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TABEER
ENERGY

Tabeer Energy (Private) Limited
Application for OGRA Construction License

Annexure C: Technical Brief

Sub-Annexures: C1 – C21

CONFIDENTIAL

8416

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TABEER ENERGY	0-8069-20	S-000-13M0-212	1

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PREP'D	N. Inoue	
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NAVIGATION SIMULATIONS STUDY

Tabeer LNG Project / FEED

FOR FINAL FEED

REV.	Date	Page	DESCRIPTION	PRE'D	CHK'D	APP'D
0	10-Mar-19	ALL	Issue for Review	N. Inoue	K.Uchino	K.Kou
1	15-Aug-19	ALL	Issue for Final FEED	F. Cogordan	K.Uchino	K.Uchino

JGC CORPORATION

Contents

1. INTRODUCTION

1.1. Background

JGC Corporation is responsible for the FEED of the proposed LNG Terminal at Pakistan using Floating Storage Regasification Unit (FSRU) technology (hereinafter referred as "the Project") owned by Mitsubishi Corporation.

1.2. Objectives of Study

The main objectives of the channel modeling and simulation report was:

- Assessment of the risk to plant associated to dangerous liquid or gas release and resulting hazardous scenarios;

1.3. Scope

The scope of work of the Navigation Simulation includes the following studies:

- The navigation study was to preliminary assess the technical and safety aspects of the proposed berth related to navigation though the Chann Wadoo Channel and the berthing and unberthing of different types and sizes of LNG carriers

2. ATTACHMENTS

Attachment-1 Navigation Study Report

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JGC Corporation
Karachi, Pakistan

Navigation Simulations for Tabeer LNG Terminal at Port Qasim

Navigation Study Report

Doc. No. P0014168-1-H1 Rev. 4 – July 2019

Rev.	4
Description	Issued for Approval
Prepared by	N. Vattuone
Controlled by	A. Rossi
Approved by	S. Cappellozza
Date	25/07/2019

Navigation Simulations for Tabeer LNG Terminal at Port Qasim

Navigation Study Report

Rev.	Description	Prepared by	Controlled by	Approved by	Date
4	Issued for Approval	N. Vattuone	A. Rossi	S. Cappellozza	25/07/2019
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ABBREVIATIONS AND ACRONYMS

AIS	Automatic Identification System
ARPA	Automatic Radar Plotting Aid
ASD	Azimuth Stern Drive Tug
AtoN	Aids to Navigation
BP	Bollard Pull
CD	Chart Datum
CLIENT	JGC Corporation
CONSULTANT	RINA Consulting S.p.A.
ECDIS	Electronic Chart Display and Information System
FSRU	Floating Storage Regasification Unit
HAZID	Hazard Identification Study
HAZOP	Hazard and Operability Study
HIPPS	High Integrity Pressure Protection System
HSE	Health Safety Environment
LAT	Lowest Astronomical Tide
LNG	Liquefied Natural Gas
LNGC	LNG Carrier
LPG	Liquefied Petroleum Gas
N	North
NE	North East
NG	Natural Gas
ORF	Onshore Receiving Facilities
PQA	Port Qasim Authority
QRA	Quantitative Risk Analysis
RADAR	Radio Detection and Ranging
R&D	Research and Development
S	South
SOLAS	Safety of Life at Sea
SOP	Standard Operating Procedures
StS	Ship to Ship
SW	South West
UKC	Under-Keel Clearance

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1 PROJECT DESCRIPTION

Tabeer Energy (Private) Limited intends to develop a FSRU based LNG import terminal at Port Qasim. The terminal will receive, re-gasify and transport re-gasified LNG (i.e. natural gas) via pipeline to a delivery point onshore.

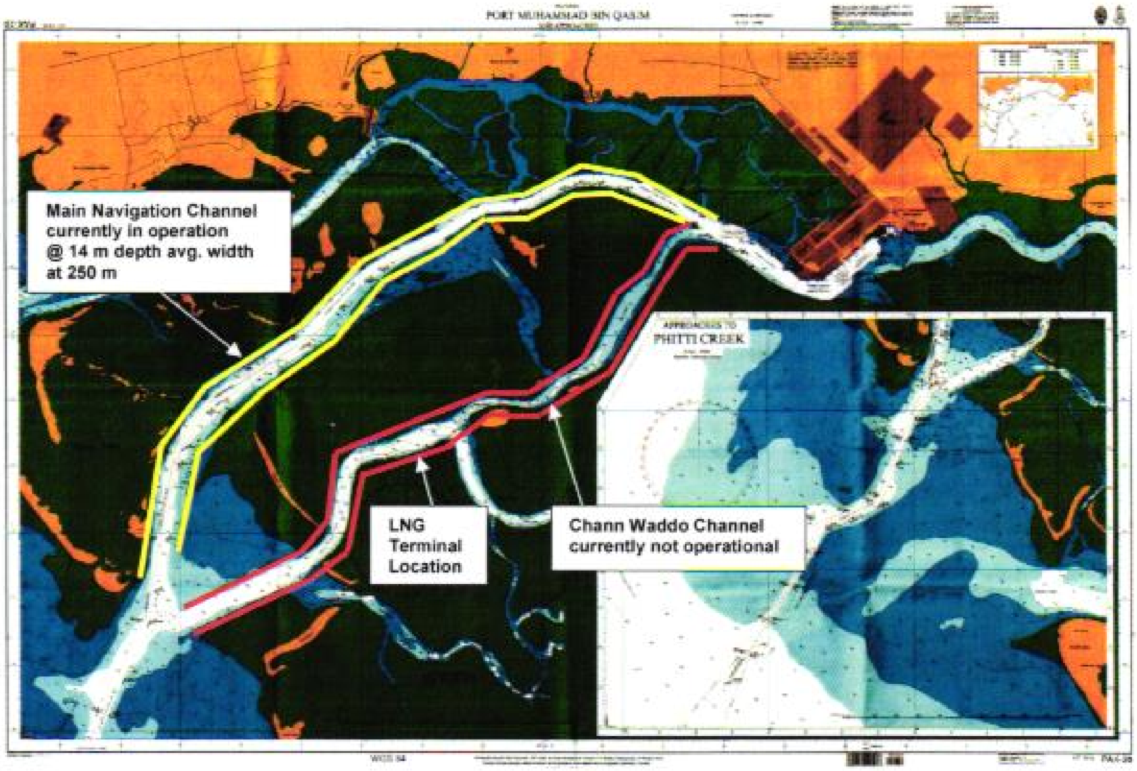

Figure 1.1: Port Qasim LNG Terminal Site

The LNG import terminal will be located at Port Qasim, in Chann Waddo Channel that currently is not in operation. Presently, the LNG carrier traffic is fully managed through the Main Channel for both entrance and exit manoeuvers due to the fact that it is the only one in operation.

It is envisaged that a 170,000 m^3 FSRU will be permanently moored at single berth jetty, the LNG transfer from the LNGCs to the FSRU will be carried out in side-by-side configuration.

The LNG is loaded into FSRU cargo tanks, in which the LNG is pumped up to required pressure and vaporized by means of seawater. Then, vaporized gas is send to Onshore Receiving Facility (ORF) through HP Loading Arms and new pipeline. In addition, power generation, service water, nitrogen and fire water system are installed on Offshore Platform.

The proposed LNG jetty to be built by Project proponents will be located in the south part of Chann Waddo Channel, nearby the connection with "LNG Zone".

The proposed location for the LNG terminal are N 2 735 081.214 E 319 481.630 (UTM 42N) (see Figure 1.1).

2 SCOPE OF THE DOCUMENT

RINA Consulting S.p.A. (in the following RINA Consulting) has been awarded a contract form JGC Corporation (In the following Client) in order to further investigate the feasibility and optimize the strategy of the navigation of different sizes of LNG Carriers to and from the new FSRU based terminal to be installed at Port Qasim as described in Section 1.

In 2018 RINA has already carried out a Real Time simulation session in order to preliminary investigate the feasibility of such section of the channel to a safe navigation of a proposed set of LNGCs based on simplified assumption on the creek current regimes of the area.

The aim of the present report is to describe the methodology, the simulation tool and the results of the navigation study performed in the simulation session held in Genoa from 25[th] to 29[th] March 2019 based on the results of the previous session as well as new project information made available by Client.

In fact, it has to be highlighted that for this real time navigation session the following project documents/data have been made available and relevant results have been considered during the execution of this session:

- ✓ Fast time simulations report (performed by others);
- ✓ Hydraulic simulation of the Port Qasim Area in Mike21 output file (performed by others);
- ✓ Real Time Navigation report for pre-FEED stage (performed by RINA Consulting).

In light of that, the scope of the present navigation study was to optimize the outcomes of the previous session and identify the most appropriate navigation strategy related to navigation through the Chann Waddo Channel and the berthing and unberthing of different types and sizes of LNG carriers.

Furthermore, an investigation of the ideal tidal window for berthing and unberthing manoeuvre has been carried out in order to identify the most suitable timing of the ship calls throughout the whole range of tide variation (12 hours semi–diurnal) for the different sizes of LNGCs considered. Although this was the basic manoeuvring strategy to be investigated, some dedicated runs for the departure of the LNGCs from the berth with peak current conditions have been tested in order to understand how to handle the ship in such occasion of general emergency scenario on the berth.

Finally, upon Client request, a dedicated investigation of the swinging manoeuvre at the turning basin has been carried out in order to understand if an optimization of the dredged surface could be possible. Basic swinging basin dimensions assumed in the modelling of the scenario are reported in the below figures and sections. This evaluation has been carried out for the different sizes of LNGCs and at different times of the tidal cycle.

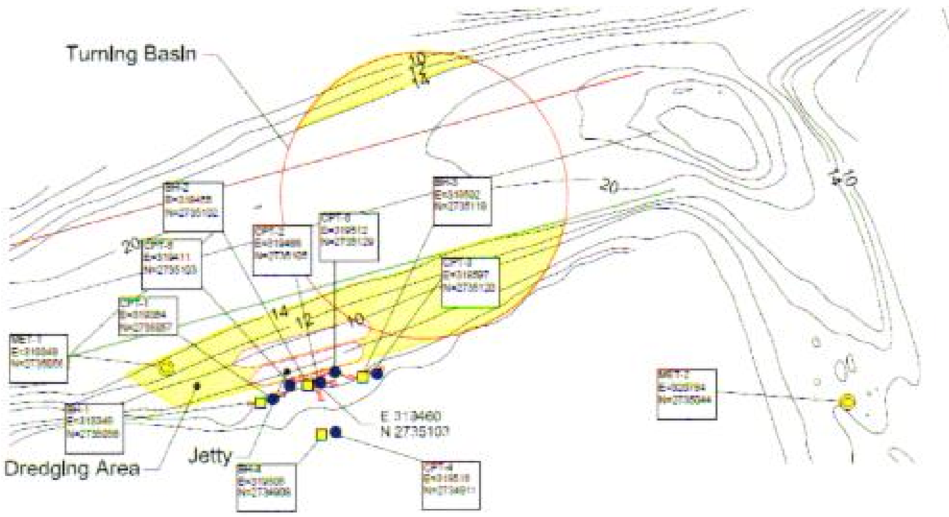

Figure 2.1: LNG Terminal Location

The present report should be read in conjunction with the previous Real Time navigation report (doc N° P0009270-1-H3-Navigation Study Report_Rev3 dated November 2018). All the assumptions relevant to Manoeuvring strategy, safety distances from the jetty, adequacy of the tugs currently operating in the LNG Carriers manoeuvers at Port Qasim, navigation channel and swinging basin dimensions, preliminary navigation aids and ship mathematical models have been kept in accordance with what has been already done in the previous simulations session report (ref [14]).

In particular, it is highlighted that the navigation channel width in correspondence of the bends has been considered as per the outcomes of the previous navigation study. Therefore, its width has been optimized in order to increase the radius of the bend as much as possible, without the need of additional dredging works (following the current natural depth of the creek).

This document does not provide any information or estimation related to any dredging works, which may be necessary in order to improve the safety and repeatability of arrival and departure manoeuvers from/to the proposed locations. Consultant, according to the international standards, determined the dimensions required for the channel to allow the ships sail through, however no detailed calculation of dredging quantities, with reference to the actual bathymetry profile, have been performed.

3 EXECUTIVE SUMMARY

RINA Consulting have undertaken a technical study to analyse, from a navigational point of view at FEED stage, the following main topics:

- optimization of the outcomes of the previous session and identification of the most appropriate navigation strategy related to navigation through the Chann Waddo Channel and the berthing and unberthing of different types and sizes of LNG carriers;
- investigation of the ideal tidal window for berthing and unberthing manoeuvre in order to identify the most suitable timing of the ship calls throughout the whole range of tide variation (12 hours semi–diurnal) for the different sizes of LNGCs considered;
- dedicated investigation of the swinging manoeuvre at the turning basin in order to understand if an optimization of the dredged surface could be possible.

The simulation session has been performed in Genoa from 25th to 29th March 2019 by means of a Full Bridge Simulator qualified as Class C developed by Transas.

Transas is one of the most important simulation tool provider and has a large number of applications all around the world for both Port Assessment and Crew Training session purposes. The mathematical model at the base of the software is able to accurately represent a realistic hydrodynamic behaviour of the simulated vessels including ship to ship interaction, bank and squat effects, loads coming from external excitations etc. In addition, it is able to guarantee a realistic virtual environment and radar representation of the simulated scenario.

Figure 3.1: Number of Transas Simulator Installations Worldwide

The simulation runs have been performed by an experienced and highly qualified Ship Pilot:

- Capt. Ian Simpson (an active pilot with experience of manoeuvring LNG Carriers, STS LNG operations and wide experience of conducting simulation studies of this nature).

An overall number of 30 simulation runs have been performed during the workshop, mixing different parameters (i.e. 2 different wind incoming directions, flood and ebb tide current directions and magnitudes at different times of the tidal cycle and 4 LNG vessel types in both ballast and loaded condition) in order to investigate different potential operational and emergency situations.

The outcomes of the present report should be read in conjunction with the previous Real Time navigation report doc N° P0009270-1-H3-Navigation Study Report_Rev3 dated November 2018, Ref [14].

3.1 MAIN OUTCOMES

The overall feasibility of navigation of Chann Waddo Creek is further confirmed for each of the vessels assessed within the existing environmental guidelines in force for navigation of the Main Navigation Channel and taking account of the new current flow data supplied.

The proposed configuration of Chann Waddo Channel is suitable for the navigation of 130k m^3 Membrane type and 170k m^3 Moss type LNG carriers under the existing wind limitations as per in force SOPs (not exceeding 20 knots) at all times of the tidal cycle. This is a fundamental result affecting the overall terminal availability as the majority of the LNGCs presently operating in the world fleet are within this size range and could therefore reach the berth during the operating daylight window with no additional limitations. Existing port SOP's require daylight transits of LNG vessels.

For Q-Max and Q Flex sized vessels, whilst the navigation of Chan Waddo Creek is feasible, it may be necessary, for the reasons detailed below, to impose limitations on the times within the tidal cycle at which the Creek transits should be undertaken.

The execution of the runs highlighted that for safe navigation throughout the channel for all the LNGCs types and sizes, a precise manoeuvring strategy is required particularly in terms of the transit speed in the different sections of the channel.

The flood current regime has been identified as the most demanding scenario for arrival manoeuvres whilst the ebb current is most demanding for vessel departures.

The maximum environmental conditions in which LNGCs may currently be moved are detailed in in the existing Port Qasim Standard Operating Procedures. Revised current flow data used in this study is derived from the hydraulic studies provided by Client (in particular current charts for the whole tidal range cycle). It has to be highlighted that the hydrodynamic database concerning current flow direction and magnitude within the area, provided to RINA Consulting, may not take into account the possibility of enhanced flow magnitudes which can be experienced during occurrence of South West monsoon period, because it has been considered unsuitable the entrance and navigation of the channel by LNGCs.

For more detail on the current flow model please refer to Section 4.7.1.

For Q-Max and Q Flex sized vessels, it has been shown that though the runs performed indicate the vessels may be maintained within the proposed channel width, vessels may come within an unacceptable proximity to the boundary of the channel (as the simulation track plots show that these vessels drift close to the extremities of the bends). Creek transits in the maximum following current are highly demanding as the vessels are set to the extremities of the bends and therefore the risk of grounding is significantly enhanced. However, these size and type of vessels are not widely employed in the world LNGC fleet, being mostly confined to specific routes. It is likely that a visit by such vessels would be rare. In light of the two observations above, it is therefore recommended that should vessels of this type be required to be accommodated at the berth, special planning regarding the transit is undertaken to avoid navigation through the 2 bends of Chan Waddo Channel in the most extreme current conditions. In this case the present LNGC transit scheduling, as detailed in the current SOPs should be applied, foreseeing the arrival in the turning basin or departure from the jetty at or around slack high water which occurs at approximately 1 hour before the time of high water at the berth.

The flood current regime has been identified as the most demanding scenario for arrival manoeuvres whilst the ebb current is most demanding for vessel departures. This is because current acting from astern of the vessel is the condition which minimizes the manoeuvring capabilities of a ship and the current acting on the vessels causes a lateral drift when navigating the channel bends. In view of this, several of the arrival runs have been performed with the most adverse creek current conditions available in order to fully test the proposed navigation through the channel. From the presented Clients hydrodynamic database, these most adverse conditions have been identified as occurring around 3 hours before High Tide Slack water at the swinging basin.

The runs have demonstrated that the whole range of vessels tested can safely undertake the arrival transit through the channel (in the current flow limitations stated above for the different size of vessels), however to safely undertake the transit of the Creek it has been necessary to limit the transit speeds as follows, from inbound passage:

- ✓ Entering Chan Waddo Channel to proposed buoy number 4; not more than 10 knots (for more detailed position of this buoy please refer to Figure 4.12);
- ✓ Navigating first inward bend and Creek to approach toward second inward bend; not more than 8 knots;
- ✓ Navigating second inward bend not more than 6 knots;
- ✓ Passing FSRU site and entering swing area; not more than 3 knots;

To retain full control these speeds must also be maintained for the outbound passage of the vessels.

It has been determined that if these speeds are exceeded it is not possible to safely navigate the channel bends or stop the vessel prior to swinging and approach the berth. Should these speeds be exceeded the escort tug required under the existing procedures will also be limited in its ability to assist the vessel if required. Maintaining these transit speeds for each of the vessels will also ensure the ship will generate the lowest swept path, which will minimise any required dredging, particularly in the channel bends.

For vessels navigating the Creek, a tethered escort stern tug, as presently required by PQA SOPs, is suitable to assist all LNGCs. For arrivals, the stern tug should be made fast in the straight section before the first bend. A second tug should be available prior to the second inward bend to assist the LNGC as required.

It is confirmed that the tug configuration (number, size and power) currently foreseen by PQA SOP to assist LNGCs, are sufficient to safely handle all types of LNG carriers during swinging, mooring and unmooring operations at the LNG berth.

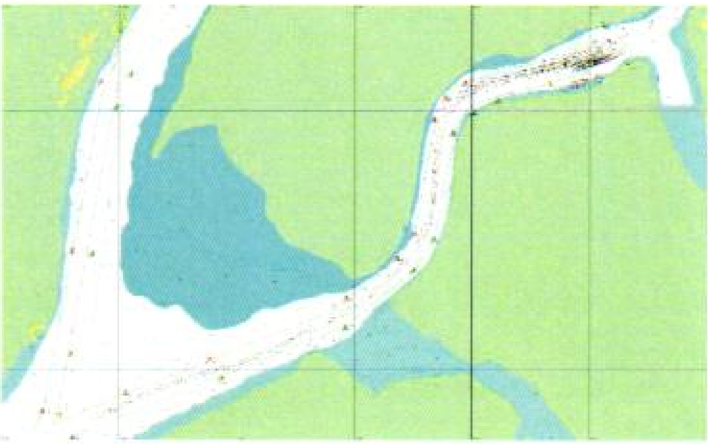

Figure 3.2: Example of Arrival Manoeuvre – Q-Max in the Most Demanding Flood Current Regime

The departure manoeuvre is achieved by detaching the LNG Carrier from the berth, which is then towed to a position, approximately 100 meters away from the berth from which it may move forward and begin the outward passage of the Chann Waddo Creek out to sea. Once the ship begins the outward transit of the exit channel the two beam tugs and the forward tug can be released, the stern tug remains attached in escorting configuration in line with existing procedures.

The runs performed have demonstrated that all the LNGCs can be safely unmoored from the berth also in maximum adverse current speed but the subsequent navigation in the creek is highly demanding in such current regime especially for the Q-Max vessels, as noted above.

The simulations have demonstrated that all ship sizes can be safely unmoored from the berth in all conditions in the event of a potential emergency. It is recommended that once unmoored from the berth the LNGC should not attempt to navigate the creek in peak current flows but should wait for a more favourable current regime before undertaking the transit, for the reasons noted above. It is possible to maintain the LNGC under full control at a safe location adjacent to the berth in adverse environmental conditions whilst awaiting favourable conditions for the transit.

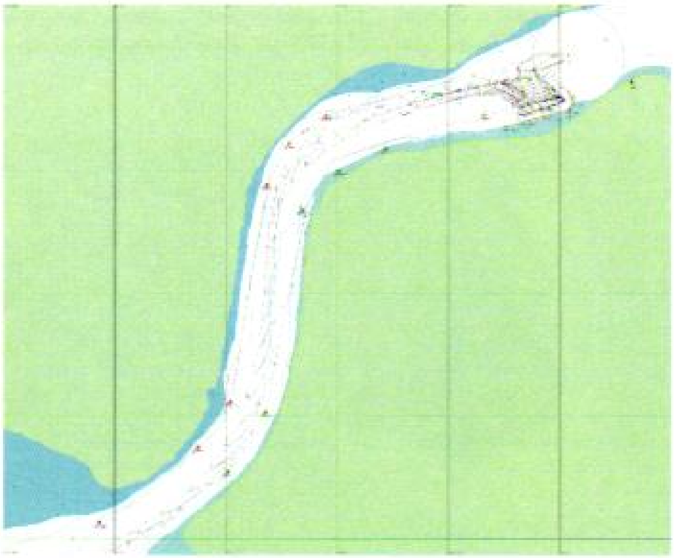

Figure 3.3: Example of Departure Manoeuvre – 170k in the Most Demanding Ebb Current Regime

Finally some dedicated runs in the last section of the channel /swinging basin have been performed. In this way it has been verified that in case the ship are scheduled in accordance with the current SOPs practice (reaching the swinging basin in a time between one hour before HAT slack water and slack water) the spaced required to all types of vessel to be swung is significantly reduced compared to the theoretical one.

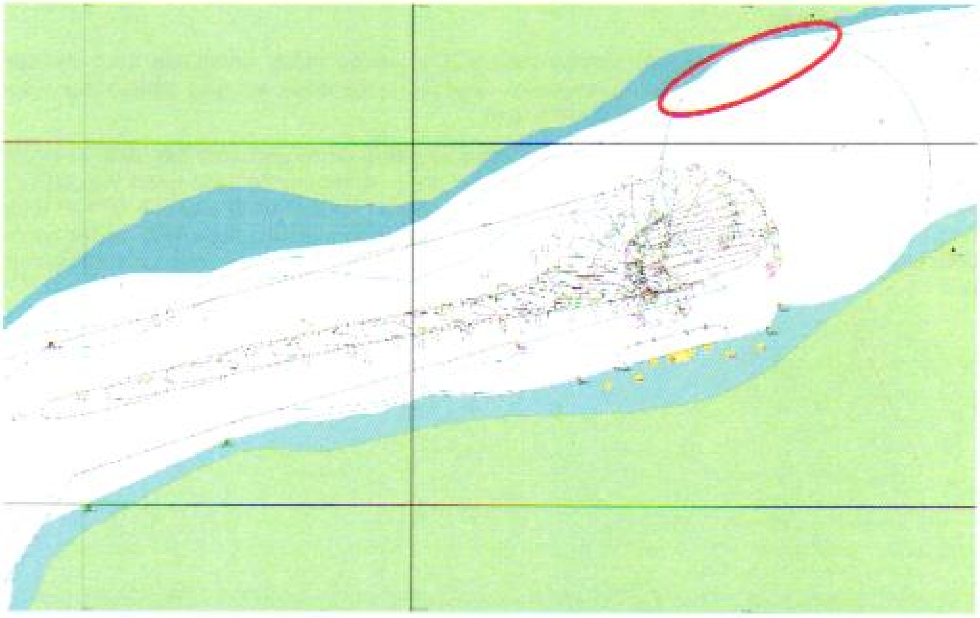

Figure 3.4: Example of Arrival Manoeuvre – Q-Max in Ideal Tidal Timing at the Swinging Basin

As can be noted from the plot above, provided that the ship reaches the swinging basin in the optimal tide window, a significant space of the theoretical swinging basin area could be saved, potentially avoiding some dredging works in the north side of the basin.

4 NAVIGATION STUDY

4.1 PROJECT LOCATION

A new Liquefied Natural Gas (LNG) Terminal is proposed to be built at Port Qasim, Pakistan. Figure 4.1 reported the location of the proposed Tabeer LNG terminal that will be built in Chann Waddo Channel.

Figure 4.1: Port Qasim Area and Jetty Proposed Location (Ref.[12])

Presently Chann Waddo Channel is not operational so that no presence of aids to navigation is foreseen in the area.

The water depth in some parts of the channel is not sufficient to allow Q-Max vessels to sail through the creek and reach the berth. Therefore, for the simulation purpose it has been assumed that the navigation channel has a water depth of 14 meters referred to LAT. It is highlighted that the bathymetry provided by Client at time of simulations was relevant to some parts of the channel only so that, for the next phase, a bathymetric survey for the whole channel from entry up to proposed Tabeer Terminal is further recommended.

4.2 BERTHING STRUCTURE

The overall layout of loading platform, breasting structures and mooring dolphins has been modelled according to available information and previous experience for similar projects since in this early design phase not all needed information were available.

However, a standard LNG jetty configuration suitable for the FSRU sizes proposed has been considered during the modelling of the environment. It is highlighted that such configuration has been customized according to the information reported in Figure 4.2 provided by the Client.

The proposed location for the LNG jetty is N 2 735 081.214 E 319 481.630 (UTM 42N) as indicated in Figure 4.1.

Figure 4.2: Jetty Layout (Ref.[8])

The berth orientation (approx. 080 N°) has been considered along the navigational direction at the specific proposed location. According to information provided by the Client, the minimum distance to be kept between the centre of the channel and the LNGC manifold is 250 meters.

Figure 4.3: Jetty Location Respect to the Middle of the Channel (Ref.[12])

4.3 CHANN WADDO CHANNEL GEOMETRY

Chann Waddo Channel is a channel with two natural bends, the first one in the proximity of the entrance of the channel and the other one is the proximity of the proposed berth location.

Herebelow is reported an extract of British Admiralty nautical chart no.59 that highlights the area between buoy no.15 and the entrance of Chann Waddo Channel.

According to the bathymetry profile provided in the nautical chart, in some parts of this area the water depth is less than 14 meters, so that some dredging works should be performed in order to guarantee a water depth of 14 meters respect to LAT and allow the entrance of ships up to Q-Max size. (Refer the blue area in Figure 4.4).

However, considering that the channel is not operated, it is highly suggested to perform a complete bathymetry survey of the whole area of interest for the project.

Figure 4.4: Nautical Chart No. 59 – Chann Waddo Channel Outside Area

The entrance of the channel is straight and has a natural width appropriate to handle the LNGCs up to Q-Max size.

Moving to north east, there is the first bend of the channel, highlighted in green in Figure 4.5 and the second bend highlighted in light blue.

From a preliminary evaluation of the natural radius and width of the first bend, it seems to be adequate to handle vessels with main dimensions similar to the ones requested for this project. While the second bend is indeed more tight with regards to the curvature radius, making it more difficult to turn around this bend compared to the first one.

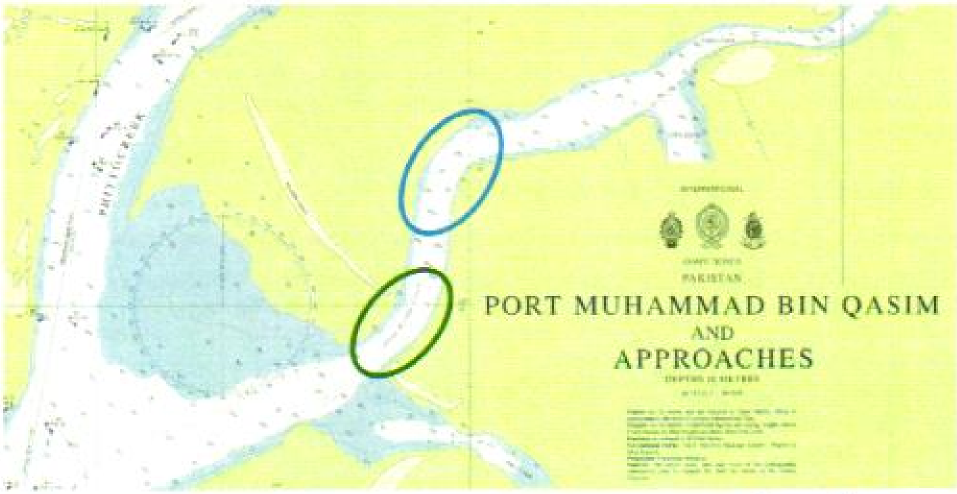

Figure 4.5: Nautical Chart No. 59 – Chann Waddo Channel 1st and 2nd Bend

4.3.1 PIANC Requirements

According to PIANC guidelines *"straight channel sections are preferable to curved ones and the designer should strive for an alignment consisting of a series of straight sections connected by smooth bends, where necessary, without abrupt angles. Individual sections may have different widths and depths and be navigated at different speeds."*

Normally, a bend will join two straight sections of the channel however two bends also could occur sequentially, as reported in figure below.

In this case, a preliminary indication of the needed distances between the two subsequent bends is reported in relation to the length and type of ships sailing through the channel.

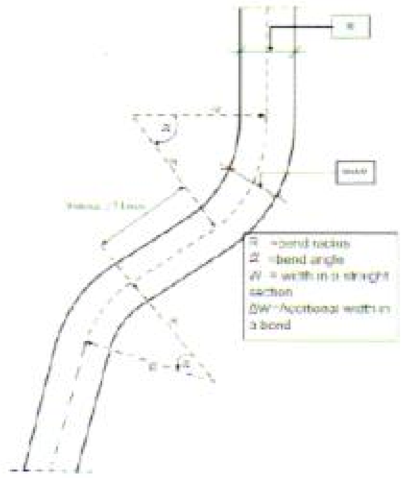

Figure 4.6: PIANC – Bend Configuration

Considering Q-Max size as the maximum size of the ship sailing through the channel, the radius of the bend should be four ship lengths (i.e. 1380 meters) in accordance with the ship turning radius and the distance between the two bends should be 1725 meters as per PIANC guidelines. However, these requirements have been deeply investigated during the simulation runs in order to properly define the required channel dimensions to safely handle the vessel around the bends.

As already agreed with Client, the definition of the minimum channel depth and width according to the main international standards (Ref. [1] to [4]) has been developed taking into account the maximum size of ship that will sail into the channel (i.e. Q-Max vessel).

4.4 MANOEUVERING AREA DEFINITION

For the simulation study, it has been assumed that Chann Waddo Channel is a one-way channel.

Since the Channel is not operational, the buoys and navigation aids indicated are presently not in place. For the simulation session, Consultant proposed a layout for buoys and navigation aids that is preliminary. Final positioning and optimum marking of the access channels and creek is a subject for future consultation with Port Qasim Authority in the next phases of the project.

The scenario has been prepared in accordance with bathymetry provided by the Client and with information available from British Admiralty Nautical Chart no.59 for channel sections not interested by bathymetry survey carried out by the Client.

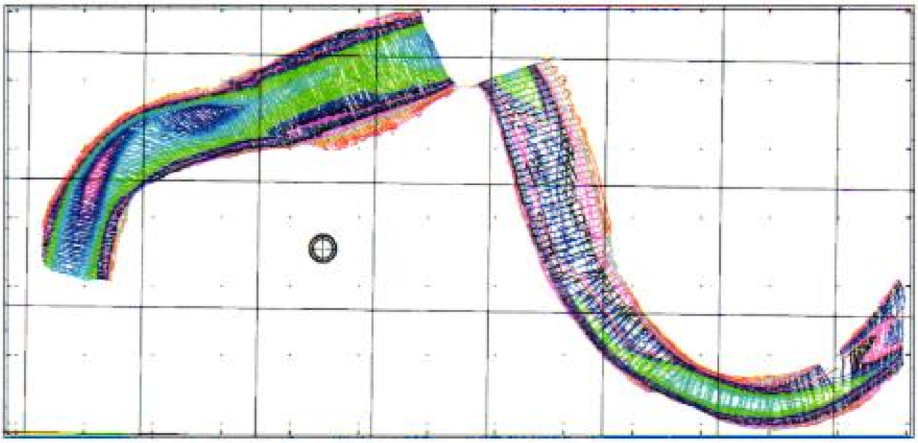

Figure 4.7: Bathymetry Provided by Client (Ref.[11])

As first step, a 270 meters channel width fairway with a water depth of 14 meters has been assumed, based on PIANC guidelines. This depth indicated is intended as maintained depth with reference to the LAT in order to ensure the necessary under keel clearance for the LNGCs draft.

