

M11 Bus-only Slip-Roads

Feasibility Report
Cambridgeshire County Council

21 August 2015



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1. Introduction

Atkins has been commissioned by Cambridge County Council (CCC) to undertake a high-level appraisal of bus-only slip lanes at Junctions 11 and 13 of the M11. Opportunities to improve bus journey time reliability have been considered which include new bus only slip roads and provision of bus-only lanes. High-level appraisals have been undertaken to review the scheme feasibility and provide indicative costs for the options.

This report emerged as the result of recommendations made by the City Deal Joint Assembly to the City Deal Executive Board on the 3rd June 2015. This report has been brought forward at this time as a result of these recommendations, however it must be noted that this is out of sequence with a full assessment of such infrastructure improvements. A full assessment of any options that are worthy of further consideration will be undertaken in due course. This report will be presented at the October cycle of City Deal Joint Assembly and City Executive Board meetings.

These proposals are not included in the Transport Strategy for Cambridge and South Cambridgeshire. As such this report avoids a policy based assessment of the appraisal options. Some of the options may not be policy compliant to the adopted local transport strategy objectives. No options are 'recommended' or 'preferred' but are set out for illustrative purposes only for completeness. Any further assessment of these (or other) options should be carried out in the context of the relevant City Deal project development framework.

1.1. Background

Currently a number of infrastructure schemes are being proposed as part of the Cambridge City Deal. These include schemes within the A428 Corridor Study and the Western Orbital Study. The A428 Corridor Study aims to provide advice to the City Deal partners on options to help deliver congestion free public transport serving the A428 corridor in order to avoid an increase in current congestion levels and public transport journey times. A number of options have been identified which will be going out to public consultation in October 2015. The Western Orbital study considers the potential to provide an orbital route to the west to improve access to existing and proposed residential and commercial areas.

This report reviews opportunities to provide bus-only slip roads at Junctions 11 and 13 of the M11 to improve journey time reliability for existing buses using these junctions. This report has been developed separately to the City Deal projects and each option considered has been taken as a stand-alone scheme designed to operate independently. However, in concluding the impact of each option it is important to consider its wider impact in terms of other proposals as well as local impacts. A full assessment of any options considered further will be undertaken in due process in the fullness of time.

1.2. Objectives of the Report

The aim of this report is to conduct an initial and high-level appraisal of the technical implications and costs of creating bus-only slip-roads to present to the October cycle of City Deal Joint Assembly and City Deal Executive Board meetings.

The junction locations are shown in Figure 1-1 for M11 Junction 13 and Figure 1-2 for M11 Junction 11.

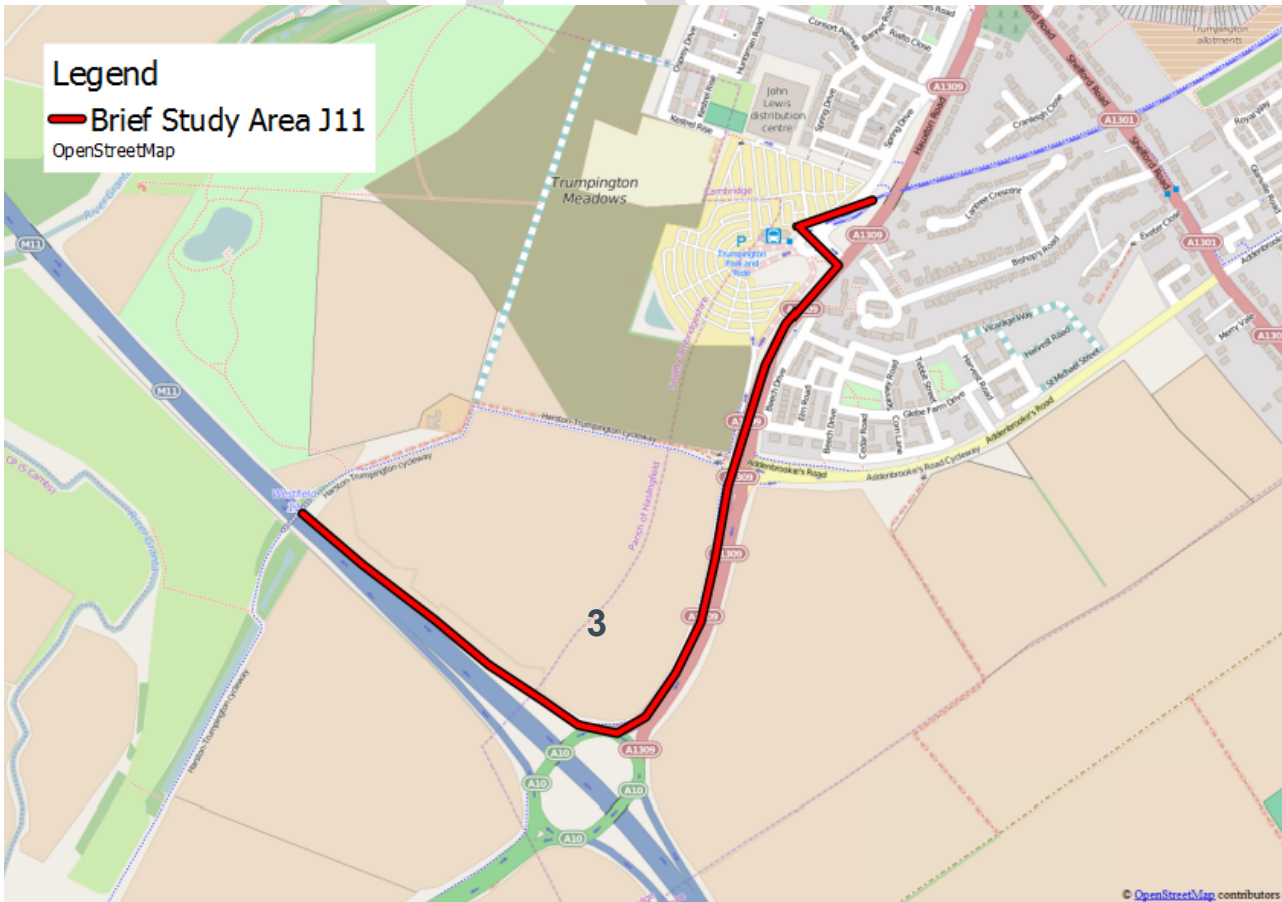
- 1) At M11 Junction 13: when turning off the A1303 (going east) onto the M11 (going south);
- 2) At M11 Junction 13: creating a bus lane alongside the existing slip-road off the M11, which would get priority treatment at the traffic lights; and
- 3) At M11 Junction 11: turning off the M11 (going south) between the existing farm and footbridge and the existing slip-road, then going round the corner of the farmland at Trumpington Meadows, running parallel to (and west of) Trumpington Road, and entering the Trumpington Road Park and Ride thence joining up to the Guided Busway.

