# 3 Alternatives Considered

## 3.1 Introduction

3.1.1 This chapter provides a summary of previous work commissioned by Transport Scotland relating to the provision of a replacement crossing over the Firth of Forth, an overview of the assessment work undertaken in the selection of a preferred route corridor, a summary of the objectives and outline of the development of the proposed scheme.

## 3.2 Background

3.2.1 In January 2008 Transport Scotland appointed the Jacobs Arup Joint Venture as its development partner for the proposed scheme. This followed confirmation of the form and location of the replacement crossing in the parliamentary announcement of 19 December 2007, which highlighted the findings of the Forth Replacement Crossing Study (Jacobs et al., 2007).

3.2.2 Jacobs Arup has been engaged in the development of all aspects of the project since January 2008, including connecting roads and future use proposals for the Forth Road Bridge. Each element was considered relative to the operation of the surrounding road network, the environment, the proposed scheme and sustainable development objectives.

**Previous Studies**

Forth Replacement Crossing Study

3.2.3 The Forth Replacement Crossing Study (FRCS) was commissioned by Transport Scotland in 2006 and was focussed on determining the form, function and location of a replacement crossing. The development and findings of each stage of the study were published in the FRCS Reports 1 to 5 (Jacobs et al., 2007). The FRCS had eight specific transport planning objectives, as follows:

- maintain cross-Forth transport links for all modes to at least the level of service offered in 2006;
- connect to the strategic transport network to aid optimisation of the network as a whole;
- improve the reliability of journey times for all modes;
- increase travel choices and improve integration across modes to encourage modal shift of people and goods;
- improve accessibility and social inclusion;
- minimise the impacts of maintenance on the effective operation of the transport network;
- support sustainable development and economic growth; and
- minimise the impact on people, and the natural and cultural heritage of the Forth area.

3.2.4 A list of 65 potential options was initially generated and this list was subject to a sifting process to reduce the list through the elimination of options which did not satisfy the objectives of the study or were not technically feasible. Five potential crossing corridors were then identified. These corridors are shown on Figure 3.1 and are as follows:

- A – Grangemouth (West of Bo'ness);
- B – East of Bo'ness;
- C – West of Rosyth;
- D – East of Rosyth/West of Queensferry; and
- E – East of Queensferry.

3.2.5 Each of the five corridors was assessed for its suitability for a tunnel or a bridge crossing. The work undertaken concluded that Corridors A and B did not meet the objectives of the study and were therefore rejected. Corridors C, D and E performed well to varying degrees against the objectives and these were taken forward to the Scottish Transport Appraisal Guidance (STAG) Part 1 Appraisal (Scottish Executive, 2003) which considered bridge and tunnel options within the three corridors.

3.2.6 In the STAG Part 1 Appraisal, critical issues emerged relating to the environment and planning objective to '*minimise the impact on people, the natural and cultural heritage of the Forth area*'. The bridge proposal in Corridors C and E performed particularly badly in this regard as both the northern and southern landfalls cross, or come very close to, Special Protected Areas (SPAs; refer to Chapter 11: Estuarine Ecology). Both were considered to have major adverse impacts on a European designated site and be unlikely to be permitted when viable alternatives exist that have less or no adverse impact. The bridge in Corridor D was considered to avoid this impact with appropriate mitigation.

3.2.7 As a result of the STAG Part 1 Appraisal, the following proposals were taken forward for further consideration:

- Corridor C – tunnel;
- Corridor D – bridge;
- Corridor D – tunnel; and
- Corridor E – tunnel.

3.2.8 The STAG Part 2 Appraisal assessed these four options, with the conclusion that environmental impacts were generally similar for the four options; typically minor to moderate adverse. However, Tunnel E and Bridge D were identified as potentially having moderate to major adverse impacts on biodiversity. For Tunnel E, the proposed immersed tube was considered likely to disturb sediments and could also impact on the Firth of Forth and Forth Islands SPAs. Potential impacts on European protected species such as cetaceans were also identified. For Bridge D, this was due to potential impacts of disturbance to protected species within the Forth Islands and Firth of Forth SPAs and potential impacts on St. Margaret's Marsh Site of Special Scientific Interest (SSSI) at the northern landfall. Impacts on SPAs would require consideration in the context of potential implications for the sites' conservation objectives under the European Union Habitats Directive (92/43/EEC) (Chapter 11: Estuarine Ecology).

