West of England Combined Authority

Mass Transit (Future4WEST)

Strategic Outline Case Addendum: Early Stage Value Engineering

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1 Introduction

1.1 Background

1.1.1. The Strategic Outline Case (SOC) for the Mass Transit programme has been prepared on behalf of the West of England Combined Authority (the Combined Authority). Within the West of England region, Mass Transit is part of a long-term ambition to inform and deliver multi-modal transport options under the banner of Future4WEST. Throughout the business case and supporting documents, the proposed scheme will be referred to as the Mass Transit programme or ‘the proposed scheme’.

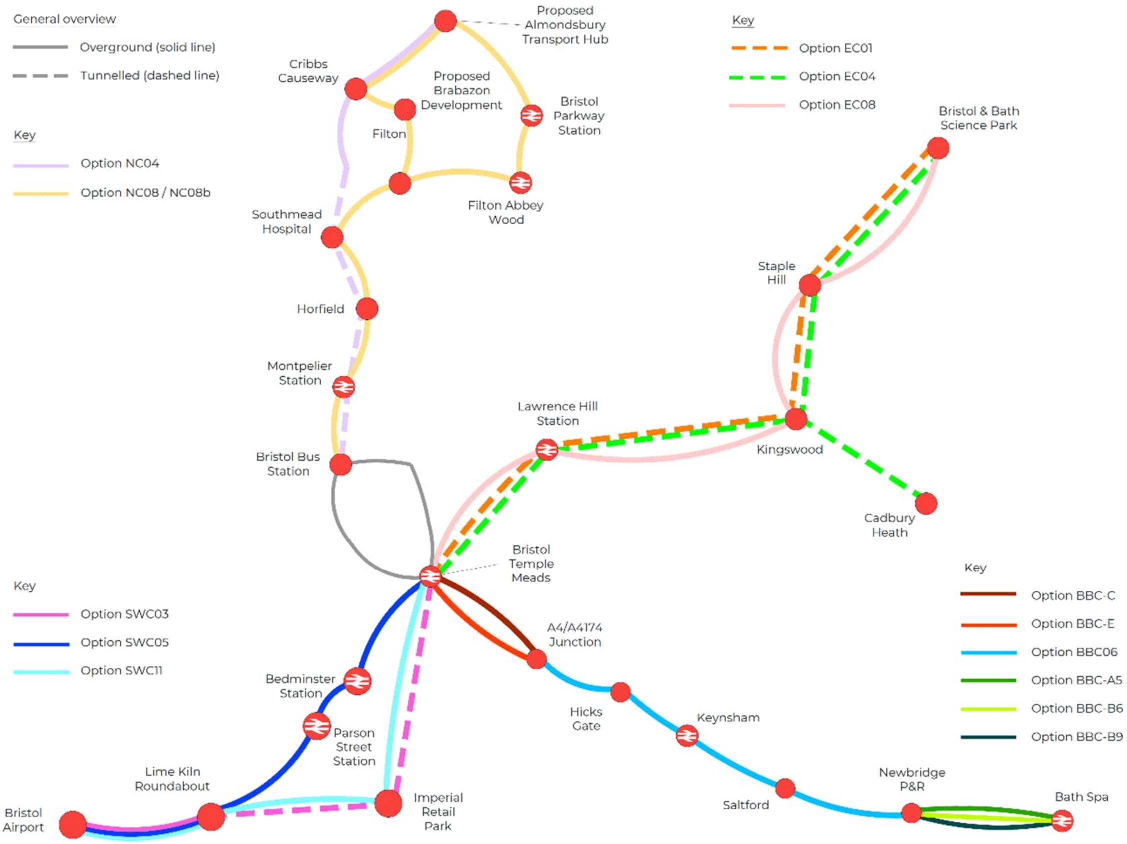
1.1.2. The SOC builds on information in the Option Assessment Report (70069287-WSP-BCA-0010, OAR). It demonstrates that the proposed scheme is based on analysis of the current situation, a clear vision of how things should be in the future, a careful consideration of the options (as presented in the OAR), a robust appraisal of costs and benefits, and a clear plan for delivering the scheme.

1.1.3. The proposed Mass Transit scheme will be a programme of works to deliver a transformational public transport network across four corridors in the West of England, which are linked within Bristol City Centre:

- North Corridor (Bristol City Centre - Proposed Almondsbury Transport Hub)
- East Corridor (Bristol City Centre - Bristol & Bath Science Park)
- Bristol - Bath Corridor (Bristol City Centre - Bath Spa railway station)
- South-West Corridor (Bristol City Centre - Bristol Airport)

1.1.4. The shortlisted corridor options are shown in Figure 1-1. It is expected that the corridors will be phased into a number of work packages, accompanied by first-mile, last-mile measures, each of which will contribute to the improvement of the network as a whole.

Figure 1-1 - Shortlisted Mass Transit Options



1.1.5. The SOC option definition was based on a fully segregated, 3.2m-wide corridor in each direction, which allows the proposed mass transit system to run separated from general traffic, frequently and reliably. Both tunnelled and overground solutions have been explored across four possible modes, broken down into two broad categories:

- Rubber-wheeled solutions: Bus Rapid Transit, Trackless Light Transit
- Steel-wheeled solutions: Very Light Rail, Light Rail Transit

1.1.6. In order to provide a fully segregated solution, various approaches were considered including running underground in tunnels, sections of cut and cover and restrictions to highway capacity or operation. These approaches formed a range of 13 measures, requiring varying overall highway corridor widths and compromises to implement. Each route was reviewed in detail throughout, and an arrangement applied which best suited the constraints on similar sections. The Feasibility Design Summary Report (70069287-WSP-HWY-0003) sets out the approach to the feasibility design and the resultant specification of each option.

