AtkinsRéalis

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Subject:	Comparison of Cost Estimate for Underground Metro (Stage 2)		

1. Summary

AtkinsRéalis completed a technical assurance review of the draft Strategic Outline Case (SOC) prepared for the Future4WEST project on behalf of the West of England Combined Authority (the Combined Authority) in May 2023. Future4WEST is a proposed Mass Transit network in West of England. Findings from the assurance review were captured in a Technical Assurance Report issued in the same month.

This technical memo documents a two-stage assessment carried out in August and September 2023 after the completion of technical assurance in May. The purpose of the assessment is to compare different scheme cost estimates for the underground network assumed for Future4WEST.

The questions to answer and headline findings from the investigation are summarised in this section, with details of the assessment and findings presented in the subsequent sections of this document.

What are the questions to answer?

The recent CECL[1] cost estimate for an underground solution for all four Future4WEST corridors is under £4 billion (£3.8 billion for single tunnel twin track, and £3.9 billion for twin tunnel single track).

This estimate is significantly lower than the existing Future4WEST Strategic Outline Case (SOC) estimate[2] for the underground network presented in the business case (i.e., £15.56 billion for rubber-wheeled and £18.34 billion for steel-wheeled options).

The questions to answer are 1) what is the cause of the substantial difference between the two estimates as the new estimate from CECL is only between 20% to 25% of the cost presented in the SOC?; and **2) is the lower estimate from CECL realistic** for the specification and scope of works upon which it was based?

These questions were explored in two stages. Firstly, an investigation was undertaken in stage 1 with a focus on the use of different price bases, and consideration of risk allowance and inflation assumptions. Secondly, cost benchmarking with a review of key assumptions and investigation on the scope of interventions costed was conducted. Due to the time constraints, the engineering feasibility of neither concept design was explored in this review.

Are the two sets of costs comparable?

The simple answer is No.

Firstly, the **two estimates were presented in different price bases and values**. The SOC estimate quoted above is based on nominal (inclusive of inflation) values, which may be interpreted as an estimate of how much the scheme delivery is going to cost following the delivery programme assumed. However, the CECL estimate is an indicative value based on current prices in 2023 only, which does not include inflation or other potential price increases in the future.

Secondly, they include **significantly different allowances for risk**. The SOC estimate includes a 40% risk allowance, whilst the CECL estimate carries only 10%. The appropriateness of risk allowance in the latter is explored further in this document.

Lastly, the **two sets of estimates are based on different scopes of underground tunnelling solutions**. The CECL assumed a 100% underground concept solution for all four F4W corridors with approximately

[1] CECL, Engineering, Innovation & 3D Visualisation, Colin Eddie Consulting
[2] Mass Transit (Future4WEST) Strategic Outline Case, Revision 3, January 2023

41km tunnelling, whilst the underground network costed in the SOC is based on a mix of underground and overground solutions with approximately 28km tunnelling.

Aligning assumptions on risk allowance and inflation with what is in the SOC estimate alone may increase the CECL estimate by about 80%, and this is before considering the realism of the base estimate which also highlighted potentially significant discrepancies.

Is the lower estimate realistic?

CECL's base estimate (before the consideration of risk allowance) is **significantly lower than industry benchmark values**. It is estimated that the Route 2 (North Corridor) tunnel cost per unit volume equates to £372/m^3, compared with an Infrastructure and Projects Authority's (IPA[3]) published benchmark[4] of £796/m^3 (both presented in 2023 prices). Judging by the cost per unit volume, the industry benchmark is well above 200% of the CECL value. It is also noted that the actual costs of some recent transport tunnelling projects in the UK are even higher than the IPA benchmark quoted.

The **CECL estimate is very optimistic in its low risk allowance** (10%) given the early stage of scheme development. The exclusion of inflation from the CECL estimate also risks misunderstanding the likely outturn cost associated with the works being estimated.

If the base costs were to significantly increase, the total outturn cost estimate with inflation and risk would increase by the same proportion leading to a far higher estimate.

The investigations documented in this note, and the published industry data **indicate that a very low level of confidence can be given to achieving a fully tunnelled solution at the cost estimated by CECL.**

What's next?

