3FMProject

Bringing Dublin Port To 2040

Environmental Impact Assessment Report

Appendix 4.2

Volume 3 Part 1

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Third & Final Masterplan Project

DUBLIN PORT COMPANY – 3FM PROJECT

SPAR BRIDGE

OPTIONS REPORT

PROJECT NO.	DOCUMENT NO.
A235995	CP1901_3FM-COWI-SBR-SP-RP-S-00001

VERSION	DATE OF ISSUE	DESCRIPTION	PREPARED	CHECKED	APPROVED
03	13/06/2024	Planning submission review	CAFL	OLSS	OLSS
02	24/11/2022	First Issue to DPC	CAFL	OLSS	PASS
01	23/11/2022	Issued for RPS for comment	CAFL	OLSS	PASS

CONTENTS

1 Introduction

This report summarises bridge options for the Southern Port Access Route. It presents a comparison of the various options and proposes a preferred solution to be progressed during the preliminary design stage.

2 Background

The Southern Port Access Route (SPAR) is a proposed infrastructure development intended to increase capacity for Dublin's ports. The scheme consists of a new road connecting the Southern Port with key connections to the north of Dublin. The road will be accompanied by an Active Travel route as well as provision for public transport via the city's LUAS system. The proposal is intended to be submitted by the Dublin Port Company (DPC) to An Bord Pleanála in 2024.

A key part of the proposal is a new crossing over the River Liffey adjacent to the existing Tom Clarke Bridge. The Tom Clarke Bridge (TCB), formerly known as the East-Link Toll Bridge, is a single leaf rolling bascule bridge opened in 1984. The TCB has become a bottleneck, the single lane carriageway in either direction and narrow footpaths are unsuitable for current demands. By diverting Port traffic onto the dedicated SPAR, congestion on the public road network across the TCB will be eased.

The highway alignment for the SPAR has been developed alongside RPS to provide a straight opening span. All opening mechanisms have been assessed based on this alignment. For further information on the alignment studies considered, refer to CP1901_3FM-RPS_26-HGN-XX-RP-C-00001.

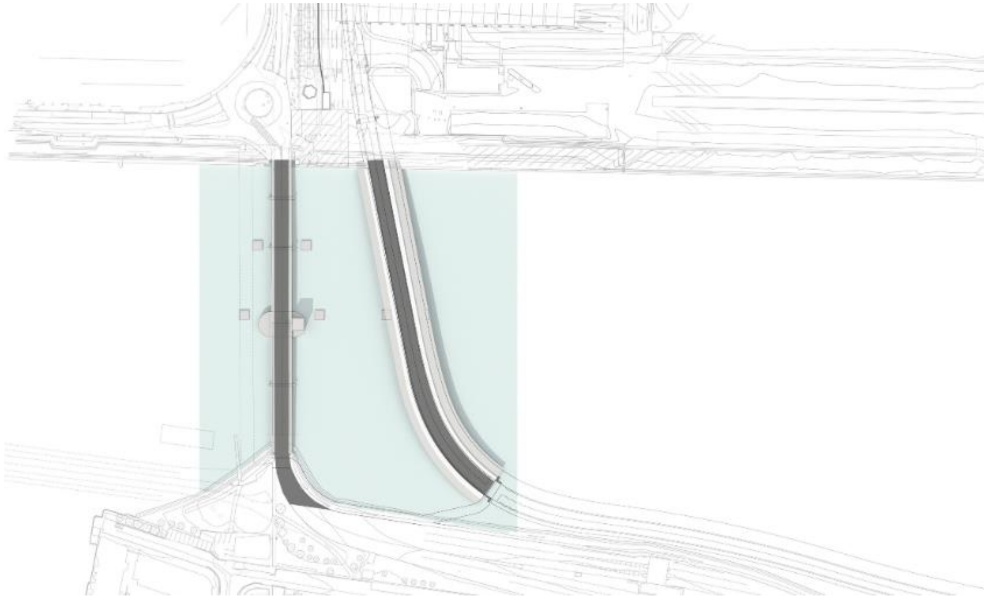


Figure 1: Existing Tom Clarke Bridge (left) with the proposed alignment for the new crossing (right)

3 Service Requirements

The key service requirements for the river crossing are:

- The navigation channel should at least match the TCB, with unlimited vertical clearance over a width of 31.5 m measured perpendicular to the riverbank.
- Highways should be designed according to best practice and Irish design standards (Transport Infrastructure Ireland publications and Design Manual for Urban Roads and Streets) for radii of curves and clear sight lines.
  - Minimum Stopping Sight Distance (SSD) – 70m
    - Note: If it is deemed upon consultation that TII publications are the appropriate standards as opposed to DMURS across the bridge, a Departure from Standard (DfS) may be required. If TII do not accept the DfS, widening of the structure on the bend may be required to ensure a minimum SSD of 90m is provided
  - Minimum radius of curvature of 90 m
- Gradients of bridge deck and approach structures should follow best practice for cyclists and disabled access
- The bridge will carry two lanes of traffic with provision for a special vehicle according to the Eurocode load model SV196.
- An Active Travel pathway with a usable width of 5 m will be included to accommodate use by pedestrians and cyclists.
- The design should be reliable and able to open in most reasonable wind and flood conditions. An allowance for climate change is applied to the design flood levels, which are therefore higher than those used for the TCB. As the TCB cannot t operate at the new design flood level, there may be some allowance for non-operation at a given flood level.

In addition, the following requirements are seen as desirable based on feedback from stakeholders for the SPAR scheme:

- The anticipated extension of the LUAS system will be allowed for using an additional Active Travel path. If the LUAS is extended to cross the river over the SPAR bridge, a track could be retrofitted on an existing part of the structure without the need for significant additional strengthening.
- The approach spans and piers should minimise obstruction of the river, even outside the navigation channel. Local rowing clubs use the river often and have expressed a desire that areas outside of the main navigation channel are not made significantly more difficult to navigate.
- The opening span should open from the South side of the river to match the TCB
- The design should provide an economic solution which exhibits architectural value, visual prominence, be of high quality and be, durable, requiring low maintenance.

4 Opening Arrangement & Mechanism

The criteria for assessing the options for the opening mechanism were:

- Ability to clear the navigation channel
- Simplicity of mechanical components
- Reliability and ease of maintenance, including protection of the mechanism from flooding
- Visual prominence
- Capital and operational costs
- Carbon footprint

For each option, an assessment based on these criteria was conducted. Some of these measures are somewhat subjective or difficult to precisely quantify, as is the weighting of each criterion. The assessment aims to provide a balanced view of each option to allow an informed choice of option.

The bridge is not expected to open frequently; it has been suggested that the bridge will open no more than a few times per week. This means the speed of a lift cycle (opening and closing) is not critical, however it is still desirable for the cycle time to be as short as possible to minimise the disruption to traffic. If possible, the opening speed should match the TCB, which is approximately 2.5 minutes for the physical raising of the moving span. The total time for the lifting operation, including the time required to clear the bridge of traffic and lowering the traffic barriers is longer.

5 Bridge Options

A wide range of bridge options have been presented to DPC during a series of design workshops. Sections 5.1 to 5.4 describes the shortlisted bridge options that have the potential to satisfy the Service Requirements.

Section 5.5 gives an overview of bridge typologies that were discounted at an earlier stage due to being unlikely to fulfil the service requirements. These discounted options are discussed in less detail.

Section 5.6 compares the shortlisted options and against the criteria defined in Section 4.

The numbering of the bridge options has been preserved from earlier workshops.

The shortlisted options fall into two basis typologies:

- A single leaf bascule bridge (Options 1, 2, 4)
- A single leaf swing bridge (Option 3)

5.1 Option 1: Dutch Bascule

Figure 2 shows a Dutch bascule arrangement. This uses two towers to carry a balanced beam, heavily weighted on one side and with a connection to the deck on the other. The connection to the deck is constantly in tension to balance the counterweight. This reduces the externally applied load required to open the bridge. An advantage of a Dutch bascule arrangement is that the lifting mechanism is elevated and so less at risk from flooding than other opening mechanisms. Hydraulic rams could be situated in the tower, driving the beam round to lift the bridge.

The Dutch Bascule has plenty of precedent as a working design for a lifting bridge. Typically, these bridges span short distances such as canals, and may have two leaves to clear larger distances.

Whilst this option has the potential to be aesthetically striking, the geometric constraints at the SPAR bridge site does not lend itself to an efficient solution. The lift angle, the maximum angle the bridge can rotate by, is less than other forms of bascule bridge with the pier sizes limited to that of the TCB. For Dutch bascules the lift angle must be restricted to ensure that wind loading on the opened deck do not cause compression in the tie cables.

Consequently, providing unlimited clearance for the whole width of the navigation channel is not possible for the Dutch bascule option without a very long opening span. This results in an uneconomic structure with piers that do not align to those of the TCB.

