Summary of

PROOF OF EVIDENCE

To be presented by

Peter Bonsall

as an expert witness

on behalf of

The North West Leeds Transport Forum (NWLTF)

at

The Public Inquiry into the

Leeds Trolley vehicle System Order

My Qualifications

I am Emeritus Professor of Transport Planning at the University of Leeds. A summary of my qualifications and experience can be found, together with a list of my publications, at www.its.**leeds**.ac.uk/people/p.**bonsall** (google "Bonsall Leeds"). My main area of expertise has been in the understanding and forecasting of transport demand and in policy appraisal.

My full CV, available on request, details my role as technical advisor/auditor for projects around the UK, elsewhere in Europe and beyond, and as expert witness to Committees of Inquiry in the UK and USA.

My Evidence

1. I have studied documentation produced by the NGT proposers and have sought further clarification from them on issues which are left unclear in the published documents. At the time of writing, I still await clarification of a number of issues and so may need to append further material to my evidence.

2. My reading of the documents leads me to conclude that there are a number of serious deficiencies in the analysis which tend to put NGT in an unduly favourable light and that insufficient attention has been paid to alternative schemes. I also note that, even accepting the proposers' own forecasts, the scheme fails a number of key tests.

3. I am drawn to the overall conclusion is that the proposal is fundamentally flawed and that its objectives could be met more effectively (and more cheaply) by other means.

4. In presenting my evidence I will draw on detailed material included in the Revised Statement of Case submitted by NWLTF in February 2014 (but, for convenience, reproduced as an appendix to this proof and referred to via italicised paragraph numbers in parentheses).

5. On the question of **deficiencies in the analysis**, I note the following**:**

   5.1. Likely over-estimation of bus journey times relative to those of NGT (*A1*).

   5.2. Likely under-estimation of delay which NGT would cause to traffic on the A660 (*A2*).

5.3. Errors in the representation of passengers' walking routes which will have inflated the predicted shift of passengers from bus to NGT (*A3*).

5.4. Errors in the estimation and application of the '*quality factors'* which are responsible for the predicted modal shift to NGT and for much of the benefit claimed for NGT in the appraisal (*A4*).

5.5. Deficiencies in the specification of bus services (*A5,A6*)

5.6. Deficiencies in the modelling of demand for park and ride services *(A7*).

5.7. Deficiencies in the estimation of the impact of NGT on accessibility and connectivity (*A8*).

5.8. Failure to give due attention to potential threats to the forecast revenue *(A9, A10*);

5.9. Significant bias in calculation of the BCR caused by:

a) Over-estimating the extent of mode shift to NGT (due to deficiencies noted above)

b) Including (arguably inflated) perceived benefits of NGT while excluding its widely perceived disbenefits - e.g. impacts on ambience, streetscape and the overall public transport offer (*A11, A12, A13*);

c) Excluding costs to road users, local bus operators and others during the construction period *(A14*);

d) Overly pessimistic assumptions about conditions in the do minimum case in respect of:
   - bus service attributes (*A15*)
   - likely traffic levels (*A16*), and
   - potential for improved signal settings (*A17, A18*);

e) Apparently failing to include all capital costs (*A19,A20*);

f) Under-estimating the mitigation costs (*A21*);

g) Exaggerating the punctuality benefit (*A22*);

h) Exaggerating annualised scheme benefits by over-representing conditions experienced during University term times (*A23*).

5.10. Numerous examples of errors/inconsistencies which, taken together, must cast doubt on the care taken over the analysis (*A24, A25*).

6. Respecting the Proposers' **failure to give full, fair and adequate attention to alternative schemes**, I note the following:

6.1. That deficiencies in the analysis discussed above will have tended to exaggerate the performance of NGT relative to all the alternatives – including the do-minimum.

6.2. The specification of the Low Cost Alternative is overly pessimistic. For example in:

a) Using articulated vehicles (rather than modern double-deckers) thereby failing to capture the beneficial impact on other traffic or the clear passenger preference (*A26.1*);

b) Not showing improvement in bus service quality(*A26.ii*) or routing (*A26.iii*);

c) Not showing reduction in bus emissions (*A26.iv*);

d) Not allowing increase in capacity, frequency (*A26.v*) or punctuality (*A26.vi*);

e) Not seriously attempting to optimise signal settings to provide improved priority for buses while minimising delay to general traffic(*A17, A18*);

f) Including only very modest improvement in bus stop quality - although such improvements are relatively cheap and are responsible for much of the benefit claimed for the NGT scheme(*A11, A27*);

g) Not including dedicated non-stop shuttles for the Bodington P&R.

6.3. That limited consideration has been given to other low cost alternatives. For example:

a) Partnership with bus operators to produce improved services, vehicle specification, ticketing, fares, bus priority at signals, bus stop facilities, boarding times and reliability.

b) Extension/provision of bus lanes where appropriate.

c) Substitution of the most problematic part of the NGT route (north of the Universities) by a Partnership or Quality Contract together with limited engineering works and phased introduction of P&R at Bodington.

d) Redirection of any available resources to other transport priorities in the City Region.

7. In respect of the proposal's **failure to meet key tests**, I note that, even accepting the proposers' own forecasts, the scheme will result in:

7.1. A public transport offer which, in many respects, will be worse than that would be available in the Do Minimum case. For example:

a) The public transport system would be less integrated, in that:

- Passengers will be faced with two alternative systems, each with their own set of stops and will have to choose between them before making their journey – rather than being able to access all services from a single stop.

- Interchange with other buses at the bus station will necessitate a significant walk from the nearest NGT stop.

- According to Para 15.136 of Doc C-1, passengers may be faced with different fare structures on NGT and on bus.

b) Users of the Trolley system would:

- On average, have to walk further to and from the stops (due to greater inter-stop spacing)

- On average have to wait longer for a service (6 minute rather than 3 minute headway)

- Have less chance of getting a seat (*A28*)

- Have to pay a higher fare for short journeys (see para 15.136 of Doc C-1).

