IMMINGHAM EASTERN RO-RO TERMINAL

Appendix 10.3 - Navigation Simulation Study – Stakeholder Demonstrations (tracked)

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Summary

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

HR Wallingford have been commissioned by ABP to undertake a series of desk studies and real time navigation simulation studies to assess the feasibility of the design for the IERRT. This work is covered in detail in a series of reports numbered DJR6612-RT001 to RT005, produced between Dec 2021 and Nov 2022 (References ~~1 to 5).~~1 to 5).

ABP also commissioned HR Wallingford to facilitate a further real time navigation simulation session to demonstrate specific scenarios to stakeholders.

The demonstrations were directed by staff from ABP, supported by experienced facilitators from HR Wallingford, to ensure that the desired stakeholder engagement was achieved. The ship manoeuvring models were controlled by suitably qualified pilots and masters.

Stakeholders from APT, DFDS, Nash Maritime, Rix Towage, James Everard Fisher and Stena were present and provided input to the scenarios and their assessment.

The objectives for the demonstrations were:

- To demonstrate that the Stena transporter class of RoRo would be suitable to operate from the IERRT.
- To demonstrate the effectiveness of the proposed risk mitigation measures in the event of a serious breakdown during the approach to the IERRT.
- To demonstrate that the Whisby Teak and Thames Fisher product tankers would be able to operate to and from the IOT Berth 8 within current operating limitations, with the IERTT in place.
- To demonstrate that vessels operating to and from the IOT berths will be able to apply appropriate navigation strategies to deal with the wind sheltering effect that might be experienced in the lee of vessels moored at IERRT.
- To demonstrate that once IERRT is built, bunker barges would be able to adopt appropriate navigation strategies to continue operations to and from IOT Berths 8 and 9.

A total of 31 demonstration simulation runs were conducted as part of the associated simulation session. Their outcomes were consistent with those undertaken for similar scenarios and supported conclusions from the previous studies.

As previously mentioned, the demonstration runs were directed by staff from ABP to ensure that the desired stakeholder engagement was achieved.

The key observations from the demonstration simulation session, with respect to the demonstration runs involving the Stena Transporter RoRo ship, were as follows:

- Overall it was noted that manoeuvring to and from the new infrastructure is challenging – as with many berthing manoeuvres - requiring precise positioning of the vessel, tugs, and their attitude to the tidal flow and the wind. Mitigating the inherent risk in the manoeuvring operations will require a robust training solution to be in place.
- Overall the Stena Transporter was less challenging to operate to and from the IERTT than the 237m long RoRo vessel used as the design vessel in previous studies. It required less powerful tug support and indications were that it would be able to operate independently in winds in excess of 25 knots.

- Any new class of vessel, and potentially individual ships within a class, will need to have appropriate operating limitations and procedures developed and reviewed. This is considered normal best practice at any berth, but the precise navigation required, combined with the strong currents at the site, makes this a particularly critical feature for safe operations at IERRT.

With respect to demonstrating the effectiveness of proposed risk mitigation measures in the event of a serious breakdown during the approach to IERRT:

- The outcome after a serious breakdown is nearly always entirely dependent on where in the manoeuvre it occurs, the prevailing conditions and the actions taken. In this case the breakdown was defined as a total ship control and power failure during the final stages of an approach to IERRT Berth 1, with the environmental conditions setting the vessel towards IOT. Masters with experience of the vessel being simulated noted that the breakdown would be highly unlikely due to the level of redundancy and equipment/system duplication inherent in the vessel's design. Nevertheless, it was agreed that a reasonable action would be to attempt to stop the ship using both anchors and that initiating this action should be delayed 20 seconds after the breakdown, to simulate the time for a master to recognise the breakdown and decide on an action plan in reality, if it happened unexpectedly.
- During the 2 runs that simulated breakdowns, the vessel was stopped within 100m of the position where the breakdown was initiated. To develop a scenario in which contact with the IOT would be likely, the vessel would need to be approaching significantly outside its normal line and at a point where the stern would normally be approximately 20m from the desired berthing position.

With respect to the Whisby Teak and Thames Fisher product tankers operating to and from IOT Berth 8, with the IERTT infrastructure in place:

- It was demonstrated that the Whisby Teak and Thames Fisher ships can be operated to and from the IOT berth in winds of up to 30 knots. It is recommended that the existing operating wind limit, for vessels arriving in south-westerly winds (setting onto the berth) of 25 knots gusting 30 knots, is maintained. This class of vessel has limited control of the bow in stronger winds, and with the size of the vessel and the lack of suitable tugs to assist at the bow, means this will remain an appropriate limit.
- A wind sheltering simulation was used to represent the increased lateral drift experienced by a vessel as it transits out of the lee of a larger vessel. In this case:
  - The sheltering model was considered to be indicative and was deliberately set to be conservative, as the fluid dynamics of air passing around a large object and their effect on a passing ship is difficult to accurately model without detailed full scale measurements, particularly in a dynamic simulation.
  - Using the sheltering simulation, it was possible to demonstrate some of the navigation strategies a product tanker could use to manage the effect as it cleared the stern of a large RoRo ferry berthed on IERRT.
  - The pilots and masters were able to use techniques to mitigate the sheltering effect and berth safely at IOT, despite the variation in wind strengths simulated. It was noted that the sheltering simulation was considered to adequately represent conditions that were apparent at other berths on the River Humber, and at the entrance to Immingham Lock.