1.1.7. The outcome of the SOC was that the proposed Mass Transit scheme is closely aligned with national, regional and local policies and plans, contributing to shared goals of decarbonisation and levelling up pockets of regional deprivation. The scheme is designed to provide a step-change in public transport connectivity in the West of England, shifting users away from private car use, which is currently dominating the region, and onto a combination of attractive and convenient public transport and first-mile, last-mile active travel solutions that link housing and employment opportunities.

1.1.8. However, based on its current scope and available modelling framework, the core appraisal undertaken as part of the SOC suggested that a fully segregated version of the scheme with current demand offers very poor to poor VfM. The appraisal of the scheme demonstrates the challenges associated with delivering a fully segregated system in a constrained urban area. Although all options deliver against the objective of journey time benefits for public transport users, for the options that are predominantly overground the level of impact on the highway network is substantial. For options with a tunnelling component, however, there are significant associated capital costs and generating benefits of the same magnitude is difficult.

1.1.9. Sensitivity tests undertaken as part of the SOC appraisal show that there is the potential for an overground Mass Transit network to deliver medium value for money based on only the monetised impacts. This is achieved under a scenario where there is high demand and the impacts on remaining highway users are not considered in the monetised appraisal. This test is suggestive of the fact that the ways in which people travel are likely to change significantly in the coming years with further policy measures to reduce the use of private car and increase sustainable travel modes. These measures would form part of wider demand management strategies across the region, and will be considered at future stages of the project.

1.1.10. High-level analysis of potential wider economic impacts shows that, were a viable solution for both public transport and highway users to be implemented, sizeable productivity and land value benefits could arise from the successful delivery of a mass transit system. The VfM for the overground networks could increase to high, were these benefits to be realised. Due to the costs associated with delivering an underground network, there is limited change in the associated VfM, even with a substantial increase in the benefits generated. These impacts demonstrate the potential scale of benefits that a mass transit solution could offer, more detailed analysis is required as the scheme develops to understand the level of benefits attributable to the specific scope of the West of England scheme.

1.1.11. One of the key findings of the core SOC appraisal was that whilst the scheme demonstrated a strong strategic fit, there was a need to consider the scope and packaging of the programme and further option development and value engineering to seek to better balance the benefits and the costs of the scheme.

1.1.12. A methodology has therefore been developed that sets out the proposed process to value engineering. This included two core components:

- Demand and benefits
  - Re-baselining: Considering the impact of using the West of England Regional Transport Model (WERTM) as opposed to GBATS/G-BATH

- Demand levers: Exploring the key demand levers and how they could be used to increase the ridership and benefits of the system

- Design
  - Identifying key concepts to reduce the scheme costs this could include level of segregation from general traffic, modal options of Mass Transit, reduce underground extents, reduce cut and cover extents or re-route the associated active travel corridors

1.1.13. Whilst this process has not been implemented fully at this stage, some early-stage high-level analysis has been undertaken to demonstrate the potential changes in costs and benefits as a result of value engineering of options. This is an early test of the future process of value engineering, there will be other locations and approaches tested beyond those considered within this early-stage analysis. This is standard practice in option development and indicates the direction of travel between SOC and Outline Business Case (OBC), with the full value engineering methodology being applied to refine options as the scheme progresses.

1.1.14. This Addendum to the SOC sets out the approach, conclusions and next steps of these early-stage value engineering considerations.

1.2 Option amendments

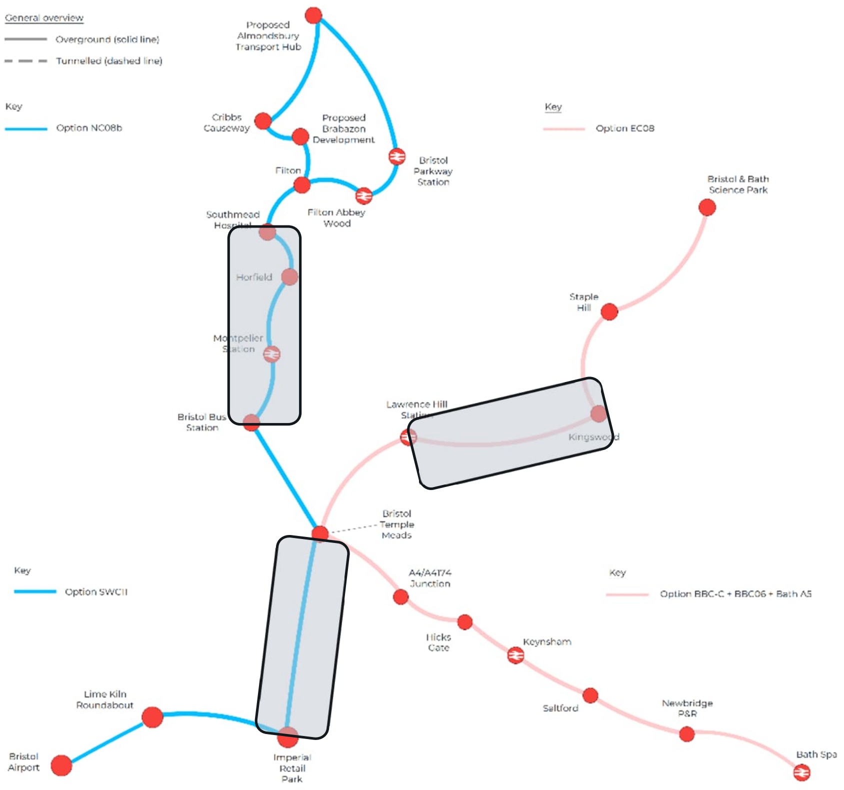
1.2.1. As the SOC identified, there is a need to balance the costs of the scheme with the constraints when running above ground. The early value engineering analysis has been centred around these factors, noting this exercise acts as a test of the future process of value engineering where other locations and/or approaches will be tested. The following corridor options, which formed the overground network, have been considered:

- NC08b
- EC08
- SWC11
- BBC

1.2.2. These options did not include significant tunnelled sections within the SOC designs, resulting in high levels of impact on the highway network, which currently exceeds the benefits to public transport users. The early-stage value engineering workstream has considered the impacts of introducing tunnelling for these options, but to a lesser degree than the options on each corridor which are already tunnelled for all or part of their length. There have been no amendments to the option on the Bristol – Bath Corridor because there is no shortlisted option including tunnelled elements on this corridor. The sections identified for tunnelling are those that are most constrained due to development density and available highways width. The impacts have been considered both in terms of costs and transport user impacts.

