Thames Pedestrian and Cycle Bridge, Canary Wharf to Rotherhithe

Chapter 5: Navigational Parameters and Impacts Study

February 2016

Authors

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Thames Pedestrian and Cycle Bridge, Canary Wharf to Rotherhithe Chapter 5: Navigational Parameters and Impacts Study		
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1. Introduction

The site on the tidal Thames presents a complex environment for a new opening bridge of high expected user flows. The bridge should open at a frequency that provides an acceptable balance between a reliable level of service to users and visual impact, operations and cost.

Objectives of the Study were to:

- Define Thames river traffic profile
- Determine the Port of London's (PLA) requirements for the bridge design and to take the project forward
- Determine a viable geometry of the bridge, specifically main span, alignment and air draughts in closed and open positions
- Define impact protection and bridge driving requirements
- Assess the bridge geometry, for impacts on bridge users, visual impact, operations and cost
- Recommend further work

Sources of information for the study were:

- Consultation with the PLA, using iterations of a concept design to test and refine the geometry
- An independent vessel traffic analysis conducted by Marico Marine, Appendix C
- Review of dimensions and operations of other bridges and the Emirates Cable Car

1.1 Routine River Traffic Profile at the Site

River traffic at the site consists of principally commercial passenger vessels, but also other commercial vessels including tugs and cargo vessels, cruise ships, and recreational vessels including Thames Sailing barges. Table 1 below provides a summary of vessel types likely to transit the site.

Vessel categories	Examples of vessel types	Approx. air-draught
HSC & Manoeuvrable Class 5 Passenger Vessels	High Speed Craft and Fast Ferries	
	Thames Clipper vessels	<10m
	Class 5 Rigid Hull Inflatable Boats (RIBs)	<10m
	Class 5 vessels with twin screw & manoeuvring aids	<10m
Traditional Class 5 Passenger Vessels	City Cruises vessels	<10m
	Thames Sailing Barges	>25m
Freight/Cargo	Tug and tows	<15m
	Tankers	<15m
	Motorised barges	<15m
Workboats & other small vessels	Recreational Pleasure Craft (motor)	<10m
	Recreational Sailing Vessels	10m-25m
	Port Tenders	<10m
	Law Enforcement Vessels	<10m
	Search and Rescue Vessels	<10m
	Anti-Pollution Vessels	<10m
Cruise Ships	Cruise ships	>30m
Commercial Vessels	Commercial cargo vessels	<10m
Naval Vessels	All naval vessels	10m-25m

Table 1: Vessel categories, Appendix C Vessel Traffic Analysis

The vessel traffic survey identified 9,591 transits were made in a month at this site (Table 2 below). The vast majority of these vessels were under 10m in air draught. The majority of vessels with air draught over 10m were non-passenger ferries. All or most vessels with 15-25m air draught were recreational vessels.[1]

In addition to the route traffic data in Table 2, several other vessel types transit the site:

- Additional recreational vessels of air draught 18m and under. Approximately 75% of such vessels are not captured in the data above as they are not recorded through the survey method.
- Occasional special events such as the Clipper Round the World Yacht Race and boat festivals occur, bringing high numbers of taller vessels on weekends
- The Paddle Steamer, Waverly, transits the site regularly in September and October each year. See Appendix C for further details.

1 Due to the limitations of the survey, there may be other vessel types that were not captured.

Vessel air draught (m)	<10	<15	<20	<25	>25	#N/A	Grand Total
Cargo	32						32
Cargo-all ships of this type	32						32
Fast Ferries	5,957						5,957
Clippers	3,067						3,067
RIB Tours	2,890						2,890
Other	295						295
Anti-pollution vessel	2						2
Fire Fighting	10						10
Law enforcement vessel	34						34
Port Tender	232						232
Search and rescue vessel	16						16
Survey vessel	1						1
Passenger	2,773	18			43		2,834
HSC-all ships of this type	2						2
Passenger-all ships of this type	2,771	18			43		2,832
Recreational	29	6	48	21	34		138
Vessel-Pleasure craft	29	1					30
Vessel-Sailing		5	48	21	34		108
Tanker	52	10					62
Tanker-all ships of this type	52	10					62
Tug	242	30					272
Tug	242	30					272
Unknown						1	1
Unknown						1	1
Grand Total	**9,380**	**64**	**48**	**21**	**77**	**1**	**9,591**

Table 2: Types and air draughts of vessels transiting the site, taken from AIS data, August 2014, Appendix C

2. PLA Requirements

For any works in the Thames, the project sponsor must fulfil the PLA's navigational and environmental requirements in order to obtain a River Works Licence from the PLA as stipulated under Section 66 of the Port of London Act.