3.2.9 Overall, the bridge option in Corridor D was recommended as the best performing option for the following reasons:

- Cost - it is significantly cheaper than the tunnel options;
- Construction Programme - it can be delivered quicker;
- Construction Risk - it has fewer risks associated with its construction; and
- Economics - it has the best Benefit to Cost Ratio (BCR).

3.2.10 The location of the bridge option in Corridor D is shown on Figure 3.2. The study also confirmed that further work was required to determine any future role for the Forth Road Bridge. Whilst outlining possible strategies for its use in future years, it was acknowledged that further information, including the findings of the Forth Estuary Transport Authority (FETA) Feasibility Study into Replacement/Augmentation of Main Cables Report (FETA, 2008) was required before any definitive decision could be made (refer to Chapter 2: Need for the Scheme).

3.2.11 The FRCS also included a summary of the network connection details of the new crossing in Corridor D to the existing road network.

3.2.12 The bridge connects to viaduct at the northern shore of the Firth of Forth which ends at the B981/B980 roundabout near Jamestown. It connects to the M90, which, it is anticipated, would be upgraded to a point close to Junction 2A/3. A major re-modelling of the existing Ferry Toll junction would be required to provide the range of movements necessary to suit the operational characteristics of the network

3.2.13 The road alignment to the south of the proposed replacement crossing under FRCS would continue in a generally southerly direction to an interchange with the M9 approximately 1 kilometre west of the existing junction 1A. The new junction would be combined with the existing junction 1A and would cater for all necessary movements.

3.2.14 The options for the connecting roads were addressed more fully in subsequent studies as reported in the Route Corridor Options Review, the DMRB Stage 2 Corridor Report and the Scheme Definition Report (see following sections).

3.2.15 Overall, the FRCS concluded that the need for a replacement crossing was justified for the following reasons:

- there is a lack of certainty that the existing Forth Road Bridge is going to be available in the future; and
- the repair/refurbishment of the existing crossing has too severe a set of impacts on the east of Scotland economy if it were to be closed (or even severely restricted) for a period of time.

3.2.16 The findings of the FRCS formed the basis for the decision made by the Scottish Government to progress the Forth Replacement Crossing project. The recommendations of the study were reflected in the announcement made to the Scottish Parliament by the Cabinet Secretary for Finance and Sustainable Growth on 19 December 2007.

## 3.3 The Proposed Scheme – Assessment and Development

3.3.1 The assessment work undertaken by Jacobs Arup throughout 2008 is documented in a series of reports published by Transport Scotland in April 2009. An overview of the findings of each report is set out below, outlining the development history of the project.

**Route Corridor Options Review**

3.3.2 The Forth Replacement Crossing: Route Corridor Options Review (Jacobs Arup, 2009a) defines the initial roads infrastructure assessment work undertaken by Jacobs Arup from January to May 2008, considering potential infrastructure routes to the north and south of the Firth of Forth that could connect the bridge option in Corridor Option D (refer to previous studies above) to the existing road network.

3.3.3 Nine route corridors were identified for assessment, comprising three options to the north of the Forth (providing connections to the A90/M90), and six options to the south of the Firth of Forth (providing connections to the A90, M9 Spur and M9).

3.3.4 Figure 3.3 indicates each of the corridor options considered as a part of this initial phase of assessment.

Initial Assessment

3.3.5 The initial assessment of route corridor options considered environmental impact, geotechnical issues associated with mine workings, cost and the economic/transportation performance associated with each option. Following a sifting workshop held with Transport Scotland on 05 March 2008, it was determined that South Corridor Options 4, 5 and 6 were not viable. Table 3.1 sets out the reasons for the removal of these route corridor options.