1.2.3. Figure 1-2 below shows the sections of the current options that have been assumed to be tunnelled as part of the value engineering exercise (grey shading); the remainder of each option would be as defined in the SOC and OAR.

Figure 1-2 - Early-stage value engineering option amendments



1.2.4. Table 1-1 shows the overall length of each option as well as the tunnelled lengths for each of these options compared to the SOC assumptions.

Table 1-1 – Option tunnelled lengths

Option	Total length (SOC)	Tunnelled length (SOC)	Tunnelled length (value engineering)
NC08b	20.50km	0.70km (cut and cover)	3.50km
EC08	10.50km	0.00km	4.25km
SWC11	15.50km	0.00km	2.50km
BBC	15.50km	0.00km	0.00km

1.3 Approach to analysis

1.3.1. The analysis undertaken at this stage is intentionally high-level to show the potential scale of impact that the future value engineering exercise could have. The indicators that have been considered include:

- Design: what do the amendments mean in terms of tunnelled lengths, stations and portals?
- Capital cost: what is the impact of the additional tunnelled sections on the capital costs of the scheme?
- Transport impacts: what is the impact of the additional tunnelled sections on the demand and benefits for public transport users and impacts on remaining highway users?

1.3.2. The subsequent chapters set out the approach undertaken and resultant outputs under each of these points. As there is no change to the option on the Bristol – Bath Corridor there are no results included for this in the following chapters.

2 Design considerations

2.1.1. The amendments to the options shown in Figure 1-2 have been considered against the approach to the design and specification of the options at SOC. To allow for comparison to the SOC conclusions the approach has been kept consistent with that of the SOC, with revisions to the specification of the option to reflect the addition of the tunnelled sections.

2.1.2. The following sections set out the assumed changes to the option designs to reflect the additional tunnelled sections shown in Figure 1-2.

2.2 Design detail

2.2.1. The level of design detail of overground and underground elements is aligned with that of the SOC. For sections of routes remaining as overground operation the design is the same as the SOC. Similarly, the principles and cross section of the tunnelled routes in the SOC have been applied to the amended underground elements, resulting in costs for a twin bore tunnel, 25m below ground level on these sections. This depth is based on a generalised assumption to be within the natural geology and to avoid building foundations and river deposits, and is consistent with the assumption within the SOC.

2.3 Tunnel length

2.3.1. The tunnelled lengths were intended to avoid the densest areas of development, areas of highest highway disbenefit and link potential portal locations. Therefore the designs considered as part of this addendum assumes the following lengths are delivered as three separate underground tunnels:

- North Corridor (3.5km long) – passing below the A38, Stokes Croft and most of Gloucester Road
- East Corridor (4.25km long) – passing below the A420, Lawrence Hill to Downend Road
- South-West Corridor (2.5km long) – passing below Totterdown and Knowle

2.4 Portal locations

2.4.1. The three tunnelled sections considered are assumed to transition to overground routes within Bristol City Centre and between the city centre and the end point of each corridor. For the SOC the underground network was assumed to continue through the city centre and so the portal locations were not considered in detail. Given the additional points of transition within the city centre, these locations have been considered at a high-level (not including design detail) to ensure proposals would not require significant additional tunnel length to provide a portal location that avoided building demolition. Indicative locations used as the tunnel extents are as follows:

- North Corridor – The Bear Pit and Horfield Common
- East Corridor – Lawrence Hill Roundabout and Kings Chase Shopping Centre (assumed redevelopment)

- South-West Corridor – Industrial land south of Mead Street and the northern extents of Walsh Avenue Field

2.5 Number of stations

2.5.1. Similar to the approach to scheme design, the baseline for station locations for each route has been the SOC overground route design. Through the revised tunnelled sections, the equivalent SOC underground route on each corridor has been reviewed, and the station locations from these assumed. The precise location of stations has not considered at this stage, in favour of the general principal of spacing along the route to inform costing. Station numbers for the amended options can be summarised as follows:

- NC08b – 21 overground ground stations, 4 underground stations
- EC08 – 7 overground ground stations, 3 underground stations
- SWC11 – 18 overground ground stations, 3 underground stations

2.5.2. As part of the SOC, all stations on these routes were classed as overground stations.

2.6 Other assumptions

2.6.1. In addition to the assumptions listed above, other key points to note regarding this high-level value engineering design are listed below:

- Active Travel – detail of overground requirements to accommodate end-to-end active travel connections alongside the tunnelled section of the route has not been considered at this stage
- Existing highway cross section – due to the coarseness of the design detail and traffic modelling at this early business case stage, impacts on the highway network have not included changes to existing features which increase junction capacity, such as right turn lanes. More detailed design is required to inform the scheme footprint and the resultant cost and network operation impacts of changes to these alignments

2.7 Next steps

2.7.1. Following the completion of the feasibility design to inform the SOC, there are a range of opportunities to revisit some of the constraints this design was produced within. These value engineering exercises can identify key concepts to reduce scheme cost and highlight the compromises in system performance required to achieve this.