With respect to bunker barge operations to and from IOT Berths 8 and 9:

- It was noted that APT do not impose formal environmental limits on bunker barge operations to and from IOT. Instead the master of the barge is responsible for considering the safety of the manoeuvre, based on the prevailing circumstances and conditions, in consultation with the marine superintendent.
- There was no detailed trails data available on which to verify the vessel manoeuvring model produced for the bunker barge, however, its manoeuvring ability was verified by the experienced master who attended the study. The model was assessed as being adequately representative for the purposes of the study, but was considered to be conservative, particularly in terms of the time taken to swing and the power

provided by the bow thruster. The decision was made to maintain these conservative features as long as they did not have an overall detrimental effect on the simulation run outcomes.

- Despite the conservative manoeuvring characteristics of the bunker barge, the master was able to manoeuvre it safely between the IERRT and the IOT with vessels berthed on both adjacent structures.
- Correspondingly, the master of the bunker barge considered that the simulated model was more difficult to navigate than in reality, and that given the space available between the other moored vessels, it would be feasible to arrive and depart on peak flood and ebb tides.
- It was noted by that the main challenge with respect to arrivals and departures at IOT Berth 9 was the available space on the jetty with a tanker already moored on Berth 8. At present this situation may result in the barge master deciding to wait for the environmental conditions to change, or for the adjacent tanker to depart. This would still be the case with IERRT in place.

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1 Introduction

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

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2 Simulation configuration

2.1 General

This real time navigation simulation study was carried out using one of the main ship bridge simulators at HR Wallingford's UK Ship Simulation Centre (UKSSC) (see Appendix A).

The simulators and associated software have been specifically designed as tools to support port design and ship manoeuvring studies. They combine HR Wallingford's extensive hydraulic modelling capabilities with realistic ship handling models. HR Wallingford's simulators are developed and managed by a team of experienced, expert maritime engineers and scientists, naval architects, master mariners, pilots, tug masters and software modelling experts. The HR Wallingford Ship Simulation System is designed and optimised for shallow water, slow speed, close-quarters ship manoeuvring and so is not the same as the systems found in some training simulators.

Ship navigation simulation is only as good as the input data, so having direct access to an extensive and highly experienced team of experts in all aspects of navigation, ship manoeuvring, wind, waves, tidal currents, dredging, coastal processes, water and civil engineering design, places HR Wallingford in a strong position as a world-leader in ship navigation simulation. It also sets HR Wallingford apart from other organisations.

The simulators present to pilots and tug masters the visual cues and other information, such as terminal infrastructure, the coastline and aids to navigation they would experience in approaching a marine terminal in reality. In this way the essential features of the human input are retained.

The simulators present comprehensive manoeuvring information so that the environmental limits and the optimal ship manoeuvring and tug strategies are be evaluated in support of the study.

2.2 Port layout

HR Wallingford have previously developed a detailed digital model of the River Humber and approaches to Immingham in conjunction with ABP Humber. The model has been validated by professional pilots and masters in various training courses and navigation assessment studies during 2021. This simulation configuration was used to represent the approaches to the new facilities and surrounding features.

The proposed port facilities around Immingham harbour were included in the simulation configuration based on engineering drawings provided by ABP during previous related studies.

The layout used in the demonstration simulation session was the same layout as that used for the simulation study carried out in July 2022 (see Reference 5), as shown in Figure 2.1.

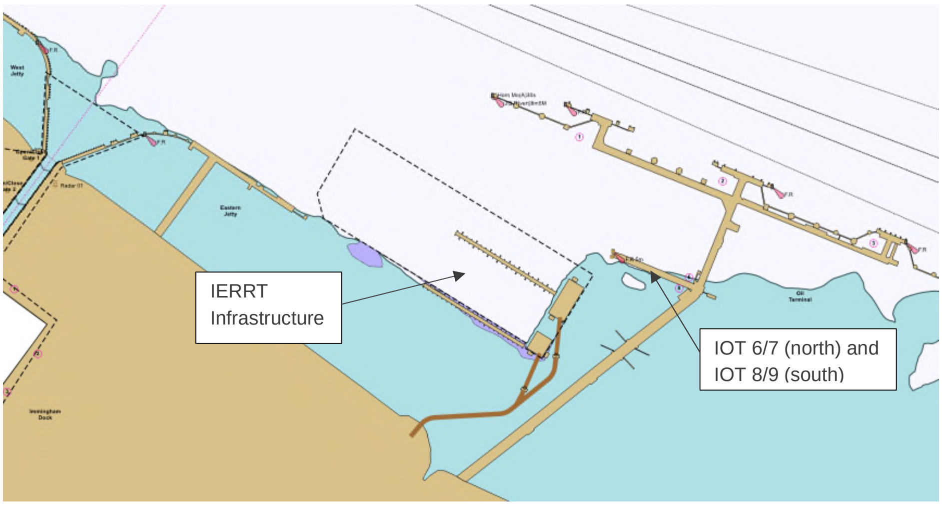

Figure 2.1: Simulator layout showing RoRo infrastructure at a 300°T orientation

2.3 Environmental conditions

The environmental characteristics for wind, current and wave applied in this study were consistent with the previous studies. The precise conditions were determined by ABP Humber to support their demonstrations.

All runs were conducted using the peak spring flow model, produced for the July 2022 navigation study (see Reference 5).

Since the study in July 2022, the flows were further verified with data collected by an ADCP survey during October 2022. HR Wallingford undertook a review of the data collected and compared it with previous data collection and the associated flow model outputs. This work is described in detail in Reference ~~6.~~6.

The survey data showed good correlation with the model values for currents in the area in which the IERTT will be constructed. The directionality of the modelled currents is very well represented, but the peak speeds in the model were about 15% to 20% lower than expected. Based on this assessment, the model speeds were all scaled up by a factor of 1.2.