**Table 3.1: Rationale for Removal of Route Corridor Options**

| Route Corridor Option | Rationale for Removal |
|---|---|
| South Corridor Option 4 | • In traffic economic terms, the vehicle kms are significantly higher than for Options 1-3 as a result of the majority of traffic movements coming from the east on the A90 or southeast on the M9.<br>• Presence of collapsed mine workings and large number of shafts within corridor area which would impact on the programme and cost of the works.<br>• Comparative cost is 65% higher than South Corridor Option 1. Not considered to provide value for money as it did not provide a significantly greater level of service for traffic or provide for a reduction in vehicle kms travelled. |
| South Corridor Option 5 | • Cost is 85% higher than South Corridor Option 1.<br>• Cost of providing the new M9 links was not proportional to the levels of traffic anticipated and was not considered value for money.<br>• Overall, the environmental impact was considered likely to be higher than the other corridors under consideration e.g. in terms of land-take and severance.<br>• Western section of the corridor passes along the edge of a known mine workings area and additional investigation and treatment would impact on the costs and programme. |
| South Corridor Option 6 | • In traffic economic terms, the vehicle kms are significantly higher than South Corridors Options 1 to 3 as a result of the majority of traffic movements coming from the east on the A90 or southeast on the M9.<br>• Comparative cost is 63% higher than South Corridor Option 1. Not considered to provide value for money as it did not provide a significantly greater level of service for traffic (e.g. M9 west traffic) or provide for a reduction in vehicle kms travelled. |

3.3.6 The remaining route corridors carried forward for further assessment were as follows:

*Northern Study Area*

- North Corridor Option 1 – An online upgrade of the existing A90/M90 between Ferrytoll Junction and Halbeath Interchange.
- North Corridor Option 2 – An offline section of carriageway, providing a new mainline between the Main Crossing and Halbeath Interchange.
- North Corridor Option 3 – A combination option requiring the online upgrade of the A90 between Ferrytoll Junction and Admiralty Junction, and a new offline section of carriageway departing the A90 at Admiralty Junction, connecting to the M90 at Halbeath Interchange.

*Southern Study Area*

- South Corridor Option 1 – A short offline section of new carriageway connecting the Main Crossing to the A90 south of Echline Junction.
- South Corridor Option 2 – A new offline carriageway connecting the Main Crossing to the M9 north of Winchburgh. This corridor follows a similar alignment to the southern corridor outlined in the FRCS (see paragraphs 3.2.3 onwards).
- South Corridor Option 3 – A new offline carriageway connecting the Main Crossing to the M9 Spur northeast of M9 Junction 1A.
- South Corridor Option 4A – An additional option identified for assessment at the sifting workshop of 5 March 2008; a combination of South Corridor Options 1 and 2 providing direct connections to the A90 and the M9. This corridor also follows a similar alignment to the southern corridor outlined in the FRCS (see paragraphs 3.2.3 onwards).

Further Assessment

3.3.7 Following further assessment of the seven options listed above, North Corridor Option 3 and South Corridor Options 3 and 4A were removed from consideration, based on the factors set out in Table 3.2.

**Table 3.2: Rationale for Removal of Route Corridor Options**

| Route Corridor Option | Rationale for Removal |
|---|---|
| North Corridor Option 3 | • No benefits over North Corridor Option 1 or North Corridor Option 2.<br>• Found to be the least effective option in meeting the proposed scheme objectives.<br>• Provides the least amount of junction connectivity, limiting local access provision.<br>• Generates a deterioration in local air quality to the highest number of properties. |
| South Corridor Option 3 | • Complexity of junction layout required to M9 and M9 Spur.<br>- requirement for multiple structures<br>- route connections made difficult given the junction's proximity to existing roads and the Falkirk – Fife Railway Line.<br>- does not provide as high a standard of road design as South Corridor Options 1 & 2.<br>• Requires the greatest number of property demolitions to implement when compared to the remaining south route corridor options available. |
| South Corridor Option 4A | • Land required for implementation would be far greater than that of South Corridor Option 1 or South Corridor Option 2 in isolation.<br>• Greatest ecological, visual and landscape impacts of the southern route corridor options.<br>• Required a high number of watercourse crossings.<br>• Cost of implementation would be greater than that of South Corridor Option 1 or South Corridor Option 2 in isolation. |

3.3.8 On the basis of this assessment, it was recommended that the following options be taken forward for DMRB Stage 2 Corridor Assessment (shown on Figure 3.4):

- North Corridor Option 1;
- North Corridor Option 2;
- South Corridor Option 1; and
- South Corridor Option 2.