2.7.2. The indicative amendments made to the SOC options demonstrate the type of potential refinements to options which would form part of value engineering. This shows the direction of travel between SOC and OBC, with more detailed value engineering methodology being applied to refine options as the scheme progresses to and into OBC.

2.7.3. The considerations of this detailed value engineering exercise could include the following:

- Segregation of Mass Transit from general traffic – transport modelling review to identify lengths of highway where the benefits of full segregation are minimal, the design can then be adjusted to reduce segregation through these sections and therefore reduce costs with minimal reduction to the operational model

- Mode/technology of Mass Transit – review the vehicle type, rubber or steel-wheeled, guided or unguided to enable the proposed cross sections to be refined
- Reduce cut and cover extents on overground options – relatively short cut and cover tunnelled sections on the overground routes increase costs. Shortening these sections further will reduce costs
- Re-route active travel corridor – the SOC typologies align the end-to-end active travel corridor with the Mass Transit route. Further study to review this assumption and look for more appropriate parallel routes would help to reduce the impacts of the proposals
- Parking review – The feasibility designs assumed that on street parking could be removed to provide space in the highway corridor for Mass Transit and active travel provision. A parking study of the corridors would consider existing parking arrangements and alternative parking opportunities to better understand the impact where on street parking may be removed
- Portal feasibility for tunnelled sections – portal locations to date are indicative. A review of the space necessary for portals, outlining the suitability and impacts of portals at specific locations will help to define tunnel lengths for consideration through OBC

3 Capital cost implications

3.1.1. This section sets out the potential cost impacts of the revisions to the SOC option on each corridor. Where appropriate comparisons are drawn with the most relevant option from the SOC.

3.2 Methodology

3.2.1. Analysis has been undertaken to provide insight into the potential capital cost implications of the amendments to the option designs discussed in Chapter 2.

3.2.2. For overground sections, the main elements of the cost estimate include items such as carriageway resurfacing, junction alternations, bridge alterations, new footway and cycleway construction.

3.2.3. For the tunnelled elements, the costs are comprised of all tunnelling construction activities, access shafts required for the construction, underground stations as well as the system requirements that may be needed. In terms of the breakdown of costs, the stations are the highest cost within the tunnel estimates, followed by the tunnelling works and then any systems requirements that are needed to operate the services.

3.2.4. In order to estimate the cost impact of the amendments shown in Figure 1-2 the following process has been followed:

- The SOC cost for each of the options formed the starting point for the cost estimate
- The costs of the new tunnelled lengths and stations have been calculated based on the methodology from the SOC and the refinements discussed in Chapter 2
- The costs of the overground sections have been updated to reflect the revised lengths and some overground stations being replaced by underground stations

3.2.5. The remainder of the cost assumptions, including the exclusions, are consistent with those set out in the Financial Dimension of the SOC to allow for comparison between results.

3.3 Cost implications

3.3.1. Table 3-1 shows the cost estimate for each of the corridor options shown in Figure 1-2. To show the scale of impact of the value engineering exercise on costs, the percentage change in cost compared to the comparable SOC options is also included.

3.3.2. The value engineered options show a decrease in capital cost in comparison to the equivalent SOC options on each corridor that included significant lengths of tunnelling, with a decrease of between 40–50% dependent on the corridor. The decrease in cost is a result of the reduction in tunnelling length and thereby also the number of underground stations required. As one of the most significant cost line items of the underground sections, the number of underground stations has a substantial bearing on the costs.

3.3.3. The costs included in Table 3-1 would clearly be a substantial increase compared to the costs associated with the overground options on each corridor with the introduction of tunnelling.

Table 3-1 – Initial value engineering capital cost implications (£m, nominal)

Corridor	Initial value engineered cost (rubber-wheeled)	Difference to comparable SOC options
NC08b (initial value engineered)	£2,884	40% reduction compared to NC04 426% increase compared to NC08b
EC08 (initial value engineered)	£2,319	51% reduction compared to EC01 979% increase compared to EC08
SWC11 (initial value engineered)	£2,158	50% reduction compared to SWC03 393% increase compared to SWC11

3.4 Impact of multiple tunnelled sections

3.4.1. If multiple tunnelled sections were to be implemented as opposed to a single continuous tunnel, this would incur the costs for the mobilisation of any tunnel boring machine(s) and the setup of the area for the siting of the portals acting as the exit and entry points for the machine. This additional establishment cost would not be incurred should a continuous tunnel option be utilised.

3.4.2. Traffic management would have to be considered as an additional cost should multiple tunnels be required and due to the nature of the transition to above ground being within Bristol City Centre, the requirements and coordination of this traffic management will be fairly complex in nature. A continuous tunnel would not need this level of traffic management within the city centre, apart from areas where ventilation shafts are to be constructed that will impact areas at surface level.

3.4.3. Consideration would also have to be given to the movement to the tunnel boring machine(s) between sites. This would require extensive planning and coordination to minimise the impact on businesses and stakeholders.

3.5 Next steps

3.5.1. There is a clear link between the design value engineering next steps and the resultant impact on the scheme costs. However, in addition to these design related cost adjustments there are also avenues for consideration in terms of reducing the cost rates themselves during a full value engineering process, including:

- A significant proportion of the costs of delivering the above ground sections is the need for resurfacing of the existing infrastructure; it could be explored whether it is feasible to utilise existing areas of surfacing that are fit for purpose and do not need to be amended
- Consider the number of underground stations required and if there is an opportunity to bring any of these above ground, although it is noted that this could impact on the catchment areas and should be considered alongside the next steps for demand and benefits discussed in the following chapter
- Consider the delivery and construction profile in more detail and revisit inflation assumptions to reflect the latest position
- Increase understanding of project risks and the impact of this on the risk allowance included in the scheme costs
- More detailed consideration of the wider costs of delivery including utilities, preliminaries, professional fees. Currently these are based on industry standard benchmarks which are appropriate for a scheme of this nature at this stage of development.