2.1 PLA Consultation

Consultation with PLA was undertaken using iterations of the reForm bridge design to define a viable geometry. The overall requirements for the bridge are to:

- Enable all regular commercial traffic to pass without the bridge opening i.e. all commercial passenger vessels (specifically Class 5 passenger vessels "HSC & Manoeuvrable Class 5" or "Traditional Class 5"), such as Thames Clippers, which form the majority of commercial river traffic at the site
- Enable safe passage of cruise ships passing at 12kts and other larger vessels, subject to their predicted tracks in the river, through a suitable clear span and air draught when open
- Enable all other craft to pass safely either under the closed bridge or via a simple procedure to request a bridge lift at any time[1]

Conclusions of the PLA consultation were:

- Main span should be as perpendicular to tidal flow as possible, to enable large ships that may slew in the current to judge the navigable width correctly, and pass the bridge safely
- Structures in the river must lie outside the Authorised Channel, plus a 15m exclusion zone from the channel edge which acts as a margin that pilots tend to take to give safe clearance from any structures
- In the open position, the bridge must accommodate any vessels that can pass underneath QE2 bridge at all stages of the tide. In the closed position, the bridge must accommodate most regular river traffic without needing the bridge to lift. Dimensions are given in Section 3.
- Smaller vessels with a sufficiently low air draught should be able to pass freely through secondary channels created between the piers and the bank
- The bridge must not fail in the closed position, as priority must be given to river traffic, and therefore requires redundancy in power systems
- The bridge must open for a period that covers the 'commit time'; for cruise ships and naval vessels this is typically 45 minutes from departing Tower Bridge and travelling downstream, as the ships cannot turn back or stop once they have left their berth. Smaller vessels will not require this commit time (see Appendix B, Section 2 for details of lift durations)

1 See Chapter 6: Operational Parameters for further detail of times of lifts, including during peak times

Initial guidance on the level of impact protection that is likely to be required was given by the PLA, subject to a navigation risk assessment:

- A suitable level of impact protection would be able to withstand impact from a standard vessel of 2500T at 10kts, however a higher specification may be preferable to account for a future increase in size of vessels. Additional temporary impact protection for periods of high traffic levels of larger ships, such as the high activity construction phase of the Thames Tideway Tunnel until 2019, which may overlap with the construction period for this bridge, could be suitable
- A bridge control room should ideally be on the bridge, on the north pier, to give best visibility up and downstream. An off-site control room could be possible but would be less responsive in the case of an emergency. Siting the control room on the bridge may also be more cost effective as no lease or land purchase is required
- River traffic levels for larger ships that require the bridge to open are unlikely to change significantly in future

The PLA require the final bridge geometry to pass their Ship Simulator Trials, and require a Navigational Risk Assessment. Acceptable mitigation measures are also needed, including an agreed operational protocol which includes the lifting procedure and communications with river traffic.

3. Bridge Geometries

3.1 Bridge Geometry Acceptable to the PLA

A geometry of the bridge in closed and open positions was determined using iterations of a concept design[1] in consultation with the PLA. The width and geometries presented below are acceptable to the PLA in principle, subject to a navigational risk assessment and ship simulator trials, which could all affect the geometry.