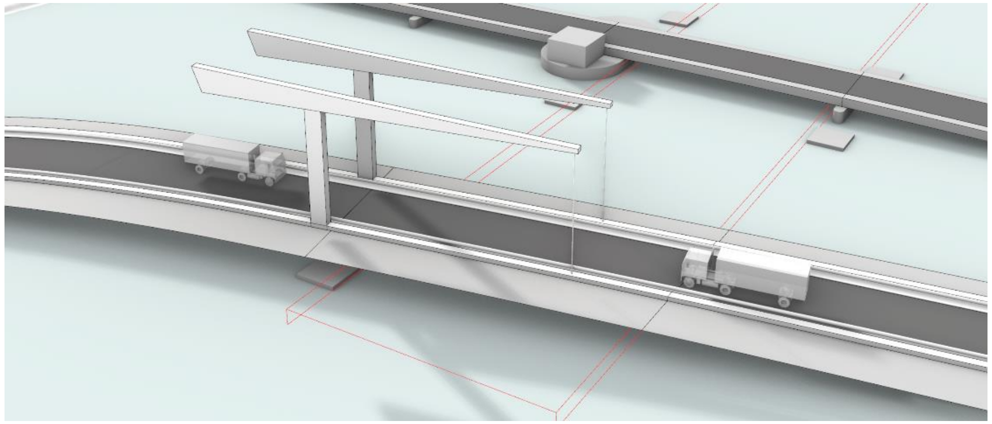


Figure 2: Option 1: Dutch Bascule

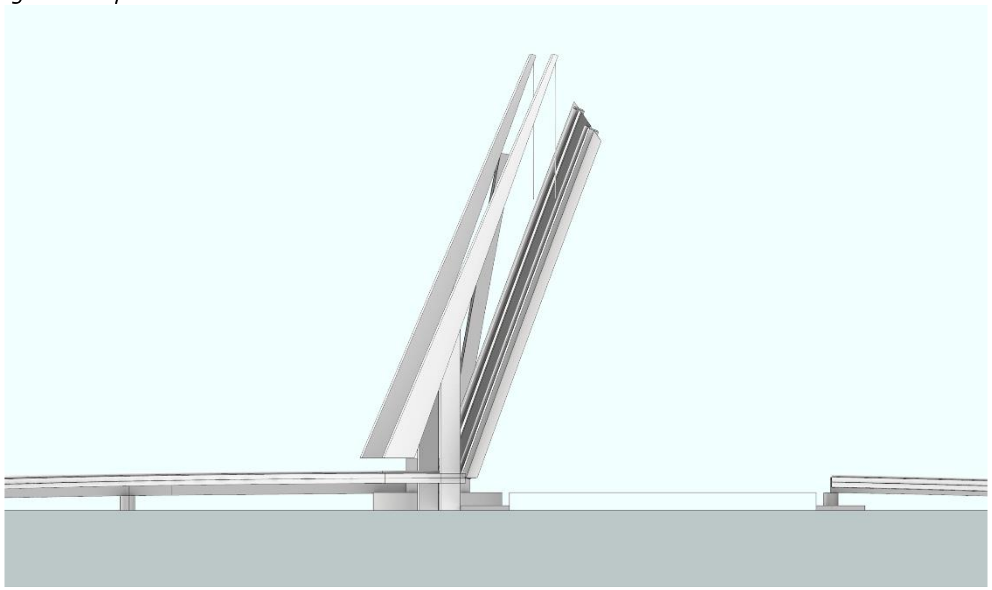


Figure 3: Option 1 in Open Position

5.2 Option 2: Rolling Bascule

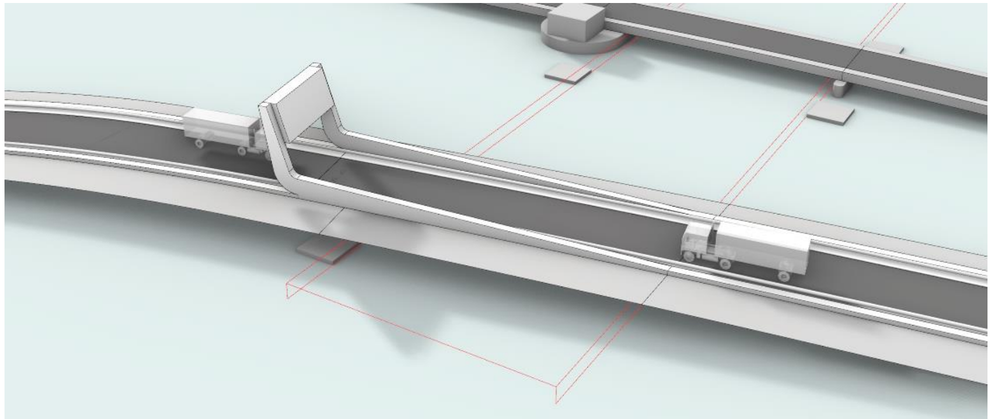
The rolling bascule is a traditional design characterised by a moving contact point between the bridge and its supports. Typically, a circular arc track is provided. This allows the bridge to translate and rotate simultaneously. A counterweight is rigidly connected to the bridge deck on the opposite side of the contact point, reducing the force required to move the structure. The bridge acts as a simple beam when closed, and as a large cantilever when open.

Option 2A: Mechanism Above Deck

Figure 4 shows the rolling support and the counterweight above the road level. The structural spine beams provide support to the span and continue upwards to connect to the counterweight. The bridge would roll back onto tracks on the adjacent span, lowering the counterweight and lifting the span. The force required to lift the bridge would be provided by rams either below the deck in the bridge pier or in line with the centre of rotation.

Such a mechanism has plenty of precedent. A good example similar in size to the proposed bridge is the Birkenhead Bridge in the UK. The above-deck counterweight would be visually prominent but not highly effective for lifting the bridge at its peak load requirement due to the short lever arm in the closed position.

Large rolling tracks would be required on the deck. This has multiple implications: the track must be designed to support the weight of the entire span at any point in the lift cycle, meaning the substructure or adjacent span must be designed accordingly; pedestrians on the bridge must be kept at a safe distance to ensure entrapment in the tracks is not a possibility; and debris must be removed to ensure the smooth running of the mechanism. The tracks are more expensive to fabricate and maintain than a fixed pivot.



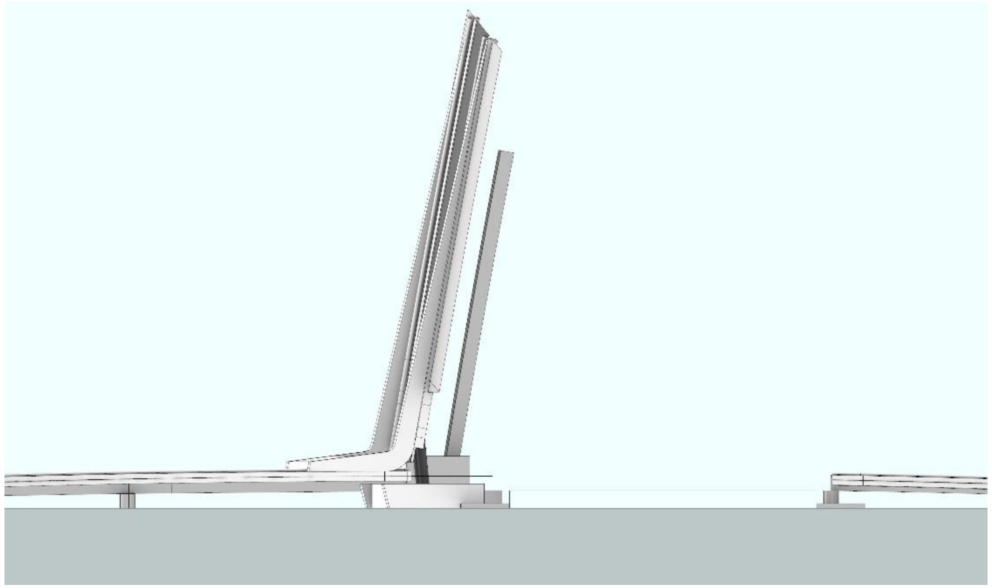


Figure 5: Option 2A in the open position

Option 2B: Mechanism Below Deck

Figure 6 shows a more understated bridge with the counterweight and rolling mechanism below deck level. The rolling tracks are positioned in the southern pier, which must be significant in size to house the counterweight and the tail of the moving span as it rotates.

There are numerous precedents for this arrangement, including the adjacent Tom Clark Bridge.

The counterweight is more efficient in this arrangement than for Option 2A. By positioning it below the deck, it is possible to align the counterweight with the centre of rotation and the deck's centre of mass. This means that the ratio of the lever arms between the rotation point and the centre of mass of the counterweight and that of the bridge deck remain constant throughout the opening cycle. This is the optimum configuration for the efficiency of the counterweight.

However, there are some challenges with this option. There is a trade-off between the lever arm for the counterweight and the size of the pier. It is likely that the southern pier would extend beyond the envelope of the Tom Clarke Bridge's pier for this option due to SPAR bridge's skewed alignment.

The hydraulic rams used to drive the bridge opening are located in the bridge pier, the top of which sits above the flood levels to protect the equipment within. The pier is made larger by the need to accommodate the counterweight when the bridge opens.

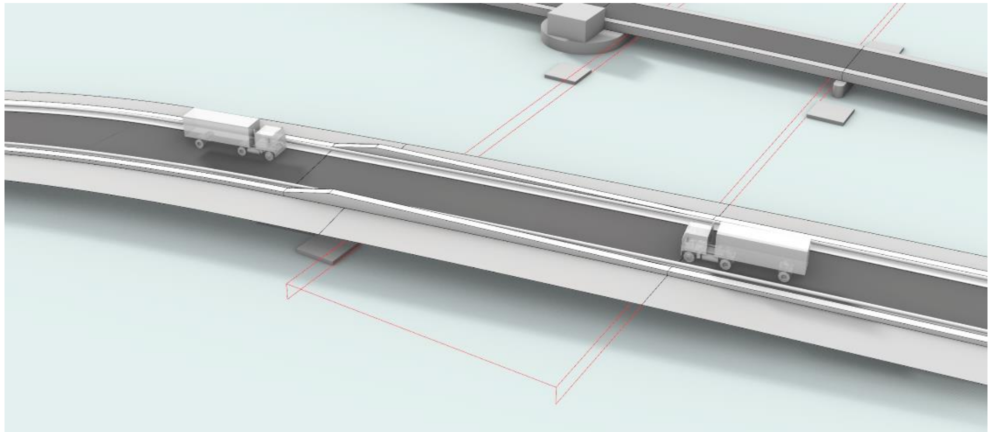


Figure 6: Option 2B: Rolling Bascule with the rolling mechanism and counterweight below deck level

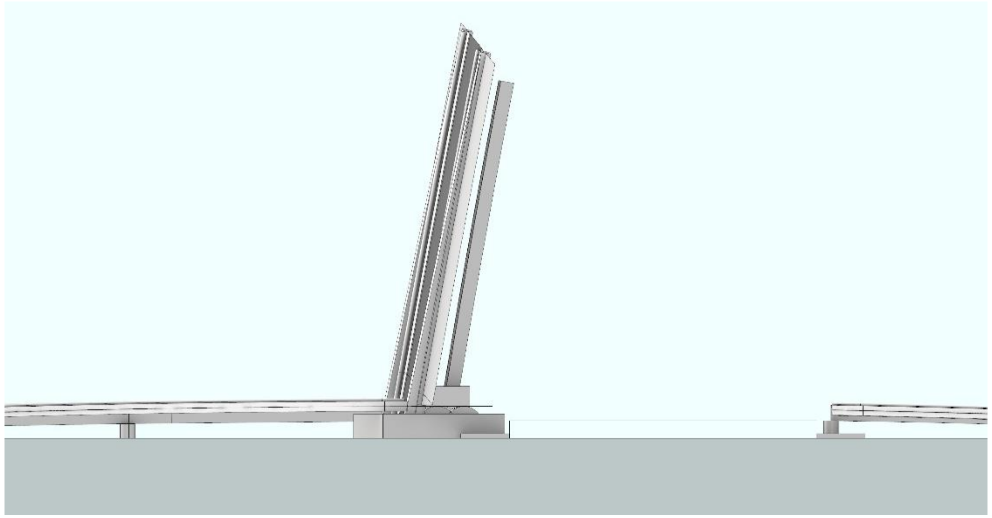


Figure 7: Option 2B in the open position

5.3 Option 3: Swing Bridge

Figure 8 shows a swing bridge which opens by rotating in a horizontal plane. A back-span provides a counterweight to reduce the imbalance when the span rotates. Because no weight is being vertically raised, the mechanical load is only required to overcome inertia and friction. The opening mechanism is more energy efficient than a lifting bridge, and the bridge is not as susceptible to wind loads.