4 Transport impacts

4.1.1. Value engineering will involve balance between the changes in costs and the impact on the performance of the system. This initial value engineering analysis has therefore considered the impact on demand (and benefits) for Mass Transit and the wider impact on remaining highway users, as well as the cost implications.

4.2 Future4WEST demand and benefits

Demand

Methodology

4.2.1. To understand the potential implications of the amendments to the options on demand, the SOC methodology has been used with appropriate adjustments to the options to reflect the changes to the tunnelled and overground operation.

4.2.2. The catchment-based spreadsheet developed for the SOC assumed a catchment area around each of the route options, with the likelihood of people within this catchment area then choosing to use Mass Transit based on a comparison of journey times for car, other public transport and Mass Transit. Within the SOC appraisal the options that were predominantly overground were assumed to have a 500m catchment and those with a tunnelled section beyond small sections of cut and cover were assumed to have a catchment area of 750m.

4.2.3. Within the SOC the routes that form the amended option shown in Figure 1-2 were considered to have a 500m catchment as they didn’t include elements of substantial tunnelling. As part of the value engineering exercise for the amended option, this catchment area has been extended to 750m, which reflects the improved perception of a partial underground network.

4.2.4. Whilst the travel times have the potential to be shorter under the value engineered option where sections of the alignment travel underground, the journey times assumed in the catchment-based spreadsheet remain unchanged from the SOC. More detailed assessment of impacts on speeds and journey times of changes to operation of Mass Transit will be undertaken as part of the full value engineering stage.

4.2.5. The remainder of the operating assumptions including frequency of service and fares remain as per the SOC appraisal.

Results

4.2.6. Table 4-1 shows the estimated 2036 daily and annual Mass Transit demand for each of the options based on the SOC appraisal and the value engineering amendments.

Table 4-1 - Daily and annual demand estimates (2036, pre-application of ramp up)

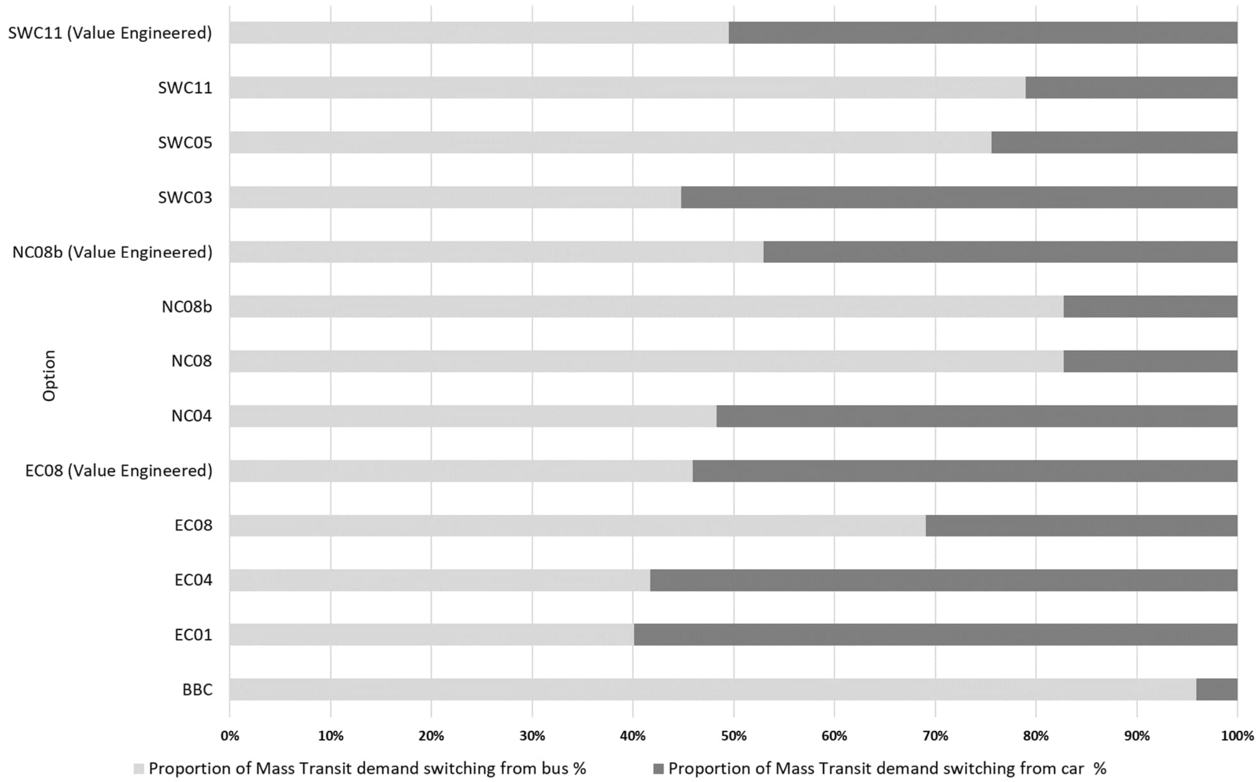
Daily	Station catchment area	Daily demand	Annual demand (m)
North Corridor			
NC04	750m	49,192	16.3
NC08/NC08b	500m	35,764	11.8
NC08b (initial value engineered)	750m	55,874	18.5
East Corridor			
EC01	750m	20,951	6.9
EC04	750m	31,396	10.4
EC08	500m	11,403	3.8
EC08 (initial value engineered)	750m	17,135	5.7
South-West Corridor			
SWC03	750m	19,320	6.4
SWC05	500m	11,979	4.0
SWC11	500m	10,354	3.4
SWC11 (initial value engineered)	750m	16,526	5.5

4.2.7. Where the catchment has been widened it leads to a large increase in estimated demand for that particular corridor. NC08b on the North Corridor shows almost a 60% increase in annual demand from 11.8 million to 18.5 million when the amendments shown in Figure 1-2 are implemented. Similar trends are observed in the East Corridor where the annual demand has increased for EC08 from 3.8 million to 5.7 million (50% increase) and on the South-West Corridor SWC11 has increased from 3.4 million to 5.5 million (62% increase).