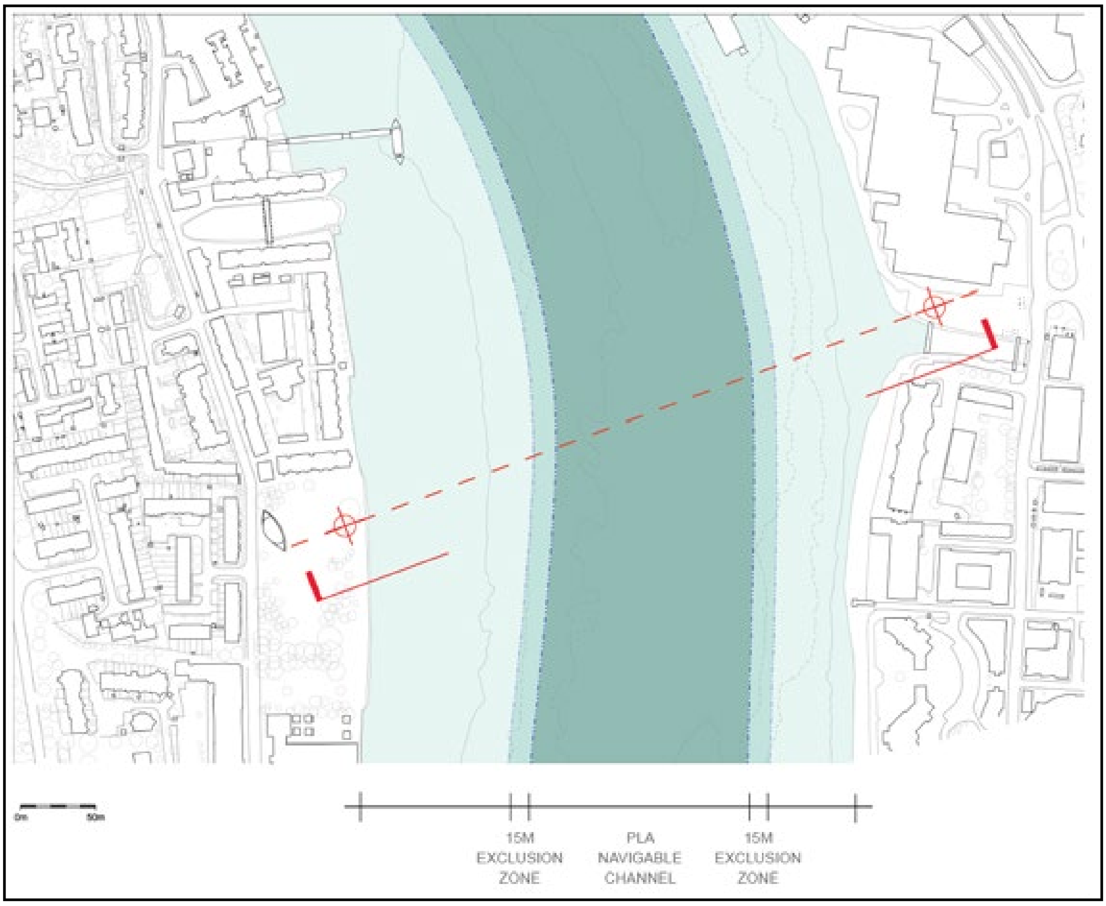

Figure 1: Proposed bridge geometries (plan view) from Chapter 3: Site Parameters and Constraints, Part 1

1 Chapter 3: Site Parameters and Constraints Form, Part 1, Section 2

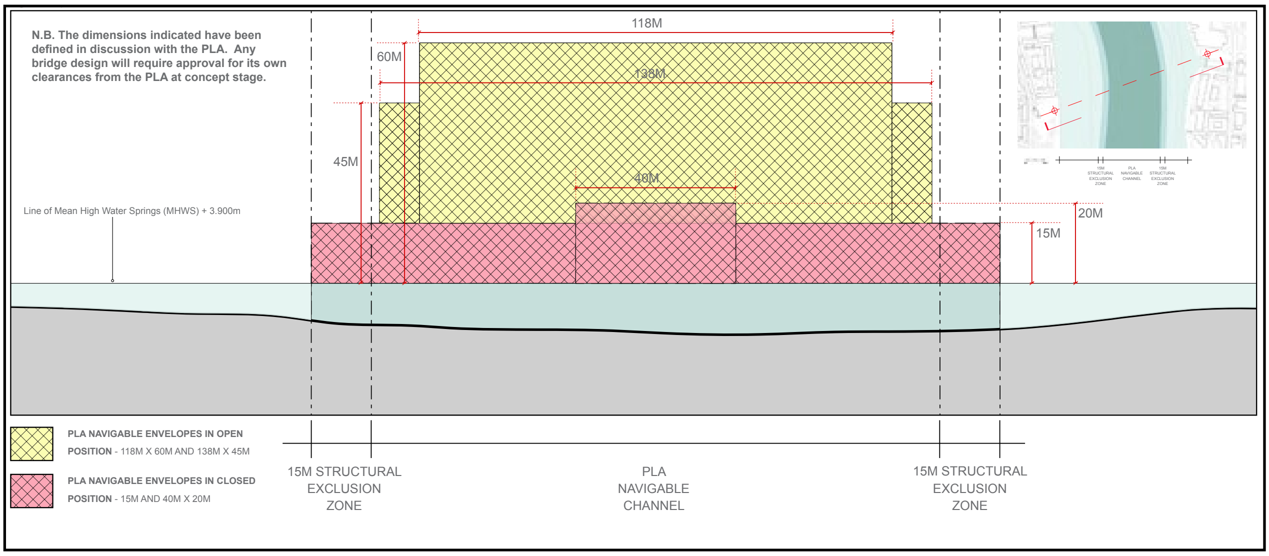

Figure 2: Proposed bridge geometries (cross section) from Chapter 3: Site Parameters and Constraints, Part 1

The clearance zones in Figure 2 were defined through consultation with the PLA, using an example design.

3.1.1 Open Position

The bridge must accommodate any vessels that can pass underneath QE2 bridge at all stages of the tide. As such a central clearance zone is required to allow the tallest vessels to pass, of width 118m and height 59.77m above MHWS, which takes into account the reduced water depth in this location compared with downstream (height of QE2: 54.1m + 5m to account for deeper water + 0.67m to account for variation in height of MHWS). However an unlimited air draught is preferable so as not to limit the maximum vessel air draught.