- In many cases have longer *perceived* journey times (*A29*)

c) Users of buses, including those who are effectively captive to bus (*A30*), would:

- In many cases suffer from less conveniently located bus stops

- On average have to wait longer for a service (6 minute rather than 3 minute headway)

- Often have longer journey times (*A31*).

d) There must be a concern that, if the TWAO were granted without specific conditions attached, financial and commercial considerations might lead the public transport offer outlined in the TWAO application to be further eroded (e.g. in respect of bus stop or trolley stop specification, bus access to priority lanes, NGT frequency, NGT fares) or that the use of Bus Quality Contract powers or a partnership agreement to protect an inefficient NGT service might deprive users of potentially lower fares.

7.2. A net decrease in public transport passenger miles combined with a net increase in car miles and with most of the predicted trolleybus users having transferred from bus or train (*A32*).

7.3. Increases in overall journey times by car (Table 58 of Doc C-1.8) which, when combined with the increased journey times by bus seriously detracts from any claim to have increased connectivity.

7.4. Increases in emissions (Table 4.9 of Doc B-2), accidents (Table 17.12 of Doc C-1), noise (para 2.5.24 of Doc B-8) and fuel consumption (Table 16.1 of Doc C-1).

7.5. A less efficient transport system (*A33*).

7.6. Deterioration in many measures of the quality of life. Viz:

a) increased congestion, traffic, accidents, emissions, traffic noise and time spent driving;

b) less convenient public transport for many users;

c) reduced use of active modes; and

d) adverse impacts on the local environment, streetscape, historic heritage and vitality of local businesses.

8. Finally, as a transport specialist, I have come to the conclusion that **the problems with the NGT proposal are fundamental rather than cosmetic**. They are exacerbated by the chosen technology but are inherent in the attempt to fit two public transport systems, each with its own set of stops and each used by only ten vehicles per hour, into a tight corridor which is currently served by a single public transport system used by around 20 vehicles per hour. I also consider that the viability of the Park and Ride schemes is threatened by the absence of dedicated express shuttle services whose capacity and frequency could be adjusted to meet demand.

Appendix: Detailed evidence provided by Peter Bonsall

Note that this material was included in the Revised Statement of Case submitted by NWLTF in February 2014. It is reproduced here for convenience.

A1. The public transport run time analyses reported in Document C-1-13 are crucial to the case for NGT (they are a key determinant of the demand forecasts and of the appraisal results and a difference of a few minutes can make a significant difference to the results). However, their accuracy and fitness-for-purpose must be in doubt given the large number of anomalies and/or errors evident in the documentation. For example:

i. The run time model predictions provided in Table 13 of Document C-1-8 indicate that, between 2008 and 2016, the journey times between Bodington and the City would increase more for buses than for cars (except inbound in the interpeak and pm peak). For example, outbound during the pm peak, bus journey time is predicted to increase by 7.99 minutes while that for cars is predicted to increase by 1.85 minute. Given that the buses run in the general traffic for most of the route, this difference could only happen if bus boarding times were increasing (which would not be consistent with the do minimum prediction - recorded in Table 48 of Doc c-1-8 - that the number of bus passengers on the A660 will have fallen by 23% during that period) or if the enforcement of bus lanes were to become less effective. **It would thus appear that the predicted DM bus run times are overly high (or the DM car times are overly low).**

ii. Paragraph 1.2 of the executive summary of Doc C-1-13 reports that the "observed" am peak period bus journey time from Bodington to the City by bus is 33 minutes. However, it is clear from the data presented in Appendix B of Document C-1-13 that it is misleading to state that the observed value was 33 minutes (there were two surveys, one – based on eight observations in March 2013 - gave an average of 33 minutes 21 secs and one- based on six observations in April 2013 - gave an average of 30 minutes and 3 secs). It appears that data which puts the performance of conventional bus services in a better light has been ignored. If all the survey data had been used, the average value would be just under 32 minutes (or just under 31 minutes if the obvious outlier is removed from the April data**). It would thus appear that bus run times are overly high.**

iii. Further to ii, it should also be noted that 5 of the 14 bus journey time observations were made on Monday mornings. This is not a fair comparison given that the highway journey times were estimated for an average Tuesday-Thursday and, **again the effect will have been to exaggerate the bus journey times relative to those of cars**.

iv. Paragraphs 2.17, 2.18 and 2.26 of Document C-1-13 indicate that Trolleybuses are assumed to receive priority from the SPRUCE system such that it has minimal delays at junctions and none at free-standing pedestrian crossings while buses will not receive the same level of priority and will therefore be delayed. Table 3.1 indicates that at various locations (Churchwood Avenue for example) the bus would be delayed but the Trolleybus would not. There is no justification for the assumption that, when a bus approaches signals immediately ahead of a trolleybus, the latter can receive priority while the former does not. **This would suggest that the NGT run times have been under-estimated.**

v. Table 3.1 and Appendix A of Document C-1-13 identify several locations where buses would be delayed at bus stops but, although some of these bus stops have no laybys (Southbound at Weetwood for example), it has been assumed that the NGT vehicles would not be delayed by these stationary buses. **Again, this would suggest that the NGT run times have been under-estimated.**

vi. The annexes to the Runtime Assessment Report (Doc C-1-13) reveal some other rather odd assumptions. For example, Annexes 33-35 indicate that, southbound along the A660 in the morning peak, the Do Minimum bus will experience 10 seconds "junction delay" at Weetwood Lane and at St Michaels Lane even though, under current conditions, they have full priority at these junctions. **Such assumptions obviously tend to increase predicted journey times for the Do Minimum bus relative to those for NGT**.

vii. The authors of C-1-13 note (in para 2.13), quite rightly, that junction delays are an important element of overall run times but then indicate (in para 2.14) that many of the estimates have relied on their own judgement informed by advice from UTC personnel and by data from any available modelling. This must raise some concern because:

- The modelling work extant at the time that the run time estimates were made has now been superseded
- There are some concerns about the quality of the junction modelling work (see A2 below)
- The errors, inconsistencies and biases referred to above do not leave one confident that subjective judgement necessarily equates to objective accuracy.