4.2.8. Combining the four corridors into a single network, the amended option based on the value engineering exercise increases the demand for Mass Transit by 50% compared to the overground networks from the SOC. The Mass Transit demand for the amended option is 4% lower than the demand estimate for the underground network from the SOC, this difference reflects the demand response to the reduced journey times.

4.2.9. Figure 4-1 shows the proportion of Mass Transit demand that has switched from each mode for each option. For options with substantial tunnelled sections the proportions of demand that have transferred from bus and car are more even. This is largely due to two factors, for these options a wider catchment area of 750m was used meaning a larger potential market for Mass Transit, and secondly the journey speeds are higher for options including tunnelling meaning journey times are more competitive with private car encouraging more modal shift. The value engineered options follow a more similar pattern to the SOC options with substantial tunnelled elements.

Figure 4-1 - Mass Transit demand switch from other modes



Wider demand considerations

4.2.10. The Mass Transit scheme would include a package of measures including active mode provision and first-mile, last-mile connectivity to provide for end-to-end journeys. These measures are not included specifically within the demand and benefits assessment to date. There is the potential that these measures would increase the catchment areas of the Mass Transit system, and therefore it would become a viable option for more people.

4.2.11. Passenger surveys on existing mass transit systems in the UK have found that the following proportions of passengers walk or cycle to access the system:

- Manchester Metrolink: 82%
- Sheffield Supertram: 75%
- West Midland Metro: 57%
- Blackpool Transport: 84%

4.2.12. There is a range of literature considering the distance travelled to access different forms of transport. London's Public Transport Access Level (PTAL) guidance[1] reflects the idea of people being willing to walk further for some modes than others:

- People will walk up to 640 metres (approximately 8 minutes) to a bus service
- People will walk up to 960 metres (12 minutes) to a rail or Tube service

4.2.13. This suggests that with provision of first-mile, last-mile infrastructure the potential demand catchment areas for the Mass Transit system could expand and this could increase the patronage levels and the benefits generated by the system.

Journey time impacts

Methodology

4.2.14. Public transport travel time impacts have been assessed using outputs from the catchment-based spreadsheet tool and using economic parameters from the TAG Data Book. The approach is consistent with that used within the SOC and documented within the Demand Forecasting Report (70069287-WSP-BCA-0013).

Results

4.2.15. The journey time impacts for each of the options based on the SOC appraisal and the value engineering amendments are presented in Table 4-2. On the North Corridor the addition of the tunnelled section to NC08b increases the journey time benefits to public transport users by 29% over the appraisal period. Similarly on the East Corridor the journey time benefits increase by 26% for EC08, and on the South-West Corridor by 32% for SWC11. It is noted that these results do not include amendments to the assumed run times for the services as a result of the additional tunnelled sections, this is likely to increase the benefits of the value engineered options further.

4.2.16. The journey time benefits of the value engineered options remain lower than for the options including substantial tunnelling on each corridor. This is due to the assumption of increased journey speeds for these options.

Table 4-2 - Journey time impacts for public transport users (£m, 2010 PV over appraisal period)

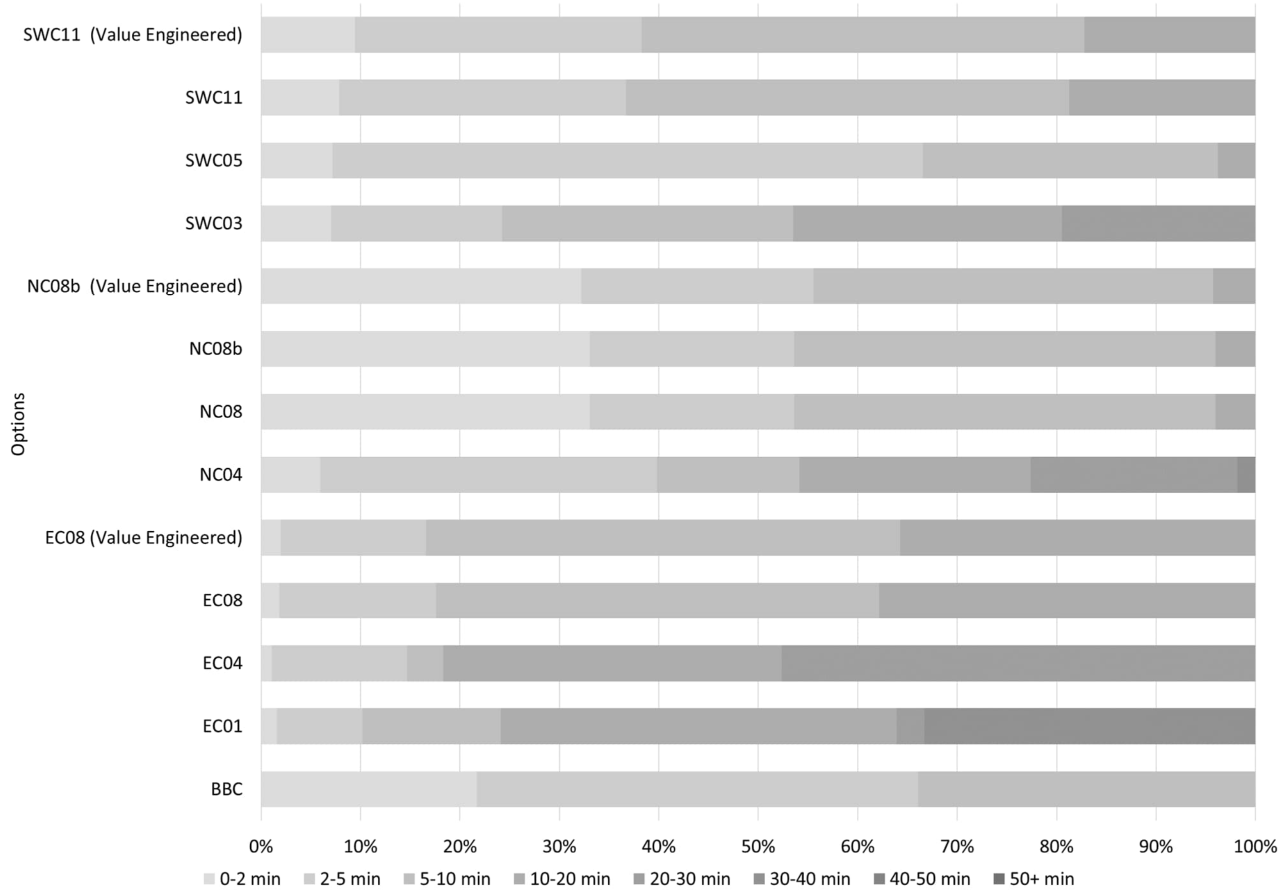
Option	Public transport journey time impacts
North Corridor	
NC04	283