In addition, the bridge should have a headway clearance of 45m for the full central width of the navigable channel to allow cruise ships, which need a wider channel available, to pass.

3.1.2 Closed Position

In the closed position, the bridge must accommodate most regular river traffic without needing the bridge to lift. Therefore the width of the Authorised Channel, plus a 15m structural exclusion zone, must remain clear, at a height of 15m above MHWS. The height may be reduced to 8.6m where the bridge opening mechanism is required over the structural exclusion zone, however this may pose an increased risk should a vessel collision occur. In addition, a headway clearance of 20m for the central 40m of the navigable channel will enable most taller regular vessels to pass through without requiring a lift.

The clearance zones presented were based on an example design, and are indicative. Any bridge design will require approval for its own clearances from the PLA at concept stage.

The geometries are presented in greater detail in Chapter 3: Site Parameters and Constraints.

3.2 Bridge Lift Frequency

The vessel traffic survey analysed river traffic in the vicinity of the proposed bridge during August 2014 to determine the likely number of lift events. If the bridge has an air draught of 20m the majority (98.98%) of vessels, including all Class 5 (HSC manual & Traditional) which form the majority of river traffic transiting the site, can pass directly under the bridge without requiring a bridge lift (see Table 3).

Vessel Air-Draught	Transits per month	Percentage	Bridge Decking at 20m above MHWS
<10m	9,380	97.81%	Never required to open
10m ≥ 15m	64	0.67%	
15m ≥ 20m	48	0.50%	
20m ≥ 25m	21	0.22%	Sometimes required to open depending on tide height
>25m	77	0.80%	Always required to open

Table 3: Percentage of transits requiring a bridge lift, Marico Marine (2015)

Approximately 75% vessels under 18m height are likely to be undetectable through the survey method, and may therefore be more frequent by a factor of 1.75

The height of tide will affect when vessels of an air draught comparable to the bridge will need to request a lift. At lower heights of tide the vessels can transit without requesting a lift. For vessels 20 to 25m, 16 of 21 vessels would require a lift, or 76% (see also Appendix C).

It is estimated that the bridge of the stated geometry would be required to lift a maximum of 93 times per month, an average of 3.1 lifts per day (Table 4 below). This equates to approximately 60 lifts per year occuring in the morning peak 7-10am.

This is higher than the number of times that Tower Bridge opens, which between 04/09/15 and 07/10/15, was on average 1.97 lifts per day.

The estimate of 3.1 lifts per day, on average, is pessimistic as it assumes that the bridge will need to lift for each individual vessel, whereas in reality two or more vessels may be able to pass during a single bridge lift (i.e. many of the vessels will aim to pass the bridge at or around high water (+/- 1hr), as they will generally sail up-river with the flood (incoming) tide and sail down-river with the ebb (outgoing) tide. This could increase the duration of lifts, but reduce their frequency.

Hour	Less than 10m	Greater than or equal to 10m and Less than 15m	Greater than or equal to 15m and Less than 20m	Greater than or equal to 20m and Less than 25m	Greater than 25m	Unknown	Grand Total
0	7	1					8
1	5	1			2		8
2	6	5			1		12
3	12	2	1		1		16
4	54	2		1			57
5	66	3	8	1	1		79
6	109	3	2	1			115
7	155	1	4	3			163
8	215	2	1		1		219
9	566	2	4	2	3	1	578
10	783	2	1		6		792
11	928	3	8	1	5		945
12	1,042	4		1	6		1053
13	855	3	4	1	9		872
14	878	1	6	3	3		891
15	941	3	6		5		955
16	854	5	3	2	7		871
17	572	3		1	2		578
18	404	7			12		423
19	313	3		1	1		318
20	324	6		3	10		343
21	205				2		207
22	71	2					73
23	15						15
Grand Total	**9380**	**64**	**48**	**21**	**77**	**1**	**9,591**

Table 4: Vessel Transits by Air-Draught and Hour of Day, Marico Marine (2015)