2.4 Ship manoeuvring models

2.4.1 Outline

There were 4 design vessels used in this demonstration simulation, as follows:

- 212m long RoRo ferry, based on the 'Stena Transporter', as requested by ABP to provide a further perspective on the operability of the IERRT, based on a slightly smaller operational vessel than that considered previously (for further information see Section 2.4.4).
- 100m long products tanker, based on the vessel 'Whisby Teak', as requested by stakeholders from APT (for further information see Section 2.4.5).
- 91.5m long tanker, based on the vessel 'Thames Fisher', as requested by stakeholders from APT (for further information see Section 2.4.6).
- 59m long product tanker, based on the 'Rix Phoenix' bunker barge, as requested by stakeholders from APT (for further information see Section 2.4.7).

2.4.2 Ship modelling limitations

HR Wallingford were aware of an artefact in the ship manoeuvring models which causes the rate of turn to reduce unrealistically quickly during a swing in strong current flows. The ship manoeuvring models were therefore considered to be conservative in situations such as at Immingham, where the vessel needs to swing across the current on approach. The effect was mitigated by ensuring that the pilot was aware of the potential change in rate of turn, so that they could adjust the rudder and power to maintain their required rate of turn accordingly.

The ship manoeuvring models for the Whisby Teak, Thames Fisher and Rix Phoenix all showed this tendency during testing and the masters were given time to adapt their normal helm and power adjustments to manage the swing appropriately. It should be noted that this technique essentially matches the normal practice that pilots would adopt in vessels in which they are unfamiliar. The Simulation Team agreed that for the purposes of these demonstration simulations, it was desirable to have the ship manoeuvring models behaving more conservatively than in reality.

2.4.3 Wind sheltering

ABP requested that HR Wallingford turn on the simulation of changes in apparent wind that would be experienced by a vessel passing in the lee of a large RoRo ship and then clearing the shelter, so experiencing the full effect of the wind forces.

HR Wallingford previously mentioned that to properly simulate this effect would require detailed Computer Fluid Dynamic (DFD) modelling, for which there was no time or budget. Consequently, the wind sheltering model that was already within the HR Wallingford Ship Simulation System was modified to provide a indicative, but realistic wind sheltering effect in this case. The attending pilots and masters found that this modelled effect was conservative and so it somewhat exaggerated the consequences of moving from a sheltered to an unsheltered area. As such, it was considered to be adequate as a training tool and to demonstrate that suitable actions can be taken to mitigate the variation in wind forces in this case.

2.4.4 Stena Transporter

The ship manoeuvring model of the Stena Transporter (see Figure 2.2 and Table 2.1) had previously been used in a series of studies at HR Wallingford and so had been verified by experienced masters and PEC holders. During this demonstration session the experienced masters present noted that the ship manoeuvring model was consistent with their experience of the vessel in reality. There were some circumstances in which the PEC holders considered the model was slightly conservative during the demonstration. However, no changes were made to the model's characteristics.

Figure 2.2: Stena Transporter

Table 2.1: Characteristics – Stena Transporter

Characteristic	Unit	Stena Transporter	
Ship type		RoRo Ferry	
Length overall	m	212	
Length between perpendiculars	m	194.8	
Beam overall	m	26.7	
Distance bridge to stern	m	190.2	
Draught	m	6.3	
Block coefficient		0.655	
Displacement	t	22,000	
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	
Rudder type		Becker flap	
Max rudder angle	°	35	
Manoeuvring engine order		**RPM**	**Speed (knots)**
Full Ahead		100	20.9
STOP		0	0
Full Astern		100	-13.6
Windage			
Windage lateral	m²	4,050	
Windage frontal	m²	770	
Wind speed (knots)		**Beam wind force (t)**	
15		15	
20		26	
25		41	
30		59	
35		80	

2.4.5 Whisby Teak

The ship manoeuvring model of the Whisby Teak (Figure 2.3 and

Table 2.2) was produced specifically for this demonstration session and was tested by an experienced Humber pilot beforehand. It was noted that the ship manoeuvring model was realistic, but conservative, particularly in terms of the power delivered by the bow thruster. However, no changes were made to the model's characteristics.

Figure 2.3: Whisby Teak

Table 2.2: Characteristics – Whisby Teak

Characteristic	Unit	100m x 18m Product Tanker – Ballast		100m x 18m Product Tanker – Laden	
Ship type		Product Tanker		Product 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	
Draught forward	m	3.73		6.0	
Draught aft	m	5.83		6.1	
Block coefficient		0.706		0.744	
Displacement	t	6,000		8,000	
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	
Rudder type		Spade		Spade	
Max rudder angle	°	70		70	
Manoeuvring engine order		**RPM**	**Speed (knots)**	**RPM**	**Speed (knots)**
Full Ahead		100	13.1	100	13.0
STOP		0	0	0	0
Full Astern		85	- 7.8	85	- 7.8
Windage					
Windage lateral	m^2	1,133		1,006	
Windage frontal	m^2	320.3		315.4	
Wind speed (knots)		**Beam wind force (t)**		**Beam wind force (t)**	
15		4		4	
20		7		7	
25		11		10	
30		17		15	
35		22		20	

2.4.6 Thames Fisher

The ship manoeuvring model of the Thames Fisher (see Figure 2.4 and Table 2.3) had been used previously in studies at HR Wallingford. A master with experience of the vessel was able to test it during the demonstration. Again, it was noted that the ship manoeuvring model was realistic but conservative, particularly in terms of the power delivered by the bow thruster, which was considered to be too low. Consequently the bow thruster power was increased prior to demonstration session to make it more realistic.