While meeting these parameters it was considered relevant to ensure that a wider assessment of the junction options was also undertaken. This provides for a more realistic set of proposals which reflect the actual constraints/opportunities of the junction.

Figure 1-1 M11 Junction 13 Focus Area



Figure 1-2 M11 Junction 11 Focus Area



In order to meet the overall objectives of the report a number of deliverables have been identified by CCC as follows:

- To prepare a report outlining a high feasibility assessment for the provision of bus-only slip roads at Junctions 11 and 13 of the M11;
- To produce an indicative concept design for Junction 11 southbound dedicated bus access to Trumpington Park and Ride, including indicative alignment and traffic control / management measures;
- To produce an indicative concept design for Junction 13 southbound and northbound dedicated bus access to the A1303, including indicative alignment and traffic control / management measures;
- To produce an indicative alignment for bus priority across the existing Junction 13 bridge, allowing for a right turn manoeuvre into the southbound slip;
- Provide a basic operational assessment of Junction 13 options;
- To provide a separate technical note reviewing the Junction 13 bridge;
- To provide a model validation report, outlining the modelling process;
- To provide an outline budget cost for each option presented, taking into account services present at the Junction 13 bridge; and
- To identify comparable bus-only slip roads on motorways in the UK.

1.3. Structure of Report

The remainder of this report is structured as follows:

- **Section 2** details the methodology undertaken to achieve the aims and objectives outlined by the City Deal Joint Assembly to the City Deal Executive Board and CCC;
- **Section 3** outlines the data obtained through desktop research and a site visit;
- **Section 4** provides details of the initial option development including those options discounted at this stage;
- **Section 5** outlines the processes involved in option testing including traffic modelling, highway design and bridge assessments;
- **Section 6** provides a provisional costing of each of the options;
- **Section 7** provides a review of those options tested in Section 5 focusing on the impacts on buses and general traffic; and
- **Section 8** provides our summary and conclusions.

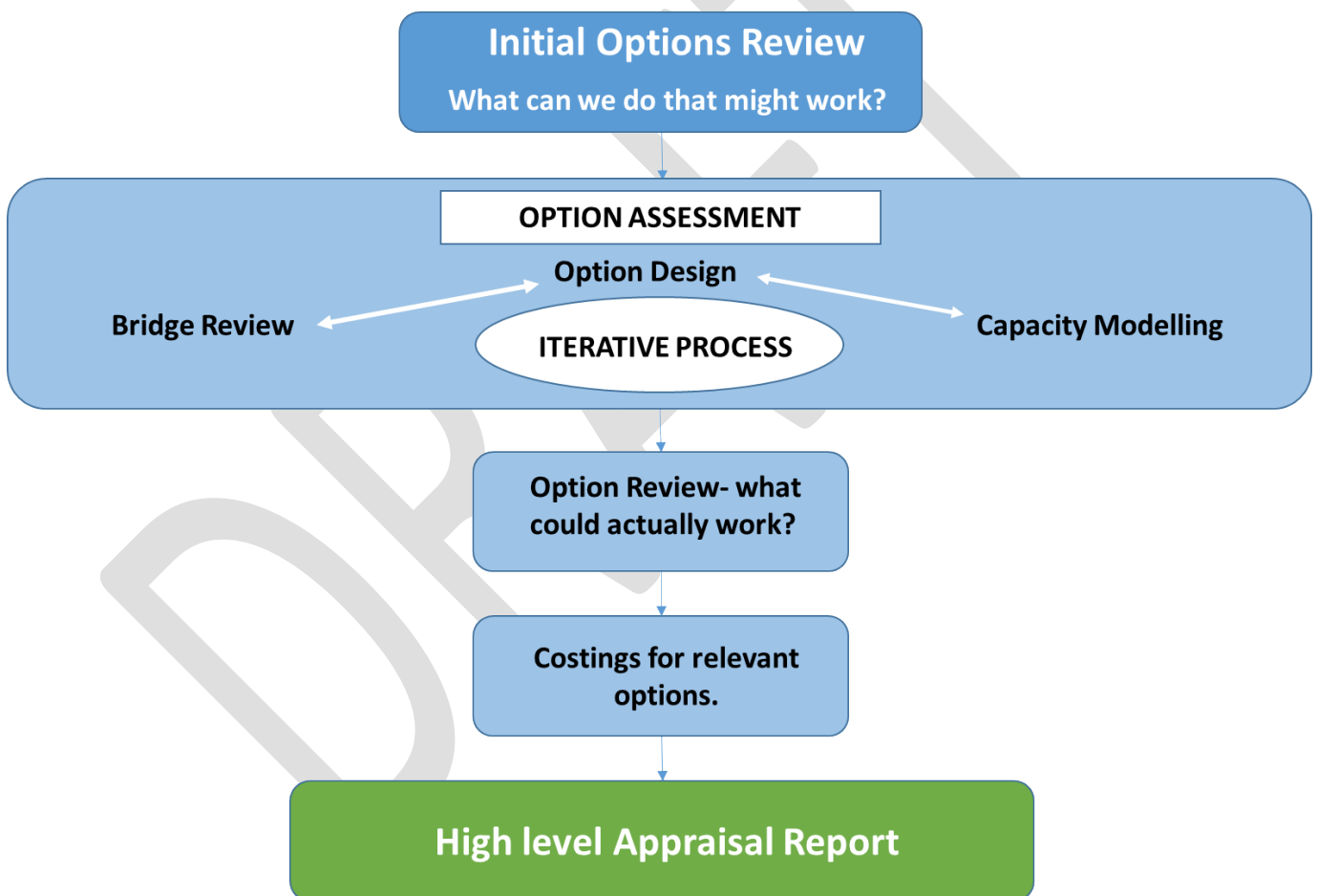
2. Methodology

This section of the report summarises the methodology used to generate, assess, review and cost options for providing bus-only slip roads at Junctions 11 and 13 of the M11.

The aim of this report is to provide an initial and high-level appraisal of the technical implications and costs of creating bus-only slip roads. The methodology focuses upon providing an assessment of the 'workability' of each option based upon highway design, bridge assessment and traffic modelling, with provisional costing of options. The assessment does not include strategic modelling or cost-benefit analysis and it is not intended that the assessment is WebTag compliant since it is outside of the City Deal process and is focussed on providing an assessment of the high-level feasibility rather than economic justification of any option.

The overall methodology followed during the assessment is set out in Figure 2-1 and summarised below.

Figure 2-1 Methodology



The methodology required close collaboration of highway engineers, bridge engineers and traffic modellers. In addition regular workshops were held with CCC to inform on current process and review options at the initial option review and option assessment stages. The methodology does not consider policy compliance review as this was considered outside the scope for this high level review project.