A2. The estimated journey times by the various modes in the various scenarios are crucial inputs to the demand model and to the appraisal. A key contributor to these estimates (particularly for the car mode) is the estimation of delays at junctions. The approach adopted (as described in Document B-9) involves using software (notably ARCADY and PICARDY) to model the ability of individual junctions to cope with flows predicted by the Leeds Transport Model. This approach is safe provided (1) that the junctions do not interact with one another (the most important assumption being that flows held up at a downstream junction do not back up so far that they prevent the smooth discharge of an upstream junction), and (2) that the flows assumed at individual junctions are consistent with each other and with the overall assumed pattern of demand. Unfortunately, there is reason to doubt that these conditions hold. For example:

i. Chapter 5 of Document B-9 presents results for the performance of individual junctions and, if there were perfect consistency, the flow into the upstream end of a given link would match the flow out of it at the downstream end (after allowing for net inflow or outflow from un-modelled side roads or frontage). Inflows in excess of outflows in a given time period indicate a build-up of congestion and vice versa. Examination of the data presented for individual junctions reveals some worrying examples of mismatch. For example, confining our attention to southbound flows in the morning peak, we see that:

   a. Comparison of the flow diagrams in sections 5.5.2.2 and 5.5.3.1 (the A660 from Lawnswood roundabout to the Spen Lane junction) reveals inflow above outflow (50 pcus) in the Do Something (with NGT) case but outflow above inflow (33 pcus) in the Do Minimum (without NGT).

   b. Comparison of the flow diagrams in sections 5.5.4.1 and 5.5.4.2 (the short stretch of A660 from Shaw Lane to Alma Road) reveals inflow above outflow (15 pcus) in the Do Something (with NGT) case but outflow above inflow (1 pcu) in the Do Minimum (without NGT).

   c. Comparison of the flow diagrams in sections 5.5.5.3 and 5.5.5.4 (the short stretch of A660 from Hyde Park junction to Cliff Road) reveals inflow above outflow (71 pcus) in the Do Something (with NGT) case but outflow above inflow (54 pcus) in the Do Minimum (without NGT).

   d. Comparison of the flow diagrams in sections 5.5.5.4 and 5.5.5.5 (the short stretch of A660 from Cliff Road to Rampart Road) reveals outflow above inflow in the Do Something and in the Do Minimum cases (69 and 20 respectively).

   There are many other examples of mismatches and it is notable that many are significant and cannot be explained by frontage activity. Also, although it not universal, there is a clear pattern to the mismatches – the with-NGT case shows that congestion is building up whereas the without-NGT case does not. This suggests that blocking-back (due to build-up of congestion at the downstream end of the link) is most particularly marked in the with-NGT case and that, if this has been ignored in the LTM, the results will be biased towards an **underestimation of delays in the with-NGT case**. Further investigation of this issue requires more information about the LTM's representation of turning movement delays and access to data on flows forecast by the LTM.

ii. It is known that, in the morning peak, traffic queuing to pass southbound through the junction of the A660 with North Lane in Headingley often backs up to or beyond Alma Road (and sometimes back to Shaw Lane and beyond). This is recognised in the commentaries included in Table 3.1 of Document C-1-13 (on page 11 it states that, the Otley Road between Shaw Lane and North Lane "*is a heavily congested link*" and that, at Otley Road between Shaw Lane and Alma Road, the do minimum scenario should assume "*a 10kph speed restriction in AM peak to reflect queuing traffic*") and yet, for the NGT scenarios it is assumed that the southbound output from junction of the A660 with Alma Road is unconstrained. The flow diagrams in Section 5.5.4.1 and 5.5.4.2 of Document B-9 further indicate that the predicted morning peak performance of the Shaw Lane-A660-Alma Road junction is dependent on an assumed reduction of 137 pcus in the traffic turning right from Shaw Lane and a reduction of 84 pcus (after allowing for the 30 pcus contributed by NGT vehicles) in the traffic turning left into Alma Road. **It would appear that the ability of this junction to perform as predicted in the NGT scenario has been exaggerated**.

A3. A key contributor to generalised cost and thus to the predicted demand for trolleybus is the assumed walking time to and from public transport. Detailed information about the assumed walking times was not published in the TWAO documentation but analysis of the predicted numbers of passengers boarding and alighting the NGT at each stop (e.g. as detailed in table 5.3 of document C-1-8) suggested that something is amiss. For example, it is predicted that the new NGT stop on Headingley Hill will attract more passengers than the NGT stop at the Arndale Centre (in the morning peak it is predicted that 11 passengers will alight here although none would alight at the Arndale Centre) whereas a knowledge of the local topography and land use makes such predictions quite unbelievable. A glance at the map of walk links and centroid connectors (attached as A34 below) seems to show that errors in the location of the centroid connectors will have caused the problem:

i. the centroid connectors from the zones centred on St Annes Road, and Wood Lane will route public transport users via the Headingley Hill NGT stop rather than the bus or NGT stops at the Arndale Centre (to which, in reality, they are much closer),

ii. the centroid connectors from the zone centred on St Michaels Road will route public transport users via the NGT stop on Headingley Hill rather than the bus stop at St Michaels church (which is, in reality, much closer).