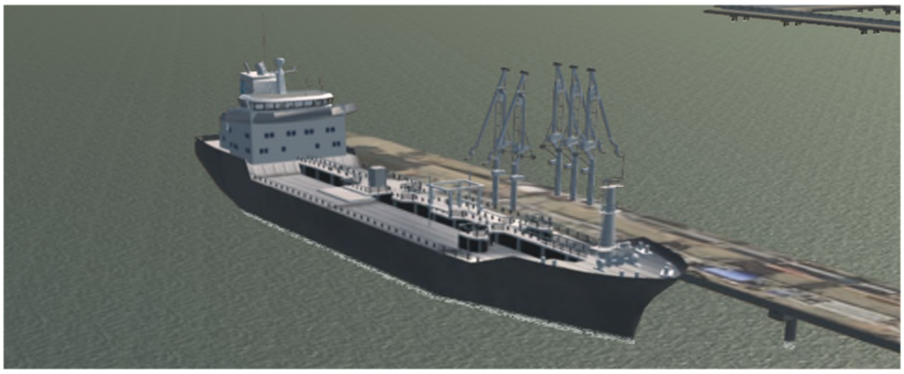

Figure 2.4: Thames Fisher

Table 2.3: Characteristics – Thames Fisher

Characteristic	Unit	Thames Fisher_4.5m		Thames Fisher_6.0m	
Ship type		Product Tanker (Ballast)		Product Tanker (Laden)	
Length overall	m	91.5		91.5	
Length between perpendiculars	m	85		85	
Beam overall	m	15.5		15.5	
Distance bridge to stern	m	19.63		19.63	
Draught	m	4.5		6	
Block coefficient		0.757		0.765	
Displacement	t	4,600		6,200	
Propulsion					
Main engine type		Ruston 8RK270M		Ruston 8RK270M	
Engine power (total)	kW	30000		30000	
No. of propellers, type		1 x CPP		1 x CPP	
Bow thrusters	t	5		5	
Rudder type		Standard		Standard	
Max rudder angle	°	35		35	
Manoeuvring engine order		**RPM**	**Speed (knots)**	**RPM**	**Speed (knots)**
Full Ahead		160	12.4	160	12.5
STOP		0	0	0	0
Full Astern		125	- 7.8	125	- 7.9
Windage					
Windage lateral	m²	564		436	
Windage frontal	m²	187		134	
Wind speed (knots)		**Beam wind force (t)**		**Beam wind force (t)**	
15		2		2	
20		4		3	
25		6		4	
30		8		6	
35		11		9	

2.4.7 Rix Phoenix

The ship manoeuvring model of the Rix Phoenix (see Figure 2.5 and

Table 2.4) was produced specifically for this demonstration session and was tested by an experienced master familiar with the vessel beforehand. It was noted that the ship manoeuvring model was particularly conservative, specifically in terms of the power delivered by the bow thruster and the rate of turn that could be achieved during a swinging manoeuvre. The model was adjusted accordingly, to increase the rate of swing that could be achieved when turning across the current, and the effectiveness of the bow thruster was also increased. After the changes had been incorporated in the model, the master considered the vessel to be more representative, but still conservative and so was more challenging to control than the vessel in reality.

Figure 2.5: Rix Phoenix

Table 2.4: Characteristics – Rix Phoenix

Characteristic	Unit	59m Product Tanker Ballast		59m Product Tanker Laden	
Ship type		Product Tanker (Ballast)		Product Tanker (Laden)	
Length overall	m	58.85		58.85	
Length between perpendiculars	m	57		57	
Beam overall	m	7.6		7.6	
Distance bridge to stern	m	12.2		12.2	
Modelled conditions					
Draught forward	m	2.355		2.93	
Draught aft	m	2.505		3.03	
Block coefficient		0.927		0.756	
Displacement	t	1,000		1,000	
Propulsion					
Main engine type		CAT 3406B		CAT 3406B	
Engine power (total)	kW	0349		0349	
No. of propellers, type		1 x fixed pitch		1 x fixed pitch	
Bow thrusters	t	1		1	
Stern thrusters	t	none		none	
Rudder type		Standard		Standard	
Max rudder angle	°	45		45	
Manoeuvring engine order		**RPM**	**Speed (knots)**	**RPM**	**Speed (knots)**
Full Ahead		610	7.2	610	7.0
STOP		0	0	0	0
Full Astern		610	- 4.7	610	- 4.5
Windage					
Windage lateral	m²	141.1		108.6	
Windage frontal	m²	25.14		21.15	
Wind speed (knots)		**Beam wind force (t)**		**Beam wind force (t)**	
15		1		0	
20		1		1	
25		1		1	
30		2		2	
35		3		2	

2.5 Tugs

2.5.1 45tBP ASD tugs

During the simulation session, up to 2 x 45tBP ASD tugs (see Table 2.5) simulated to support manoeuvres of the Stena Transporter to and from IERRT.

The same tug models were also used to support some manoeuvres made by the Whisby Teak and Thames Fisher to the IOT.

Table 2.5: 45tBP ASD tug

Characteristic	Unit	45t 24m x 9m ASD tug	
Ship type		ASD tug	
Length overall	m	24.4	
Beam overall	m	9.15	
Modelled conditions			
Draught	m	4.8	
Displacement	t	370	
Propulsion			
Main engine type		2 x Cat 3512C	
Engine power (total)	kW	2,460	
No. of propellers, type		2 x Azipod	
Manoeuvring engine order		**RPM**	**Speed (knots)**
Full Ahead		300	12.5
STOP		0	0
Full Astern		300	10.0

2.5.2 Spurn Head 10tBP work boat

Vessels operating at IOT Berth 8 are normally supported by a workboat which is able to deliver 10tBP of support by pushing. As with the previous studies, this vessel was simulated by a 16m long work boat, similar to the Spurn Head vessel. The model was centrally controlled by the Simulator Operator in a realistic manner, in response to the master or pilot's commands.

