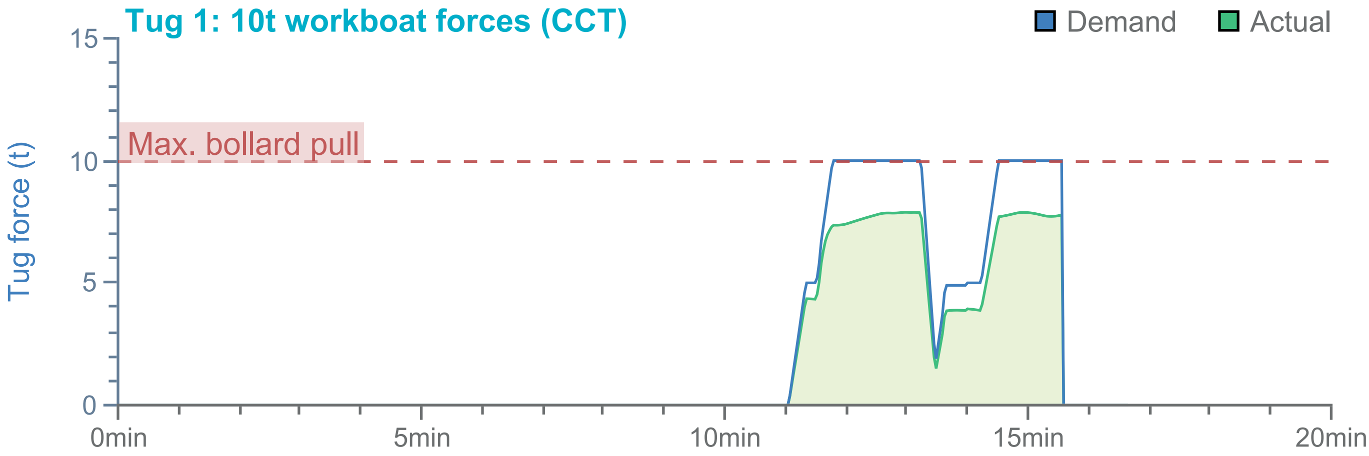


Rudder angle

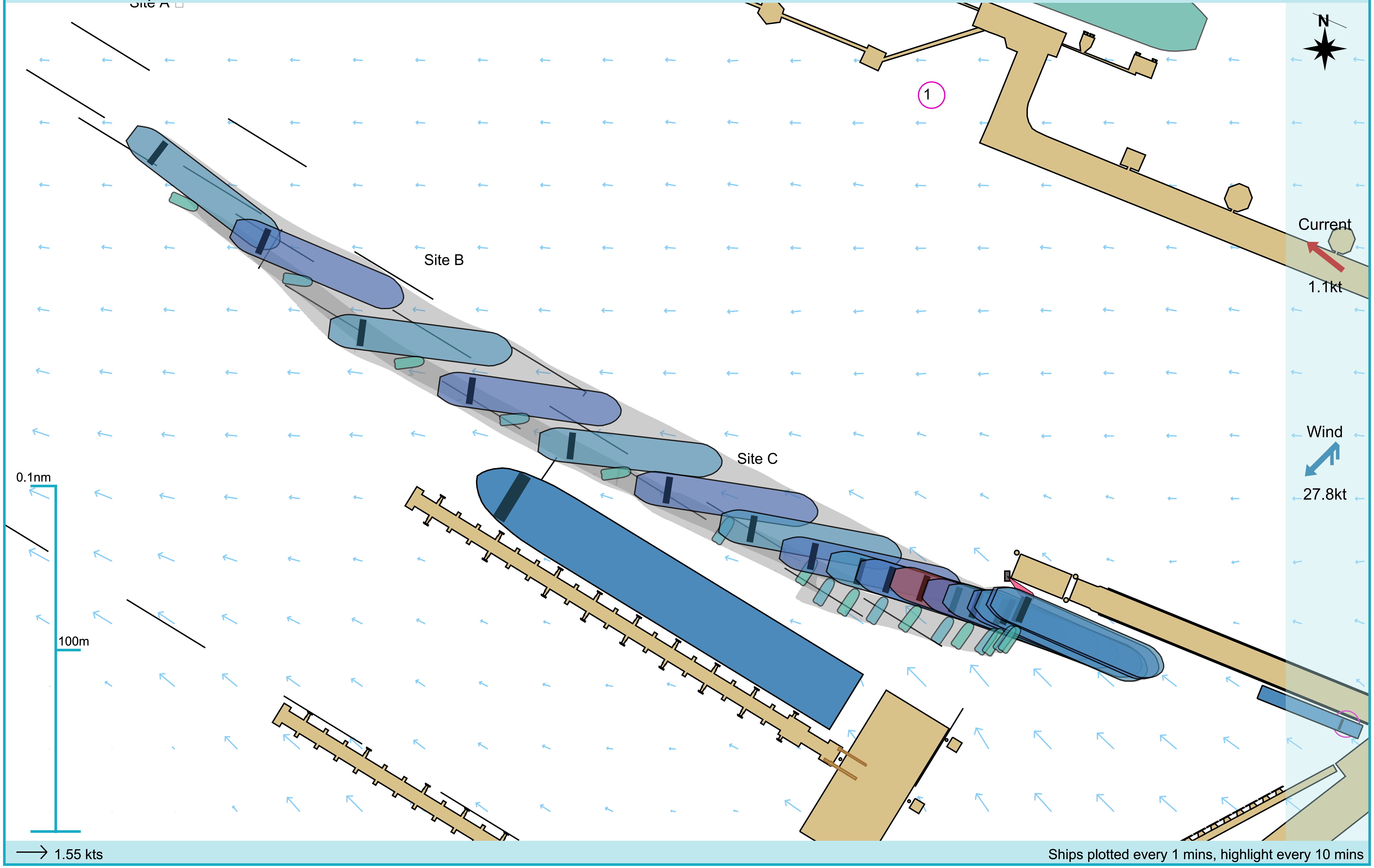


Thrusters



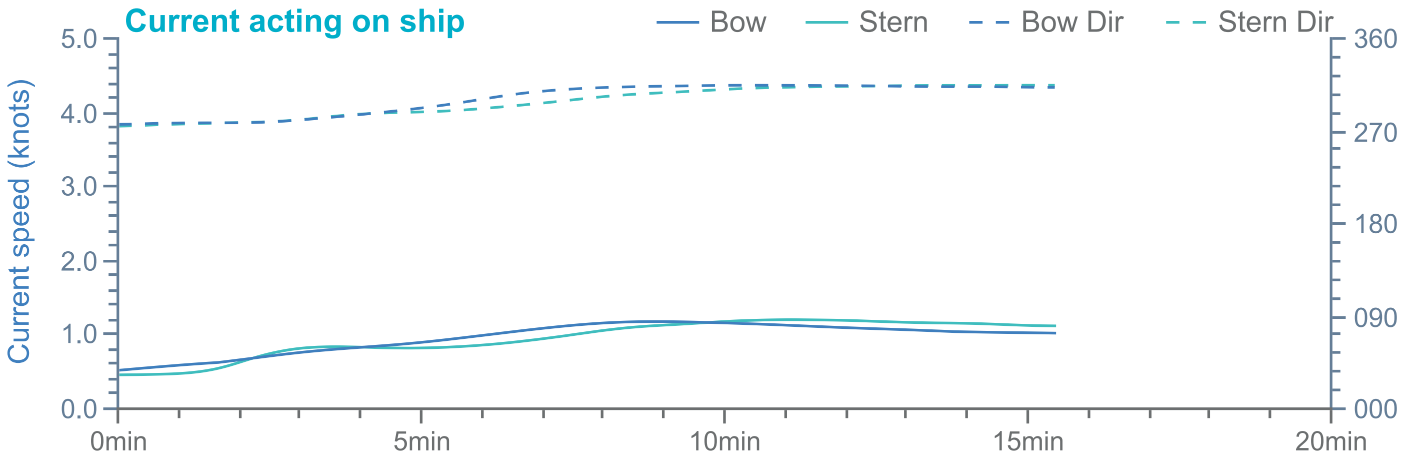

Tug 1: 10t workboat forces (CCT)
🟦 Demand
🟩 Actual
Max. bollard pull
Tug force (t)
15
10
5
0
0min
5min
10min
15min
20min

Manoeuvre track plot

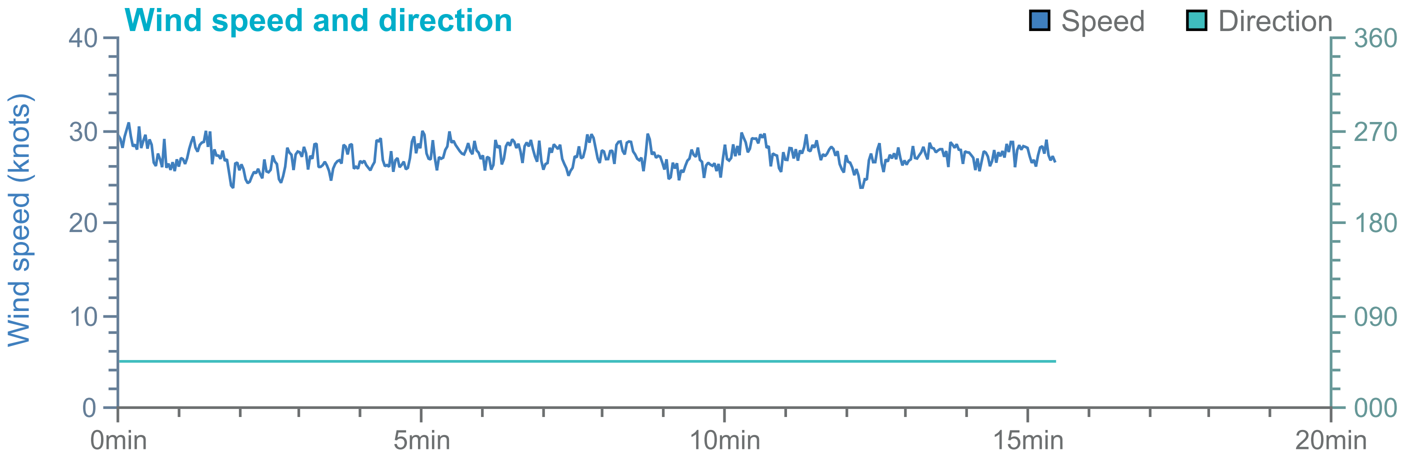


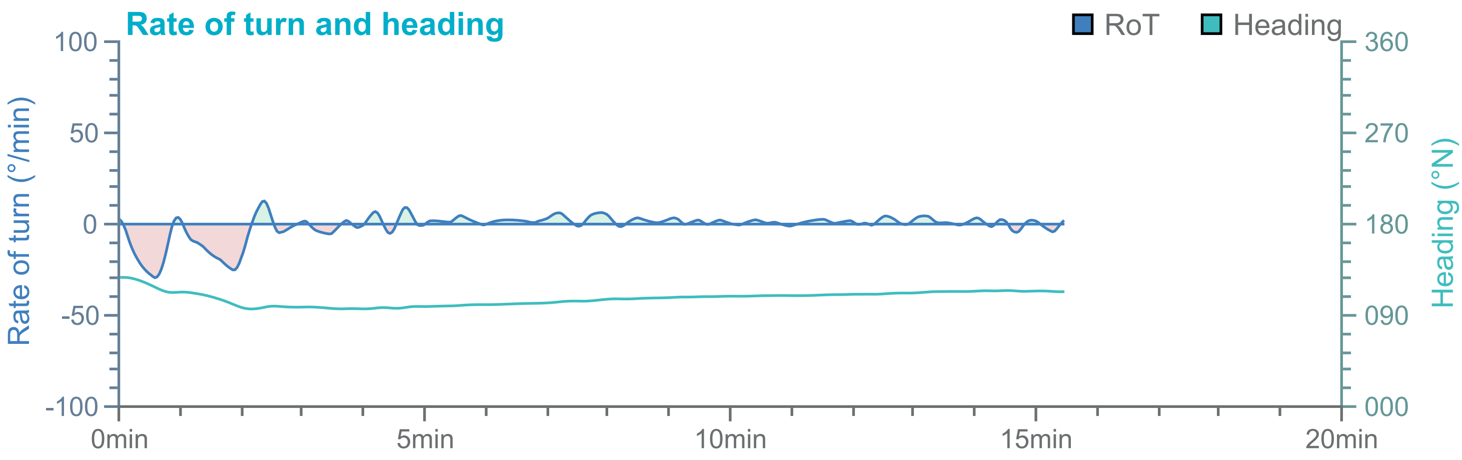
Ships plotted every 1 mins, highlight every 10 mins

Current acting on ship

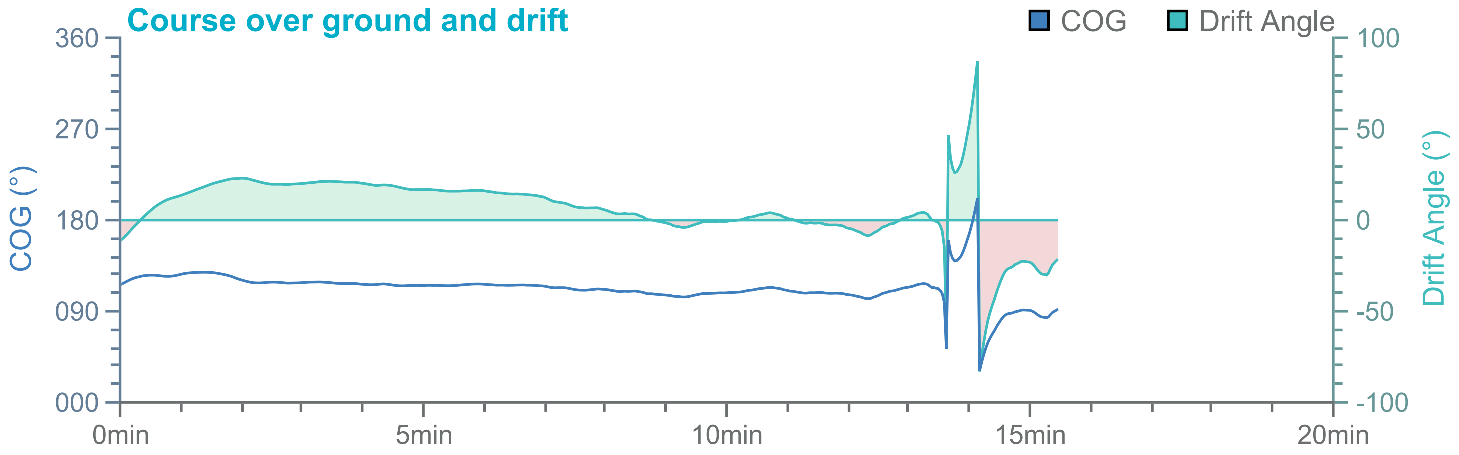


Wind speed and direction

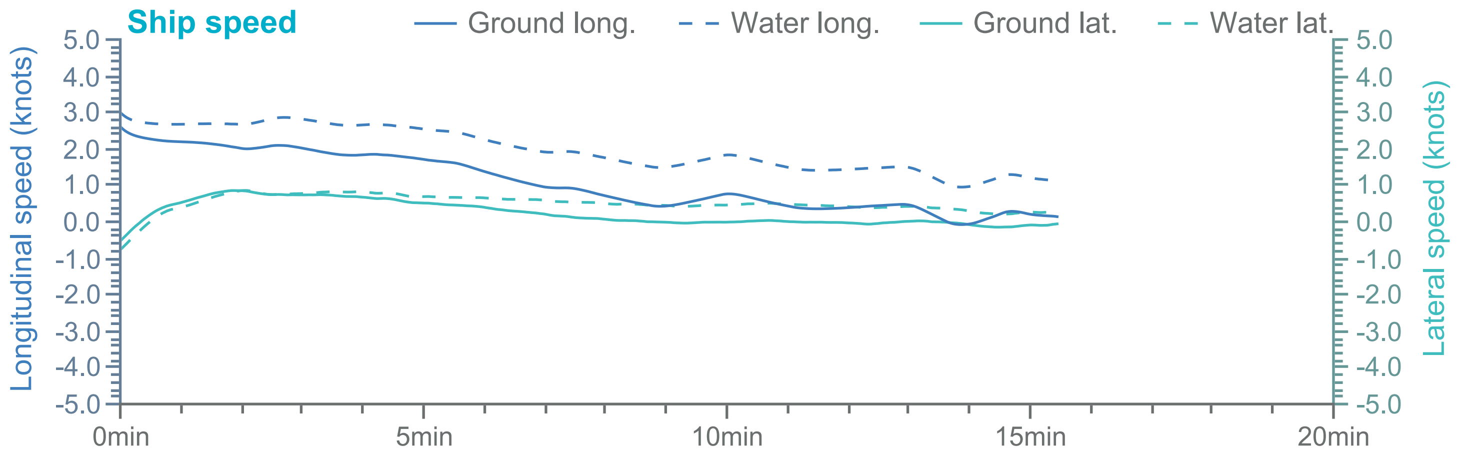




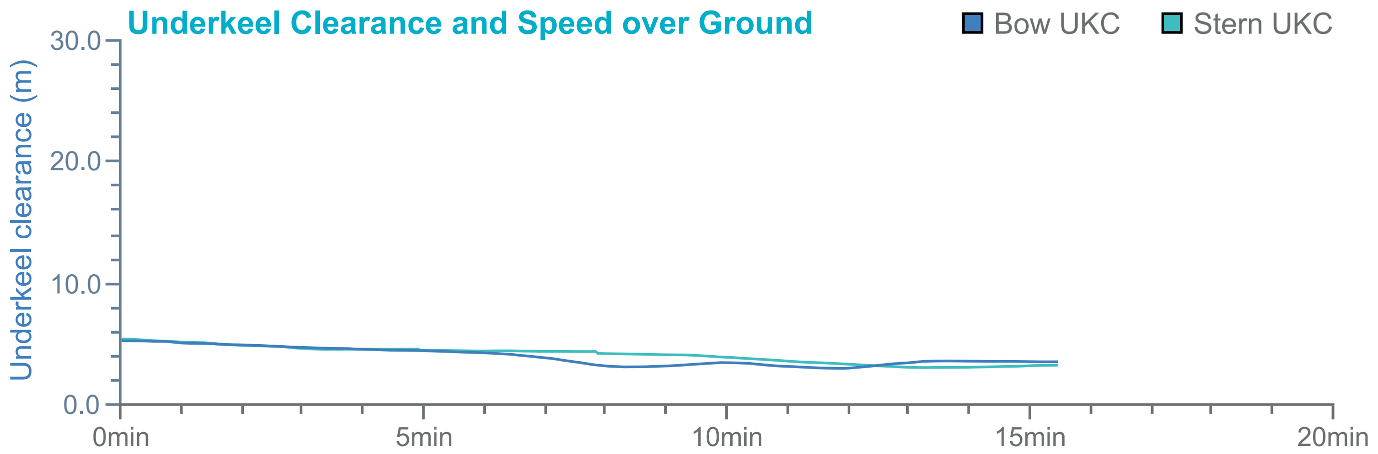
Rate of turn and heading



Course over ground and drift

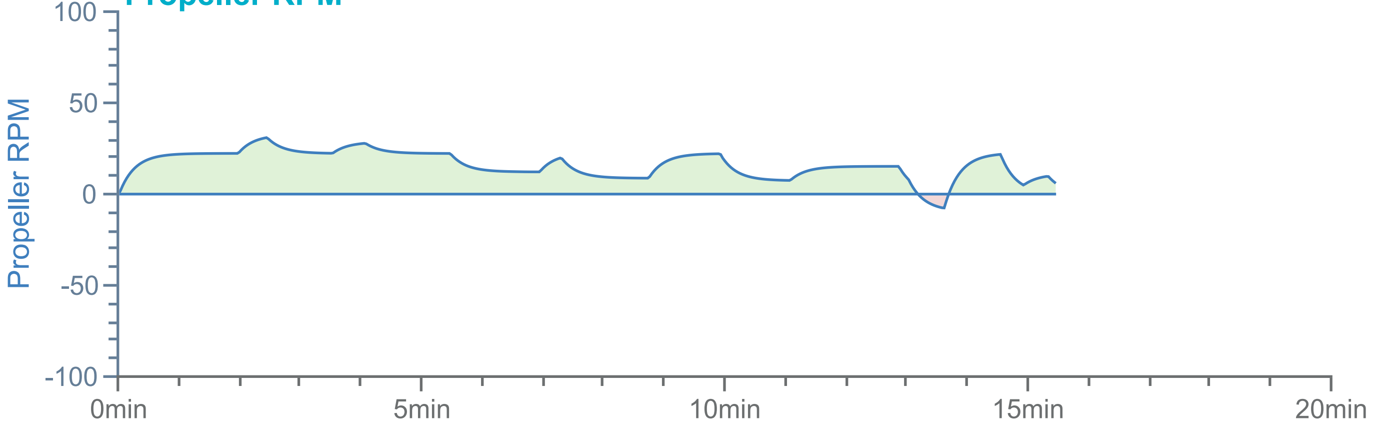


Ship speed

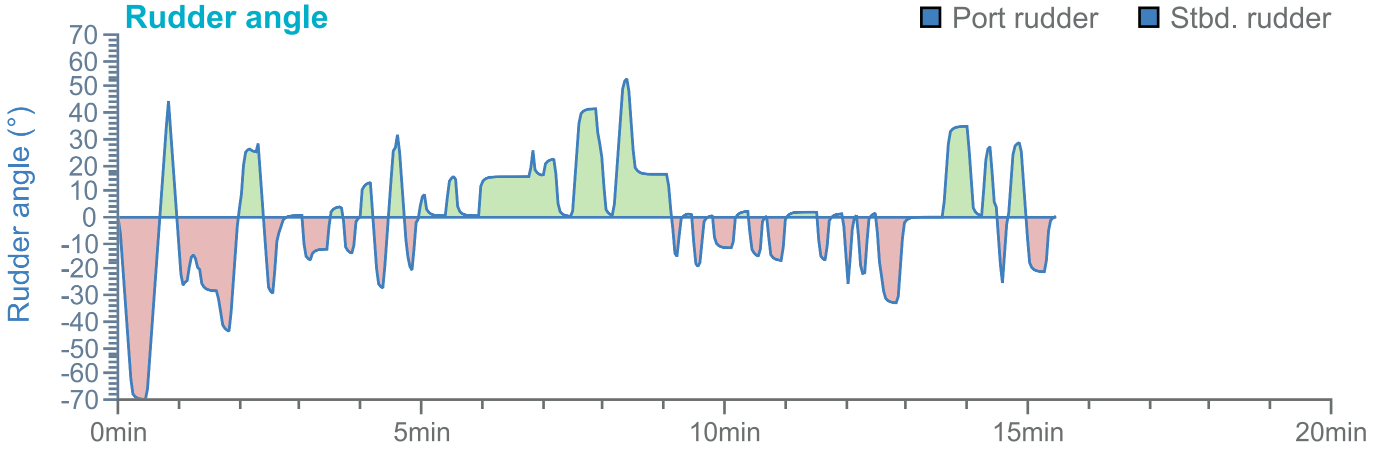


Underkeel Clearance and Speed over Ground

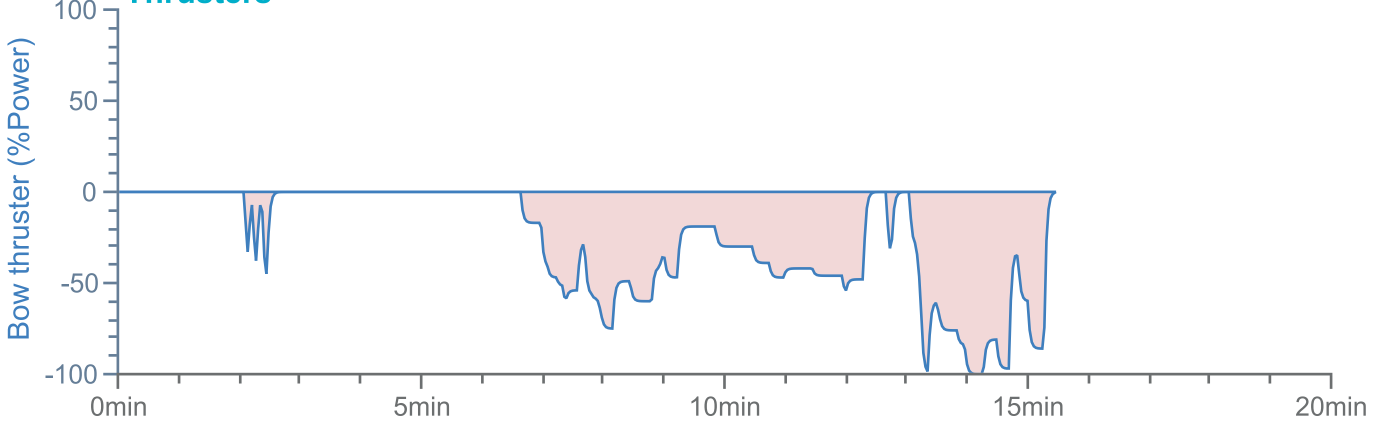
Propeller RPM

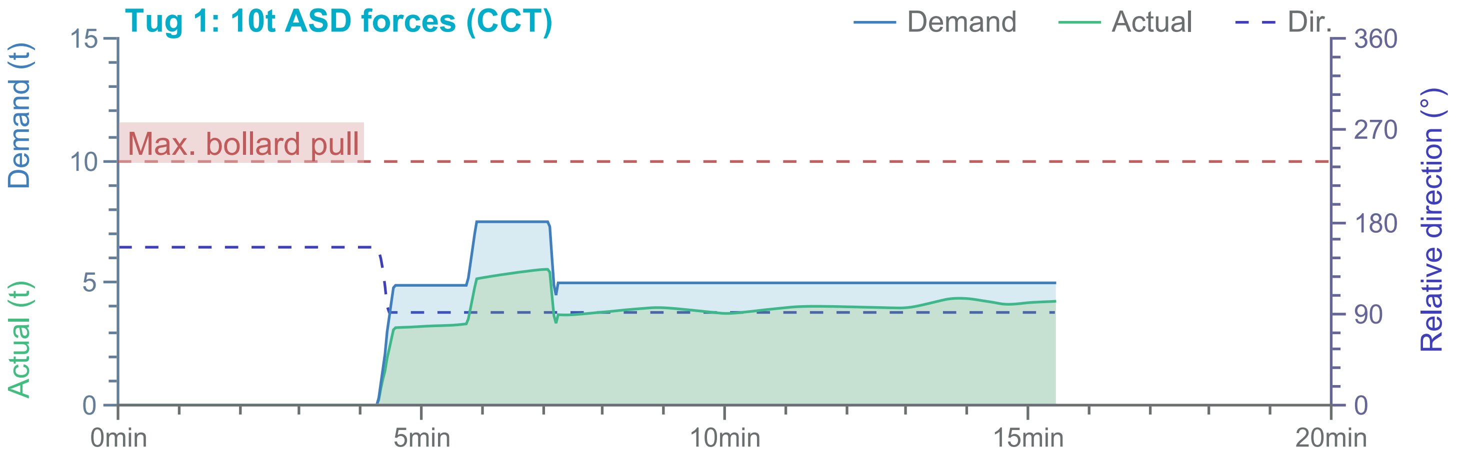


Rudder angle

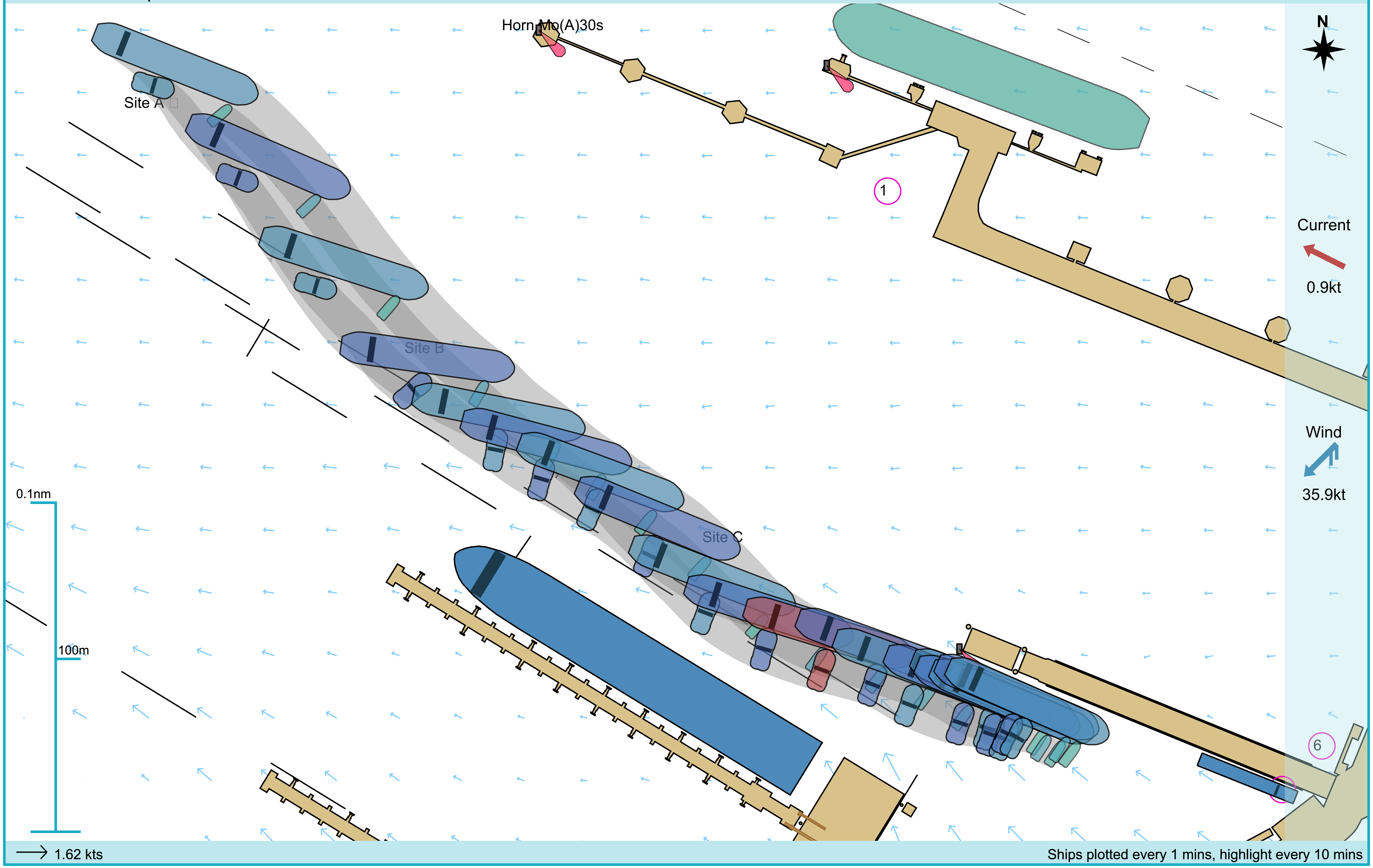


Thrusters




Tug 1: 10t ASD forces (CCT)
Demand
Actual
Dir.
Demand (t)
Actual (t)
Relative direction (°)
Max. bollard pull
15
10
5
0
360
270
180
90
0
0min
5min
10min
15min
20min