Swing bridges are fairly common and current precedent includes the Samuel Beckett Bridge a short distance along the River Liffey.

The aesthetic form is relatively flexible and could include above deck supports or a deep beam.

The opening mechanisms can be located within the bridge pier, the top of which sits above the flood levels to protect the equipment within. The bridge must lock into the adjacent parts at both ends, normally via a locking pin designed to prevent uplift. Swing bridges are mechanically particularly complex if the bridge is lifted off the slew bearing for the 'open to highway traffic' condition. This is often done to protect the slew bearing from fatigue loading caused by vehicular traffic.

The centre of rotation must be offset from the navigation channel such that the width of the open bridge remains clear. This means the pier could not be aligned with the Tom Clarke Bridge and would provide an additional obstruction in the river. Other river traffic, such as rowers, would need to be kept clear of the open bridge for safety reasons, rendering more of the river unusable while the bridge is open (Figure 9) than for a bascule bridge.

Similarly, additional fendering is required to protect the bridge from ship impacts in the open position, this fendering is permanent and therefore provides obstruction to other river users when the bridge is closed.

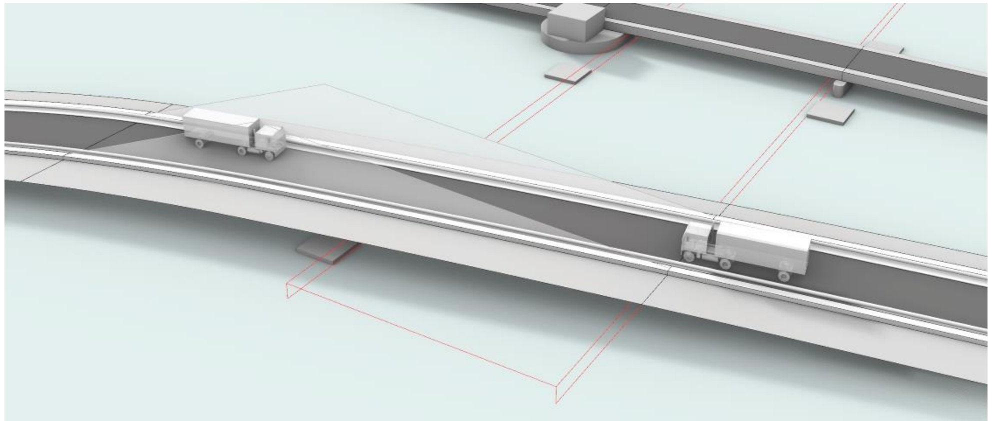


Figure 8: Option 3: Swing Bridge

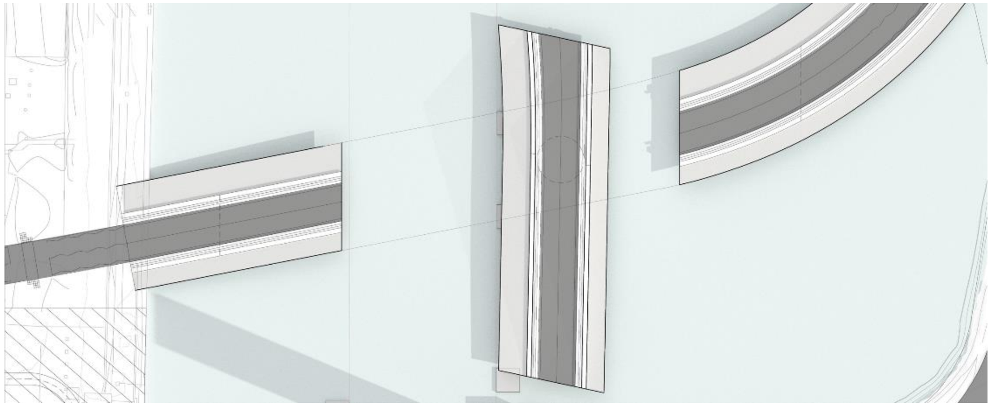


Figure 9: Plan view of Option 3 in the open position

5.4 Option 4: Fixed Pivot Bascule

Option 4 considers bascule bridges with fixed pivots. These are less mechanically complex than rolling bascules. The movement is limited to rotation only, rather than translation, because the centre of rotation does not move as the bridge opens.

Option 4A: Double Pivoting Bascule

Figure 10 shows a counterweight above the deck. The counterweight is supported on struts that are pivoted about a separate pivot to the deck. This is distinct from the rolling mechanism used to provide the above-deck counterweight in Option 2A. The separate pivots provide additional flexibility to optimise the counterweight position and so is more efficient that a single pivot with the counterweight fixed to the moving span.

An alternative arrangement with an above-deck counterweight on the same pivot as the deck was also considered. This lacked the drama of the double pivot scheme and the geometric constraints limit the effectiveness of the counterweight.

The two pivots provide a unique aesthetic as well as an unusual opening sequence. The back-tilted counterweight induces a tension in a tie which connects to the bridge, which in turn provides some assistance to the lifting of the span. The effectiveness of the counterweight is determined by the geometry of the key components but has the potential to be more efficient than an equivalent weight in the single pivot configuration. The overhead structure can also be used to create a visually prominent structure, providing a distinctive landmark for the port.

With pivots required at the southern end of each spine beam, the base of each strut, and the ends of the ties, there are more moving parts to consider from an operational perspective than Option 4B below. However, fixed pins are generally lower maintenance than the rolling tracks required for Option 2.

Rams would be provided in the southern pier to drive the lifting of the bridge. The counterweight would then descend in a controlled manner under its own weight as the bridge lifts.

Like the rolling bascule, this design creates a zone where there is a risk of crushing injuries form the scissor action of the bridge and counterweight arm. Therefore, it will be necessary to mitigate this risk, as a minimum, by clearing bridge users from the vicinity.

The dynamic behaviour of the counterweight must be carefully considered. Any deflection of the deck around the cable anchorage would directly translate to movement of the counterweight.

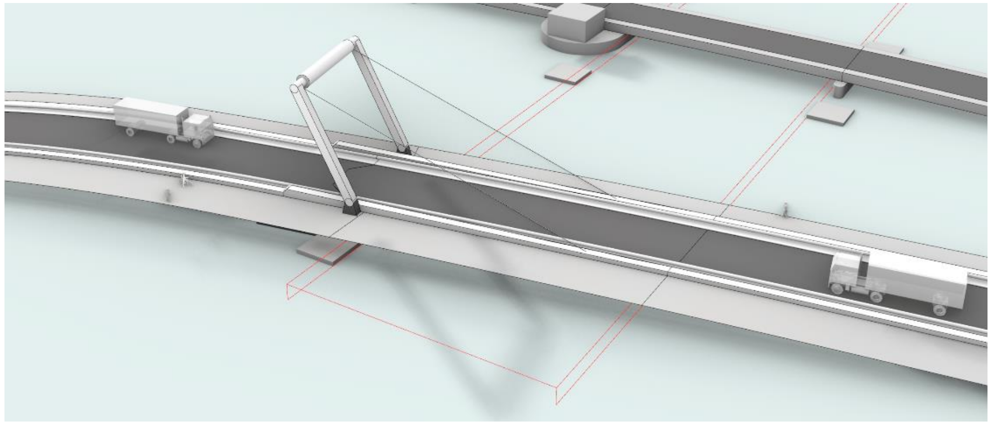


Figure 10: Option 4A: Double Pivoting Bascule with a counterweight supported above the deck

Option 4B: No Counterweight

Figure 11 shows a fixed-pivot bascule with no counterweight.

Counterweights are provided to lifting bridges to reduce the load required to raise the bridge. Historically, these were important as the mechanical components were relatively limited in size and strength. Counterweights also have the benefit of reducing the energy required to lift the bridge, as the total change in gravitational potential energy can be reduced. However, depending on the frequency of lifting, it may be less advantageous to spend capital cost on the weight to reduce the operational cost of the lifts.

Advances in mechanical equipment mean that it is now feasible for the rams below deck to lift the bridge without counterweight. This would remove the need for additional supporting structures, and potentially reduce the lifetime cost and embodied carbon of the bridge.

This strategy offers a low-lying, elegant, and minimalist solution when the bridge is closed, with the soffit of the bridge and the size and shape of the opening span providing drama and visual interest when opened.