2.1. Initial Option Review

Work on the report commenced with an internal workshop held by Atkins on 16th July, closely followed by a workshop between CCC and Atkins on 22nd July to scope potential options for providing bus-only slip roads at Junctions 11 and 13 of the M11. The workshops focused upon the options outlined by the City Deal Joint Committee (see Section 1.2), however, other options for providing bus-only slip roads were also considered where these were considered to be in line with the aims and objectives of the report.

The purpose of the initial options review was to generate options and discuss any which were felt to be unworkable at this early stage. As a result of discussions some options were discounted and did not continue to the option assessment stage. During the initial options review stage a desktop review of other bus-only slip roads within the UK was also undertaken to inform the development of options during the option assessment stage.

2.2. Option Development and Assessment

Following the initial options review a total of 3 options for Junction 11 and 4 options for Junction 13 were considered in the option development and assessment stage. The option development and assessment followed an iterative process with bridge assessment, highway design and traffic modelling all taking place simultaneously.

During the option development and assessment process any options shown to be unworkable in terms of bridge assessment, highway design or traffic modelling were immediately discounted.

2.2.1. Bridge Assessment

A bridge assessment was undertaken based on information provided by Highways England and utilities searches undertaken by Atkins. The assessment at Junction 13 was undertaken to consider whether it was feasible to reconfigure the highway cross section within the width available between the bridge parapets to provide additional space for buses. The full assessment is presented in a Technical Note in Appendix D.

2.2.2. Design

Options identified at the initial options review were developed to a feasibility design stage within CAD. The designs were developed to a scale of 1:500 as 2D arrangements based on DMRB design standards. Consideration of buildability was provided as comments for each of the options.

2.2.3. Traffic Modelling

A microsimulation traffic model was developed for Junction 13 of the M11 to provide an indication as to if there were any high-level operational issues that may prevent an option from being considered further. The model was developed using available data, including a traffic count undertaken in 2014 and OS Base plans and information on signal timings and junction operation gathered during a site visit.

Microsimulation modelling has not been undertaken for Junction 11 of the M11 as possible schemes at this junction would not have an impact upon local traffic. Nevertheless data on existing queueing at the junction has been used to inform the development of options. This is further outlined in Section 5.4 of this report.

2.2.4. Option Review

An option review workshop between CCC and Atkins was held on 5th August to review each of the options assessed and identify any that should not be taken forward to the costing stage. An internal meeting was also held on 12th August to record the performance of each of the options considering:

- Can the option be constructed?
- Does it offer journey time savings or increased reliability to buses?
- Does it adversely impact existing vehicular traffic?
- Does it offer wider benefits? and
- What are the key risks and issues?

2.2.5. Option Costing

An initial costing exercise was carried out for each of the options remaining following the option review. This was a high level costing based on standard information for construction, combined with professional opinion on additional costs.

2.3. Limitations of this Report

The aim of the report was for an initial high-level assessment of the technical implications and costs of providing bus-only slip roads. Due to the need to report at the October cycle of City Deal Joint Assembly and City Deal Executive Board meetings the time available to undertake the assessment was constrained. A number of assumptions have been made in order to provide an initial high-level assessment and these are outlined below:

- Design has been undertaken at a feasibility level only, to inform other assessments and provide an indication on whether construction of the option would be feasible. Further design including 3D design would need to be undertaken should any option be developed following this report;
- Traffic modelling has been undertaken for the immediate Junction 13 of the M11 only. Due to time constraints strategic modelling has not been used to inform this report, however possible strategic effects have been identified where possible based on professional opinion. Further modelling, including strategic modelling would be required should any option be developed following this report;
- A bridge assessment has been undertaken using available information from Highways England. The assessment is not a Structural Review to BD 101/11 and Assessment to BD 21/01 as this was not possible given the tight programme and is beyond the scope of a high-level assessment. Should any option be developed following this report, this level of assessment would be required;
- This report is an initial high-level appraisal and is not WebTag compliant and therefore the level of detail is reduced and any numerical results won't necessarily reflect the real performance of options;
- The report does not include options outside of the restricted geographical area as stated in the City Deal Board instruction and therefore limits options that may be outside of this area;
- The report is commissioned ahead of the A428 consultation and therefore does not consider public or stakeholder engagement; and
- The report is commissioned ahead of the sequential Western Orbital study programme

Further detailed assumptions made within the traffic modelling are outlined in Section 5.3.

3. Data Collection and Desktop Study

This section of the report outlines the data collected to inform the development of options to provide bus-only slip roads at Junctions 11 and 13 of the M11. This includes a desktop study of similar schemes in the UK and a site visit to review conditions for buses and general traffic at each junction.

3.1. Desktop Study

An initial desktop investigation was undertaken to identify any existing bus-only slip roads within the UK which would provide a basis for design of options for M11 Junctions 11 and 13. The review also aimed to identify whether bus-only slip roads had been considered feasible in other locations.

3.1.1. Existing Bus-Only Slip Roads

Four examples of existing bus-only slip roads have been identified through desktop research and information provided by Highways England.

3.1.1.1. London Luton – Parkway Road to Airport Way

This route is located at London Luton Airport, connecting Parkway Road to Airport Way (A1081), providing a more direct route for buses between the rail station and airport. This slip road serves the rail-air shuttle service from the Luton Airport Parkway rail station to the airport. The road was installed as part of the East Luton Corridor Improvements Scheme. The service runs every 10 minutes until midnight and there is one bus for each arriving train between midnight and 5am. A location plan is shown in Appendix A.

The bus-only slip road in this location originates from Parkway Road close to Luton Parkway Station. It is likely that bus and traffic speeds in this location would be relatively slow. The bus-only slip road merges with a bus lane on New Airport Way, rather than with a general traffic lane. These conditions are not considered to be a good proxy for conditions at Junctions 13 of the M11 where buses may be required to merge with general traffic or high-speed traffic on the M11. However potential options for Junction 11 may involve dedicated bus provision similar to that provided between Parkway Road and Airport Way.

3.1.1.2. M4 Junction 4 to 4a (Heathrow Airport Spur): Bus Lane (Lane 4) and advance signals with bus gate signals

The M4 spur bus lane was Britain's first motorway bus lane. The M4 spur provides general vehicle access to Heathrow Airport. The spur is frequently congested, with queues stretching up to 1.4km back to the M4. The two-way bus lane, opened in 1997 allows buses to avoid these queues. The location of the bus-only lane is shown in Appendix A.

The introduction of the bus lane on the M4 Spur did not reduce the remaining capacity for general traffic. The bus lane runs adjacent to lane 3 of the M4 Spur (on the outside lane of the carriageway). It starts on the spur itself (with appropriate signage) and finishes around 50 metres from the Heathrow access roundabout (Tunnel Road roundabout) at a bus gate. This bus gate allows the bus to enter the roundabout prior to general traffic.