Paragraph below reported in detail the approach followed for the definition of the navigation area requirements.

4.4.1 Navigation Area Requirements – Concept Design

In general, the concept design stage includes the preliminary design of the channel width and depth using data and formulae given in design guidelines, together with other relevant data related to the vessels characteristics and the metocean conditions.

In this phase, the definition of needed width and draught for Chann Waddo Channel has been carried out following PIANC guidelines for the Concept Design stage.

4.4.1.1 Vertical Requirements (UKC)

As far as channel depth is concerned, it is highlighted that the vertical design of navigation channels is affected by different factors. Figure 4.8 shows that the required safe depth of a channel is determined by water level, ship and bottom factors.

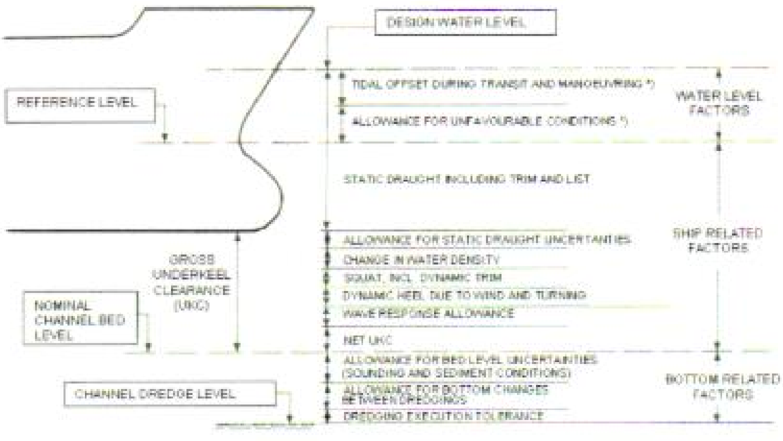

Figure 4.8: Channel Depth Factors

In the Concept Design stage, PIANC provided guidelines for the definition of draught for deep-draught channels (refer to para 2.3 of Ref.[1]). The Concept Design method represents good modern practice and channels designed to this method should result in a conservative design with an adequate level of navigational safety.

This approach has been followed for the calculation of the water depth needed for Chann Waddo Channel to allow Q-Max vessels to sail through.

It has to be noted that ship related factors are the most important in vertical channel design. In addition to the ship draught T, the ship factors can be estimated separately for ship squat, dynamic heel and wave response allowance or combined together. A simplified approach for the Concept Design stage is to combine the above factor into one called F_S that includes all these ship effects. The approximation depends on ship speed, wave effects, ship maximum draught T, type of channel.

Here below is reported the table provided by PIANC for the calculation of the channel depth components.

Table 4.1: Channel Depth Components (Ref.[1], Para 2.3.2, Table 2.2)

Description	Vessel Speed	Wave Conditions	Channel Bottom	Inner Channel	Outer Channel
Ship Related factors F_S					
Depth h	≤10 kn	None		1.10 T	
	10 – 15 kn			1.12 T	
	>15 kn			1.15 T	
	All	Low Swell (H_S<1m)			1.15 T to 1.2 T
		Moderate Swell (1m<H_s<2m)			1.2 T to 1.3 T
		Heavy Swell (H_S>2m)			1.3 T to 1.4 T
	Add for Channel Bottom type				
	All	All	Mud	None	None
	All	All	Sand/Clay	0.4 m	0.5 m
	All	All	Rock/Coral	0.6 m	1.0 m

If the ship has a large windage area it is suggested to include separated estimation for dynamic heel, as it is especially prone to heeling by strong crosswind. A conservative estimate of a roll angle due to turning and windage area exposed is φ_{WR} between 1 to 2 degrees. The equivalent sinkage of the ship bilge keel S_K is given by $S_K = F_K{*}B/2{*}\sin(\varphi_{WR})$

Taking into account the above, the following table reported the results for the vertical dimension of the fairway, considering the parameters listed below:

- Vessel speed: between 10 and 15 knots;
- Q-Max full load draught: 12 meters;
- Bottom: sandy/clay;
- Roll Angle ϕWR: 1° due to wind, maximum beam 53.4 meters;

- Bilge keel factor F_K: typical values are between 0.76 to 0.90. Conservatively considered as 0.90

Table below shows also the resulting gross UKC.

Table 4.2: Required Depth and Gross UKC

Ship Related Factor F_S [m]	Dynamic Heel S_K [m]	Bottom Clearance for Channel Bottom Type [m]	Required water depth [m]	Gross UKC [m]
13.2	0.42	0.4	14.0	2.0

4.4.1.2 Horizontal Requirements

As concern the evaluation of the width, PIANC guidelines gives the following formula for the overall bottom width W of a one-way access channel with straight sections:

$$W = W_{BM} + \Sigma W_i + W_{BR} + W_{BG}$$

Where:

- W_{BM} is the width of basic manoeuvring lane as a multiple of the design ship's beam B. The values to be considered depends on the manoeuvrability of the ship and are reported in table below.

Table 4.3: Basic Manoeuvring Lane W_{BM}

Ship Manoeuvrability	Good	Moderate	Poor
Basic Manoeuvring Lane W_{BM}	1.3 B	1.5 B	1.8 B

- ΣW_i are additional widths to allow for the effects of wind, current, etc. as given in Table 4.4.

Table 4.4: Additional Widths for Straight Channel Sections ΣW_i

Width W_i	Vessel Speed	Outer Channel (open water)	Inner Channel (protected water)
(a) Vessel speed V_s (kts, with respect to the water)			
$V_s \geq 12$ kts	fast	0.1 B	
8 kts $\leq V_s < 12$ kts	mod	0.0	
5 kts $\leq V_s < 8$ kts	slow	0.0	
(b) Prevailing cross wind V_{cw} (kts)			
- mild $V_{cw} < 15$ kts (< Beaufort 4)	fast	0.1 B	
	mod	0.2 B	
	slow	0.3 B	
- moderate 15 kts $\leq V_{cw} < 33$ kts (Beaufort 4 - Beaufort 7)	fast	0.3 B	
	mod	0.4 B	
	slow	0.6 B	
- strong 33 kts $\leq V_{cw} < 48$ kts (Beaufort 7 - Beaufort 9)	fast	0.5 B	
	mod	0.7 B	
	slow	1.1 B	
(c) Prevailing cross-current V_{cc} (kts)			
- negligible $V_{cc} < 0.2$ kts	all	0.0	0.0
- low 0.2 kts $\leq V_{cc} < 0.5$ kts	fast	0.2 B	0.1 B
	mod	0.25 B	0.2 B
	slow	0.3 B	0.3 B
- moderate 0.5 kts $\leq V_{cc} < 1.5$ kts	fast	0.5 B	0.4 B
	mod	0.7 B	0.6 B
	slow	1.0 B	0.8 B
- strong 1.5 kts $\leq V_{cc} < 2.0$kts	fast	1.0 B	-
	mod	1.2 B	-
	slow	1.6 B	-
(d) Prevailing longitudinal current V_{lc} (kts)			
- low $V_{lc} < 1.5$ kts	all	0.0	
- moderate 1.5 kts $\leq V_{lc} < 3$ kts	fast	0.0	
	mod	0.1 B	
	slow	0.2 B	
- strong $V_{lc} \geq 3$ kts	fast	0.1 B	
	mod	0.2 B	
	slow	0.4 B	
(e) Beam and stern quartering wave height H_s (m)			
- $H_s \leq 1$ m	all	0.0	0.0
- 1 m $< H_s < 3$ m	all	~0.5 B	-
- $H_s \geq 3$ m	all	~1.0 B	-
(f) Aids to Navigation (AtoN)			
- excellent - good		0.0	
-moderate		0.2B	
		0.4 B	
(g) Bottom surface			
- if depth $h \geq 1.5\,T$		0.0	
- if depth $h < 1.5\,T$ then - smooth and soft		0.1 B	
- rough and hard		0.2 B	
(h) Depth of waterway h		$h \geq 1.5\,T$: 0.0 B	$h \geq 1.5\,T$: 0.0 B
		$1.5\,T > h \geq 1.25\,T$: 0.1 B	$1.5\,T > h \geq 1.15\,T$: 0.2 B
		$h < 1.25\,T$: 0.2 B	$h < 1.15\,T$: 0.4 B
(i) High cargo hazards		See explanation in box(i) overleaf	

- W_{BR}, W_{BG} are bank clearance on the "red" and "green" sides of the channel as reported in table below.

Table 4.5: Additional Width for Bank Clearance W_{BR} and W_{BG}

Width for bank clearance (W_{BR} and/or W_{BG})	Vessel Speed	Outer channel (open water)	Inner channel (protected water)
Gentle underwater channel slope (1:10 or less steep)	fast moderate slow	0.2 *B* 0.1 *B* 0.0 *B*	0.2 *B* 0.1 *B* 0.0 *B*
Sloping channel edges and shoals	fast moderate slow	0.7 *B* 0.5 *B* 0.3 *B*	0.7 *B* 0.5 *B* 0.3 *B*
Steep and hard embankments, structures	fast moderate slow	1.3 *B* 1.0 *B* 0.5 *B*	1.3 *B* 1.0 *B* 0.5 *B*

Note:
1. W_{BR} and W_{BG} are widths on 'red' and 'green' sides of channel

Based on the main characteristics of the ships, the channel and the whole area of interest, the following values have been assumed for each of the above mentioned coefficient.

Table 4.6: Required and Assumed Width for Chann Waddo Channel

W_{BM} [m]	ΣW_i [m]	W_{BR} [m]	W_{BG} [m]	W [m]	Assumed W [m]
81	152	16.2	16.2	265.4	270

As described above, the width assumed for the straight sections of the fairway is 270 meters and it has been considered in the middle of Chann Waddo Channel as indicated in figure below.

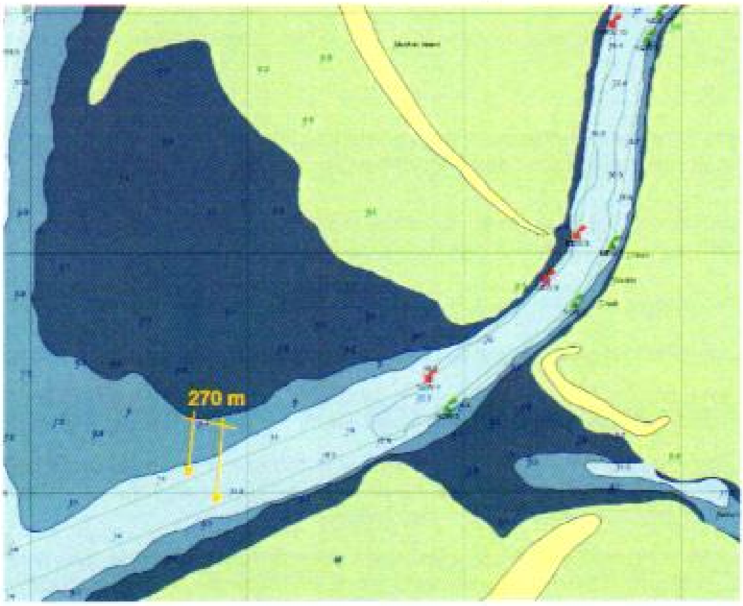

Figure 4.9: Simulation Session – Extract of Scenario 1

Since the evaluation of the Nautical Chart and the very first runs, it has been clear that the radius of the second bend was not sufficient to safely handle the vessels round the bend, mainly Q-Max vessel. These requirements have been further identify also during the first session of real time simulations during the pre-FEED stage.

In fact, all the relevant runs have indicated that the radius of the second bend was not sufficient to safely allow passage of the LNGC vessels round the bend, particularly the largest studied Q-Max vessel.

In light of this finding, for the present Real Time simulation runs, the final configuration of the channel identified in the previous session has been considered, with the relocations of the buoys in order to maximize the observed dimensions of the fairway. In particular, the green buoys in the second bend have been moved to -14 meters natural depth contour to increase the useable fairway width and improve the bend radius as much as possible without the need for dredging works.

Figure below reports the bathymetry provided by the Client, assumed to be referred to the CD, and the optimized simulation scenario with green buoys position.

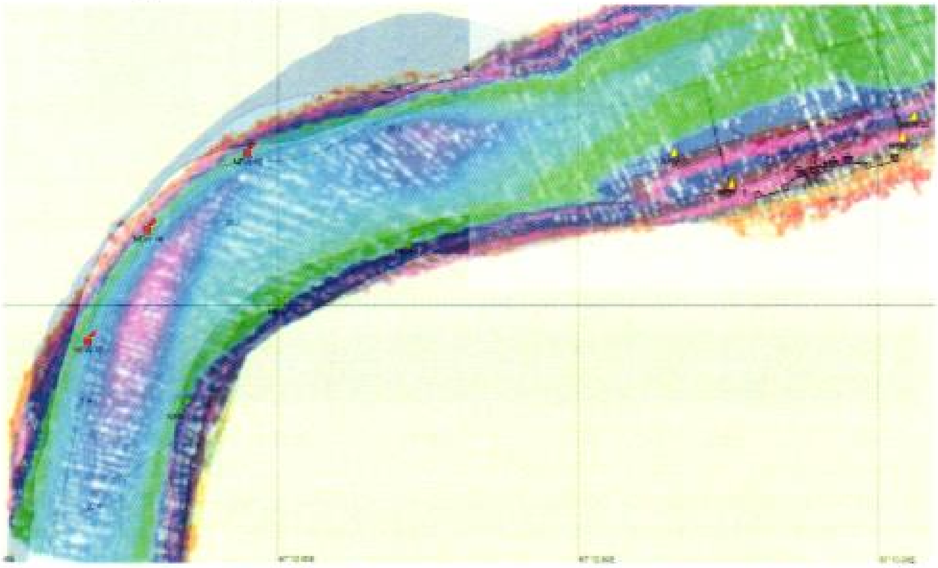

Figure 4.10: Simulation Session – Final Scenario and Channel Bathymetry

4.4.1.3 Turning Basin

The turning basin is the area where the vessels are assisted by tugs to their berths and may be tuned forehand. In the Concept Design phase, the nominal diameter of the turning basin should be ≥ $2L_{OA}$

For the simulations, the turning basin has been assumed to have a diameter of $2L_{OA}$ of the longest ship in accordance with PIANC requirements and information provided by the Client.

4.4.2 Navigation Aids Preliminary Layout

Currently Chann Waddo Channel is not operational so that there are no aids to navigation into the channel.

For this simulation session, Consultant proposed a preliminary layout in accordance with main international requirements (Ref. [1] and Ref. [5]) and Ship Master experience.

It is highlighted that Ship Masters' and Port Qasim Harbour Authority's experience of appropriate fairway marking is of importance since in the fairway design phase the distance which the A to N can be detected, recognised and identified by mariners is a critical consideration in the navigation of fairways.

Pairs of buoys have been arranged on either side of the fairway to indicate the lateral limits of manoeuvrable zone. No beacons or lit buoys have been positioned along the channel since presently night navigation is not allowed as per PQA SOP.

In the region of the bends, additional buoys have been placed in order to give guidance in the approach-sections to the bends and when navigating the bends.

It is anticipated that lights are installed on the jetty to mark the presence of the LNG berth; however, some indicative fairway buoys have been added in the proximity of the berth.

Two beacons have been included on each side of the channel to identify the boundary of the turning basin.

In general, the buoyage included in the simulations is in accordance with IALA region A.

At the point at which Chann Waddo Channel diverges from the Main Channel, a safe water mark indicating safe navigable water to either side have been added.

A South cardinal mark has been placed close north of the approach channel to mark the southern extent of an area of shoals to be avoided; this also serves as a visual reference for vessels entering the Chann Waddo Channel from the existing Main navigation channel.

Lateral buoys have been added to mark the limits of the navigable fairway in the approach channel and within Chann Waddo Channel. In proximity to the berth, yellow buoys of the appropriate shape have been added to give a visual indication of the extent of the manoeuvring area.

The easterly limit of the area proposed for the swinging of the arriving LNGC has been marked by a pair of cardinal beacons. As earlier described the optimum marking of the Approach Channel, Creek and in proximity to the berth should form part of the discussions to be held with the Port Authority.

Therefore, in accordance with the above and with the outcomes of the previous Real Time simulation session, the following scenario has been modelled in the simulator.

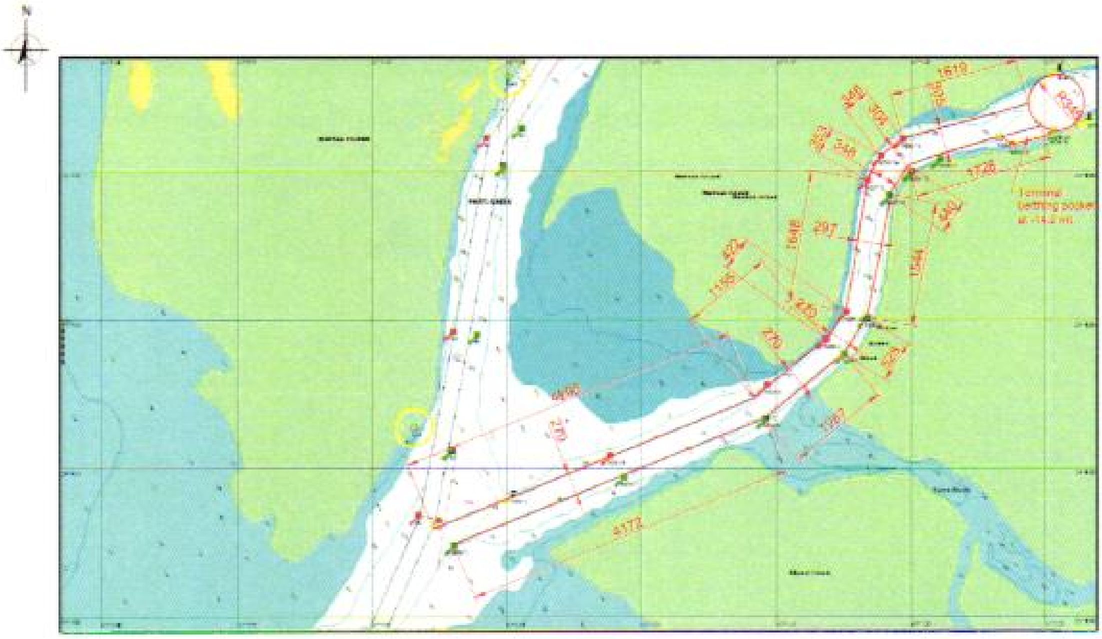

Figure 4.11: Simulation Session – Final Scenario Channel Dimensions

In addition, three figures have been prepared with the aim of showing the numeration of buoys along the navigation channel. In order to ensure a clean visual representation, the following figures show the entire navigation channel subdivided in three parts, divided as follows:

- Figure 4.12: Area between entrance Chann Waddo Channel and first bend;
- Figure 4.13: Area between first and second bend;
- Figure 4.14: Area between second bend and berth.

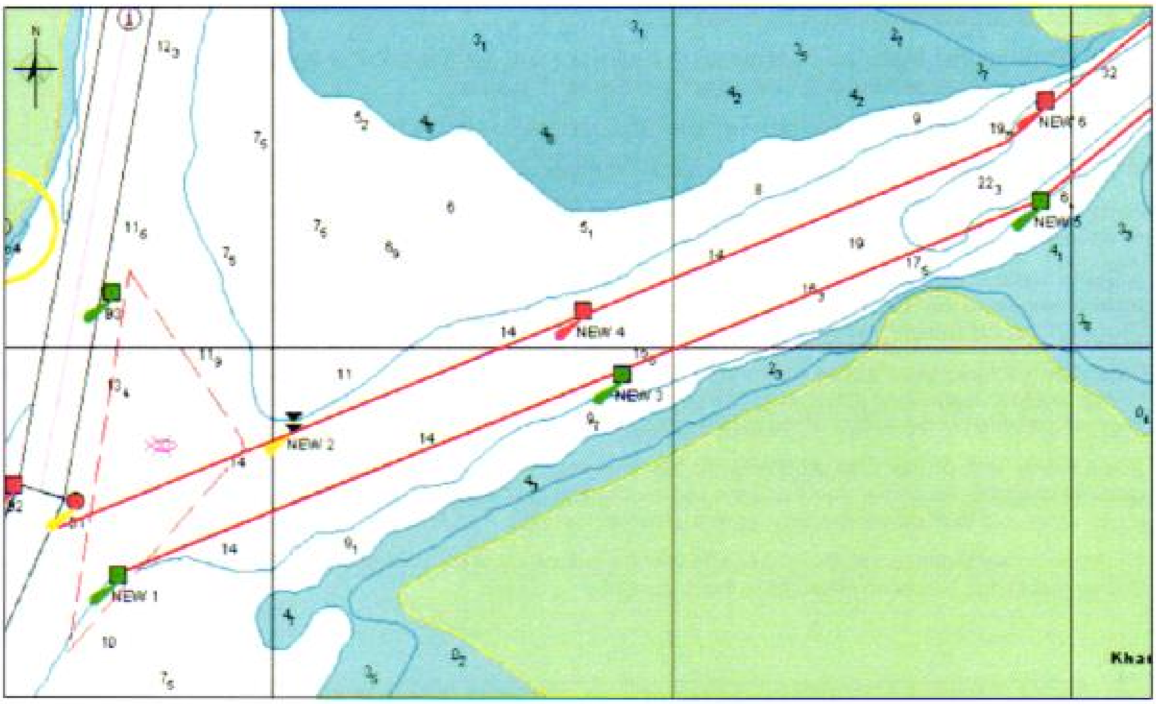

Figure 4.12: Buoys Layout between Chann Waddo Channel Entrance and First Bend

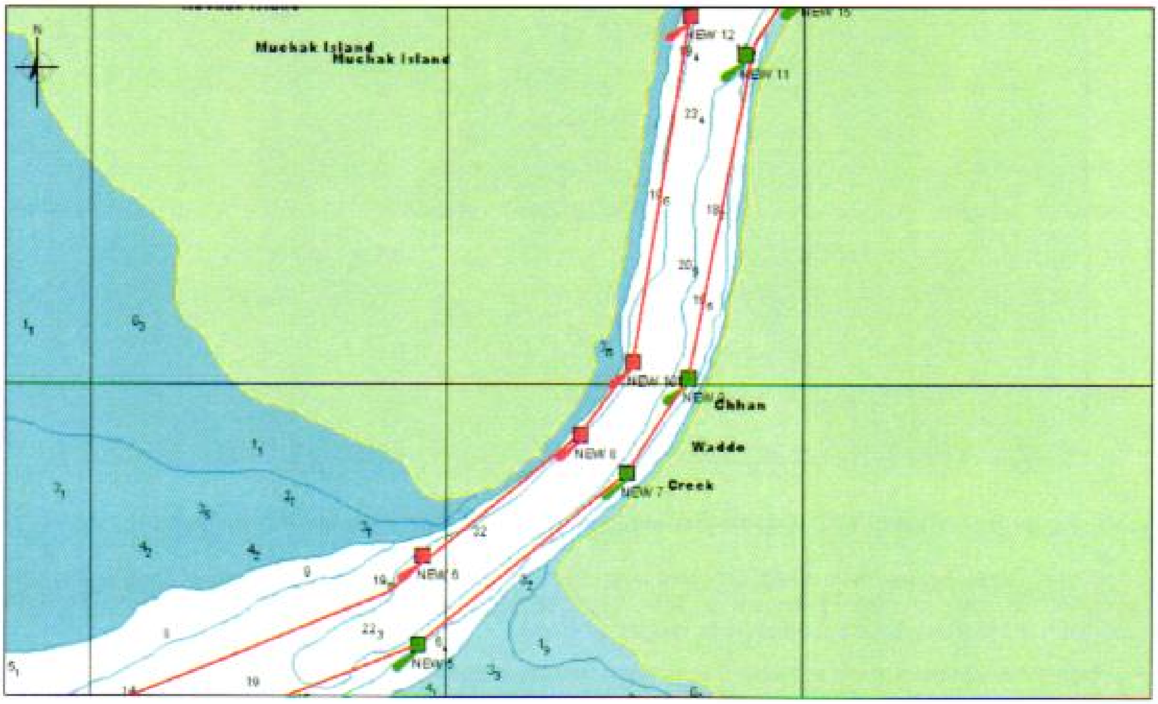

Figure 4.13: Buoys Layout between First and Second Bend

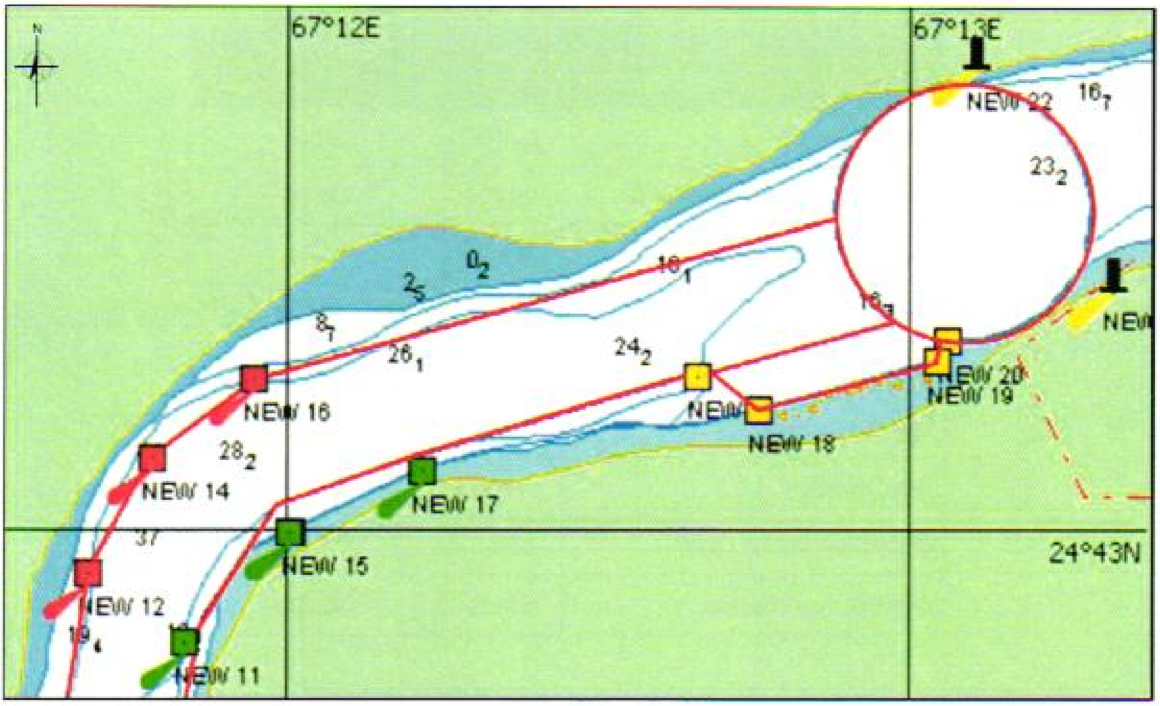

Figure 4.14: Buoys Layout between Second Bend and Berth

4.5 SHIPS AND TUGS MODELS

4.5.1 Ship Models

The aim of the present study is to verify different sizes of LNG Carriers that can be safely received at the LNG berth proposed location with the new updated information based on the hydraulic study results made available by Client.

For this purpose, the following ship models have been considered in accordance with Client.

Table 4.7: LNG Carrier Membrane Type 260k m^3 – Main Particulars

Ship Type Main Characteristics		Membrane 260k m^3
Length Overall	L_{OA} [m]	345.00
Length between perpendicular	L_{BP} [m]	332.00
Beam	B [m]	53.80
Depth	D [m]	27.00
Draught (Full Load)	T_{AM} [m]	12.00
Draught (Ballast)	T_{AM} [m]	9.60
Gas Capacity	[m^3]	266,000
Displacement (Full Load)	Δ [ton]	171,300
Displacement (Ballast)	Δ [ton]	142,000

Figure 4.15: Q-Max LNG Carrier - Example

Table 4.8: LNG Carrier Membrane Type 210k m^3 – Main Particulars

Ship type Main Characteristics		Membrane 210k m^3
Length Overall	L_{OA} [m]	315.00
Length between perpendicular	L_{BP} [m]	303.00
Beam	B [m]	50.00
Depth	D [m]	27.00
Draught (Full Load)	T_{AM} [m]	12.00
Draught (Ballast)	T_{AM} [m]	9.60
Gas Capacity	[m^3]	210,000
Displacement (Full Load)	Δ [ton]	143,000
Displacement (Ballast)	Δ [ton]	113,000

Figure 4.16: Q-Flex LNG Carrier - Example

Table 4.9: LNG Carrier Moss Type 170k m^3 – Main Particulars

Ship type Main Characteristics		Moss 170k m^3
Length Overall	L_{OA} [m]	299.98
Length between perpendicular	L_{BP} [m]	286.00
Beam	B [m]	52.00
Depth	D [m]	28.00
Draught (Full Load)	T_{AM} [m]	11.55
Draught (Ballast)	T_{AM} [m]	9.50
Gas Capacity	[m^3]	177,422
Displacement (Full Load)	Δ [ton]	124,700
Displacement (Ballast)	Δ [ton]	81,550

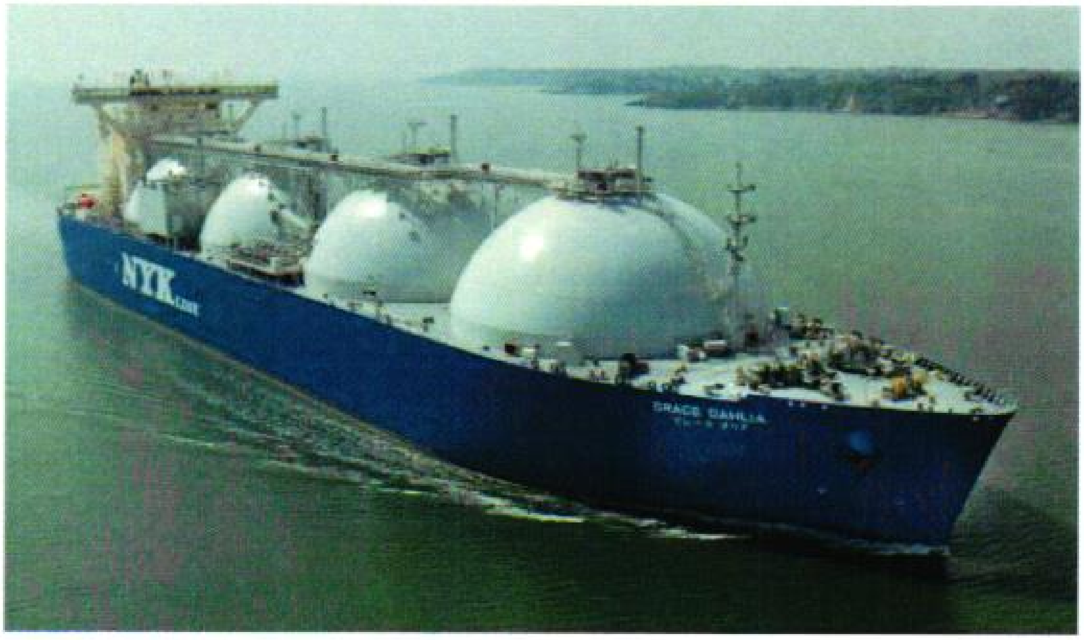

Figure 4.17: Moss type 170k m^3 LNG Carrier - Example

Table 4.10: LNG Carrier Membrane Type 130k m^3 – Main Particulars

Ship type Main Characteristics		Membrane 130k m^3
Length Overall	L_{OA} [m]	274.34
Length between perpendicular	L_{BP} [m]	260.56
Beam	B [m]	43.30
Depth	D [m]	25.40
Draught (Full Load)	T_{AM} [m]	10.86
Draught (Ballast)	T_{AM} [m]	9.50
Gas Capacity	[m^3]	130,300
Displacement (Full Load)	Δ [ton]	89,640
Displacement (Ballast)	Δ [ton]	67,600

Figure 4.18: Membrane Type 130k m^3 LNG Carrier – Example

As per information provided by the Client, it has been assumed that an FSRU with a storage capacity of 170,000 m^3 is permanently moored to the jetty. The main characteristics are as noted in Table 4.11.

Table 4.11: FSRU 170k m^3 – Main Particulars

Ship type Main Characteristics		Membrane 170k m^3
Length Overall	L_{OA} [m]	294.0
Length between perpendicular	L_{BP} [m]	283.0
Beam	B [m]	46.0
Depth	D [m]	26.50
Draught (Full Load)	T_{AM} [m]	11.50
Draught (Ballast)	T_{AM} [m]	9.40
Gas Capacity	[m^3]	173,000
Displacement (Full Load)	Δ [ton]	108,000
Displacement (Ballast)	Δ [ton]	88,000

Figure 4.19: FSRU 170k m^3 - Example

For each ship model, two different loading conditions have been considered in order to properly verify arrival and departure situations considering that this is an LNG import terminal.