Fundamental errors of this kind must cast doubt on the reliability of the model predictions and we note that **the errors noted above will have boosted NGT patronage at the expense of bus patronage.**

A4. The predicted demand for the trolleybus (hence the trolleybus revenue, the residual demand for buses and for car travel, hence the number of buses likely to remain and hence the traffic conditions on the A660) is dependent, not only on the assumed journey times discussed in *A1, A2* and *A3* above, but also on '*quality factors*' and '*penalties*' which have been assumed to influence mode choice. Details of the manner in which these factors have been used is obscure. According to paragraph 4.2 of document C-1-8 the penalty for using a bus rather than NGT is about 5.7 minutes per trip (*'around 11'* minus '1.27' minus '*over 4*') whereas, the Quality Factors Report (C-2-4) refers to a boarding penalty of 5.55 minutes and a further penalty averaging 11.73 minutes and paragraph 3.2 of the Transport Model update Document (C-1-3) refers only to an '*overall transfer penalty*' of 10 minutes (relevant details have been requested but, as of 21 March, have not yet been provided). The most detailed description of the penalties is in the Quality Factors Report (Doc C-2-4) so it is those which we now examine. The penalty equivalent to 5.55 minutes of journey time is imposed for boarding a bus rather than a trolley bus and a further penalty, averaging 11.73 minutes of journey time, is imposed for using a typical bus stop rather than a typical NGT stop. These values, which are apparently applied to all travellers except those on employers' business, were derived from stated preference work carried out for Metro in 2008 and described in Document C-4-24. Careful reading of these documents reveals some interesting facts:

i. The figure of 5.55 minutes was derived by dividing the willingness to pay (WTP) for a journey on a "*very new bus*" rather than on an "*old bus*" by the value of time while travelling on a vehicle with "*plenty of seating spaces*". This seems to be a very odd choice of numerator since, although there were no WTP values available for a journey on a trolleybus, WTP values were available (in Table 2 of Document C-2-4) for a journey on a "*a new bus with new technology like FTR*" rather than on an "*old bus*" (the graphics below were used to explain the difference between the vehicle types to respondents and note that the FTR vehicle has more in common with the proposed trolleybus than does the very new bus). If the numerator for the FTR-like vehicle had been used the penalty value would have been 4.15 minutes (10.01/2.41) rather than 5.5 minutes.

"old bus"

"very new bus "

" new bus with advanced technology like FTR"

"trolleybus"

But it also seems odd to have chosen "*plenty of seating spaces*" as the denominator since values were available for the value of time while travelling on a vehicle with "*all seats taken but plenty of room to stand*" (which is a much better description of the expected conditions on the proposed trolleybus). If the more appropriate numerator and denominators available in Table 2 of document C-2-4 had been used, the penalty for boarding an "old bus" rather than an NGT vehicle would have been 3.64 minutes rather than 5.55 minutes. **The use of the 5.55**

minute penalty thus seems unduly favourable to NGT – even if the competitor vehicle is an old bus and will have exaggerated the demand for NGT.

ii. Although the values in Table 2 of Document C-2-4 indicate that the willingness to pay for a journey on a "very new bus" might be 4.2 pence greater than that for one on a vehicle "like FTR" (and note again that the FTR-like vehicle has a lot in common with the trolleybus), this preference has not been allowed for in the analysis or appraisal of NGT, the NBA or the LCA. Dividing the WTP values in Table 2 by appropriate values of time, one could argue that, when considering the choice between NGT and a very new bus, rather than apply a penalty of 5.5 minutes for choosing the bus, a penalty of about 1.86 (5.55-3.64) minutes should be applied for choosing the NGT vehicle. **This would, of course, have a devastating impact on the predicted demand for NGT.**

iii. Although the Stated Preference survey did reveal a willingness to pay to travel on a vehicle with "*plenty of seating spaces*" rather than one with "*all seats taken but plenty of room to stand*", this was apparently ignored in the analysis and forecasting (Metro have been asked to supply the further details required to confirm this but have not yet responded). A failure to allow for a disinclination to stand will have resulted in an overestimation of demand for NGT. (In fact the value of having access to a seat derived from Metro's Stated Preference work is lower than might have been expected given the results of research in the rail industry – but this may simply result from the fact, noted in paragraph 5.9 of document C-4-24, that the results came from a survey sample which excluded anyone with access to free travel (i.e. the old and infirm – the very people who are likely to have greatest disinclination to stand and who constitute an above average proportion of people in Weetwood and West Park). There is thus very good reason to assume that the true value of passengers' disinclination to stand is greater than that estimated in the Stated Preference work. **Use of an accurate measure of passengers's disinclination to stand would reduce the predicted demand for NGT.**

iv. The 11.73 minute penalty applied to journeys made via a typical bus stop (rather than via a typical NGT stop) is derived, by a method described in document C-2-4, from a constrained sum of WTPs for specified attributes (CCTV, good lighting, electronic displays, etc) which are to be provided at NGT stops but which are not found at a typical bus stop. (Document C-4-24 concluded, in paragraph 9.5, that there was "*strong evidence that whether the service is provided by a bus, trolleybus or tram is less important to travellers than other characteristics of the service.*" and this was taken to justify the approach which was adopted – namely the estimation of stop-type penalties as a function of the WTPs for their attributes). The values used in the current study are higher than those normally accepted by DfT. Professional opinion is divided as to the reliability of such values and the validity of combining them, but there must be the suspicion that some at least of the WTP values from the Metro study will be overestimates. For example, the conclusion that commuters would be willing to pay 25.5p per trip for "*good lighting*" on each and every trip was derived using the graphics below – despite the fact that most of the trips would be made in daylight. **Correction of any over-estimates would reduce the penalty for using "typical" bus stops and would reduce the predicted demand for NGT.**

"The stop is poorly lit"

"the stop is very well lit"

v. Document C-2-4 notes, in paragraph 2.12, that models based on stated preference results often overestimate propensity to shift mode and that this tendency should be corrected by using scaling factors based on revealed preference data. It further notes that a scaling factor could be applied to the car/public transport choice but not to the bus/NGT choice. It is not known whether such a scaling factor was applied in the models whose results were reported in January 2014 (details of the models have been requested but they have not yet been provided), but if no scaling was applied for the bus/NGT choice, the use of NGT will have been overpredicted and the quality benefits will have been exaggerated.