The M4 Spur bus lane is a good example of an existing bus lane in operation in the UK which provides 'visible' priority to buses over general traffic, promoting the use of sustainable modes of travel over the private car.

3.1.1.3. M606 Junction 1 to M62 Bradford: High Occupancy Vehicle (HOV) bypass lane (2+ lane)

A 'high-occupancy vehicle lane' is provided on the M606/M62 junction near Bradford. It is the UK's first motorway carpool lane. The 2.7 km lane scheme is southbound only and allows vehicles with more than one person in the car a fast track onto the M62 eastbound at Junction 26. The location of the HOV lane is shown in Appendix A.

Whilst not specifically a bus lane, buses are able to use the HOV lane to access the M62 eastbound at the junction and is a clear example of a measure promoting the use of sustainable modes of travel over the private car.

3.1.1.4. A52 Brian Clough Way, Nottingham: Bus Lane

Highways England provided information relating to the A52 Brian Clough Way in Nottingham, which has a bus lane from its junction with Ilkeston Road/Derby Road to its junction with Wollaton Vale. The bus lane is in addition to the two running lanes and run towards the town centre only. The location of the bus-only lane is shown in Appendix A.

3.1.2. Proposed Bus-Only Slip Roads

The desktop review has also considered proposed schemes for bus-only slip roads.

3.1.2.1. A47 Postwick Interchange

A bus-only slip road was proposed by an objector as part of Alternative Option 6A of the A47 Postwick Interchange Scheme in Norfolk. The proposed westbound merging slip road would extend from the existing Postwick Park and Ride roundabout and connect to the A47. This option was ultimately deemed unviable because it was considered to be an *“unacceptable risk on the safe operation of the A47 trunk road due to predicted queuing onto the mainline”* and had *“a number of design issues which raise safety concerns with elements of highway geometry significantly below design standards”*. One major safety concern was that it would lead to increased likelihood of side swipe conflicts at the junction. ¹

3.1.2.2. Transport for London Blackwall Tunnel to Silvertown Tunnel

Transport for London (TfL) have also proposed the installation of 4 bus only slip roads between Blackwall Tunnel and Silvertown Tunnel, and the North Greenwich bus station in London, and potentially for commuter coaches serving the Greenwich Peninsula. A bus-only slip road servicing Blackwall Tunnel southbound would be located after the tunnel portal and onto Millennium Way, whilst a northbound bus-only slip road will be provided from Tunnel Avenue to Blackwall Lane Northbound. Silvertown tunnel will have a bus-only slip road from Boord Street to Millennium Way and a second bus-only slip road from Millennium Way to the tunnel approach. ² These schemes are in the early stages of development and have not been granted planning permission.

3.1.3. Summary

Review of existing bus-only slip road schemes in the UK shows that all existing schemes considered are in operation at airport locations. In these locations they provide a key link between public transport interchanges and prevent buses from being delayed by considerable general traffic queues. However the method for this assessment is to provide a linear improvement adjacent to general traffic congestion instead of providing movement specific priority between different classes of road. Nevertheless the desktop study indicates that bus-only slip roads have been implemented elsewhere in the UK.

Other schemes have also been proposed within the UK. There is evidence that these schemes have led to safety concerns. This suggests that if an option to provide bus-only slip roads at Junction 11 and/or 13 of the M11 was to be taken forward detailed assessment of safety would need to be included in the detailed design.

3.2. Utilities Searches

A utilities search was conducted in order to determine the services running along the M11 Junction 13 Bridge. Services within the bridge are detailed in the full service report included in Appendix B of this report.

3.3. Traffic Counts

The traffic counts used to inform the assessment were collected on Wednesday 18th June 2014 as part of the A428 Corridor Study. The M11 on and off-slip junctions were included as part of this wider data collection and has been made available for use in this assessment. Data was collected as a single day Manual Classified Count in 30 minute intervals, supported by two-week Automatic Traffic Counts.

¹ <http://www.norfolk.gov.uk/view/NCC144139>

² <https://tfl.gov.uk/cdn/static/cms/documents/st-silvertown-tunnel-transport-assessment.pdf>

4. Initial Option Review

This section of the report outlines the initial option review. The initial option review led to the generation of a range of options to provide bus-only slip roads at both Junctions 11 and 13 of the M11 at this stage as hand-drawn sketches. These options were discussed at two workshops and any which were outside of the scope of the report or were not feasible for reasons of highway design or traffic impact were discounted.

4.1. Initial Scoping

As outlined in Section 2 of this report initial scoping was undertaken at an internal workshop on 16th July, followed closely by a Client workshop with CCC on 22nd July. Initial plans for all the options considered at this stage are shown in Appendix C and summarised below.

4.1.1. Junction 11

4.1.1.1. Options Taken Forward

Initial option review indicates that the options below are likely to be workable in design terms and meet the overall aims and objectives of this assessment. As a result these options will be further considered during the option assessment stage of this report.

Junction 11: Option A

This option provides a bus-only access road running off-line but adjacent to the existing general traffic slip road from the M11 towards Trumpington Park and Ride. This option also provides a fully segregated bus-only access to the Park and Ride site.

Junction 11: Option B

This option provides a bus-only access route parallel to the existing off slip and bypasses the existing traffic signals at the end of the slip road. The existing slip-road would be widened to accommodate the extra lane. The bus only access route then continues onto the dedicated Park and Ride traffic lane beyond the junction.

Junction 11: Option C

This option provides a bus-only slip road leaving the M11 prior to the existing agricultural bridge (for buses travelling southbound on the M11). It is likely that this option could require widening of the existing agricultural bridge. The segregated bus-only lane could continue to the Park & Ride site.

The agricultural bridge is located 55m upstream from the start of the M11 Junction 11 southbound off-slip and 540m from the stopline at the top of the off-slip. Highway designers present at the workshop indicated that it is not possible to provide a bus-only slip road leaving the M11 south of the agricultural bridge due to the proximity of Junction 11 that meets DMRB standards.

4.1.1.2. Option Discounted

It is important to note that 'discounted' options only means 'discounted within the limited scope of this study'. This study was specifically limited in terms of its brief. As such there may – within the wider City Deal context – be a case for revisiting some of the options discounted within this report as part of the overall scheme development work for the Western Orbital and A428 Cambridge City Deal projects.

Junction 11: Option D

This option provides a bus priority measure at the existing M11 Junction to allow buses to move through the junction ahead of general vehicular traffic which would be held back at the signals.

Initial review suggests that this option would not provide any benefit to buses unless a segregated bus lane could be provided at the slip. A bus lane could not be provided at this location without widening and in this case either Option A or Option B would offer greater benefits as buses would have a free flow arrangement. For this reason this option was discounted at the initial option review stage and will not be considered during the option assessment stage of the assessment.