3.3.9 This recommendation was accepted by Transport Scotland, and the four options above were taken forward to DMRB Stage 2 assessment.

**DMRB Stage 2 Corridor Report**

3.3.10 The Forth Replacement Crossing: DMRB Stage 2 Corridor Report (Jacobs Arup, 2009b) details the assessment work undertaken from May to August 2008.

3.3.11 The purpose of the report was to document the factors taken into account in the progression of the remaining route corridor options, considering the engineering, environmental, traffic and economic advantages/disadvantages and constraints associated with each corridor option, with cognisance of the scheme objectives.

3.3.12 Figure 3.4 indicates the route corridor options considered in the DMRB Stage 2 Corridor Report.

Assessment Results

3.3.13 The assessment of each route corridor option identified a preference for a combination of North Corridor Option 1 with South Corridor Option 1. A summary of the justification for this preference, considering each of the assessment elements, is provided in the following paragraphs, with further detail provided in the Stage 2 Corridor Report (Jacobs Arup, 2009b).

*Engineering Assessment*

3.3.14 Whilst there were no reasons identified in the engineering assessment to preclude the promotion of any of the options, North Corridor Option 1 and South Corridor Option 1 were deemed to offer the preferred solution.

3.3.15 North Corridor Option 1 was found to be preferable to North Corridor Option 2 on the basis that it would improve mainline carriageway provision and give opportunities for new/improved junction arrangements. Maximising the use of the existing infrastructure also generally reduces overall scheme costs.

3.3.16 South Corridor Option 1 was found to be preferable to South Corridor Option 2 on the grounds that it would require less new road construction and make best use of existing road infrastructure. This, coupled with the provision of new/improved junction arrangements, provided a better Benefit to Cost ratio (BCR).

*Environmental Assessment*

3.3.17 North Corridor Option 1 and South Corridor Option 1 were identified as the preferred option combination in terms of potential environmental impacts, given their use of existing infrastructure.

3.3.18 North Corridor Option 1, which would be largely online, was considered to affect the fewest land interests, cross fewer pedestrian/cyclist routes, have lower ecological impact, and lower potential for impacts on sites of geological importance than North Corridor Option 2. Furthermore, it was deemed to have less potential for flood risk and water quality impacts. Noise and air quality impacts would be similar for either northern route corridor option but, on balance, North Corridor Option 1 was considered to be preferable. The predominantly online nature of North Corridor Option 1 would also result in lower landscape and visual change, and was found to be preferable in terms of view from the road as well as driver stress.

3.3.19 South Corridor Option 1 would require less new infrastructure than its alternative and would pass through less sensitive areas. It would affect few land interests, fewer pedestrian/cyclist routes, have less ecological impact and lower potential to encounter contaminated land. It would also require less flood risk mitigation, result in few watercourse crossings and is considered to have least impact on water quality.

3.3.20 South Corridor Option 2 was assessed to be better in terms of overall noise effects as it would divert traffic away from the A90 south of South Queensferry. Air quality impacts would be similar for either southern route corridor option.

3.3.21 South Corridor Option 1 was preferred in terms of landscape and visual impacts as it would be much more contained and, in contrast to South Corridor Option 2, would not cut through open, rural landscape. South Corridor Option 2 would also increase the isolation of the designed landscape of Dundas Estate.

*Traffic and Economic Assessment*

3.3.22 Through a comparison of the economic evaluations associated with all possible corridor option combinations, it was recognised that North Corridor Option 1 would be the most economically efficient option north of the Firth of Forth.

3.3.23 Operational benefits were noted with corridor combinations containing South Corridor Option 2, with a proportion of Edinburgh bound traffic assigning to the A904 as a more direct route from the proposed Main Crossing to Scotstoun Junction and Edinburgh via the A90. The benefits, including benefits attributed to traffic from Fife using the A904, would result in a higher Net Present Value (NPV). However, South Corridor Option 2 would also incur a substantial additional cost and therefore a similar BCR when compared to those combinations containing South Corridor Option 1.

3.3.24 Given the additional cost associated with South Corridor Option 2, and the similarity in BCR when compared to South Corridor Option 1, it was concluded that North Corridor Option 1 paired with South Corridor Option 1 would offer, overall, the preferred solution.