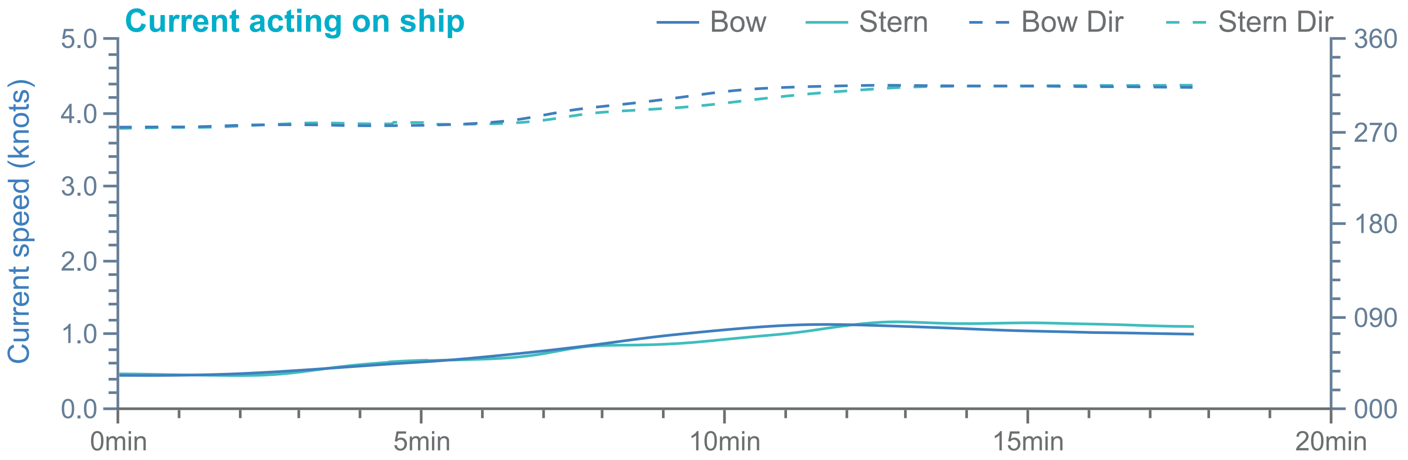
Manoeuvre track plot

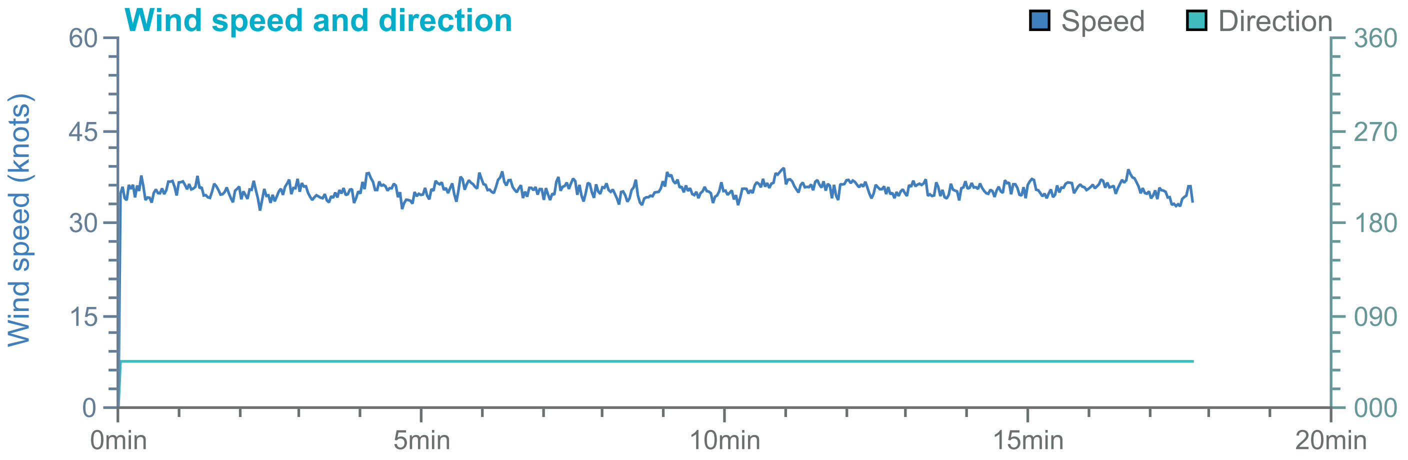


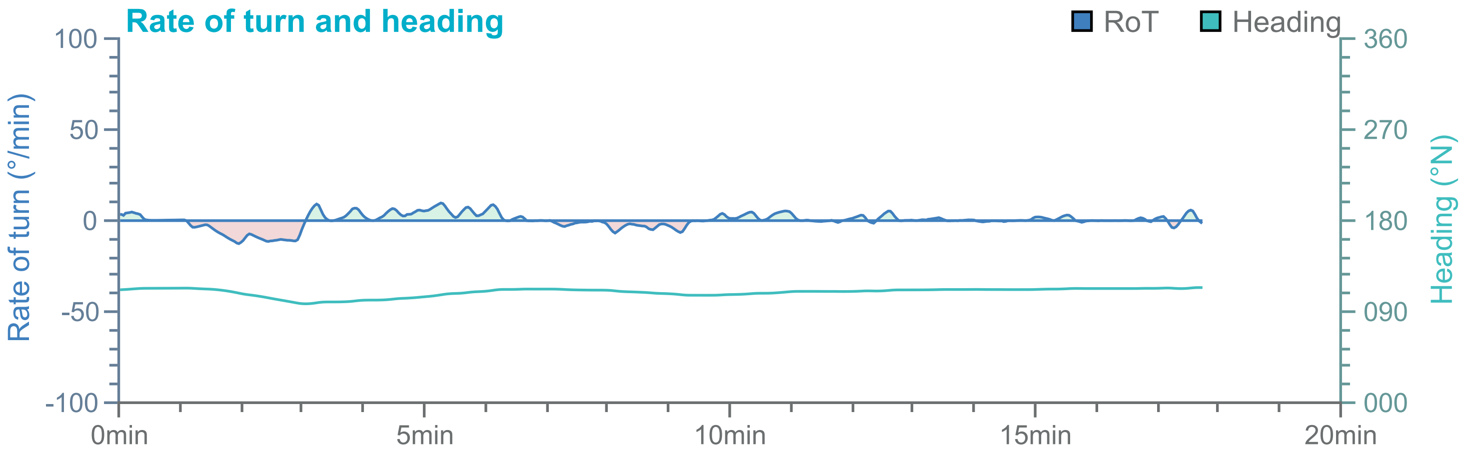
Ships plotted every 1 mins, highlight every 10 mins

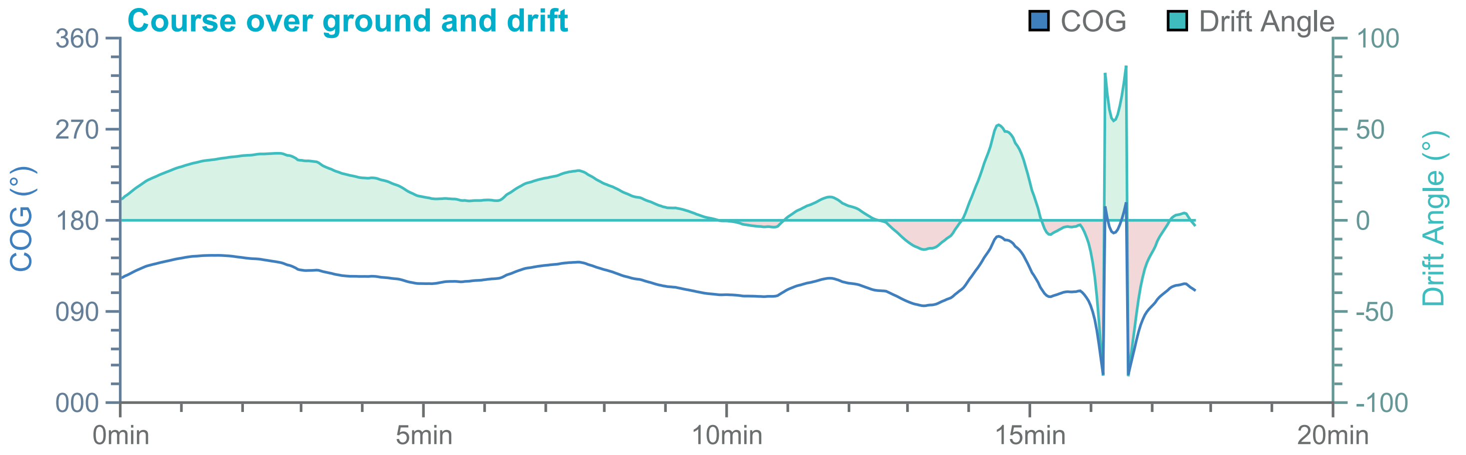
Pilot: JMS
Manoeuvre: Other

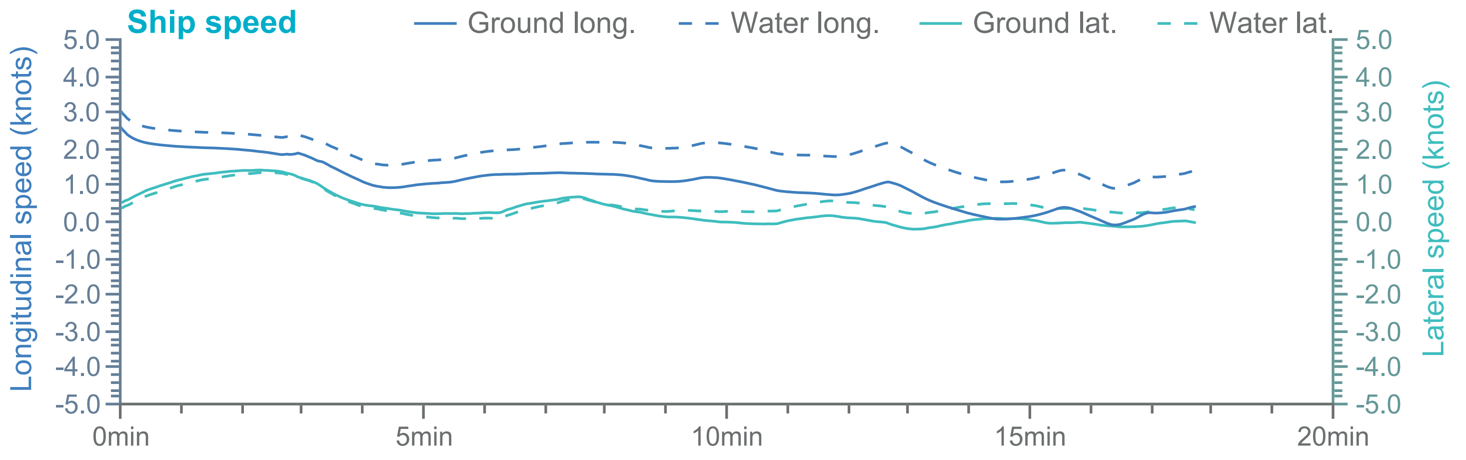
Ship: 100m x 18m Product Tanker

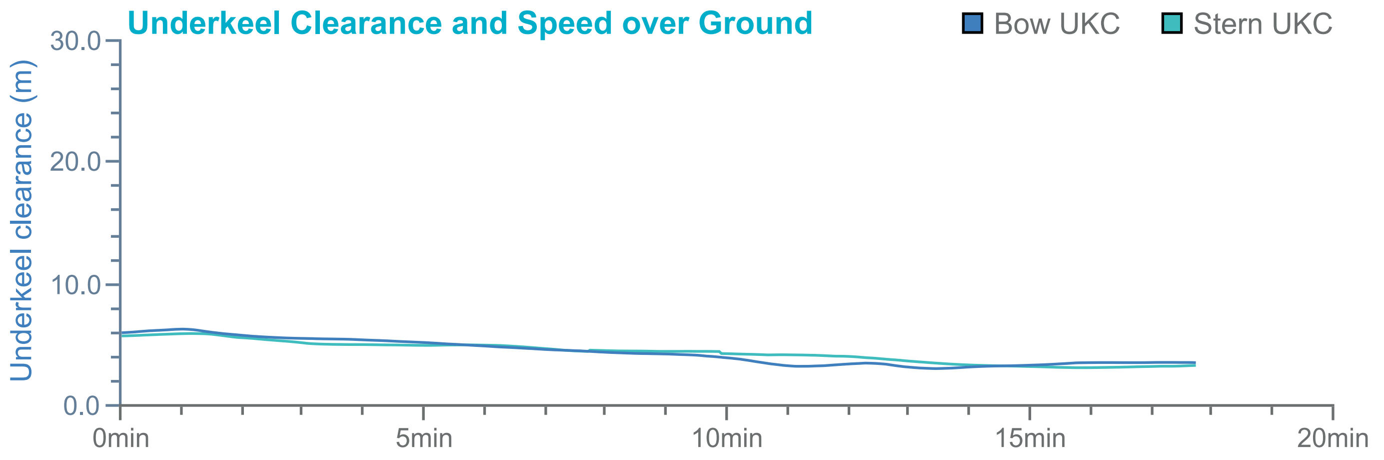

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
Current direction (°N)
360
270
180
090
000
0min
5min
10min
15min
20min


Wind speed and direction
Speed
Direction
Wind speed (knots)
60
45
30
15
0
Wind direction (°N)
360
270
180
090
000
0min
5min
10min
15min
20min

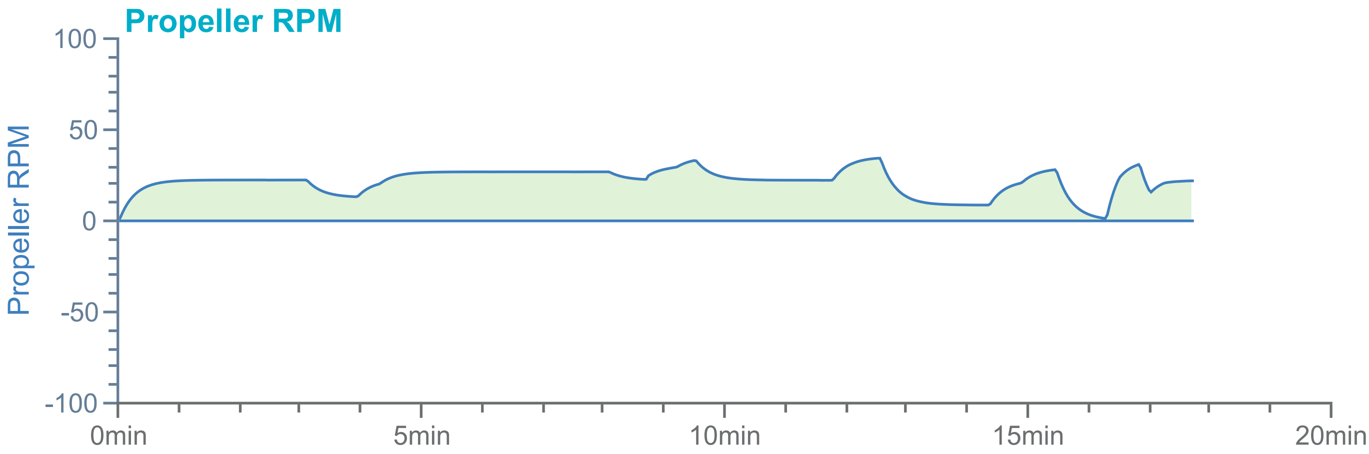

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
100
50
0
-50
-100
360
270
180
090
000
0min
5min
10min
15min
20min


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

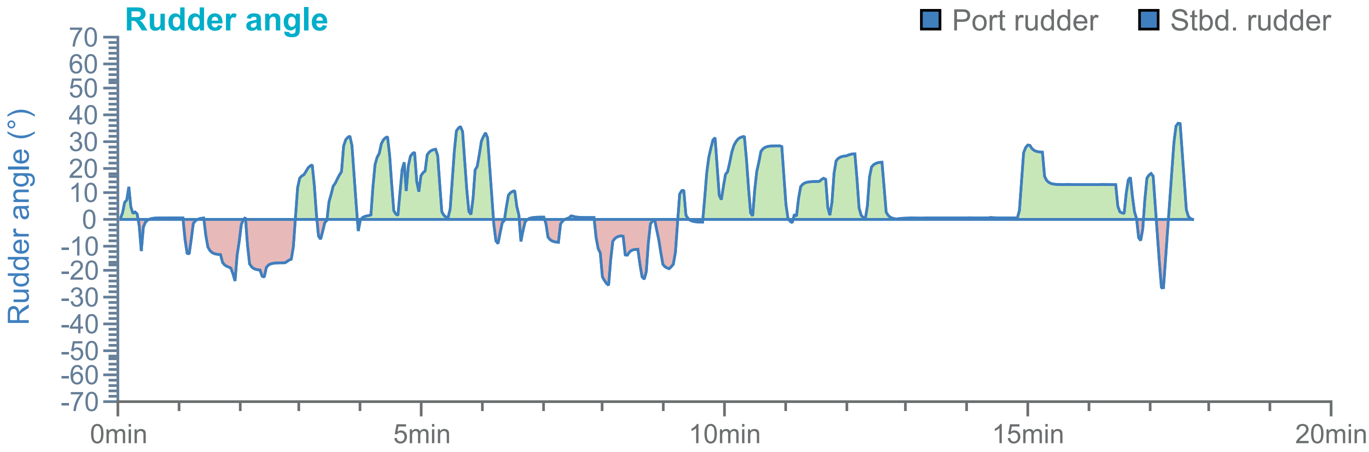

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min


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

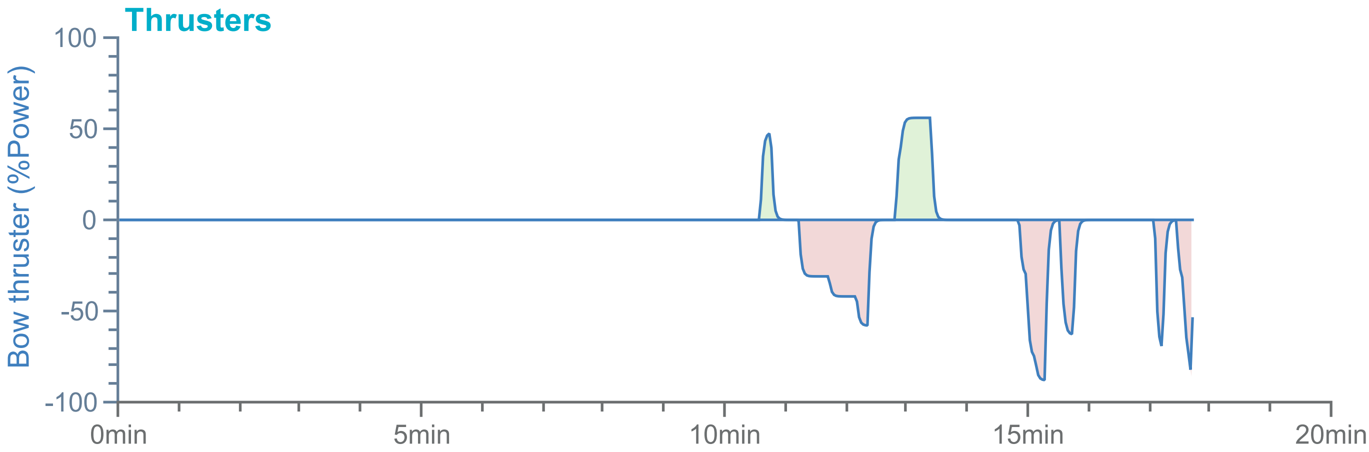
Propeller RPM



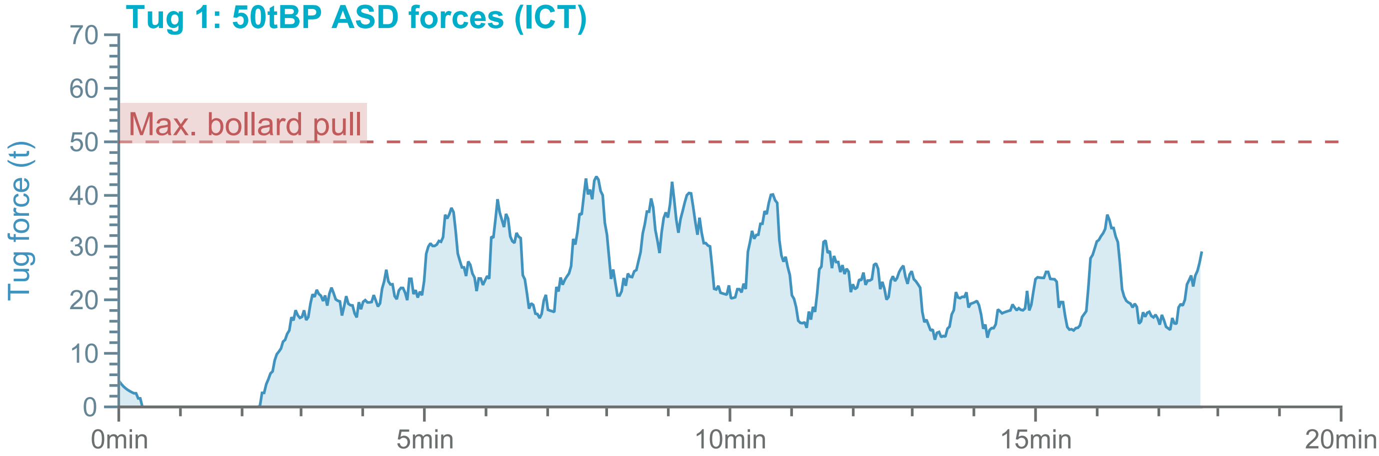
Rudder angle



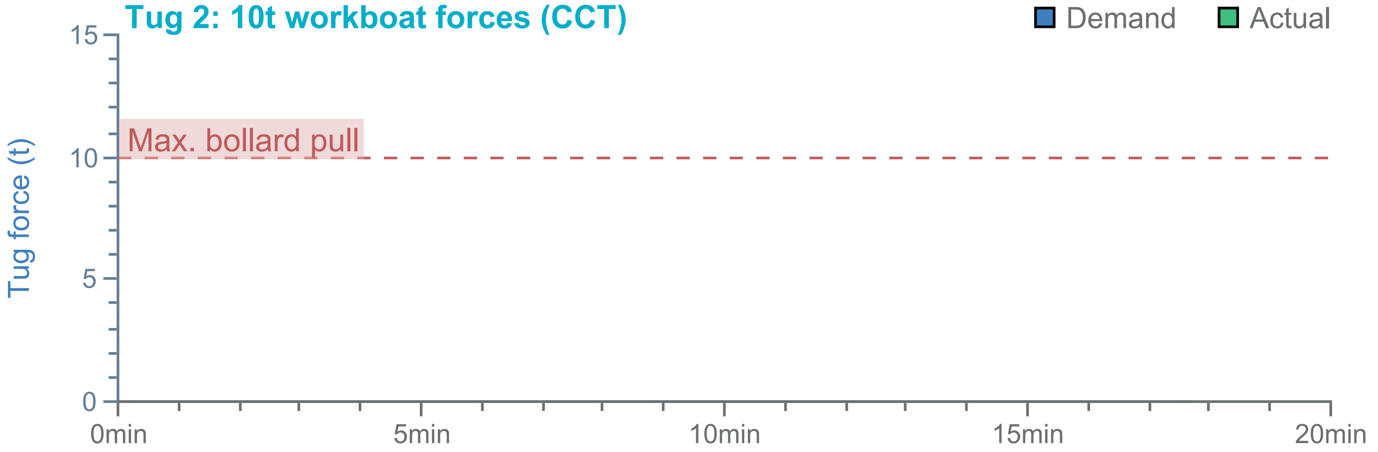
Thrusters



Tug 1: 50tBP ASD forces (ICT)