4.1.2. M11 Junction 13

4.1.2.1. Options Taken Forward

Initial option review indicates that the options below are likely to be workable in design terms and meet the overall aims and objectives of the report. As a result these options will be further considered during the option assessment stage of the assessment.

Junction 13: Option 1

This option provides a bus-only lane eastbound over the M11 on Madingley Road towards Cambridge. No signals are present in this option, allowing the bus to continue forward unobstructed. An introduction of bus detector loops would enable a 'green wave' across the bridge towards Cambridge and the M11 southbound. A new signal controlled junction would be required to the east of the bridge for the M11 southbound on-slip.

Junction 13: Option 2

Option 2 provides a bus priority measure based on vehicle detection on the eastbound approach to Madingley Road Bridge for buses turning right onto the M11. Buses can be held at the signals to allow traffic coming off the M11 to turn onto Madingley Road and merge into the straight-ahead lane unobstructed. Buses heading eastbound would have priority at the signals over other vehicles. The introduction of bus detector loops to enable a 'green wave' across the bridge towards Cambridge and the M11 southbound. A new signal controlled junction would be installed to the east of the bridge for the M11 southbound on-slip to ensure that traffic does not block back across the bridge preventing the bus gate from operating effectively.

Junction 13: Option 4

Option 4 requires the construction of a new gyratory at the junction with all-traffic capacity. This would involve a new structure over the M11 to the north of the current bridge. The gyratory would accommodate 3 traffic lanes.

Junction 13: Option 5

This option provides of a bus-only loop to the north of Junction 13 to bring buses from the Madingley Road Bridge south onto the M11 prior to general traffic joining. In order to prevent buses turning right onto the slip road a bus lane is proposed to run across the bridge and down the loop, unopposed. A total of 4 lanes would run across the bridge (3 eastbound and 1 westbound). The potential for a bus stop to serve Madingley Park & Ride and the Cambridge North-west development was also discussed.

4.1.2.2. Options Discounted

Junction 13: Option 3

This option provides a segregated bus-only slip road on the off-side of the existing M11 off-slip. This would allow buses on the slip road to by-pass existing traffic queues and reach the signals at the top of the slip road quickly.

At the initial review workshop it was agreed that for this option to provide a real benefit to buses the bus lane would need to extend far to the south of the junction along the M11 for this option to offer any real benefit to buses. This is because during peak periods traffic can queue along the M11 as far back as the Coton junction. Provision of a bus-only lane on the slip only would limit the capacity of the M11 Junction 13 off-slip which would consequently lead to greater congestion on the slip and M11. Highways England also reviewed this option and suggested that it would not be workable. As a result this option was discounted at the initial review stage and will not be considered during the option assessment stage of the assessment.

Junction 13: Option 6

This option consists of a new structure to the north of Junction 13 for buses to join the M11 prior to general traffic in a similar manner to Option 5.

Initial option review recognised that this could offer wider benefits if provided with one of the options currently being reviewed as part of the A428 Cambridge City Deal Study. However this option was considered out of scope for this report, based on the requirements outlined by the City Deal Joint Assembly and City Deal Executive Board and as a result it will not be considered in the option assessment stage of the report.

Junction 13: Discounted Option 7

This option consists of new bus-only slip roads onto the M11 at the location of the existing Coton footbridge.

Initial option review recognised that this could offer wider benefits if provided with one of the options currently being reviewed as part of the A428 Cambridge City Deal Study. However this option was considered out of scope for this report, based on the requirements outlined by the City Deal Joint Assembly and City Deal Executive Board and as a result it will not be considered in the option assessment stage of the report.

4.2. Summary

The initial option review generated 3 options for Junction 11 and 4 options for Junction 13 which were considered suitable for further assessment in the option assessment stage of the report.

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5. Option Development and Assessment

This section of the report outlines the development and assessment of the initial options. This includes feasibility highway design and traffic modelling. In addition the results of an assessment of the bridge crossing of the Junction 13 of the M11 are detailed.

5.1. Bridge Assessment

An assessment of the M11 Junction 13 Bridge has been conducted as part of this report. A separate technical note, outlining the detailed findings, is provided in Appendix D of this report. The bridge assessment concluded that:

- Widening of the carriageway across the M11 Junction 13 Bridge is feasible within the existing structure providing that the lane width across the 3 lanes does not exceed 10.95 m (3 x 3.65m lanes) and that the lanes remain in the same location on the bridge deck;
- The carriageway can be widened to 12.9-13.65m, with the diversion of services from one side of the bridge to the other (i.e. either all services run through the northern service trench or all services run through the southern service trench. This option would require further assessment due to the increase in width beyond 3 x 3.65m lanes (which has an effect on bridge loading); and
- By diverting the services from the bridge entirely, the carriageway width can be widened to 15.3m, leaving the verges at a minimum width of 0.6m. This would allow the provision of 4 lanes across the carriageway. This option would require significant further modelling and assessment. A new bridge or extension to the existing bridge would be required to accommodate services and non-motorised users under this scenario.

The results of the bridge assessment support the development of any of the options from the initial option development. However the level of modifications required to the bridge will vary for each option as follows:

- Options 1 and 2 can be accommodated with minor changes to the existing carriageway. Lanes could either remain as existing or be modified to provide 3.65m lanes (to meet highway standards) with minor works and no stats diversions required;
- Option 4 would require a new bridge to be constructed to the north of the existing structure. This is feasible with no modifications to the existing structure (or with minor modifications to increase lane width as described for Options 1 and 2 above); and
- Option 5 would require the provision of four lanes across the bridge (three general traffic lanes and one bus-only lane). This would require a total minimum width of 14.2m (3.5m bus lane, 0.6m reservation, 3.5 metre traffic lane and two further 3.3m traffic lanes) and is only possible with the complete diversion of services from the bridge.

5.2. Design

Feasibility design drawings of all options are presented in Appendix E of this report. These have been designed in accordance with DMRB. This section of the report outlines the assumptions and notes made during the design of each option in turn. It has been assumed that any land required to accommodate these works would be available and that existing pedestrian crossing facilities would be maintained. A detailed design note is presented in Appendix F.

5.2.1. Junction 11: Option A

The current layout of the roundabout was maintained, however the length of slip road was limited by the distance from the adjacent off-slip. The segregated bus lane that has been assumed to be bus only, would provide access to the P&R site. There is potential for this to be made an all-traffic lane to the P&R.

Further work would need to consider appropriate signage to indicate the bus only lane. A more detailed assessment of the impact of the existing queuing at this junction would also be advised.

5.2.2. Junction 11: Option B

The current layout of the roundabout has been maintained and the slip-road widened to provide a bus-only slip exiting earlier. There is potential for this to be made an all-traffic lane to the P&R.