A5. The use of the attribute-based factors described in *A4* above can only be justified if they were applied fairly to all the competing modes. However, the modelling and appraisal of the proposed trolleybus (and of the NBA) has been based on the assumption that:

i. Metro's improvement to bus stops will not extend beyond installation of CCTV (as indicated in paragraph 4.2 of document C-1-8);
ii. Bus operators will not provide more attractive vehicles;
iii. The fleet of trolleybuses will for ever be regarded as "newer" than the buses with which they will be competing. A much more realistic assumption would allow for the likelihood that bus operators would allocate their most attractive vehicles on the important Headingley routes, cascading their older stock onto less important routes – an option not realistically available to the trolleybus operator). The likely result is that, by 2031, the Leeds trolleybuses would be much older than the buses which would otherwise have plied the route. Hence, since customer preference for new stock is well known (and was reflected in the finding from the stated preference work that an improvement from "old bus" to "very new bus" would be valued more highly than a shift from "old bus" to "FTR"), the mode choice model ought thus to include a "penalty" for use of the older trolleybuses rather than for use of what are likely to be newer buses. It could be argued that, since the Trolleybuses

will become “old” this penalty should be even greater than the 1.86 minutes calculated at A4.ii above.

A6. The demand forecasts and appraisal results are also dependent on a number of other assumptions whose basis is at least questionable. Namely:

i. That bus operators will not provide improved boarding times (and hence reduce journey times and reduce the unreliability associated with bus-bunching).

ii. That the bus operators will not seek to compete with the trolleybus by offering lower fares (the promoters have assumed that the fares of bus and trolleybus will be broadly similar - see *PEBC 8.16 or Document C-1-6*). In actual fact, as of February 2014, a new bus operator (Yorkshire Tiger) is <u>already</u> offering lower fares along the most profitable stretch of the route.

A7. A significant portion of the predicted NGT patronage is due to use of the Bodington and Stourton P&R sites. It is therefore important to be sure that the prediction of P&R usage is robust. Section 4.2.1 of Document C-1-3 explains that the demand for park and ride has been forecast via a parking choice model which predicts where drivers heading for the centre of Leeds will choose to park - in the city centre, further out, or at a P&R site. Some aspects of this model give cause for concern. For example:

i. The parking choice model was unable to replicate the observed use of existing P&R sites without the addition of some very significant car-park-specific penalties and by underweighting the public transport element of the cost of using P&R sites. It is not known what penalties were applied in forecasting the use of Bodington and Stourton P&R sites but it is noted that the generalised costs of P&R trips had to be re-weighted (multiplying the car element by 1.71 and the NGT element by 0.82) in order to replicate the extents of existing P&R catchments. The fact that the model required the inclusion of large car-par-specific penalties and significant adjustment (for which no justification exists in demand modelling theory) to the generalised cost matrix is an obvious cause for concern. (The modellers recognition of this may be evident in Section 4.5.1.2 of Document C-1-3 where, commenting on the validation tests, they say that “*While this provides assurance in the broad magnitude of the forecasts it also suggests that where precise detailed forecasts are required this should be supplemented by more detailed scheme level analysis.”*).

ii. A key reason for using a P&R service rather than seeking to park in the city centre is the time taken searching for (and accessing) city centre parking. However, data on this is difficult to obtain and, as explained in Section 4.2.1.2 of Document C-1-3, these times were estimated by a method which, according to its authors “*is not designed to model significantly and consistently over-crowded car-parks*”.

iii. The “alternative specific constants” (ASCs) used to help predict the choice between parking in the city-centre or at the Bodington and Stourton P&R sites were estimated in the light of the ASCs which best explained the level of usage in existing P&R sites (the “calibration sites were Garforth, King Lane and New Pudsey). This approach, while understandable, is likely to have resulted in an inflated prediction of demand for these two new sites because:

a. The calibration sites have rail or non-stop bus shuttles whereas the NGT vehicles serving the Bodington and Stourton sites will stop to pick-up and set-down passengers at intervening stops.

b. There is no shortage of capacity on the shuttles returning to the calibration sites whereas people returning to the Bodington and Stourton P&R sites will have to compete for space with other passengers using the NGT services. Users of the Bodington and Stourton P&R sites will not be able to assume that they will get a seat on their evening peak service or indeed that there will be any space on the first NGT service – with 6 minutes additional waiting time for those who fail to get a place on the first vehicle.

c. Research has shown that the most successful P&R sites have dedicated express shuttles, the Stated Preference results summarised in Table 2 of Document C-2-4 indicted that lack of a guaranteed seat generates a perceived “penalty” of at least 0.34 pence per minute (or, as noted in *A4.iii* above, arguably more), and extra waiting time during the evening peak is valued very highly.

A8. The assessment of NGT’s impact on accessibility and connectivity concentrates on predicted reductions in in-vehicle time. It appears to not to have taken account of the greater average walking distance, the longer average waiting times, the increased likelihood of having to stand while on the vehicle or the likelihood of decreased frequency of buses serving places not on the NGT route (DfT guidance, in *Door to Door - A Strategy for improving Sustainable Transport Integration* – published in 2013, stresses, in item 3 of the Executive Summary, the importance of ‘*… the cost, convenience and complexity of the entire door-to-door journey – not simply one element of it*’).