If the Combined Authority deems it appropriate following the review, next logical steps would be: 1) preparation of comparable estimate reflecting the CECL tunnelling proposals but reflecting industry practice; 2) A review of other elements of CECL's costs for the proposed solutions such as underground stations and systems; and 3) a review of the engineering feasibility of the CECL proposals.

In addition to investigation on the cost for underground solutions, it is also recommended to consider the value challenge and re-scoping exercise that was suggested after the first technical review in May 2023, which may not only reduce the cost by value-challenging the scope and specification of the Mass Transit network, but also identify schemes (both Mass Transit solutions and complementary measures) that are likely to result in a stronger Value for Money position.

2. Understanding the questions to answer

The SOC examined in this comparison is Revision 3 of the document issued in January 2023. Cost estimates for the underground network are reported in Table 4-1 and Table 4-2 of the SOC (page 136) for the rubber-wheeled and steel-wheeled options, respectively. These costs have been extracted from the SOC and summarised in Table 1.

Table 1 – SOC cost estimate for the underground network option for Future4WEST - £m, nominal

Option	Construction costs	Prep and admin	Base cost	Inflation	Risk	Vehicle Cost (BRT)	Total
Rubber-wheeled	6,629	1,301	7,930	4,440	3,172	18	**15,561**
Steel-wheeled	7,785	1,520	9,305	5,221	3,722	101	**18,340**

The breakdown by spending year of the same estimates has also been presented in Table 4-3 and Table 4-4 of the SOC (page 139) as summarised in Table 2 below.

[3] IPA is the government's centre of expertise for infrastructure and major projects, joint reporting to HM Treasury and the Cabinet Office.

[4] IPA's tunnelling cost benchmark was primarily based on data obtained for sixteen UK tunnels from both the transport and utilities sectors, in ground conditions ranging from soft rock to cohesive and non-cohesive soils. Construction methods included Tunnel Boring Machine (TBM), backhoe shield and excavator, with precast concrete or shotcrete linings. Benchmark values quoted in this document are specifically for transport projects.

Table 2 – SOC cost estimate for the underground network option for Future4WEST - £m, nominal

Year \ Option	Rubber-wheeled	Steel-wheeled	Year \ Option	Rubber-wheeled	Steel-wheeled
2022/23	12	14	2029/30	116	136
2023/24	22	26	2030/31	119	138
2024/25	22	26	2031/32	2,624	3,085
2025/26	23	27	2032/33	2,848	3,333
2026/27	34	40	2033/34	3,130	3,651
2027/28	111	129	2034/35	3,177	3,718
2028/29	113	132	2035/36	3,210	3,886
Total				**15,561**	**18,340**

The relevant tables in the SOC referenced suggest that the **cost estimate for the underground network is £15.56 billion for rubber-wheeled and £18.34 billion for steel-wheeled options**. The costs are presented in nominal values in the SOC. It is understood that a new SOC Revision 4 was prepared post the completion of Revision 3. The cost estimates have not changed in the new revision, so any numbers observed in this investigation remain the same.

The CECL estimate was extracted from a redacted version of its presentation[5] in August 2023 with commercially sensitive information removed. Separate cost estimates were presented by CECL for single tunnel twin track and twin tunnel single track options for the tunnelling work in each of the four routes proposed for Future4WEST, as shown on page 30 and 31 of the CECL presentation. **The combined costs in the CECL estimate range between £3.8 billion and £3.9 billion**. These were presented on page 33 of the CECL presentation as summarised in Table 3 below. A further and more detailed breakdown of the estimated costs for the Single Tunnel – Twin Track for Route 2 (North Corridor) was provided on page 29.

Table 3 – CECL cost estimate for the combined underground network

	Single Tunnel – Twin Track	Twin Tunnel – Single Track
Combined Construction (assuming four JVs)	£3,596,693,787	£3,752,146,756
Combined Design	£155,000,000	£160,000,000
Total	**£3,751,693,787**	**£3,912,146,756**

Although the two sets of estimates are not directly comparable (as found in subsequent investigation), the difference in the values presented is significant, with the new estimate from CECL being 20% to 25% of the costs presented in the SOC.