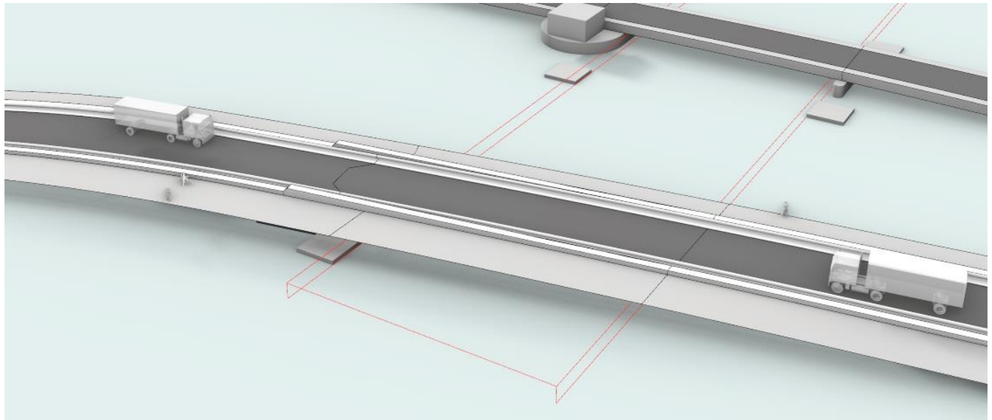


Figure 11: Option 4B: Fixed Pivot Bascule with no counterweight

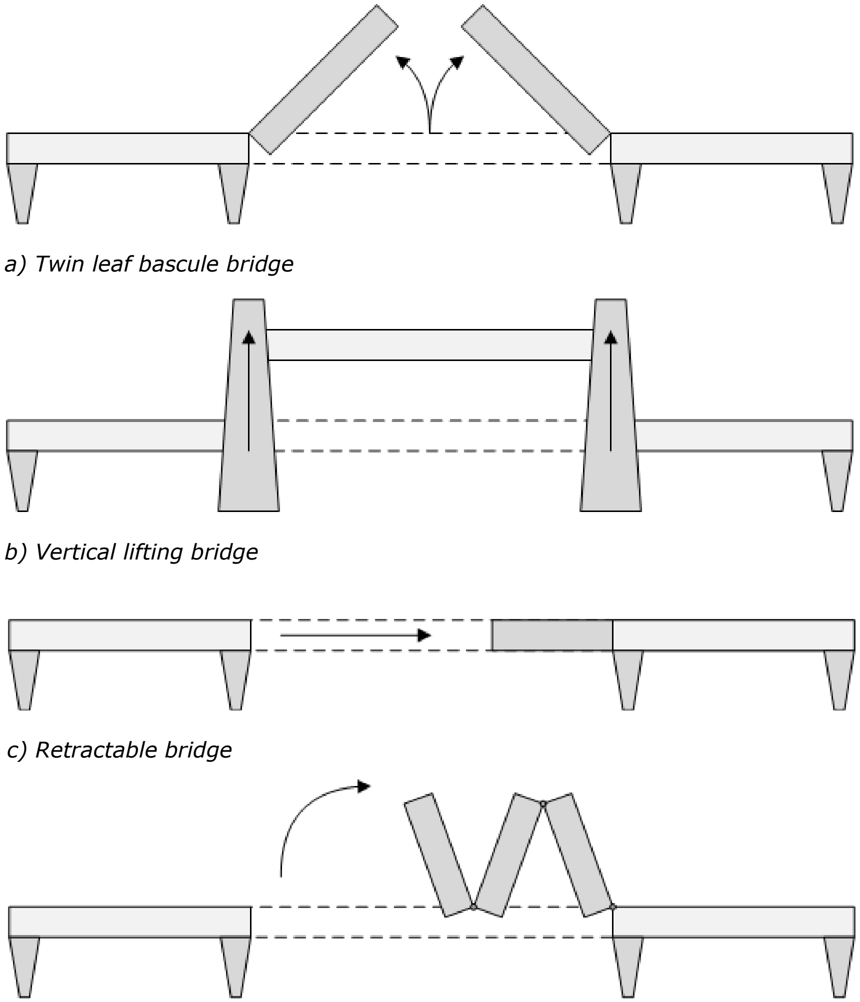
5.5 Options Not Considered

Some options for opening bridges have precedent on various scales around the world but were deemed inappropriate for the SPAR Bridge because of site constraints or shortcomings in these designs.

Examples of options not considered further include:

- Double leaf swing or bascule arrangements were ruled out due to the requirement to open the bridge from the South side to match the TCB.
- Vertical lifting bridges, such as the Kingsferry Bridge in Kent, UK. Such bridges could span the required distance and be fit to carry heavy traffic but would not provide unlimited vertical clearance.
- Retractable bridges, such as the Inner Harbour Bridge in Copenhagen, Denmark. While the opening mechanism is elegant and provides unlimited clearance, these bridges are mechanically very complex and occupy a large space in plan. The curvature of the approach span complicates the design further.

Folding bridges, such as the Hörn Bridge in Kiel, Germany. This example spans over 25 m but carries only light traffic. The concept would not be practical to apply to this location or for heavy traffic.



a) Twin leaf bascule bridge

b) Vertical lifting bridge

c) Retractable bridge

d) Folding bridge

Figure 12: Options not considered

5.6 Option Comparison

The below table contains a comparative assessment of the options presented. Except for the navigational channel clearance and the flood level suitability, the criteria are presented in no particular order.

Option	1: Dutch Bascule	2A: Above Deck Rolling Bascule	2B: Below Deck Rolling Bascule	3: Swing	4A: Above Deck Fixed Pin	4B: Fixed Pin, No Counterweight
Meets design flood levels	✓	✓	✓	✓	✓	✓
Navigational clearance	×	✓	✓	✓	✓	✓
Mechanical simplicity	●●	●●	●●	●	●●	●●●
Capital cost	€€€	€€	€€	€€€	€€	€
Operational cost						
› Opening energy	€€	€€€	€€	€	€€	€€€
› Maintenance burden	€	€	€	€€€	€€	€
Carbon footprint	●●●	●●	●●	●	●●●	●●
Visual prominence	●●●	●●●	●	●●	●●●	●
Impact on other river traffic	●	●	●	●●●	●	●
Pier size	●	●●	●●●	●	●	●
Pier position compatible with TCB	✓	✓	×	×	✓	✓

Key to Criteria

Meets design flood levels: Bridge and lifting mechanism could be sufficiently protected from flooding to the design level; this criterion is essential.

Navigational clearance: Bridge opens to provide a navigation channel with unlimited clearance at least equal to that of the Tom Clarke Bridge; this criterion is essential.

Mechanical simplicity: The simplicity of components in the lifting mechanism, affecting maintenance and reliability. More dots = positive, fewer dots = more complexity.

Capital cost: An approximate indication of the cost of materials and labour for construction, considering the size and complexity of the structure.

Operational costs: Approximate costs for the energy required to lift the bridge and maintain the moving parts.

Carbon footprint: An approximate indication of the embodied carbon in the structure plus the emissions required to lift the bridge. Fewer dots are positive.

Visual prominence: The visibility of the structure, considering both the open and closed positions. More dots are positive.

Impact on other river traffic: The impact of the structure on river traffic outside the navigation channel, considering pier locations and unusable river space. Fewer dots are positive.

Pier size: Size of the main pier holding the lifting mechanism, and whether this fits within the width envelope of the TCB pier. Fewer dots are positive and a pass-fail assessment is also provided.

6 Counterweights

The provision of a counterweight is intended to reduce the demand on the lifting mechanism during the opening of the bridge. The counterweight works by providing a moment about the pivot point in the opposite direction to that exerted by the weight of the lifting span. During a lift, the counterweight moves downwards while the span lifts upwards, reducing the total change in gravitational potential energy of the system.

The maximum demand on the lifting mechanism arises at the point where the span's lever arm (measured horizontally) is greatest. This is typically when the bridge is in its closed position, or in the very early stages of the lift. A counterweight is therefore most effective if its lever arm is also maximised at this point (Shown with example weights and lengths in Figure 13).

To ensure the bridge can close even in the event of mechanism failure, it is desirable to choose the counterweight such that the bridge is nose-heavy for the entirety of the lift. Depending on the alignment of the counterweight and span weight with the pivot point, this may mean that the counterweight is relatively small and provides only minimal assistance at the beginning of the lift.

A counterweight would have been necessary on older structures when mechanical equipment was less effective and reliable. Modern structures can operate without a counterweight and depending on the frequency of lifting it may be more cost effective not to provide one; that is, the additional cost of the energy required to lift the structure during its design life would not outweigh the cost of providing the counterweight during construction. A similar comparison is also true for embodied carbon, meaning a smaller counterweight can often be a more environmentally friendly strategy. Furthermore, as power generation moves towards renewable sources, the operating carbon is expected to reduce.

A counterweight may be desirable for architectural reasons even if there is some additional associated cost. The supporting structure for an elevated counterweight can be distinctive and provide visual prominence, should this be desirable. For a relatively small counterweight (such as that required for a nose-heavy bridge), the weight could be provided by a range of materials to suit the aesthetic of the structure and balance embodied carbon and capital costs.

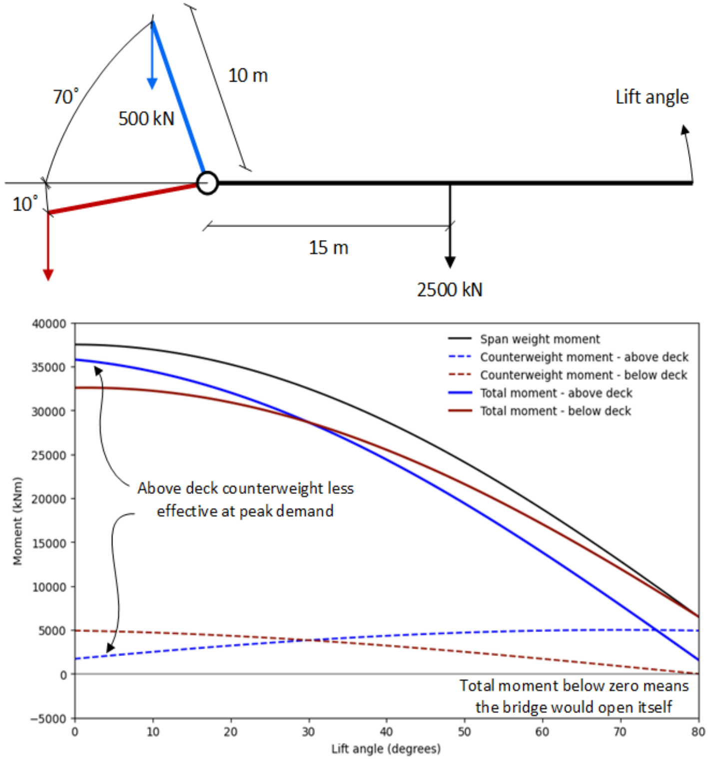


Figure 13: Simplified example bascule arrangement with either an above-deck or below-deck counterweight, illustrating the effectiveness of each solution.

7 Deck Configuration

The deck must be constructed to support the bridge in two key conditions: closed, acting as a simply supported span and loaded with traffic and pedestrian loads; and open, acting as a cantilever carrying its self-weight and wind. The midspan and areas closest to the rams are therefore the most highly loaded parts of the structure.

The deck will comprise a two-lane carriageway with each lane 3.5 m wide, an Active Travel path 5.5 m wide, and a 3.3 m wide supplementary path with provision for the future development of the LUAS. 1.4 m is also allocated either side of the carriageways for a Vehicle Restraint System (VRS) zone and associated structural free zone (SFZ), and a further 0.5 m for hard strips on the road.

Two spine upstand beams, each approximately 1m wide, provide the primary longitudinal structure. Placing these between the roadway and walkways provides physical separation between vehicular traffic and other bridge users, creating a more pleasant pedestrian environment. Lifting the structure relative to the road/walking surfaces lifts the opening span above the flood levels whilst mitigating the need to lift the abutments significantly above grade. The arrangement also reduces effort for bridge users by reducing the elevation gain.

These spines will be constructed as box sections with variable height and plate thicknesses according to the demand on the section. A maximum spine height of approximately 3 m is currently proposed.

The pathways cantilever out from the spine beams, creating a slender edge running the length of the bridge.