4.5.2 Tugs

The tug configuration typically used at Port Qasim to handle an LNG Vessel has been considered during the simulations.

Two different type of tugs are available at Port Qasim and they are involved in different steps of the manoeuvers depending on their Bollard Pull capacity; LAMNALCO MUKALLA, LAMNALCO HODEIDAH, LAMNALCO SANA'A and LAMNALCO ADEN main characteristics are reported in table below:

Table 4.12: Tug – Main Characteristics

Tug type Main Characteristics		1	2
Length Overall	L_{OA} [m]	33.31	33.31
Beam	B [m]	14.5	14.5
Gross Tonnage	GT	724	724
Bollard Pull	[t]	75	85
Speed	[kn]	14	14
Installed Power	[kW]	6,120	6,120

Figure 4.20: Tug Operating at Port Qasim

In accordance with PQA recommendations and current operational strategy for LNG tankers (Ref.[7]), for the simulation it has been assumed that one tug is escorting the LNGC at stern during arrival manoeuvre starting from the entrance of the channel while the other three tugs will be involved in the manoeuvers when the LNGC is manoeuvring around the turning basin and approaching the jetty only.

Since RINA Consulting is not able to predict which type of tugs will be involved in the manoeuvers, conservatively four ASD tugs with a bollard pull of 75 tons have been considered in the simulations.

The typical configuration of tugs operating at Port Qasim and at other terminals worldwide is one that has been employed for this simulation session.

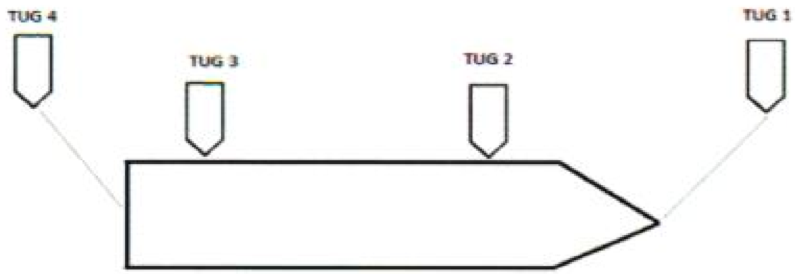

Figure 4.21: Tugs Configuration Operating at Port Qasim for LNG Carriers

4.6 SIMULATION CENTRE

The simulation runs have been performed by means of RINA Consulting real time ship handling simulator in Genova that is a TRANSAS Full Bridge Simulator qualified as Class C fit for purpose especially for engineering activities.

The System is composed by:

- 1 (one) Instructor Workplace including:
  - Main Instructor Control and Monitoring Module,
  - Tug and Mooring Functionality Module;
- 1 (one) Bridge – Software:
  - Conning Software (1 module),
  - Navi Sailor 4000 ECDIS Software (1 module),
  - Navi Planner 4000 (planning tools),
  - RADAR/ARPA Software (1 module);
- 1 (one) Bridge - Hardware:
  - Manoeuvring Console,
  - Mini Azipod right,
  - Mini Azipod left,
  - Steering Shaft,
  - Steering Wheel,
  - IBID display, touchscreen (used for AIS, Autopilot, rotate visuals, ...),
  - Mini Telegraph (split, for 1 or 2 propellers);
- 1 (one) General Console Including ECDIS, RADAR, Conning (3 pcs) with dedicated keyboards and 24" monitors;
- 3D Scenario on Monitor LCD 50 inches (7 pcs) installed into metal mock-up for 210 degrees visual.

Figure 4.22: RINA Consulting Simulator in Genova, Italy (March 2019)

4.6.1 Simulation Tool

RINA Consulting real time ship handling simulator is named NaviTrainerPro 5000, the tool has been developed by TRANSAS and enables simulator training and certification of Officers, Captains and Pilots on all types of vessels as well as port assessment studies.

NTPRO 5000 simulates integration of ship/channel hydrodynamic effects and operational procedures so that simulators can be used not only for traditional maritime training but also for number of R&D applications as an effective port /channel /terminal design tool.

In the following, the general algorithms used in the Simulation Mathematical modelling algorithms:

- 6-DoF ship motion equation;
- Hull hydrodynamic model;
- Stability and flotation model;
- Air cushion model;
- Heel tank model;
- Ballast tank model;
- Hull aerodynamic model;
- Main engine model;

Propulsive algorithm agents model:

- Active steering devices model;
- Rudder model;
- Engine model;
- Model of environmental effects (wind, waves, current);
- Model of shallow water effect;
- Model of 6-DoF pitch, additional wave resistance and drifting effect;
- Wave roll/pitch model;
- Wind-generated and swell wave model;
- Model of the distributed current effect;

- Model of hydrodynamic interaction with other ships (tugboats, barges) and geographical peculiarities of the area;
- Model of mechanical interaction with other ships (tugboats, barges) and mooring walls;
- Anchor model;
- Model of multi-functional autopilot;
- SMM incorporates the following model types: displacement ships, semi-glider ship, catamaran ships, tugs, barges, helicopters and aircrafts;
- Models are based on the actual prototypes and are adjusted from the data of sea and tank tests (if available).

Furthermore, the following real modelled effects are considered in the mathematical model:

- Shallow water effect on the hydrodynamic properties of the hull, propulsive agents/propeller and helms;
- Shallow water effect on changing the propulsive quality;
- Squat effect;
- Hydrodynamic interaction with other ships (tugboats, barges) and geographical peculiarities of the area (uneven seabed, shoal, mooring wall);
- Hydrodynamic interaction between the ship and waterway boundaries (walls, inclined bottom, channels, underwater banks);
- Ship collision with a ship (tugboat, barge);
- Ship bump with mooring walls and aids to navigation;
- Grounding;
- Soft grounding effect;
- Navigation in muddy strata areas;
- Lock effect;
- Enhanced Planning Effect;
- Air cushion effect;
- Propeller going of water.

In addition to the Simulator itself, each particular scenario can be detailed modelled or modified by means of Model Wizard software (provided by TRANSAS).

Model Wizard allows creation of a 3D model of a geographical area (scene) for Navi-Trainer simulator, therefore the file with scene construction results has a format compatible with one of the scenes to be installed in the simulator.

Bathymetry, berth layouts, navigation aids, and all the other components of the scenario can be properly updated in order to match the actual characteristics of the area.

Figure 4.23: Port Qasim Area Updating – Example

4.7 METOCEAN DATA

4.7.1 General

Metocean data used in the simulations has been based on data provided by the Client.

In the following sections, the data collected are taken from the SOP currently in use at Port Qasim for LNG Vessels (Ref. [7]) and other metocean technical studies of the area performed by other Parties for the present project (Ref.[10], [15] and [17])

In particular, the metocean data reported in [10] have been carried out by a local Consultant that was already involved in the installation of some sensors for current, wave and wind.

The report has been based on detected information collected from April to June 2018; Figure 4.24 reported the location of the detection point through the channel.

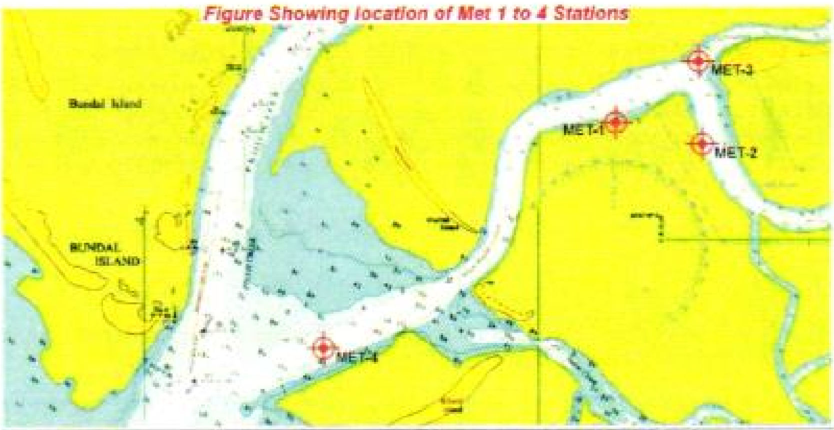

Figure 4.24: Detection Points in Chann Waddo Channel (taken from Ref.[10])

This data relates to three months only so is not sufficient to provide complete overview of the metocean data in the area of interest for the berth design lifetime.

As pointed out in the outcomes of the previous Real Time simulation session, more accurate hydrodynamic assessment of the area has been carried out by other Parties involved in the project and calibrated with the real data detected on site. This process has led to the definition of a MIKE 21 current flow model with an output file simulating 15 days of tidal variation in the area of interest.

The flow model which is representing the overall current regime in the creek, is not taking into account extreme current peak conditions that would develop during the monsoon / typhoon period.

However, the proposed MIKE 21 current flow model provided to RINA Consulting has been validated by means of measured site current and water level data, and is therefore as representative as possible of the actual flow conditions existing in the creek during operational conditions. These operational conditions are the ones which are relevant to the navigation simulations.

It is to be noted that extreme conditions are not relevant to study of the navigation operations, because under such conditions, the LNGCs would not attempt to enter the creek, and would instead stay moored offshore, on stand-by, until the metocean conditions revert back to normal.

Here below are listed the main inputs used during the simulation session:

- Current operational wind limits:

Table 4.13: PQA SOP Wind Operational Limits (Ref.[7])

Description	Nautical Manoeuvres	Mean Wind Speed [knots]	
Berthing FSRU/LNGC	Tugs have full control on vessel / vessel berthing	20	
Stopping LNG transfer and disconnect arms	2 tugs make fast engines / crew on standby	25	Consolidate cargo tanks if required
LNG Departure from FSRU/berth	4 tugs fast. Pilot onboard	30	Depart berth and anchor

- LNG vessels will be handled in all weather conditions with mean wind speed of 20 knots however during bad weather where mean wind speed is not in excess of 25 knots the initiating of the LNG vessels transit will be undertaken in controlled / favourable environmental conditions;
- Initiating of transit is prohibited if the visibility is less than 2 mile;
- The transit through the channel to the berth can be completed during daylight hours;
- The LNG vessel should arrive in the turning basin in slack current condition. Scenarios outside of this preferred tidal window have been included to investigate the feasibility of vessel transits outside of the existing PQA requirements. Vessel transits at times and in current flows corresponding to High Water +1 hour or +2 hours have been considered in order to investigate whether transit of the creek is feasible in the event of potential delay of the LNG Vessel;
- Main observed wind direction are SW and NE corresponding to the principal monsoon seasons.

4.7.2 Wind

Consultant has been provided with Ref.[10], that reported the outcomes of metocean data detected from April to June 2018; here below the wind rose taken from the report is reported.

As already described, these data are relevant to 3 months only when the prevailing incoming wind direction is SW, although Consultant is aware that in the winter monsoon period the prevailing wind direction is NE.

From past experience for similar projects in the area of interest, NE wind speed values are lower respect to the SW ones.

In light of the above, the majority of the runs have been performed with 20 knots of SW wind while also some runs have been carried out with 20 knots of NE wind. Wind from this direction is less likely to reach 20 knots and have been included to provide a worst case scenario for aspects of the vessel manoeuvres.

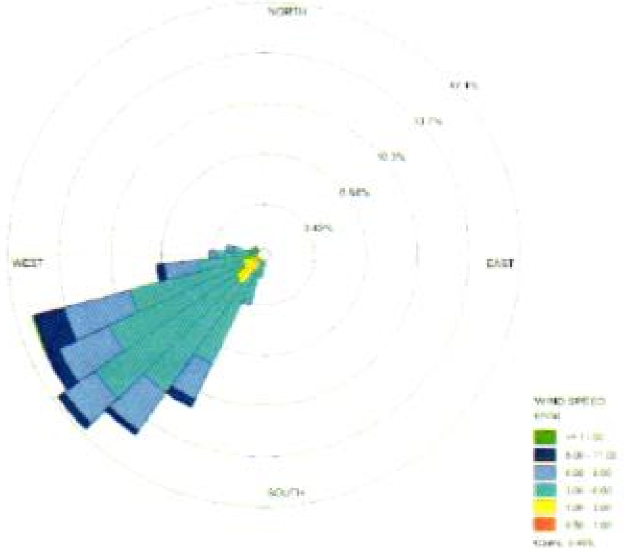

Figure 4.25: Wind Rose (Taken from Ref.[10])

In addition to the above mentioned data that has been used also for the previous simulation session, the following updated wind rose has been provided by Client. The population used for this new updated statistic is based on 28 years of OWI hindcast data point located 30km offshore Port Qasim.

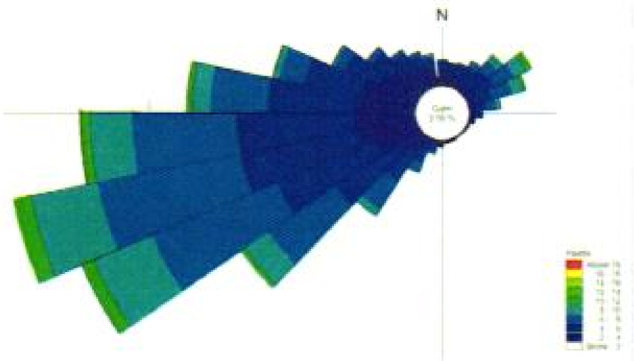

Figure 4.26: Wind Rose (from [17])

Finally, the following intensity and direction for the simulation runs have been identified:

- Main incoming direction SW and NE, considering the orientation of the proposed location in Chann Waddo Channel;
- The mean wind speed considered as base case for all the runs is 20 knots in accordance with Table 4.13;
- Wind gusts up to 25 knots have been considered.

4.7.3 Waves

According to available information, the wave height in the channel is negligible and mainly related to the wind while outside Chann Waddo Channel the mean significant wave height is of abt. 0.5 meters.

In the simulation runs, a wave height of 0.5 meters has been considered in the offshore area, between buoy no.15 and the area outside the creek.

In the channel, a wave height from 0.5 to 0.1 meters has been considered moving from the outside area to the berth.

4.7.4 Tides

As per information available from Ref.[10] and from Consultant experience for similar projects, tides in the study area are mixed, mainly semidiurnal.

It has highlighted that the SOP and the current best practice from PQA pilots recommend to reach the turning basin in slack current conditions in order to guarantee a berthing manoeuvre in optimized current conditions. Considering that this is a theoretical arrival condition, during the simulation runs, reasonable current values (for both Ebb and Flood conditions) have been considered.

In particular, conditions representing +/- 2 and +/- 3 hours before the High Tide Slack water at berth location have been considered for arrival cases, while for departures different timings of the tide cycle have been selected, from +/- 3 hours before the High Tide Slack water at berth location to 15 minutes before Ebb peak.

4.7.5 Current

For the present study a hydrodynamic model of the current regime in the area of interest has been made available to RINA Consulting (see Ref [15]). This current flow model is representative of 15 days of simulation performed with the software Mike21. For the purpose of this Real Time simulation session, considering that at Port Qasim the tidal variation is semi-diurnal, the most conservative 12 hours have been extracted from the Mike21 output file and then loaded in the simulator. In addition to a more accurate database in terms of direction of the current and speed, with the present current map it is also possible to appreciate the time domain modifications of the current path all along the development of each single time domain run.

The following figures are representing the current flow regime considered during the Real Time simulations in the most demanding time frame of the maximum flood peak.

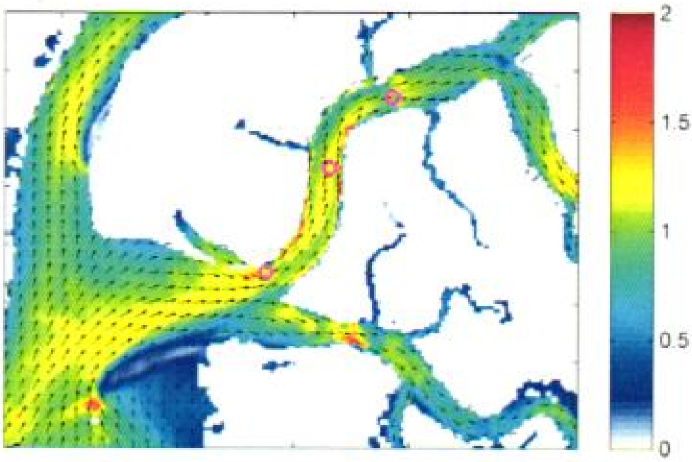

Figure 4.27: Current Map for Peak Flood Conditions (Extracted from[15])

For three representative points along the navigation route (highlighted with purple circles in the figure above), the time series reporting the current speed have been extracted and plotted in the below chart. Therefore, the maximum values of current in between of the two bends and in front of the berth location is approx. 1.2 meter per second (please refer to green and red line in the chart below).

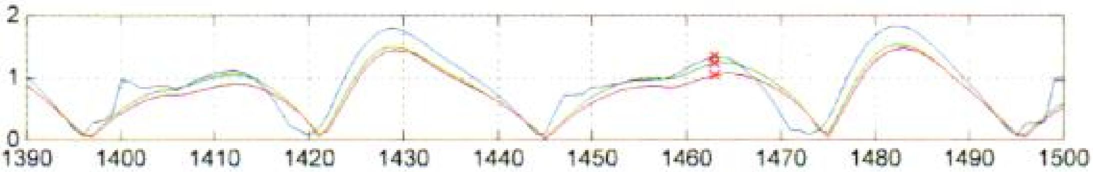

Figure 4.28: Current Flow Time Series

The following figures are representing the current flow regime considered during the Real Time simulations in the most demanding time frame of the maximum flood peak.

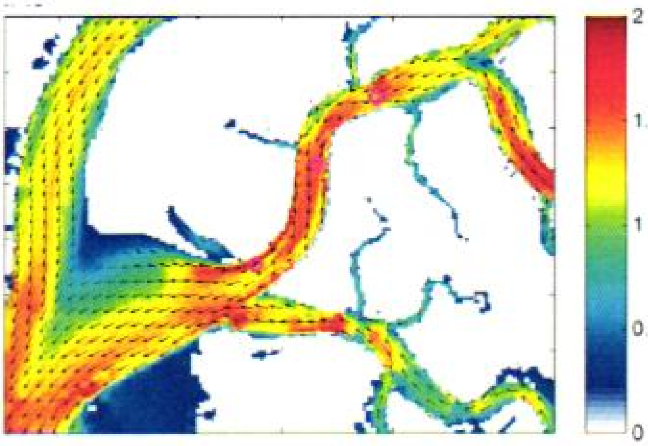

Figure 4.29: Current Map for Peak Ebb Conditions (Extracted from [15])

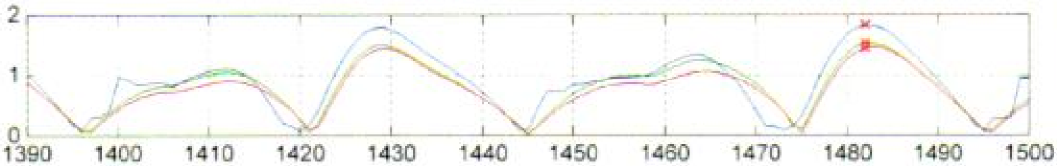

Figure 4.30: Current Flow Time Series

For three representative points along the navigation route (highlighted with purple circles in the figure above), the time series reporting the current speed have been extracted and plotted in the below chart. Therefore, the maximum values of current in between of the two bends and in front of the berth location is approx. 1.2 meter per second (please refer to green and red line in the chart below).

As expected, the peak ebb conditions have maximum current speed higher than the flood cases with values up to approx. 3 knots.

4.8 NAVIGATION SIMULATION STUDY

4.8.1 Attendies

The simulation runs have been performed by an experienced and highly qualified Ship Master:

- Capt. Ian Simpson (an active Pilot with experience of manoeuvring LNG Carriers, STS LNG operations and wide experience of conducting simulation studies of this nature).

The workshop held in Genoa in the period between the 25th and 29th March 2019.

4.8.2 Methodology

An overall number of 30 runs have been performed during the simulation workshop.

Different mix of metocean conditions, type of manoeuvre, type of ship, berthing location and foreseeable failure scenarios have been tested.

The manoeuvers have been carried out considering:

- Presence of the FSRU already berthed to the proposed LNG berth;
- Departure and arrival manoeuvers performed to and from the proposed location and all the manoeuvers have been conducted considering "bow out" berthing strategy for both FSRU and LNG Carriers, which is that commonly required at LNG berths worldwide.
- Considering that PQA usually handles LNG Carriers from the outer anchorage area up to buoy no.15, no simulation runs are required to revalidate the passage from the outer fairway to outside Chann Waddo Channel. Therefore Buoy no.15 has been considered as a common point for the commencement of all manoeuver runs;
- Majority of arrival simulations have been performed with an initial ship speed around 8-10 knots which equates to a speed of approximately slow to half ahead for the study vessels;
- Metocean conditions have been selected in order to be as much conservative as possible, especially in terms of creek current intensity. The majority of the arrival and departure manoeuvers have been conducted with not ideal conditions (e.g. simulating a delay of the ship of approx. +/- 1 or +/- 2 hours for the arrival at the swinging basin, starting therefore the runs at buoy no.15 +/- 2 or +/- 3 hours before High Tide Slack water);
- In analogy with the arrival runs, the timing set up for the departures is considering the ship leaving the berth once the unmooring operations have been completed and the LNGC is ready to sail. Starting timing of each exercise has been therefore set up to cover the whole range of tidal variation in the most demanding conditions;
- The available tugs bollard pull has been set equal to the 100% of the nominal bollard pull, orders to the tug instructor have been made as follow (as percentage of the nominal BP):
  - Minimum Pull/Push 10%
  - Slow Pull/Push 25%
  - Half Pull/Push 50%
  - Full Pull/Push 75%
  - Maximum Pull/Push 100%;
- Emergency departure with the most intense regime for ebb current flow has been performed;
- Gusted wind up to 25 knots has been considered for the majority of the runs;
- Tugs operating in pull configuration have been considered with approx. 50 to 60 meters of tow line length.

After the conclusion of each manoeuvre, a dedicated de-briefing session has been performed involving all the team in order to discuss the observed outcome and conclusion arising from the run.

Figure 4.31: De-Briefing Session

4.8.3 Simulation Matrix

A preliminary Simulation Matrix has been proposed before starting the simulation session and it has been fine-tuned and agreed with Client during the session itself based on the outcomes of the performed runs:

Table 4.14: Simulation Matrix

Description	Arrival / Departure	Ship Type	ID	Wave [Hs]		Wind		Current		Results / Notes
				m	°	°	kn	°	Timing*	
Preliminary Runs, definition of the optimum manoeuvring strategy	Arrival	Q-Max	1	0.5	SW	270	10	Flood	2 hrs before HAT	Familiarisation run to identify the optimum channel transit speed which will allow the vessel to safely navigate the channel bends. Speeds exceeding 6 knots in the approach to the second bend result in excessive lateral drift and a loss of control of the ship. Use of stern tug may be necessary to keep the ship speed under control at the desired knots.
	Arrival	Moss 170,000 cm	2	0.5	SW	253	10	Flood	2 hrs before HAT	Familiarisation run to identify the optimum channel transit speed which will allow the vessel to safely navigate the channel bends. Speeds exceeding 6 knots in the approach to the second bend result in excessive lateral drift and a loss of control of the ship. Use of stern tug may be necessary to keep the ship speed under control at the desired knots.
	Arrival	Membrane 130,000 cm	3	0.5	SW	253	10	Flood	3 hrs before HAT	Familiarisation run to identify the optimum channel transit speed which will allow the vessel to safely navigate the channel bends. Speeds exceeding 6 knots in the approach to the second bend result in excessive lateral drift and a loss of control of the ship. Use of stern tug may be necessary to keep the ship speed under control at the desired knots.
From entrance Chann Waddo Channel to Berth	Arrival	Q-Max	4	0.5	SW	253	10	Flood	2 hrs before HAT	The ship remains under control within the confines of the channel. Vessel able to navigate the bends. Control of the ship speed is fundamental if vessel is to remain in optimum position throughout Creek transit.
From end of 1st bend into the Berth	Arrival	Q-Max	5	0.5	SW	253	10	Flood	2 hrs before HAT	To determine the speed passing the moored FSRU and the safe approach speed to swinging position. To evaluate an appropriate swinging strategy.
Full Creek Transit including swing & approach to moored FSRU. From entrance Chann Waddo Channel to Berth	Arrival	Q-Max	6	0	0	253	10	Flood	3 hrs before HAT	Maintaining optimum vessel positioning throughout the Creek transit is more demanding than the previous runs due to the higher current regime. Although the ship can be controlled and is able to complete the bends, aggressive manoeuvring techniques are required to ensure the vessel may safely navigate the bends and avoid excessive lateral drift. Swinging of the ship prior to approaching the berthed FSRU requires the full longitudinal extent of the proposed swinging basin as the vessel experiences large set due to the high current.
From entrance Chann Waddo Channel to Berth	Arrival	Moss 170,000 cm	7	0.5	SW	253	10	Flood	3 hrs before HAT	Maintaining optimum vessel positioning throughout the Creek transit challenging due to higher following current but manageable with an appropriate manoeuvring strategy.
From entrance Chann Waddo Channel to Berth	Arrival	Moss 170,000 cm	8	0.5	SW	270	20**	Flood	3 hrs before HAT	Manoeuvre is difficult but manageable with an appropriate manoeuvring strategy. Higher and gusting wind from SW requires careful positioning of the vessel in the approach to 2nd bend where the full available width of channel is utilised. Safe transit and swing achieved. Transit in port maximum wind speeds can be safely achieved.
From entrance Chann Waddo Channel to Berth	Arrival	Q-Max	9	0.5	SW	270	20**	Flood	3 hrs before HAT	Maintaining optimum vessel positioning throughout the Creek transit is more demanding than the previous runs due to the higher current regime and leeway induced by the higher wind speed. Although the ship can be controlled and is able to complete the bends, aggressive manoeuvring techniques are required to ensure the vessel may safely navigate the bends and avoid excessive lateral drift. Swinging of the ship prior to approaching the berthed FSRU requires the full longitudinal extent of the proposed swinging basin as the vessel experiences larger set due to combination of the high current and westerly wind.
From entrance Chann Waddo Channel to Berth	Arrival	Membrane 130,000 cm	10	0.5	SW	270	20**	Flood	3 hrs before HAT	Safe transit, swing and berthing can be safely achieved using similar techniques as those employed for larger vessels.
From Berth to outside 2nd bend	Departure	Moss 170,000 cm	11	0.5	SW	253	20**	Flood	3 hrs before HAT	For this vessel: outward passage is achievable in the same conditions as arrivals. Care is necessary to achieve optimum vessel positioning when rounding bend west of berth as vessel experiences high degree of set & leeway in these environmental conditions.

Description	Arrival / Departure	Ship Type	ID	Wave [Hs]		Wind		Current		Results / Notes
				m	°	°	kn	°	Timing*	
										Similar speeds to those of the inward passage are required to achieve safe transit
From Berth to outside 2nd bend	Departure	Q-Max	12	0.5	SW	253	20**	Flood	3 hrs before HAT	For this vessel, outward passage is achievable in the same conditions as arrivals. Similar speeds to those of the inward passage are required to achieve safe transit.
From Berth to outside 1st bend	Departure	Moss 170,000 cm	13	0.5	SW	253	20**	Flood	3 hrs before HAT	Repeat of run 11 to address issues identified at 1st outward bend. Commencing outward turn when further west with higher rate of turn results in vessel following a safer track. Conclusion is that these vessels may safely transit in these conditions if a similar speed profile and lateral channel position is adopted as on inward passage.
From Berth to outside 2nd bend	Departure	Q-Max	14	0.5	SW	253	20**	Ebb	15 mins before max ebb	The outward transit cannot be safely achieved. In the 2nd bend, the ship is set to south and grounded due to the significant lateral motion induced by current acting on vessels beam when setting the turn into 2nd outward bend. Difficult to maintain transit speeds required in the following current. Not recommended to be performed.
From Berth to outside 2nd bend	Departure	Moss 170,000 cm	15	0.5	SW	253	20**	Ebb	15 mins before max ebb	Similar outcome to run 14. Vessel remains within the channel but only by employing aggressive manoeuvring techniques & use of stern tug. Transits in these conditions are not recommended to be performed as vessel uses full extent of available channel and is not fully in control.
From Berth to outside 2nd bend	Departure	Q-Max	16	0.5	SW	253	20**	Ebb	15 mins before max ebb	Similar outcome to run 14. Vessel remains within the channel but only by employing aggressive manoeuvring techniques & use of stern tug.
From Berth to outside 2nd bend	Departure	Q-Max	17	0.5	SW	253	20**	Ebb	1 hr after max ebb	Transit is achievable if previously identified speed and heading are carefully controlled.
From Berth to outside 2nd bend	Departure	Q-Max	18	0.5	SW	253	20**	Ebb	Max ebb	Similar outcome to run 15. Vessel remains within the channel but only by employing aggressive manoeuvring techniques. It is not easy to control of the ship's position particularly in the 2nd bend. Transits in these conditions are not recommended to be performed as vessel uses full extent of available channel and is not fully in control.
From Berth to outside 2nd bend	Departure	Q-Max	19	0.5	SW	253	20**	Ebb	30 mins after max ebb	Less demanding than run 14 but still difficult. Manoeuvre is manageable with an appropriate manoeuvring strategy; this is the limiting condition for ebb current. Commencing transits earlier on the ebb tide are not recommended.
From Berth to outside 2nd bend	Departure	Moss 170,000 cm	20	0.5	SW	253	20**	Ebb	30 mins after max ebb	Transits with this vessel at this time on the tide are achievable but still require careful speed management and vessel positioning. Same as run 19.
From Berth to outside 2nd bend	Departure	Moss 170,000 cm	21	0.5	SW	253	20**	Ebb	15 mins before max ebb	Similar outcome to run 14. Vessel remains within the channel but only by employing aggressive manoeuvring techniques & use of stern tug. Transits in these conditions are not recommended to be performed as vessel uses full extent of available channel and is not fully in control.
From Berth to outside 2nd bend	Departure	Membrane 130,000 cm	22	0.5	SW	253	20**	Ebb	15 mins before max ebb	Outward transits of this vessel in these conditions may be achieved. Vessel uses full extent of the channel and similar speed and positioning must be employed to achieve safe transit.
From entrance Chann Waddo Channel to Berth	Arrival	Moss 170,000 cm	23	0.5	NE	53	20**	Ebb	1 hr after max ebb	To investigate arrival and swing in typical environmental conditions. In addition, to investigate minimum space required for swinging this vessel in non-extreme conditions. Transit safely achieved by employing similar strategy as earlier runs. Sufficient space exists for vessel to safely swing adjacent to the berth without provision of an additional turning circle.

Description	Arrival / Departure	Ship Type	ID	Wave [Hs]		Wind		Current		Results / Notes
				m	°	°	kn	°	Timing*	
From entrance Chann Waddo Channel to Berth	Arrival	Q-Flex	24	0.5	SW	253	20**	Flood	3 hrs before HAT	Q-Flex vessel experiences similar problems as the Q-Max vessel in these conditions. Vessel generates high lateral drift in bends that results in vessel grounding. Conclusions regarding Q-Flex vessel not significantly different from those regarding the Q-Max.
From entrance Chann Waddo Channel to Berth	Arrival	Q-Flex	24a	0.5	SW	253	20**	Flood	3 hrs before HAT	Repeat of run 24 to determine if use of escort tug will improve outcome. Vessel continues to experience high lateral set east of 2nd bend and uses maximum available channel width. Transits in these current conditions are extremely challenging. Consideration should be given to optimising the time of approach for these vessels.
From entrance Chann Waddo Channel to Berth	Arrival	Q-Flex	25	0.5	SW	253	20**	Flood	3 hrs before HAT	Repeat of runs 24 & 24a. Similar outcome vessel on limit of channel. Consideration should be given to optimising the time of approach for these vessels. .
From Berth to outside 2nd bend	Departure	Q-Flex	26	0.5	SW	253	20**	Ebb	15 mins before max ebb	Vessel experiences strong lateral drift in bends. Conclusions similar to those of Q-Max vessel in similar conditions. See run 14.
From exit of the 2nd bend to Berth	Arrival	Q-Max	27	0.5	SW	253	20**	Flood	1 hr before HAT	To investigate arrival and swing in typical environmental conditions. In addition, to investigate minimum space required for swinging this vessel in non-extreme conditions. Sufficient space exists for vessel to safely swing adjacent to the berth without provision of an additional turning circle.
From exit of the 2nd bend to Berth	Arrival	Moss 170,000 cm	28	0.5	SW	253	20**	Flood	1 hr before HAT	To investigate arrival and swing in typical environmental conditions with alternative swinging strategy. In addition, to investigate minimum space required for swinging this vessel in non-extreme conditions. Sufficient space exists for vessel to safely swing adjacent to the berth without provision of an additional turning circle.
From exit of the 2nd bend to Berth	Arrival	Membrane 130,000 cm	29	0.5	SW	253	20**	Flood	1 hr before HAT	To investigate arrival and swing in typical environmental conditions with smaller vessel. In addition, to investigate minimum space required for swinging this vessel in non-extreme conditions. Sufficient space exists for vessel to safely swing adjacent to the berth without provision of an additional turning circle.