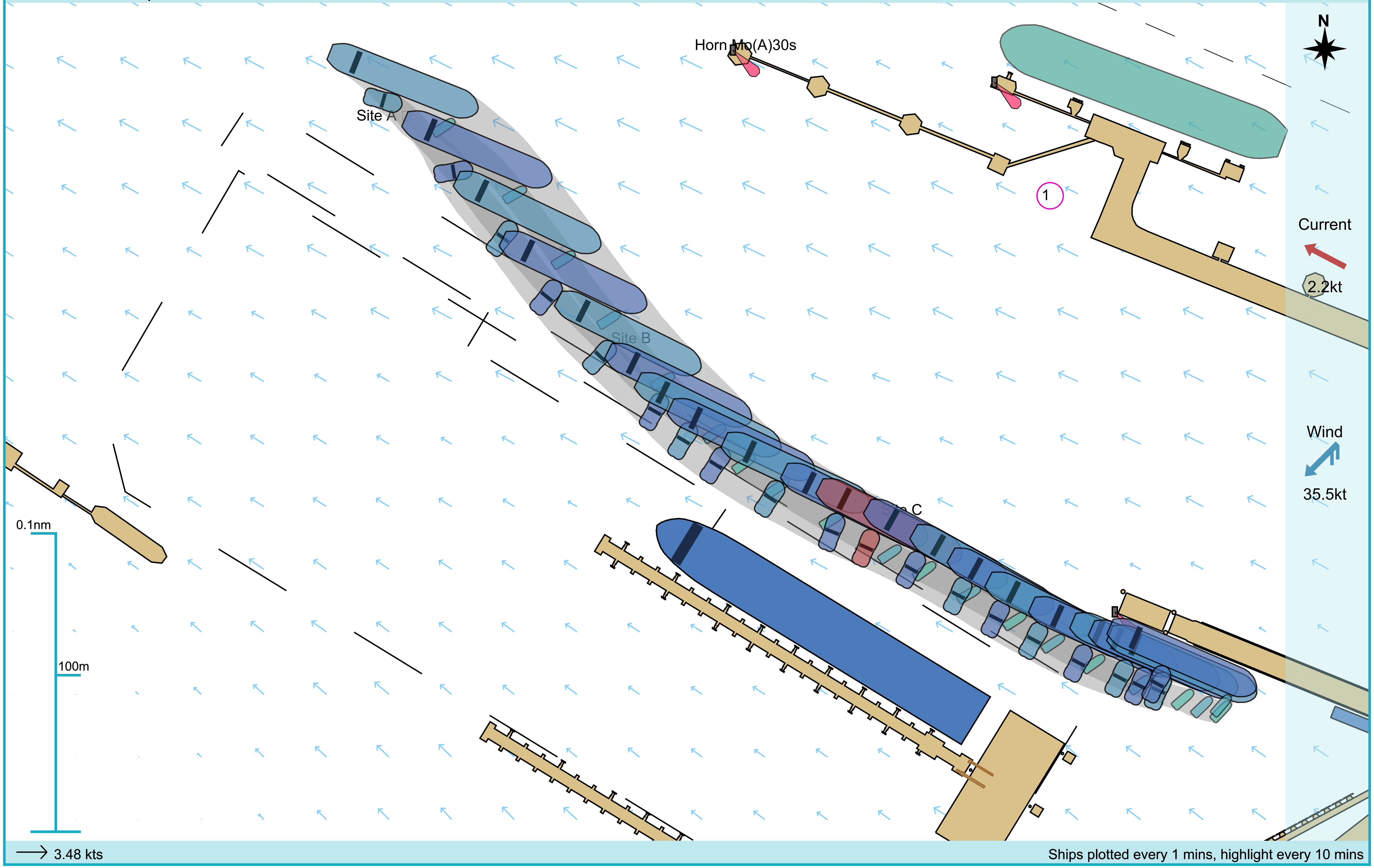


Tug 2: 10t workboat forces (CCT)



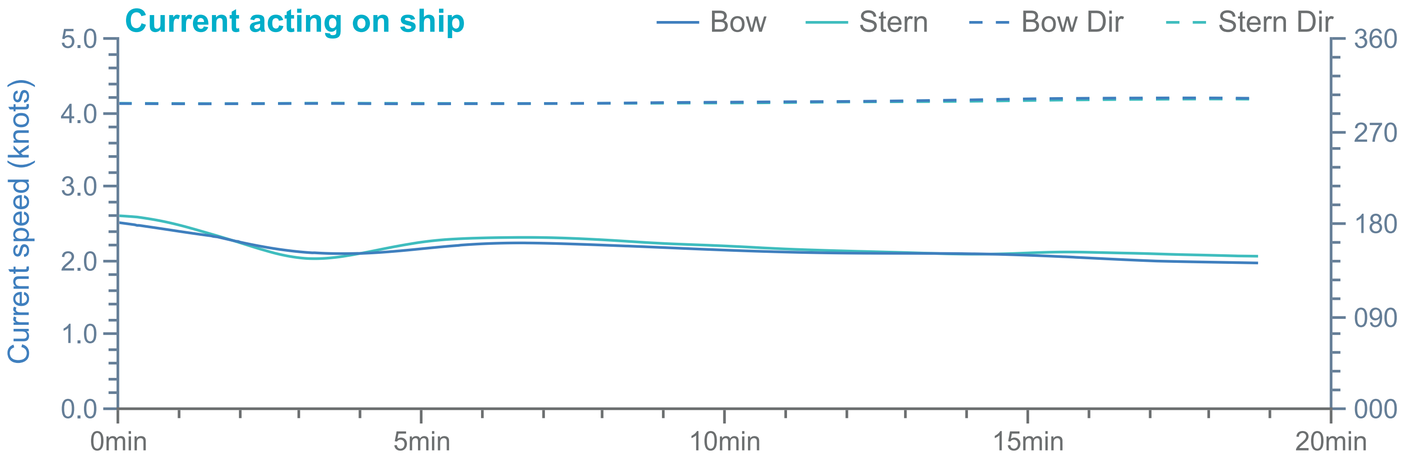
Overview | Environment | 100m x 18m Product Tanker | Tugs

Manoeuvre track plot

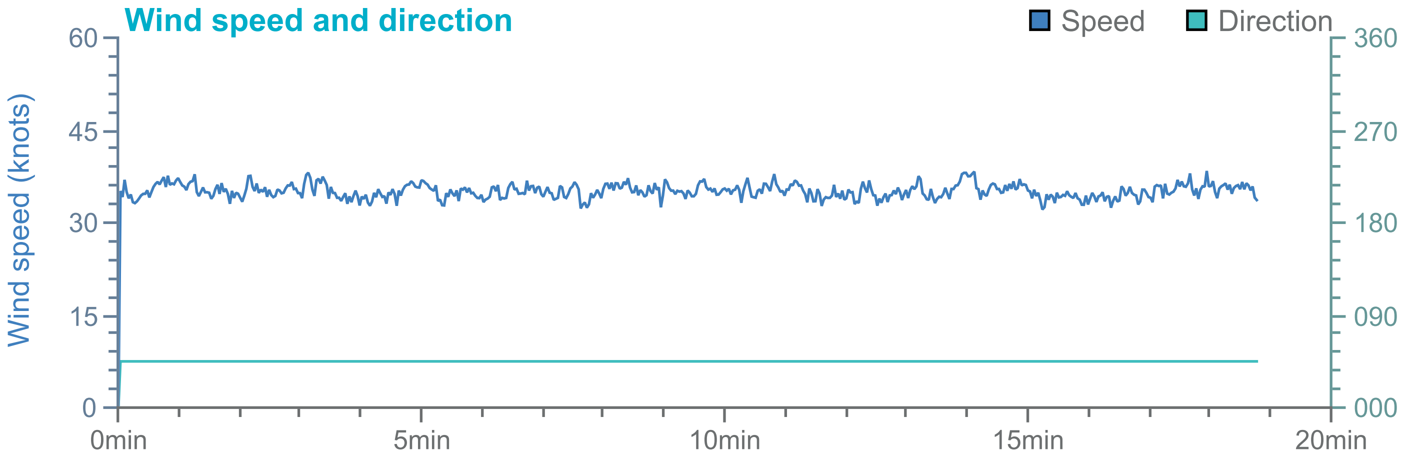


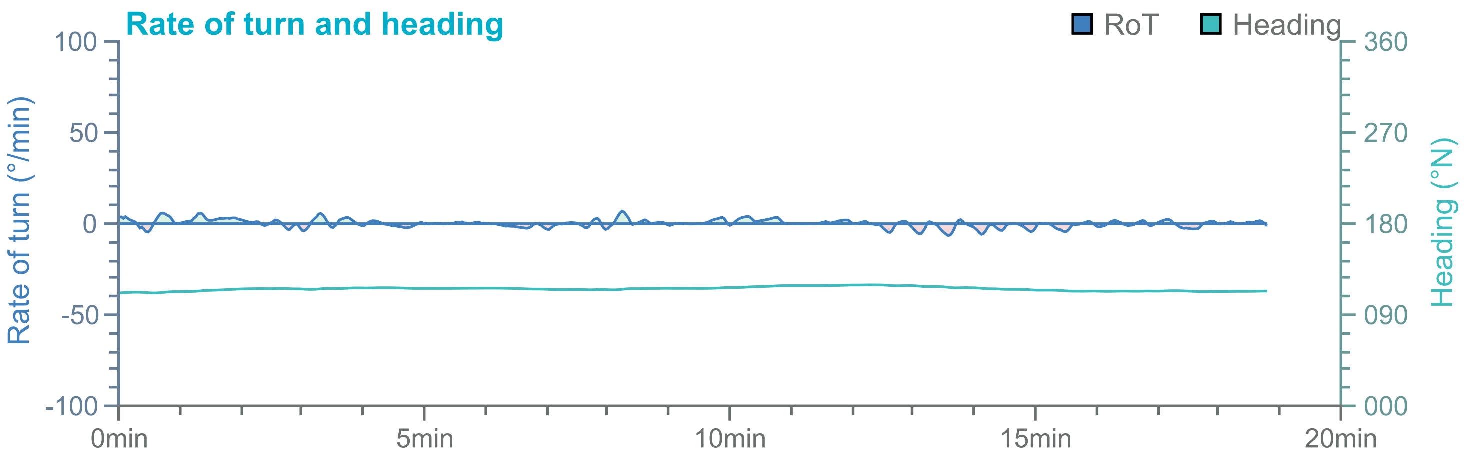
Ships plotted every 1 mins, highlight every 10 mins

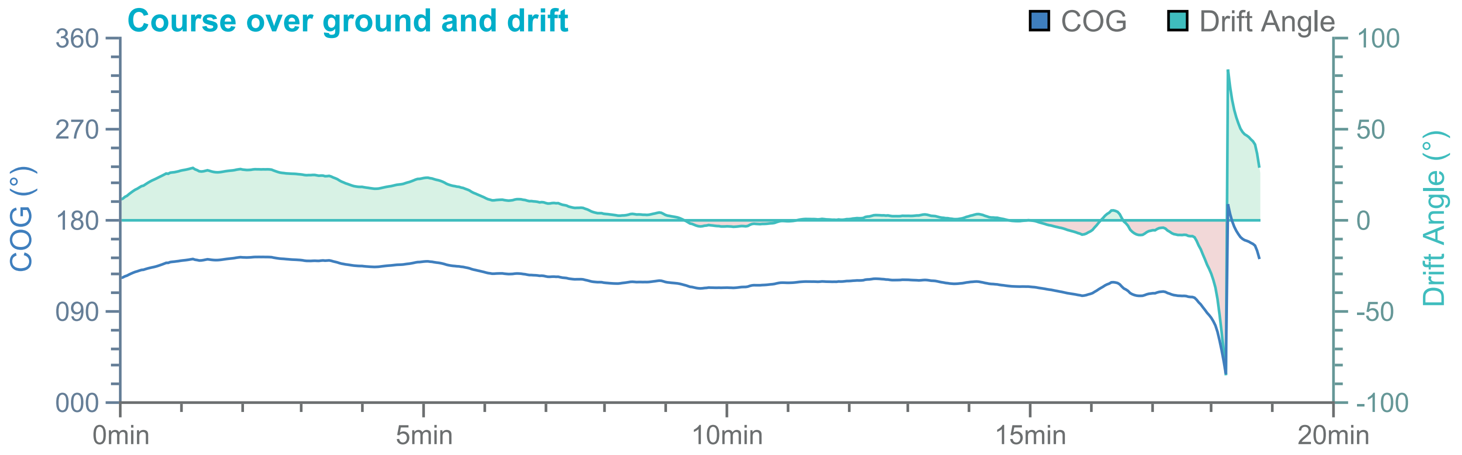
Current acting on ship

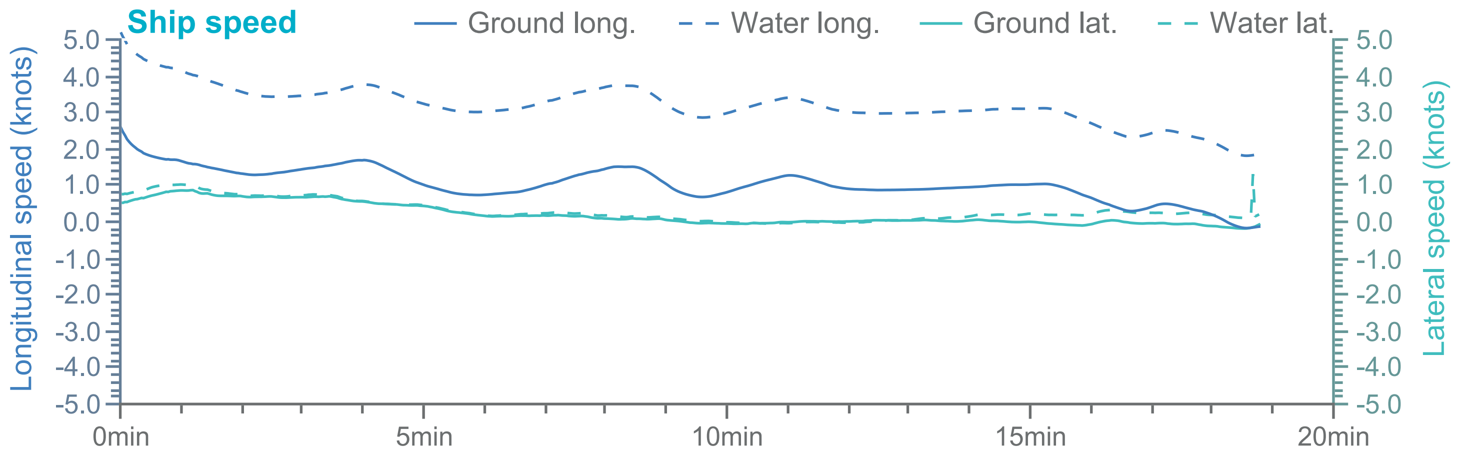


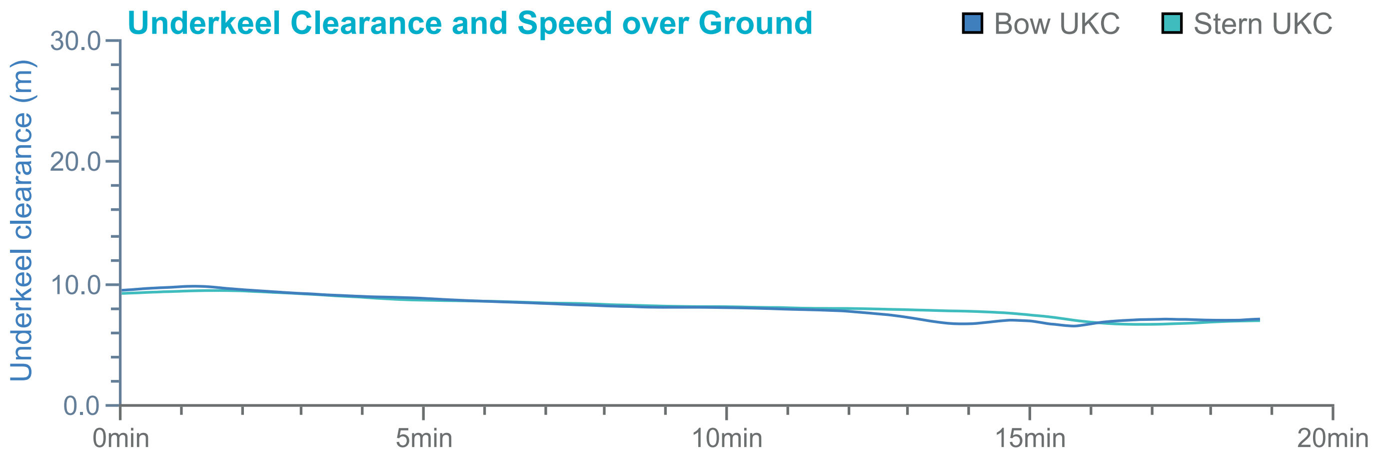
Wind speed and direction

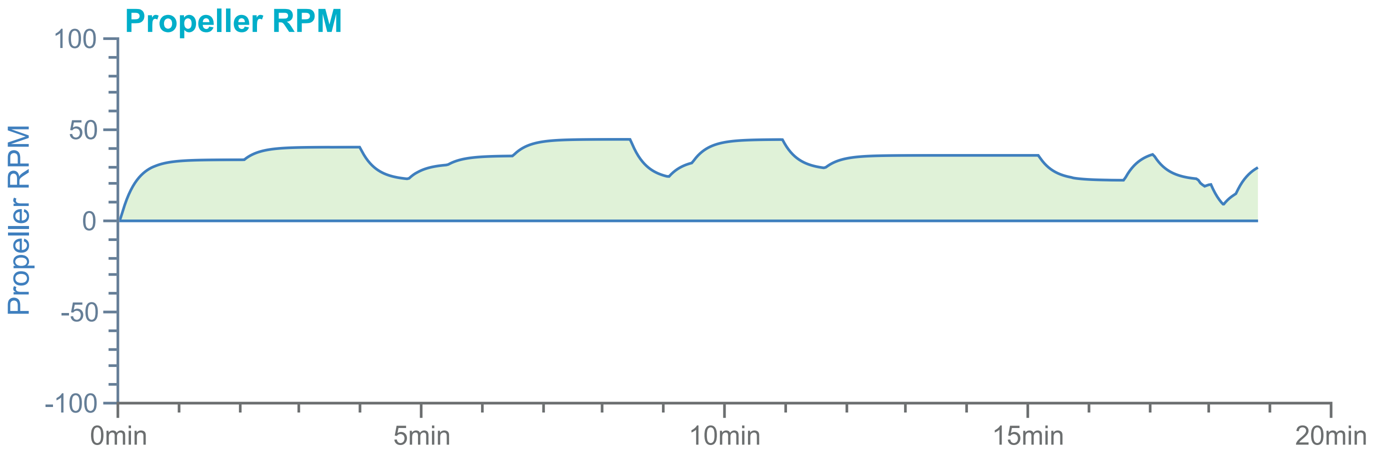


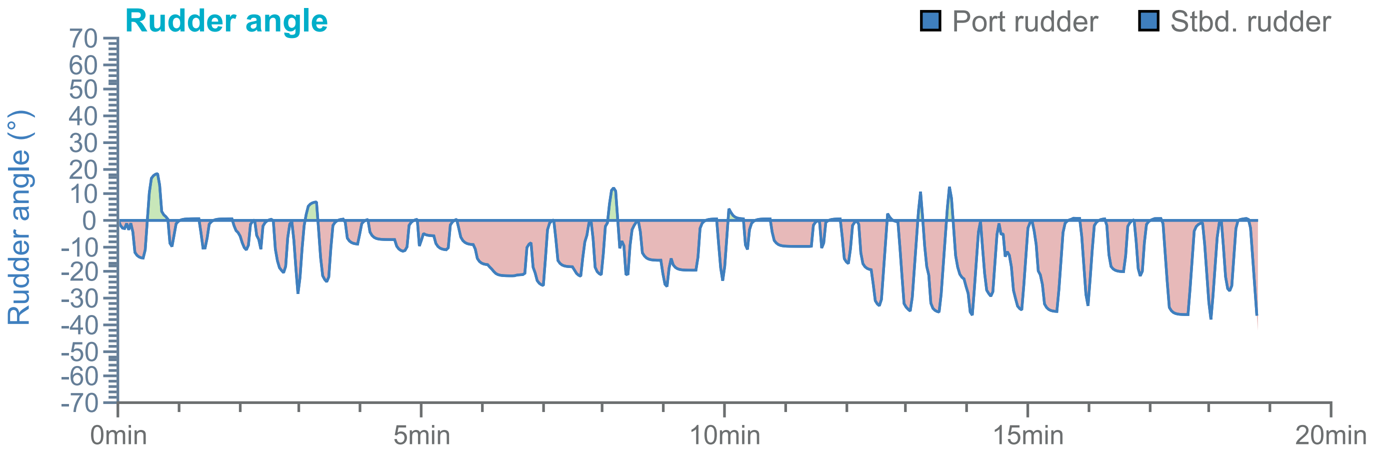

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
100
50
0
-50
-100
360
270
180
090
000
0min
5min
10min
15min
20min

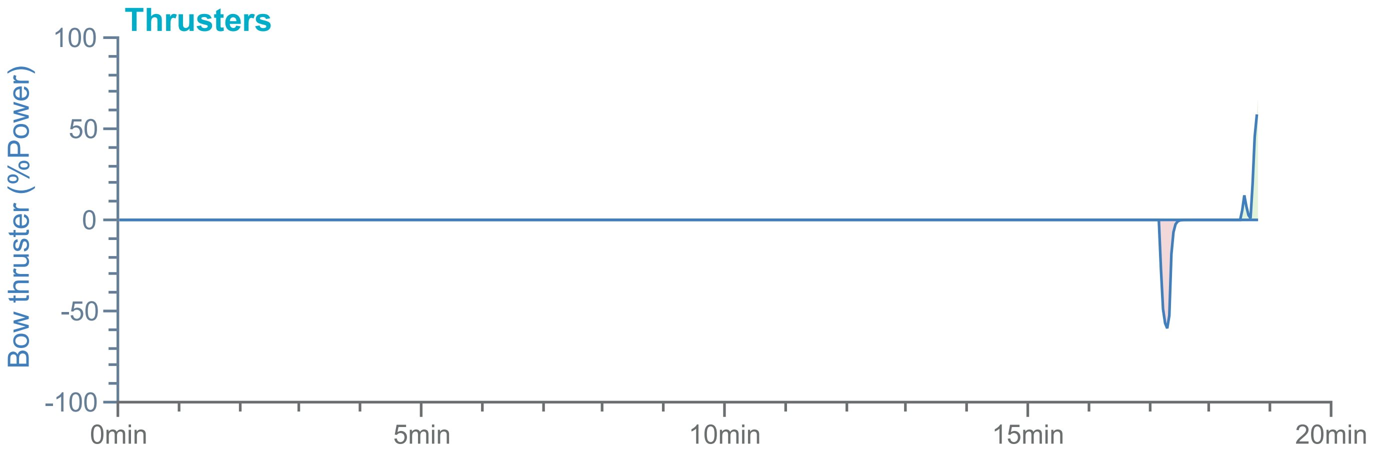

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min
20min

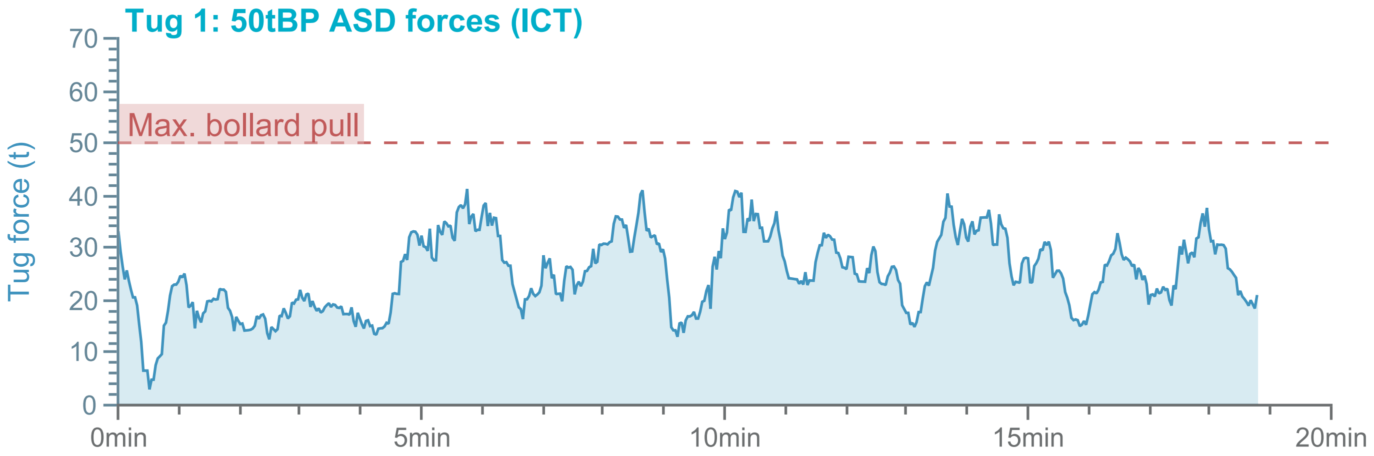

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min

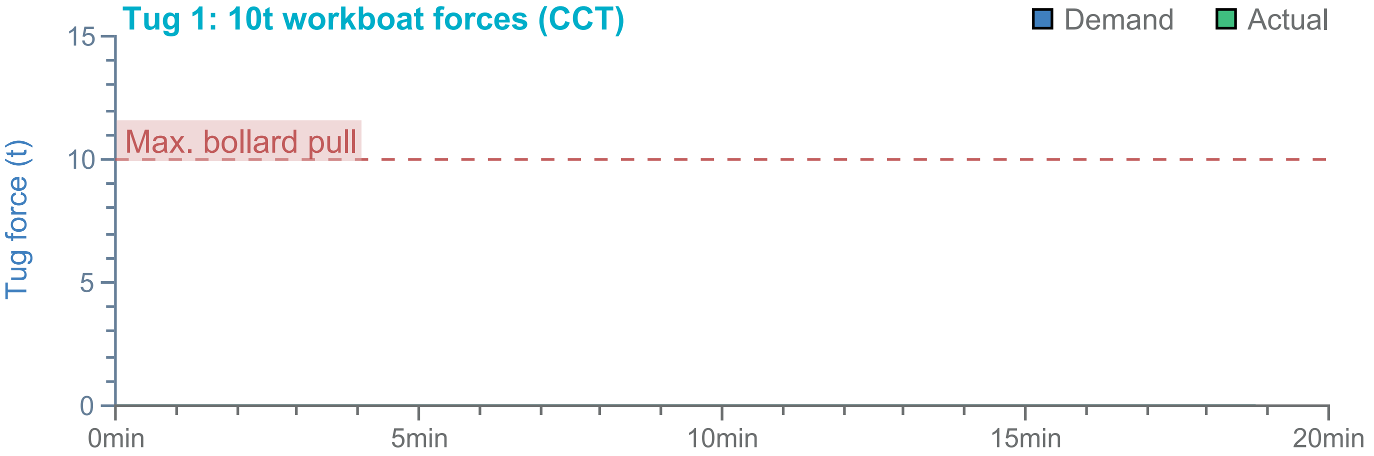

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min
20min


Propeller RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min
20min

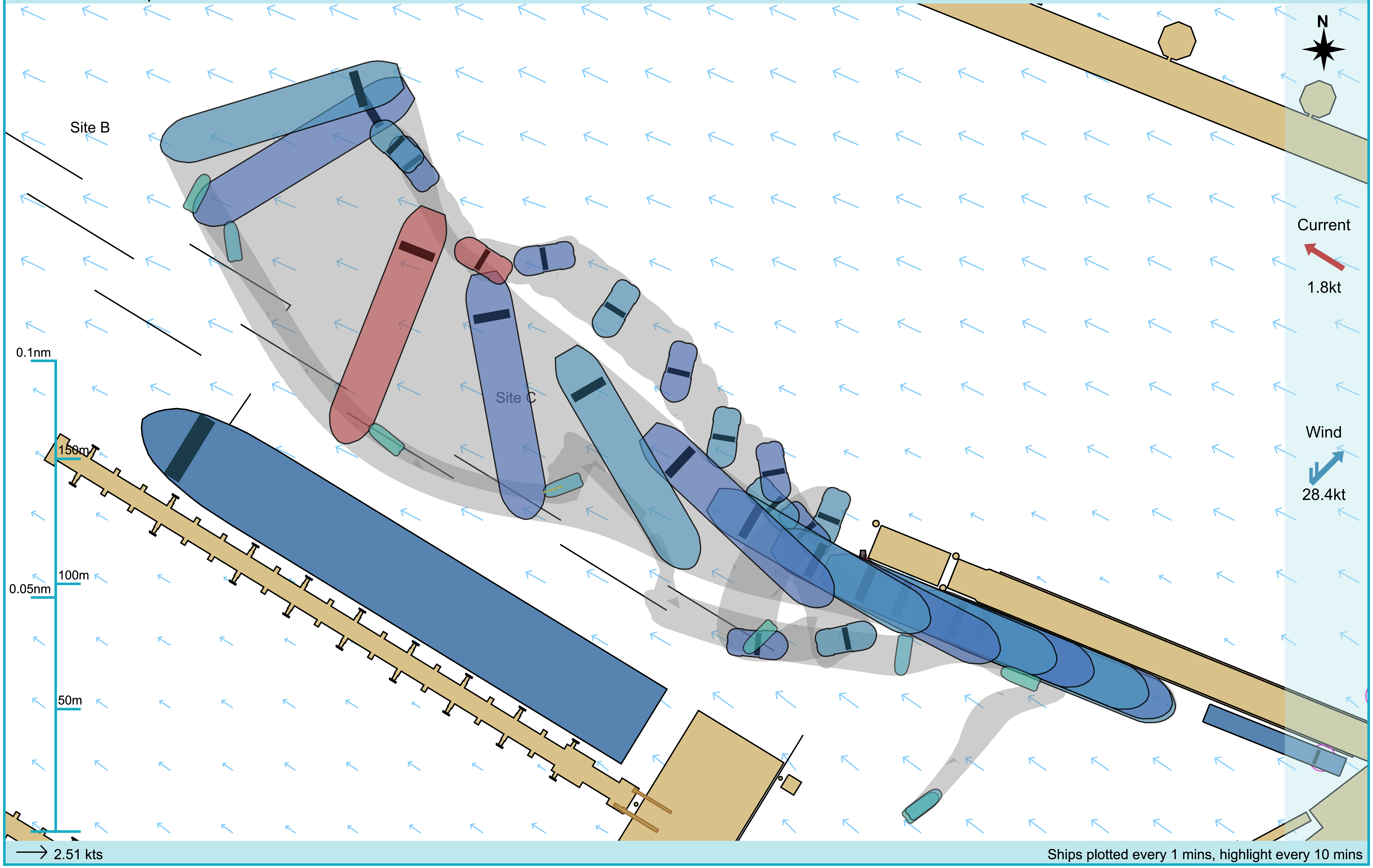

Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min
20min


Thrusters
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min
20min

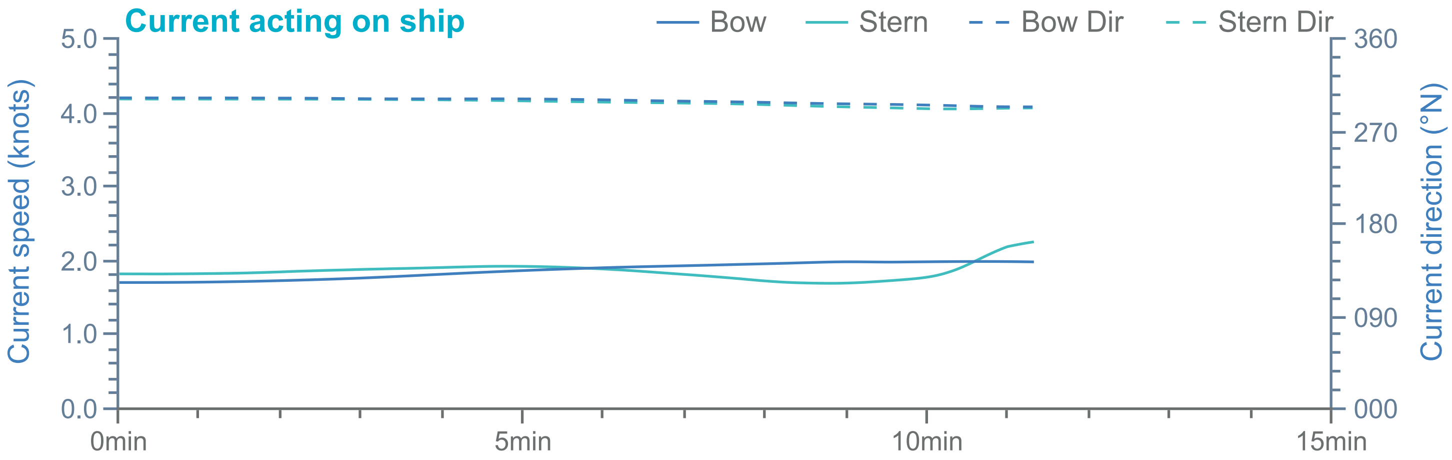

Tug 1: 50tBP ASD forces (ICT)
Max. bollard pull
Tug force (t)
0
10
20
30
40
50
60
70
0min
5min
10min
15min
20min