*Sustainability Assessment*

3.3.25 A high level evaluation of the northern and southern route corridor options against the project's sustainability objectives identified North Corridor Option 1 and South Corridor Option 1 as the preferred option combination.

*Sensitivity Check: South Corridor Option 4B*

3.3.26 To validate the conclusions being drawn from the DMRB Stage 2 assessment process, it was agreed that it was necessary to undertake a sensitivity check against an additional option, South Corridor Option 4B. This option was identified at the Forth Replacement Crossing Route Corridor Workshop, held with Transport Scotland on 25 June 2008, with the objective of providing a direct link from the proposed Main Crossing to the M9 and a direct link to the A90.

3.3.27 South Corridor Option 4B was similar to South Corridor Option 4A (refer to paragraph 3.3.5) but to a reduced standard of alignment and junction design. This option was capable of relieving some of the traffic pressures which could occur on the existing road network with the implementation of South Corridor Option 2 in isolation. South Corridor Option 4B represented an alternative development of the direct southerly connection, similar in concept to the network connection described in FRCS.

3.3.28 To implement this option, the closure of the recently completed M9 Spur would be required. Scotstoun Junction and M9 Junction 1A would also need to be removed, each of which would become redundant. A new all-movements junction is provided on the M9 northeast of Winchburgh to provide access to the proposed Main Crossing.

3.3.29 It was assessed that whilst South Corridor Option 4B is capable of providing direct access to the A90 and the M9, the land-take required in the implementation of such a proposal would be far higher than that required for South Corridor Option 1 and South Corridor Option 2 in isolation, and this option would have a higher environmental impact overall. South Corridor Option 4B would impact on Swineburn Wood, Ross's Plantation, Muiriehall and Carmelhill woodland complexes as per South Corridor Option 2. There would also be higher potential for South Corridor Option 4B to impact on otter and water vole (current populations or potentially suitable habitat) at Linn Mill Burn and Swine Burn in comparison to either of the other two southern route corridor options. In terms of cultural heritage, South Corridor Option 4B would have the highest overall potential impact on Designed Landscapes but in terms of potential impacts on the water environment, it would require the fewest crossings of Swine Burn and have the least geomorphological impacts on this watercourse.

3.3.30 Further to this, the anticipated cost associated with the implementation of this option was determined to be greater than that associated with South Corridor Option 1 and of a comparable order with South Corridor Option 2.

3.3.31 Considering the environmental impacts, the cost associated with the implementation of this option and the amount of existing road infrastructure made redundant through its provision, South Corridor Option 4B was removed from further assessment in advance of the detailed assessment provided within the DMRB Stage 2 Corridor Report.

<u>DMRB Stage 2 Corridor Report Recommendation</u>

3.3.32 Based on the outcomes of the assessment work undertaken, the overall recommendation of the DMRB Stage 2 Corridor Report was that North Corridor Option 1 and South Corridor Option 1 be taken forward as the preferred corridors.

3.3.33 Whilst making this recommendation, the DMRB Stage 2 Corridor Report also noted that the improvement need not be implemented over the full extent of the corridor, with further work being

required to define the road improvements within the corridor which would offer the best value for money.

**The Managed Crossing Scheme**

3.3.34 In considering the outcome of the DMRB Stage 2 Corridor Report in tandem with the assessment work undertaken on the potential future use of the Forth Road Bridge, options for optimising the proposed scheme were considered. The key considerations in this process were as follows:

- the DMRB Stage 2 Corridor Report concluded that the Full Corridor Scheme need not be implemented in full and that project planning work should be progressed to give further detailed consideration to the form and function of the junctions required, and the extent of the road infrastructure improvements provided within the preferred corridors; and
- the Forth Road Bridge could be capable of adaptation for multi-modal use, including future tram/light rail use and it was determined that this would be taken forward as a planning assumption.

3.3.35 The scheme, which has been defined to take account of the combined output from these separate exercises is referred to as the Managed Crossing Scheme, details of which are contained within the Forth Replacement Crossing: Scheme Definition Report (Jacobs Arup, 2009c). The initial layout considered under the Managed Crossing Scheme is shown on Figure 3.5.