[1] Assessing transport connectivity in London, TfL, 2015

Option	Public transport journey time impacts
NC08/NC08b	115
NC08b (initial value engineered)	148
East Corridor	
EC01	197
EC04	195
EC08	72
EC08 (initial value engineered)	91
South-West Corridor	
SWC03	117
SWC05	38
SWC11	38
SWC11 (initial value engineered)	50

4.2.17. Figure 4-2 shows a breakdown of the demand for each option by the level of journey time saving.

Figure 4-2 - Proportion of Mass Transit demand by journey time saving band



4.2.18. The figure shows that the levels of demand by time saving for the initial value engineered options are largely consistent with the overground equivalents on each corridor. This is due to the assumption of journey times remaining unchanged from the SOC, even those these options now involve a substantial length of tunnelling. If the journey time were amended to reflect the tunnelled sections it is likely that the distribution of demand by time savings would mirror more the existing options with underground elements on each corridor.

Next steps

4.2.19. The analysis has identified several important trends that could be explored through more detailed value engineering exercises. The points for further consideration include:

- The success of Mass Transit will be highly dependent on the demand catchment area and the perception of the scheme. Therefore, further work to understand how these can be influenced are likely to be important to the success of the scheme. In particular, public engagement and work on first-mile, last-mile options are likely to be valuable.
- Current demand and benefits analysis has assumed no change to the underlying public transport network as a result of the introduction of the mass transit system. In reality there is likely to be some rationalisation of services to provide an efficient and effective transport system.

- The current analysis has not included any change to the journey times as a result of the amendments to options, this should be implemented to understand the full impact of the changes
- Understanding the key demand levers and how these could be used to maximise usage of the Mass Transit system, including public transport fares, frequency, interchange, stop locations, parking charges and availability.
- The demand analysis and public transport user benefits have been modelled using a catchment-based spreadsheet. This method was proportionate and used the best available tools at the time that the SOC was undertaken. Future demand modelling at the OBC stage will be undertaken using WERTM. This change of approach is likely to yield different forecast results which could change some of the conclusions of the SOC. To facilitate understanding of the potential change it is proposed to undertake interim testing between SOC and OBC. This would test how the model behaves under a central scenario and an optimistic scenario which takes into account guidance relating to certain Common Analytical Scenarios (e.g. behavioural change), regional policy changes (e.g. parking constraint), customer perception and first-mile, last-mile changes.

4.3 Highway impacts

Methodology

4.3.1. Within the SOC appraisal the GBATS and G-BATH models have been used to calculate journey time changes to highway users as a result of the options. The DfT's Transport User Benefit Appraisal (TUBA) software was then used to calculate, and monetise, the time impacts for highway users. The coding within GBATS and G-BATH of each of the options in Figure 1-2 was revisited as part of the value engineering exercise. The amended options involve converting sections of the overground operation into tunnelled sections. The assumption applied within the highway model at SOC was that tunnelled sections will not impact the operation of the highway network at surface level. Therefore, the coding from the initial SOC option testing was removed from the sections identified to be converted into a tunnel. Table 4-3 below sets out how the amendments to the options impact the highway model coding.

Table 4-3 - Highway assignment model scenarios

Option	SOC model coding	Initial value engineering amendments
NC08b	Removed existing bus lanes and closed the road to through traffic on south of Gloucester Road.	The section along Gloucester Road between the Bearpit junction and the B4468 Muller Road junction is to be converted into a tunnel and has been assumed to not change the surface level transport network from the existing layout. The scheme

Option	SOC model coding	Initial value engineering amendments
		north of this section will remain as what has been coded in the NC08b option as part of the SOC appraisal.
EC08	Changed stretch on A421 between Chalks Road/A420/Blackswarth Road junction and A420/A431 junction to one-way in the eastbound direction.	The tunnelled section replaces the overground section completely. It has been assumed that there is no impact on the highway network.
SWC11	One-way for general traffic (except buses) on Salcombe Road in the northbound direction, and on Ravenhill Road in the southbound direction.	The tunnelled section replaces the overground section completely. It has been assumed that there is no impact on the highway network.

4.3.2. From the assumptions listed in the table above only the North Corridor option (N08b) required being re-run in GBATS and G-BATH. For the options on the East Corridor (EC08) and South-West Corridor (SWC11), the revised tunnelled sections encompass the areas where previously there were restrictions or reductions in capacity on the highway network coded into the GBATS model. Therefore these options are now assumed to have no adverse impact on the highway network.