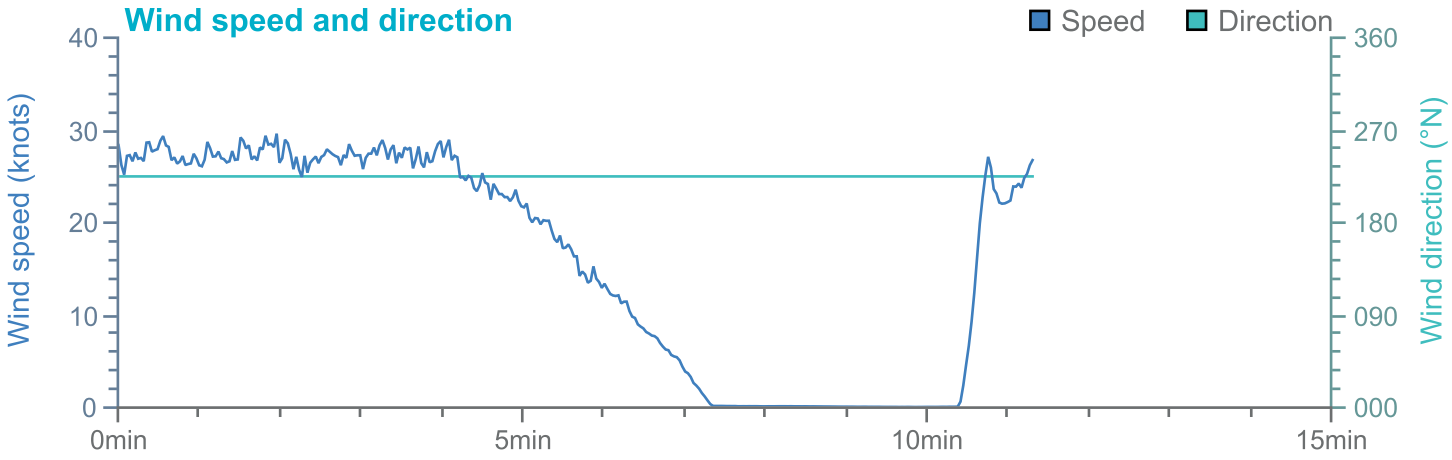

Tug 1: 10t workboat forces (CCT)
Demand
Actual
Max. bollard pull
Tug force (t)
0
5
10
15
0min
5min
10min
15min
20min

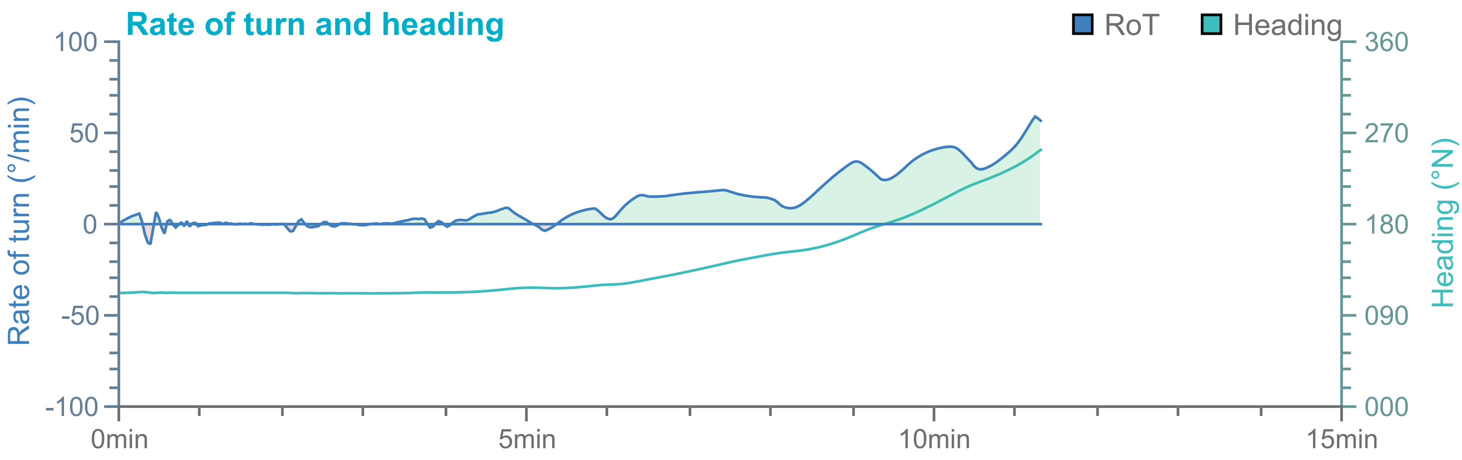
Manoeuvre track plot

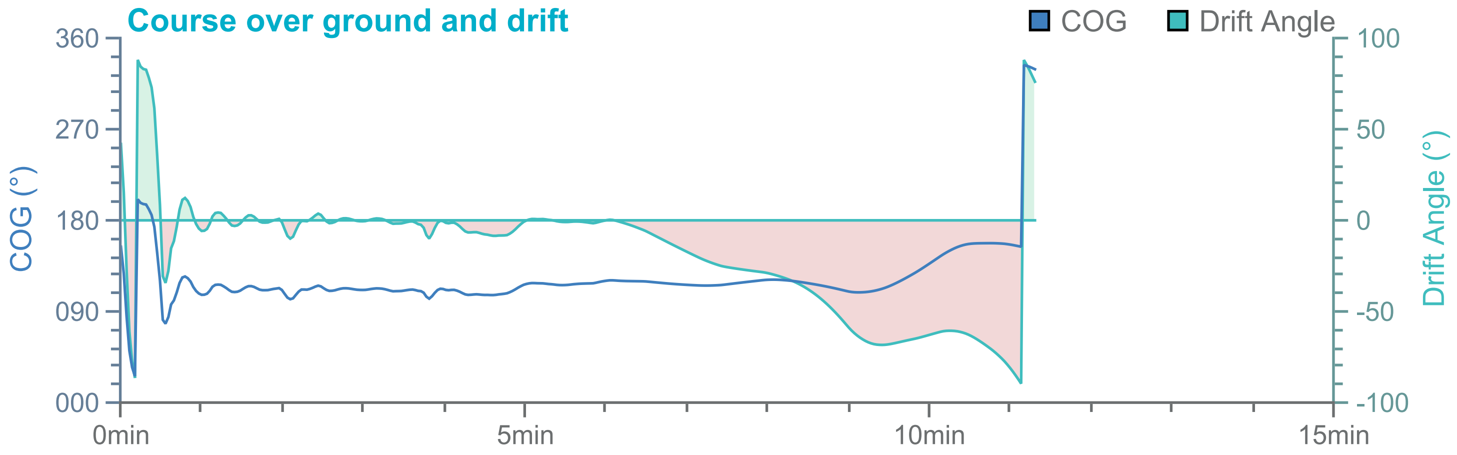


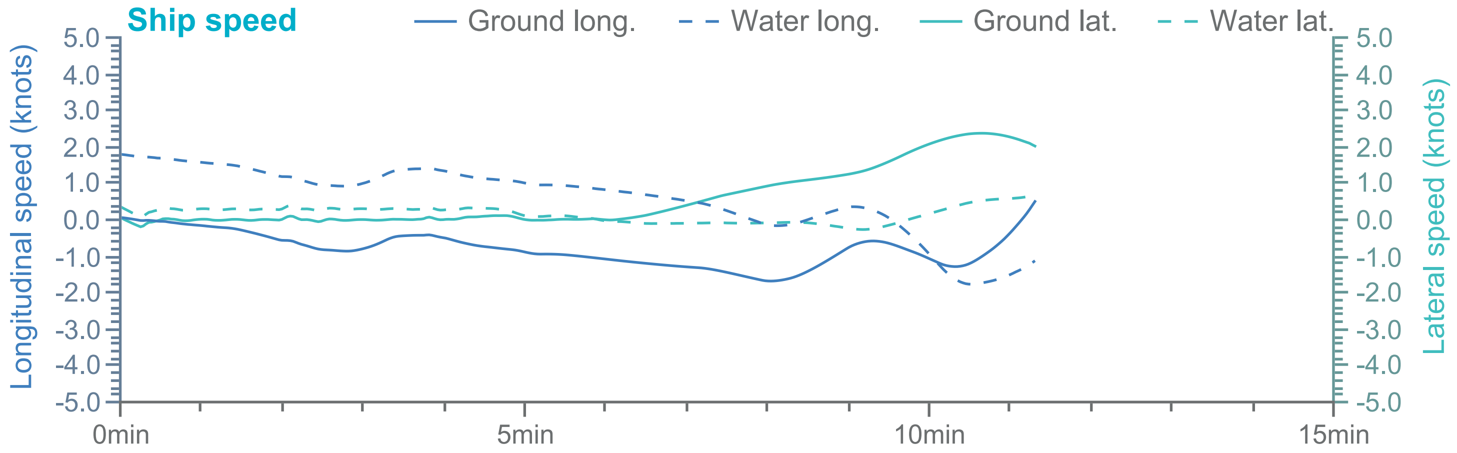
Ships plotted every 1 mins, highlight every 10 mins

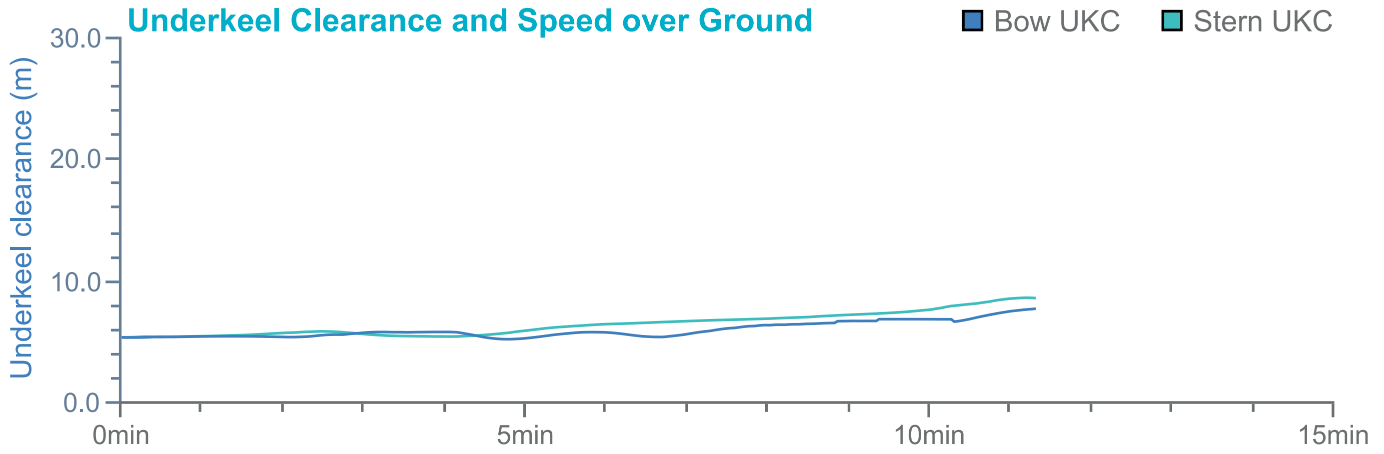

Current acting on ship
Bow
Stern
Bow Dir
Stern Dir
Current speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
Current direction (°N)
360
270
180
090
000
0min
5min
10min
15min

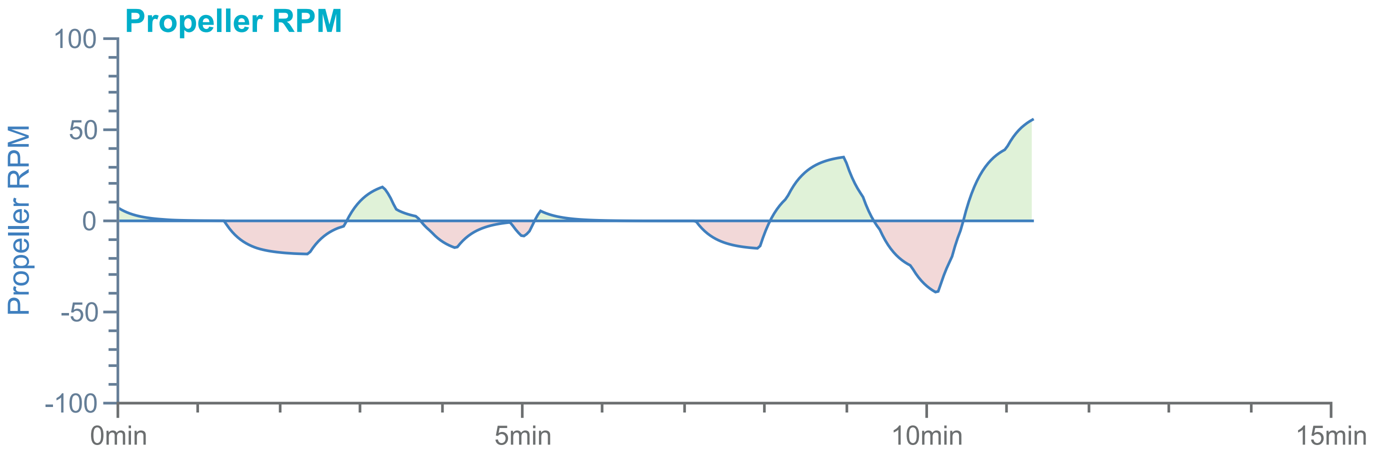

Wind speed and direction
Speed
Direction
Wind speed (knots)
40
30
20
10
0
Wind direction (°N)
360
270
180
090
000
0min
5min
10min
15min

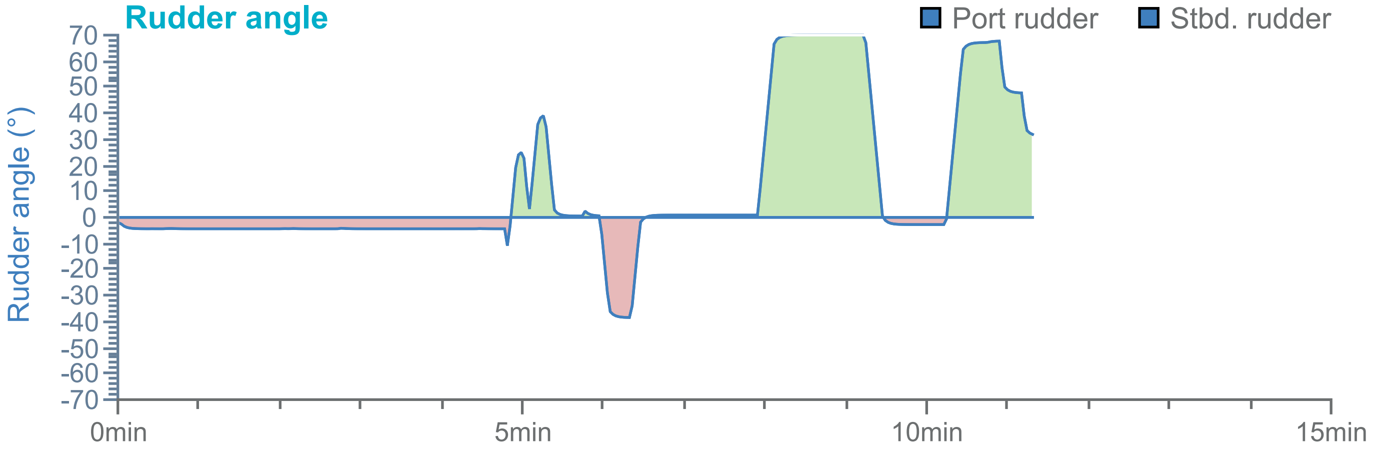

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
Heading (°N)
100
50
0
-50
-100
360
270
180
090
000
0min
5min
10min
15min

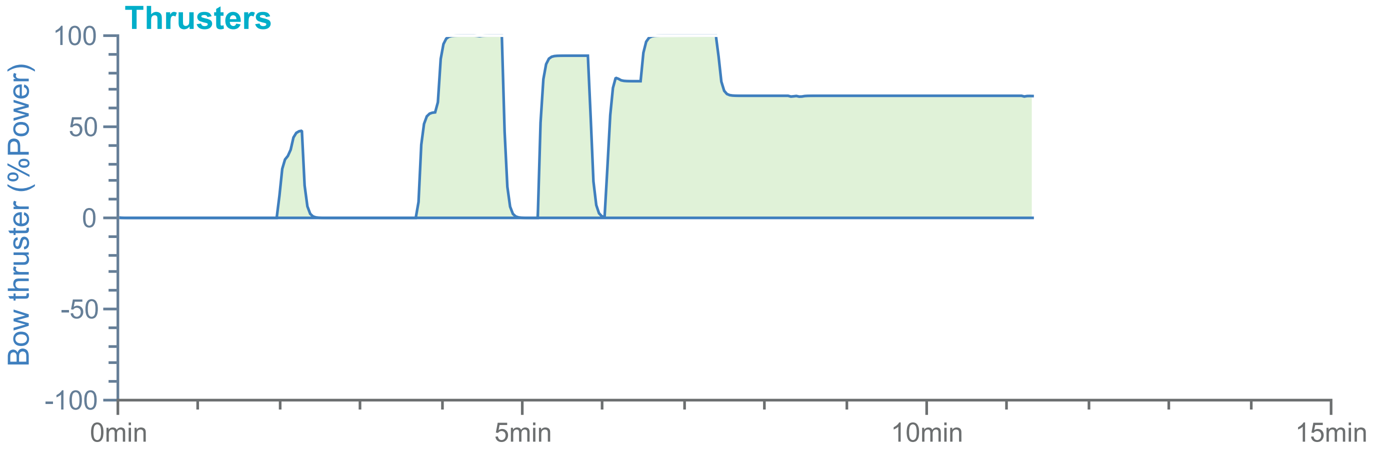

Course over ground and drift
COG
Drift Angle
COG (°)
Drift Angle (°)
360
270
180
090
000
100
50
0
-50
-100
0min
5min
10min
15min

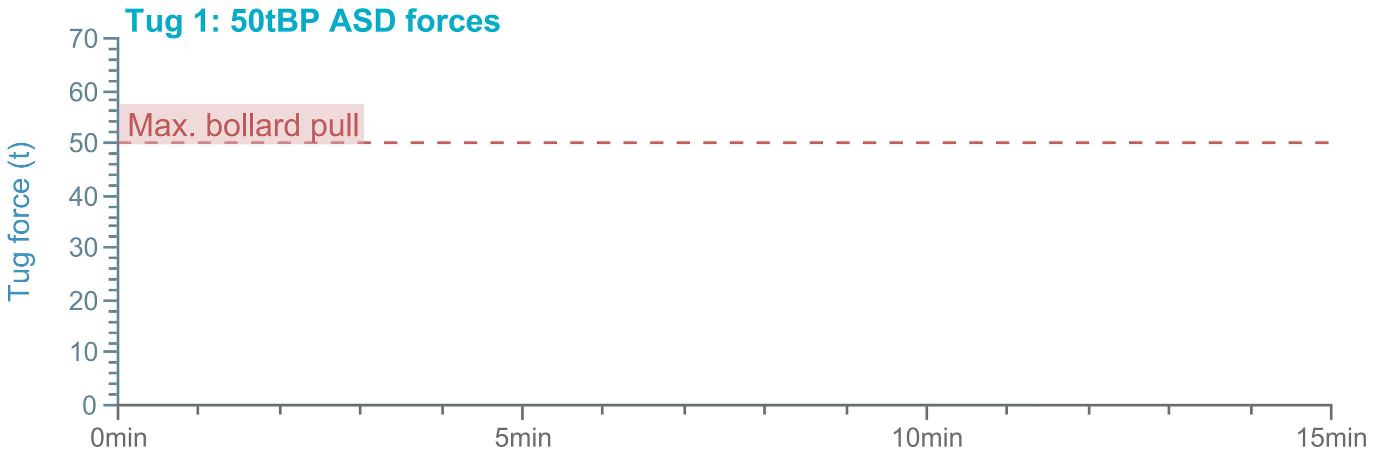

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min

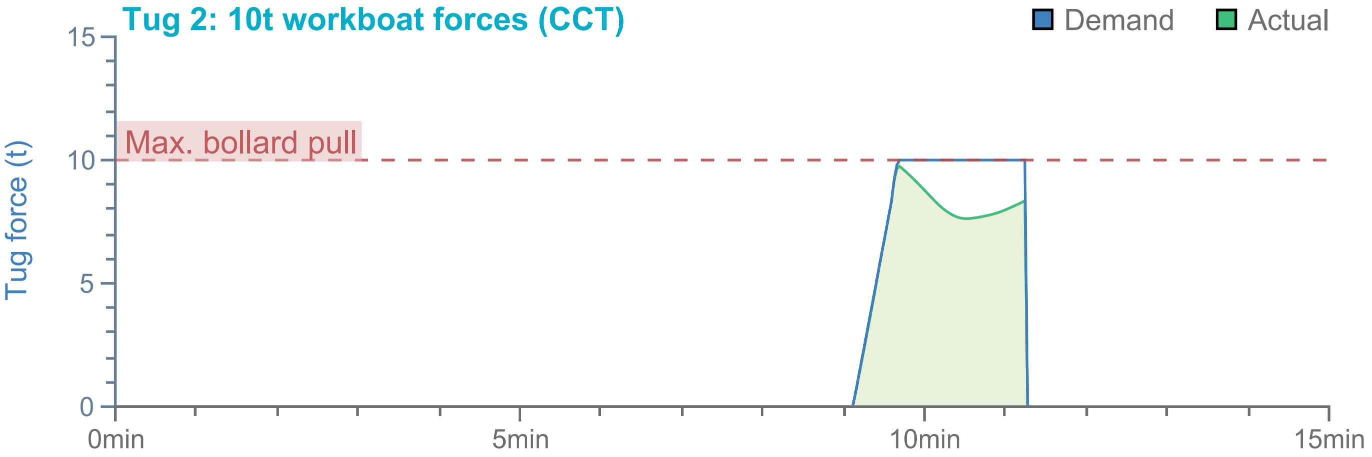

Underkeel Clearance and Speed over Ground
Bow UKC
Stern UKC
Underkeel clearance (m)
30.0
20.0
10.0
0.0
0min
5min
10min
15min


Propeller RPM
Propeller RPM
100
50
0
-50
-100
0min
5min
10min
15min

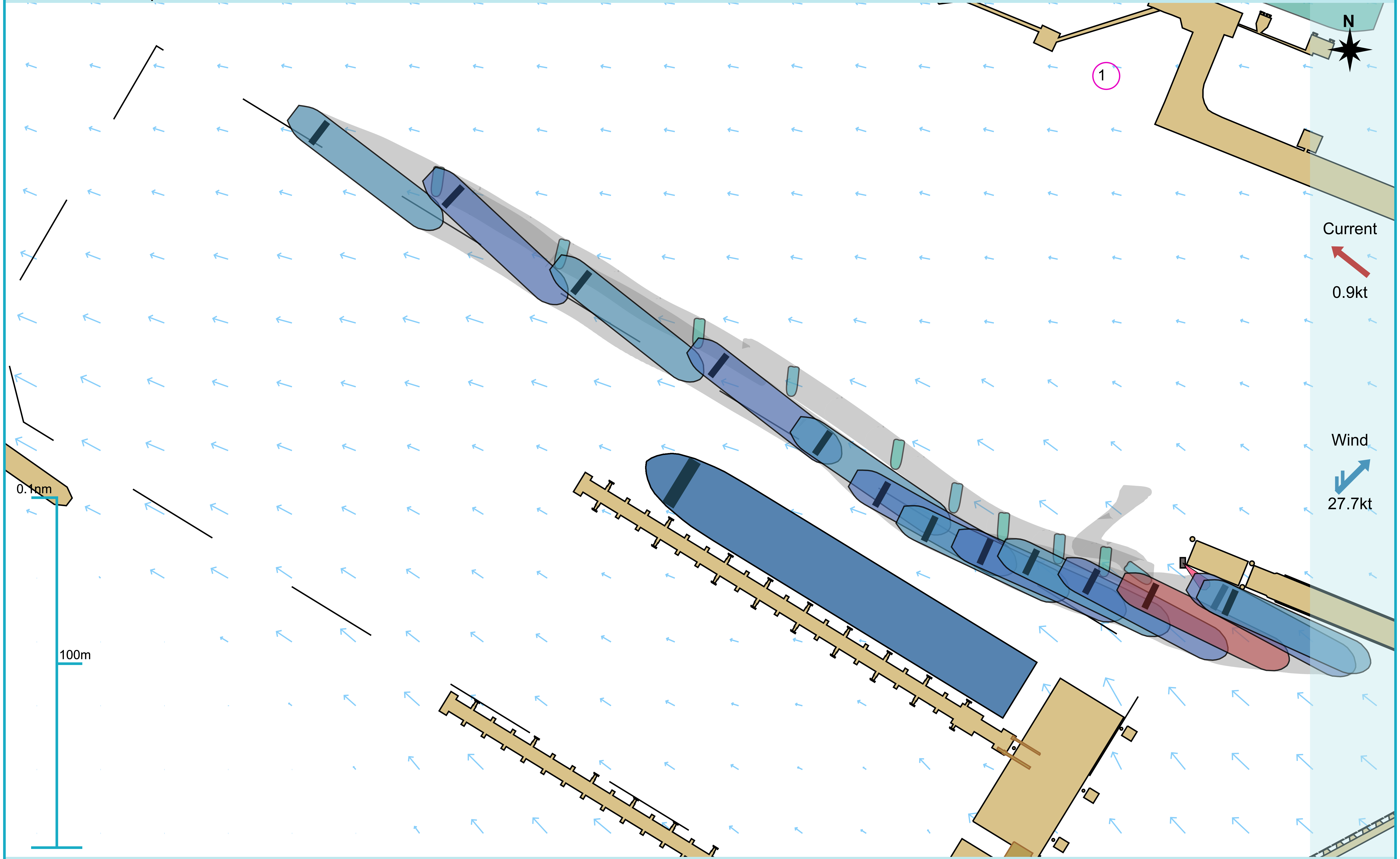

Rudder angle
Port rudder
Stbd. rudder
Rudder angle (°)
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0min
5min
10min
15min