The questions to answer are 1) what is the cause of the substantial difference between the two estimates?; and **2) is the lower estimate from CECL realistic** for the specification and scope of works upon which it was based? Potential factors to consider include but are not limited to:

- Different price base and values in the presentation of monetary values.
- Varying assumptions on risk contingency and cost inflation over time.
- Scope of the works for which costs have been included within the estimates (or which have been specifically excluded).
- Scope and specification of the underground tunnel(s) assumed such as length and size.
- Different costing methodology or assumptions applied within the tunnel estimate(s), such as rates, quantity, shift pattern, drive rates and assumptions in respect of the disposal of excavated material, etc.

A two-staged investigation was completed. The first stage was conducted in August 2023 with a focus on the basic assumptions on price base of the monetary values presented and consideration of contingency and inflation, i.e., the first two bullets of the list above. The second stage was completed in September 2023, which explored the remainder of the above list based on information available.

This document outlines the analysis and findings from the investigation in both stages following the four steps outlined below. Only the capital costs of the proposed interventions were considered.

- Scope of interventions

[5] CECL tunnelling Presentation Final redacted content.pdf

- Base cost estimate
- Consideration of risk allowance
- Presentation of monetary values in the estimates

3. Investigate the scope of interventions

The first step of the investigation was to understand if both CECL and SOC estimates were based on broadly the same underground solutions.

Assumptions for the underground network in the SOC were extracted from the business case and presented in Table 4 below. It is clear that the underground network costed in the SOC is actually based on a mix of underground and overground solutions for different strategic corridors identified. The details on the City Centre network considered in the SOC underground network have not been confirmed in the SOC. However, the cost for the City Centre network is relatively modest as it is an overground solution. Its absence therefore does not materially impact the findings from the investigation.

Table 4 – SOC underground network scope by corridor

Corridor	Option	Description	Route Length in km	Over-ground Length in km	Under-ground Length in km	Nominal CAPEX (£m)	
						Rubber-wheeled	Steel-wheeled
North Corridor	NC04	Bristol Temple Meads to Southmead Hospital, Cribbs Causeway, Aztec West and Almondsbury Tunnelled section between Bristol Temple Meads and Filton	13.5	6.0	7.5	4,846	5,713
East Corridor	EC04	Bristol Temple Meads to Science Park via Staple Hill, with additional spur to Cadbury Heath Underground for full length	13.1	-	13.1	6,021	7,117
Bristol – Bath Corridor	BBC-C + BBC06 + A5	Bristol Temple Meads to Bath Spa via the A4 and A36 Utilises and builds on infrastructure delivered as part of BBSC	15.5	15.5	-	352	404
South-West Corridor	SWC03	Bristol Temple Meads to Bristol Airport via Imperial Retail Park and A38 Tunnelled section between Bristol Temple Meads and Highbridge Green junction	15.0	8.0	7.0	4,332	5,106
City Centre	Not reported		Not reported	-	Not reported	Not reported	Not reported
Total (excluding City Centre route)			57.1	29.5	27.6	15,551	18,340

In contrast to the SOC assumptions, CECL assumed a 100% underground solution for all four F4W corridors with 41.5km tunnelling, whilst the tunnels in the underground network costed in the SOC only total 27.6km. A comparison of the tunnel length assumed in CECL's and the SOC estimate is presented in Table 5 by corridor.

Table 5 – Comparison of CECL and SOC assumptions on tunnel length by corridor

Routes defined in CECL estimate	F4W Corridors in the SOC	CECL Tunnel Length (km)	SOC Tunnel Length (km)
1 - Airport	South-West Corridor	9.1	7.0
2 - North	North Corridor	14.2	7.5
3 - North East	East Corridor	10.6	13.1
4 - South East	Bristol – Bath Corridor	7.6	-
Total		41.5	27.6

The finding is that the **CECL and SOC estimates are based on quite different underground solutions** despite them both following a similar network vision of four strategic corridors. The length of tunnels assumed was found to be significantly different. There was not sufficient information to compare the size of the tunnels assumed, or to ascertain the engineering feasibility of either solution in the review.

This finding has significantly shaped the remainder of the investigation conducted in this review. As the two estimates are based on a different scope of intervention, for which only limited information was available, the question to answer in the remainder of the review has changed from fully understanding the difference in the two estimates to **ascertaining the realism of the CECL estimate against the specification and the scope of works for the solution that CECL assumed**.

The evolution in the question to answer has been reflected in the remainder of the review as documented in subsequent sections of this document. The SOC estimate and its relevant assumptions were only referenced where necessary to provide a fuller context.