2.5.3 Tug control

Tugs assisting the vessels in the simulation were centrally controlled by the Simulator Operator following the master or pilot's commands, in a manner similar to that which would be expected in practice, with realistic delays applied. The response of each centrally controlled tug was governed by a tug performance model that ensured the response times and maximum force deliverable by each tug varied 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.

Time delays were automatically simulated in a realistic manner as summarised in Table 2.6. The delay accounts for the period between an order being given by the pilot to the actual full force being delivered in the tow-line or when pushing. This accounts for human response and mechanical lag.

Table 2.6: Tug response times

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

2.5.4 Tug effectiveness

In areas exposed to waves the effective bollard pull of the tugs will be reduced because:

- A proportion of the tug's power is required to keep the tug in position/under control and/or to keep up with the ship's forward and lateral speed.
- The tug is unable to deliver a constant level and angle of thrust due to tug motions and possible line snatching.
- When the tugs are pushing at the ship's side in waves, the relative motion can result in unacceptably high impact loads and degradation as the tug moves relative to the ship's hull.

Furthermore the wave-induced motions of the ship and the tug in any particular sea state are generally different and therefore the tug moves relative to the ship. This particularly affects tugs when pulling on short lines or when pushing onto the ship's hull. In long period waves, the relative motion between the tug and the ship can be less than in short period waves, and hence, tugs are generally more effective in longer period waves that in short period waves.

As the wave height increases, the effective bollard pull for each tug reduces until at a particular wave height the tug will not be effective at all, delivering zero bollard pull. Tugs operating in direct push mode are the most affected and those operating in the indirect assist modes are least affected.

In general, it is accepted that specialist harbour tugs can operate, albeit at reduced effectiveness, in significant wave heights of up to approximately 2.0 to 2.5m when working on a line, and up to approximately Hs 1.0 to 1.5m pushing at the ship's side. Beyond this limit, tug effectiveness becomes more uncertain. As a consequence, in areas exposed to wave action, it is usually more effective to keep the tugs operating on lines. Where tugs are fitted with dynamic (render recovery) winches, this increases their efficiency in waves, as the render recover winch reduces the likelihood of snatch loads in the tow line.

The tugs had their effectiveness degraded automatically when underway, operating in a current or when operating in waves, according to the factors shown in Figure 2.6 and Figure 2.7.

These tug effectiveness curves in waves are based on an extensive study carried out by HR Wallingford, following a survey of 10 tug operators who regularly operate in a range of wave conditions. However, it is acknowledged that they provide a conservative estimate of degradation and therefore tug operations would normally be expected to be more effective in reality.