Thrusters
Bow thruster (%Power)
100
50
0
-50
-100
0min
5min
10min
15min


Tug 1: 50tBP ASD forces
Tug force (t)
70
60
50
40
30
20
10
0
Max. bollard pull
0min
5min
10min
15min


Tug 2: 10t workboat forces (CCT)
🟦 Demand
🟩 Actual
Tug force (t)
15
10
5
0
Max. bollard pull
0min
5min
10min
15min

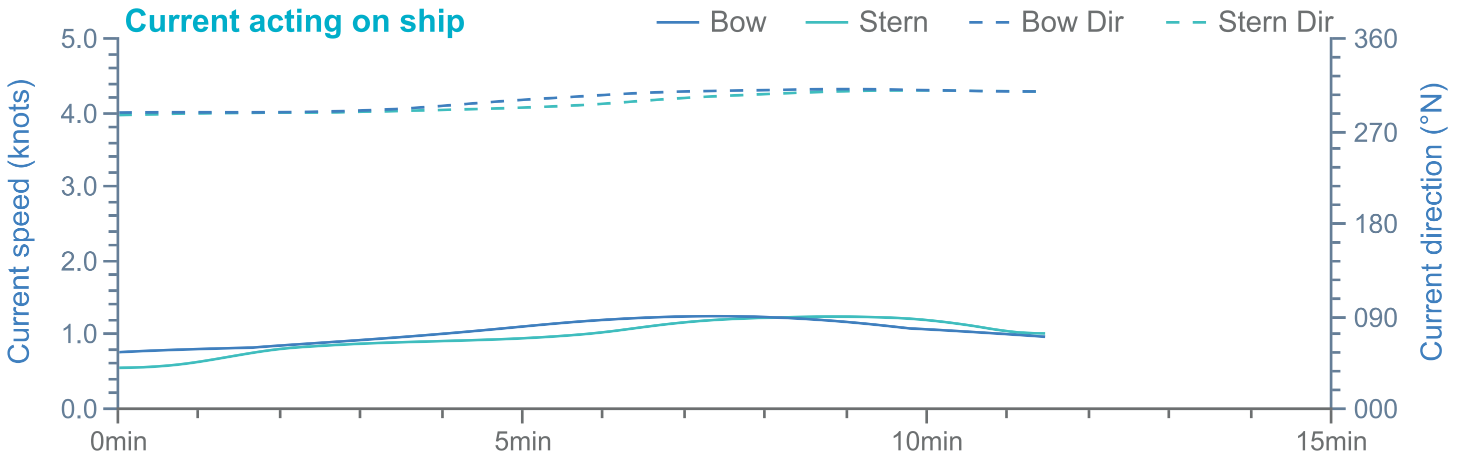
Manoeuvre track plot



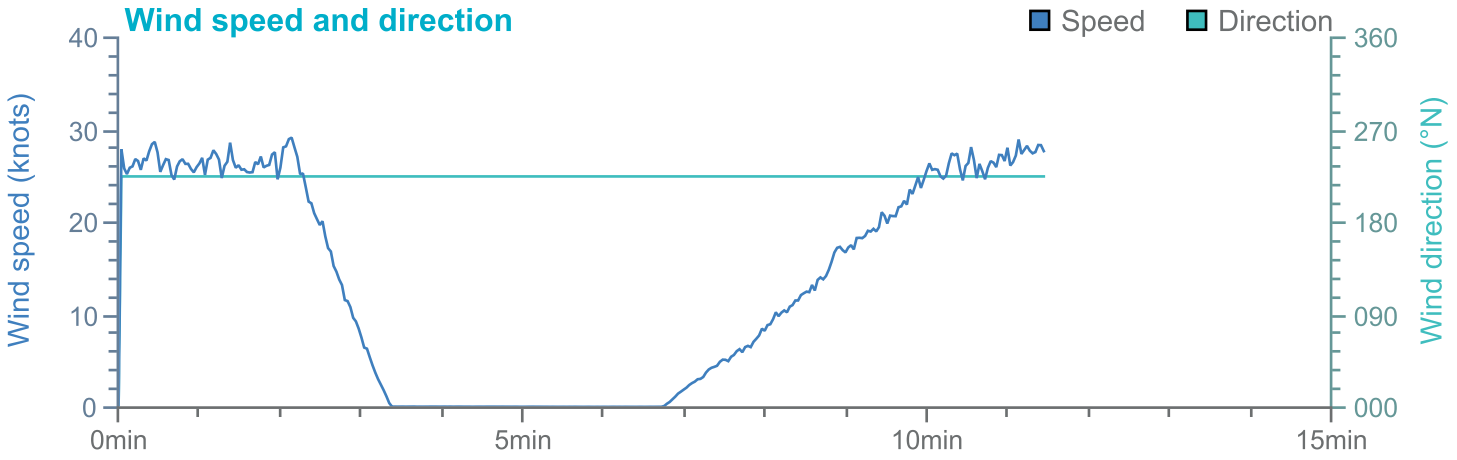
1.58 kts

Ships plotted every 1 mins, highlight every 10 mins

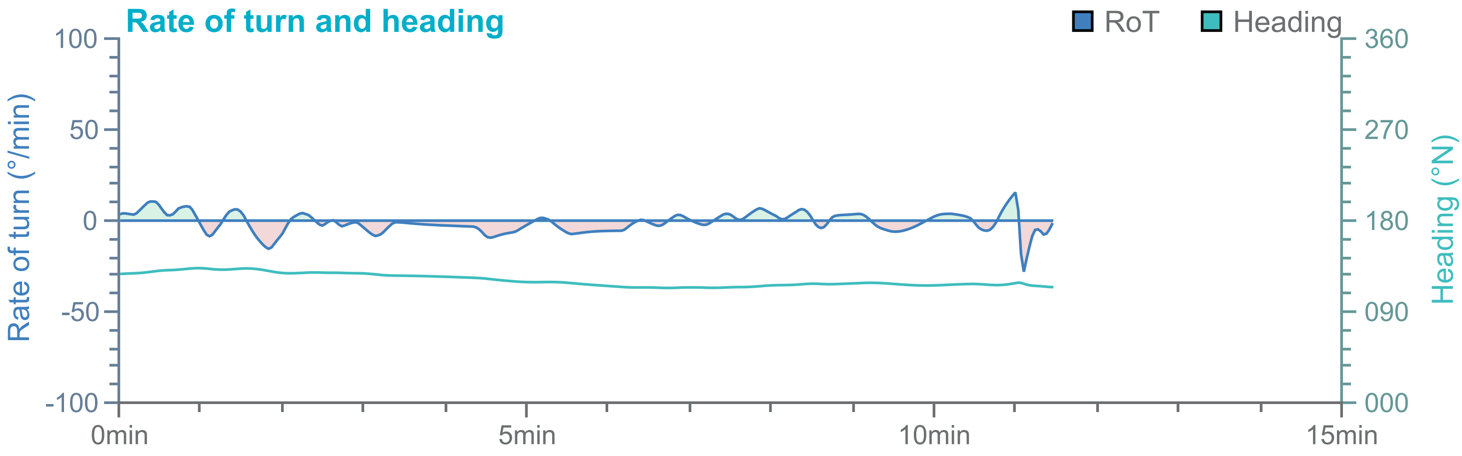
Current acting on ship



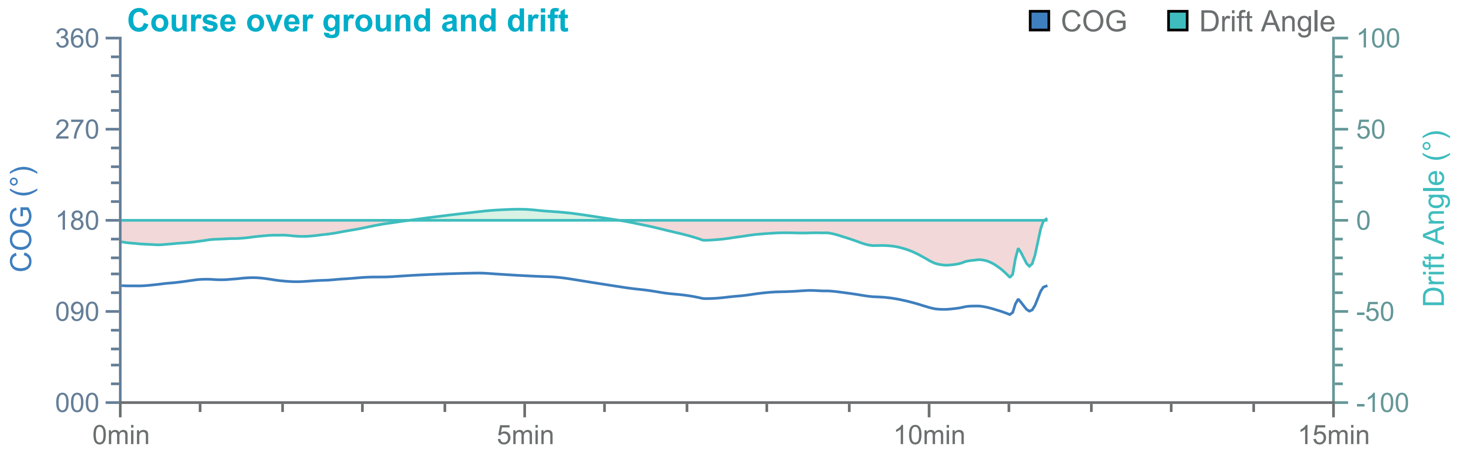
Wind speed and direction



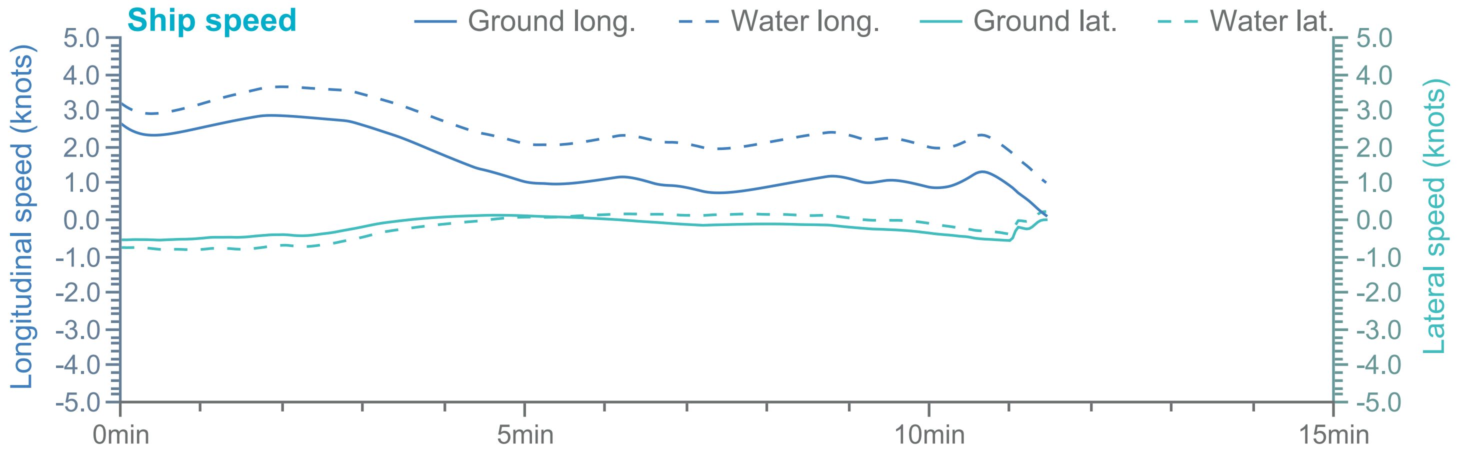
Rate of turn and heading



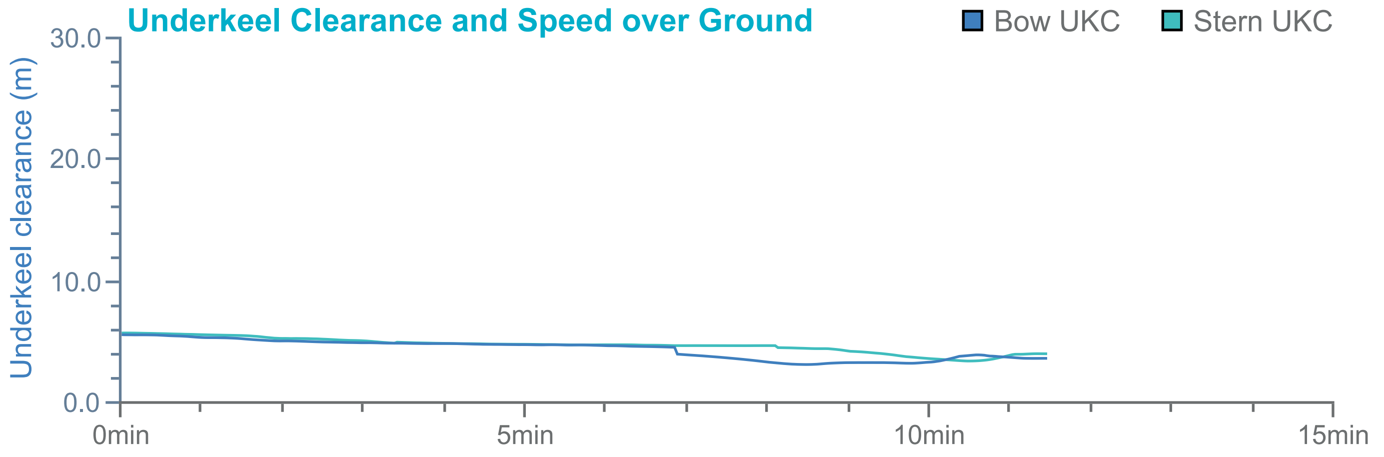
Course over ground and drift



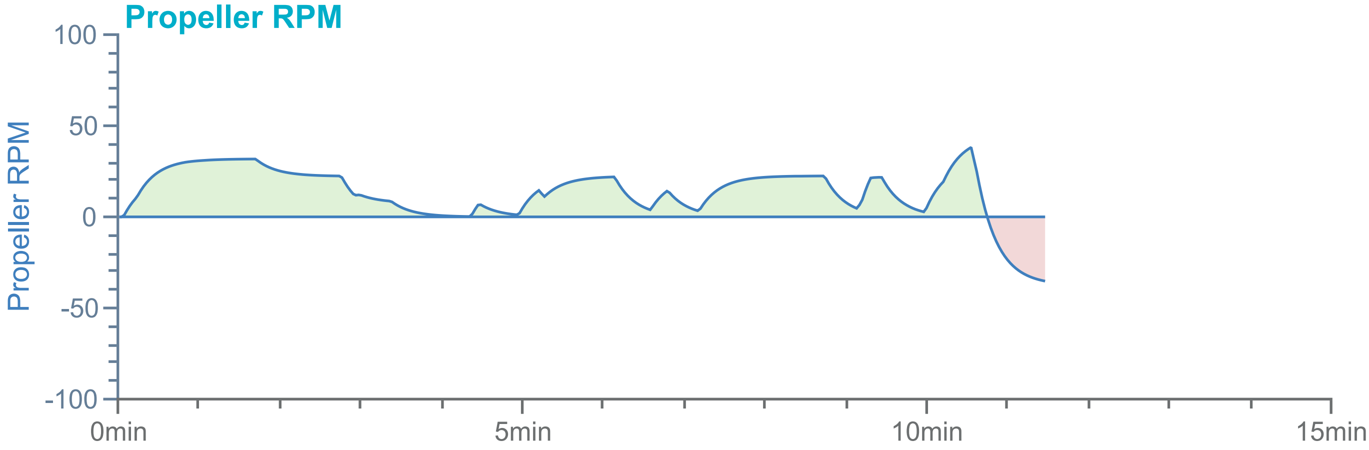
Ship speed



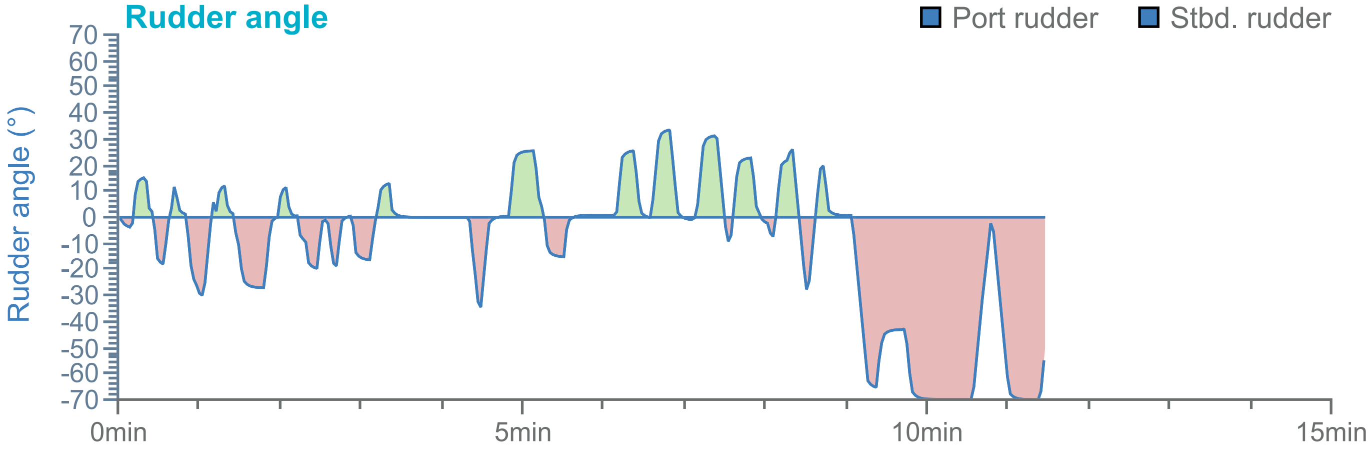
Underkeel Clearance and Speed over Ground



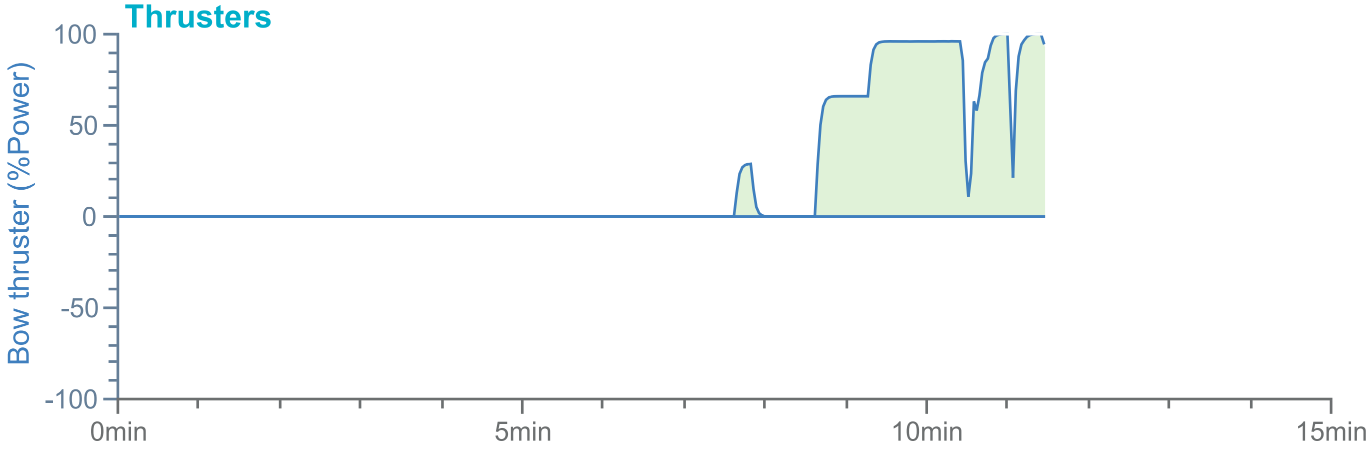
Propeller RPM



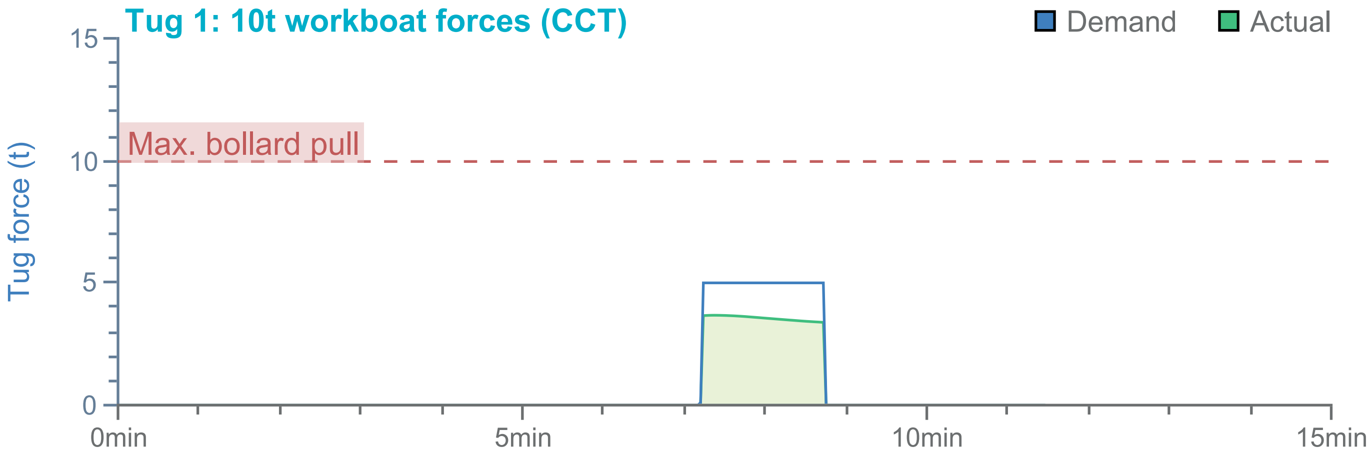
Rudder angle



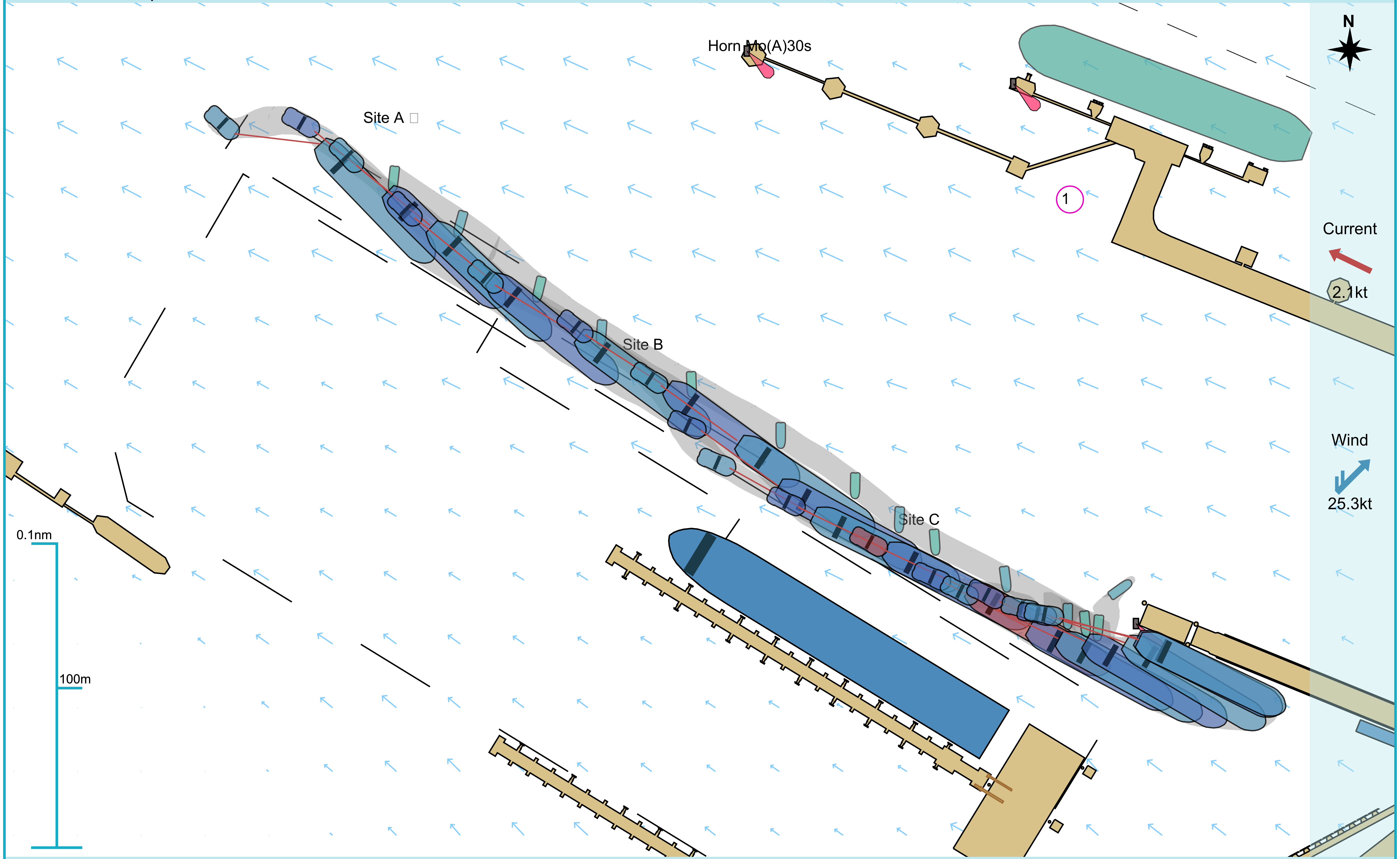
Thrusters



Tug 1: 10t workboat forces (CCT)