Further work would need to consider appropriate signage to indicate the bus only lane. A more detailed assessment of the impact of the existing queuing at this junction would also be advised along with assessment of the pedestrian / cycle infrastructure.

5.2.3. Junction 11: Option C

The design of Option C progressed following the initial option review. Iterations of the design for a bus-only slip road and escape lane, for general traffic movements made into the bus lane in error, determined that space was not available to achieve this prior to or after the agricultural bridge. As a result the final design extends the off-slip at Junction 11 for all traffic to the north of the agricultural bridge, with a bus-only slip road branching from the extended off-slip. As the bus-only lane travels adjacent to the off-slip the need for an escape lane is removed.

In the event that this option is progressed, further assessment would be required on the widening of the agricultural bridge and a new structure to accommodate a two lane slip-road at the location of the existing agricultural bridge. Further work would need to consider appropriate signage to indicate the bus only lane.

5.2.4. Junction 13: Option 1

The design process involved reinstating the previously removed elongated bus lane junction bypass island. If taken forward, the reason behind the original removal would have to be determined. Consideration would also need to be made of the existing narrow lane width across the bridge, in order to meet DMRB standards.

5.2.5. Junction 13: Option 2

As with Option 1, the reason behind the removal of the elongated bus lane junction bypass island would need to be determined. In addition, further structural assessment and consultation with statutory undertakers is required at detail design phase to determine the nature of the bridge widening.

5.2.6. Junction 13: Option 4

The new structure has been located at a suitable distance to allow for future expansion of the junction as well as accommodating 3 x 3.65m lanes. The nature of the high-level design would allow the majority of the junction to be built off-line therefore reducing the disruption to the existing traffic network. Further consideration of this option would need to take into account the location of stats and the existing GVC.

5.2.7. Junction 13: Option 5

Further consideration of this option at detailed design stage would need to take into account the location of a gas pipeline which has been identified close to the proposed location of the on-slip. Effective signage would need to be provided to ensure that drivers on the M11 are warned of slow merging traffic.

5.3. High Level Modelling Assessment: Junction 13

Options to provide bus-only slip roads at Junction 13 of the M11 are likely to have considerable effects on existing traffic using the junction. As a result the impact of options for this junction have been assessed using traffic modelling. The results of this modelling are described in this section of the report, with a Technical Note, presented in Appendix G providing further detail.

5.3.1. Site Visit

The site visit on the 3rd August identified that Junction 13 operates in two stages (A1303 traffic in one stage and slip road traffic in a second stage) and that the bus gate indicated on OS base plans for eastbound buses entering Junction 13 is not in operation (i.e. the bus signal mirrors the A1303 eastbound signal and does not offer buses any form of priority). The phasing of the traffic signals was also observed, so that this could be replicated where possible within the model. It was noted that since the site visit occurred outside DMRB Neutral Traffic times, during school holidays, the observations may not be representative of typical traffic conditions.

5.3.2. Method and Assumptions

Microsimulation modelling has been selected as an appropriate method for conducting an initial high-level assessment of the options for M11 Junction 13. The process followed to develop the microsimulation model is summarised below.

5.3.3. Base Model

A 2014 base model was developed on which to test the options for the junction. The performance of Junction 13 is sensitive to the performance of the Park and Ride access junction on Madingley Road and other junctions within the corridor. Therefore it is recommended that if any of the options are taken forward more detailed modelling of adjacent junctions would need to be considered as part of any further assessment of these options.

To provide a suitable validation of the base model, a number of assumptions were made. These assumptions are related to the limited scope of the model and the availability of information at the time for this assessment, namely:

- Additional traffic demand was added at the western end of Madingley Road to the observed stopline traffic counts at M11 junction 13 to replicate the observed length of queues;
- Site observations suggest that a key cause of the queues at Junction 13 are the tailbacks from the adjacent P&R junction. Assumptions have been made regarding the operation and timing of the traffic signals and pedestrian crossing; and
- No signal plan information was made available for M11 junction 13. A vehicle actuated signal control, reactive to gaps in flow, has been derived to provide a best estimate of the on-street operation of the traffic signals.

5.3.4. Option Modelling

The four options taken forward from the Initial Option Review of Junction 13 were modelled within VISSIM (Options 1, 2, 4 and 5). The performance of each of these options is detailed in the technical note provided as a separate document and summarised below.

Option 1

This option causes little change to the eastbound travel time from Madingley Mulch to Coton for general vehicular traffic, but does improve the bus travel time from Coton to the P&R. This is because the option provides benefits to buses at the stopline (bus priority), but cannot offer benefits to buses waiting in a queue to reach the stopline.

Option 2

This option operates in a very similar manner to Option 1 with the only difference for buses being they may face a red light when bus priority is unable to react immediately (i.e. when an opposing stage is yet to reach its minimum green). This offers improved safety of the merge movement between buses and general traffic on the M11 Bridge however it does not reduce the overall performance of the junction.

Option 4

This option has been tested as a priority junction, however there is an opportunity to signalise the junction if required. This option gives priority the eastbound flow from Madingley Road as there is no conflict when entering the roundabout, providing free flowing access to the Park and Ride site. The M11 off-slip right turners also have priority into the offside lane, but then must access the middle lane on the northern section of the circulatory to continue into the City, or offside lane to enter the Park and Ride site.

The middle lane is heavily utilised by the Madingley Road flow and therefore lane changing becomes difficult for the M11 flow and this results in queues tailing back on the off-slip. This also restricts the priority given to buses either turning right on to the M11 (which would use the nearside lane) or those entering the Park and Ride site (using the offside lane), since the access to these lanes may be restricted by the queue in the middle lane, or by vehicles attempting to merge into this lane and blocking the offside or nearside lanes.

It should be noted that the influence of the adjacent Park and Ride junction is the primary determining factor for the performance of this option. While the option in isolation may improve the operation of Junction 13 itself, restrictions elsewhere in the network may not allow the junction to operate to its ultimate potential. Strategic modelling would be required to reflect the impact of other junctions on Junction 13 of the M11 and this is outside the scope of this report.

Option 5

This option operates in a similar manner to the other options, helping to improve reliability for buses once they reach the bus lane 300m west of the M11 off-slip junction. Buses still have to travel through the queue approaching the M11 off-slip, so the majority of bus delay still remains and journey times do not improve significantly. The operation of the junction for general traffic is largely unaffected, however the merge point for buses is moved to east of the overbridge, giving rise to slight congestion at this point for buses accessing the Park and Ride site.

Summary

The high-level modelling work undertaken does not highlight any specific issues that would prevent any of the above options being taken forwards for further consideration at this stage. The performance of any option would be ultimately reliant on the conditions and performance of the adjacent network and junctions. It is important to note that, with the exception of Option 4, none of the options proposed have the potential to improve these existing queues. Unless these queues are bypassed by public transport infrastructure or mitigated, buses will remain delayed as they are also held in the queues until they reach the bus lane approximately 300m on approach to the junction.