4. Benchmarking the base cost estimate

Realism of the base cost in CECL's estimate was assessed initially by comparing with Infrastructure and Projects Authority's (IPA) published benchmark values. These values were obtained from IPA's published case study in benchmarking tunnelling costs and production rates in the UK[6]. This comparison and subsequent analysis were mainly focused on CECL's estimate for Route 2 (North Corridor) which is a single tunnel twin track option of 14,153m in length, as this is the only estimate with supporting inputs and assumptions made available.

Comparison with the IPA's benchmark values was based on the average tunnelling cost per km and per face area, which incorporated two primary drivers for tunnelling cost, i.e., tunnel length and size. This metric is effectively equivalent to the average cost per unit volume. Cost in £m per cubic metre was therefore selected.

It was found that CECL's Route 2 (North Corridor) tunnel base construction cost per unit volume for the single tunnel twin track option equates to £372/m^3 (without risk), compared with the industry benchmark of £796/m^3 derived from IPA's published case study. Both values quoted have been adjusted to 3rd Quarter 2023 prices so they are comparable using Tender Price indices published by the Building Cost Information Service (BCIS). Therefore, the **industry benchmark is well above 200% of the CECL's estimate** per unit volume. Further comparison was also carried out using benchmark cost data held within AtkinsRéalis' in-house cost database from which it is also noted that the actual outturn costs of some recent transport tunnelling projects in the UK are in fact higher than the IPA benchmark quoted.

Although a detailed breakdown was not provided, a high-level pro-rata exercise was also carried out against CECL's twin single track tunnel estimate for Route 2. This generated a higher cost per unit volume of £422/m^3 but this is still far lower than the IPA's benchmark.

Figure 1 illustrates the analysis underpinning the finding above. All four F2W strategic corridors have been approximately marked on the X-axis based on their tunnel length assumed in CECL's estimate, and their corresponding costs per unit volume were looked up using the fitted power curve from IPA based on industry data on cost for transport tunnelling projects. It was found that the estimated costs per unit volume (based on industry benchmark collated by IPA) approximately fall between the region of £600 to £800/m^3. These average costs were presented in 2017 prices in IPA's figure so in current prices the range is likely to be from £720 to £960/m^3. This also suggests that the industry benchmark average cost per unit volume quoted above for Route 2 (North Corridor) whilst appropriate for the longer Route 2 drive is actually towards the lower end of the benchmark range.

Further examination of CECL's inputs and assumptions for Route 2 suggests the following potential contributing factors to their low cost per unit volume:

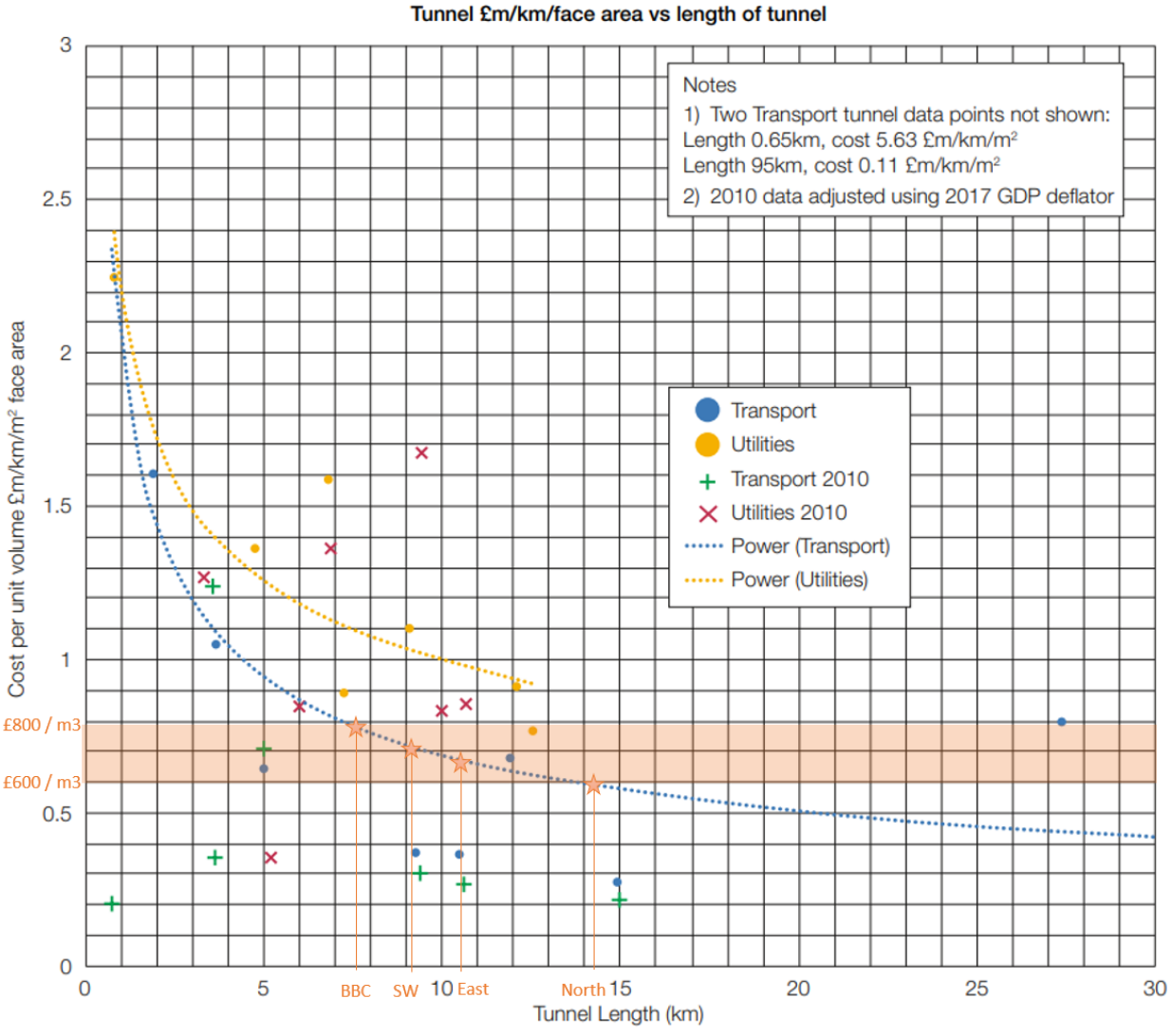
- Optimistic shift pattern -Their estimate has assumed a 2 x 12 hours shift pattern for tunnelling activities. The tunnelling industry has in recent years moved more towards a 3 x 8 hours shift pattern to avoid excessive operative fatigue and this carries with it a higher cost. (Recently constructed tunnels at Hinkley Point C power station and on HS2 are believed to have adopted a 3 x 8 hour shift pattern.)

6 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/762006/CCS207_CCS1118018748-001_Benchmarking_tunnelling_costs_and_production_rates_in_the_UK_Web_Accessible.pdf

- Potentially optimistic long average drive rate - A long average rate of 121 m/week has been assumed. (By comparison the tunnels constructed for Crossrail achieved a similar drive rate only as a maximum, and this for smaller bore tunnels constructed predominantly in London Clay)
- Optimistic assumption on the cost of excavated material disposal - A rate of £12.50/m^3 has been assumed on the basis of a suitable spoil disposal facility being identified which is relatively close to each drive site and which will not attract land fill or aggregate taxes. Route 2 would need such a site to be able to accommodate circa 1 million m^3 of material. No indication has however been provided as to where such disposal might take place. The concern associated with this assumption is that it may prove impractical / unrealistic, and that offsite disposal could cost considerably more. Similarly, as the use of a slurry TBM is proposed, excavated material would require treatment before it could be placed elsewhere, and it is not clear if such allowance has been made within the rate used.
- Exclusion of TBM / tunnelling power supplies – This could be a significant cost dependent on the availability/location of a suitable supply. (That for the Silvertown road tunnel currently being constructed is believed to have cost circa £14million, and those for the two HS2 Phase 2 bored tunnels are estimated at circa £8million each.)

Although there was only a short time period available to review the CECL tunnelling estimates (and a breakdown has only been provided for Route 2 single tunnel twin track option), investigations summarised in this document and the published data **indicate that a very low level of confidence can be given to achieving a fully tunnelled solution at the cost estimated by CECL**, particularly when the risk allowance is also taken into consideration (which is elaborated in the next section of the document).