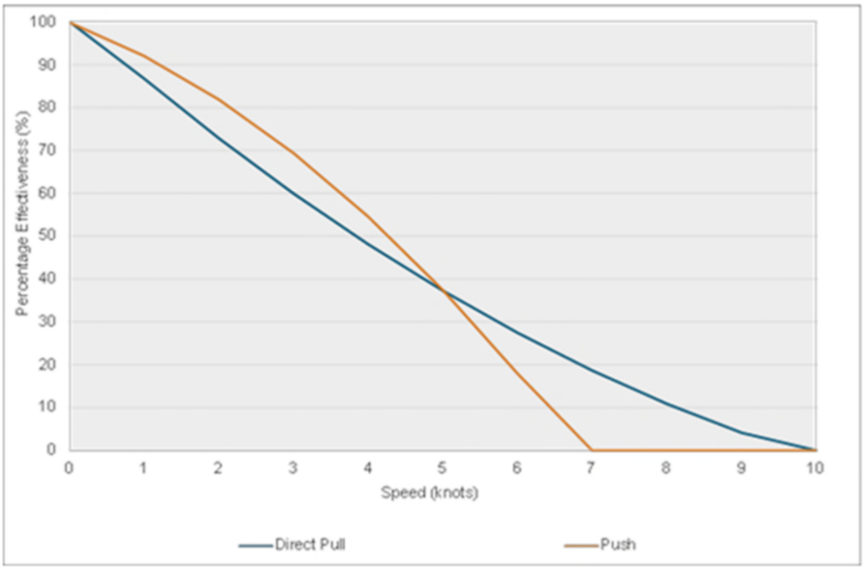

Figure 2.6: Tug effectiveness underway

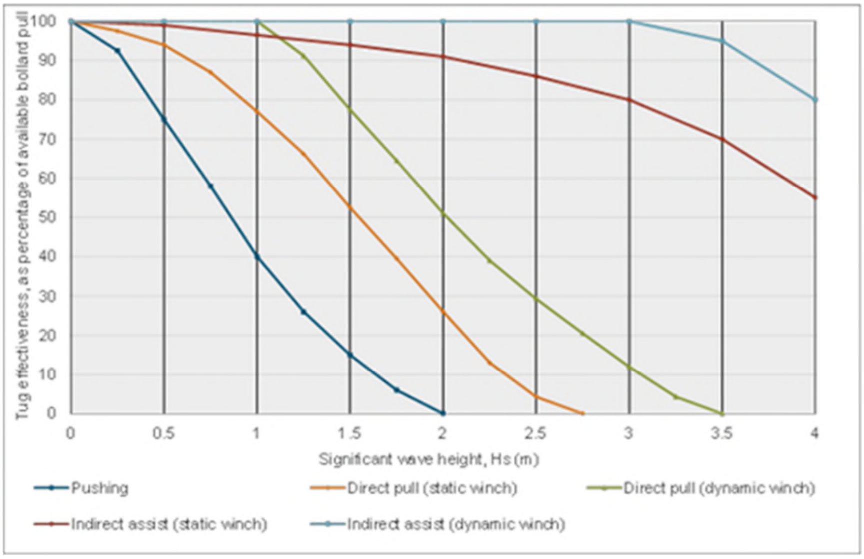

Figure 2.7: Tug effectiveness in waves

3 Navigation simulation

3.1 Simulation session

As previously mentioned, the demonstration simulation session was conducted using real time navigation simulation at HR Wallingford's UK Ship Simulation Centre, using one full mission ship bridge simulator. The demonstrations were directed by staff from ABP, supported by experienced facilitators from HR Wallingford, to ensure that the desired stakeholder engagement was achieved, and the ship manoeuvring models were controlled by suitably qualified pilots and masters.

Stakeholders from APT, DFDS, Nash Maritime, Rix Towage, James Everard Fisher and Stena were present and provided input to the scenarios and their assessment, and all attendees formed the Simulation Team for this work as shown in Table 3.1.

Table 3.1: Simulation Team

Name	Role	Representing
Dr Mark McBride	Group Manager - Ships & Dredging	HR Wallingford
Dr James Clarke	Technical Director - Ships and Dredging	HR Wallingford
Mike Parr	Project Lead	HR Wallingford
Liam Monahan-Smith	Simulator Operator	HR Wallingford
Morgan Robinson	Simulator Operator	HR Wallingford
Oliver Peat	Project Development Manager	ABP
Paul Bristowe	Head of Marine at Humber	ABP
Andrew Firman	Harbour Master at Humber	ABP
Joseph Smith	Pilotage Operations Manager	ABP
Kurt Jensen	Assistant Dock Master	ABP
Ian Cousins	VLS Pilot	ABP
Tim Aldridge	Maine Consultant	ABP Mer
Nigel Basset	Principal Associate Consultant	Nash Consulting
Neal Keena	Marine Superintendent	APT
Gareth Bonner	Tug Master & Marine Advisor	SMA Towage
Mark Hornshaw	Barge Master	Rix Shipping
John O'Sullivan	Master	
Paul Lammers	Fleet Operations Manager	DFDS
Jesper Nielsen	Marine Superintendent	DFDS
Lars Zee	Master (PEC Holder)	Stena
Gi Fewinga	Master (PEC Holder)	Stena
Brian Greenwood	Partner (providing legal advice to DCO process)	Clyde & Co LLP

3.2 Briefing and debriefing

The original run plan was provided by ABP, which was specifically designed to meet the requirements of the demonstration session.

The pilots and tug masters were briefed on the simulation run conditions and objectives before each simulation run. At the end of each run a debrief and discussion was used to capture the views of the pilot and tug masters, and other members of the Simulation Team.

The debriefing discussions considered the events of the run and key conclusions, including any need for repeat runs or any requirement to alter the run schedule. Expertise from across the Simulation Team contributed to this important element of the study.

3.3 Grading of results

As this was a demonstration simulation session, the runs were not formally graded.

3.4 Simulation run summary

A total of 31 simulation runs were completed as summarised in Table 3.2.

Some of the details were amended to assist with the record of the demonstration when compared to the track plots.

3.5 Simulation track and data plots

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

Table 3.2: Simulation run summary

Run ID	Pilot	Manoeuvre	Vessel	Tugs	Tide	Wind	Comment
01	GYF	Arrival	Stena Transporter	None	Peak ebb HW +3	10 knots SW	Familiarisation run, so no significant issues reported.
02	LZ	Arrival	Stena Transporter	None	Peak flood HW -2	10 knots NE	Familiarisation run, so no significant issues reported.
03	GYF	Arrival	Stena Transporter	None	Peak flood HW -2	20 knots NE	No significant issues reported.
04	LZ	Departure	Stena Transporter	None	Peak flood HW -2	20 knots NE	No significant issues reported.
05	GYF	Arrival	Stena Transporter	2 x 45tBP tugs Tug 1: Centre-lead forward (CC) Tug 2: Centre-lead aft (OT)	Peak flood HW -2	30 knots NE	Tugs were available, but not required by the pilot in this scenario.
06	LZ	Arrival	Stena Transporter	2 x 45tBP tugs Tug 1: Centre-lead forward (CC) Tug 2:Starboard quarter (OT)	Peak ebb HW+3	30 knots NE	Tugs were available, but not required by the pilot in this scenario.
07a	LZ	Departure	Stena Transporter	2 x 45tBP tugs Tug 1: Centre-lead forward (CC) Tug 2: Starboard quarter (OT)	Peak flood HW -2	30 knots NE	It was noted that when departing on the flood, it might be more appropriate to allow the ship to transition further north before commencing swing.
07b ~~(Run 8 on TP)~~	GYF	Departure	Stena Transporter	2 x 45tBP tugs Tug 1: Centre-lead forward (CC) Tug 2: Starboard quarter (OT)	Peak flood HW -2	30 knots NE	Allowing the vessel to be manoeuvred further north away from Immingham East Jetty makes the swing more comfortable in the space available.
08 ~~(Run 8A on TP)~~	LZ	Departure	Stena Transporter	2 x 45tBP tugs Tug 1: Centre-lead forward (CC) Tug 2: Centre-lead aft (OT)	Peak ~~flood~~ebb HW ~~-~~+3	30 knots NE	No significant issues reported.
09	LZ	Arrival	Stena Transporter	-	Peak flood HW -3	20 knots ~~225~~SW	No significant issues reported.