A9. The demand forecasts and appraisal results are dependent on a number of assumptions whose basis is at least questionable. Namely:

i. That the socio-economic characteristics of the population resident in the northern part of the NGT Catchment area will continue to generate substantial demand for public transport. The student population is falling while the new population associated with new housing developments will have higher car ownership and will thus be less captive to public transport. A recent report by Unipol (attached as an appendix to the Statement of Case submitted by the West Park Residents' Association - TWA/13/APP/04/OBJ/1720), reveals that, between 2006 and 2012, the number of students living in street properties in Beketts Park, Far Headingley and West Park fell by 57% while those in Central Headingley fell by 19%. The report indicates that the reductions are in large part due to the construction of purpose-built student accommodation near, and to the south of, the University campuses.

ii. That the falling levels of traffic flow on the A660 in recent years do not reflect an underlying switch from travel to e-activity. The presence of two universities means that involvement in the information economy is very pronounced in the A660 sector and, as is clear from recent statistics, the reductions in peak traffic flow are more marked in the A660 corridor than in any other corridor into Leeds – suggesting that they are not simply a result of economic recession. (DfT census data http://api.dft.gov.uk/v2/trafficcounts/countpoint/id/17374.csv and (http://www.dft.gov.uk/traffic-counts/area.php?region=Yorkshire+and+The+Humber&la=Leeds) reveals that, between 2002 and 2012, the flow of traffic on the A660 at Woodhouse Moor has fallen by 17% while the total for all main roads in Leeds has remained almost constant).

A10. The appraisal has failed to give due attention to a number of downside risks. For example:

i. The possibility that the forecast revenue might be severely reduced if bus operators were to compete with NGT by offering lower fares (thus leading to a reduced market share and/or reduced revenue per passenger for NGT).

ii. The risk of an escalation in costs of equipping, operating and maintaining a system which is unique in the UK (using right hand drive trolley vehicles for which a competitive range of suppliers will not exist).

iii. The possibility that eventual costs of upgrading might be substantial (when the merits of evolving battery technology are accepted, the purchase of a fleet of new vehicles and the removal of redundant equipment - as required by the provisions of a TWAO - will be only partially offset by the second-hand value of redundant overhead wires and obsolete trolley vehicles).

A11. The perceived values and penalties described in *A4* above have been included in the calculation of benefits in the TEE tables (where they dominate the benefits claimed for punctuality and passenger time savings) and in the calculation of overall BCR (where they are responsible for a large part of the assessed benefits). It should thus be recognised that **the economic case for the scheme rests entirely on the valuation of vehicle and bus stop attributes which could be achieved without investment in NGT**. This may not be against the letter of the rules but it is most definitely against their spirit if no equivalent allowance is made for perceptions of negatives such the loss of streetscape ambience.

A12. The appraisal of the NGT scheme (e.g. in Table 17.4 of Document C-1) shows a total net benefit of £448m (2010 values, over a 60 year appraisal period). The main contributor to this is an estimated £701m in passenger travel time savings. However, as is clear from the Appraisal Summary Table (Table 17.12 in Document C-1) and on page 11 of the TUBA Report (Document C-1-17), these travel time savings relate to perceived (not resource) savings and include "*quality benefits*" which are assumed to result from use of the trolleybus. It is interesting to consider the implications of this; taking the 5.5 minute boarding time penalty which according to document C-2-4 has been applied to bus journeys and valuing this for the 75% of the 11.79 million NGT journeys per annum which were transferred from bus, and using the recommended PSV passenger Value of Time (£21.69/hr) this contributes £17m (5.5/60 x 21.69 x 11.79 x 0.75) to the time savings in the first year and, over the 60 year appraisal period, using the recommended discount rate, contributes around £440m of benefit (even assuming no growth in patronage beyond year one). In other words the net benefit calculated for the scheme is almost entirely due to the boarding time penalty whose value is open to question (see *A4* above and note that, if one used a value of 3.64 minutes rather than 5.55 minutes, the travel time saving would be reduced by £288m). (Note that there is some uncertainty as to the size of penalties which were applied and that much greater numbers are at stake if the penalties were actually more than 5.55 minutes).

A13. Document A-01-02 para 3.3 states that part of the NGT Vision is to create an '*integrated transport system for Leeds*'. This aspiration was also identified in the WYLTP. However, the NGT proposals actually represent a move away from integration because:

i. Passengers will be faced with two alternative systems, each with their own set of stops and will have to choose between them before making their journey – rather than being able to access all services from a single stop.

ii. Interchange with other buses at the bus station will necessitate a significant walk from the nearest NGT stop.

iii. Passengers will be faced with different fare structures on NGT and on bus (paragraph 15.136 of Document C-1 states that "*NGT fares will use a two stage fare system and will offer a fare broadly equal to the conventional bus network for the majority of passengers. The exception to this is passengers who currently make short distance trips and currently pay the lowest bus fare; any such passengers who choose to use NGT will pay more, as the lowest fare stage is not replicated*").

A14. The appraisal has failed to give due regard to some important elements of the cost of the NGT proposal. For example:

i. The additional travel time and vehicle operating costs during the construction period have been ignored (DfT advice is clear – in paragraph 10.11 of TAG unit A1.3

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/275245/webtag-tag-unit-a1-3-user-and-provider-impacts.pdf – it states that "*Costs to existing transport users due to the construction of a project and costs (or benefits) to users arising during future maintenance should be recorded in the TEE tables where they are likely to be significant*").

ii. Revenue lost to local bus operators during the construction period have been ignored (again, in paragraph 11.12 of TAG unit A1.3, DfT indicate that the impact on operators' revenues should be considered).

A15. The modelling and appraisal of the proposed trolleybus (and of the NBA) has been based on the assumption that:

i. Metro's improvement to bus stops will not extend beyond installation of CCTV (as indicated in paragraph 4.2 of document C-1-8)

ii. Bus operators will not provide more attractive vehicles

iii. Bus operators will not provide improved boarding times (and hence reduce journey times and the unreliability associated with bus-bunching).