Notes

* Relative time with respect to the current flow set in the simulator at the beginning of the each run

** Wind gust up to 25 knots every 3 minutes

4.9 SIMULATION RESULTS

An overall number of 30 simulation runs have been successfully performed during the workshop. All these runs have been performed in order to verify the suitability of the proposed location to receive LNG vessels.

The aims of the analysis were:

- optimization of the outcomes of the previous session and identification of the most appropriate navigation strategy related to navigation through the Chann Waddo Channel and the berthing and unberthing of different types and sizes of LNG carriers;
- investigation of the ideal tidal window for berthing and unberthing manoeuvre in order to identify the most suitable timing of the ship calls throughout the whole range of tide variation (12 hours semi–diurnal) for the different sizes of LNGCs considered;
- dedicated investigation of the swinging manoeuvre at the turning basin in order to understand if an optimization of the dredged surface could be possible.

The runs have been performed in different metocean conditions (i.e. wind direction, current regimes) and with different size and type of LNG Carriers.

4.9.1 Main Outcomes

- It is confirmed that for Chann Waddo Channel, the width configuration of the channel considering a wider profile throughout the bends as proposed in Figure 4.10 is necessary to increase the safety of the navigation.
- Basic strategy of the arrival manoeuvre is the same proposed in the outcomes of the previous simulation session in pre-FEED stage. Once the ship has passed the second bend, the speed has to be reduced in the proximity of the berth, complete the swing in the turning basin and manoeuvre the ship adjacent to the berth location with the assistance of the attendant tugs. Once the ship is parallel with the jetty orientation at a distance of approximately 100 meters it can then be safely pushed alongside the FSRU berthed at the jetty to complete the mooring operations.

Figure 4.32 highlights that in the most demanding flood current scenario, the ship in the second bend sets to red (north) side of the channel reducing the safe margin from the edge of the channel.

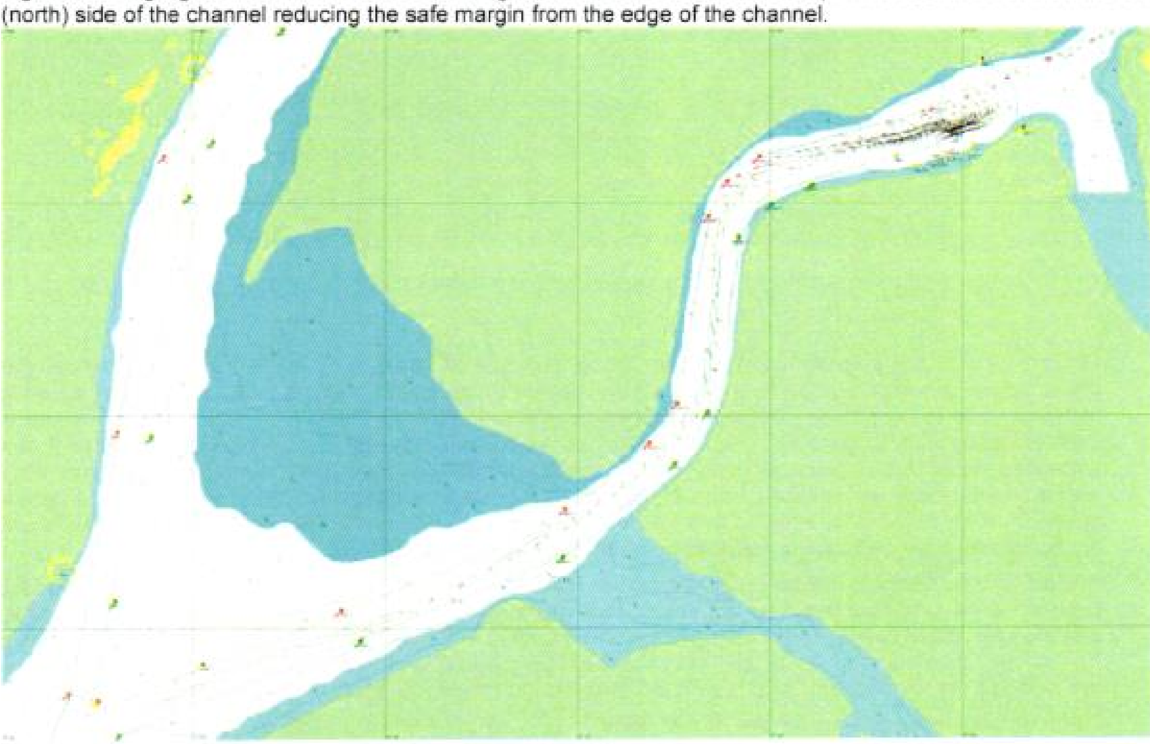

Figure 4.32: Example of Arrival Manoeuver for 170k in Peak Flood Conditions (Run 8)

It can be deducted from the runs performed that the arrival manoeuvre in terms of safe navigation throughout the bends can be performed without tidal flow limitations ensuring the full availability of the 12 hours daylight for LNGC sizes up the 170k.

For the larger size of LNGCs such as Q-Flex or Q-Max, it has to be highlighted that the navigation in the most demanding current flood scenarios has been achieved although the manoeuvre is demanding. In particular, the ship speed must be kept under control in all the sections of channel with all the means available including stern tug. Considering the size of these vessels and their displacement it is not recommended that arrival manoeuvres take place in the most demanding flood conditions but are scheduled to achieve the entrance within the current SOPs applied at Port Qasim. These require the LNGC to reach the swinging basin at a time between one hour before HAT slack water and slack water.

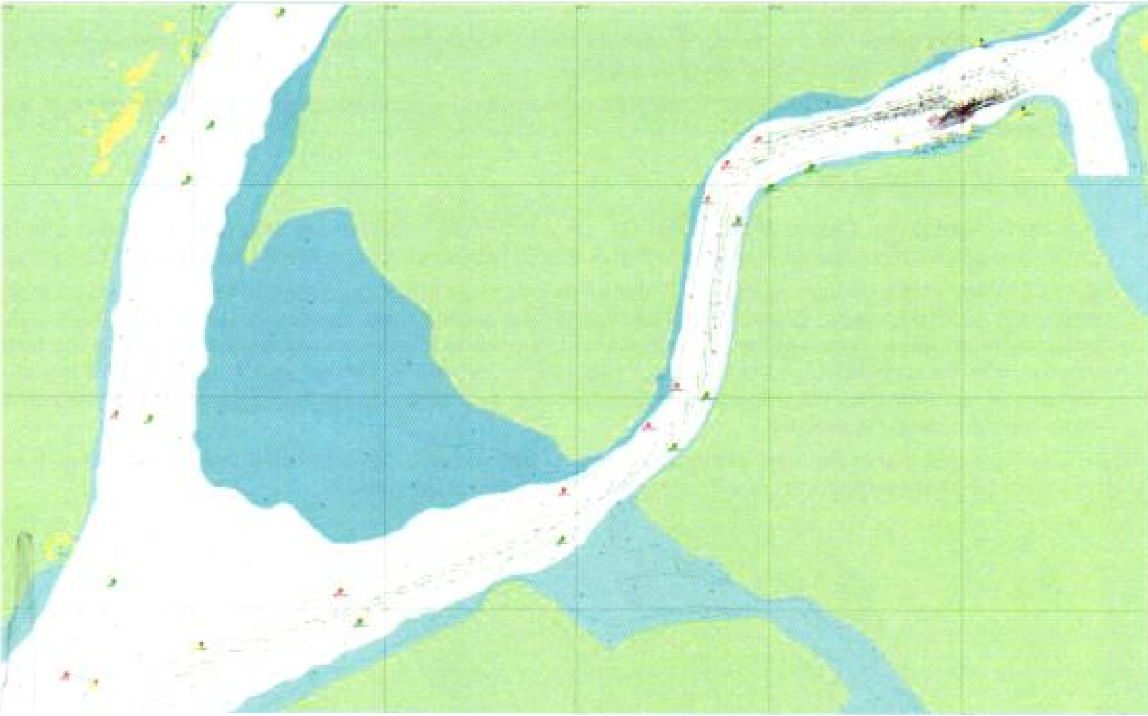

Figure 4.33: Example of Arrival Manoeuvre for Q-Max in Peak Flood Conditions (Run 9)

However, for all the potential combinations (timing and type of vessels) of feasible and safe manoeuvres stated above, the main outcomes of this session relevant to the arrival cases is that a precise manoeuvring technique has to be properly applied. In particular, the runs have demonstrated that the whole range of vessels tested can successfully perform the arrival manoeuvre through the channel (in the current flow limitations stated above for the different size of vessels). It has been validated that manoeuvre can be done with an initial vessel speed of 10 knots at the entrance of Chan Waddo Channel. Approaching the bends, speed must be decreased, down to 8 knots in approaching the first bend, 6 knots in the second bend and finally 3 knots when passing the FSRU prior to arrival into the swinging area.

- Should another terminal will be proposed further north in the creek which requires an LNGC to pass the position of the proposed jetty, as the vessel must not exceed 6 knots in the second bend a reasonable passing ship speed in front of the FSRU has been evaluated to be 5-6 knots. This requirement is also due to the fact that shortly after passing the Tabeer terminal the passing ship will require to be stopped to complete the swinging manoeuvre for that jetty so that her speed after the second bend would not be increased.
- The swinging circle with a diameter of 690 meters ($2L_{OA}$ as per PIANC guidelines (Ref.[1])) is of adequate dimensions to allow the ship to rotate 180 degrees to berth portside to the FSRU. However, it has been verified that in case the ship are scheduled in accordance with the current SOPs practice (reaching the

swinging basin in a time between one hour before HAT slack water and slack water) the space required to all types of vessel to be swung is significantly reduced compared to the theoretical one.

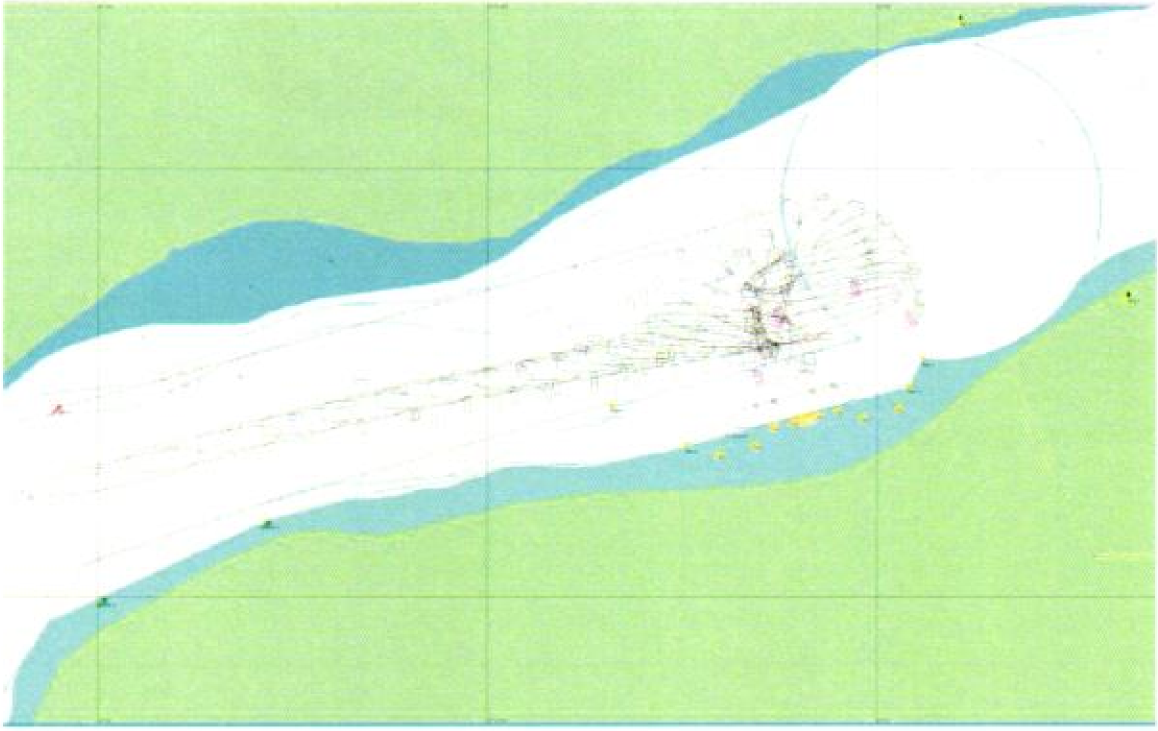

Figure 4.34: Example of Arrival/Swinging Manoeuvre for Q-Max in Ideal Flood Conditions (Run 27)

It has to be highlighted that in case the swinging manoeuvre will be attempted in not ideal tidal window, the space required for the ship to be swung is larger, approximately as per the theoretical sizing.

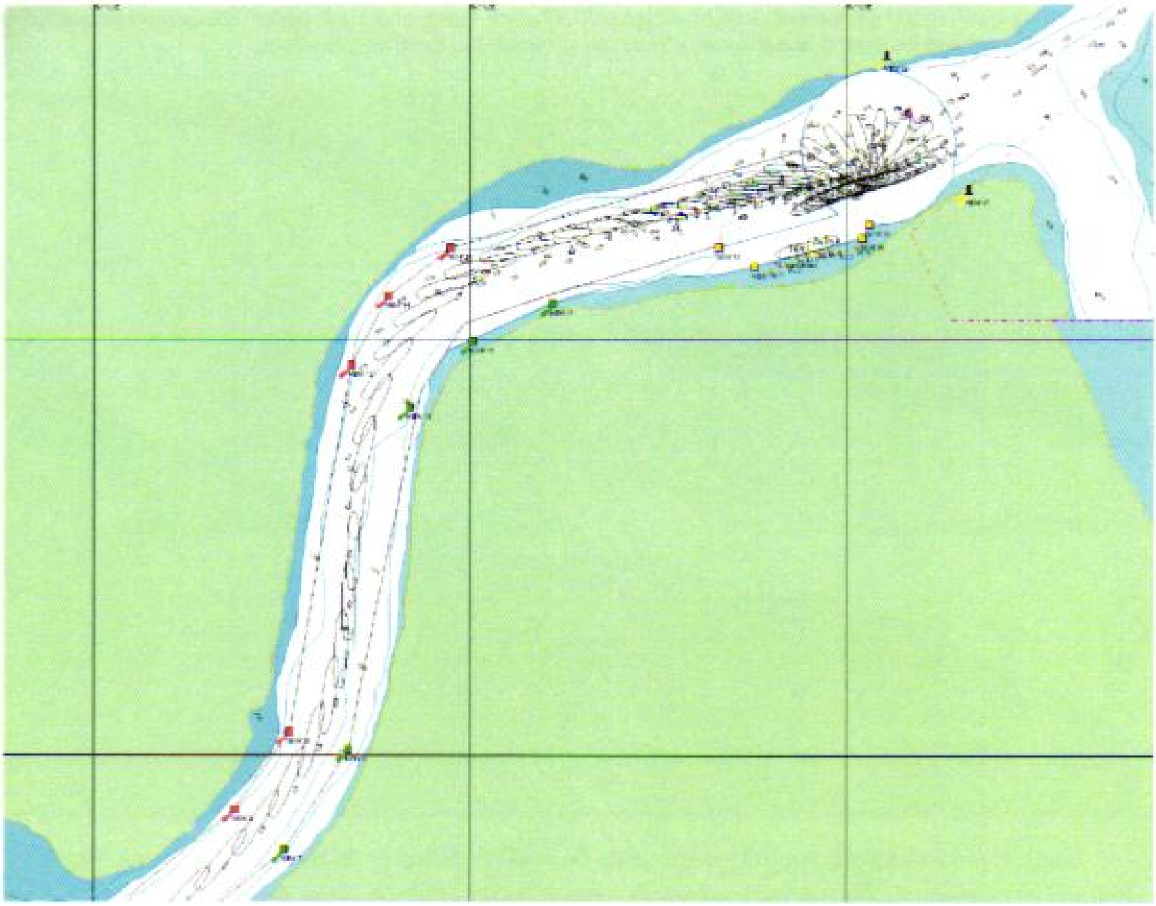

Figure 4.35: Example of Arrival/Swinging Manoeuvre for Q-Max in Peak Flood Conditions (Run 6)

However, the space required to swing the ship is suggesting that the turning basin can be elliptical shaped potentially saving some dredging to the north side of the proposed manoeuvring area.

- The departure manoeuvre is achieved by releasing the mooring lines of the LNG Carrier from the berth, which is then towed to a position approximately 100 meters away from the jetty from which position it may move ahead and begin the outward passage of the Chann Waddo Channel to sea. Once the ship begins the outward transit of the exit channel the two beam tugs and the forward tug can be released, the stern tug remains attached in escorting configuration in line with existing procedures.

  However, in analogy with the arrival manoeuvre, the most critical situation for the ship is to navigate the bends with the peak ebb current (pushing on the ship stern). In this situation, the ship is less manoeuvrable and more prone to be set on the fairway edges reducing the safe margin for navigation. The strategy to be applied is the same for the arrival, ship speed shall be kept under control to safely navigate the 2 bends. In particular, the first one shall be passed below 6 knots while the second one below 8 knots. However, as pointed out in several runs, the navigation of the creek is not recommended in case of peak ebb current (max flow around 3 knots). These conditions can set the ship out of the channel, especially Q-Flex and Q-Max vessels due to their length, displacement and aspect to current. The figure below shows an example where a Q-Max vessel grounded after the second bend. It is therefore recommended not to navigate the creek in such harsh conditions but to wait alongside the FSRU for standard departures or in case of emergency on the berth/FSRU requiring the LNGC do be detached to keep the LNGC in front of the berth controlled by tugs until a favourable current flow exists.

  In addition to the above and as already demonstrated in the pre-FEED stage, in case of emergency on the jetty, the LNGC can be safely managed by tugs in front of the berth or in the swinging basin even in the peak ebb condition waiting for further instructions to attempt a new berth alongside the FSRU or to leave the port.

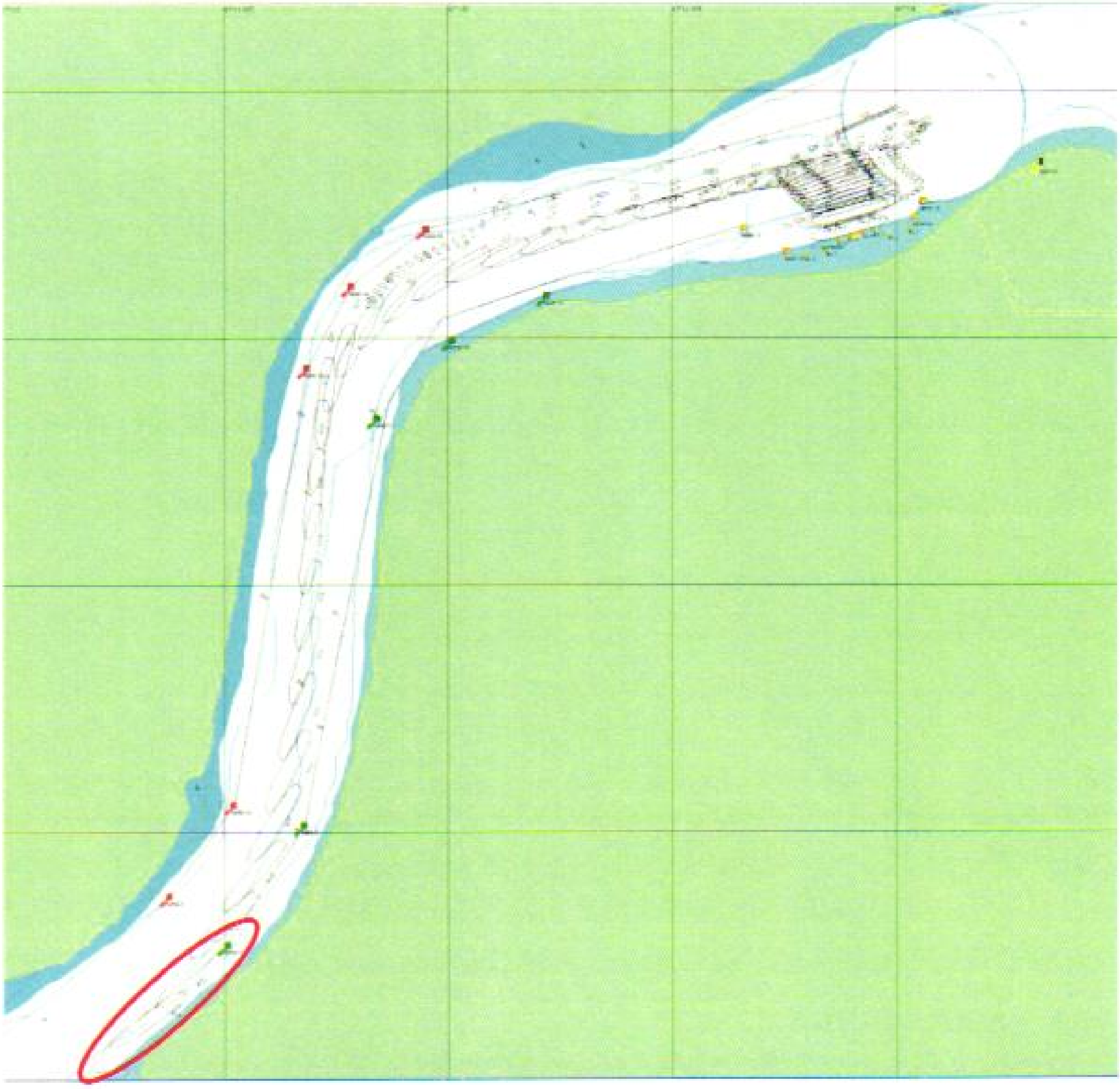

Figure 4.36: Example of Departure Manoeuvre in Peak Ebb Conditions – Q-Max Grounded (run 14)

For standard departure, the preferred time to start navigating the creek is about 30 minutes after the ebb peak and with all the other flood conditions.

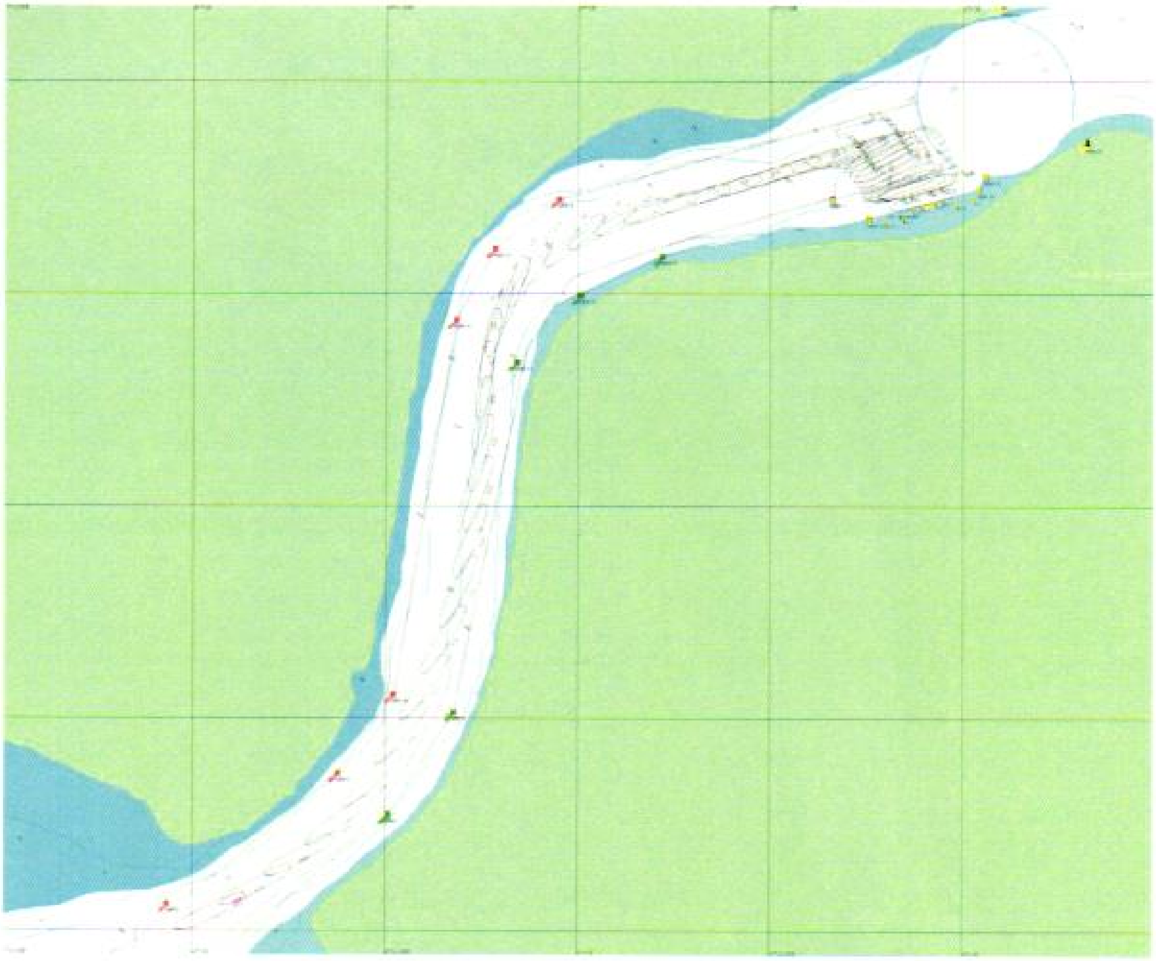

Figure 4.37: Example of Departure Manoeuver 30 Minutes after Ebb Peak – Q-Max No Grounded (Run 19)

4.9.2 Additional Cases

As requested by Client, some additional runs have been performed with the Q-Flex vessel for both arrival and departure manoeuvre. The outcomes are the same applicable for the Q-Max vessels:

- Arrival manoeuvre is not recommended in the peak flood current condition;
- Swinging manoeuvre in the basin if not performed in the ideal tidal window is requiring the whole theoretical basin diameter;
- Departure in peak ebb condition is not recommended.

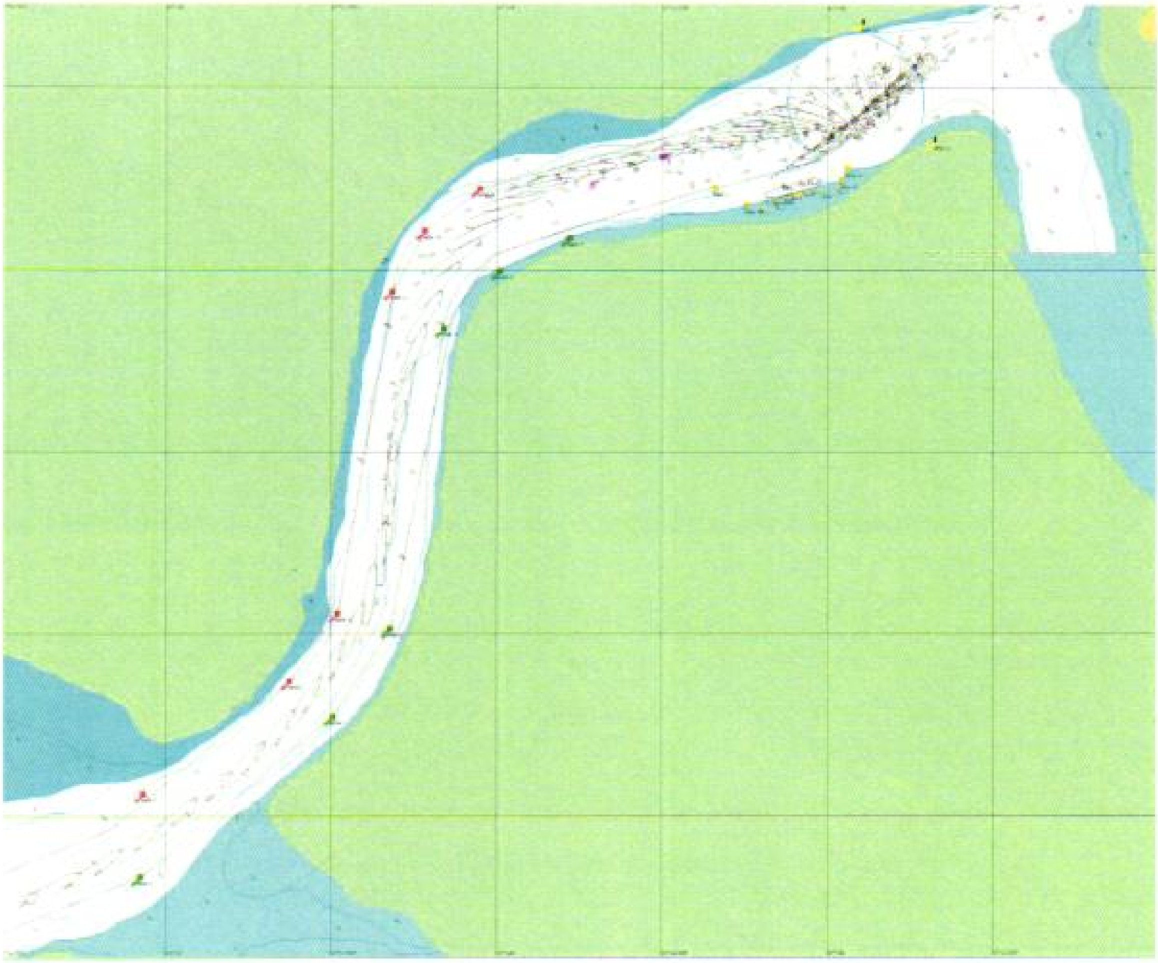

Figure 4.38: Example of Arrival Manoeuvre in Peak Flood Conditions – Q-Flex (Run 25)

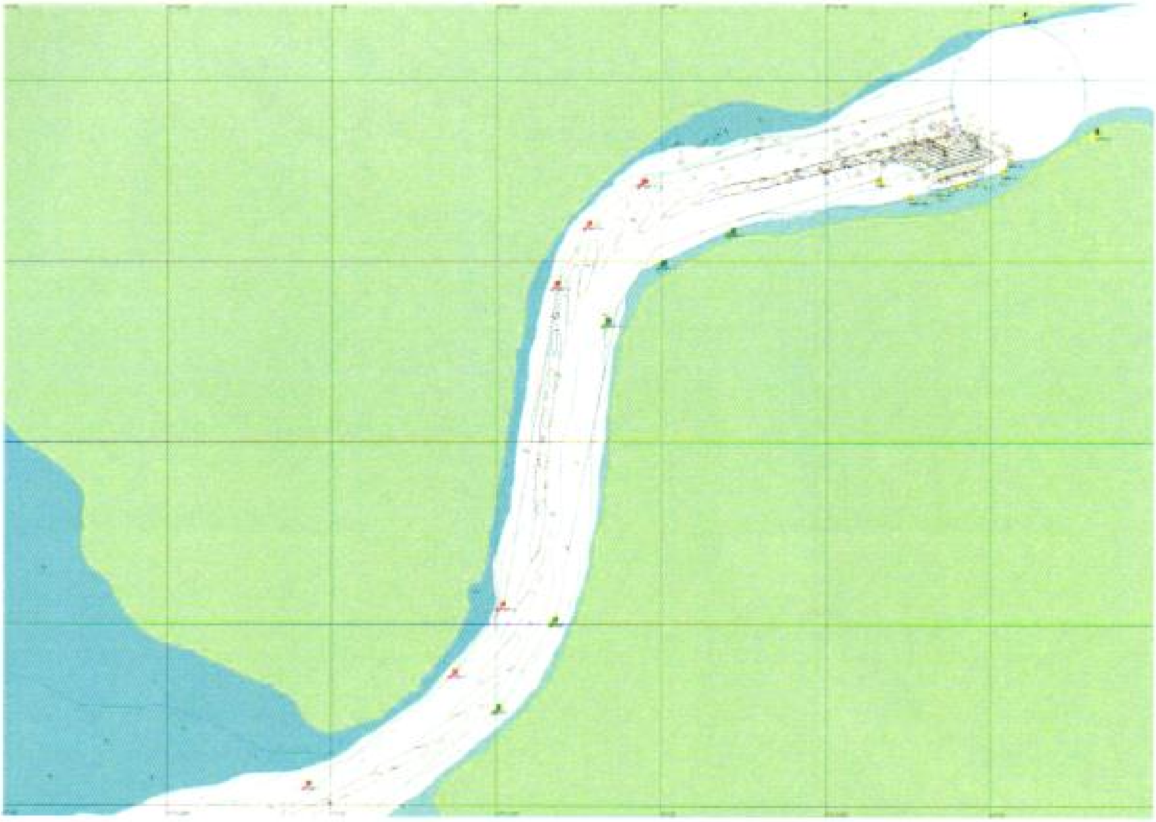

Figure 4.39: Example of Departure Manoeuvre in Peak Ebb Conditions – Q-Flex (Run 26)

5 CONCLUSIONS

The simulation session performed leads to the following conclusions:

- Following the operational conditions stated in the PQA SOPs and presently in force for the Main Navigation Channel, use of the Chann Waddo Creek to access the proposed berth can be considered acceptable in terms of navigation and the swinging, berthing and unberthing manoeuvres required for all the different types of LNG Carriers expected to be accommodated at the berth (from 130k m^3 Membrane type to Q-Max size). All berthing manoeuvres require to be properly scheduled as per SOPs as transits are particularly demanding due to the morphology of the landscape but can be achieved with the suitably trained Pilots;
- In case of not ideal arrival conditions the following observations can be stated:
  - Up to 170k Gas Capacity LNGCs, although the manoeuvre is demanding, can safely navigate the creek in the whole tidal window without any particular restriction to the operability (during daylight) provided that the proposed manoeuvring strategy is followed and ship speed is maintained underneath the proposed limits in the different sections of the channel (trained Pilots) as listed here below:
    - Not more than 10 knots when entering Chann Waddo Channel to proposed buoy number 4;
    - Not more than 8 knots when navigating first inward bend and Creek to approach toward second inward bend;
    - Not more than 6 knots when navigating second inward bend;
    - Not more than 3 knots when passing FSRU site and entering swing area.
  - For larger LNGC sizes (Q-Flex and Q-Max) it is recommended not to attempt the arrival manoeuvre in the peak flood conditions but to consider a tidal window in which the arrival of the ship in the swinging basin is timed to be around 1 hour before HAT slack water, in line with current SOPs. This is further motivated by the facts that the Chann Waddo Creek channel has not previously been in operation and that Q-Max vessels have previously been not operated at Port Qasim;
- The proposed turning basin based on a theoretical design suggested by PIANC is suitable for performing the manoeuvring of the largest vessels for both arrival and departure manoeuvres even if the ideal tidal window is missed. However, it has to be highlighted that if the scheduling of the ship entrance will be aligned with the current SOPs, the ship will reach the swinging basin at the ideal tidal window, allowing a significant reduction of the space required by the ship (even for the Q-Max size) to complete the swinging manoeuvre and be aligned with the FSRU heading, ready to berth;
- It is recommended to perform the departure manoeuvre avoiding the peak ebb current regime, the first feasible timing for departure is not before 30 minutes after the ebb peak. In all flood conditions the departure can be safely performed.