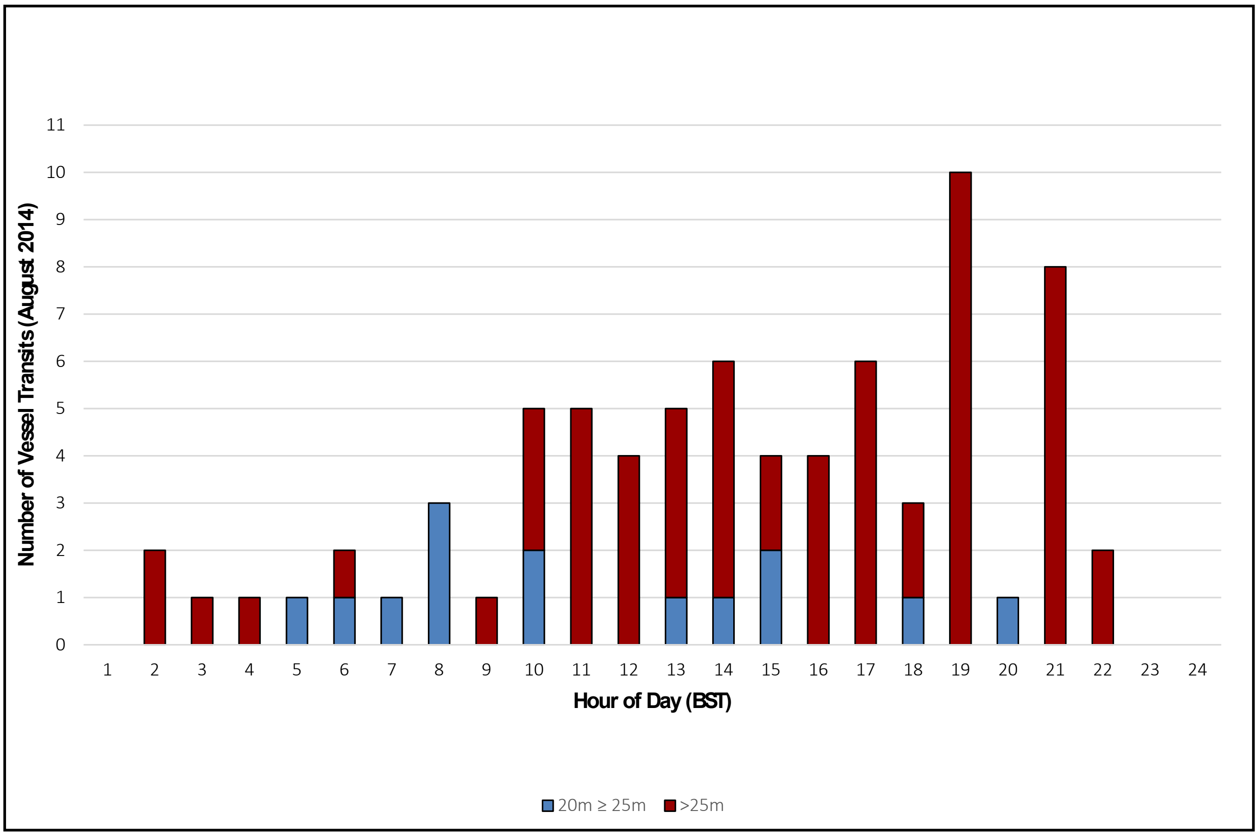

Figure 3: Vessel Transits by Air-Draught and by Time of Day (BST) - Weekdays only, Marico Marine (2015)

The vessel types requiring a lift some or all of the time are:

- Thames Sailing Barges (under 25m)
- Recreational sailing vessels (10-25m)
- Cruise ships (30m+)
- Some Naval vessels (10-25m)

The times at which the lifts occur is shown in the Figure 4 below, which include a safety margin of 5%.