Manoeuvre track plot



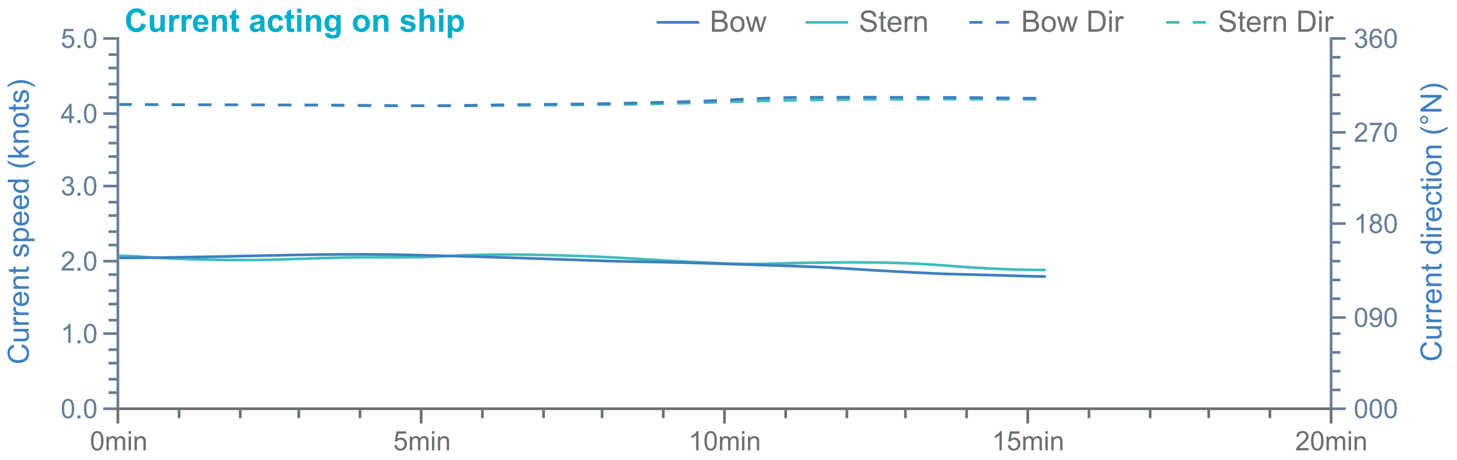
→ 3.08 kts

Ships plotted every 1 mins, highlight every 10 mins

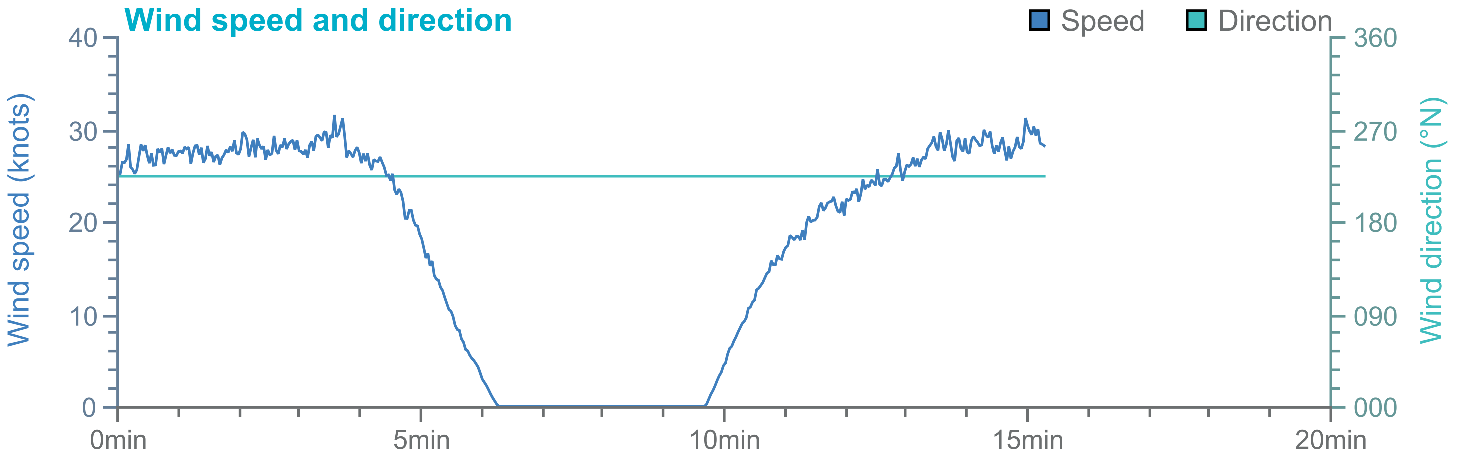
Pilot: JMS
Manoeuvre: Other

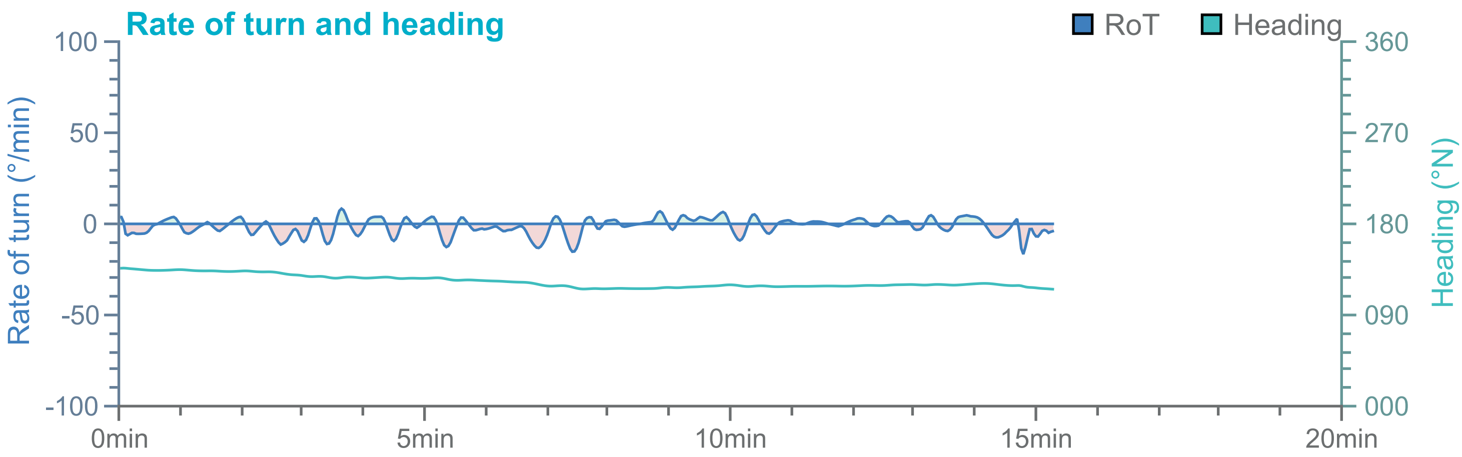
Ship: 100m x 18m Product Tanker

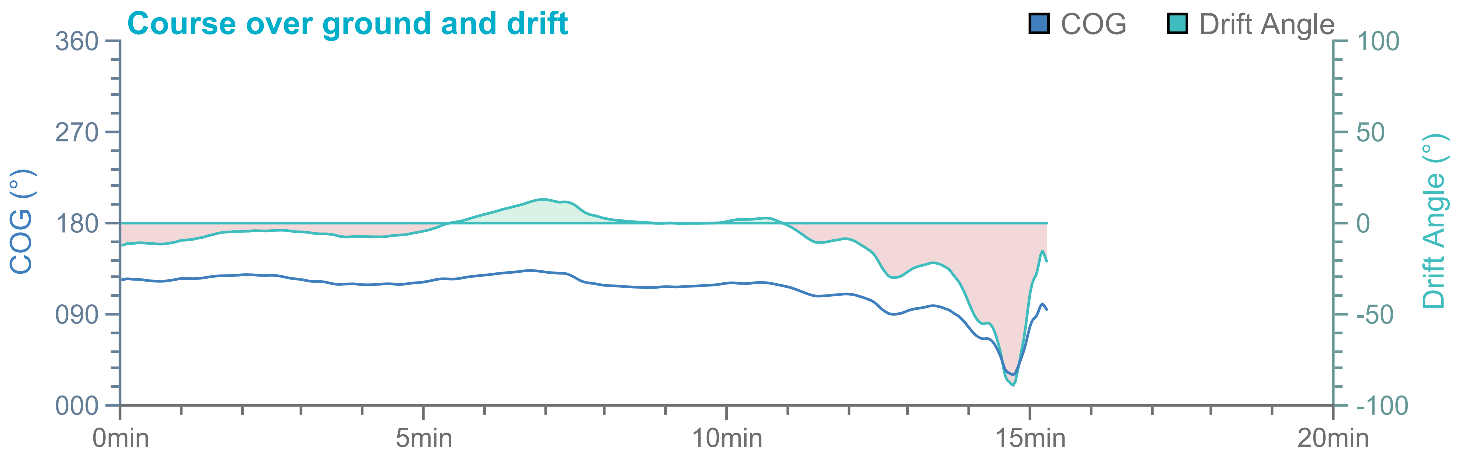
Current acting on ship

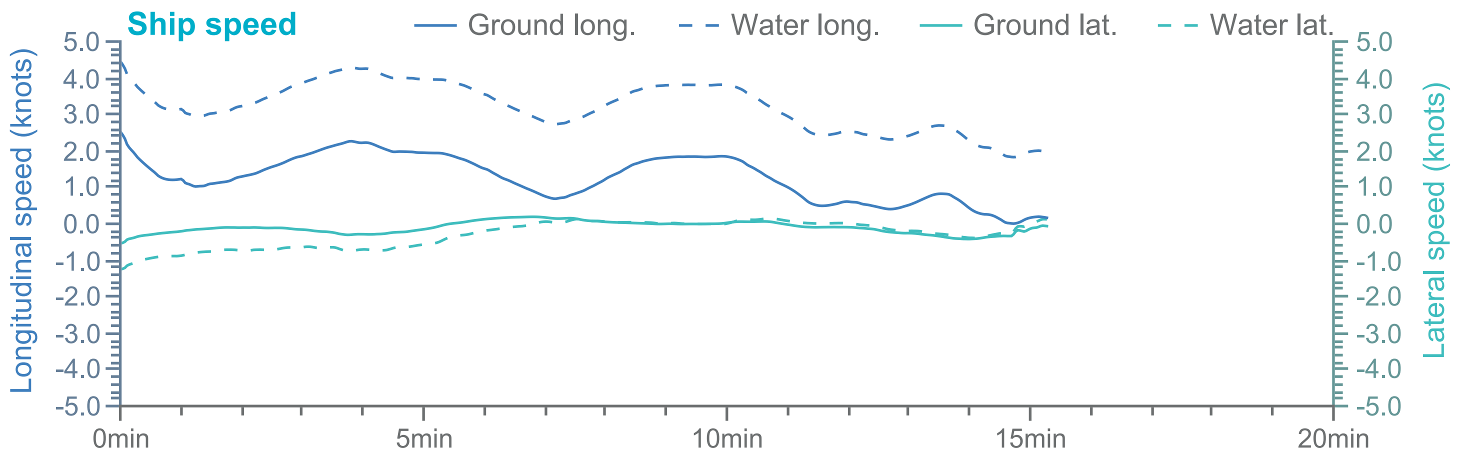


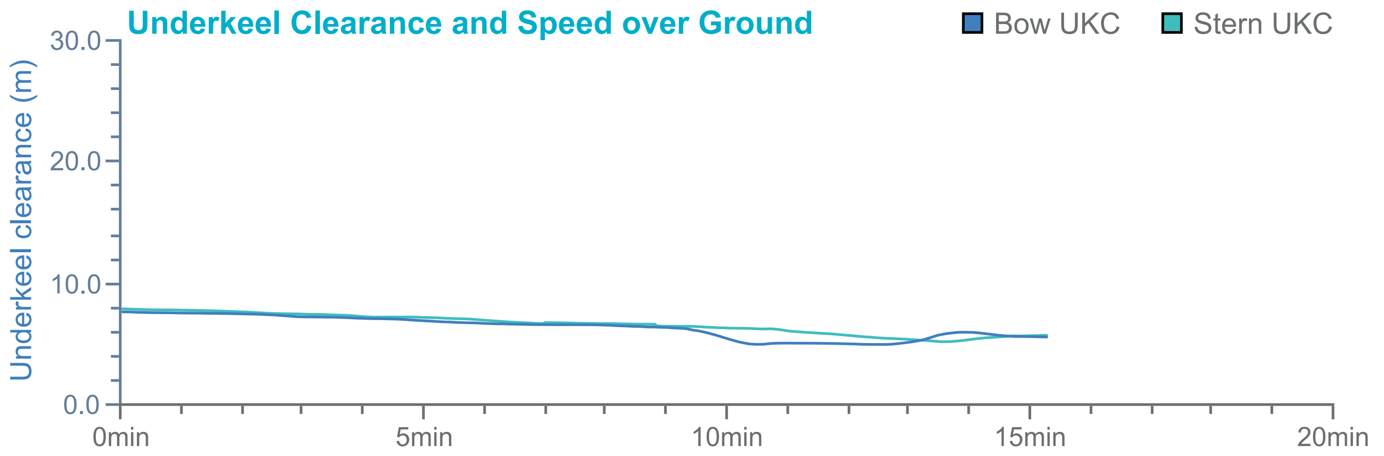
Wind speed and direction



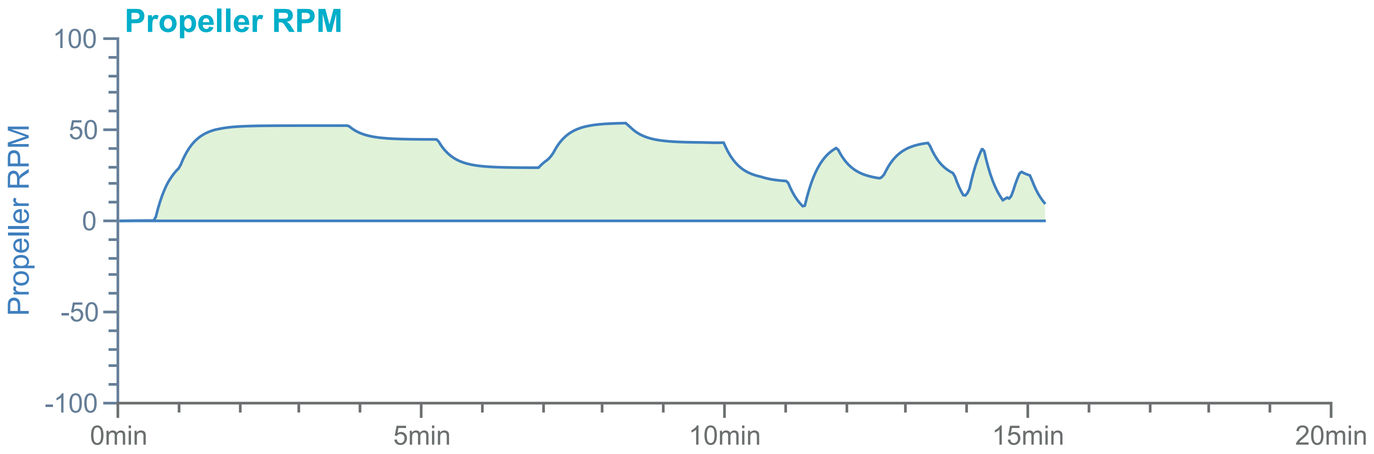

Rate of turn and heading
RoT
Heading
Rate of turn (°/min)
100
50
0
-50
-100
Heading (°N)
360
270
180
090
000
0min
5min
10min
15min
20min


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

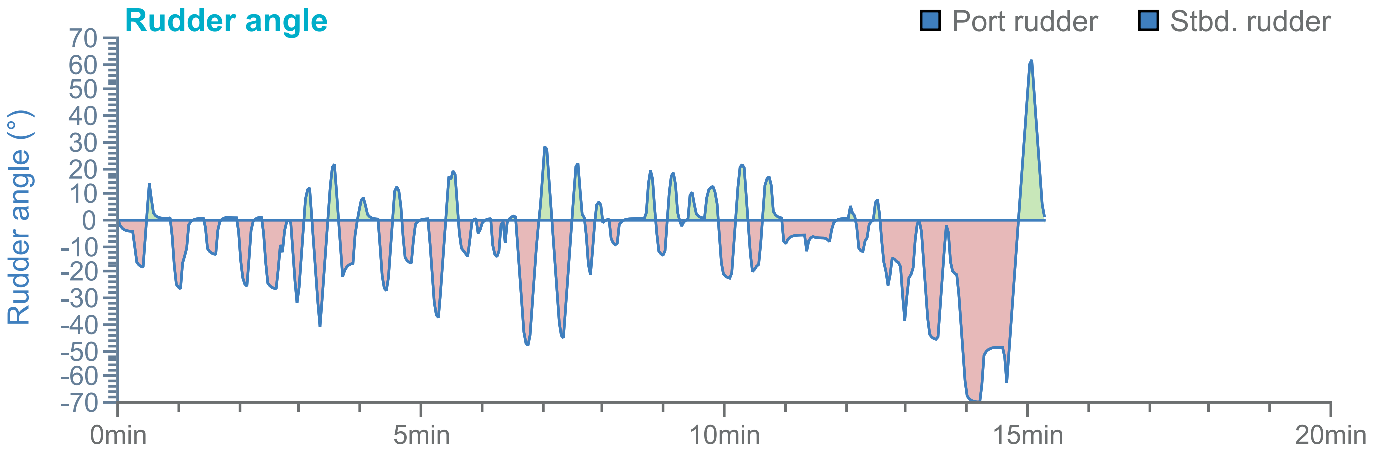

Ship speed
Ground long.
Water long.
Ground lat.
Water lat.
Longitudinal speed (knots)
Lateral speed (knots)
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
0min
5min
10min
15min
20min


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

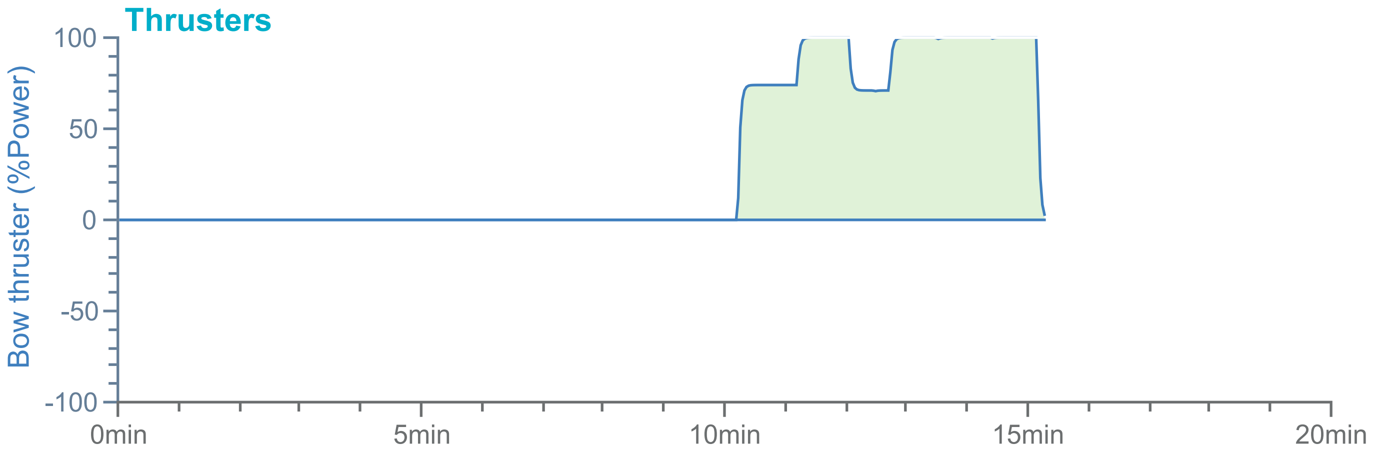
Propeller RPM



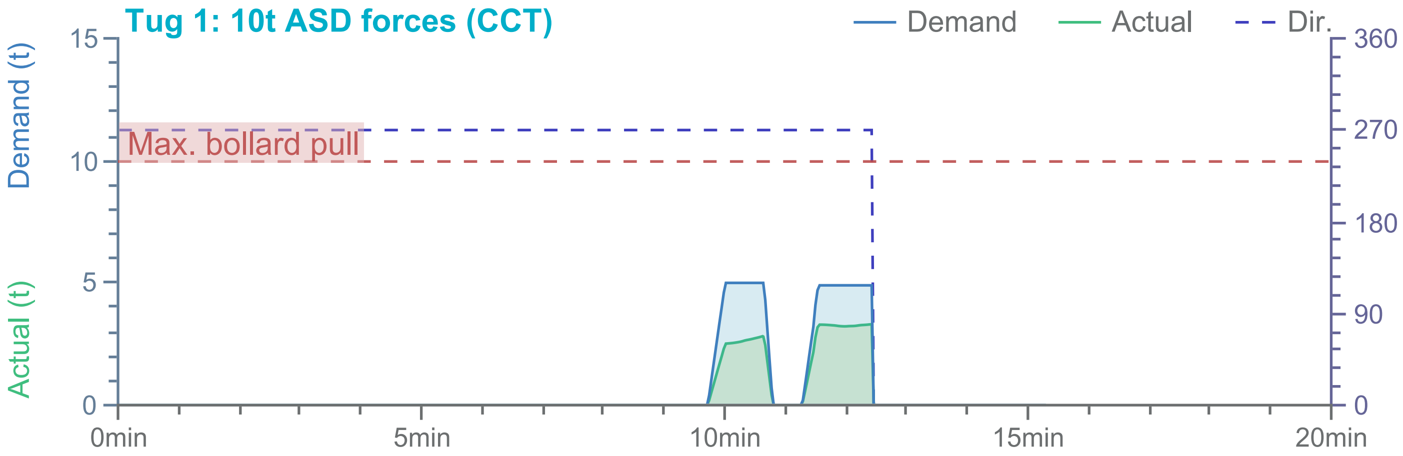
Rudder angle



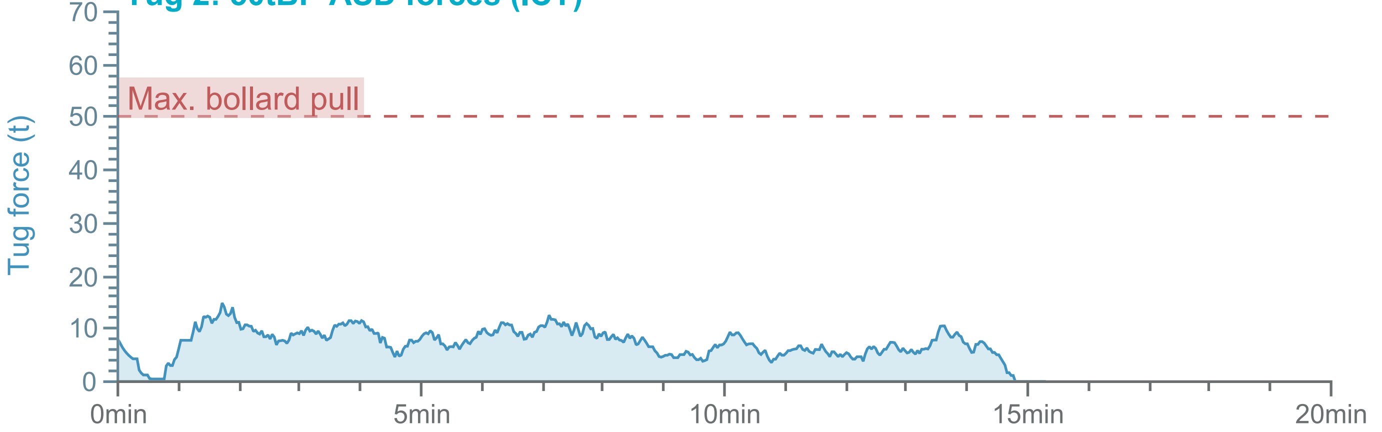
Thrusters



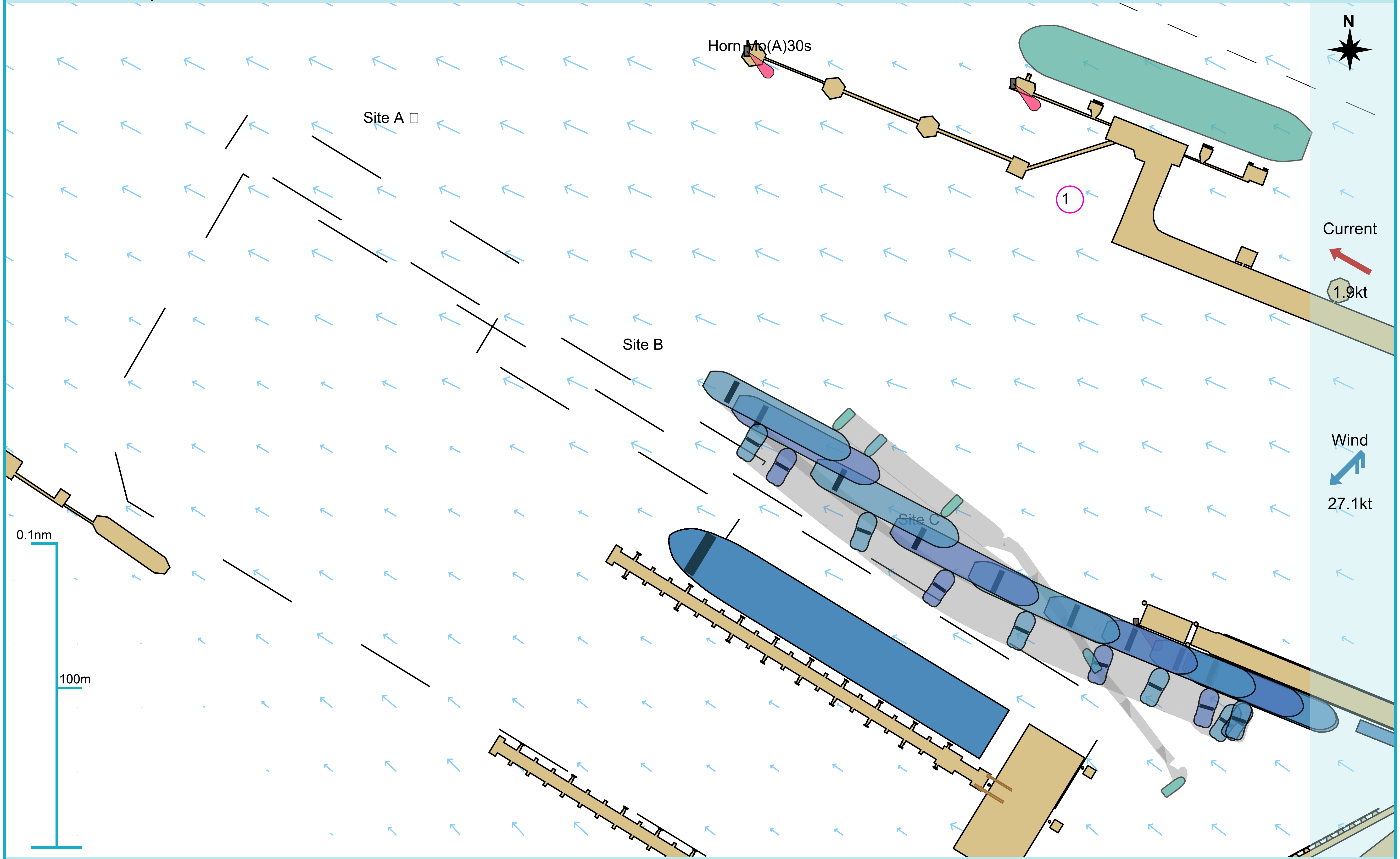
Tug 1: 10t ASD forces (CCT)



Tug 2: 50tBP ASD forces (ICT)