6 RECOMMENDATIONS

The following main recommendations are suggested for the future developments of the project:

- Before proceeding with the dredging works, it is suggested to perform a bathymetry survey from outside Chann Waddo Channel to the bend adjacent to the berth, since presently it is not available;
- The proposed strategy for the navigation of the creek as well as the potential optimization of the swinging basin dredging works shall be further verified and agreed with PQA. It is recommended to perform a dedicated simulation session which includes the Local Pilots and Officials in order to agree with them the above mentioned observations;
- Considering that the proposed creek is currently not operational, it is highly recommended to start handling such LNG vessels (especially Q-Flex and Q-Max) in ideal and benign conditions in line with current SOPs in order to let the Local Pilots familiarize themselves with the specific requirements of this navigation channel and these particular vessels;
- In analogy with the previous point, unberthing manoeuvre to be made outside of the window of occurrence of peak ebb currents in the channel and in the turning basin (strong ebb current is the most demanding current condition for departure);
- The proposed vessel speeds in the different sections of the channel have to be properly followed to safely perform the manoeuvre. Considering that the understanding of the manoeuvring strategy is the most important factor for the feasibility of the manoeuvres, a dedicated training session to the Local Pilot is highly recommended.

NICVA/ANDRO/SCZ:tds

904

REFERENCES

[1] PIANC, 2014, "Harbour Approach Channels Design Guidelines", Report No 121.

[2] PIANC, 1997, "Approach Channel A Guide for Design", June.

[3] SIGTTO, "Site Selection and Design for LNG Ports and Jetties" Information Paper N°14.

[4] SIGTTO, 2003, "LNG Operations ion Port Areas".

[5] IALA, 2011, "The use of Aids to Navigation in the Design of Fairways" Edition 1, June.

[6] Admiralty Nautical Chart N°59, 2015, "Port Muhammad Bin Qasim and Approaches".

[7] Port Qasim Authority, 2016, "Standard Operating Procedures for Operating Conventional LNG Carriers", PQA Notice SOP/Conv 001/16, April.

[8] D-000-1225-001_Rev0_General_Plot_Plan,

[9] Preliminary Jetty Layout_20180711_R3.

[10] Draft Metocean Data Collection Report – June 2018.

[11] CW-Jhari 13th June bathymetry Chann Waddo Channel.

[12] D-000-1310-001_0.pdf JGC Overall Site Plan.

[13] S-000-1311-001_Attachment-Investigation Location for Jetty.

[14] P0009270-1-H3-Navigation Study Report_Rev3.

[15] HD_Map_V23_Small Area.dfsu

[16] Pakistan FSRU Pre-FEED Study_Fast Time Navigation Simulation FINAL Rev Cs

[17] JGC email dated 8 March 2019 relevant to the new hindcast wind data

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APPENDIX A

Appendix A

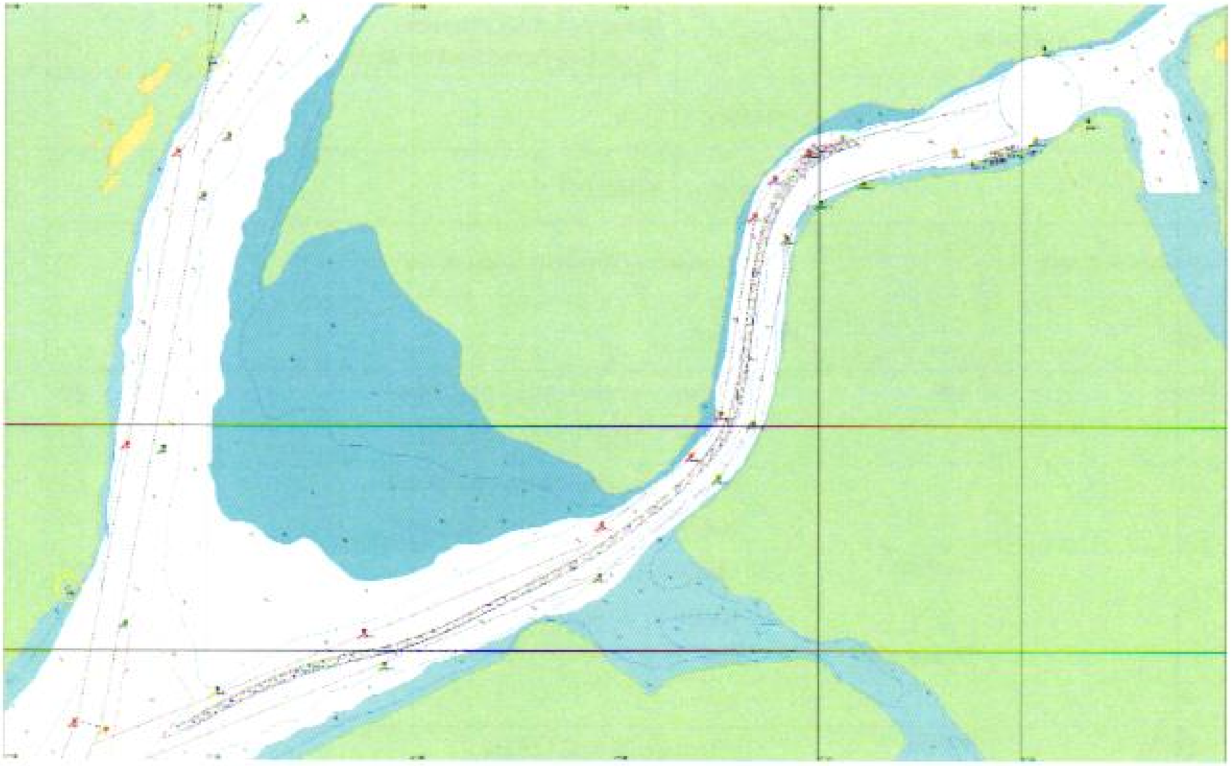
Plot Runs

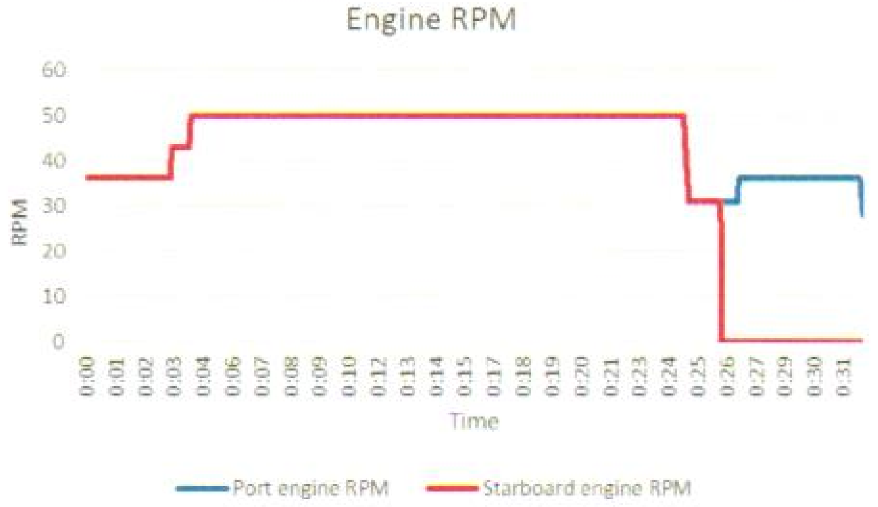
Doc. No. P0014168-1-H1 Rev. 4 – July 2019

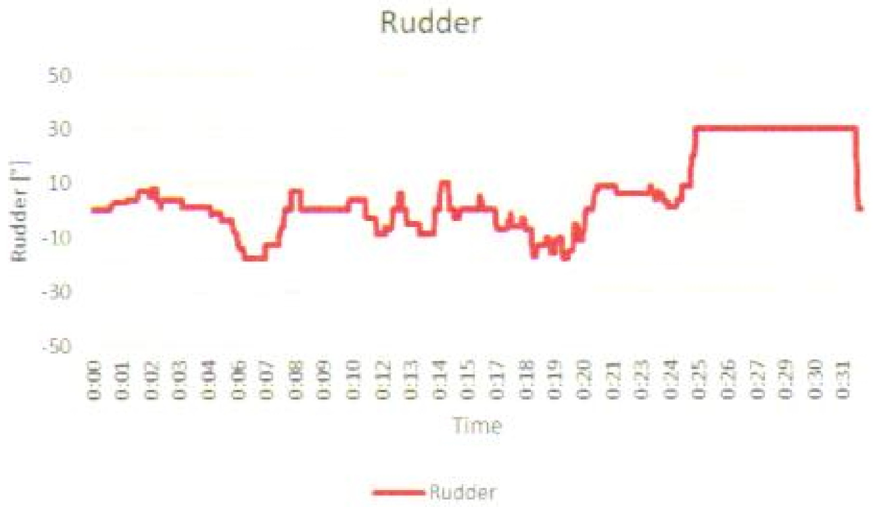
RINA

Date:	25/03/2019	Project:	Mitsubishi – JGC Corporation Tabeer LNG Terminal at Port Qasim	
Time start:	16:30	Time finish:	16:50	
Run n.	1	File name:	MTI2019_01	
Manouvre description:		Training session – Arrival with Q-Max vessel		
Captain		Ian Simpson		
Vessel	Type	Q-Max	(345m – 53.8m – 266,000m3)	☒
		Q-Flex	(315m – 50.0m – 210,000m3)	☐
		Moss	(300m – 52.0m – 177,000m3)	☐
		Membrane	(274m – 43.3m – 130,000m3)	☐
	Condition	Loaded	(Draft: 12.0 m)	☒
		Ballast	(Draft: 9.60 m)	☐
	Thruster used	Yes		☐
		No		☒
Condition	Position	From buoys B1-B2 to Terminal		☒
		From Terminal to buoys B1-B2		☐
		From buoys B1-B2 to second bend		☐
		From second bend to Terminal		☐
	Manoeuvre	Arrival		☒
		Departure		☐
	Tugs	N.: 3 tugs		
Metocean	Current	Dir.: Flood	Speed: 2 hours before HAT	
	Wind	Dir.: 270°	Speed: 10 Kts	

Note:
Familiarisation run to identify the optimum channel transit speed, which will allow the vessel to safely navigate the channel, bends. Speeds exceeding 6 knots in the approach to the second bend result in excessive lateral drift and a loss of control of the ship). Use of stern tug may be necessary to keep the ship speed under control at the desired knots.

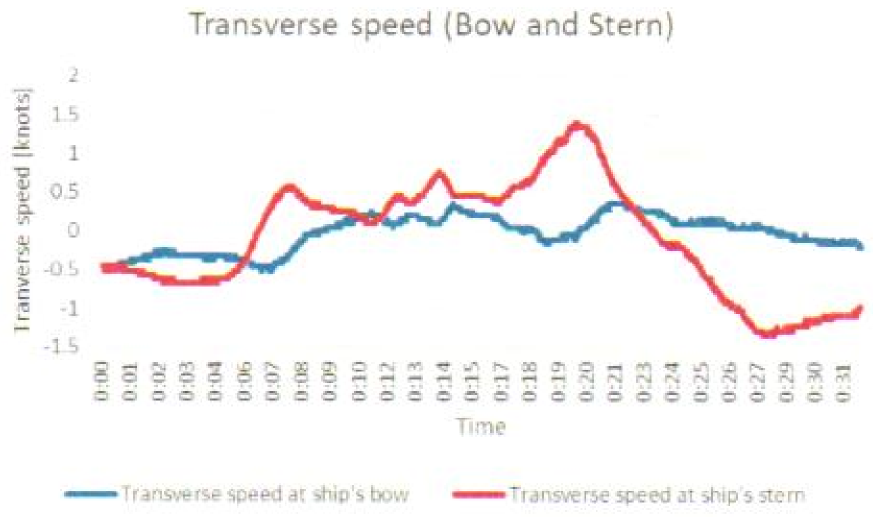


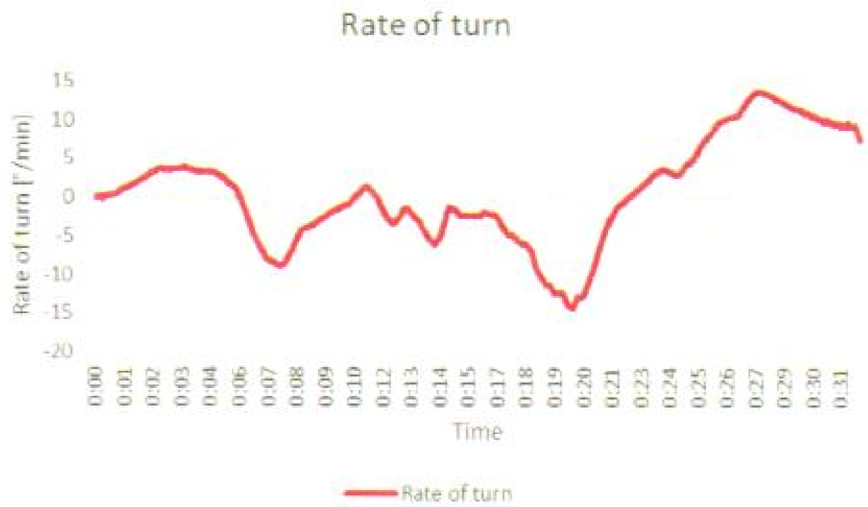

Engine RPM
RPM
Time
Port engine RPM
Starboard engine RPM

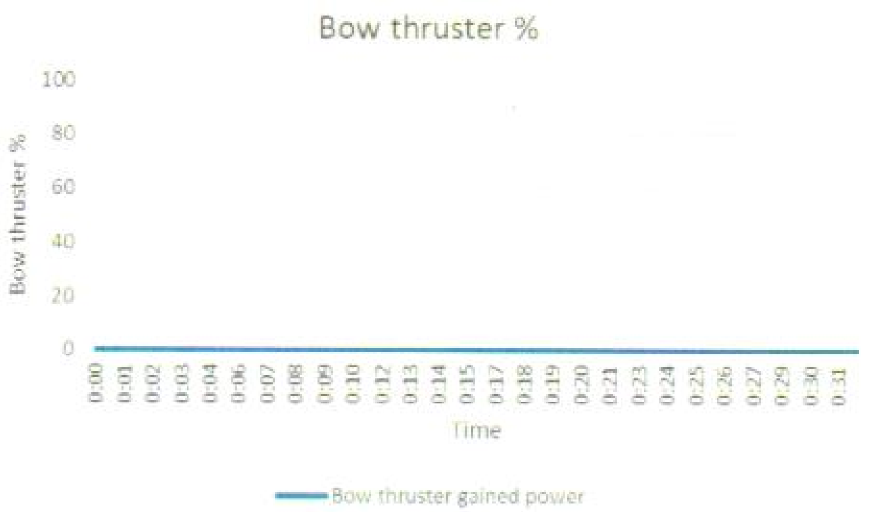

Rudder
Rudder [°]
Time
Rudder

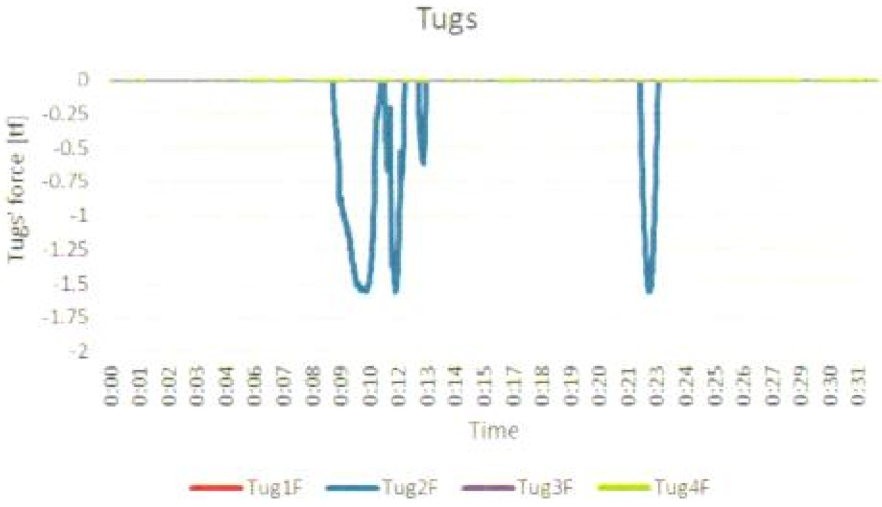

Speed OverGround (SOG)
SOG [knots]
Time
SOG

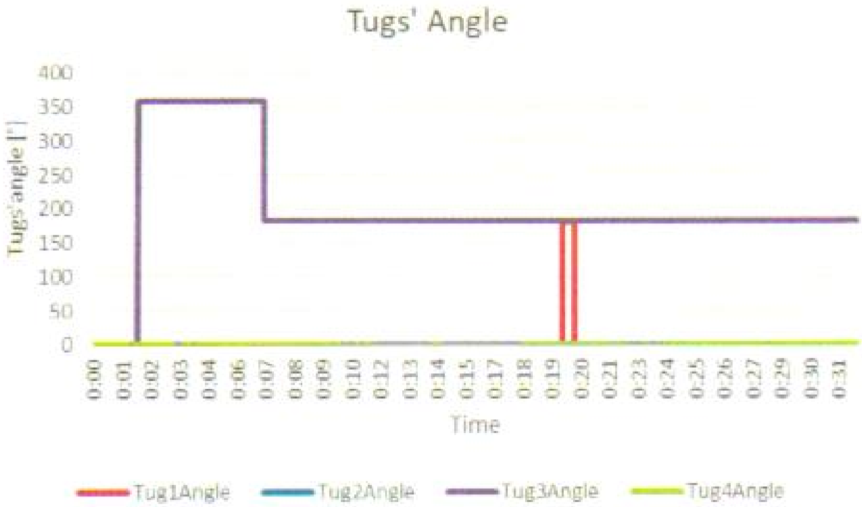
809


Transverse speed (Bow and Stern)
Tranverse speed [knots]
2
1.5
1
0.5
0
-0.5
-1
-1.5
0:00 0:01 0:02 0:03 0:04 0:06 0:07 0:08 0:09 0:10 0:12 0:13 0:14 0:15 0:17 0:18 0:19 0:20 0:21 0:23 0:24 0:25 0:26 0:27 0:29 0:30 0:31
Time
Transverse speed at ship's bow
Transverse speed at ship's stern


Rate of turn
Rate of turn [°/min]
15
10
5
0
-5
-10
-15
-20
0:00 0:01 0:02 0:03 0:04 0:06 0:07 0:08 0:09 0:10 0:12 0:13 0:14 0:15 0:17 0:18 0:19 0:20 0:21 0:23 0:24 0:25 0:26 0:27 0:29 0:30 0:31
Time
Rate of turn


Bow thruster %
Bow thruster %
100
80
60
40
20
0
0:00 0:01 0:02 0:03 0:04 0:06 0:07 0:08 0:09 0:10 0:12 0:13 0:14 0:15 0:17 0:18 0:19 0:20 0:21 0:23 0:24 0:25 0:26 0:27 0:29 0:30 0:31
Time
Bow thruster gained power

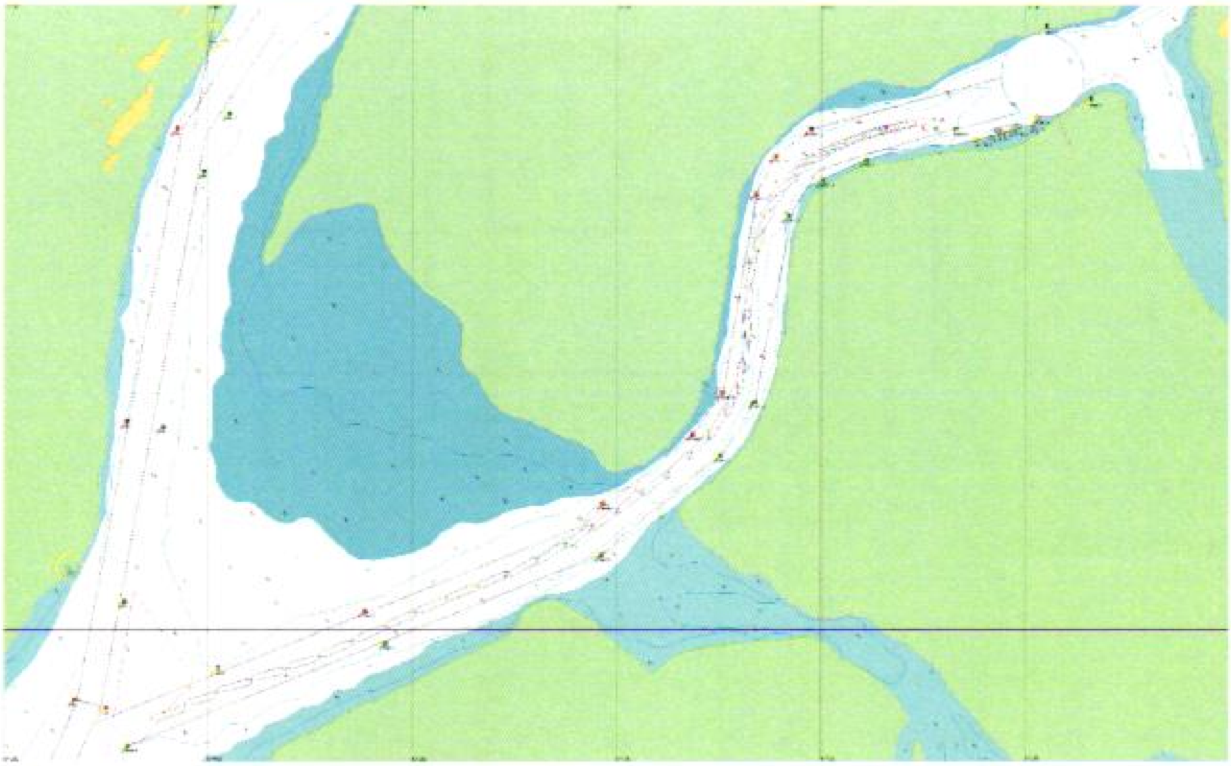

Tugs
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
-2
Tugs' force [tf]
0:00 0:01 0:02 0:03 0:04 0:06 0:07 0:08 0:09 0:10 0:12 0:13 0:14 0:15 0:17 0:18 0:19 0:20 0:21 0:23 0:24 0:25 0:26 0:27 0:29 0:30 0:31
Time
Tug1F
Tug2F
Tug3F
Tug4F

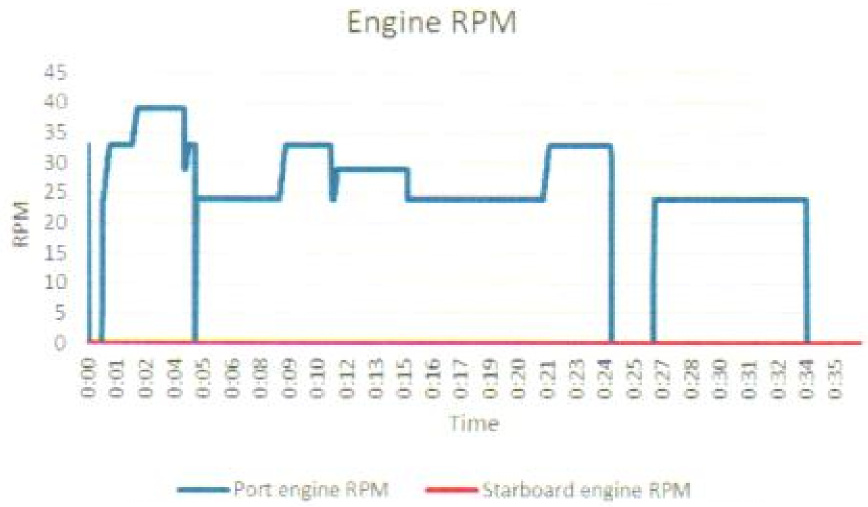

Tugs' Angle
400
350
300
250
200
150
100
50
0
Tugs'angle [°]
0:00 0:01 0:02 0:03 0:04 0:06 0:07 0:08 0:09 0:10 0:12 0:13 0:14 0:15 0:17 0:18 0:19 0:20 0:21 0:23 0:24 0:25 0:26 0:27 0:29 0:30 0:31
Time
Tug1Angle
Tug2Angle
Tug3Angle
Tug4Angle

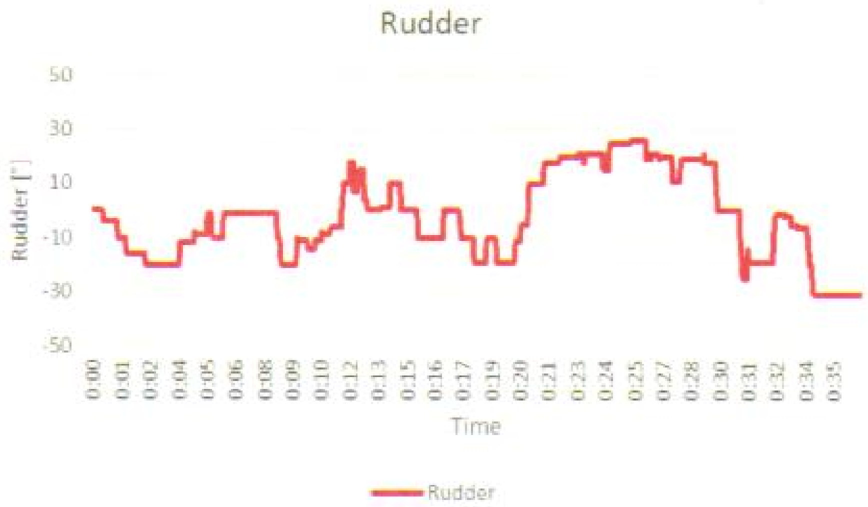
Date:	25/03/2019	Project:	Mitsubishi – JGC Corporation Tabeer LNG Terminal at Port Qasim
Time start:	17:10	Time finish:	17:50
Run n.	2	File name:	MTI2019_02
Manouvre description:		Training session – Arrival with Moss 170k m^3 vessel	
Captain		Ian Simpson	

Vessel	Type	Q-Max	(345m – 53.8m – 266,000m3)	☐
		Q-Flex	(315m – 50.0m – 210,000m3)	☐
		Moss	(300m – 52.0m – 177,000m3)	☒
		Membrane	(274m – 43.3m – 130,000m3)	☐
	Condition	Loaded	(Draft: 11.55 m)	☒
		Ballast	(Draft: 9.50 m)	☐
	Thruster used	Yes		☐
		No		☒
Condition	Position	From buoys B1-B2 to Terminal		☒
		From Terminal to buoys B1-B2		☐
		From buoys B1-B2 to second bend		☐
		From second bend to Terminal		☐
	Manoeuvre	Arrival		☒
		Departure		☐
	Tugs	N.: 4 tugs		
Metocean	Current	Dir.: Flood	Speed: 2 hours before HAT	
	Wind	Dir.: 253°	Speed: 10 Kts	

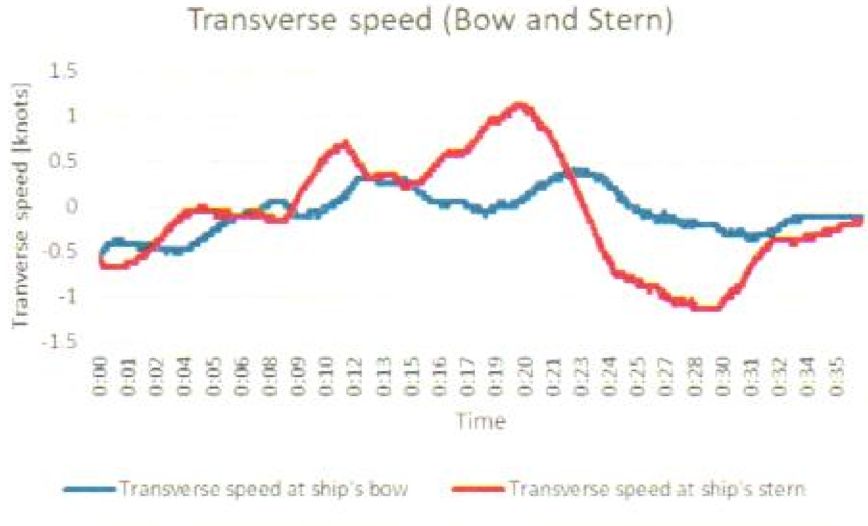
Note:
Familiarisation run to identify the optimum channel transit speed, which will allow the vessel to safely navigate the channel, bends. Speeds exceeding 6 knots in the approach to the second bend result in excessive lateral drift and a loss of control of the ship). Use of stern tug may be necessary to keep the ship speed under control at the desired knots.