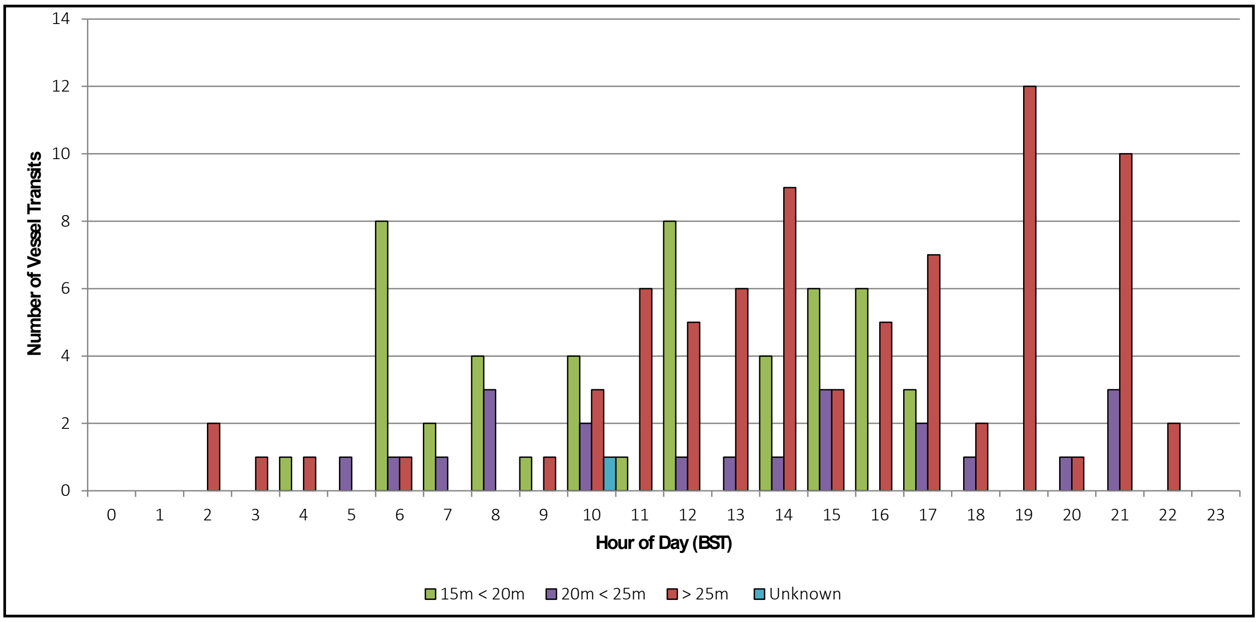

Figure 4: Vessel Transits by Air-Draught and by Time of Day (BST) - Marico Marine (2015)

3.2.1 Navigable Channel Width

To confirm suitability of the pier locations, an analysis of vessel tracks and swept paths was conducted, which showed:

- the majority of vessels use the Authorised channel most of the time
- the greatest density of transits occur towards the northern pier
- however there is a significant level of use of more than the stated width of the Authorised channel by all vessels

Therefore the bridge piers will cause vessels to use the Authorised channel or any secondary channels more frequently than current traffic, causing some convergence in the channels. The width of the Authorised channel is 184m, and the widest ships to transit the site are cruise ships such as the Ocean Majesty, with a width (Beam) of 23m. Cruise ships of wide beam transit the channel approximately 10 times a month and as such the impact of convergence will be low.

3.3 Implication of 184m Span

A bascule bridge with span of 184m is likely to be the longest in the world, with a current known example recently completed in Rethe, Hamburg, with a 104m span. This creates strong opportunity to demonstrate innovation through engineering and design, and is likely to contribute to the bridge’s landmark status. However, this also creates risk associated with the innovation required to design a record-breaking bridge, and is likely to increase the capital cost, as such a high optimism bias is already taken into account into the cost estimate. A reduction in span would likely bring a cost benefit due to the ability to lower this risk.

A more dramatic change to the navigable channel could be to allow a pier within the channel with substantial dolphins to protect the pier, which would facilitate a swing bridge with a typical span

It is, however, unlikely a reduction in the navigable channel width and use would be agreed by the PLA because reducing the span would increase the risk to existing river traffic.

3.4 Implication of 20m Recommended Closed Position Clearance

By comparison the geometry for the bridge is significantly greater in scale than Tower Bridge. This is because the navigable channel at Tower Bridge is narrower, as it is positioned on a straight section of the river and ships are more easily able to maintain steerage. The Emirates Air Line sets a more relevant precedent, with piers clear of the navigable channel and an upper air draught of 60.4m above MHWS (which can increase to over 70m by removing the cars from the cable).

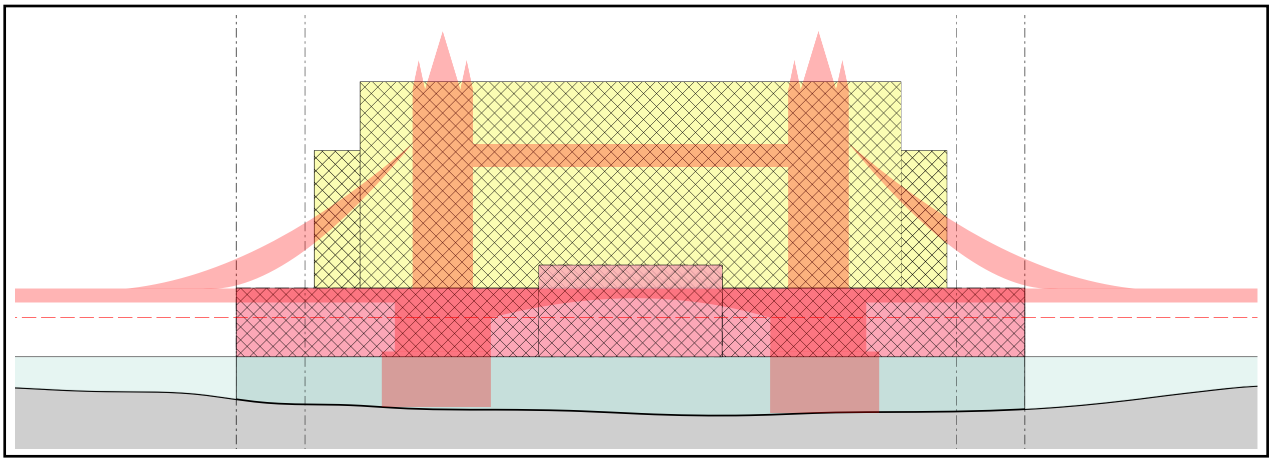

Figure 5: Geometries compared to Tower Bridge and Thames Barrier, from reForm, Chapter 3: Site Parameters and Constraints, Part 1

3.4.1 Potential to Reduce the Bridge Height

A reduced height of the bridge would bring benefits to the landing site particularly Durand's Wharf, cost and accessibility due to lower and shorter ramps, stairs and lift shafts. Additionally a reduced scale would likely be preferred by local stakeholders, particularly in Rotherhithe. The vessel traffic analysis was used to assess the impacts of alternative heights of the bridge on river traffic types, the frequency of bridge lifts, and the impact on peak periods.