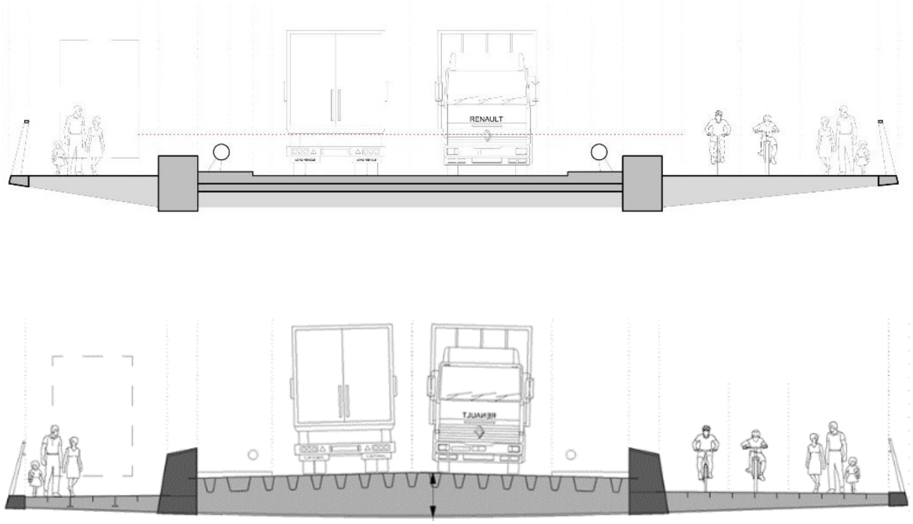


Figure 14: Design development of deck cross section

8 Architectural Concept

All the options considered present opportunities to create a beautiful structure. The double pivoting option offers the most drama during the opening sequence, with the counterweight arm and bridge deck moving relative to each other in an unusual manner. The infrequency of opening adds to the drama and sense of surprise.

The counterweight arm offers a visually prominent structure which acts as both a gateway into the port for bridge traffic and up the River Liffey into Dublin city centre for marine traffic.

The bridge site is located on the boundary between the city and the port. The recent development to the city introduces some tall buildings adjacent to the bridge site, including the 80m tall Capital Dock development. To the South of the bridge low lying houses set back from the main road look across the river towards the port.

The port cranes are visible on the skyline and the counterweight arm is sized to be a similar scale to the cranes within the port. The design intent is to express the connections and pivots of the opening span to reinforce the sense of the bridge as a piece of machinery.

The beams and counterweight arms are shaped so both elements sit together in a considered manner in the open and closed positions.

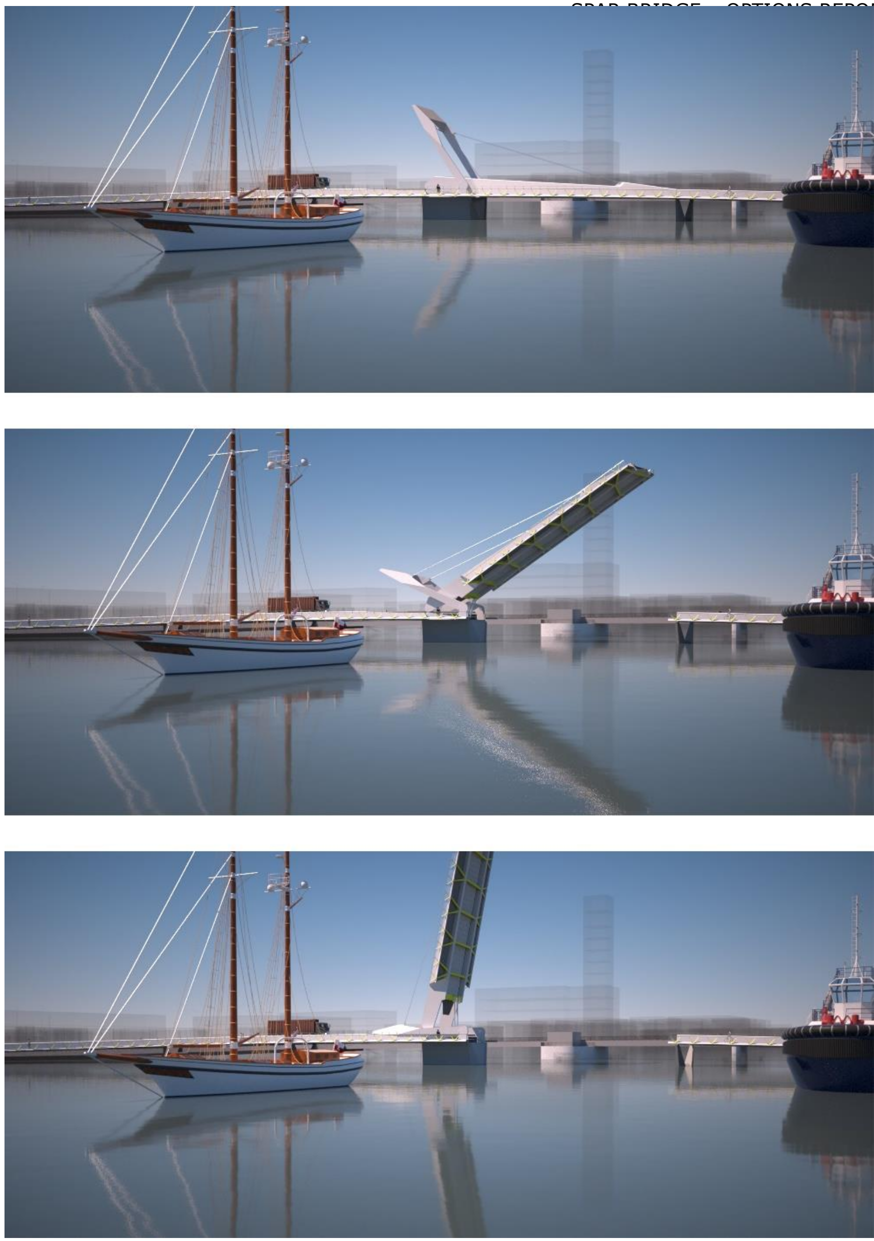


Figure 15: Opening sequence of the proposed scheme, viewed from river

The design of the bridge soffit is important because it will be visible to marine traffic – including the local rowers – and when the bridge opens the soffit is revealed to the wider public.

The choice of materials for the walkway and parapets are a key part of the design. The bridge users are closer to these tactile elements and will experience them more directly. The form of parapet relates to the soffit, linking the topside and underside of the structure. For the walkways, various finishes such as bonded aggregate, timber, and aluminium decking are possible; each with different lifespans, robustness, and maintenance requirements to be considered.

Use of colour and tone is important to highlight particular key elements, such as the parapets, under-deck transverse beams, spine beams, or the counterweight and support structure. Darker colours on the piers can be used to highlight the line of the bridge itself.

Materiality also offers an opportunity to tailor the appearance of the structure and highlight a key element. For example, the use of a local stone for the counterweight may be desirable to display a cultural connection to the local area.

Additional elements required for the operation of the bridge such as the traffic and pedestrian barriers, signage and wigwags require future development.

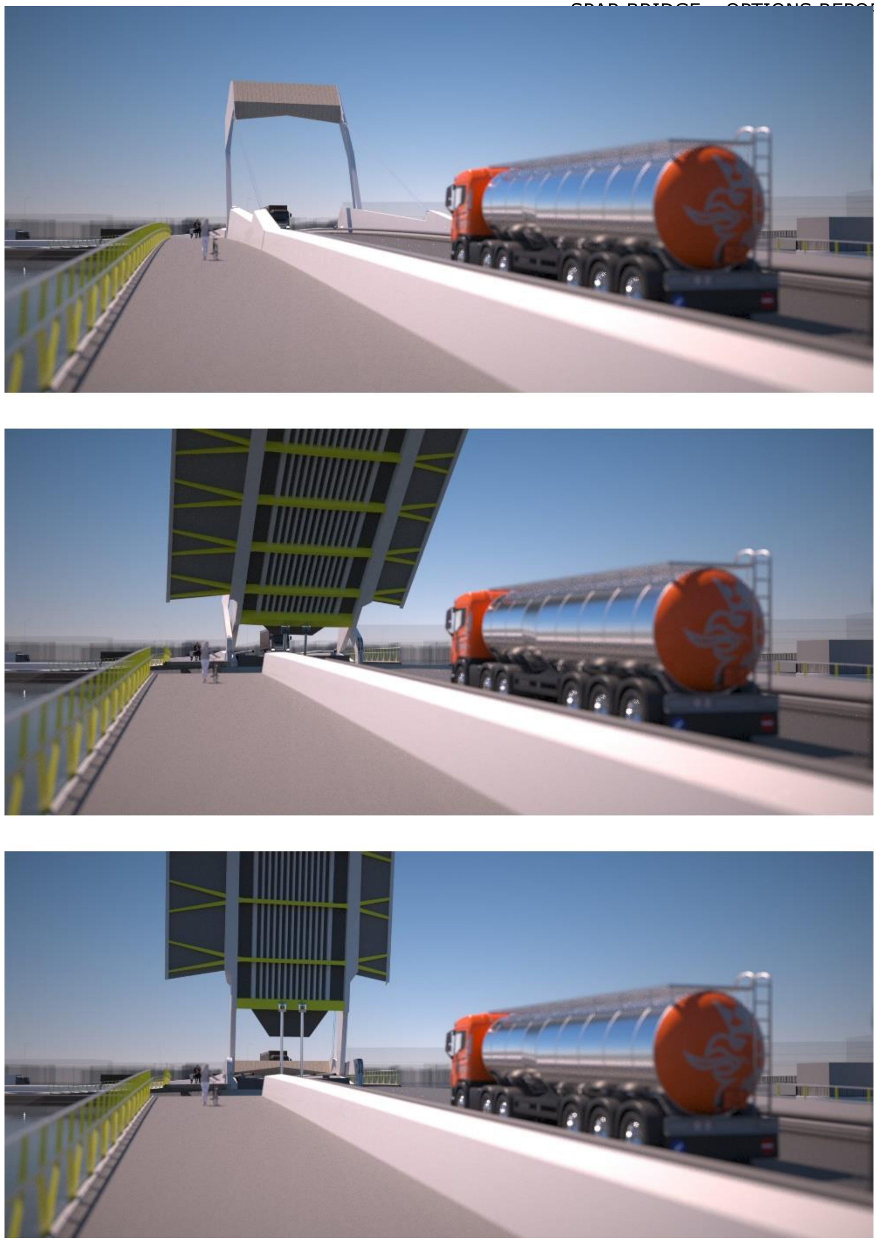


Figure 16: Soffit during opening sequence, viewed from north side of bridge

9 Selected Option

Bascule bridge arrangements (Options 1, 2, 4) are favoured over a swing bridge (Option 3) due to:

- Mechanical simplicity. This is likely to improve reliability.
- It sterilises less of the river channel than a swing bridge due to a smaller swept area.
- A bascule bridge arrangement allows the main pier to be aligned with the Tom Clarke Bridge Pier. This is not possible with a swing bridge.

The fixed pivot arrangements (Option 4) are favoured over rolling bascules (Option 2) due to avoiding the need for a running track which are complex to fabricate and require more maintenance than a fixed pivot.

