Using PIANC guidelines to develop an operating tool for planning ship manoeuvres

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Summary
In 2021 the operator of a Liquified Natural Gas (LNG) terminal in Western Australia identified the need to modify the operating parameters for ship manoeuvres. As part of the review of operating parameters, HR Wallingford were commissioned to develop a new operating tool to aid decision making for ship manoeuvres at the LNG terminal. An initial desk based study was completed using industry standard guidance, which was then verified by a real time navigation simulation study. The resulting tool is specific to ship type and the forecast environmental conditions.

Keywords: ships, navigation, LNG, operating criteria, operating tool.

1. Introduction

In 2021 the operator of an LNG terminal in Western Australia identified the need to modify the operating parameters for ship manoeuvres.

The terminal previously used a basic table to identify operating parameters to be used by the marine pilots at the facility, when planning ship manoeuvres. As part of the review of operating parameters, HR Wallingford were commissioned to develop a new operating tool to aid decision making for ship manoeuvres at the LNG terminal. An initial desk based study was completed using industry standard guidance, which was then verified by a real time navigation simulation study.

2. Desk based review

The first stage of the study was a desk based review of the site characteristics, environmental conditions and operating parameters and procedures.

The review of site characteristics and environmental conditions provided a complete understanding of the metocean conditions in which the LNGCs and condensate tankers operate at the terminal.

The existing operating procedures were reviewed to establish an understanding of typical approach speeds, manoeuvring strategies and the deployment of the tugs that were previously available. These reviews informed the subsequent stages of the study.

3. Design ships

Previously, the terminal determined tug requirements and limiting wind speeds for manoeuvres based on the exposed lateral windage area, with ships put in one of two groups. This study identified the need to provide greater detail and determine operating parameters by ship type. Based on a review of ships that have operated at the LNG terminal, a total of 10 design ship groups were established, which included:

- Three membrane tank LNGC groups, including ships with capacities from 135,000m^3 to 215,000m^3.
- Four spherical tank LNGC groups, including ships with capacities from 125,000m^3 to 177,000m^3.
- Two Sayaendo/Sayaringo tank LNGC groups, including ships with capacities from 155,000m^3 to 176,000m^3.
- One condensate tanker group with capacity up to 115,000 deadweight tonnes (DWT).

Characteristics such as dimensions and windage areas were identified to represent ships in each ship size range.

4. Desk assessment of tug requirements

The desk study included a review of tug requirements for safely manoeuvring the design ships at the terminal.

This assessment calculated the wind, current and wave forces acting on the ships using coefficients in OCIMF MEG4 (Reference 1) and the windage area profiles of the ships. The forces were calculated as acting perpendicular to the ship during berthing and unberthing to be the most conservative method.

The aggregate of the calculated forces for each ship was then translated into the tug bollard pull required to manoeuvre the ship. This was calculated in line with the method detailed in PIANC guidelines report WG116-2012 (Reference 2), which included operational considerations such as tug efficiency losses due to operating in waves and relative tow line angles. To apply a suitable level of redundancy, a safety operation factor was also used which included at least the bollard pull of one tug. The assessment also included calculating how long the ship would take to stop, using the maximum force from the available tugs. This was a static assessment that did not include dynamic effects such as turning ships, which was considered later in the real time navigation simulations.

The desk study resulted in a set of environmental conditions which were considered the upper limit for operation at a static level. These conditions were then verified using real time navigation simulations.

5. Navigation simulations

A real time navigation simulation study was conducted at HR Wallingford's Australia Ship Simulation Centre to verify the desk assessment of tug requirements, and to identify manoeuvring strategies and operating limits for LNGCs and condensate tankers with the available tugs.

A total of 33 simulation runs were conducted, which included standard arrival and departure manoeuvres and a series of failure scenarios, with the available tugs assisting the largest design ships. The failure scenarios included assessment of risk to the berth in the event of a failure to one tug close to the berth during berthing or unberthing, and a review of the risk of a ship grounding after a steering failure in the channel.

For failures at the berth, the ship's final berthing speed was compared to the allowable berthing speed for the fender design. For steering failures in the channel, the proximity to the channel boundaries or speed leaving the channel (grounding speed), where appropriate, was assessed to understand the severity of grounding.

The study demonstrated the influence of relative directions of wind, currents and waves on feasibility of manoeuvres. An extensive tidal model of the terminal was included in the navigation simulations to provide an accurate representation of the flows in the manoeuvring areas. A range of wind directions were applied to verify the desk assessment, with the most frequent and most onerous wind directions at the terminal also simulated as required.