Figure 1[7] – IPA transport project tunnelling cost per unit volume against tunnel length



[7] This figure is an adaptation of Figure 4 in IPA's published case study (see footnote 6) with four F4W corridors marked.

5. Consideration of risk allowance

A 40% risk allowance was applied in the SOC estimates, as stated Section 4.3.23 of the SOC Revision 3. This was also confirmed by comparing the risk allowance and base cost summarised in Table 1 of this document, as illustrated in Table 6.

Table 6 – Risk in the SOC cost estimate as a % of base cost

Option	Base cost	Risk	Risk as a % of base cost
Rubber-wheeled	7,930	3,172	40%
Steel-wheeled	9,305	3,722	40%

Only a 10% risk allowance was applied in the CECL estimates, as stated in the cost table on page 30 of its presentation.

At the early stage of scheme development, the choice of the uplift for risk allowance reflects the perception of individual cost estimating teams on the certainty of costs and robustness of the base estimates. It is not possible to draw a definitive view on the suitability of the risk values selected by CECL as no information on the engineering feasibility of the solution costed or its associated risks was available.

For projects at similar stage of development to F4W, one would anticipate a significantly higher initial risk allowance pending execution of significant further design and feasibility consideration and a formal Quantitative Risk Assessment (QRA) and production of a modelled 3-point estimate.

For example, Transport for London (TfL) would under their early stage estimating guidance on similar schemes adopt an uplift range of:

- Outcome definition stage - Between 40 and 60%
- Feasibility stage - Between 30 and 40%

Under the same guidelines, and in our own experience, a 10% uplift would not normally be expected until the scheme had reached detailed design stage.

We believe therefore that the 40% risk allowed in the SOC estimates is more appropriate at this stage of scheme development though still potentially at the lower end of what might be applied, and that the 10% allowed by CECL would not adequately reflect the likely level of risk/uncertainty at this stage.

6. Comparing the presentation of monetary values

Presentation of monetary values mainly involves the use of different price base and / or the inclusion or exclusion of cost inflation. Although different representations are expected at different stages of cost estimates, it is important that such differences are normalised when comparing different financial values.

6.1. Price base

All SOC cost estimates were clearly marked as nominal values in the SOC report. These represent an estimate of how much the proposed interventions will cost at the time of spending or procuring the services in the future. It is basically an estimated outturn[8] cost for delivering the scope of the underground network based on the information available at the time.

The CECL estimate is reported to be based on 2023 Q3 (page 19 of the CECL presentation).

The two estimates have an incomparable price base, with the CECL value fixed to 2023 whilst the SOC estimate including a mix of price bases for each future year when expenditures are expected to occur for the delivery of Future4WEST. The former (use of a fixed price base) is commonly used at the start of the costing process for infrastructure interventions, whilst the latter (use of nominal values) is the usual choice for representing scheme cost when considering the financial viability of a proposal as the estimated nominal values attempt to represent the actual cost of delivery.

6.2. Inflation

Consideration of inflation is closely related to their different approaches for price base.

[8] Generally, the outturn cost refers to the actual, total construction cost calculated at the end of the project, but it may also refer to the cost of a specific contract, or to costs incurred over a defined period.

As the CECL estimate is based on 2023 Q3 prices only, inflation was excluded. This means the cost increase between now and the end of construction is not covered in the current estimate. This is clearly acknowledged by CECL in their list of assumptions on page 19 of the CECL presentation.

Analysis of the costs presented in the SOC suggests that the total inflation applied over the assumed entire construction period is exactly 40% of the sum of the base cost and risk allowance. Details of this analysis can be found in Annex A of this document.

Similar to the finding from the price base investigation, **the CECL cost estimate does not include inflation in the future** as documented in its presentation. Based on the information available, **the SOC cost estimates are believed to include a total inflation of exactly 40% of the estimated scheme base costs plus risk**.

6.3. Adjustments to make different estimates more comparable

In light of the significant difference in price base and inflation considered between the two estimates, the CECL cost can be normalised by adjusting its assumption on risk allowance to 40% and including a total inflation of 40%.

The above exercise was undertaken at the initial stage of the investigation, which effectively increased the CECL estimate by approximately 80% by presenting it in nominal values. Details of this process are presented in Annex B.