Of 9,591 recorded transits in August 2014, 69 (0.72%) had an air draught of 15-25m, all of which were recreational vessels. Naval vessels may be of a similar air draught however none were recorded and are therefore not considered in this analysis, assuming that their transit is infrequent.

Vessels with air draught 10-15m included passenger ships, tugs and tows in addition to some recreational vessels and were therefore excluded from the analysis.

3 different bridge heights were tested against the vessel traffic data:

- 20m above MHWS: recommended by the PLA to enable most regular river traffic to pass
- 18m above MHWS: All or most vessels above 18m air draught were found to be detectable through the AIS data, and therefore data is accurate for these vessels[2]

2 All vessels above 18m were found to be detectable by AIS in the survey, however in practise some may not

- 15m above MHWS: Vessels 15-18m air draught are likely to not be detectable through AIS data. Vessels below 15m in height include freight and recreational vessels so for simplicity 15m was selected

Reducing the height of the bridge would increase the frequency of bridge lifts, including during the peak periods (See Table 5). This would affect the AM peak to a greater extent than the PM peak.

However, all vessels affected by a decrease by up to 5m, from 20m to 15m, would be recreational vessels of air draught 15-25m; no other vessels would be affected.

In total, reducing the bridge height by 2m, from 20m to 18m would increase the number of vessels transits requiring a lift by 27 per month, an increase in frequency of 29%. This represents an additional 0.28% of total vessel transits at the site.

Bridge overhead clearance above MHWS	20m	18m	15m
Total lifts per month (high estimate)	93	120	135
Proportion of all vessels at the site that require a bridge lift	0.97%	1.25%	1.40%
Vessel type affected	Cruise ships, some recreational over 20m	Cruise ships, principally recreational	Cruise ships, principally recreational
Weekday AM peak time lifts per month (high estimate)	5	15	21
Weekday PM peak time lifts per month (high estimate)	14	18	20
Height of stairs/lift shaft Durand's Wharf	11m (~4 storeys)	9m (~3 storeys)	6m (~2 storeys)
Length of ramp, Durand's Wharf (assumes 1:20 gradient and no shallower)	365m	325m (40m reduction)	265m (100m reduction)
Capital cost	£108m	~2% reduction	~5% reduction

Table 5: Impacts of reducing bridge height

Assumptions and notes:

1. High estimates were calculated assuming a) all vessels over the bridge clearance require a lift, although a proportion could be discounted due to the state of tide which would enable more vessels to pass, and some vessels will group together under a single lift, b)75% vessels 18m or under do not carry AIS transponders and so an adjustment to the data has

been made, and c) peak times are 7-10 am and 4-7 pm.

2. Operational costs may increase with an increase in lift frequency
3. Recreational vessels typically require a shorter lift duration as they do not require a commit time of 45 minutes, and therefore crowd build up would be moderate (see Appendix B, Section 2 for details of lift durations).

3.4.2 Potential for Traffic Restrictions

To offset the increase in frequency of bridge lifts, minor restrictions on river traffic could be considered. Since the total numbers of vessels is very low compared to the predicted pedestrian and cycle demand[3], and all or most additional vessels requiring a lift are recreational, restrictions to recreational river traffic during the peak periods would significantly improve performance of the bridge during times of heavy use by pedestrians and cyclists, with the following operational benefits:

- Less crowding and associated impacts locally
- Pulsed cycle flow after lifts would reduce and therefore have a lower impact on traffic on CW and Rotherhithe banks
- Simpler crowd management measures required, leading to operational costs

The majority of recreational vessels to transit the site use St Katharine's Dock to moor, and can only enter or exit the Dock approximately 2 hours before and after high water.. Therefore any restrictions imposed will have an impact on St Katharine's Dock. Consultation with St Katharine's Dock would be required, including a detailed survey of recreational vessels at the site. Further, restrictions could be accompanied by a new mooring for vessels to wait for a scheduled bridge lift.

It is assumed that wider traffic restrictions, affecting a range of vessel types, would require a significantly greater review of river traffic on the Thames.