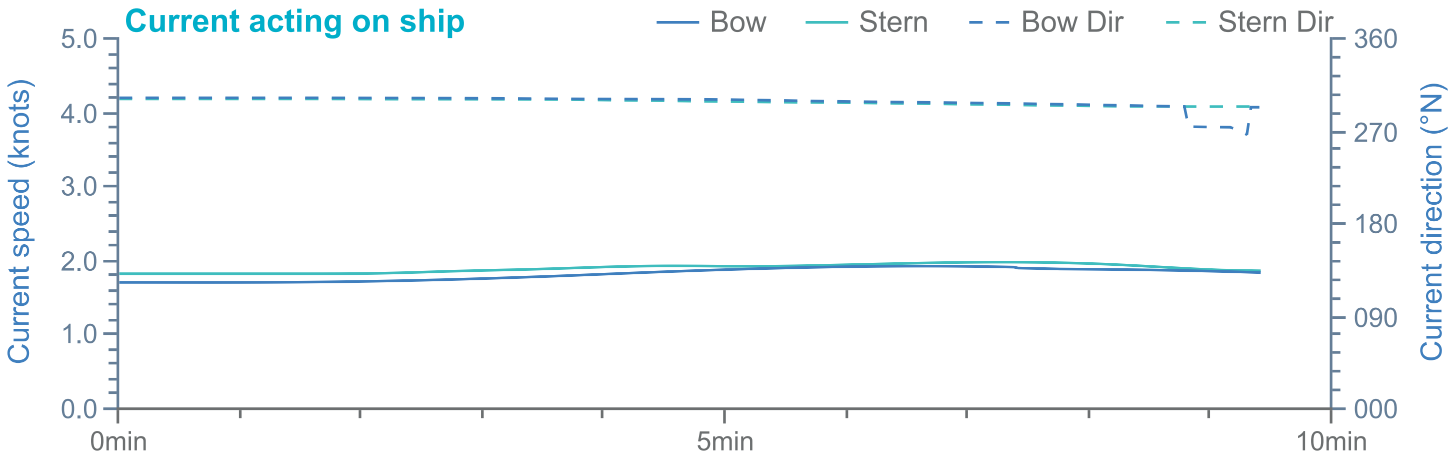


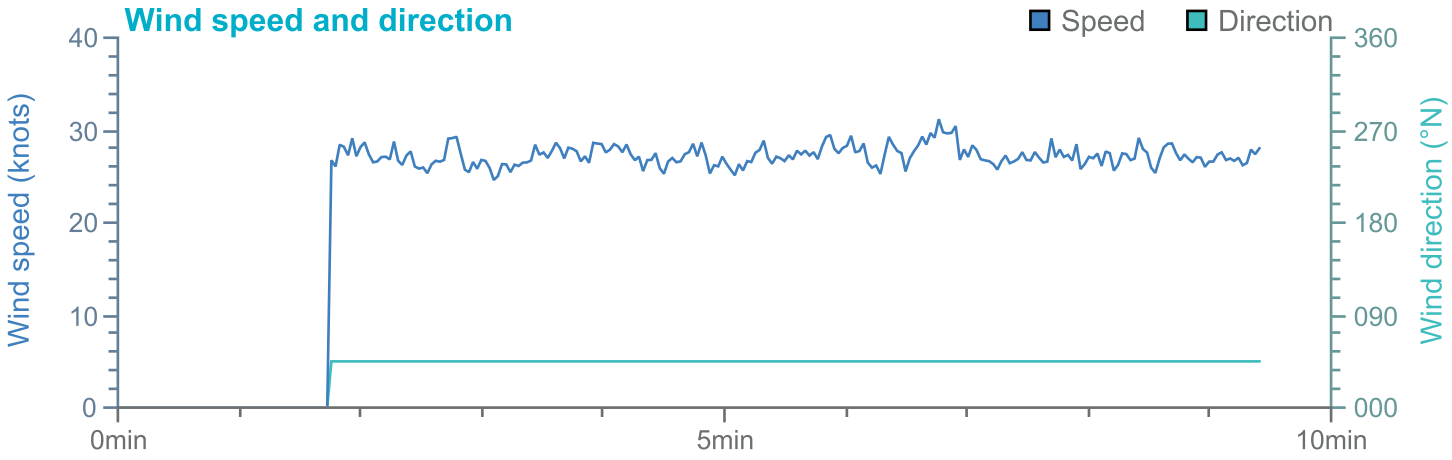
Manoeuvre track plot

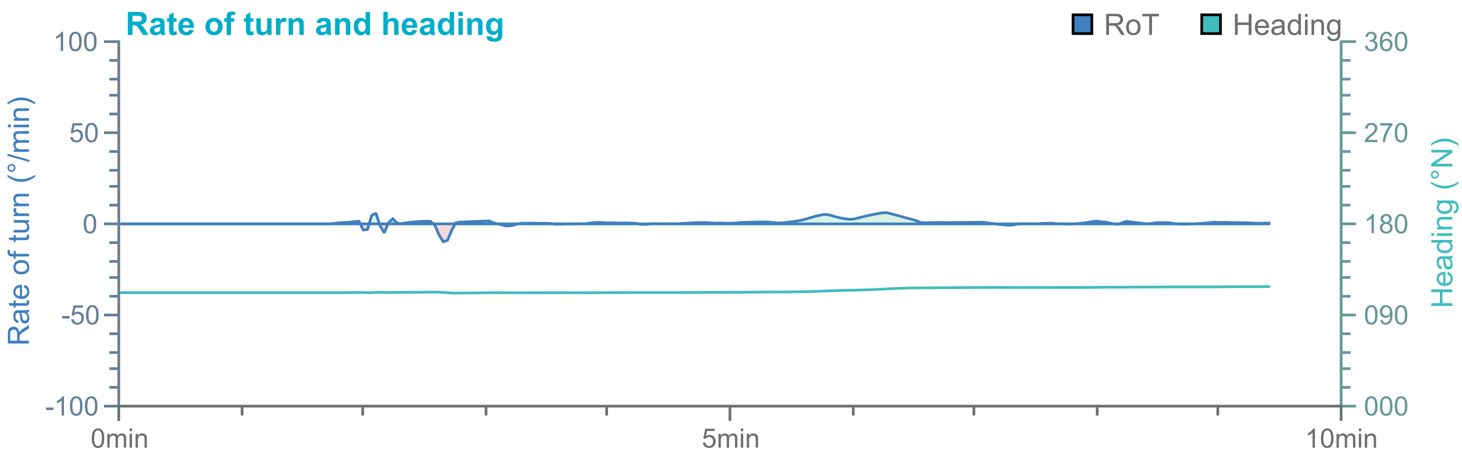


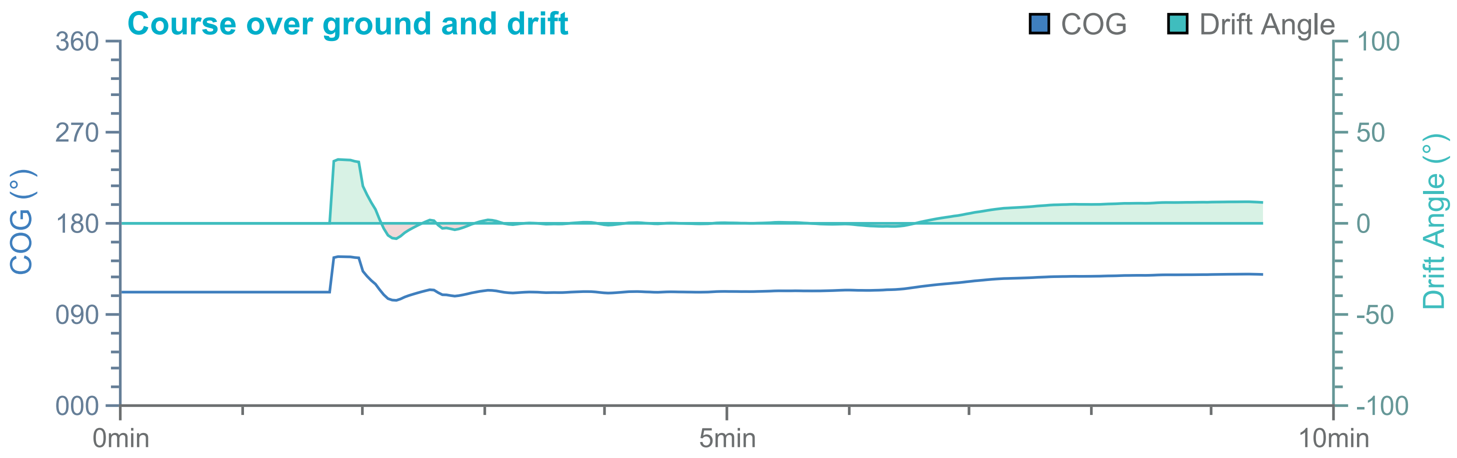
3.08 kts

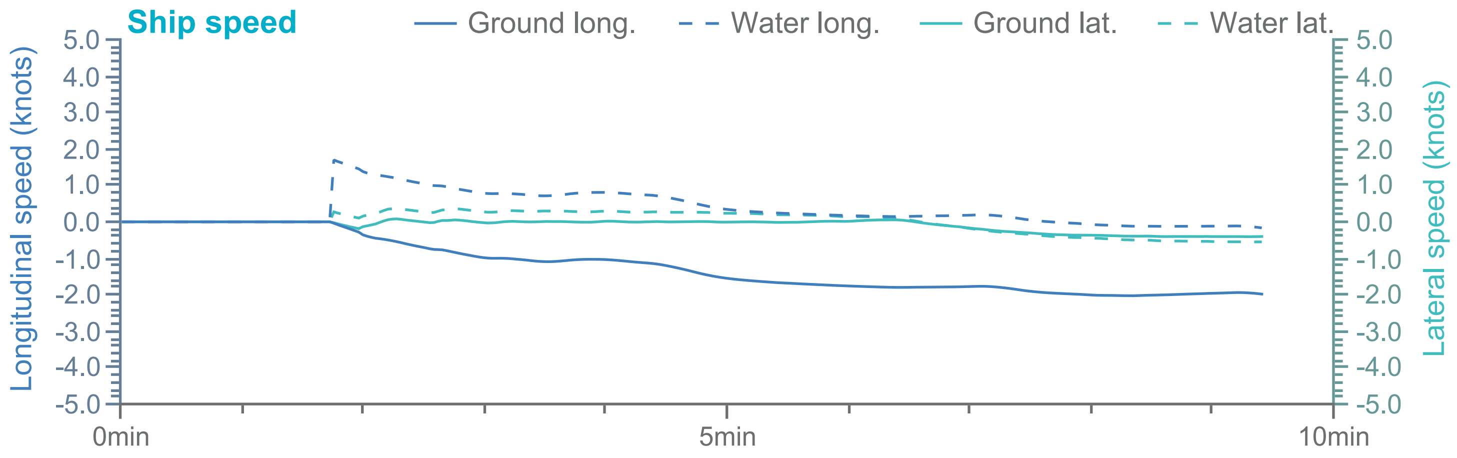
Ships plotted every 1 mins, highlight every 10 mins

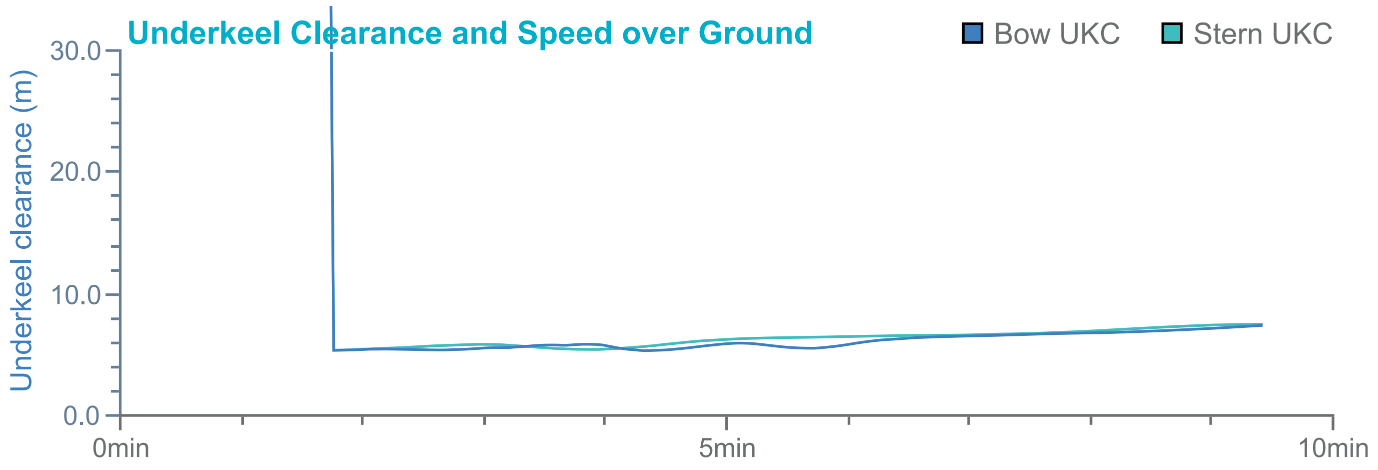

Current acting on ship

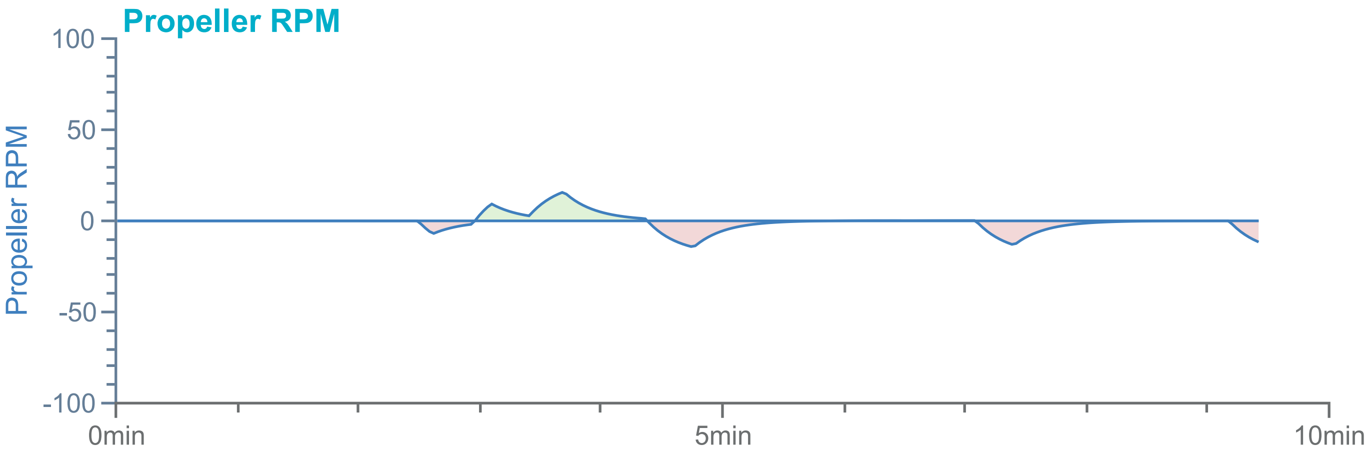

Wind speed and direction

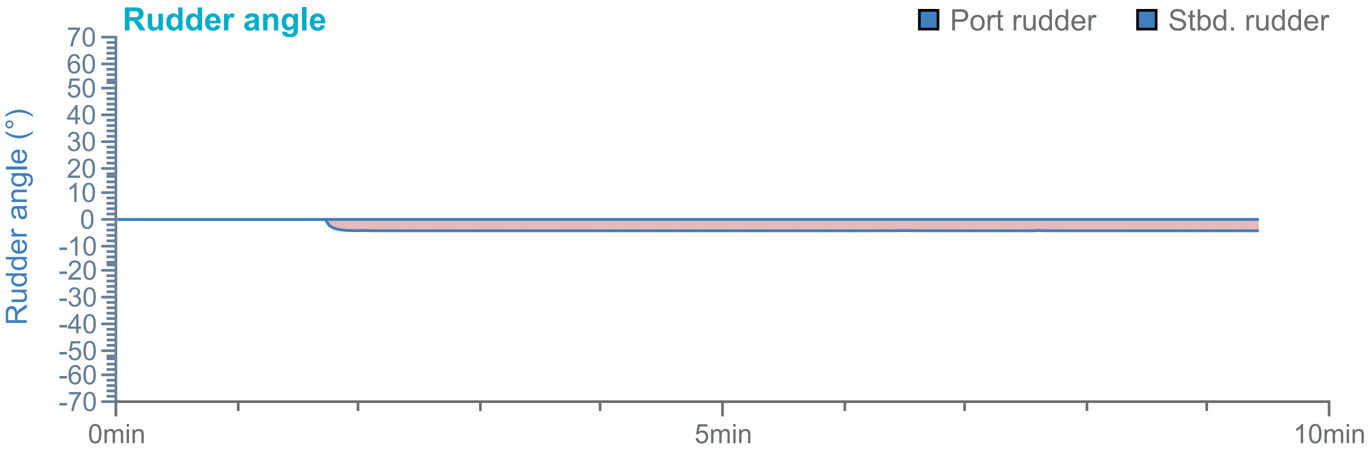

Rate of turn and heading

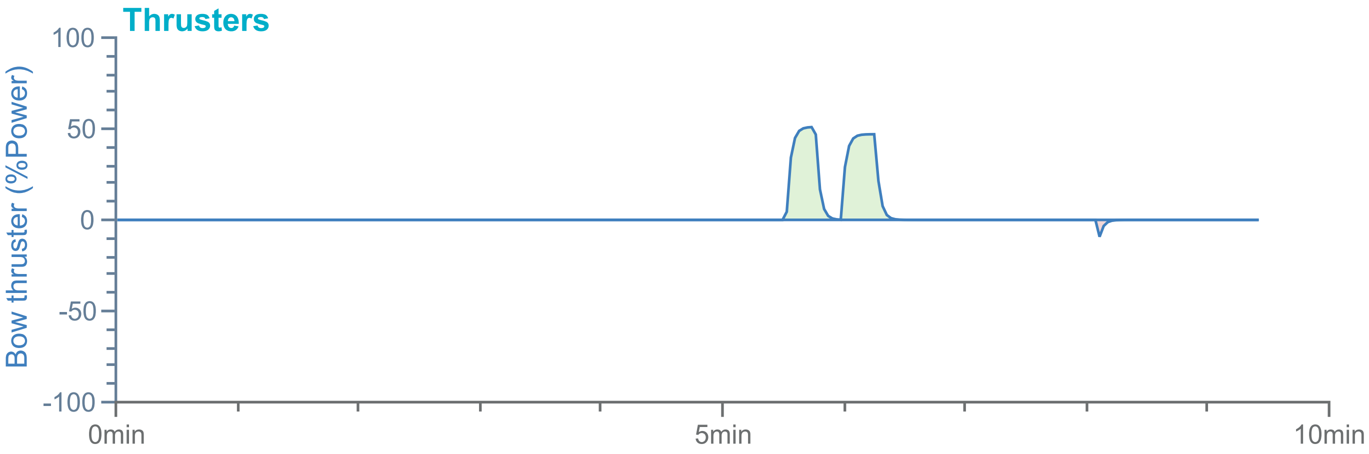

Course over ground and drift


Ship speed

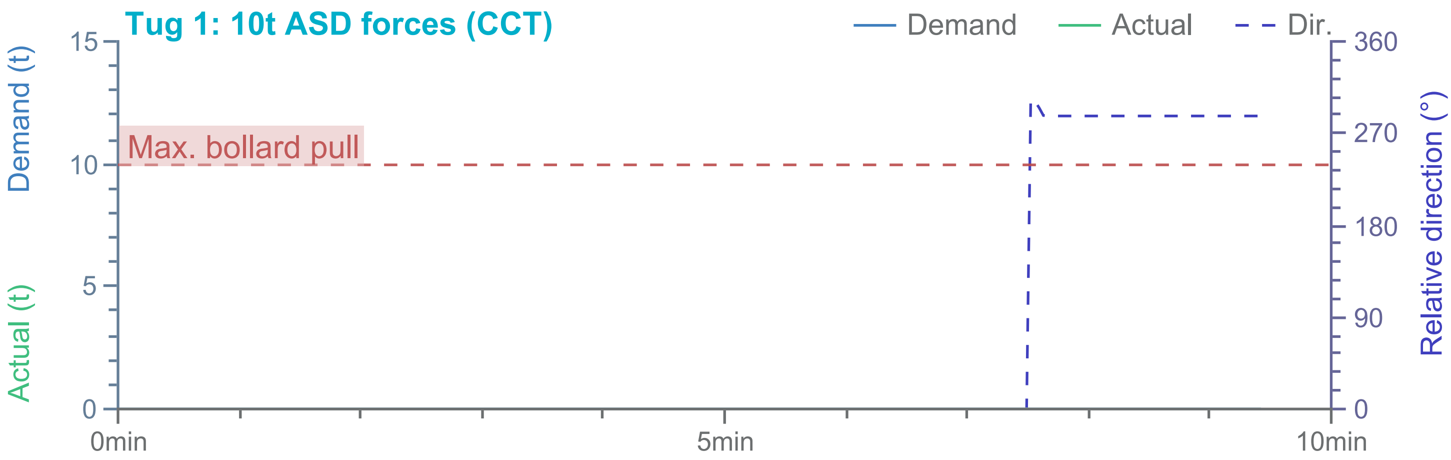

Underkeel Clearance and Speed over Ground


Propeller RPM

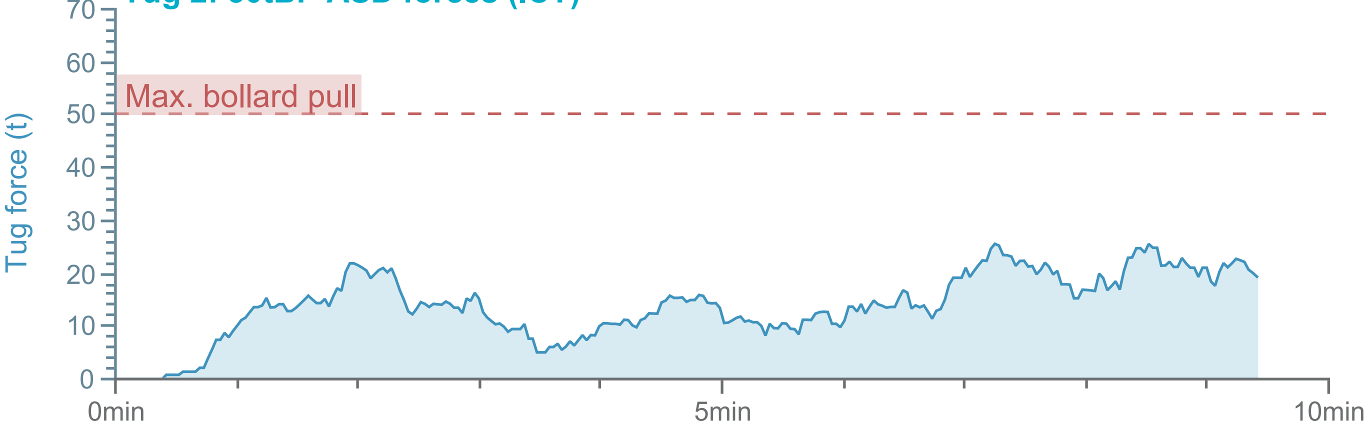

Rudder angle


Thrusters

Tug 1: 10t ASD forces (CCT)



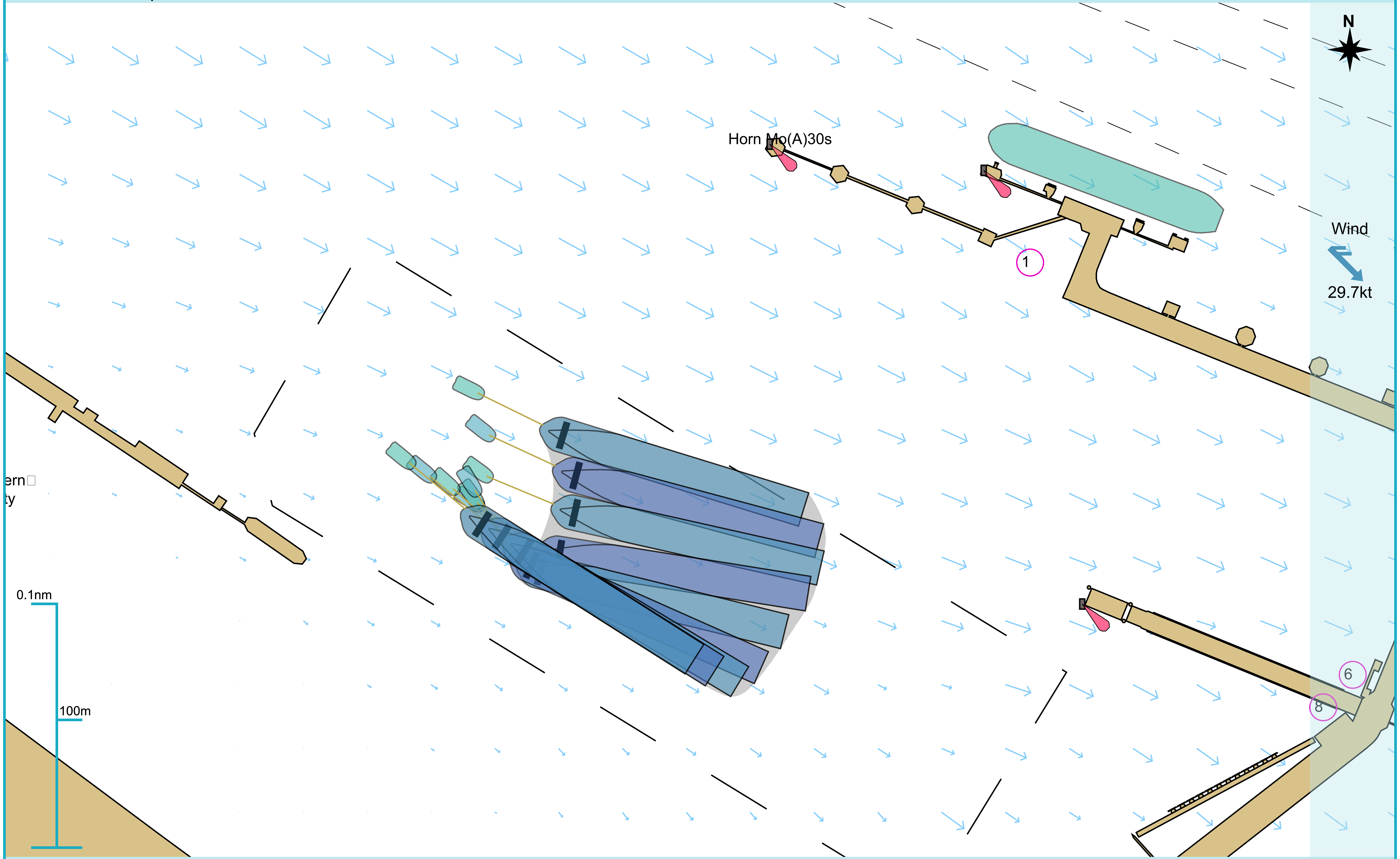
Tug 2: 50tBP ASD forces (ICT)



C Simulation track and data plots – Continuation

Project: Humber
Session: DJR6612_13-14_December 2023
Configuration: Peak_Spring - no IERRT
Run: 03_cont.