The Dutch bascule (Option 1) is discounted due to not achieving the requirement clearance envelope whilst aligning the main pier with the Tom Clarke Bridge's pier.

The double pinned bascule (Option 4a) is seen as the most aesthetically interesting option, while being able to provide the unlimited clearance required for the navigation channel. The additional maintenance burden of a second set of pivots is not significant as all pivots would be inspectable from deck level.

The counterweight is chosen to ensure the bridge remains nose heavy, such that in the event of ram failure the bridge could be slowly let down to a closed position. This means the chosen size of the counterweight is around 150 t and could feasibly be made from a range of materials.

The images in this section show the developed concept for the design which is proposed to be taken forward.

See also Appendix A for the full option selection presentation (Sketchbook 09; Proposed SPAR Bridge) given on 17/10/22

Images included of the selected option:

Figure 17: Schematic elevation view in closed position

Figure 18: Schematic elevation view in open position

Figure 19: Closed position, viewed from river

Figure 20: Closed position, viewed from north side Active Travel path

Figure 21: During opening, viewed from north side Active Travel path

Figure 22: Open position, viewed from north side Active Travel path

Figure 23: Closed position, viewed from Tom Clarke Bridge

Figure 24: During opening, viewed from Tom Clarke Bridge

Figure 25: Open position, viewed from Tom Clarke Bridge

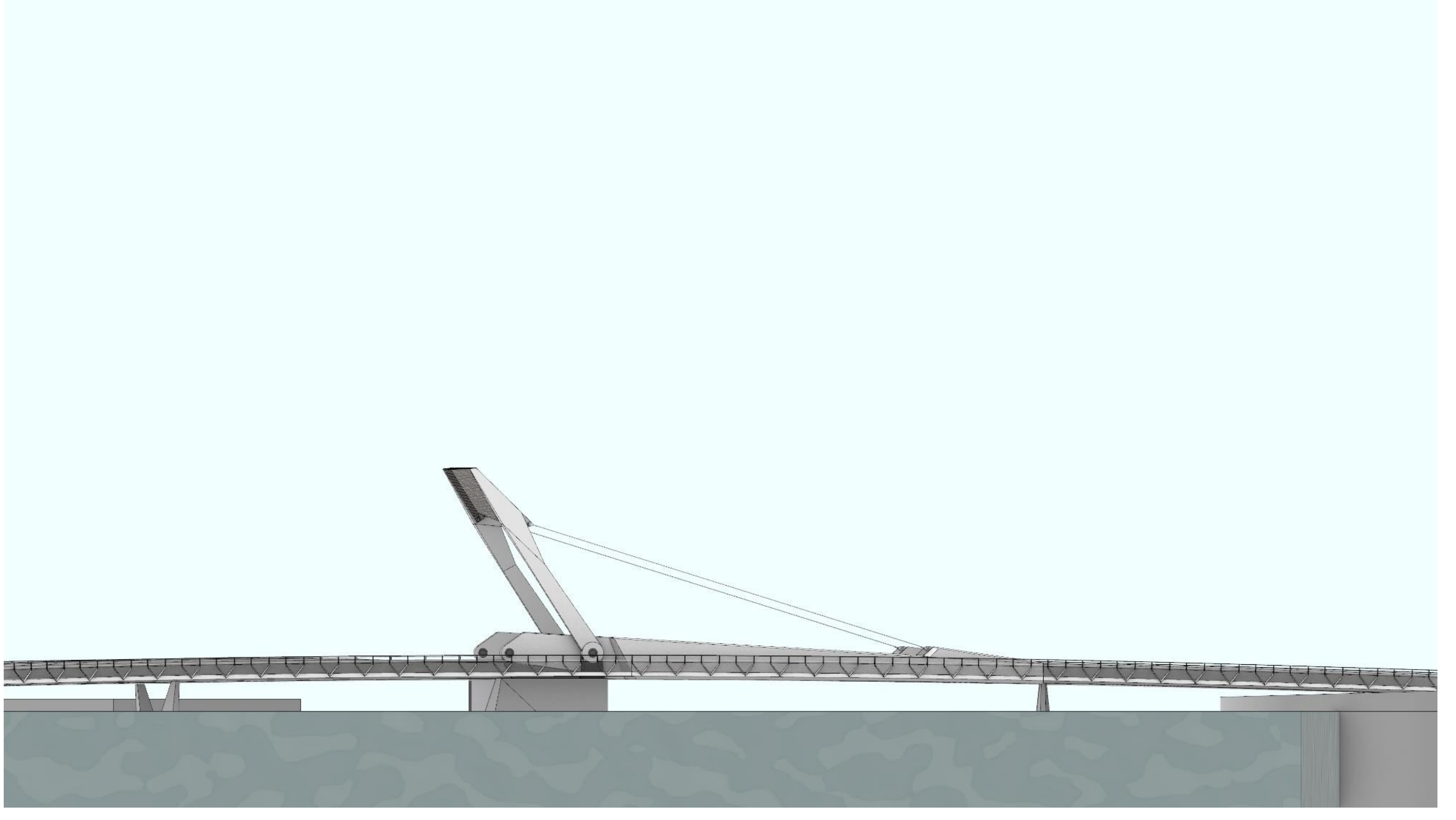