A16. (duplicate of *A9.iv* above) It is possible that the falling levels of traffic flow on the A660 in recent years reflect an underlying switch from travel to e-activity. The presence of two universities means that involvement in the information economy is very pronounced in the A660 sector and, as is clear from recent statistics, the reductions in peak traffic flow are more marked in the A660 corridor than in any other corridor into Leeds – suggesting that they are not simply a result of economic recession. (DfT census data http://api.dft.gov.uk/v2/trafficcounts/countpoint/id/17374.csv and (http://www.dft.gov.uk/traffic-counts/area.php?region=Yorkshire+and+The+Humber&la=Leeds) reveals that, between 2002 and 2012, the flow of traffic on the A660 at Woodhouse Moor has fallen by 17% while the total for all main roads in Leeds has remained almost constant).

A17. Although some extension of bus priority is specified for the LCA, the modelling results suggest that it has not been properly designed and/or that the potential for more efficient signal settings has been ignored. According to B1.14 of document C-1-1, the provision of more effective priority for buses was rejected because it would result in additional congestion. However, given that the NGT scenario is itself predicted to generate additional congestion, the application of this restriction was clearly selective (and, in fact, some significant benefits could be achieved with minimal impact on general traffic – for example at the junction of Blackman Lane with Woodhouse Lane where buses are currently delayed by a minute or more but could be given absolute priority over a very insignificant cross flow).

A18. If the comparison of scenarios is to be meaningful it must compare like with like. A vital prerequisite is thus that the optimisation of junction designs in the alternative scenarios has received the same attention as it has in the NGT scenario. Document C-1-8 indicates that, with careful design and attention to signal settings, the junctions along the A660 can accommodate the NGT with no appreciable delay caused to other traffic. This shows what can be achieved by careful design of junctions and signal settings but there are several indications to suggest that this degree of attention has not been lavished on the optimisation of junctions in the DM and LCA scenarios. For example:

i. Document C-1-8 suggests (in section 2.4) that optimisation has been attempted in the Do Minimum scenario only for junctions where long delays were evident. Junctions with less severe congestion have apparently been ignored.

ii. The approach to the optimisation of signals in the NGT scenario appears to have been quite different from that used in the other scenarios. A footnote in Table 4.1 of Document C-1-13 (page 23) explains that NGT's southbound journey time is lower in the am peak than in the interpeak (a fact identified in our original Objection letter) because the signals give more priority to the northbound NGT in the am peak than in the interpeak; however we note that the DM Bus and LCA Bus are both much slower in the am peak than in the interpeak and conclude that the minimisation of with-flow congestion in the am peak has received much less priority in the no-NGT scenarios than it did in the NGT scenario.

iii. The runtime analyses summarised in Table 4.1 of Document C-1-13 (page 23) suggest that, southbound from Bodington to the city, the LCA bus is slower than the "bus with NGT" and even than the "Do Minimum bus" (despite supposedly benefitting from various junction improvements and having faster boarding times). This suggests that the junction "improvements" for the LCA were not very carefully designed.

A19. The (negative) value of the loss of trees associated with the proposed scheme. This is remarkable given the strength of public opinion on this issue. A sample survey of 21 trees at St Chads using the Capital Asset Value for Amenity Trees (CAVAT) method suggested they were worth £500,000. (See NWLTF Appendix C). The full value of all 400+ trees to be lost and of those to be lopped can only be speculated on, however given that this sample is largely representative of the overall size, age and quality of trees proposed for removal along the entire route and using data provided by Mott MacDonald within their Arboricultural Assessment, it is possible to extrapolate value of approximately £14,000,000 worth of trees for the proposed entirety of tree loss along the route - a figure which could make a difference to the overall BCR.

A20. We have found no reference to the inclusion of costs for the required relocation of bus stops

A21. Mitigation costs:

i. The cost of maintaining (primarily watering) the new trees has apparently not been fully quantified (and we note that research for the Department of Communities and Local Government and published by ADAS in their Trees in Towns II report, published in 2008, shows that at least 25% of new tree planting in towns and cities perished).

ii. The potential cost of mitigation of damage to heritage assets has not been allowed for. A professional assessment of the NGT Environmental Statement (NWLTF appendix D) concludes, in section 1.4, that the potential cost is unknown and that the proposed use of a 'Grampian' condition to cover all future mitigation of damage to heritage assets is neither enforceable nor reasonable because the archaeological works required cannot be specified in advance.

A22. The appraisal of the NGT scheme, including the calculation of the BCR, includes a significant benefit (£84.2m over the 60 year period) attributed to improved punctuality. However, this estimate, which is explained in document C-1-11, will have been inflated in the following respects:

i. Although the estimate of unpredictable variability has apparently (see paragraph 2.7 of C-1-11) allowed for known effects related to the time of day and some aspects of seasonality, it does not allow for the fact that differences between travel times in and out of term time are well understood and anticipated by travellers (and hence should be excluded from the calculation of variability).

ii. The extent of variation in public transport journey times has been calculated without including the walking time (inclusion of the walking time, which is relatively predictable, would reduce the standard deviation and thus reduce the estimate of variability)

iii. Although it is hard to imagine how a journey by NGT can achieve greater predictability than walking, it has been assumed (see for example Table 3.1 of C-1-11) that travellers who shift from active modes will benefit from a significant increase in punctuality.

A23. The appraisal of the NGT scheme was based on an annualisation of the impacts predicted for different times of day. The peak period impacts were estimated for peak periods during school and university terms (when congestion is at its most marked and hence when NGT would perform best relative to its competitor modes). No estimate of the performance of NGT outside of University and school terms has been published despite the fact that such conditions apply for 28 weeks a year. An adjustment to allow for the fact that the modelled peak period might not be typical was made using data from automatic traffic counts (see Page 5 of Document C-1-2) and from public transport passenger counts (Table 24 in Document C-1-2) but the traffic and passenger counts were Leeds-wide and so will not have reflected the much more marked effects of the University term time in the A660 corridor.