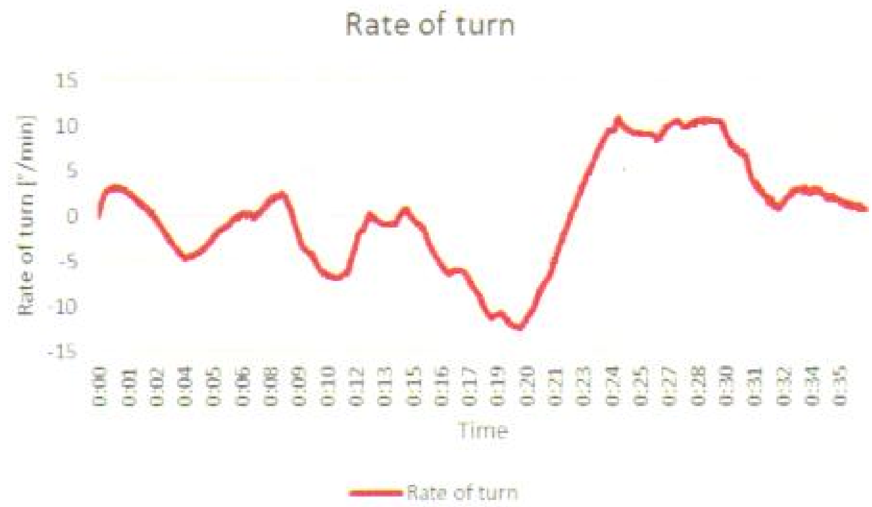


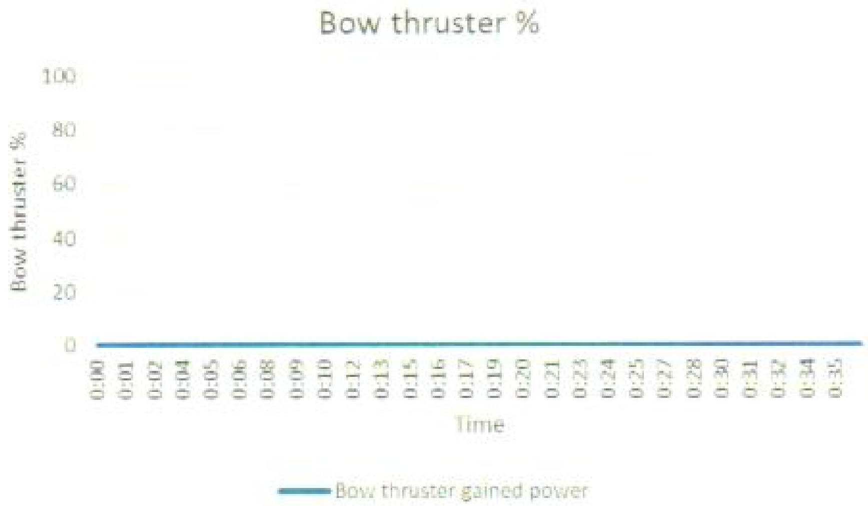

Engine RPM
45
40
35
30
25
20
15
10
5
0
RPM
0:00 0:01 0:02 0:04 0:05 0:06 0:08 0:09 0:10 0:12 0:13 0:15 0:16 0:17 0:19 0:20 0:21 0:23 0:24 0:25 0:27 0:28 0:30 0:31 0:32 0:34 0:35
Time
Port engine RPM
Starboard engine RPM

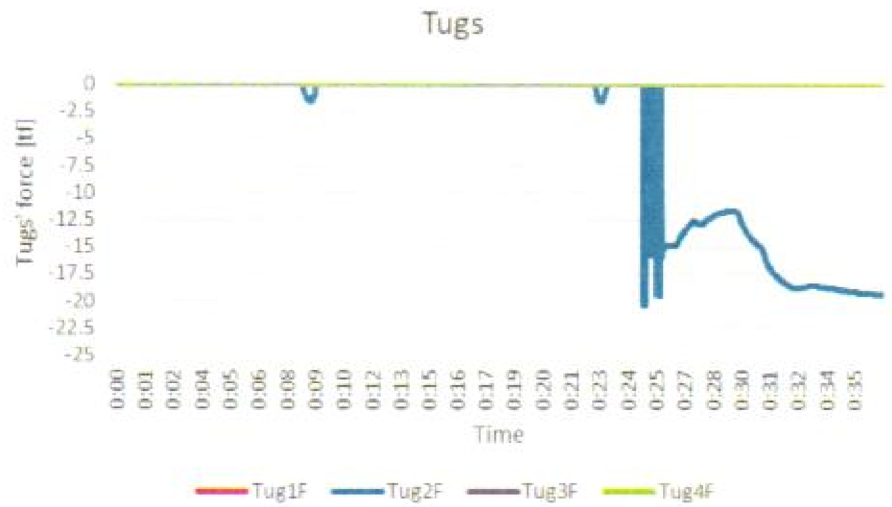

Rudder
50
30
10
-10
-30
-50
Rudder [°]
0:00 0:01 0:02 0:04 0:05 0:06 0:08 0:09 0:10 0:12 0:13 0:15 0:16 0:17 0:19 0:20 0:21 0:23 0:24 0:25 0:27 0:28 0:30 0:31 0:32 0:34 0:35
Time
Rudder

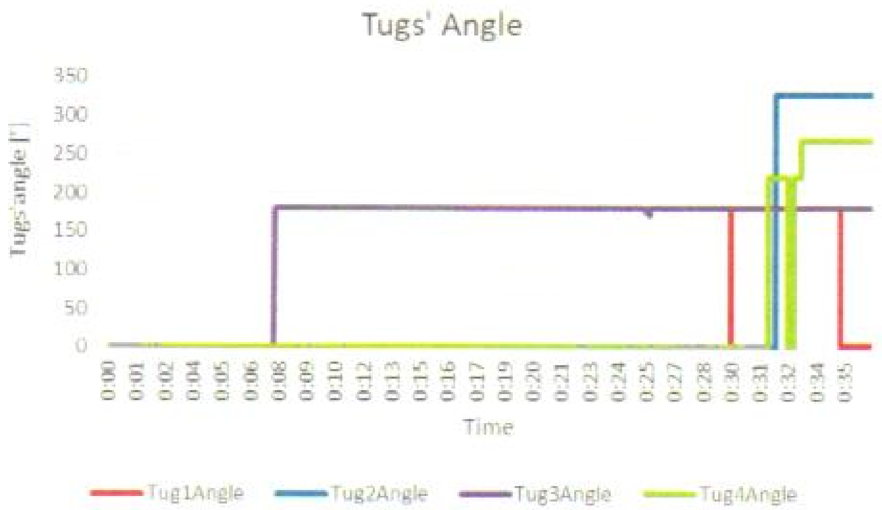

Speed OverGround (SOG)
6
5
4
3
2
1
0
SOG [knots]
0:00 0:01 0:02 0:04 0:05 0:06 0:08 0:09 0:10 0:12 0:13 0:14 0:16 0:17 0:18 0:20 0:21 0:22 0:24 0:25 0:26 0:28 0:29 0:30 0:32 0:33 0:34 0:36
Time
SOG


Transverse speed (Bow and Stern)
Tranverse speed [knots]
1.5
1
0.5
0
-0.5
-1
-1.5
Time
Transverse speed at ship's bow
Transverse speed at ship's stern


Rate of turn
Rate of turn [°/min]
15
10
5
0
-5
-10
-15
Time
Rate of turn


Bow thruster %
Bow thruster %
100
80
60
40
20
0
Time
Bow thruster gained power

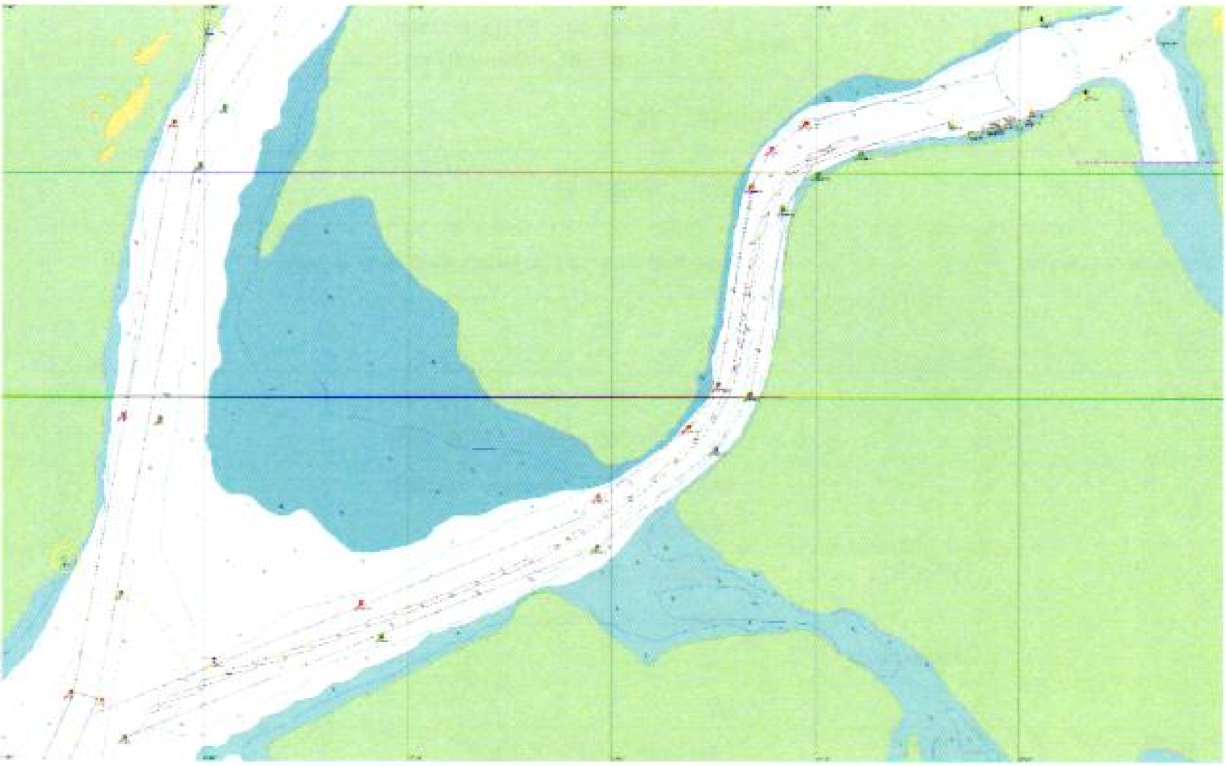

Tugs
Tugs' force [tf]
Time
Tug1F
Tug2F
Tug3F
Tug4F

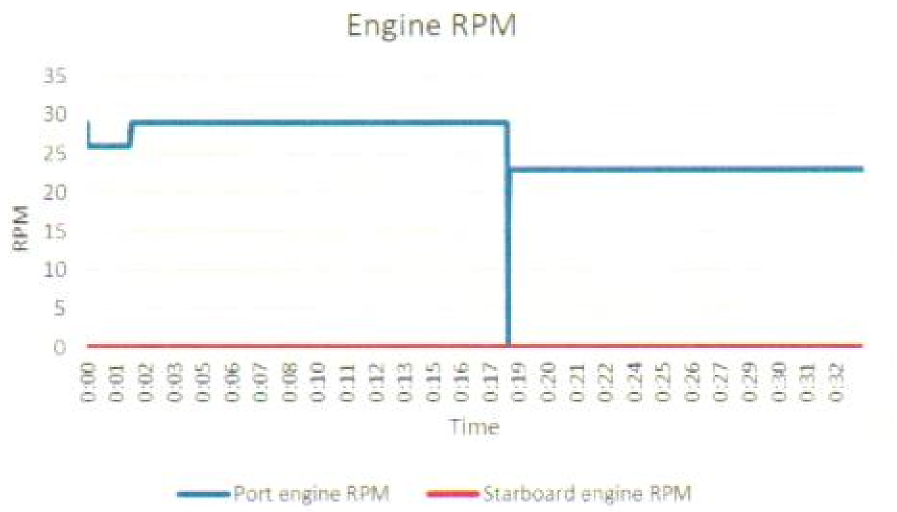

Tugs' Angle
Tugs'angle [°]
Time
Tug1Angle
Tug2Angle
Tug3Angle
Tug4Angle

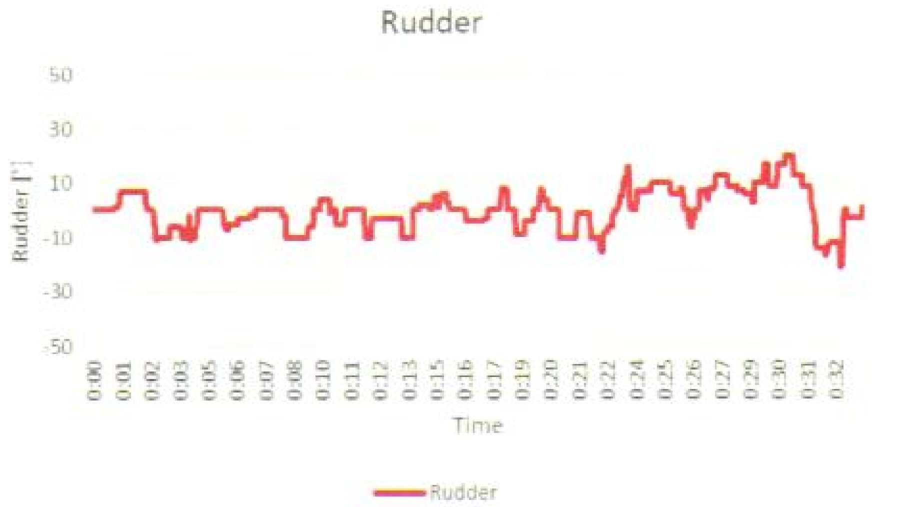
Date:	25/03/2019	Project:	Mitsubishi – JGC Corporation Tabeer LNG Terminal at Port Qasim
Time start:	18:00	Time finish:	18:40
Run n.	3	File name:	MTI2019_03
Manouvre description:		Training session – Arrival with Membrane 130k m³ vessel	
Captain		Ian Simpson	

Vessel	Type	Q-Max	(345m – 53.8m – 266,000m3)	☐
		Q-Flex	(315m – 50.0m – 210,000m3)	☐
		Moss	(300m – 52.0m – 177,000m3)	☐
		Membrane	(274m – 43.3m – 130,000m3)	☒
	Condition	Loaded	(Draft: 10.86 m)	☒
		Ballast	(Draft: 9.50 m)	☐
	Thruster used	Yes		☐
		No		☒
Condition	Position	From buoys B1-B2 to Terminal		☒
		From Terminal to buoys B1-B2		☐
		From buoys B1-B2 to second bend		☐
		From second bend to Terminal		☐
	Manoeuvre	Arrival		☒
		Departure		☐
	Tugs	N.: 1 tug		
Metocean	Current	Dir.: Flood	Speed: 3 hours before HAT	
	Wind	Dir.: 253°	Speed: 10 Kts	

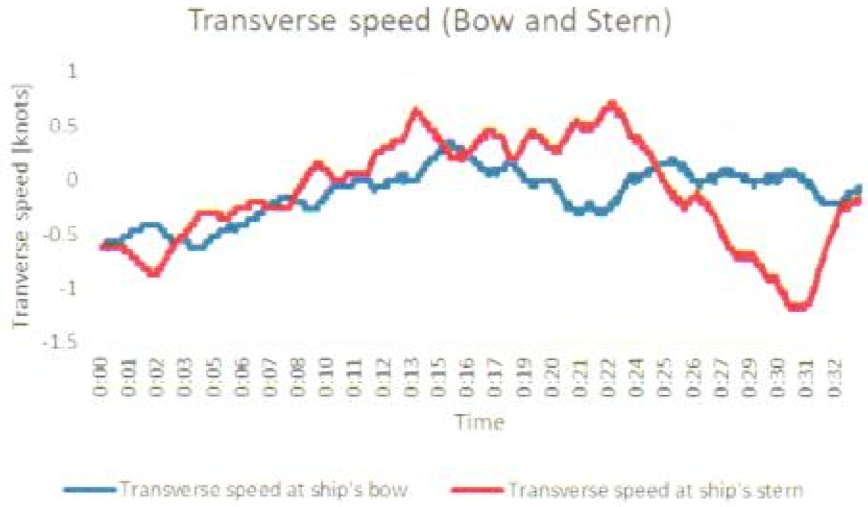
Note:
Familiarisation run to identify the optimum channel transit speed, which will allow the vessel to safely navigate the channel, bends. Speeds exceeding 6 knots in the approach to the second bend result in excessive lateral drift and a loss of control of the ship). Use of stern tug may be necessary to keep the ship speed under control at the desired knots.

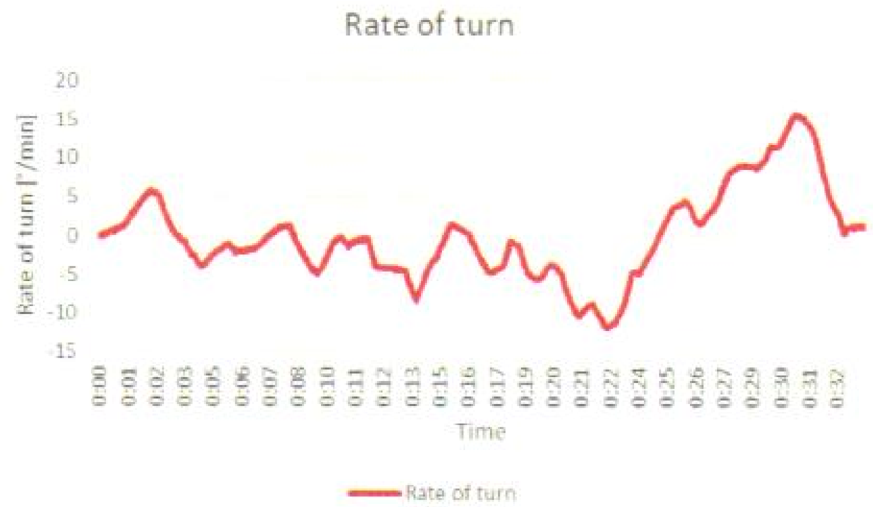


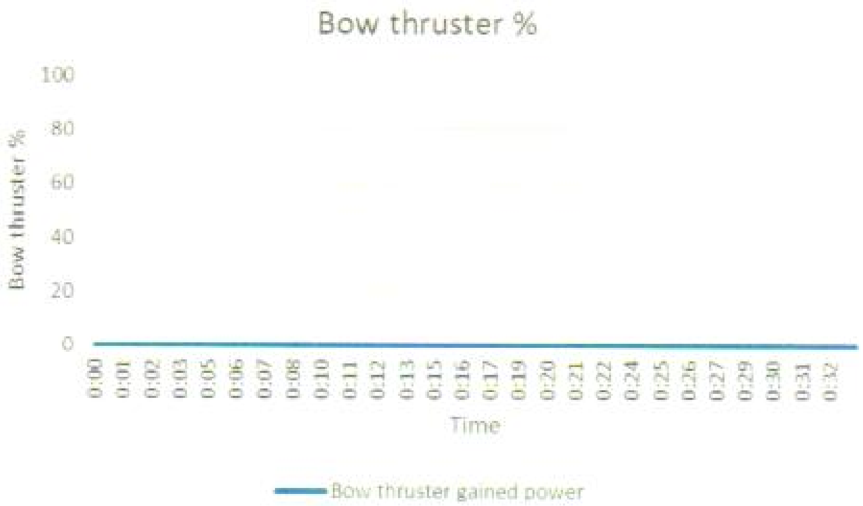

Engine RPM
35
30
25
20
15
10
5
0
RPM
Time
Port engine RPM
Starboard engine RPM

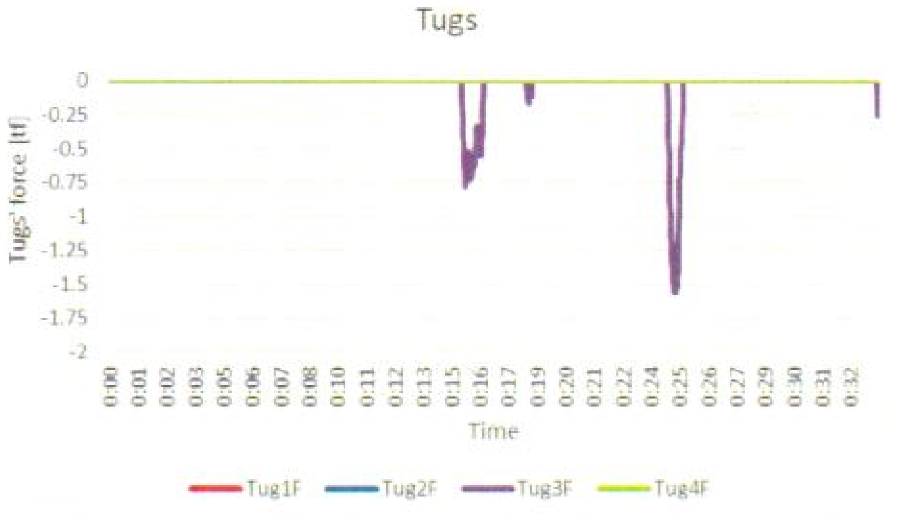

Rudder
50
30
10
-10
-30
-50
Rudder [°]
Time
Rudder


Speed OverGround (SOG)
5
4
3
2
1
0
SOG [knots]
Time
SOG


Transverse speed (Bow and Stern)
Tranverse speed [knots]
Time
Transverse speed at ship's bow
Transverse speed at ship's stern


Rate of turn
Rate of turn [°/min]
Time
Rate of turn


Bow thruster %
Bow thruster %
Time
Bow thruster gained power

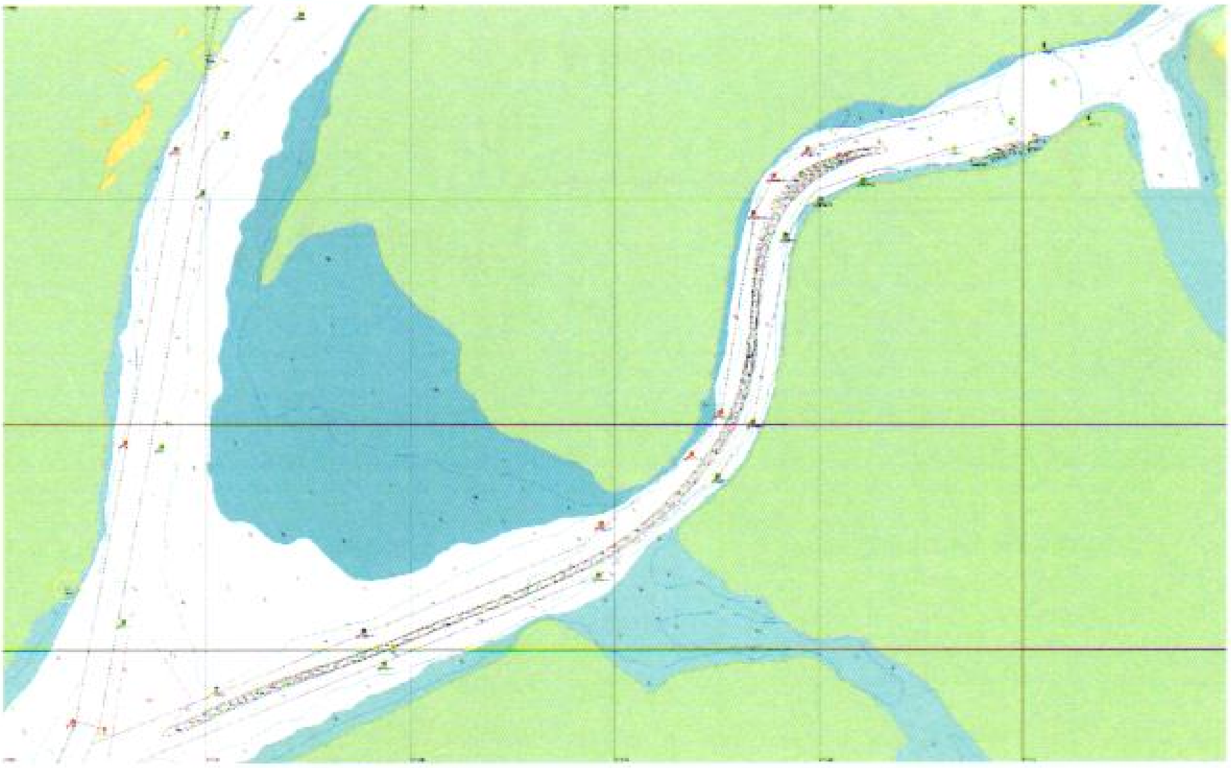

Tugs
Tugs' force [tf]
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
-2
Time
Tug1F
Tug2F
Tug3F
Tug4F

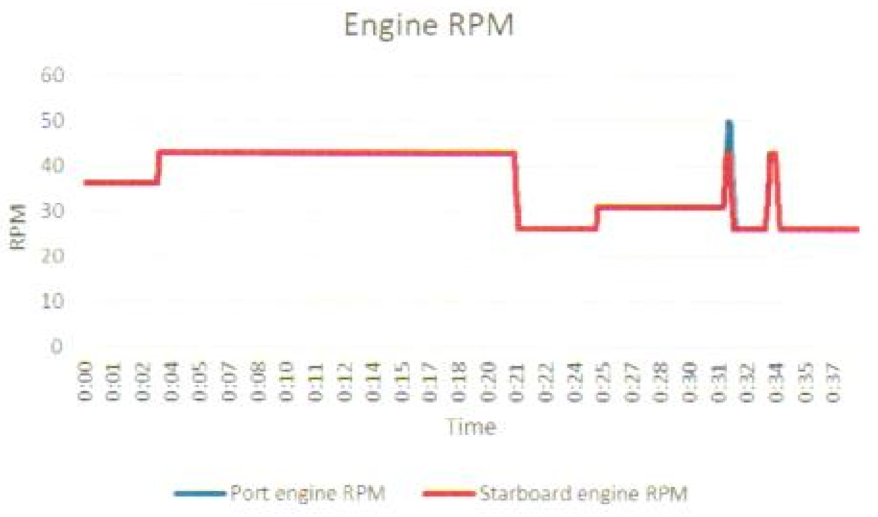

Tugs' Angle
Tugs'angle [°]
400
350
300
250
200
150
100
50
0
Time
Tug1Angle
Tug2Angle
Tug3Angle
Tug4Angle

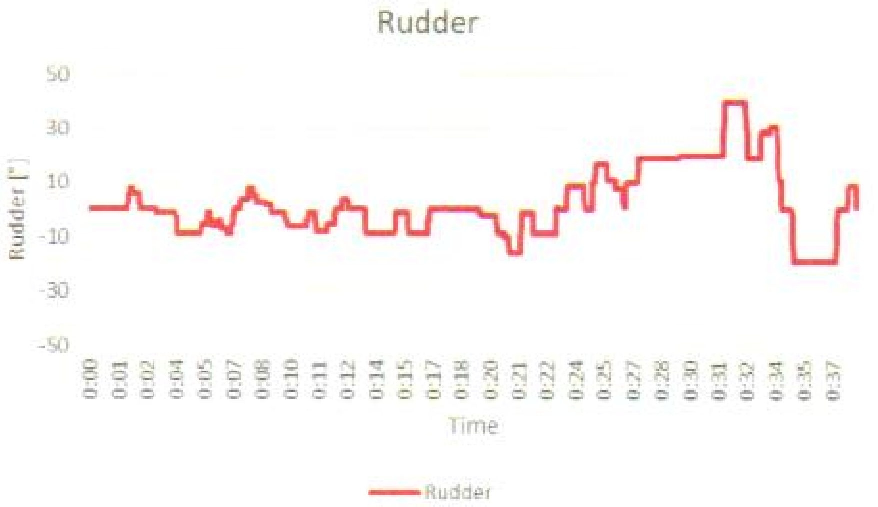
Date:	26/03/2019	Project:	Mitsubishi – JGC Corporation Tabeer LNG Terminal at Port Qasim
Time start:	9:15	Time finish:	9:50
Run n.	4	File name:	MTI2019_04
Manouvre description:		Arrival with Q-Max vessel – Flood 2 hours before HAT & 253° at 10 knots	
Captain		Ian Simpson	

Vessel	Type	Q-Max	(345m – 53.8m – 266,000m3)	☒
		Q-Flex	(315m – 50.0m – 210,000m3)	☐
		Moss	(300m – 52.0m – 177,000m3)	☐
		Membrane	(274m – 43.3m – 130,000m3)	☐
	Condition	Loaded	(Draft: 12.0 m)	☒
		Ballast	(Draft: 9.60 m)	☐
	Thruster used	Yes		☐
		No		☒
Condition	Position	From buoys B1-B2 to Terminal		☐
		From Terminal to buoys B1-B2		☐
		From buoys B1-B2 to second bend		☒
		From second bend to Terminal		☐
	Manoeuvre	Arrival		☒
		Departure		☐
	Tugs	N.: 4 tugs		
Metocean	Current	Dir.: Flood	Speed: 2 hours before HAT	
	Wind	Dir.: 253°	Speed: 10 Kts	

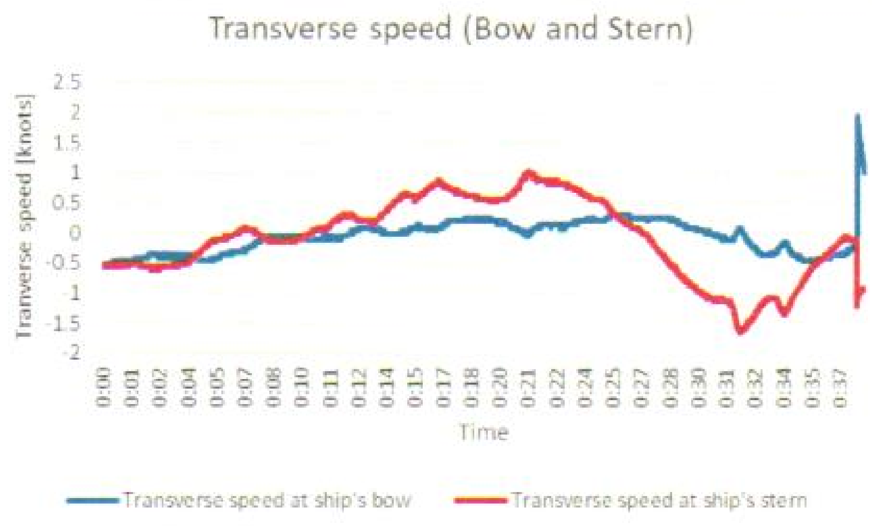
Note:
The ship remains under control within the confines of the channel. Vessel able to navigate the bends. Control of the ship speed is fundamental if vessel is to remain in optimum position throughout Creek transit.