Manoeuvre track plot



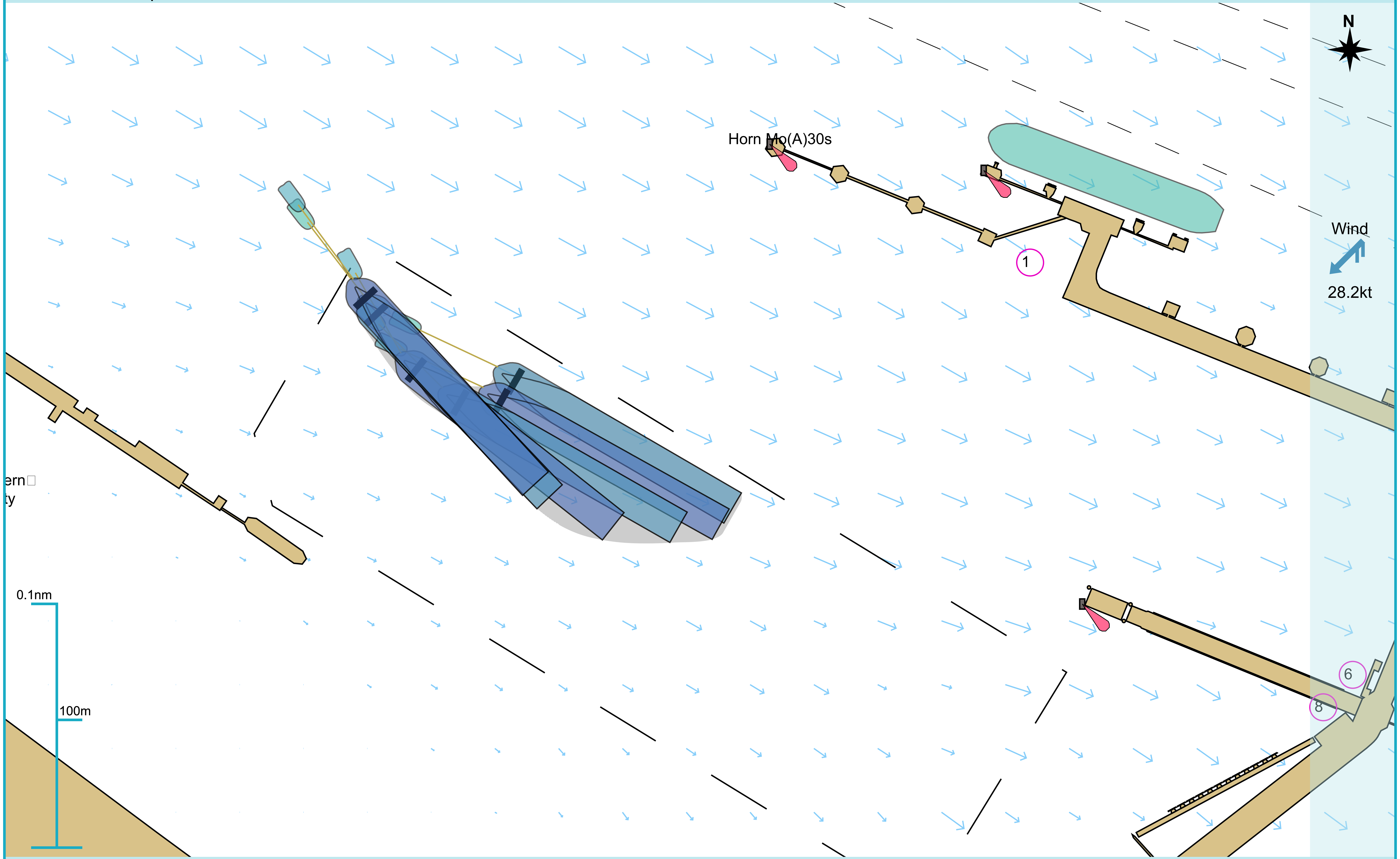
→ 3.74 kts

Ships plotted every 1 mins, highlight every 10 mins

Pilot: LMO
Manoeuvre: Other

Ship: Stena Transporter

Manoeuvre track plot



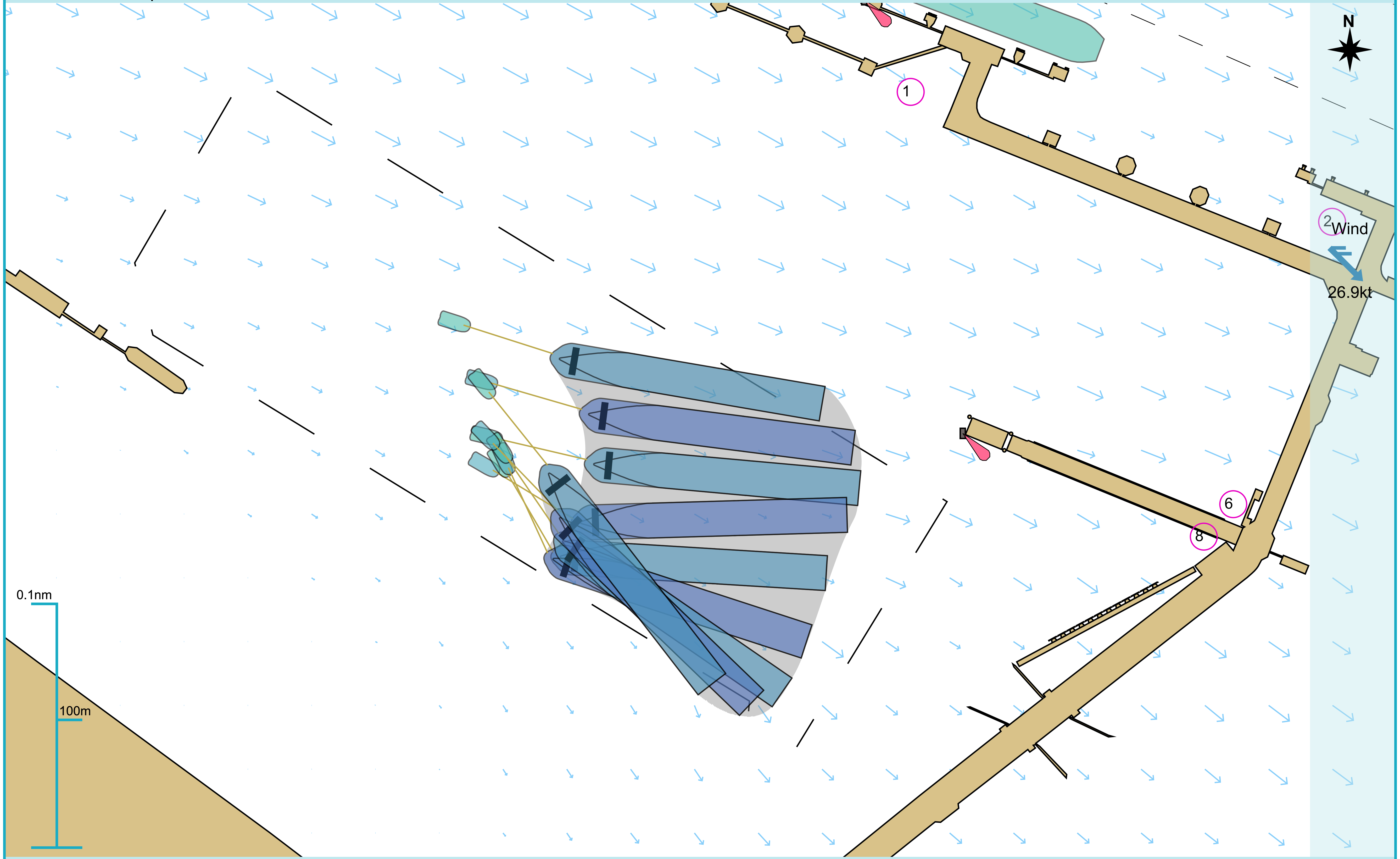
3.74 kts

Ships plotted every 1 mins, highlight every 10 mins

Pilot: LMO
Manoeuvre: Other

Ship: Stena Transporter

Manoeuvre track plot



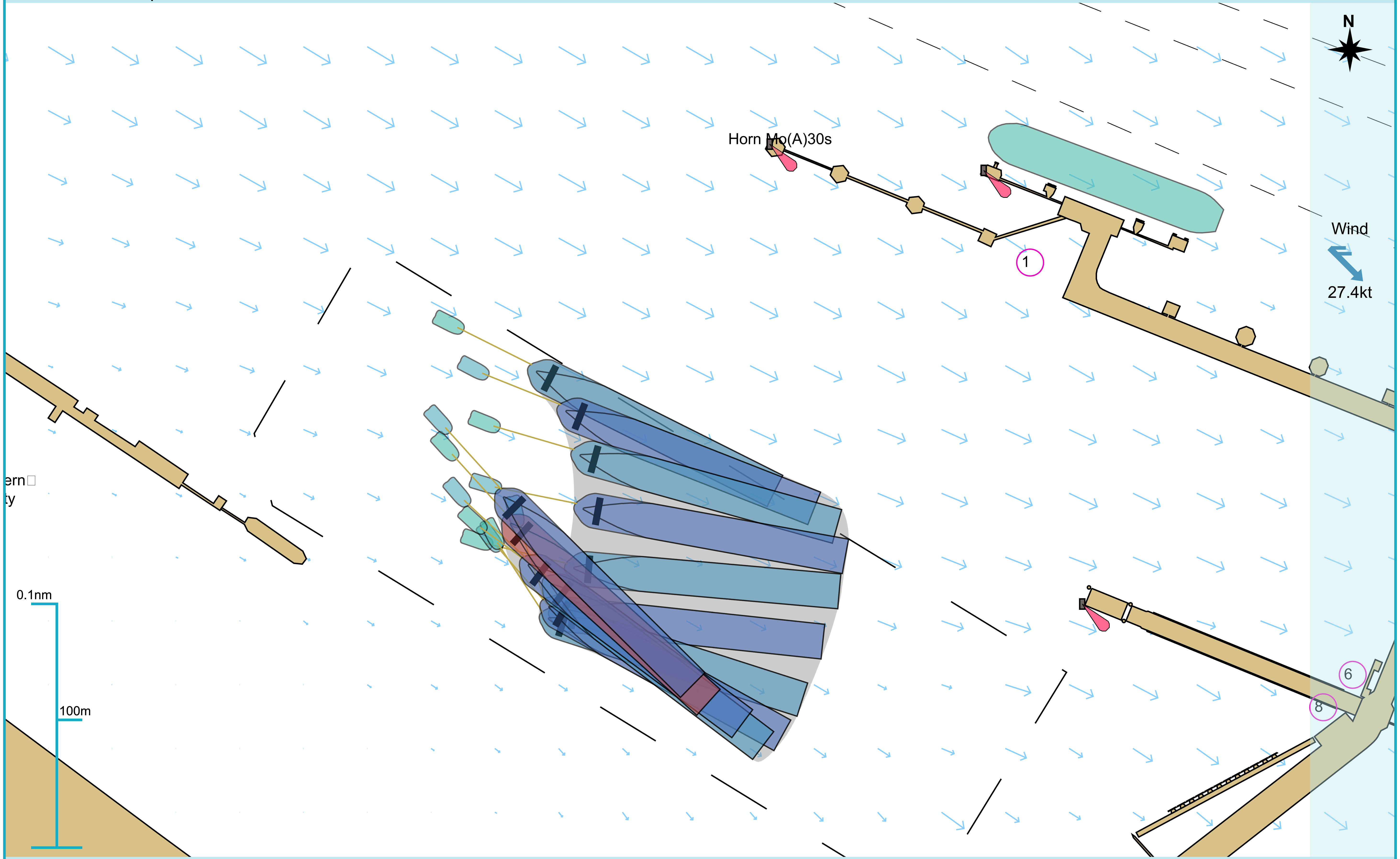
→ 3.99 kts

Ships plotted every 1 mins, highlight every 10 mins

Pilot: JMS
Manoeuvre: Other

Ship: Stena Transporter

Manoeuvre track plot

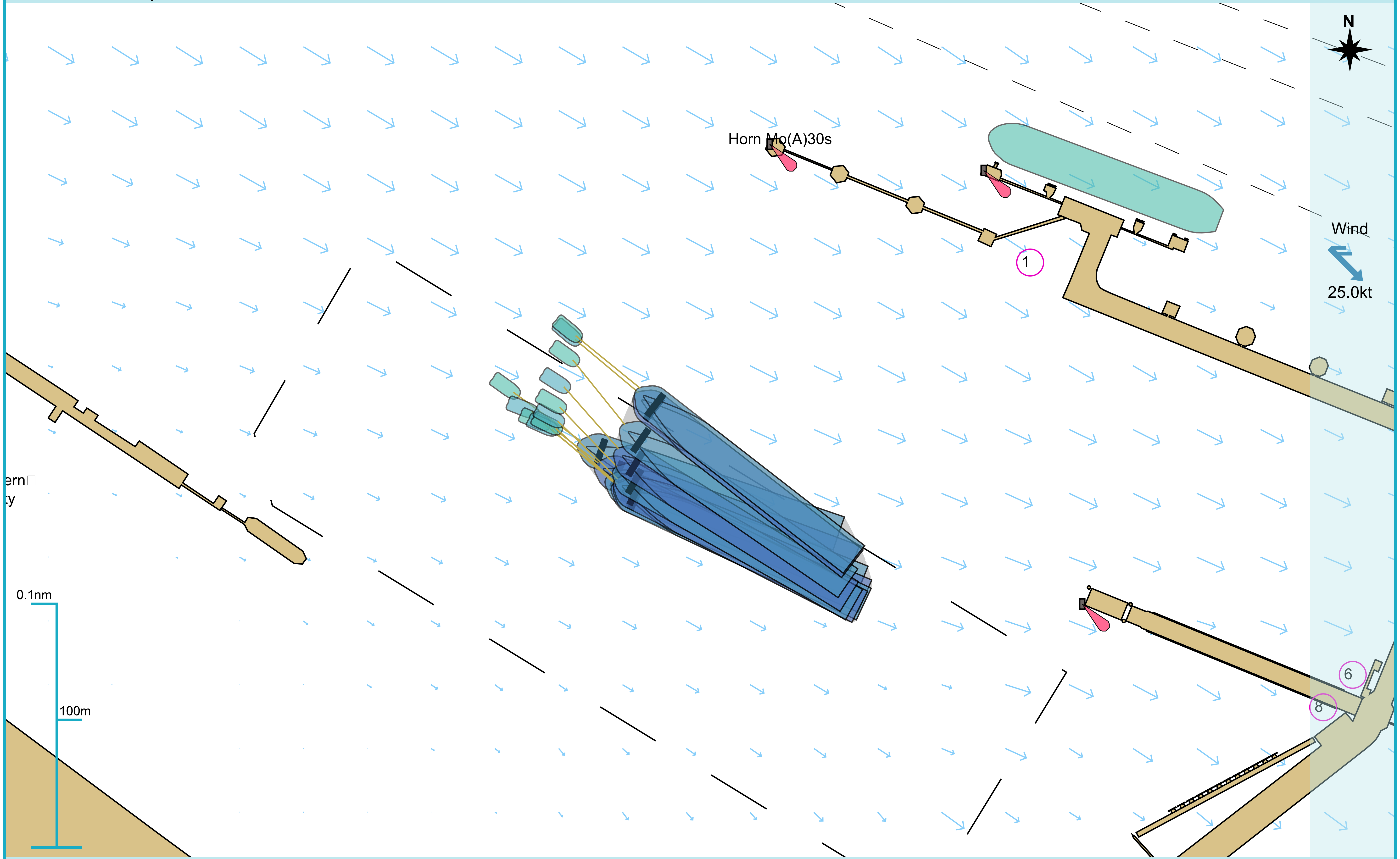


→ 3.74 kts

Ships plotted every 1 mins, highlight every 10 mins

Project: Humber
Session: DJR6612_13-14_December 2023
Configuration: Peak_Spring - no IERRT
Run: 06c cont.

Manoeuvre track plot



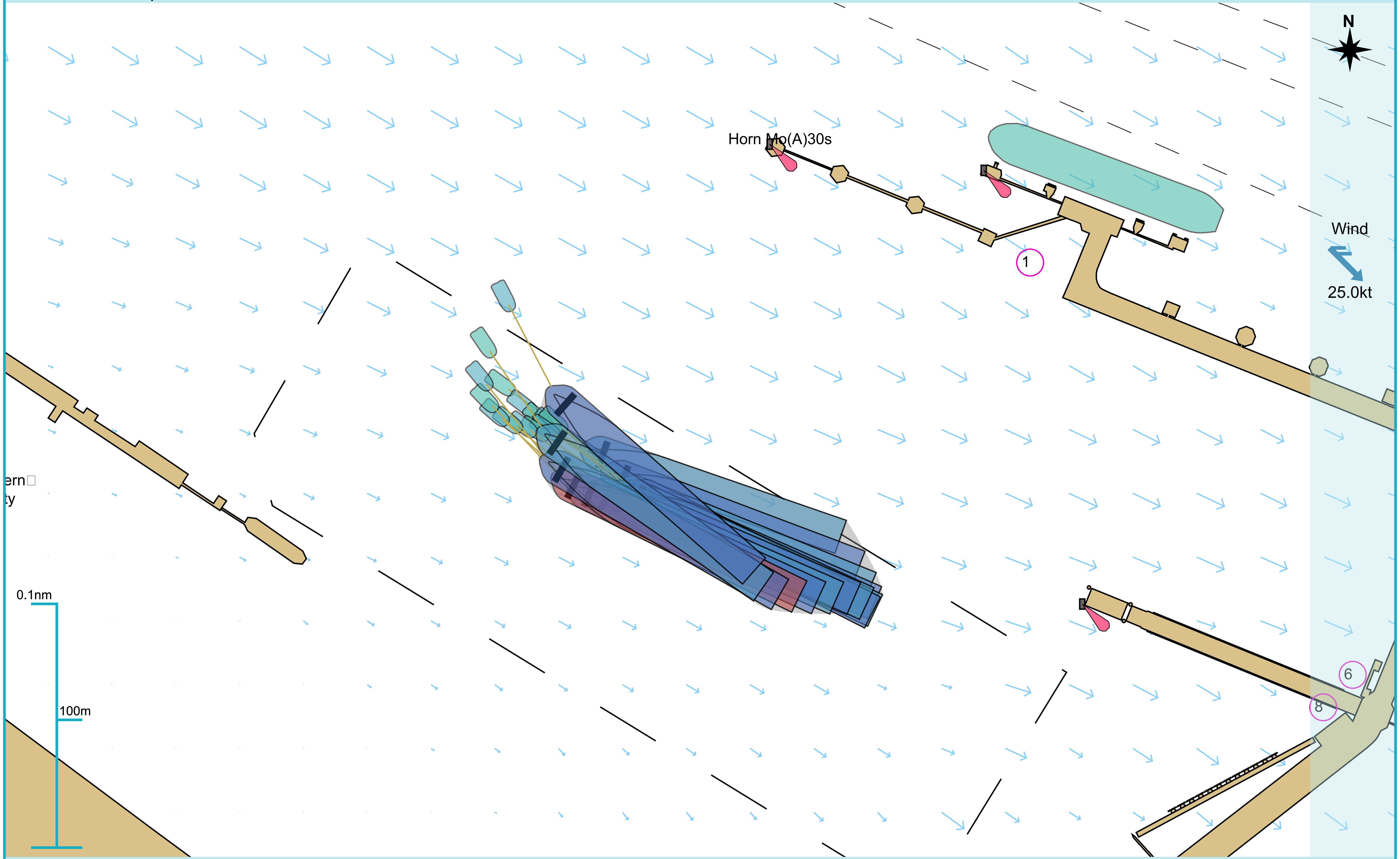
→ 3.74 kts

Ships plotted every 1 mins, highlight every 10 mins

Pilot: Imo
Manoeuvre: Other

Ship: Stena Transporter

Manoeuvre track plot



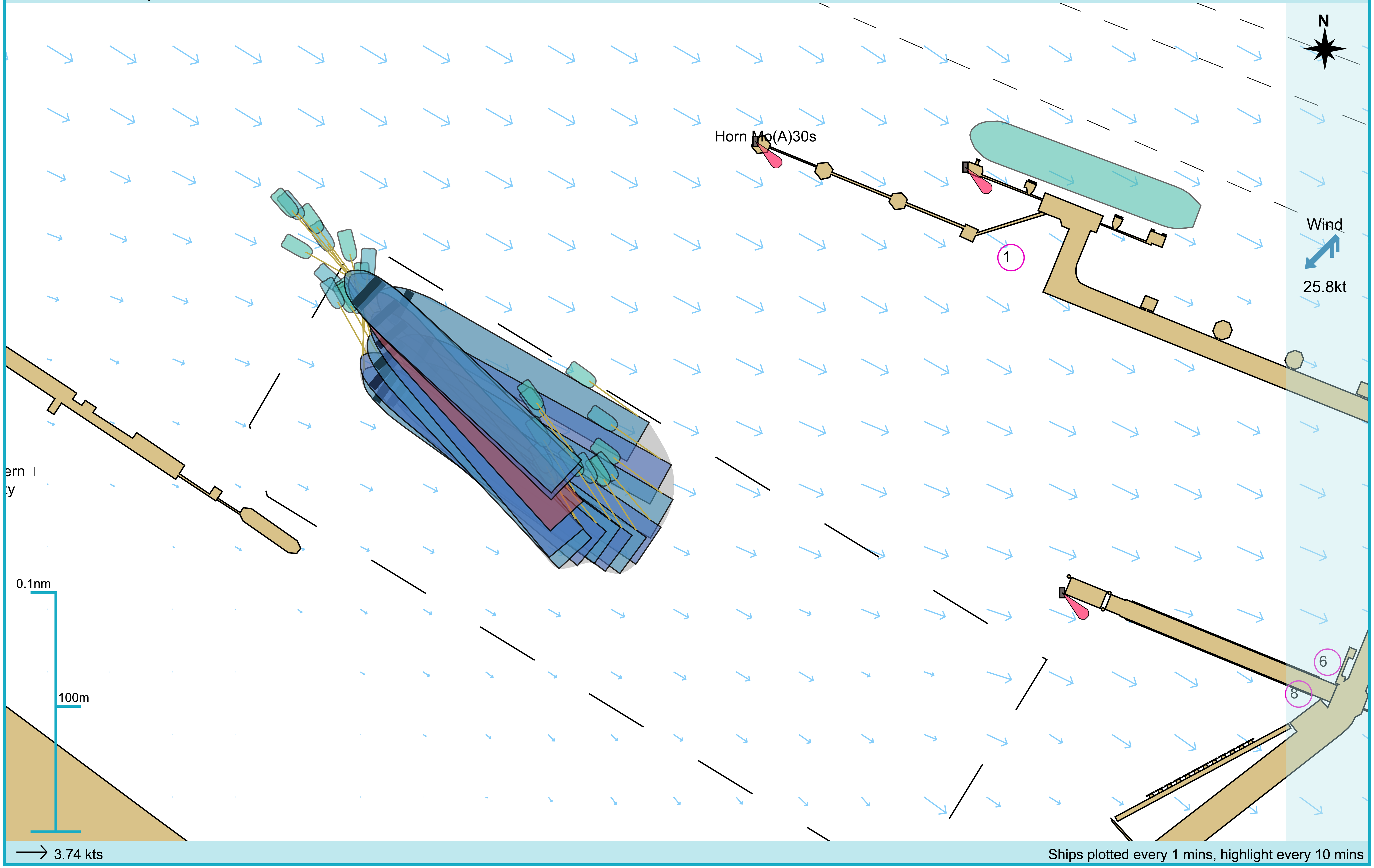
3.74 kts

Ships plotted every 1 mins, highlight every 10 mins

Pilot: Imo
Manoeuvre: Other

Ship: Stena Transporter

Manoeuvre track plot

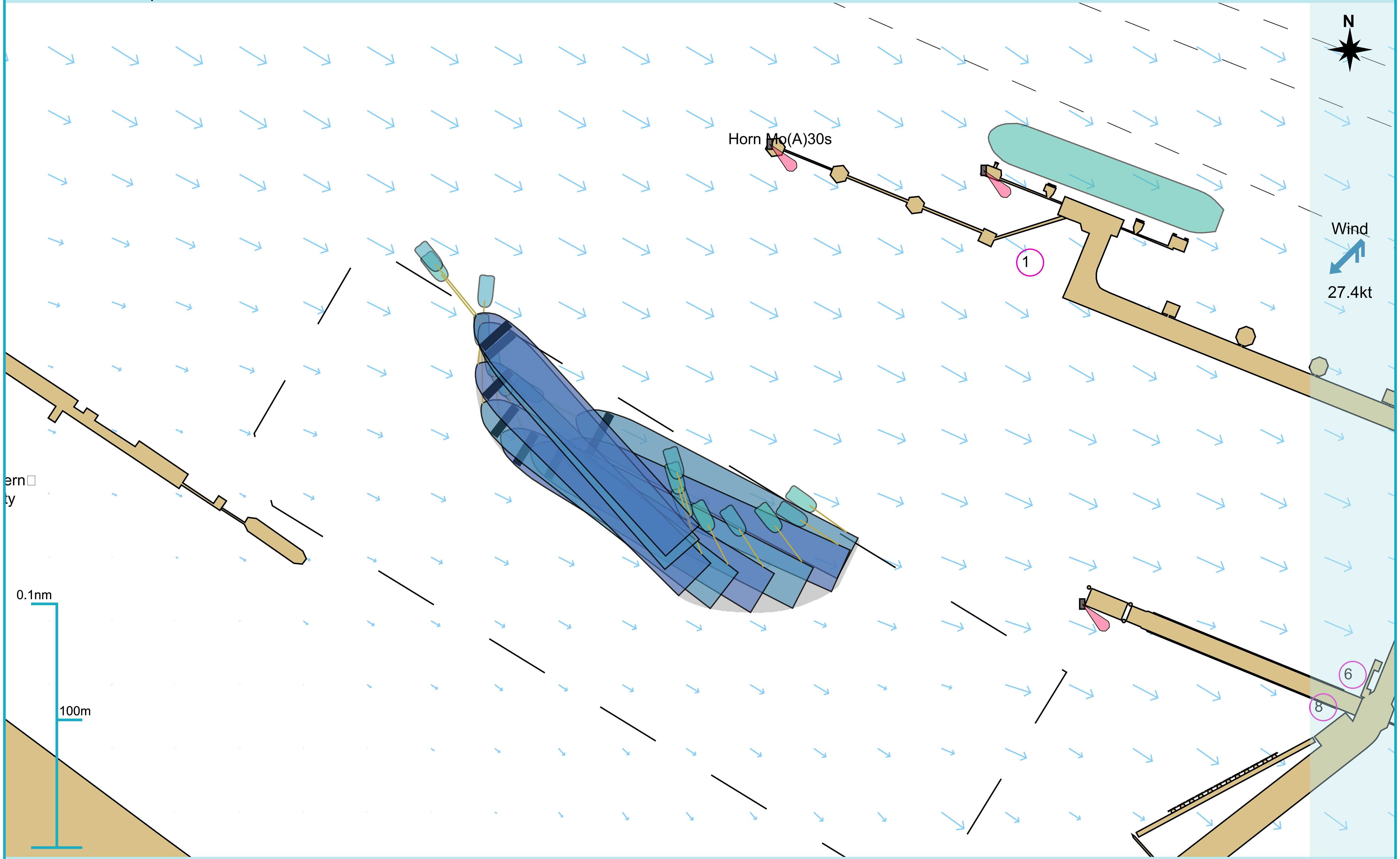


Ships plotted every 1 mins, highlight every 10 mins

Pilot: Imo
Manoeuvre: Other

Ship: MV Celine

Manoeuvre track plot



→ 3.74 kts

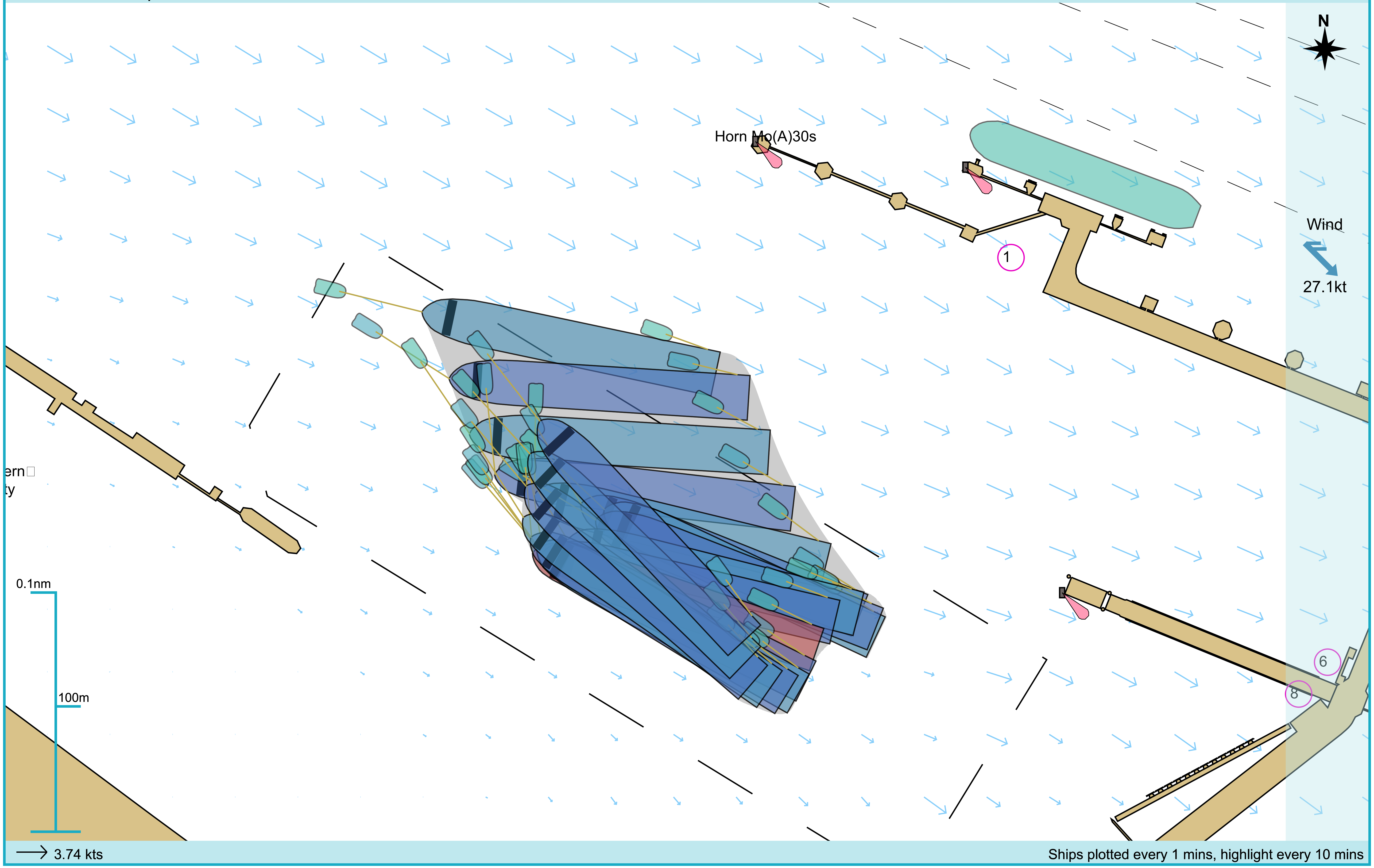
Ships plotted every 1 mins, highlight every 10 mins

Pilot: Imo
Manoeuvre: Other

Ship: MV Celine

Project: Humber
Session: DJR6612_13-14_December 2023
Configuration: Peak_Spring - no IERRT
Run: 09b cont.

Manoeuvre track plot



Ships plotted every 1 mins, highlight every 10 mins

Pilot: Imo
Manoeuvre: Other

Ship: MV Celine

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D 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.

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