It is noted that this adjustment does not alter the base cost estimate from CECL as this is beyond the scope of this investigation. As set out in Sections 3 and 4 of this document, when compared to industry benchmarks, the tunnelling costs from CECL appear to be on the low side, potentially half of the industry benchmark. **If the base costs were to significantly increase, the total outturn cost estimate with inflation and risk would increase by the same proportion leading to a far higher estimate**.

7. Conclusions and recommendations

Whilst currently focussed only on the tunnelling costs included within one of the route sections of CECL's proposed scheme we believe that there are several issues which would contribute to a low level of confidence that the estimate from CECL is realistic for the specification on which it was based, namely:

- A high-level review suggests that the base construction costs are significantly lower than both our own data from previously executed schemes where we have had an involvement, and published benchmark data.
- There are several potentially optimistic assumptions supporting the estimate produced by CECL which have likely contributed to this, as have certain key items which have been stated as being excluded from the estimate.
- The 10% uplift allowed by CECL for risk would not adequately reflect the likely level of risk/uncertainty at this stage.

If the Combined Authority decides to investigate/consider the CECL proposals and associated estimates further, it is recommended to consider:

1) A more scheme specific review and preparation of a comparable estimate reflecting the CECL tunnel proposals.

2) Other elements of cost for the proposed solutions such as underground solutions and systems be reviewed and benchmarked against comparable schemes.

3) An engineering feasibility review of the CECL proposals be undertaken.

In addition to further investigation on the cost for underground solutions (if deemed required), it is also recommended to consider the **value challenge and re-scoping exercise** that was suggested during the first technical review completed in May 2023, which may not only reduce the cost by value-challenging the scope and specification of the Mass Transit network, but also identify schemes (both Mass Transit solutions and complementary measures) that are likely to offer stronger Value for Money. Key actions in the recommended exercise are listed below with full details available in the technical assurance report prepared in May 2023.

- Develop, specify and develop forecasts for additional to BAU "aspirational" policy and strategy reference scenarios that consider push measures, housing and employment growth broader transport supply measures – translate into travel market analysis for MRT.
- Market, need and value challenge and re-scope MRT propositions to identify revised and priority MRT delivery propositions supported by analysis against BAU and aspirational reference scenarios.

- Identify and recommend re-scoped MRT and broader transport network intervention proposition(s) and way forward for scheme specific business case development and delivery.

Annex A – Details on inflation applied in the SOC estimate

The nominal value cost estimates in the SOC started from a price base of 2022 and considered inflation to each future year between 2023 and 2036. As documented in Section 4.3.26 on page 143 of SOC Revision 3, this included 10% inflation in 2023 and 2% each year thereafter.

Further examination of the cost inflation reported in the SOC for the entire network option(s) or their individual components revealed that the total inflation applied over the assumed entire construction period happens to be exactly 40% of the sum of the base cost and risk allowance. This can be observed in the SOC cost figures presented in Table 1 of this document, where the numbers in the 'Inflation' column are 40% of the sum of numbers in the 'Base cost' column and the 'Risk' column. This observation is illustrated in Table 7 below.

Table 7 – Inflation in the SOC cost estimate as a % of base cost plus risk

Option	Base cost	Risk	Total of Base + Risk	Inflation	Inflation as a % of base cost plus risk
Rubber-wheeled	7,930	3,172	11,102	4,440	40%
Steel-wheeled	9,305	3,722	13,027	5,221	40%

Annex B – Normalising the price base, risk allowance and inflation between the two cost estimates

It is noted that this normalising exercise was undertaken at the early stage of the investigation. It was focused on changes to price base and risk allowance only and did not alter the base cost estimate from CECL as this is beyond the scope of this investigation. As set out in Sections 3 and 4 of this document, when compared to industry benchmarks, CECL's estimated tunnelling costs appear to be on the low side, potentially half of the industry benchmark. **If the base costs were to significantly increase, the total outturn cost estimate with inflation and risk would increase by the same proportion leading to a far higher estimate** (than the values presented in this normalising exercise).

Investigation highlighted a clear difference between the CECL and SOC estimates for the underground network in terms of price base, risk allowance and cost inflation. Ideally impacts from these basic economic assumptions should be controlled in the comparison so the real difference attributed to different costing assumptions and methodology can be revealed.