It is therefore highly important that further work is undertaken to consider the full impacts of any option in the context of the wider corridor as a whole using a more holistic and detailed modelling approach, as the ultimate performance of any option would be influenced by a better understanding of the performance and interactions of adjacent junctions and clarification over the assumptions stated above.

5.4. Traffic Flow Analysis: Junction 11

Further analysis of the design of Junction 11 Options A and B has been conducted. Based on the AM and PM average speeds on the southbound off-slip shown in Appendix H, it is predicted that the two options will not provide a large benefit in terms of bus journey time savings as buses have the potential to be held up on the slip before entering the bus-only lane.

The AM peak Trafficmaster data shows that in the traffic has an average speed of 10-20mph. The PM peak traffic an average speed of 20-30mph along the length of the slip. Given the queues shown above, it is considered that Options A and B may offer little benefit to buses in terms of journey time reliability.

6. Option Costing

All options considered within the option development and assessment stage have been the subject of a high-level assessment of the cost of implementation. A provisional cost has been prepared based on feasibility drawings and derived from the latest competitive rates taken from Atkins' records to indicate an outline cost for the proposed works. The costs do not include land acquisition, service diversions and temporary traffic management measures. The results are summarised in Table 6-1. The full costing details are shown Appendix I.

It is important to note that these costs are indicative and will need to be updated as further detail becomes available. Options have been provided as a range of costs. For Options C, Option 4 and Option 5 the construction of new bridges within the options produces a wider range of costs. This accounts for the fact that construction of new bridges, particularly over a motorway carriageway, has the potential to involve complicated construction methods.

Table 6-1 Option Costing

Option	Cost (Approximate)
J11 Option A	£1.2 million
J11 Option B	£800,000
J11 Option C	£4.7 million - £5.7 million
J13 Option 1	£150,000- £425,000*
J13 Option 2	£150,000- £425,000*
J13 Option 4	£22 million - £42 million
J13 Option 5	£4.2 million – £7.2 million

*The lower end of this range does not include widening of the existing Junction 13 Bridge to provide 3.65m lanes to meet DMRB standards. The upper end of the range allows for widening to meet DMRB standards.

7. Option Review

Option review was undertaken at an internal meeting on 13th August, involving bridge engineers, highway designers and traffic modellers. The aim of the option review was to identify the benefits and constraints of each of the options. The option review does not measure the relative performance of each of the options against the others. It should be recognised that the options may only provide benefits in the peak hours only where congestion would otherwise delay buses.

The option review considered the following:

- Can the option be constructed?
 - This considered whether the design process identified any reasons why the option could not be constructed. Where the design process identified that the option could be constructed, options requiring further mitigation or design/safety consideration were identified;
- Does it offer journey time savings or increased reliability to buses?
 - This considered whether the microsimulation modelling identified journey time savings for buses within the option. Where journey time savings were identified options which would also offer increased reliability were also identified;
- Does it adversely impact upon existing vehicular traffic?
 - This considered whether the microsimulation modelling identified impacts upon existing traffic queueing or journey times for the option. Where impacts on existing traffic were identified options which would produce major impacts on existing traffic flows and queueing were identified;
- Does it offer wider benefits?
 - This considered whether the option would offer wider benefits linked to proposed developments, options currently being considered within the A428 corridor study or options currently being considered within the Western Orbital study; and
- Key risks and issues:
 - This identifies whether any key risks or issues were identified during the option assessment stage.

The results of the option review are shown in Table 7-1.

Table 7-1 Option Review

Option	Cost	Can it be constructed?			Does it offer journey time savings to buses?			Does it adversely impact vehicular traffic?			Does it offer other/wider benefits?		Key risks and issues
		No	Yes (with mitigation)	Yes	No	Yes	Yes (and improved reliability)	No/ positive impact	Minor	Major	Yes	No	
J11 Option A – Slip off-line at junction	£1.2million		✓ M11 off-slip may require extension to meet design standards during detailed design.			✓ Benefits are limited as existing queueing on the off-slip extends onto the M11 in peak periods (see Section 5.2).		✓				✓ Direct access to P&R	Enforcement and signage of bus-only lane needs further consideration. Land acquisition should be considered at detailed design.
J11 Option B – slip on-line at junction	£800,000			✓ with embankment widening.		✓ Benefits are limited as existing queueing on the off-slip extends onto the M11 in peak periods (see Section 5.2).		✓				✓	Land acquisition should be considered at detailed design. Enforcement and signage of bus-only lane needs further consideration. Option to make bus lane all vehicle access to Park & Ride.

Option	Cost	Can it be constructed?			Does it offer journey time savings to buses?			Does it adversely impact vehicular traffic?			Does it offer other/wider benefits?		Key risks and issues
		No	Yes (with mitigation)	Yes	No	Yes	Yes (and improved reliability)	No/ positive impact	Minor	Major	Yes	No	
J11 Option C – slip from agricultural bridge	£4.7-5.7 million		✓ new bridge required. Land take may be considerable.				✓ as buses are removed from the M11 off-slip prior to existing queues.	✓ positive due to removal of existing bus lane on A1309 leading to increased capacity and potential reduction in blocking back to M11.			✓ A bus stop could be provided in Trumpington Meadows development Direct access to P&R avoiding Hauxton Road Junction.		Considerable land acquisition may be required for this option. Enforcement and signage of bus-only lane needs further consideration.
J13 Option 1 – bus only lane – no signals	£150,000-425,000		✓ fits within existing carriageway. Minor improvement in journey time.		✓ improvement in journey time across the junction however buses remain in A1303 queues on approach.			✓			✓		Conflict of right turning traffic with bus lane (safety issue) – needs to be considered further in detailed design.

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Option	Cost	Can it be constructed?			Does it offer journey time savings to buses?			Does it adversely impact vehicular traffic?			Does it offer other/wider benefits?		Key risks and issues
		No	Yes (with mitigation)	Yes	No	Yes	Yes (and improved reliability)	No/ positive impact	Minor	Major	Yes	No	
J13 Option 2 – bus only lane with signals	£150,000-425,000		✓ widening provides no capacity benefit but may provide safety benefit.	✓ without widening.		✓		✓ widening provides no capacity benefit but may provide safety benefit.				✓	Existing lane width is substandard.
J13 Option 4 – new gyratory structure	£22-42 million		✓ New structure required across M11.			✓ eastbound buses are required further.		✓ potential to modify lane arrangement to improve conditions for particular movements at the junction.			✓ potential access to development and P&R site. Wider strategic benefits – fits with A428 Cambridge City Deal Study.		Modifications to P&R junction may be required Strategic assessment required due to potential to change strategic movement across the City. Land Acquisition Cycle and Pedestrian Routes would need further consideration in detailed design.