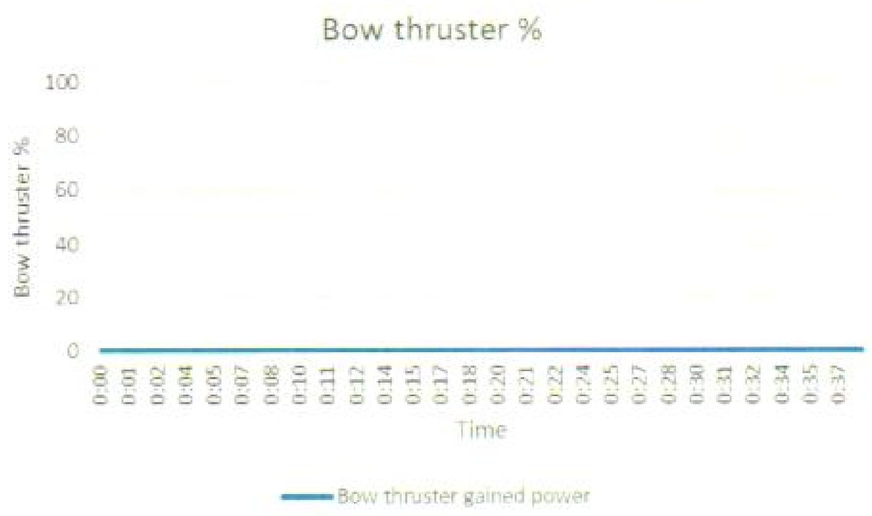

Engine RPM
RPM
Time
Port engine RPM
Starboard engine RPM

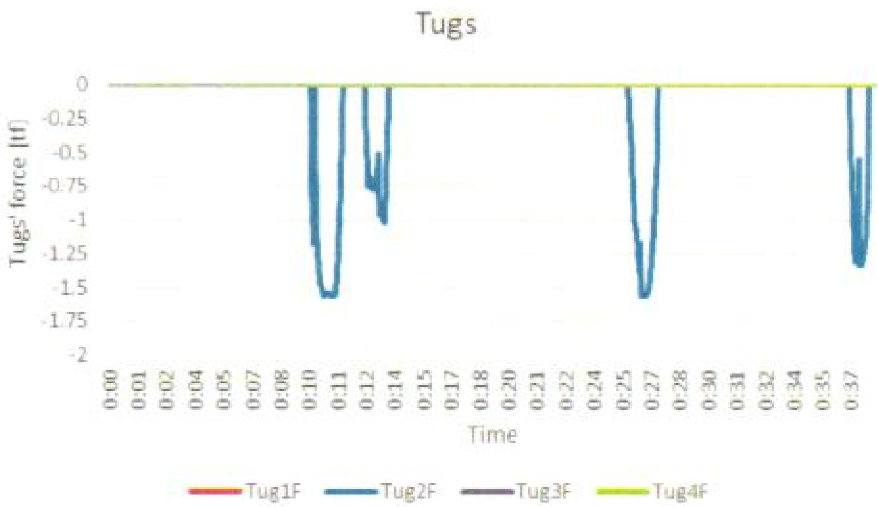

Rudder
Rudder [°]
Time
Rudder

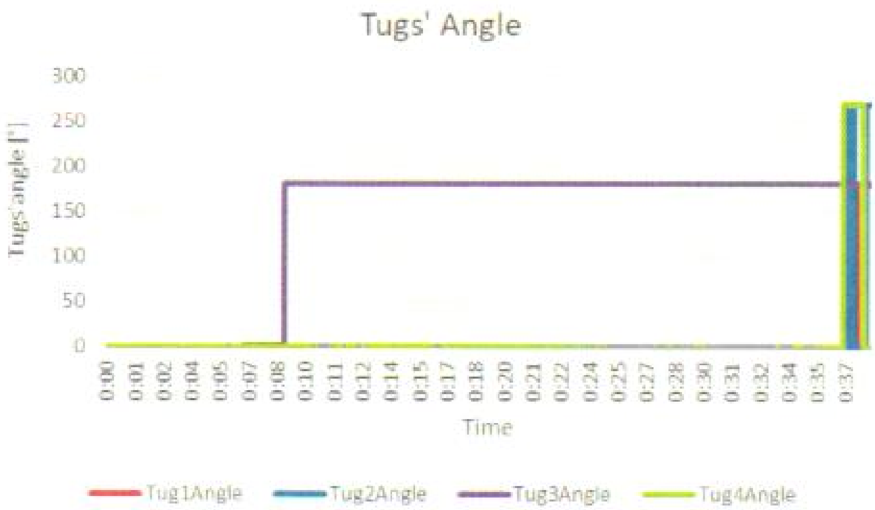

Speed OverGround (SOG)
SOG [knots]
Time
SOG


Transverse speed (Bow and Stern)
Tranverse speed [knots]
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0:00
0:01
0:02
0:04
0:05
0:07
0:08
0:10
0:11
0:12
0:14
0:15
0:17
0:18
0:20
0:21
0:22
0:24
0:25
0:27
0:28
0:30
0:31
0:32
0:34
0:35
0:37
Time
Transverse speed at ship's bow
Transverse speed at ship's stern


Rate of turn
Rate of turn [°/min]
35
30
25
20
15
10
5
0
-5
-10
-15
0:00
0:01
0:02
0:04
0:05
0:07
0:08
0:10
0:11
0:12
0:14
0:15
0:17
0:18
0:20
0:21
0:22
0:24
0:25
0:27
0:28
0:30
0:31
0:32
0:34
0:35
0:37
Time
Rate of turn

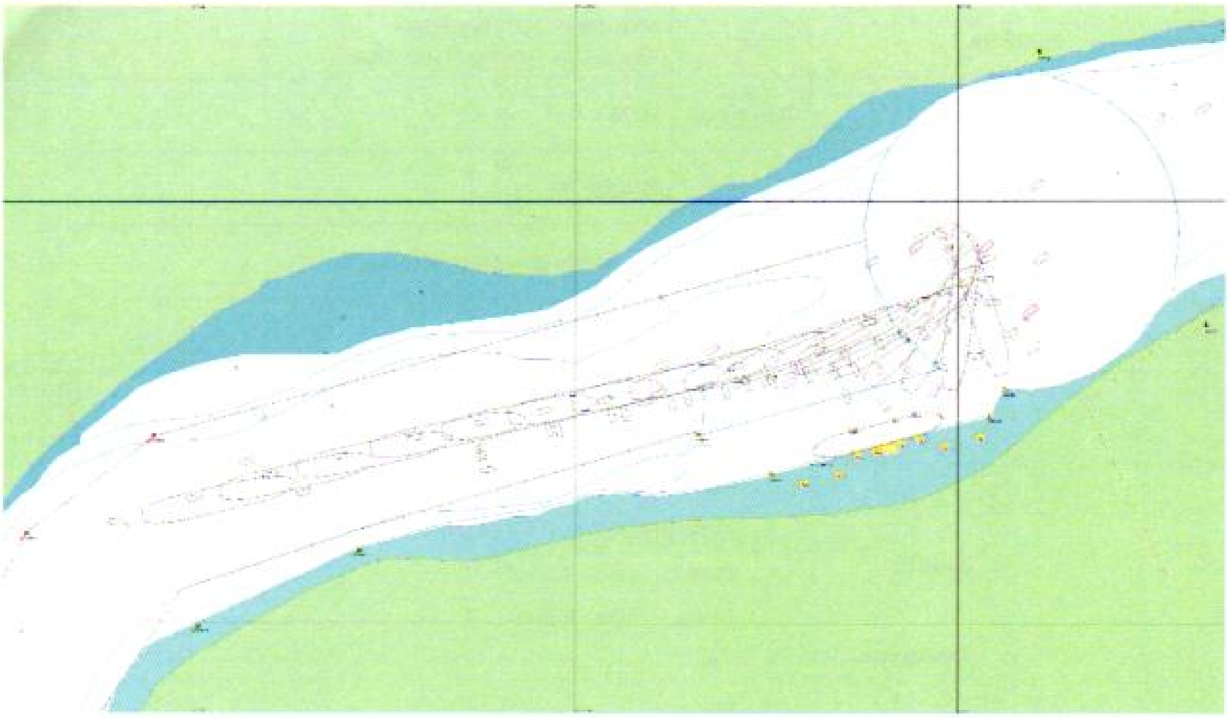

Bow thruster %
Bow thruster %
100
80
60
40
20
0
0:00
0:01
0:02
0:04
0:05
0:07
0:08
0:10
0:11
0:12
0:14
0:15
0:17
0:18
0:20
0:21
0:22
0:24
0:25
0:27
0:28
0:30
0:31
0:32
0:34
0:35
0:37
Time
Bow thruster gained power

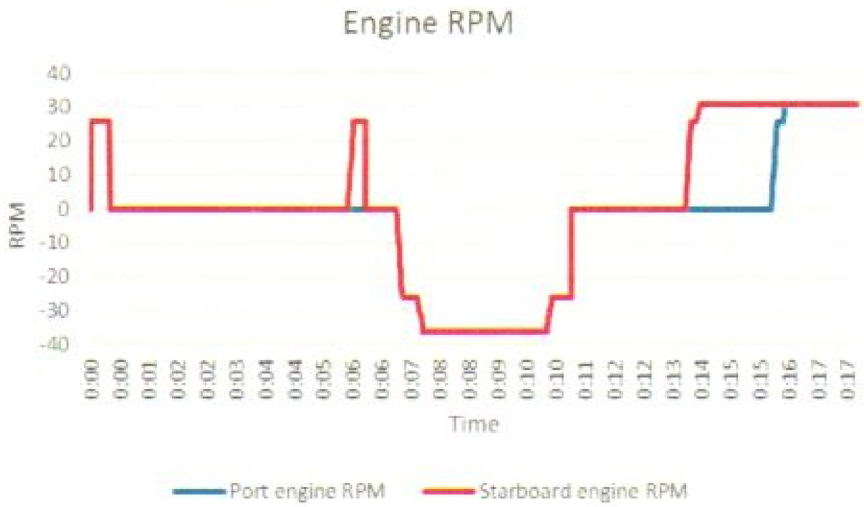

Tugs
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
-2
Tugs' force [tf]
0:00
0:01
0:02
0:04
0:05
0:07
0:08
0:10
0:11
0:12
0:14
0:15
0:17
0:18
0:20
0:21
0:22
0:24
0:25
0:27
0:28
0:30
0:31
0:32
0:34
0:35
0:37
Time
Tug1F
Tug2F
Tug3F
Tug4F

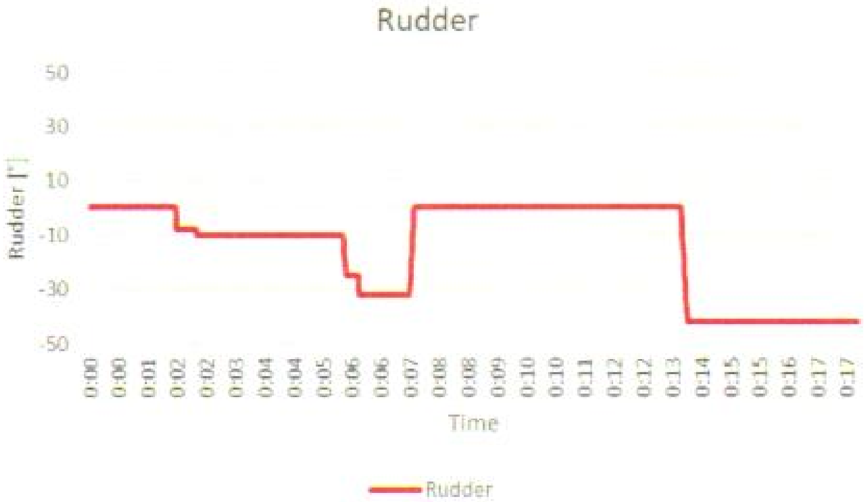

Tugs' Angle
300
250
200
150
100
50
0
Tugs'angle [°]
0:00
0:01
0:02
0:04
0:05
0:07
0:08
0:10
0:11
0:12
0:14
0:15
0:17
0:18
0:20
0:21
0:22
0:24
0:25
0:27
0:28
0:30
0:31
0:32
0:34
0:35
0:37
Time
Tug1Angle
Tug2Angle
Tug3Angle
Tug4Angle

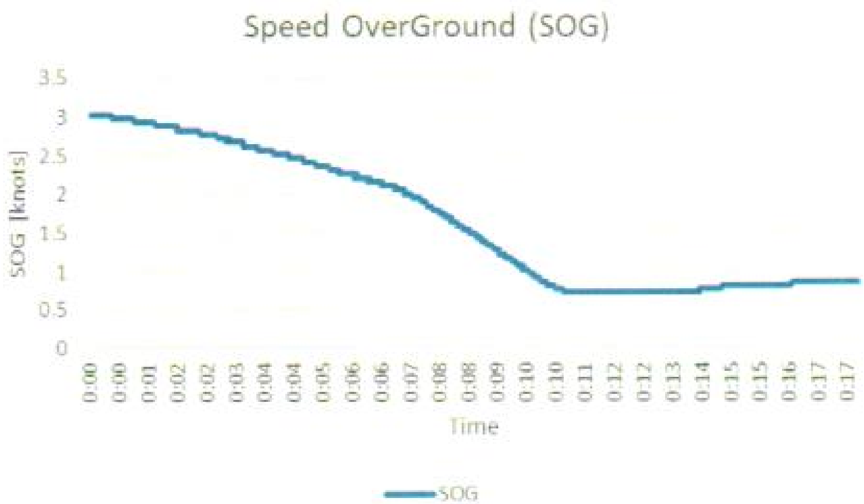
Date:	26/03/2019	Project:	Mitsubishi – JGC Corporation Tabeer LNG Terminal at Port Qasim	
Time start:	10:00	Time finish:	10:20	
Run n.	5	File name:	MTI2019_05	
Manouvre description:		Arrival with Q-Max vessel – Conclusion of Run n. 4		
Captain		Ian Simpson		
Vessel	Type	Q-Max (345m – 53.8m – 266,000m3)		☒
		Q-Flex (315m – 50.0m – 210,000m3)		☐
		Moss (300m – 52.0m – 177,000m3)		☐
		Membrane (274m – 43.3m – 130,000m3)		☐
	Condition	Loaded (Draft: 12.0 m)		☒
		Ballast (Draft: 9.60 m)		☐
	Thruster used	Yes		☐
		No		☒
Condition	Position	From buoys B1-B2 to Terminal		☐
		From Terminal to buoys B1-B2		☐
		From buoys B1-B2 to second bend		☐
		From second bend to Terminal		☒
	Manoeuvre	Arrival		☒
		Departure		☐
	Tugs	N.: 4 tugs		
Metocean	Current	Dir.: Flood	Speed: 2 hours before HAT	
	Wind	Dir.: 253°	Speed: 10 Kts	

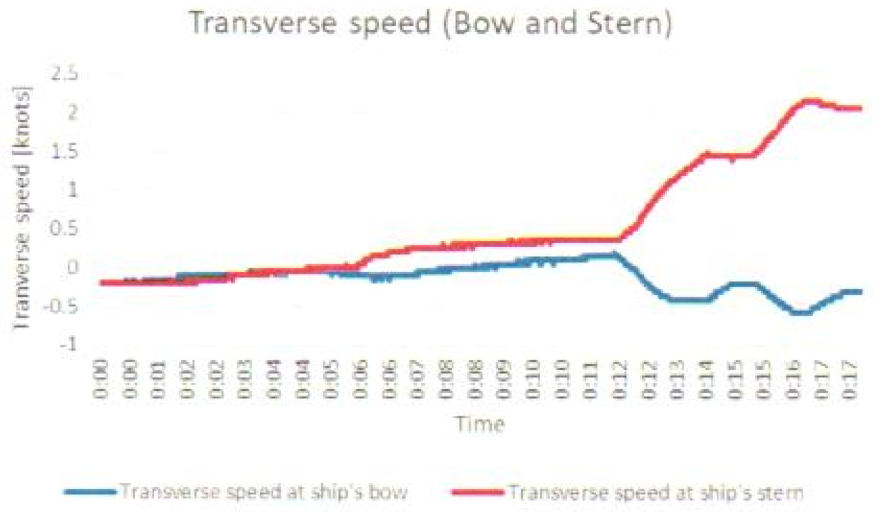
Note:
To determine the speed passing the moored FSRU and the e safe approach speed to swinging position. To evaluate an appropriate swinging strategy.

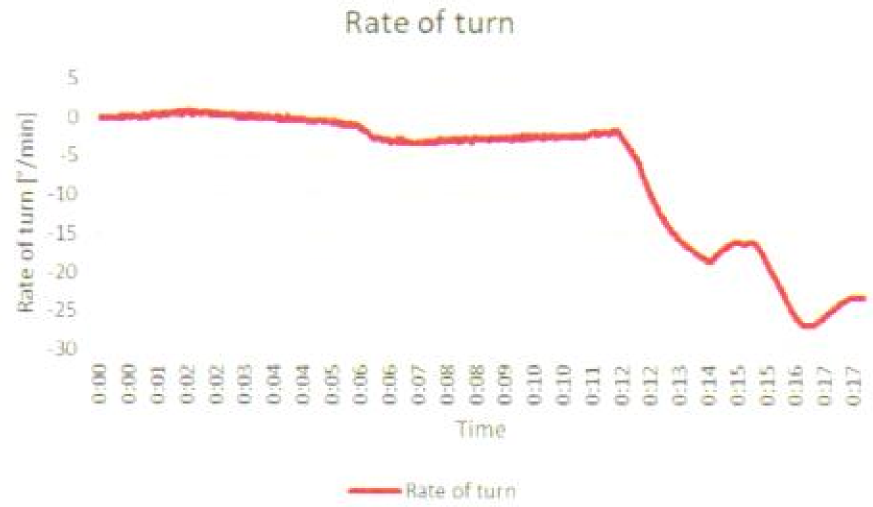


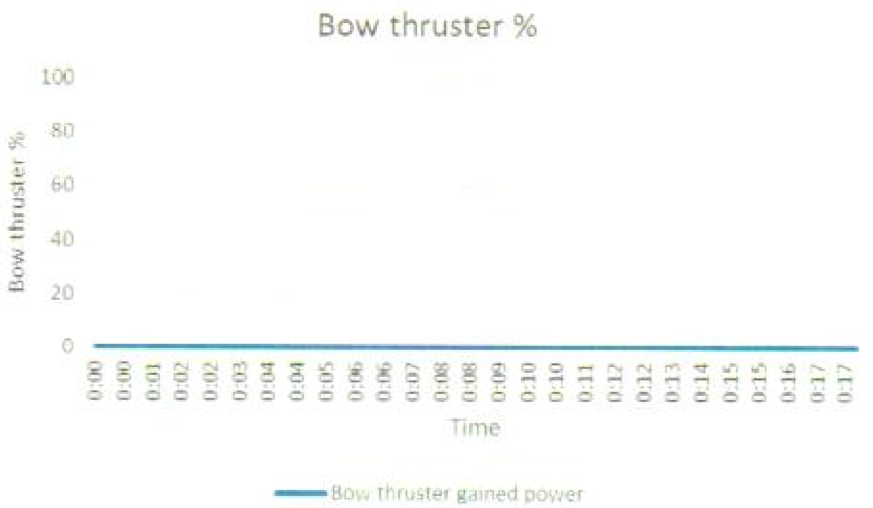

Engine RPM
RPM
Time
Port engine RPM
Starboard engine RPM

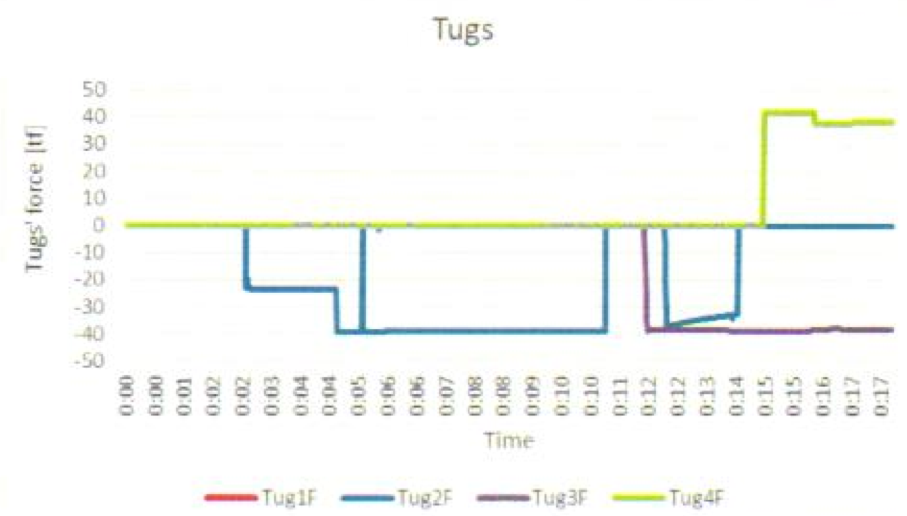

Rudder
Rudder [°]
Time
Rudder

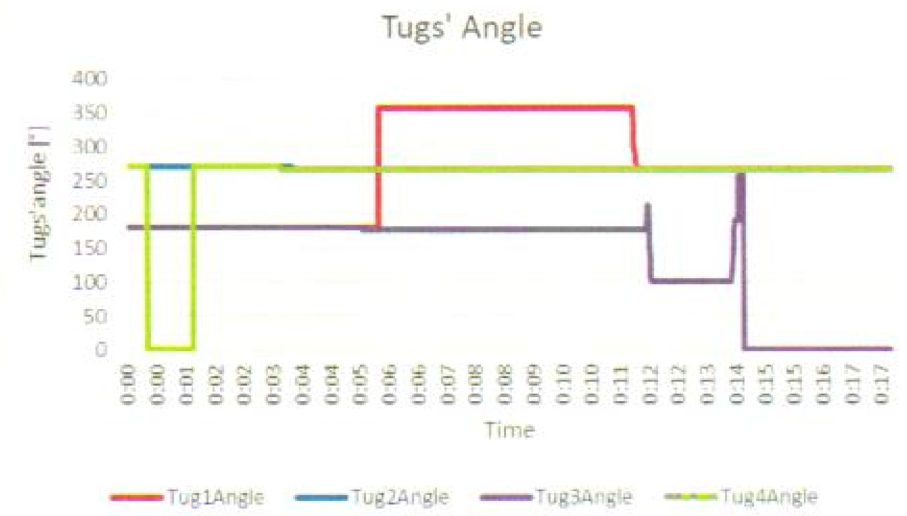

Speed OverGround (SOG)
SOG [knots]
Time
SOG


Transverse speed (Bow and Stern)
Tranverse speed [knots]
Time
Transverse speed at ship's bow
Transverse speed at ship's stern


Rate of turn
Rate of turn [°/min]
Time
Rate of turn


Bow thruster %
Bow thruster %
Time
Bow thruster gained power


Tugs
Tugs' force [tf]
Time
Tug1F
Tug2F
Tug3F
Tug4F

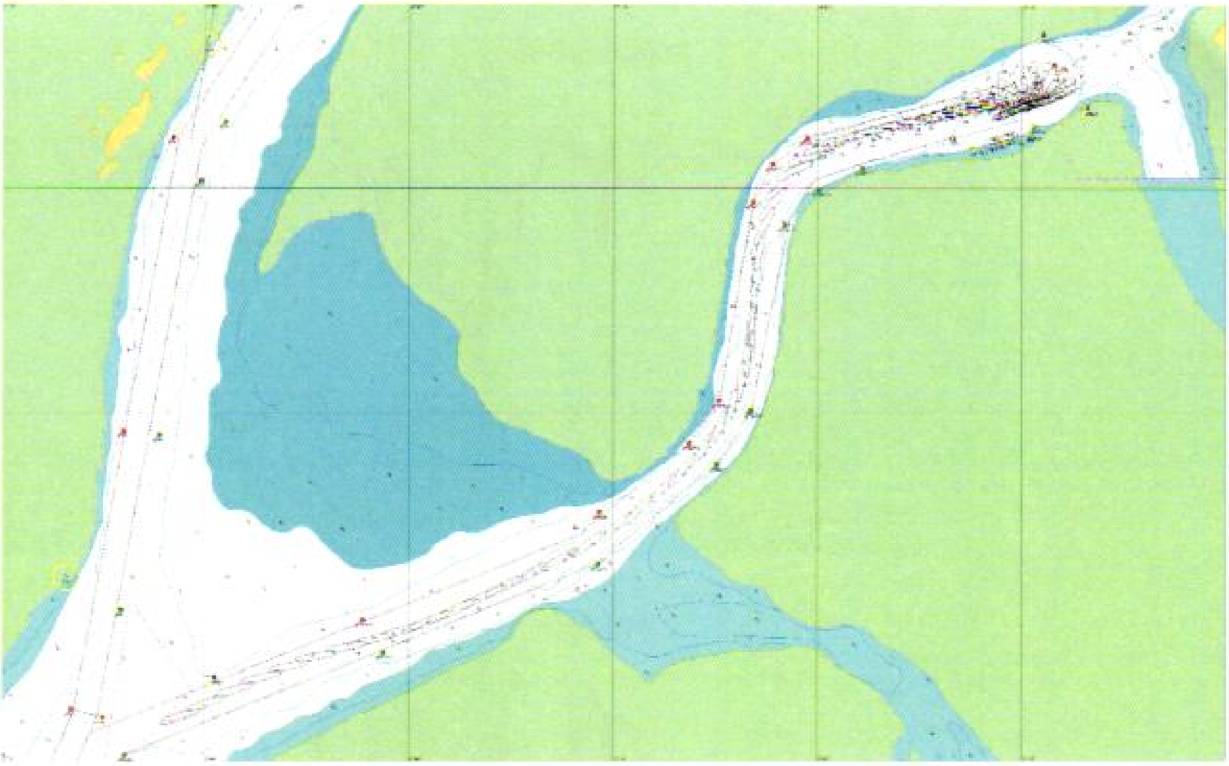

Tugs' Angle
Tugs'angle [°]
Time
Tug1Angle
Tug2Angle
Tug3Angle
Tug4Angle

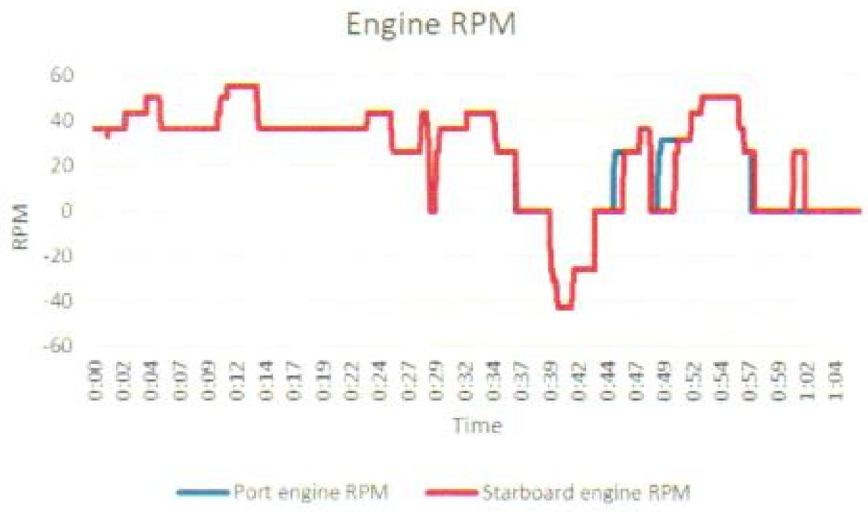
Date:	26/03/2019	Project:	Mitsubishi – JGC Corporation Tabeer LNG Terminal at Port Qasim
Time start:	10:30	Time finish:	11:10
Run n.	6	File name:	MTI2019_06
Manouvre description:		Arrival with Q-Max vessel – Flood 3 hours before HAT & 253° at 10 knots	
Captain		Ian Simpson	

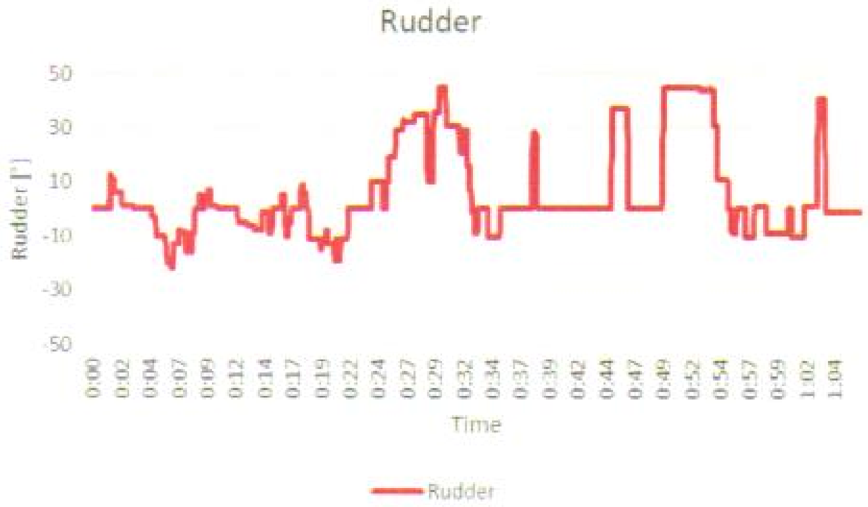
Vessel	Type	Q-Max	(345m – 53.8m – 266,000m3)	☒
		Q-Flex	(315m – 50.0m – 210,000m3)	☐
		Moss	(300m – 52.0m – 177,000m3)	☐
		Membrane	(274m – 43.3m – 130,000m3)	☐
	Condition	Loaded	(Draft: 12.0 m)	☒
		Ballast	(Draft: 9.60 m)	☐
	Thruster used	Yes		☐
		No		☒
Condition	Position	From buoys B1-B2 to Terminal		☒
		From Terminal to buoys B1-B2		☐
		From buoys B1-B2 to second bend		☐
		From second bend to Terminal		☐
	Manoeuvre	Arrival		☒
		Departure		☐
	Tugs	N.: 4 tugs		
Metocean	Current	Dir.: Flood	Speed: 3 hours before HAT	
	Wind	Dir.: 253°	Speed: 10 Kts	

Note:

Maintaining optimum vessel positioning throughout the Creek transit is more demanding than the previous runs due to the higher current regime. Although the ship can be controlled and is able to complete the bends, aggressive manoeuvring techniques are required to ensure the vessel may safely navigate the bends and avoid excessive lateral drift. Swinging of the ship prior to approaching the berthed FSRU requires the full longitudinal extent of the proposed swinging basin as the vessel experiences large set due to the high current.

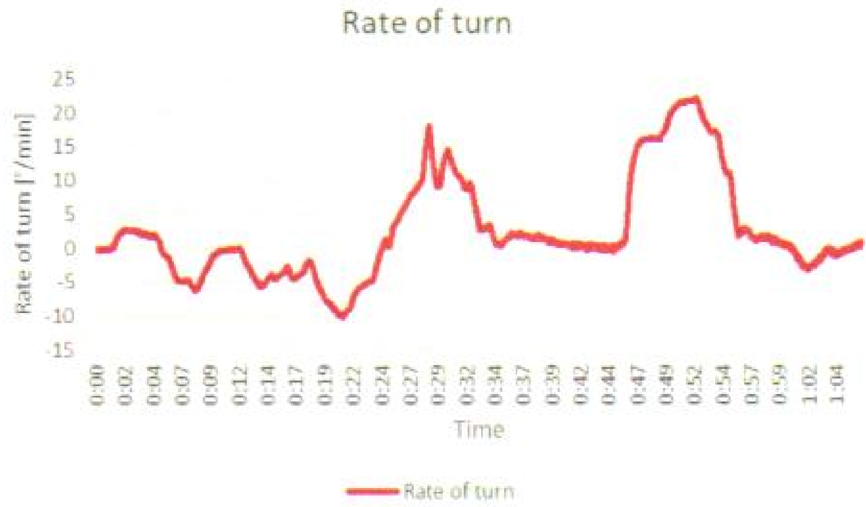


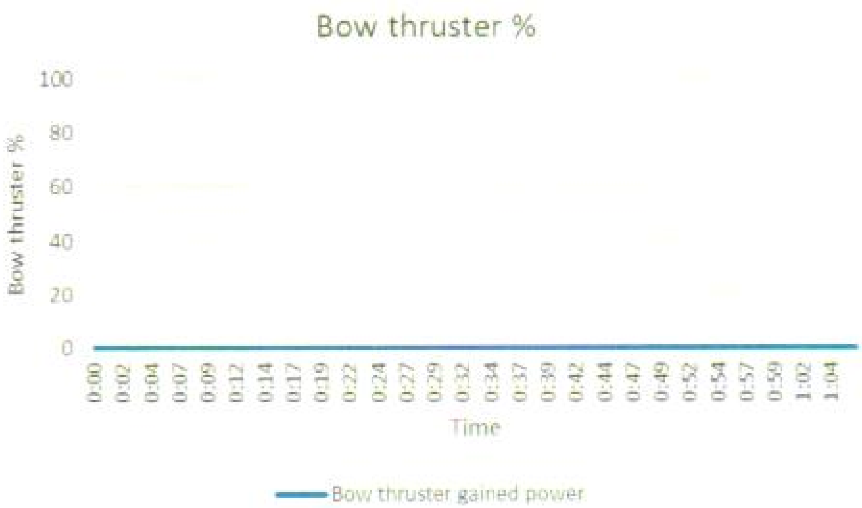

Engine RPM
60
40
20
0
-20
-40
-60
RPM
0:00
0:02
0:04
0:07
0:09
0:12
0:14
0:17
0:19
0:22
0:24
0:27
0:29
0:32
0:34
0:37
0:39
0:42
0:44
0:47
0:49
0:52
0:54
0:57
0:59
1:02
1:04
Time
Port engine RPM
Starboard engine RPM

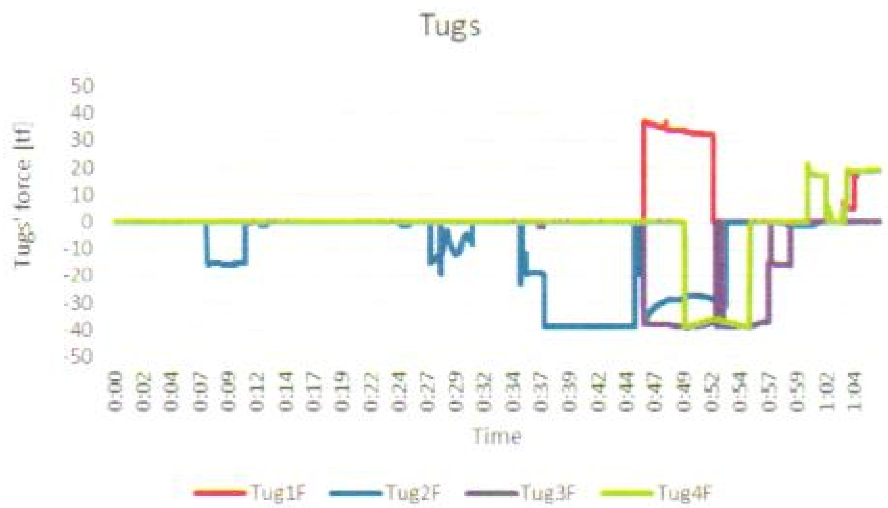

Rudder
50
30
10
-10
-30
-50
Rudder [°]
0:00
0:02
0:04
0:07
0:09
0:12
0:14
0:17
0:19
0:22
0:24
0:27
0:29
0:32
0:34
0:37
0:39
0:42
0:44
0:47
0:49
0:52
0:54
0:57
0:59
1:02
1:04
Time
Rudder

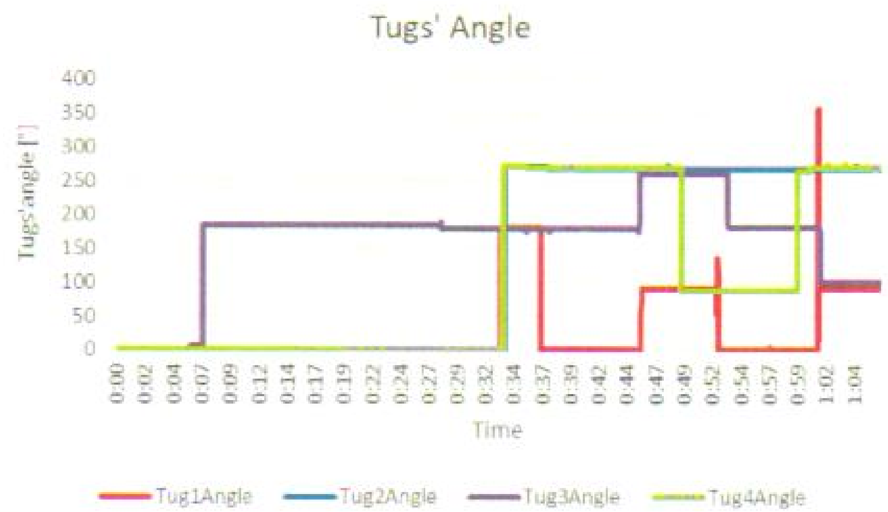

Speed OverGround (SOG)
5
4
3
2
1
0
SOG [knots]
0:00
0:02
0:04
0:07
0:09
0:12
0:14
0:16
0:19
0:21
0:24
0:26
0:28
0:31
0:33
0:36
0:38
0:40
0:43
0:45
0:48
0:50
0:52
0:55
0:57
1:00
1:02
1:04
Time
SOG