The exclusion of the influence from different price base, risk and inflation assumptions was attempted in this investigation by amending the relevant assumptions in the CECL estimates. Adjusted CECL estimates were prepared and presented in Table 8 and Table 9 below. These do not represent estimates from CECL, nor new estimates from the author of this document on what the cost of the underground network could be. They are simply hypothetical estimates built on top of the CECL work and represent a cost with the same allowance for inflation and risk as the SOC estimate.

The two tables (from CECL) corresponding to Table 8 and Table 9 below can be found on pages 30 and 31 of the CECL presentation. Any numbers in red in Table 8 and Table 9 represent values adjusted or derived where necessary in this adjustment for the purpose of normalising assumptions on inflation and risk. The remaining values are identical to the original CECL estimates.

Table 8 – Adjusted CECL estimate with 40% risk and 40% total inflation for twin tunnel single track

Route	Route 1 - Airport	Route 2 - North	Route 3 - North East	Route 4 - South East	Total
Length (m)	9,064	14,153	10,630	7,603	41,450
Tunnel Construction	£195,796,694	£280,825,986	£220,362,948	£166,395,197	£863,380,825
Stations	£332,313,960	£664,627,920	£332,313,960	£387,699,620	£1,716,955,460
Systemwide, track and comms	£58,739,008	£84,247,796	£66,108,884	£49,918,559	£259,014,247
Risk (40%)	£234,739,865	£411,880,681	£247,514,317	£241,605,350	£1,135,740,213
Contractor's Staff (10%)	£58,684,966	£102,970,170	£61,878,579	£60,401,338	£283,935,053
Prelims, overhead and Profit (15%)	£132,041,174	£231,682,883	£139,226,803	£135,903,010	£638,853,870
Total (without inflation)	£1,012,315,667	£1,776,235,436	£1,067,405,491	£1,041,923,074	£4,897,879,668
Total (with 40% inflation)	£1,417,241,934	£2,486,729,610	£1,494,367,688	£1,458,692,303	**£6,857,031,535**

Table 9 – Adjusted CECL estimate with 40% risk and 40% total inflation for single tunnel twin track

Route	Route 1 - Airport	Route 2 - North	Route 3 - North East	Route 4 - South East	Total
Length (m)	9,064	14,153	10,630	7,603	41,450
Tunnel Construction	£177,947,826	£247,729,775	£198,355,604	£152,696,022	£776,729,227
Stations	£332,313,960	£664,627,920	£332,313,960	£387,699,620	£1,716,955,460
Systemwide, track and comms	£53,384,348	£74,318,932	£59,506,681	£45,808,807	£233,018,768
Risk (40%)	£225,458,454	£394,670,651	£236,070,498	£234,481,780	£1,090,681,382

Contractor's Staff (10%)	£56,364,613	£98,667,663	£59,017,625	£58,620,445	£272,670,346
Prelims, overhead and Profit (15%)	£126,820,380	£222,002,241	£132,789,655	£131,896,001	£613,508,277
Total (without inflation)	£972,289,581	£1,702,017,182	£1,018,054,023	£1,011,202,675	£4,703,563,460
Total (with 40% inflation)	£1,361,205,413	£2,382,824,055	£1,425,275,632	£1,415,683,744	**£6,584,988,845**

The risk allowance in the original CECL estimate was increased from 10% to 40%. The percentage was applied to the sum of estimated costs for Tunnel Construction, Stations and Systemwide, track and comms, in the same way as it was in the CECL work.

The 15% assumption on Prelims, overhead and profit in the CECL estimate has not changed, but the financial value for these items was updated as the 15% assumption was applied to the sum of all preceding items including the adjusted risk allowance (changed from 10% to 40%).

Inflation was not included in the CECL estimate so a new total was derived with 40% total inflation built in, in the same way as the SOC estimate.

The normalised CECL estimate is about £6.9 billion for twin-tunnel single track option and £6.6 billion for single tunnel twin track option in nominal values. Although these are consistent with the SOC estimates in terms of price base, risk allowance and inflation, the significant difference in the scope of interventions costed and base cost estimate remains as these have not been altered. These two aspects were explored separately in Sections 3 and 4 of this note. **If the base costs were to significantly increase, the total outturn cost estimate with inflation and risk would increase by the same proportion leading to a far higher estimate** (than the values presented in this normalising exercise).