The simulations confirmed the suitability of continuing certain aspects of the existing procedure with the available tugs, including the positioning of tugs with the ship and slowing the ship immediately after a failure. The simulations also identified some modifications to the operating procedure, such as reducing the maximum channel transit speed from 8 to 7 knots to reduce the probability of grounding in the event of a failure.

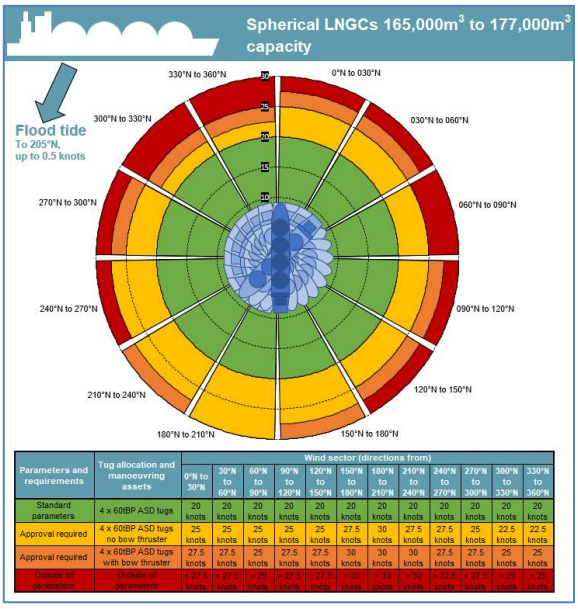
The influence on the ship's swept path from reducing the ship's transit speed in the channel was subsequently reviewed. The swept path assessment followed deterministic methods detailed in PIANC guidelines report WG121-2014 (Reference 3).

6. Determining operating limits

The results of the desk assessment of tug requirements and real time navigation simulations assisted in determining updated operating limits for the LNG terminal. Due to the influence of the relative directions of the environment on ship manoeuvres, the operating parameters were determined for a range of combinations of wind and current direction, which were presented in the form of environmental roses.

The environmental roses were developed for all of the design ship size ranges, and formed the detailed operational tool for the terminal pilots to use when planning ship manoeuvres. The roses show limiting wind speeds for 30° wind direction sectors, which are colour coded to show where senior approval is required, and where a bow thruster increases the limiting wind speed for operations. For each ship group, three environmental roses are available, depending on tidal conditions at the time of the manoeuvre; these represent flood tide, ebb tide and slack water conditions.

For the majority of ship types, the study increased operating wind speed limits when compared to the previous parameters, to at least 20 knots. An example operational rose is shown in Figure 1.



Parameters and requirements	Tug allocation and manoeuvring assets	Wind sector (directions from)											
		0°N to 30°N	30°N to 60°N	60°N to 90°N	90°N to 120°N	120°N to 150°N	150°N to 180°N	180°N to 210°N	210°N to 240°N	240°N to 270°N	270°N to 300°N	300°N to 330°N	330°N to 360°N
Standard parameters	4 x 60tBP ASD tugs	20 knots	20 knots	20 knots	20 knots	20 knots	20 knots	20 knots	20 knots	20 knots	20 knots	20 knots	20 knots
Approval required	4 x 60tBP ASD tugs no bow thruster	25 knots	25 knots	25 knots	25 knots	25 knots	27.5 knots	30 knots	27.5 knots	27.5 knots	25 knots	22.5 knots	22.5 knots
Approval required	4 x 60tBP ASD tugs with bow thruster	27.5 knots	27.5 knots	25 knots	27.5 knots	27.5 knots	30 knots	30 knots	30 knots	27.5 knots	27.5 knots	25 knots	25 knots
Outside of parameters	Outside of parameters	> 27.5 knots	> 27.5 knots	> 25 knots	> 27.5 knots	> 27.5 knots	> 30 knots	> 30 knots	> 30 knots	> 27.5 knots	> 27.5 knots	> 25 knots	> 25 knots

Figure 1 Example operational environmental rose (Source: HR Wallingford).

7. Conclusions

The operating criteria study provided a review of the existing operating procedure for an LNG terminal, with modifications recommended where necessary with the available tug fleet. An operational tool for planning ship manoeuvres at the terminal was developed and is under trial by terminal personnel to aid decision making. The use of the tool is designed to ensure operability at the terminal, so reduce shipping delays, while maintaining safe ship movements.

References

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