Run ID	Pilot	Manoeuvre	Vessel	Tugs	Tide	Wind	Comment
10	GYF	Departure	Stena Transporter	-	Peak flood HW -3	20 knots ~~225~~SW	No significant issues reported.
11a	LZ	Arrival	Stena Transporter	2 x 45tBP tugs Tug 1: Starboard shoulder (CC) Tug 2: Starboard quarter (OT)	Peak flood HW -3	30knots SW	Run was aborted to allow Pilot to establish a better setup for the initial swing. No particular issues identified.
11b	LZ	Arrival	Stena Transporter	2 x 45tBP tugs Tug 1: Starboard shoulder (CC) Tug 2: Starboard quarter (OT)	Peak flood HW -3	30 knots SW	Turning more directly towards Immingham harbour enabled a more efficient swing.
12	GYF	Departure	Stena Transporter	2 x 45tBP tugs Tug 1: Starboard shoulder (CC) Tug 2: Starboard quarter (OT)	Peak ebb HW+3	30 knots SW	No significant issues reported.
13	IC	Test anchoring procedure	Stena Transporter	-	Peak ebb HW+2	10 knots SW	Run to establish procedure and settings for anchor simulation.
14	LZ	Full control and power failure during berthing	Stena Transporter	-	Peak ebb HW+2	10 knots SW	Full power and control failure initiated with environmental forces setting the vessel towards IOT finger pier. Vessel stopped within 50m of failure position.
15	LZ	Full control and power failure during berthing	Stena Transporter	-	Peak ebb HW+2	20knots SW	Full power and control failure initiated with environmental forces setting the vessel towards IOT finger pier. Vessel stopped within 70m of failure position.
16	IC	Arrival	Whisby Teak	1 x 16tBP workboat Tug 1: Port quarter (CC)	Peak ~~ebb~~flood HW~~+2~~-3	20 knots SW	No significant issues reported.
17	JS	Arrival	Thames Fisher	-	Peak ~~ebb~~flood HW~~+2~~-3	20 knots SW	No significant issues reported.
18	IC	Departure	Whisby Teak	1 x 16tBP workboat Tug 1: Port quarter (CC)	Peak flood HW -3	20 knots SW	No significant issues reported.

Run ID	Pilot	Manoeuvre	Vessel	Tugs	Tide	Wind	Comment
19	IC	Arrival	Whisby Teak	1 x 16tBP workboat 1 x 45tBP tug Tug 1: Port midships (CC) Tug 2: Centre-lead aft (OT)	Peak flood HW -3	30 knots SW	Pilot assessed that he was able to satisfactorily manage the lateral speed of the vessel onto the roller fender.
20	IC	Departure	Whisby Teak	1 x 45tBP ASD tug 1 x 16tBP workboat ATD Tug 1: Port Midships (CC) Tug 2: Centre-lead aft (OT)	Peak flood HW -3	30 knots, SW	No significant issues reported.
21	IC	Arrival	Whisby Teak	1 x 45tBP ASD tug Tug 1: Starboard midships (OT)	Peak flood HW -3	30 knots, NE	No significant issues reported.
22	IC	Departure	Whisby Teak	1 x 45tBP ASD tug 1 x 16tBP workboat ATD Tug 1: STBD midships (OT) Tug 2: Port shoulder (CC)	Peak flood HW -3	30 knots NE	No significant issues reported.
23	MH	Arrival	Rix Phoenix	1 x 16tBP workboat ATD Tug 1: Port shoulder (CC)	Peak flood HW -3	10 knots SW	Master was disorientated with simulation perspective so rerun in Run 25.
24	MH	Arrival	Rix Phoenix	1 x 16tBP workboat ATD Tug 1: Port shoulder (CC)	Peak ebb HW+2	10 knots SW	Master was not expecting the effect of wind as vessel cleared end of the jetty, resulting in contact with berthed vessel on IOT, so rerun in Run 26.
25	MH	Arrival	Rix Phoenix	1 x 16tBP workboat ATD Tug 1: Port shoulder (CC)	Peak flood HW -3	10 knots SW	Run aborted as the master was disorientated with the simulation perspective, so rerun in Run 26.
26	MH	Arrival	Rix Phoenix	1 x 16tBP workboat ATD Tug 1: Port shoulder (CC)	Peak flood HW -3	10 knots SW	Master assessed that there was sufficient space to manoeuvre between IOT and IERRT and swing for arrival.
27	MH	Arrival	Rix Phoenix	1 x 16tBP workboat ATD Tug 1: Port shoulder (CC)	Peak ebb HW+2	10 knots SW	Master confident in ability to control the vessel bow into to tide to achieve an appropriate position for approach to the berth.