4.3.3. The SOC modelling framework does not consider variable demand, therefore the modal shift to Mass Transit has not been reflected within the highway modelling. The same number of highway users are assumed in the with and without scheme scenarios.

4.3.4. The Traffic Forecasting Report (70069287-WSP-TPM-007) provides further detail of the approach to highway modelling as part of the SOC appraisal.

Journey time impacts

4.3.5. The economic benefits have been appraised using the same method as applied for the initial SOC modelling. The 2036 model year has been extracted from the TUBA results.

4.3.6. Table 4-4 below shows a comparison of the highway user journey time impacts for the SOC options and the value engineered options. The impact of the value engineering options can be seen by considering the comparable overground options from the SOC.

4.3.7. As the options on the East and South-West corridors are now assumed to have no impact on the highway network this removes the current disbenefits within the SOC appraisal results. For the North Corridor the addition of the tunnelled section removes the need for significant restrictions on the southern section of Gloucester Road. The amendments to NC08b are showing a benefit to highway users as a result of the scheme, this is caused by model noise with minor changes further north within the Cribbs Causeway area causing reassignment. The scale of this benefit/model noise is relatively small.

4.3.8. At an overall network level, the amendments made to the options reduces the overall transport user highway impact in 2036 by 51% compared to the SOC overground network.

Table 4-4 – Journey time impacts for highway users (£m, 2010 PV in 2036 (single year))

Corridor	Highway journey time impacts	Difference to comparable SOC options
NC08b (initial value engineered)	0.8	Pre-value engineering NC08b had -£3m (2010 PV) highway disbenefits in 2036
EC08 (initial value engineered)	-	Removal of all EC08 highway disbenefits
SWC11 (initial value engineered)	-	Removal of all SWC11 highway disbenefits

Next steps

4.3.9. Consideration of the impacts on the highway network will be an important factor feeding into the design elements of the value engineering. The following avenues will be explored as part of the full value engineering exercise:

- Further identification of pinch points on each of the corridors and detailed consideration of the most effective way to overcome these, tying this in with the areas where providing segregation for Mass Transit is most beneficial for public transport users
- Consider in further detail the impacts of tunnelling at surface level to ensure this is captured
- As discussed in Chapter 2, impacts on the highway network have not included changes to existing features which increase junction capacity, such as right turn lanes. This will be considered going forwards to inform the scheme design
- Consider Mass Transit within a wider package of measures which may impact on highway usage including demand management, parking strategies and longer term growth profiles due to behavioural change
- Consider wider mitigation measures to the highway network to alleviate the impacts of the Mass Transit operation
- The next steps above will need to be considered carefully as the project transitions from the methodology used at SOC to the methodology to WERTM. Consideration should be given to collection of additional data so that current and future highway network performance can be better understood

Summary

4.3.10. One of the key findings of the core SOC appraisal was that whilst the scheme demonstrated a strong strategic fit, there was a need to consider the scope and packaging of the programme and further option development and value engineering to seek to better balance the benefits and the costs of the scheme. A process for detailed value engineering has been set out, proposing to consider the key demand levers alongside amendments to scheme designs which could impact on costs and also the operational performance of the options.

4.3.11. Whilst this process has not been implemented fully at this stage, some early-stage high-level analysis has been undertaken to demonstrate the potential changes in costs and benefits as a result of value engineering of options. This is an early test of the future process of value engineering, there will be other locations and approaches tested beyond those considered within this early-stage analysis. This is standard practice in option development and indicates the direction of travel between SOC and Outline Business Case (OBC), with the full value engineering methodology being applied to refine options as the scheme progresses.

4.3.12. Sections of the overground options from the SOC that resulted in significant highway disbenefits were identified and have been assumed to run underground on these stretches. The impact of this on costs, demand and benefits for Mass Transit and resultant impacts for highway users has been considered at a high-level to show the potential scale of change of amendments such as this.

4.3.13. The high-level value engineering has identified the following:

- Including multiple sections of tunnelling will require consideration of locations of portals and whether stations are positioned above or below ground
- Including tunnelled sections increases the capital costs significantly compared to fully overground options, but reduces the capital costs by between 40-50% when comparing to options with more significant lengths of tunnelling
- There will be additional mobilisation costs associated with multiple tunnelled elements, as well as traffic management costs and consideration of moving any tunnel boring machine(s). The multiple tunnelled elements will mean these impacts will largely be within Bristol City Centre (with associated constraints)
- Passengers can be more willing to travel further to access a transport system such as rail or underground compared to bus. Therefore the demand catchment area may be greater for options which have substantial tunnelled elements, increasing the ridership on Mass Transit
- The daily demand for the Mass Transit system could increase by between 50-60% compared to the equivalent fully overground options as a result of the inclusion of tunnelled sections. The daily demand is ~4% lower than for the equivalent underground network

- The increase in demand could result in further journey time benefits associated with the system, these could increase further if the journey times were reflective of the additional underground sections
- The inclusion of tunnelled sections at key pinch points at surface level could reduce the adverse highway impacts on each corridor significantly, noting more detailed consideration of the surface level impacts of tunnelled sections should be considered going forwards

4.3.14. Overall, this early-stage analysis has demonstrated the potential benefits which undertaking value engineering will have. The indicative amendments to the options are seen to balance the challenges identified within the SOC between the costs of operating underground and the impacts at surface level of above ground operation. The analysis has shown the potential to reduce costs compared to a fuller tunnelled solution, increase the demand and benefits of an above ground solution and reduce the adverse impacts on the remaining highway network.

4.3.15. This analysis has shown the direction of travel which would be expected between SOC and OBC, with the full value engineering methodology being applied to refine options pre-OBC. For each of the design, cost and transport impact workstreams the next steps have been identified that will allow a more robust exercise to be undertaken to underpin the business case.

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