3 Chapter 2: Outline Business Case

4. Bridge Driving Controls and Procedures

4.1 Bridge Driving Controls

The bridge requires bridge driving controls that enable it to be opened on demand, although most river traffic that requires Tower Bridge to lift tends to give advanced notice. It is recommended that the notice period for bridge lifts is at least 7 days for all river traffic, to enable adequate staffing to operate the bridge safely for all users.

The PLA advised that the bridge controls should be 24-hour staffed so that the bridge can be opened without notice.

The PLA also recommended the control room should be positioned on the bridge itself, particularly on the north side for best visibility up and downstream. This would need to be beyond the sacrificial structure (i.e. on a secondary pier or bridge ramp). An advantage would be that the bridge driver can support crowd management on the north bank, particularly in off-peak times with small to moderate crowd sizes.

It has however been considered that the control room could be offsite, and the bridge operated remotely. Associated with an enforced notice period for bridge lifts, this would significantly reduce the operational costs of the bridge, and is in practise elsewhere, such as Chicago, USA. Remote operation could be from Tower Bridge, as the bridge will need to be opened before large vessels depart from Tower Bridge and therefore both bridges could be synchronised through existing or adapted communications platforms. Alternatively a permanent control station sited on the north or south bank could be negotiated.. This needs to be investigated at the next stage in discussion with the PLA and landowners.

The bridge driving controls require a minimum of 2 power sources for redundancy, however this needs to be confirmed by the bridge operator and their insurer. The controls should be accessible for maintenance from the deck and include measures to mitigate trespassing.

4.2 Bridge Driving Procedures

In order to obtain a River Works Licence to proceed to construction in the Thames, an acceptable bridge operations procedure needs to be agreed with the PLA, the Operator and the insurer. This should include:

- Technical and logistical measures to ensure the commit time can be met
- Communication with vessels
- Redundancy in power systems and communications

The procedure is discussed in detail in the Chapter 5, Operational Parameters.

5. Impact Protection

Pier impact protection is required to mitigate damage to the bridge, and endangering users of the bridge. The level of protection required is typically identified through a risk based approach.

The vessel traffic analysis showed the most common vessel type transiting the site, and therefore most likely to collide with piers, is a commercial Class V passenger vessel, such as a Thames Clipper, with an Gross Tonnage of 270 and maximum impact speed of 12kts.

However, the PLA advised impact protection is designed to protect against a collision with 2500T vessels, to account for tugs and tows which also pass the site regularly.

The worst credible collision type is with cruise ships, in which it is assumed impact protection is not able to adequately protect the bridge, leading to catastrophic damage. This scenario is extremely unlikely due to existing mitigation measures such as compulsory pilotage through the port. In the case of collision with a cruise ship, to safeguard users of the bridge, the bridge requires a sacrificial structure landside of the main pier. It is beneficial to navigation to exclude fenderings or protective dolphins - and integrate impact protection into pier design, to minimise the number of structures in the river.

Due to a low relative variation of pier structure and cost, at concept design stage a higher specification as recommended by the PLA was adopted. A moderate cost saving could be identified should the level of impact protection be lowered, however the requirements will need to be confirmed at the next stage to meet the PLA and bridge operator's insurance requirements.

In addition, the PLA advised temporary impact protection may be required should construction overlap with the Thames Tideway tunnel construction. Further assessment is needed at the next stage, through a navigational risk assessment and detailed construction methodology, to specify the level of temporary protection.

6. Further Work

- Ship Simulator Trials and Navigational Risk Assessment to be passed at later stages in the programme, in order to obtain the legally required River Works License from the PLA to conduct works in the tidal Thames[1]
- The parameters and methodology for the Ship Simulator Trials should be obtained from the PLA in order to inform a full navigational risk assessment given the high potential impact on bridge users and operations of timings and frequency of bridge lifts
- A hydrodynamic study into the effect on the river regime of any piers in the river is required; the parameters for the study to be agreed with the PLA.
- For this study it was assumed there would be no significant change in river traffic. Minor reductions or restrictions, particularly at commuter peak times, would bring significant benefits to the operation of the bridge, increasing the level of service to bridge users and reducing operational costs and should be considered
- Although the PLA have indicated it unlikely, a significant increase in vessels with air draughts higher than 15-20m would impede the successful operation of the bridge. This should be confirmed through a navigational risk assessment at the next stage
- Minor river traffic restrictions should be considered to reduce peak time disruption. This draws on other port examples, such as in Chicago, USA. Wider river stakeholders such as St Katharine's Docks will need to be engaged to determine a suitable balance between impacts on river and land traffic
- The location of the bridge control room should be confirmed with the likely bridge operator, PLA and key stakeholders, following a review of technological requirements at the next stage
- Signals and lighting on the bridge will need to comply with the PLA's Thames Byelaws 2012 and should be incorporated in the final design

1 PLA., Port of London Act, Section 66 (1968)