Key Features

3.3.36 The key features associated with the Managed Crossing Scheme are as follows:

- use of the Forth Road Bridge for public transport, buses, taxis, pedestrians and cyclists, with future opportunity to upgrade for use by Light Rapid Transit (LRT) which may take the form of guided bus, light rail or tram;
- a new cabled-stayed bridge with three mono-towers and a single level deck with wind shielding, providing two general lanes of traffic and a hard shoulder in each direction (the hard shoulders being capable of carrying public transport during Forth Road Bridge closures or general traffic in times of maintenance);
- north of the proposed Main Crossing, provision of a new high-quality dual carriageway with hard shoulders connecting the bridge to the A90/M90, incorporating junction enhancements at Admiralty and Ferrytoll and road widening in the northbound direction between those junctions;
- south of the proposed Main Crossing, provision of a new high-quality dual carriageway with hard shoulders linking the bridge to the A90 and M9, making use of the recently completed M9 Spur with an enhanced M9 Junction 1A providing free-flow, all-ways access;
- provision of a new junction arrangement providing access to South Queensferry and existing local routes;
- provision of an Intelligent Transport System (ITS) along the full length of the scheme corridor from the M90 Halbeath Junction over the proposed Main Crossing to the M9, improving traffic flow and reducing congestion without the need for an additional traffic lane; and
- potential for the development of the Park and Ride site at Ferrytoll and the potential introduction of new park and ride facilities at Rosyth, Halbeath, and South Queensferry.

Design Refinement

3.3.37 The development of the Managed Crossing Scheme for the purposes of DMRB Stage 3 assessment and this Environmental Statement was undertaken between November 2008 and April 2009. Throughout this period, the proposed scheme was enhanced and refined from an engineering, environmental and traffic perspective. This work took into account the comments of

stakeholders and the feedback received from the public following the exhibition events held in January 2009.

3.3.38 The principle focus for development during this period was in the refinement of the mainline carriageway and junction designs.

3.3.39 North of the Firth of Forth, the principle focus was in the development of Ferrytoll Junction. The junction, one of the key components of the scheme and having been the subject of an iterative design process, was refined to provide safe and reliable access between strategic and local routes, whilst also providing access and egress to the Forth Road Bridge in its role as a public transport crossing.

3.3.40 South of the Firth of Forth, the mainline carriageway (from the A90 to the proposed Main Crossing), the new junction at South Queensferry and the junction improvements at M9 Junction 1A were also subject to further development.

3.3.41 The development of the mainline carriageway and junction proposals at South Queensferry resulted in the proposed junction arrangement moving west, where it is capable of providing direct connections between the proposed Main Crossing and the A904. The placement of the junction also enabled the vertical geometry of the mainline carriageway to be refined, reducing the visual impact of the new carriageway.

3.3.42 M9 Junction 1A was progressed from the initial conceptual design of a free-flow junction providing full functionality between the M9 and M9 Spur, into a loop arrangement. This layout provided the same level of functionality as that previously considered, whilst reducing the amount of land required by maximising the use of existing infrastructure.

3.3.43 The proposed scheme, encompassing the refinements above and as assessed within this ES, is discussed in further detail within Chapter 4 (The Proposed Scheme).

**Development of the Main Crossing Design**

3.3.44 The initial development work undertaken on the Main Crossing design resulted in a shortlist of concepts being developed at a Forth Replacement Crossing team workshop from 11-15 February 2008. These concepts were required to provide the following features:

- a dual two lane motorway with 3.3m hard shoulders and footway/cycleway facilities; and
- a multi-modal (public transport) corridor.

3.3.45 The bridge options were developed to carry the multi-modal public transport corridor in the central area of the bridge, or on the lower level of a double decked structure.

3.3.46 Further details on the work undertaken during this phase of assessment are contained within the Forth Replacement Crossing: Main Crossing (Bridge) Scheme Assessment Report, Development of Options (Jacobs Arup, 2009d).

3.3.47 Given the very high cost associated with making provision for multi-modal public transport, a decision on the preferred bridge option was deferred pending further investigations into the suitability of the Forth Road Bridge as a facility that could be used to assist cross-Forth travel.