Run ID	Pilot	Manoeuvre	Vessel	Tugs	Tide	Wind	Comment
28	MH	Departure with 100m berthed on 8	Rix Phoenix	1 x 16tBP workboat ATD Tug 1: Port shoulder (CC)	Peak ebb HW+2	Managed up to 25 knots SW	Vessel passed close to tanker on IOT. Master considered that he could have initially manoeuvred further to the south of IOT before passing the tanker, which would have alleviated the issues experienced.
29	MH	Departure with 8 berthed	Rix Phoenix	1 x 16tBP workboat ATD Tug 1: Port shoulder (CC)	Peak ebb HW+2	Managed up to 30 knots SW	Vessel passed close to tanker on IOT. Master considered that he could have initially manoeuvred further to the south of IOT before passing the tanker, which would have alleviated the issues experienced.
30	IC	Arrival	Whisby Teak	1 x 45tBP ASD tug 1 x 16t ATD workboat Tug 1:Starboard shoulder (OT) Tug 2:Port midships (CC)	Peak flood HW -3	30 knots SW	Pilot assessed that he was able to satisfactorily manage the lateral speed of the vessel onto the roller fender.
31	JO	Arrival	Thames Fisher	1 x 45tBP ASD tug Tug 1: Starboard quarter (CC)	Mean spring flood	20 knots SW	No significant issues reported.

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4 Key observations

The key observations from the demonstration simulation session, with respect to the demonstration runs involving the Stena Transporter RoRo ship, were as follows:

- Overall it was noted that manoeuvring to and from the new infrastructure is challenging – as with many other berthing manoeuvres - requiring precise positioning of the vessel, tugs, and their attitude to the tidal flow and the wind. Mitigating the inherent risk in the manoeuvring operations will require a robust training solution to be in place.
- Overall the Stena Transporter was less challenging to operate to and from the IERTT than the 237m long RoRo vessel used as the design vessel in previous studies. It required less powerful tug support and indications were that it would be able to operate independently in winds in excess of 25 knots.
- Any new class of vessel, and potentially individual ships within a class, will need to have appropriate operating limitations and procedures developed and reviewed. This is considered normal best practice at any berth, but the precise navigation required, combined with the strong currents at the site, makes this a particularly critical feature for safe operations at IERRT.

With respect to demonstrating the effectiveness of proposed risk mitigation measures in the event of a serious breakdown during the approach to IERRT:

- The outcome after a serious breakdown is nearly always entirely dependent on where in the manoeuvre it occurs, the prevailing conditions and the actions taken. In this case the breakdown was defined as a total ship control and power failure during the final stages of an approach to IERRT Berth 1, with the environmental conditions setting the vessel towards IOT. Masters with experience of the vessel being simulated noted that the breakdown would be highly unlikely due to the level of redundancy and equipment/system duplication inherent in the vessel's design. Nevertheless, it was agreed that a reasonable action would be to attempt to stop the ship using both anchors and that initiating this action should be delayed 20 seconds after the breakdown, to simulate the time for a master to recognise the breakdown and decide on an action plan in reality, if it happened unexpectedly.
- During the 2 runs that simulated breakdowns, the vessel was stopped within 100m of the position where the breakdown was initiated. To develop a scenario in which contact with the IOT would be likely, the vessel would need to be approaching significantly outside its normal line and at a point where the stern would normally be approximately 20m from the desired berthing position.

With respect to the Whisby Teak and Thames Fisher product tankers operating to and from IOT Berth 8, with the IERTT infrastructure in place:

- It was demonstrated that the Whisby Teak and Thames Fisher ships can be operated to and from the IOT berth in winds of up to 30 knots. It is recommended that the existing operating wind limit, for vessels arriving in south-westerly winds (setting onto the berth) of 25 knots gusting 30 knots, is maintained. This class of vessel has limited control of the bow in stronger winds, and with the size of the vessel and the lack of suitable tugs to assist at the bow, means this will remain an appropriate limit.
- A wind sheltering simulation was used to represent the increased lateral drift experienced by a vessel as it transits out of the lee of a larger vessel. In this case:
  - The sheltering model was considered to be indicative and was deliberately set to be conservative, as the fluid dynamics of air passing around a large object and their effect on a passing ship is difficult to accurately model without detailed full scale measurements, particularly in a dynamic simulation.
  - Using the sheltering simulation, it was possible to demonstrate some of the navigation strategies a product tanker could use to manage the effect as it cleared the stern of a large RoRo ferry berthed on IERRT.

- The pilots and masters were able to use techniques to mitigate the sheltering effect and berth safely at IOT, despite the variation in wind strengths simulated. It was noted that the sheltering simulation was considered to adequately represent conditions that were apparent at other berths on the River Humber, and at the entrance to Immingham Lock.

With respect to bunker barge operations to and from IOT Berths 8 and 9:

- It was noted that APT do not impose formal environmental limits on bunker barge operations to and from IOT. Instead the master of the barge is responsible for considering the safety of the manoeuvre, based on the prevailing circumstances and conditions, in consultation with the marine superintendent.
- There was no detailed trails data available on which to verify the vessel manoeuvring model produced for the bunker barge, however, its manoeuvring ability was verified by the experienced master who attended the study. The model was assessed as being adequately representative for the purposes of the study, but was considered to be conservative, particularly in terms of the time taken to swing and the power provided by the bow thruster. The decision was made to maintain these conservative features as long as they did not have an overall detrimental effect on the simulation run outcomes.
- Despite the conservative manoeuvring characteristics of the bunker barge, the master was able to manoeuvre it safely between the IERRT and the IOT with vessels berthed on both adjacent structures.
- Correspondingly, the master of the bunker barge considered that the simulated model was more difficult to navigate than in reality, and that given the space available between the other moored vessels, it would be feasible to arrive and depart on peak flood and ebb tides.
- It was noted by that the main challenge with respect to arrivals and departures at IOT Berth 9 was the available space on the jetty with a tanker already moored on Berth 8. At present this situation may result in the barge master deciding to wait for the environmental conditions to change, or for the adjacent tanker to depart. This would still be the case with IERRT in place.

5 References

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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.

Appendices

A Ship and tug simulation at HR Wallingford

B Simulation track and data plots

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