Option	Cost	Can it be constructed?			Does it offer journey time savings to buses?			Does it adversely impact vehicular traffic?			Does it offer other/wider benefits?		Key risks and issues
		No	Yes (with mitigation)	Yes	No	Yes	Yes (and improved reliability)	No/ positive impact	Minor	Major	Yes	No	
J13 Option 5 – bus only loop to the north of existing structure	£4.2-7.2 million	✓	✓ Bridge widening to 4 lanes may not be possible within existing structure. All services require diversion. New structure to support pedestrian and cycle movements may be required.				✓ eastbound buses are required to travel further however reliability is increased.	✓			✓ Potential stop for Cambridge North West Development and access to the P&R site.		Distance between bus and traffic slips may lead to safety concerns and requires consideration at detailed design. Structural assessment of bridge required Secondary structure for pedestrians and/or cyclists and stairs relocation likely to be required.

8. Summary and Conclusions

8.1. Summary

Atkins were commissioned by CCC to produce an initial and high-level appraisal of the technical implications and costs of creating bus-only slip roads:

- 1) At M11 Junction 13: when turning off the A1303 (going east) onto the M11 (going south);
- 2) At M11 Junction 13: creating a bus lane alongside the existing slip road off the M11, which would get priority treatment at the traffic lights; and
- 3) At M11 Junction 11: turning off the M11 (going south) between the existing farm and footbridge and the existing slip-road, then going round the corner of the farmland at Trumpington Meadows, running parallel to (and west of) Trumpington Road, and entering the Trumpington Road Park and Ride thence joining up to the Guided Busway.

The aim of this report is to inform a report to the October cycle of City Deal Joint Assembly and City Deal Executive Board meetings.

8.1.1. Initial Options Review

The assessment commenced with a review of the potential options to provide bus-only slip roads at each of the junctions. A workshop attended by CCC and Atkins designers, traffic modellers and bridge engineers identified any options which were not considered workable and these options were not progressed to the next stage of the assessment. The initial option review generated 3 options for Junction 11 and 4 options for Junction 13 which were considered suitable for further assessment in the option assessment stage.

8.1.2. Option Development and Assessment

Option development and assessment followed an iterative process with bridge review, highway design and traffic modelling being undertaken simultaneously. This allowed each aspect to be informed by the others, for example the traffic modelling identified that a certain lane arrangement maximised the performance of the option, therefore this could be fed into the option design.

8.1.3. Option Costing

All options considered within the option development and assessment stage were the subject of a high-level assessment of the cost of implementation. A provisional cost has been prepared based on feasibility drawings and derived from the latest competitive rates taken from Atkins' records to indicate an outline cost for the proposed works.

8.1.4. Option Review

Option review was undertaken at an internal meeting on 13th August, involving bridge engineers, highway designers and traffic modellers. The aim of the option review was to identify the benefits and constraints of each of the options. The option review does not measure the relative performance of each of the options in comparison to the others.

8.2. Conclusions

This report has identified that a number of options are available to provide bus-only slip roads at Junctions 11 and 13 of the M11. Costings and concept designs have been provided for each option.

8.2.1. Junction 11

The provision of a bus-only slip road at the existing M11 southbound off-slip (Option A and Option B) is technically feasible within DMRB design standards, at a relatively low cost. However the existing junction experiences queuing on approach to the M11 off-slip during peak periods and the provision of a dedicated bus-only slip road in this location could offer limited journey time savings for buses as they would be subject to any existing traffic queues on approach to the junction.

The provision of a bus-only slip road exiting the M11 prior to the agricultural bridge is considered outside the scope of the initial recommendations of this report. However this option was progressed as it would be the only way to provide a segregated bus-only slip road which commenced before existing traffic queues at the

junction (a similar option could not be provided to the south of the bridge as it would not meet DMRB design standards). It would be a relatively expensive scheme to construct, however this option would provide better journey time reliability and improved journey times for buses as they would leave the M11 prior to any traffic queues on approach to the junction.

In summary, minor modifications to the existing layout of Junction 11 of the M11 to provide bus-only slip roads could offer small improvements to journey times for buses. This is based on a number of assumptions and as the report provides a high-level of assessment a number of further assessments would be required to provide certainty. In order to provide greater benefits to journey times and reliability the bus-only slip is required to leave the M11 before the location of the existing agricultural bridge to the north of the junction bypassing existing traffic queues on the M11 on approach to Junction 11, which is a relatively high cost option.

8.2.2. Junction 13

Modifications to the existing arrangement across the bridge at M11 Junction 13 (Options 1 and 2) would provide a small improvement to journey times for buses, allowing them to turn right onto the M11 ahead of vehicular traffic. These options could be implemented at relatively low cost. However buses approaching the junction would still be subject to existing queueing on approach, particularly on the M11 off-slip and A1309 (although a bus lane is provided for 300m on approach to the junction). The journey time benefit crossing the bridge is considered to be minimal compared to the time spent in these existing queues, which would not be reduced under Option A or Option B.

The provision of a gyratory system with a new bridge structure at the junction (Option 4) has the potential to offer improvements to buses in terms of journey time savings and increased reliability. A gyratory system also offers flexibility for the future of the junction as new junction arms could be added in the future if required. It could also offer the potential to benefit vehicular traffic, depending on the junction layout used. However this option would be very costly to implement and any benefit may be limited due to the operational performance of existing adjacent junctions.

The provision of a bus-only loop to the north of Junction 13 to bring buses from the Madingley Road Bridge south onto the M11 prior to general traffic joining would improve journey times for buses, despite the increased travel distance provided by the bus-only loop. However this option would be very costly to implement and further detailed assessment would be required on the safety of buses merging onto the M11.

In summary, minor modifications to the existing layout of Junction 13 of the M11 to provide bus priority across the existing bridge structure would offer limited journey time savings for buses. Major interventions in the form of a new gyratory or bus-only loop at the junction have the potential to offer greater journey time savings and/or increased reliability for buses, however may be limited in their benefit by the performance of the adjacent sections of the road network. They would also offer greater flexibility for future growth, however these options would be costly to construct.

Appendix A. Examples of Existing Schemes

A.1. Luton Airport

DRAFT

A.2. Heathrow Spur

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A.3. M606 Bradford

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A.4. Brian Clough Way, Nottingham

DRAFT

Appendix B. Utilities Searches Report

DRAFT

Appendix C. Initial Option Plans

DRAFT

Appendix D. Bridge Assessment Technical Note

DRAFT

Appendix E. High-level Drawings

DRAFT

Appendix F. Design Process Note

DRAFT

Appendix G. Modelling Technical Note

DRAFT

Appendix H. Traffic Flow Analysis

DRAFT

Appendix I. Costings Summary

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