Transverse speed (Bow and Stern)
Tranverse speed [knots]
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
Time
Transverse speed at ship's bow
Transverse speed at ship's stern


Rate of turn
Rate of turn [°/min]
25
20
15
10
5
0
-5
-10
-15
Time
Rate of turn


Bow thruster %
Bow thruster %
100
80
60
40
20
0
Time
Bow thruster gained power

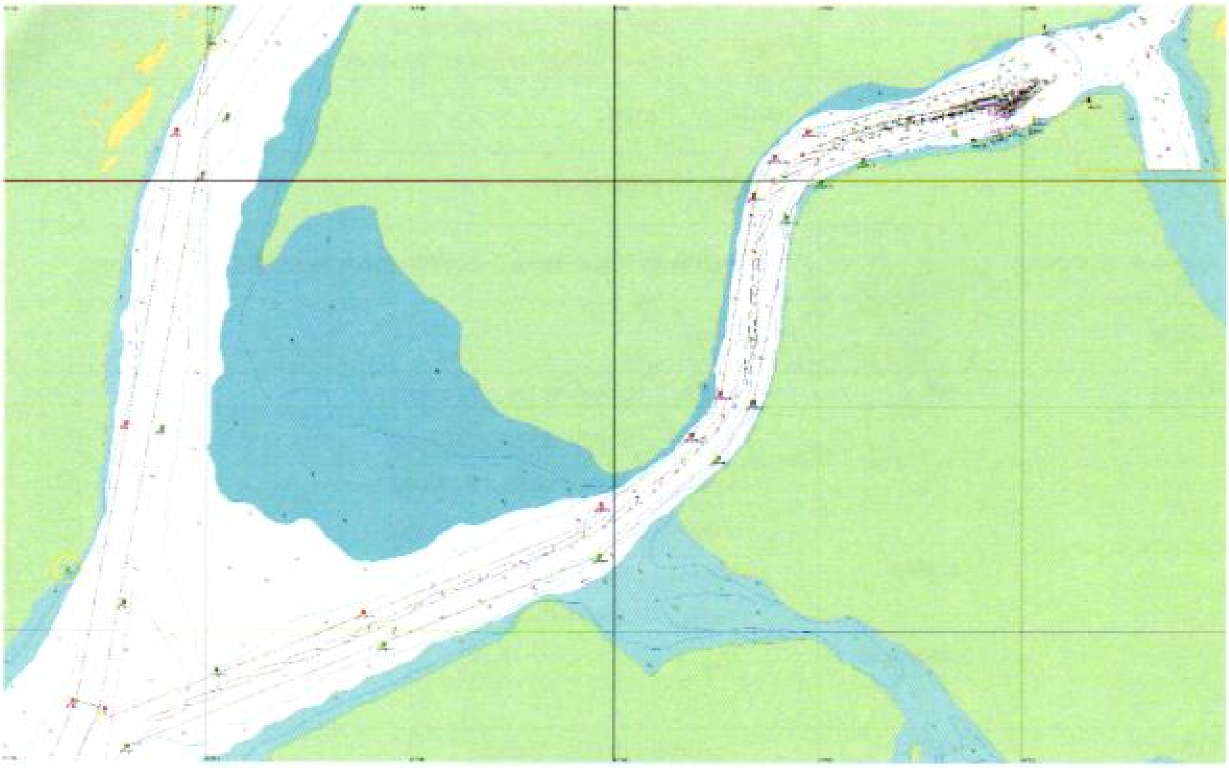

Tugs
Tugs' force [tf]
50
40
30
20
10
0
-10
-20
-30
-40
-50
0:00 0:02 0:04 0:07 0:09 0:12 0:14 0:17 0:19 0:22 0:24 0:27 0:29 0:32 0:34 0:37 0:39 0:42 0:44 0:47 0:49 0:52 0:54 0:57 0:59 1:02 1:04
Time
Tug1F
Tug2F
Tug3F
Tug4F

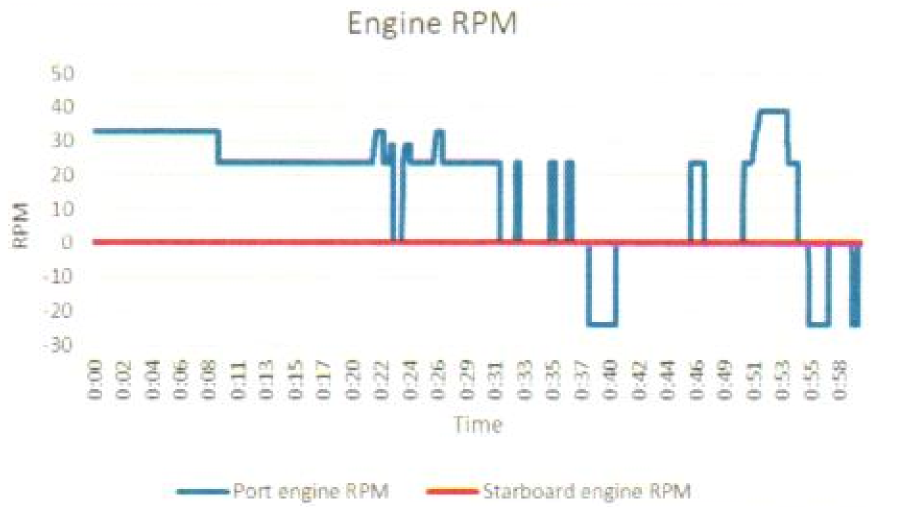

Tugs' Angle
Tugs'angle [°]
400
350
300
250
200
150
100
50
0
0:00 0:02 0:04 0:07 0:09 0:12 0:14 0:17 0:19 0:22 0:24 0:27 0:29 0:32 0:34 0:37 0:39 0:42 0:44 0:47 0:49 0:52 0:54 0:57 0:59 1:02 1:04
Time
Tug1Angle
Tug2Angle
Tug3Angle
Tug4Angle

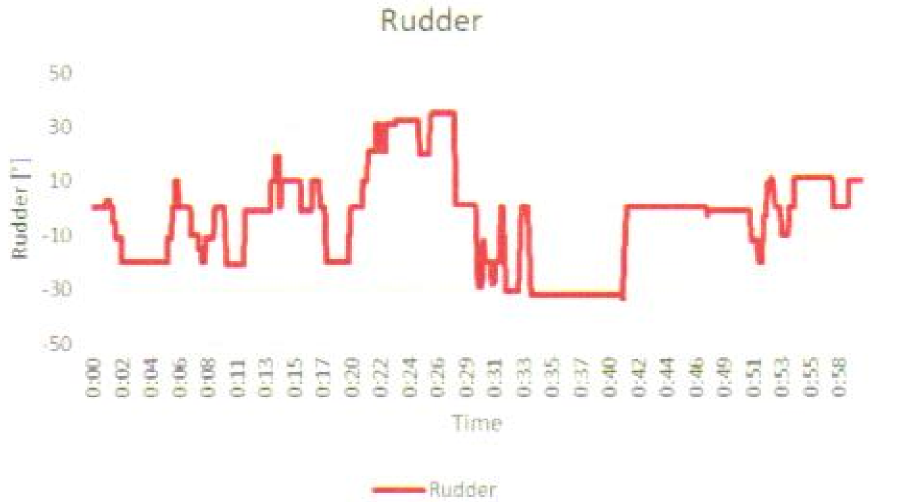
Date:	26/03/2019	Project:	Mitsubishi – JGC Corporation Tabeer LNG Terminal at Port Qasim
Time start:	12:25	Time finish:	13:00
Run n.	7	File name:	MTI2019_07
Manouvre description:		Arrival with Moss 170k m^3 vessel – Flood 3 hours before HAT & 253° at 10 knots	
Captain		Ian Simpson	

Vessel	Type	Q-Max	(345m – 53.8m – 266,000m3)	☐
		Q-Flex	(315m – 50.0m – 210,000m3)	☐
		Moss	(300m – 52.0m – 177,000m3)	☒
		Membrane	(274m – 43.3m – 130,000m3)	☐
	Condition	Loaded	(Draft: 11.55 m)	☒
		Ballast	(Draft: 9.50 m)	☐
	Thruster used	Yes		☐
		No		☒
Condition	Position	From buoys B1-B2 to Terminal		☒
		From Terminal to buoys B1-B2		☐
		From buoys B1-B2 to second bend		☐
		From second bend to Terminal		☐
	Manoeuvre	Arrival		☒
		Departure		☐
	Tugs	N.: 4 tugs		
Metocean	Current	Dir.: Flood	Speed: 3 hours before HAT	
	Wind	Dir.: 253°	Speed: 10 Kts	

Note:
Maintaining optimum vessel positioning throughout the Creek transit challenging due to higher following current but manageable with an appropriate manoeuvring strategy.



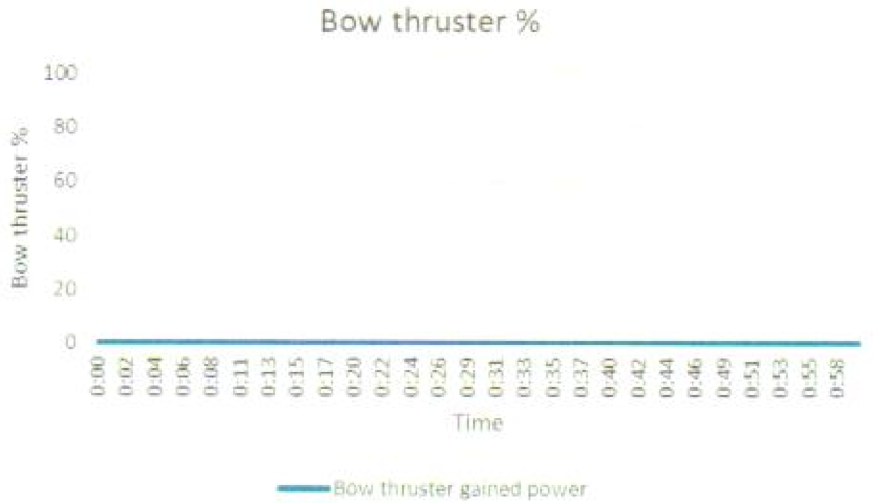

Engine RPM
50
40
30
20
10
0
-10
-20
-30
RPM
Time
Port engine RPM
Starboard engine RPM

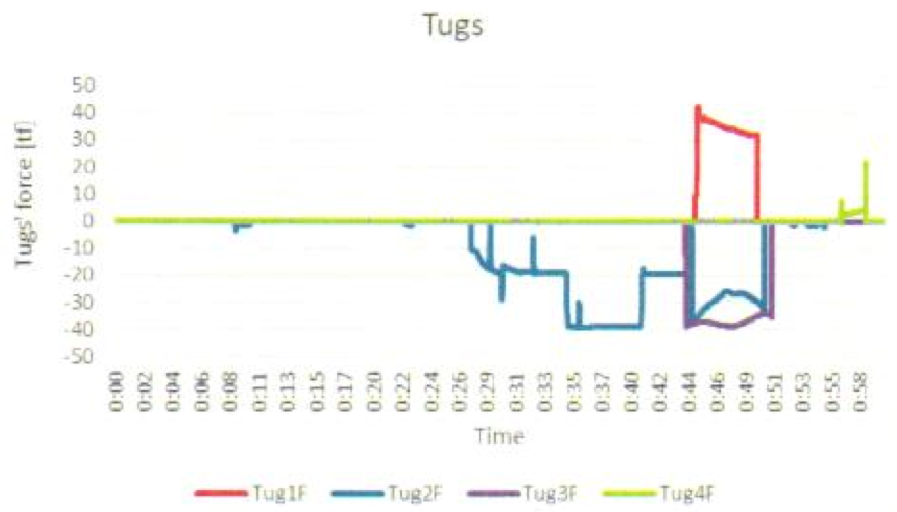

Rudder
50
30
10
-10
-30
-50
Rudder [°]
Time
Rudder

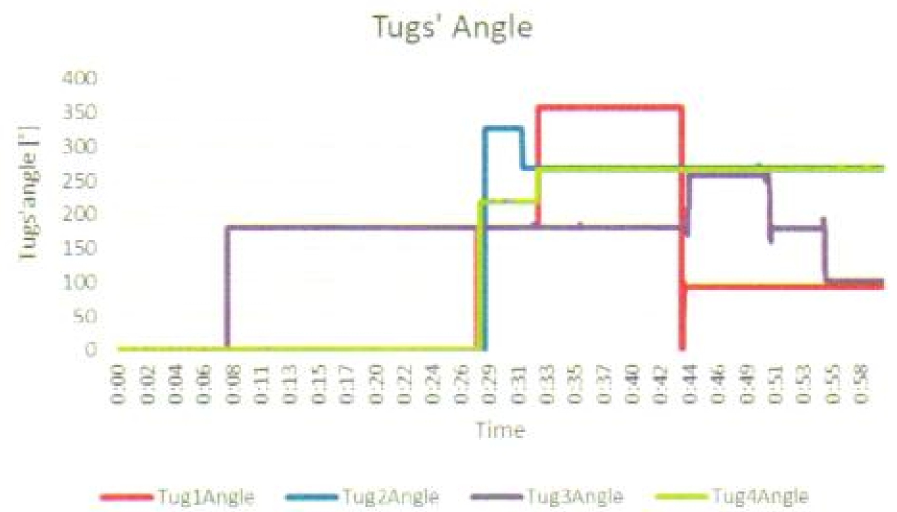

Speed OverGround (SOG)
6
5
4
3
2
1
0
SOG [knots]
Time
SOG


Transverse speed (Bow and Stern)
Tranverse speed [knots]
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
0:00
0:02
0:04
0:06
0:08
0:11
0:13
0:15
0:17
0:20
0:22
0:24
0:26
0:29
0:31
0:33
0:35
0:37
0:40
0:42
0:44
0:46
0:49
0:51
0:53
0:55
0:58
Time
Transverse speed at ship's bow
Transverse speed at ship's stern


Rate of turn
Rate of turn [°/min]
35
30
25
20
15
10
5
0
-5
-10
-15
0:00
0:02
0:04
0:06
0:08
0:11
0:13
0:15
0:17
0:20
0:22
0:24
0:26
0:29
0:31
0:33
0:35
0:37
0:40
0:42
0:44
0:46
0:49
0:51
0:53
0:55
0:58
Time
Rate of turn


Bow thruster %
Bow thruster %
100
80
60
40
20
0
0:00
0:02
0:04
0:06
0:08
0:11
0:13
0:15
0:17
0:20
0:22
0:24
0:26
0:29
0:31
0:33
0:35
0:37
0:40
0:42
0:44
0:46
0:49
0:51
0:53
0:55
0:58
Time
Bow thruster gained power


Tugs
Tugs' force [tf]
Time
Tug1F
Tug2F
Tug3F
Tug4F

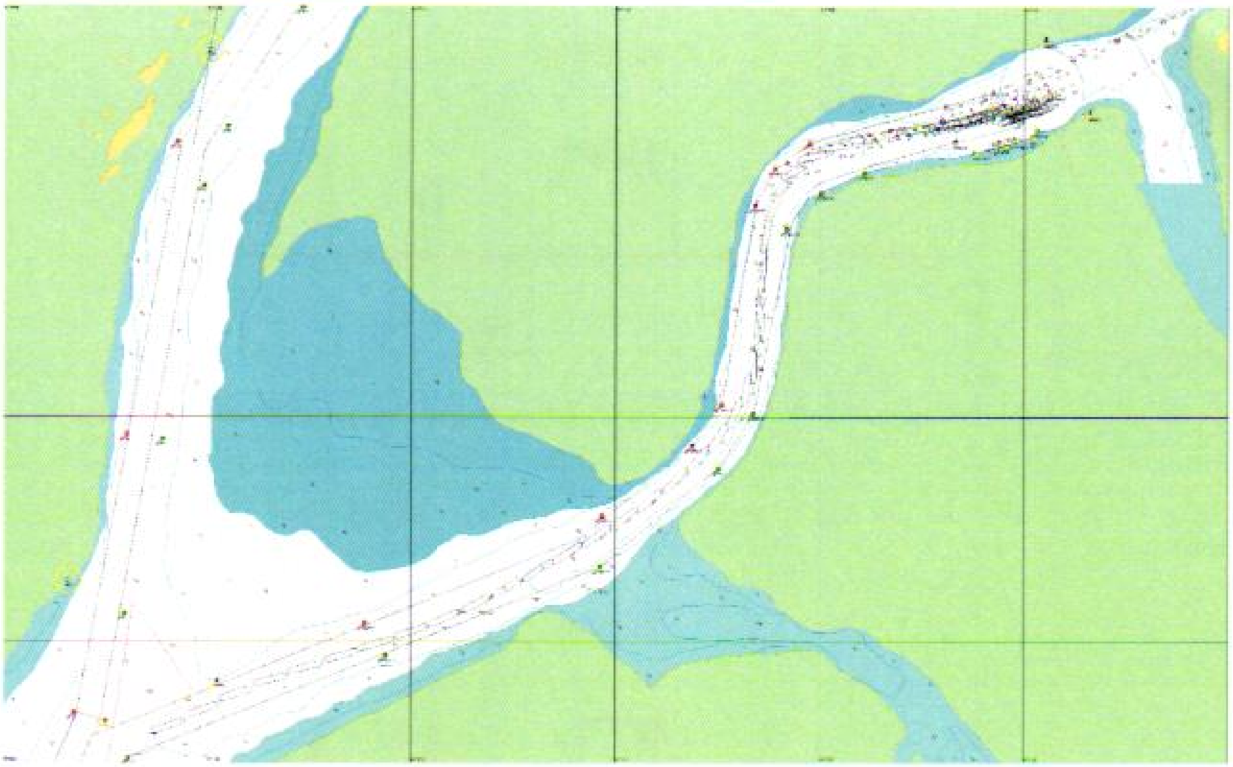

Tugs' Angle
Tugs'angle [°]
Time
Tug1Angle
Tug2Angle
Tug3Angle
Tug4Angle

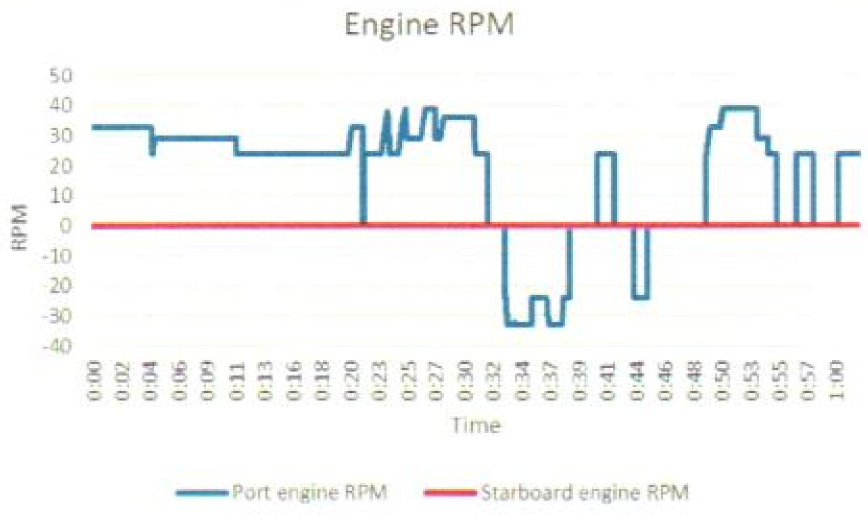
RINA

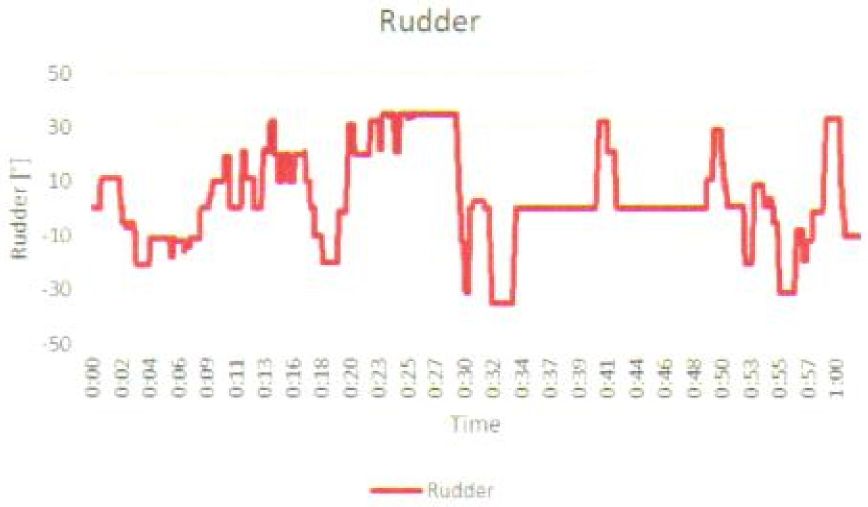
Date:	26/03/2019	Project:	Mitsubishi – JGC Corporation Tabeer LNG Terminal at Port Qasim
Time start:	14:35	Time finish:	15:35
Run n.	8	File name:	MTI2019_08
Manouvre description:		Arrival with Moss 170k m^3 vessel – Flood 3 hours before HAT & 270° at 20 knots (with gusts to 25 knots)	
Captain		Ian Simpson	

Vessel	Type	Q-Max	(345m – 53.8m – 266,000m3)	☐
		Q-Flex	(315m – 50.0m – 210,000m3)	☐
		Moss	(300m – 52.0m – 177,000m3)	☒
		Membrane	(274m – 43.3m – 130,000m3)	☐
	Condition	Loaded	(Draft: 11.55 m)	☒
		Ballast	(Draft: 9.50 m)	☐
	Thruster used	Yes		☐
		No		☒
Condition	Position	From buoys B1-B2 to Terminal		☒
		From Terminal to buoys B1-B2		☐
		From buoys B1-B2 to second bend		☐
		From second bend to Terminal		☐
	Manoeuvre	Arrival		☒
		Departure		☐
	Tugs	N.: 4 tugs		
Metocean	Current	Dir.: Flood	Speed: 3 hours before HAT	
	Wind	Dir.: 270°	Speed: 20 Kts (gusts to 25 kts every 3 min)	

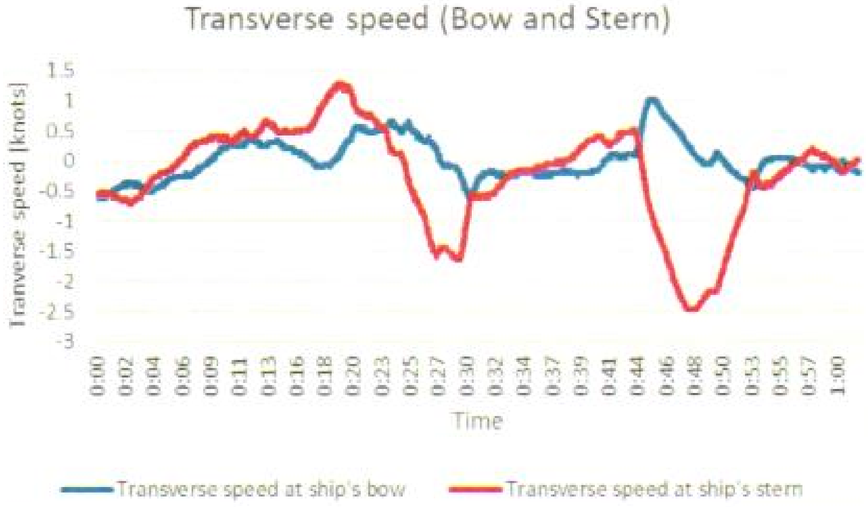
Note:
Manoeuvre is difficult but manageable with an appropriate manoeuvring strategy. Higher and gusting wind from SW requires careful positioning of the vessel in the approach to 2nd bend where the full available width of channel is utilised. Safe transit and swing achieved. Transit in port maximum wind speeds can be safely achieved.

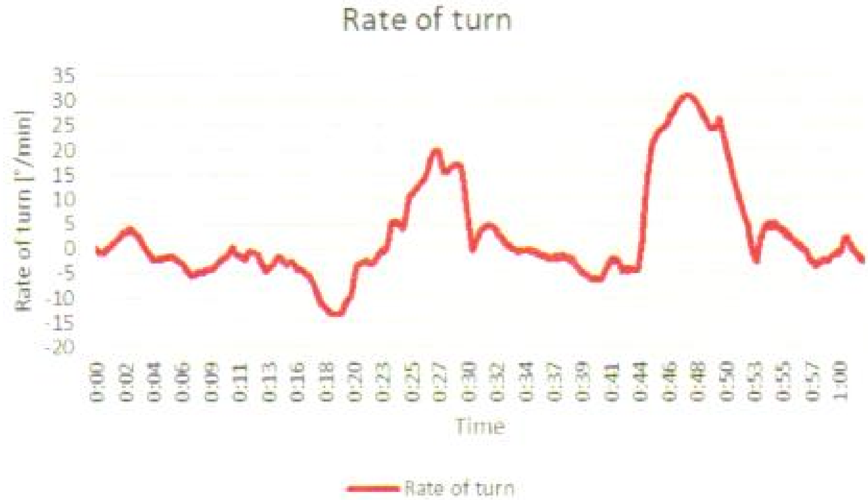


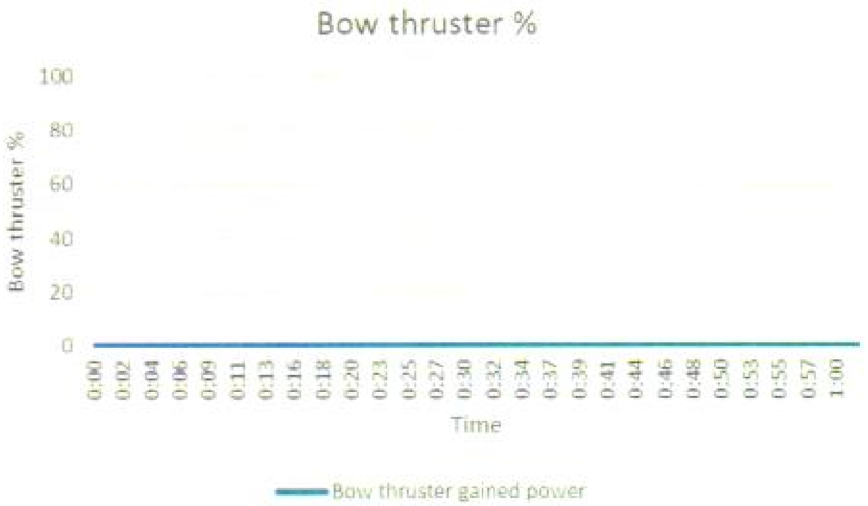

Engine RPM
50
40
30
20
10
0
-10
-20
-30
-40
RPM
0:00
0:02
0:04
0:06
0:09
0:11
0:13
0:16
0:18
0:20
0:23
0:25
0:27
0:30
0:32
0:34
0:37
0:39
0:41
0:44
0:46
0:48
0:50
0:53
0:55
0:57
1:00
Time
Port engine RPM
Starboard engine RPM

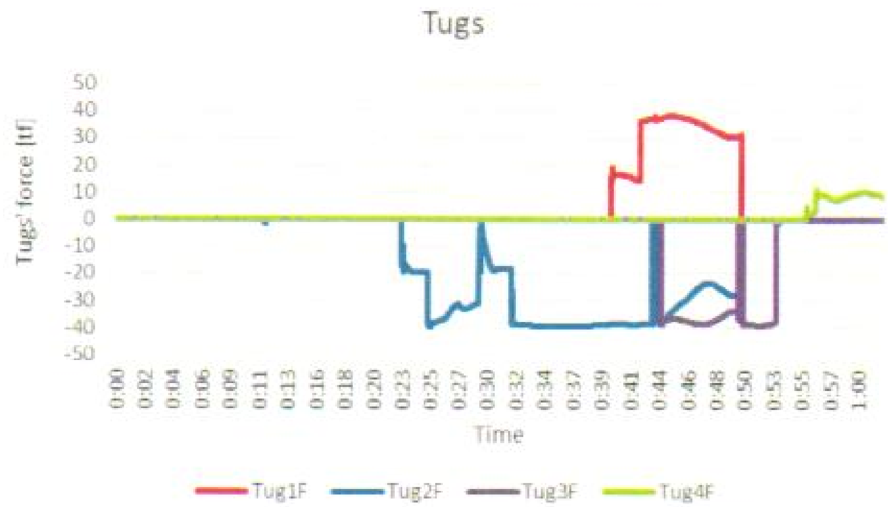

Rudder
50
30
10
-10
-30
-50
Rudder [°]
0:00
0:02
0:04
0:06
0:09
0:11
0:13
0:16
0:18
0:20
0:23
0:25
0:27
0:30
0:32
0:34
0:37
0:39
0:41
0:44
0:46
0:48
0:50
0:53
0:55
0:57
1:00
Time
Rudder

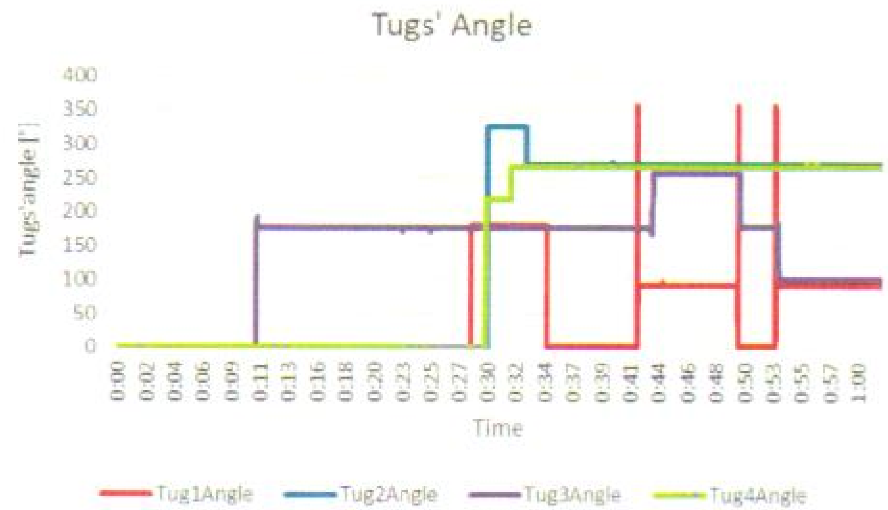

Speed OverGround (SOG)
6
5
4
3
2
1
0
SOG [knots]
0:00
0:02
0:04
0:06
0:08
0:11
0:13
0:15
0:17
0:20
0:22
0:24
0:26
0:29
0:31
0:33
0:35
0:37
0:40
0:42
0:44
0:46
0:49
0:51
0:53
0:55
0:58
1:00
Time
SOG


Transverse speed (Bow and Stern)
Tranverse speed [knots]
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
0:00 0:02 0:04 0:06 0:09 0:11 0:13 0:16 0:18 0:20 0:23 0:25 0:27 0:30 0:32 0:34 0:37 0:39 0:41 0:44 0:46 0:48 0:50 0:53 0:55 0:57 1:00
Time
Transverse speed at ship's bow
Transverse speed at ship's stern


Rate of turn
Rate of turn [°/min]
35
30
25
20
15
10
5
0
-5
-10
-15
-20
0:00 0:02 0:04 0:06 0:09 0:11 0:13 0:16 0:18 0:20 0:23 0:25 0:27 0:30 0:32 0:34 0:37 0:39 0:41 0:44 0:46 0:48 0:50 0:53 0:55 0:57 1:00
Time
Rate of turn


Bow thruster %
Bow thruster %
100
80
60
40
20
0
0:00 0:02 0:04 0:06 0:09 0:11 0:13 0:16 0:18 0:20 0:23 0:25 0:27 0:30 0:32 0:34 0:37 0:39 0:41 0:44 0:46 0:48 0:50 0:53 0:55 0:57 1:00
Time
Bow thruster gained power


Tugs
Tugs' force [tf]
50
40
30
20
10
0
-10
-20
-30
-40
-50
0:00
0:02
0:04
0:06
0:09
0:11
0:13
0:16
0:18
0:20
0:23
0:25
0:27
0:30
0:32
0:34
0:37
0:39
0:41
0:44
0:46
0:48
0:50
0:53
0:55
0:57
1:00
Time
Tug1F
Tug2F
Tug3F
Tug4F


Tugs' Angle
Tugs'angle [°]
400
350
300
250
200
150
100
50
0
0:00
0:02
0:04
0:06
0:09
0:11
0:13
0:16
0:18
0:20
0:23
0:25
0:27
0:30
0:32
0:34
0:37
0:39
0:41
0:44
0:46
0:48
0:50
0:53
0:55
0:57
1:00
Time
Tug1Angle
Tug2Angle
Tug3Angle
Tug4Angle