Forth Road Bridge - Feasibility of Multi-Modal Corridor Report

3.3.48 As described in Chapter 2 (Section 2.2), the work undertaken by FETA during 2008 resulted in a more positive prognosis being reported for the future of the Forth Road Bridge. Taking this into consideration, an assessment was undertaken to establish the viability of retaining and utilising the existing bridge as a part of the Forth Replacement Crossing project. In particular, the FETA reports

increased the attractiveness of including the use of the existing bridge to realise the following advantages:

- the backlog of maintenance on the Forth Road Bridge, including possible cable replacement, could be completed more efficiently and without traffic disruption and economic impact if a replacement crossing were to be in place and traffic volumes reduced before the work was undertaken;
- if the strategy could remove HGV traffic from the Forth Road Bridge, then many of the maintenance issues would reduce in severity, and on-going maintenance costs for the Forth Road Bridge would be reduced; and
- sharing the required functionality between a replacement crossing and the Forth Road Bridge would allow a narrower and much less expensive replacement crossing, and would allow the greatest operational flexibility in the event that either bridge required temporary closure.

3.3.49 The feasibility of possible arrangements to accommodate pedestrian and cycle traffic, light road traffic and/or public transport, and any future light rail or tram traffic were reviewed and reported in the Forth Road Bridge: Feasibility of Multi-Modal Corridor Report (Jacobs Arup, 2009e).

3.3.50 The study assessed the capability of the existing bridge to carry a range of options for tram/light rail based public transport, together with retained footways. All options were assessed to be geometrically feasible, and all but one reduced the load on the main cables. Modifications to the movement joints on the bridge, in particular at the main towers, would be required.

3.3.51 In conclusion, all of the options for tram/light rail based public transport were assessed to have positive potential. The load reduction would mitigate the loss of cable strength that had already occurred and extend the period before cable replacement or augmentation became necessary. If the current dehumidification scheme is a success, it was deemed that cable replacement or augmentation could be deferred indefinitely.

3.3.52 An independent technical audit of this work was undertaken, with the results provided in 'The Forth Road Bridge Audit of Future Multi-Modal Use: Summary Report' (Faber Maunsell, 2008). The findings of the report 'Forth Road Bridge – Feasibility of Multi-modal Corridor Report' (Jacobs Arup, 2009e) concurred with the summary report prepared by Faber Maunsell.

3.3.53 On the basis that the Forth Road Bridge could be capable of adaptation for multi-modal use, including future tram/light rail use, it was determined that this would be taken forward as a planning assumption.

Development of D2M Alternatives for Main Crossing

3.3.54 Following a review of the facilities required for the Forth Replacement Crossing, the project team concluded that the relocation of multi-modal and pedestrian/cycle facilities to the Forth Road Bridge would enable a narrower cross-section to be adopted on the proposed Main Crossing, consisting of:

- dual two lane carriageway with hard shoulder in each direction;
- widened hard shoulder to enable future hard shoulder running in times of maintenance or by buses diverted from the Forth Road Bridge during periods of strong winds; and
- sufficient width of bridge deck to enable the rearrangement of the functions to provide a multi-modal corridor and dual two lane carriageway or a pedestrian/cycleway with dual two lane carriageway and narrow hard shoulder.

3.3.55 A range of deck and tower options were considered with aesthetic, construction and cost parameters all taken into account. Two deck options were considered; a single corridor utilising an 'H' or 'A' or 'diamond' tower or a twin corridor utilising a central mono-tower. The tower options considered are detailed in Figure 3.5.

3.3.56 Following the analysis and review of each of the options, the recommended option for further development was determined to be a single deck, twin corridor bridge with mono-towers. The following factors contributed to this recommendation:

- it provides a unique and instantly recognisable image;
- it is the simplest to construct overall, and in the shortest period of time;
- it represents a cost comparable to the lowest cost option; and
- it is aesthetically the most pleasing design and is considered to be that which best complements the setting of the existing rail and road bridges.

3.3.57 This work is reported in the Forth Replacement Crossing: Main Crossing (Bridge) Scheme Assessment Report, Development of D2M Alternatives (Jacobs Arup, 2009f).

## 3.4 References

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