Figure 17: Schematic elevation view in closed position

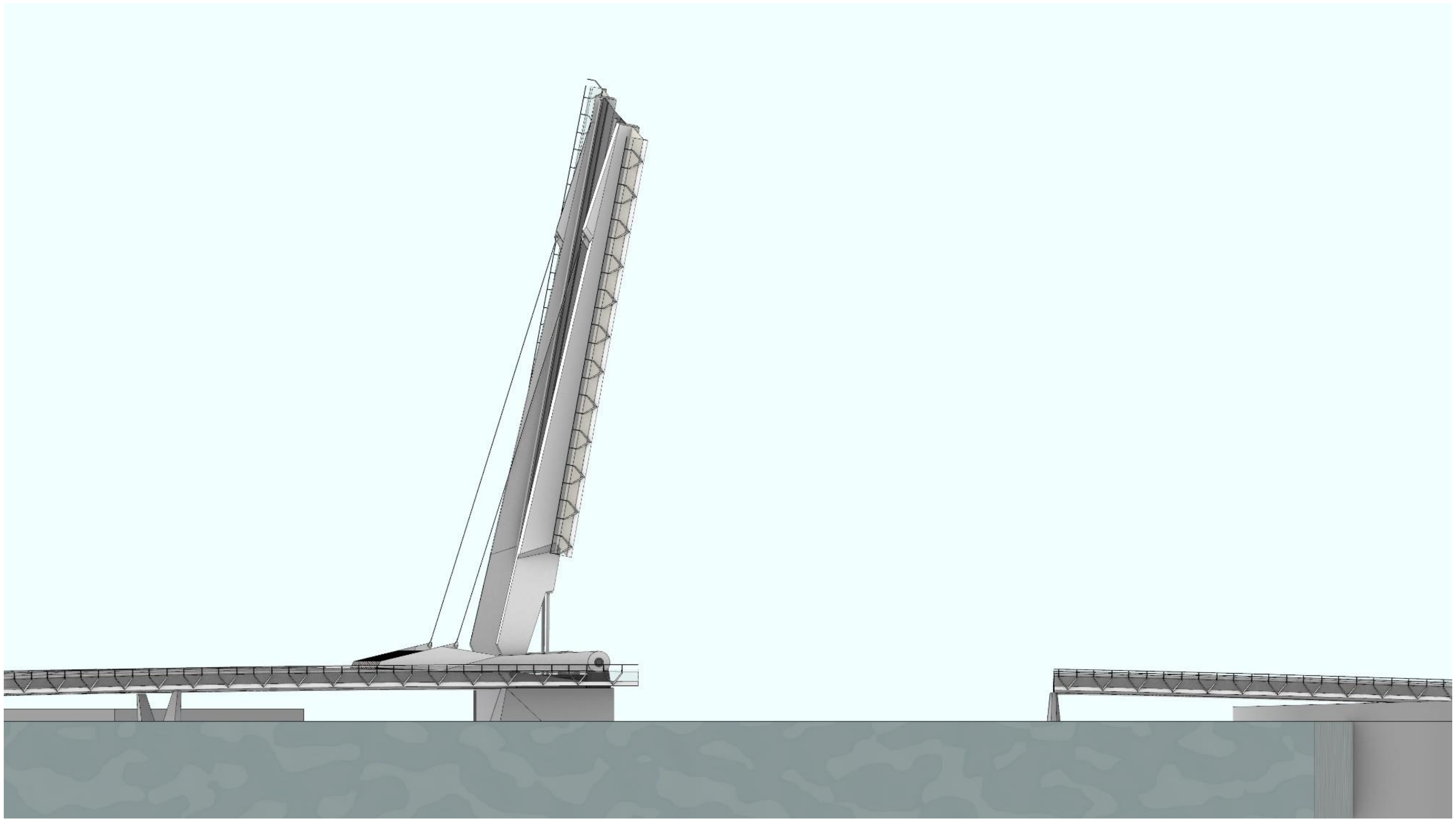


Figure 18: Schematic elevation view in open position

Figure 19: Closed position, viewed from river

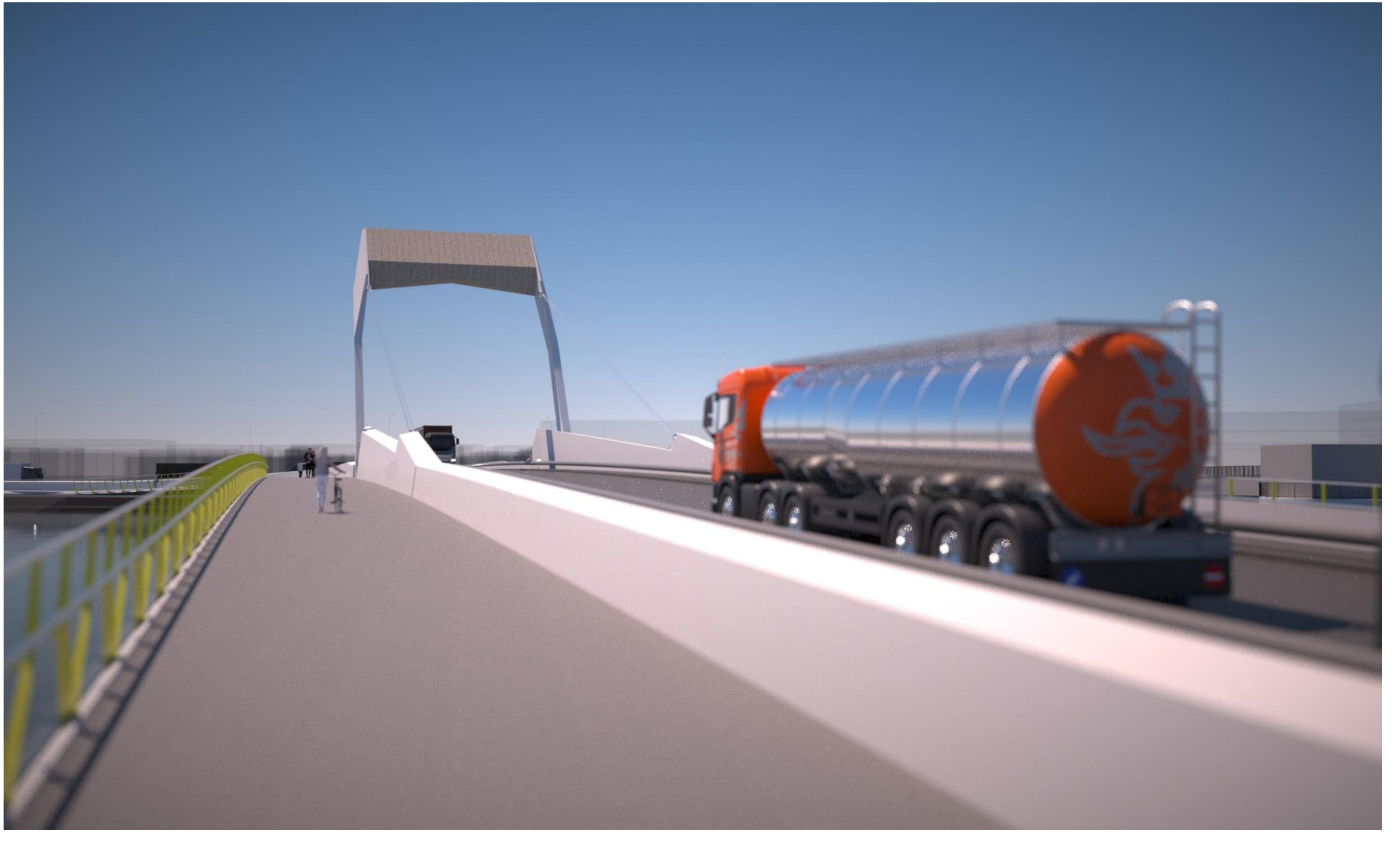


Figure 20: Closed position, viewed from north side Active Travel path

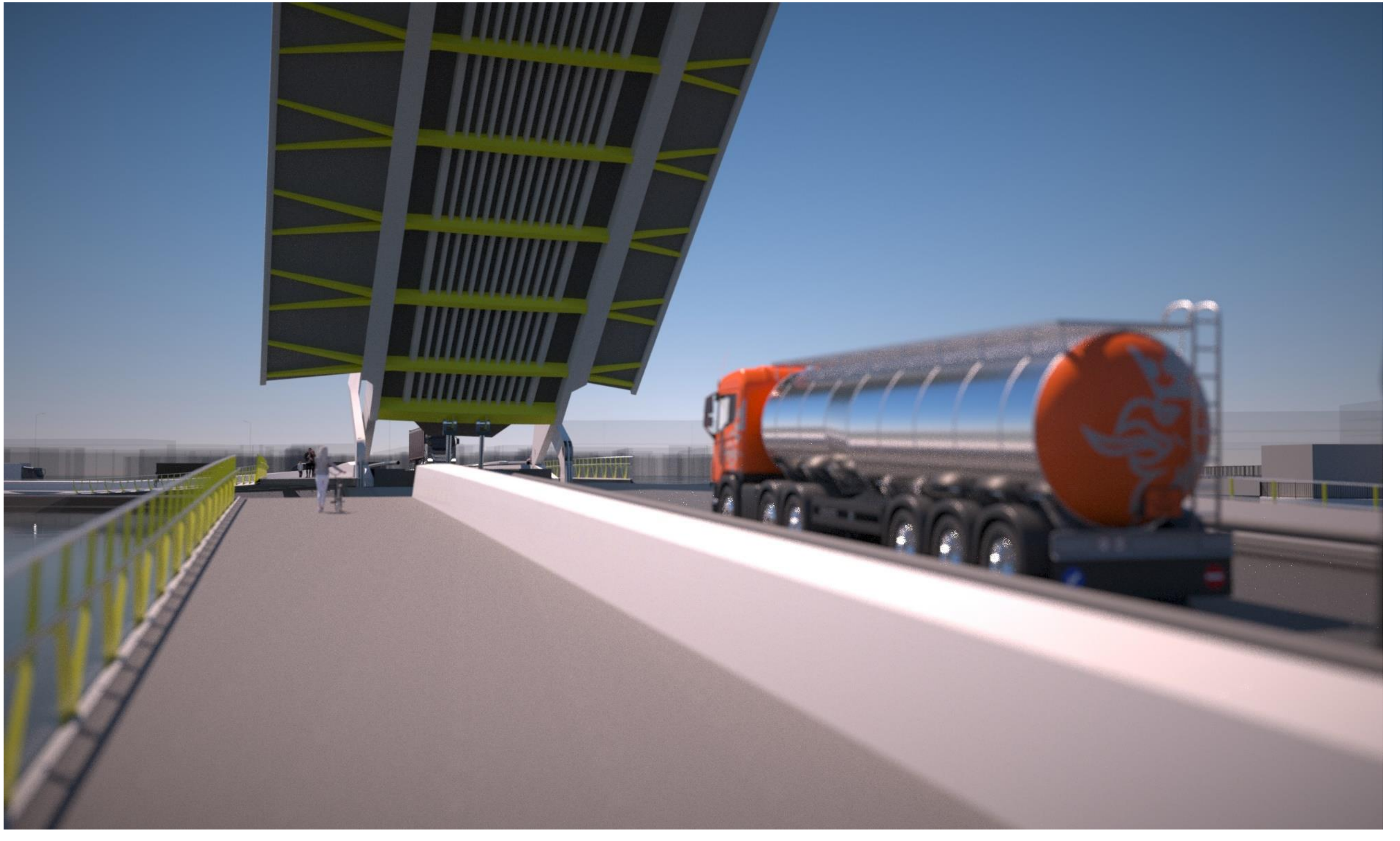


Figure 21: During opening, viewed from north side Active Travel path

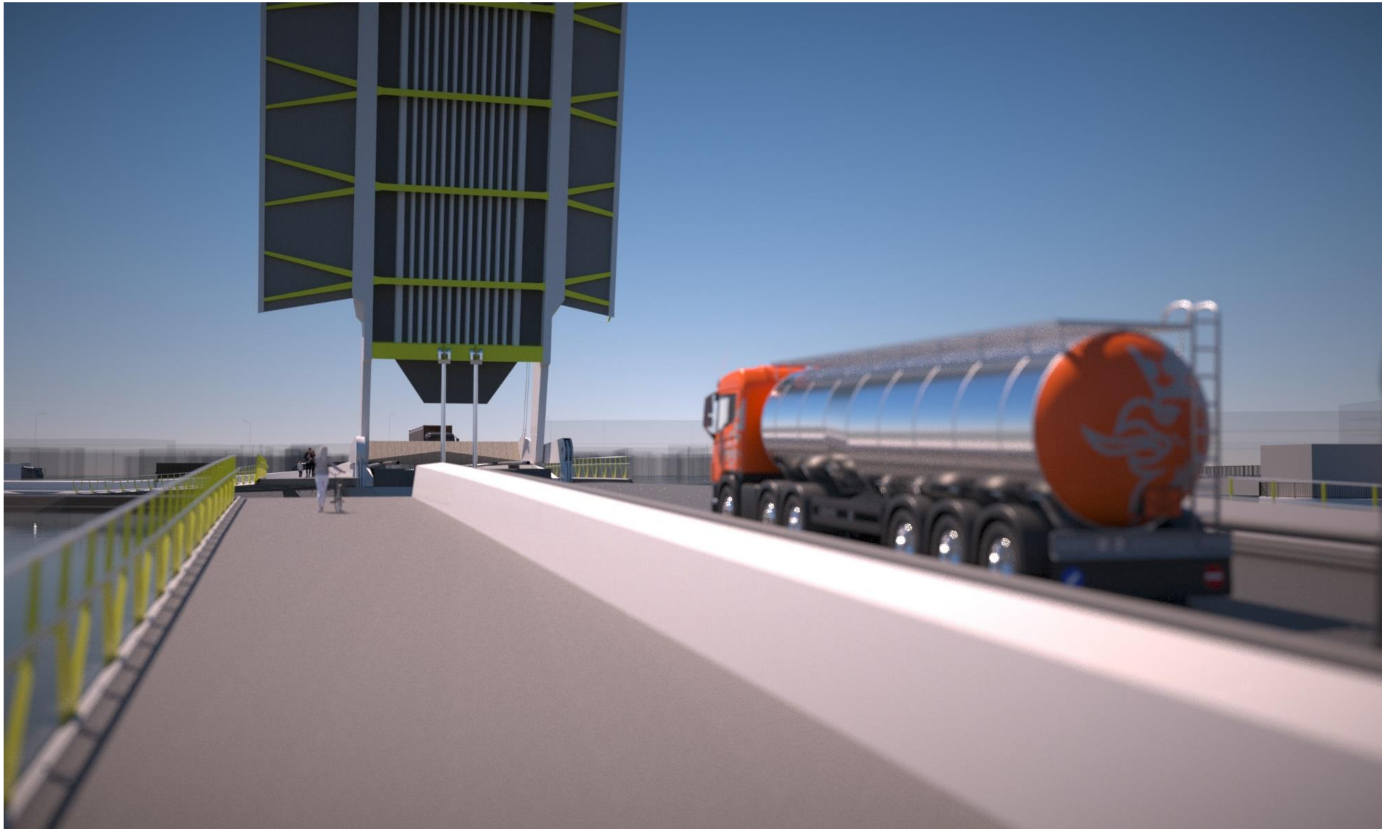


Figure 22: Open position, viewed from north side Active Travel path

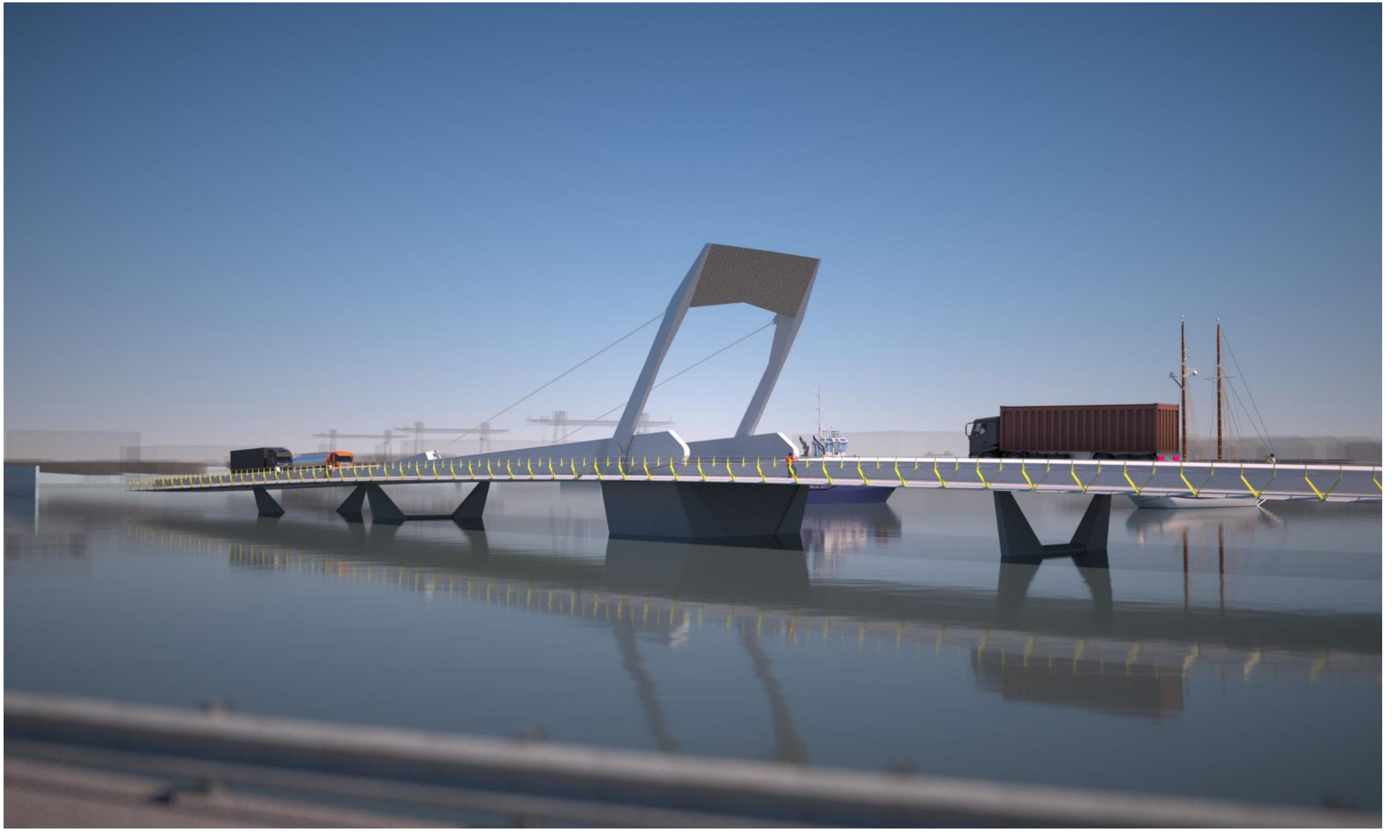


Figure 23: Closed position, viewed from Tom Clarke Bridge

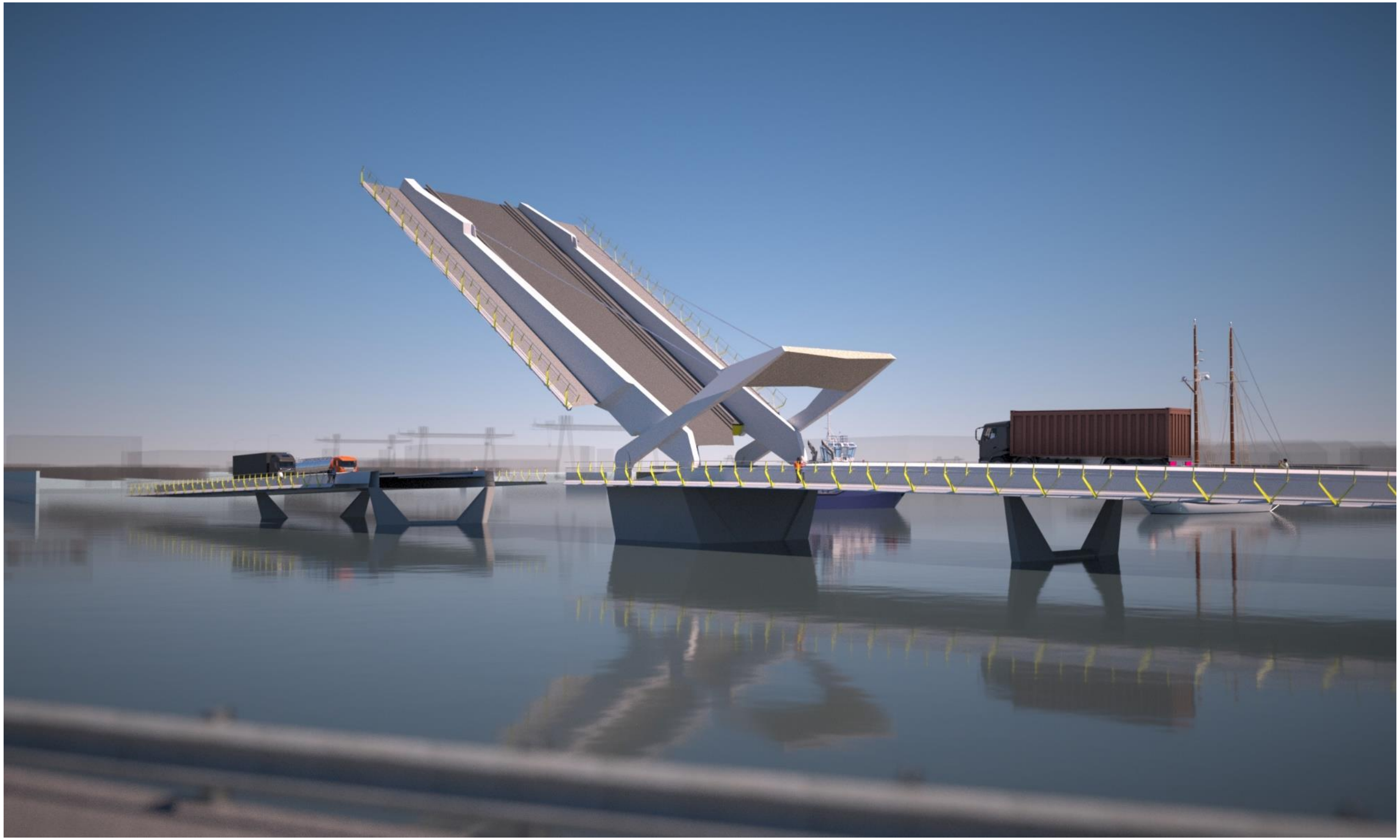


Figure 24: During opening, viewed from Tom Clarke Bridge

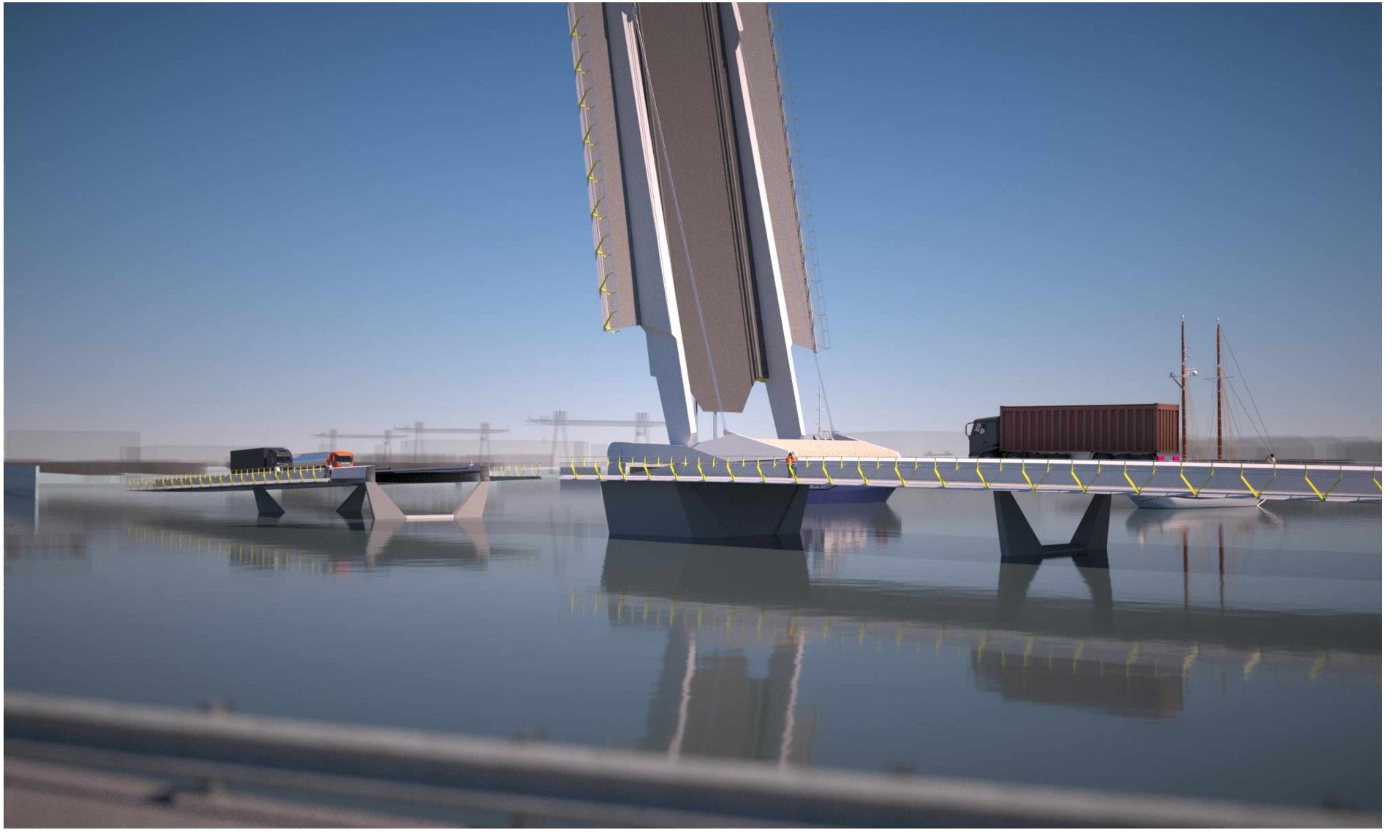


Figure 25: Open position, viewed from Tom Clarke Bridge