A24. The public transport demand forecasts have a number of very curious features which must raise doubts about their reliability. For example:

i. Table 47 of document C-1-8 indicates that, for the base year, the model predicts the outbound flow of public transport passengers in the Woodhouse Lane Corridor to be 4908 (am peak, interpeak and pm peak combined) whereas it predicts the equivalent inbound flow to be only 2373. There is no obvious explanation for this remarkable lack of symmetry.

ii. Table 10 of appendix 11 of the PEBC (dated March 2012) indicates 36,015 public transport trips in the 2008 morning peak base case while Table 18 of document C-1-8 (dated January 2014) indicates the same thing as 70,878. Either one of the two figures is a mistake or this is an indication of a massive change in the model's prediction. Neither of which possibilities engenders much confidence.

iii. There seems to be some uncertainty about the level of current demand for buses. Appendix 13 of Appendix 3 of the PEBC reports results of the bus occupancy survey which are different from those reported in its Appendix 8 (which deals with bus flow modelling). The morning peak southbound flow at woodhouse flow is variously reported as 1400 or 1045.

A25. The analysis documents also contain many errors which, even if not crucial to the outcome, clearly raise questions about the quality control on the analysis and on the reliability of other claims made for the proposed trolleybus system. For example:

i. The number of NGT users transferring from bus as quoted in Table 12.4 of Document C-1 differ from that quoted in Table 51 of Document C-1-8.

ii. Document A-08e-4 (Socio-economics Technical appendix K) claims (in Table 3.6 on p15) that the development of 1385 houses at Kirkstall Forge is *"in close proximity to St Chads NGT stop*" and that the resulting change in accessibility is "*significantly beneficial"*. (Kirkstall Forge is actually about 1.5 miles from St Chads NGT stop as the crow flies and the walk would involve an exhausting trek crossing three roads, ignoring the bus routes thereon, crossing a railway line, climbing several steep gradients and passing through two woods and across a campus).

iii. The Programme Entry Business Case (in section *2.12, p10/87)* states that the bunching of bus services is '*due to traffic congestion'*. This suggests a limited understanding of the causes of bus bunching – its fundamental cause is long dwell times at bus stops rather than congestion.

iv. There seems to be some confusion over the year for which public transport run time estimates have been (Document B-9 says, in Section 3.41 and in the titles to tables 4.1 *et seq*, that estimates are for 2016 whereas document C-1-13 says that they are for 2020 – even though the titles of tables in Appendix A to that document contain the code "2016").

A26. Although Document C-1-1 (the Alternatives Review) recognises, in para1.3, that "*To obtain the TWAO …. the Promoters must demonstrate that they have considered an appropriate and reasonable set of alternatives to the promoted option*", the consideration of alternative, lower cost, solutions to Leeds' transport problems has not been adequate. For example, the specification of the Low Cost Alternative (LCA) assumes:

i. use of an articulated vehicle (rather than a modern double-decker) and therefore omits the beneficial impact on other traffic (note also that the Stated preference work, reported in Document C-4-24, indicated a passenger preference for modern double-deckers over FTR-like vehicles);
ii. no improvement in bus service quality (Table 2 of Document C-1-9, describing the input assumptions for the LCA, states that bus service quality will be the same as existing buses);
iii. no improvement in routing (e.g. to provide a cross city service or to avoid the inefficient routing at Blackman Lane).
iv. no reduction in bus emissions (despite legislation already in place);
v. no increase in capacity or frequency (note that bus frequencies and capacities have already increased above the levels extant in early 2013);
vi. no improvement in punctuality (such as would be achieved by reduced boarding times).

A27. The LCA assumes a very modest improvement in bus stop quality (e.g. it excludes any further provision of at-stop information) despite the fact that such improvements are relatively cheap (the Capital Costs Report, Document C-2-18 , indicates that the total cost for all of the NGT stops was around £5.2m) and are responsible for the majority of the scheme benefits.

A28. Those who choose to use the NGT will be less likely to get a seat than they were when they used buses (current buses have 70 seats and space for 20 standing (i.e. 77% seated) and, although the number of sets per NGT vehicle is not yet known, it has been estimated that achievement of the quoted 160 places in a single articulated vehicle would leave room for no more than 45 (i.e.28% seated).

A29. Even setting aside the concerns we have expressed as to the accuracy of the predicted run times (see *A1* above), and ignoring the fact that bus journey times are likely to be reduced by speeding up the boarding times, it can be shown (see *A35* below) that the journey from Bodington to the city centre would be only 8 minutes quicker by NGT in the morning peak and only 2 minutes quicker in the interpeak - during which period many more trips are made. Furthermore, if the usual weightings are applied to the various elements of journey time it can be shown that the perceived journey time by NGT is up to 5 minutes longer than that by the Do Minimum bus).

A30. The anticipated increase in overall bus journey times is much more important than any improvement offered by NGT for those people who are effectively captive to bus services. For example, those who:

i. have an origin or destination is on a bus route not served by NGT (e.g. along the northern extremities of the #28, #1, #93 or #97 routes, to the east of the city centre or via a connection at the bus station)
ii. have walking difficulties and whose nearest stop is a bus stop rather than an NGT stop, or
iii. would be unable to stand for the duration of the journey.

A31. Door-to-door Journey times by bus are actually predicted to increase (the predicted reduction of 1.3 minutes in the am term time peak and of 1.2 minutes at other times quoted in Table 4.1 of document C-1-13 for the southbound journey from Bodington to the city is misleading because it relates only to in-vehicle time; the overall door-to-door journey times would all show increases because the average waiting time will increase by 1.5 minutes due to the reduced frequency).

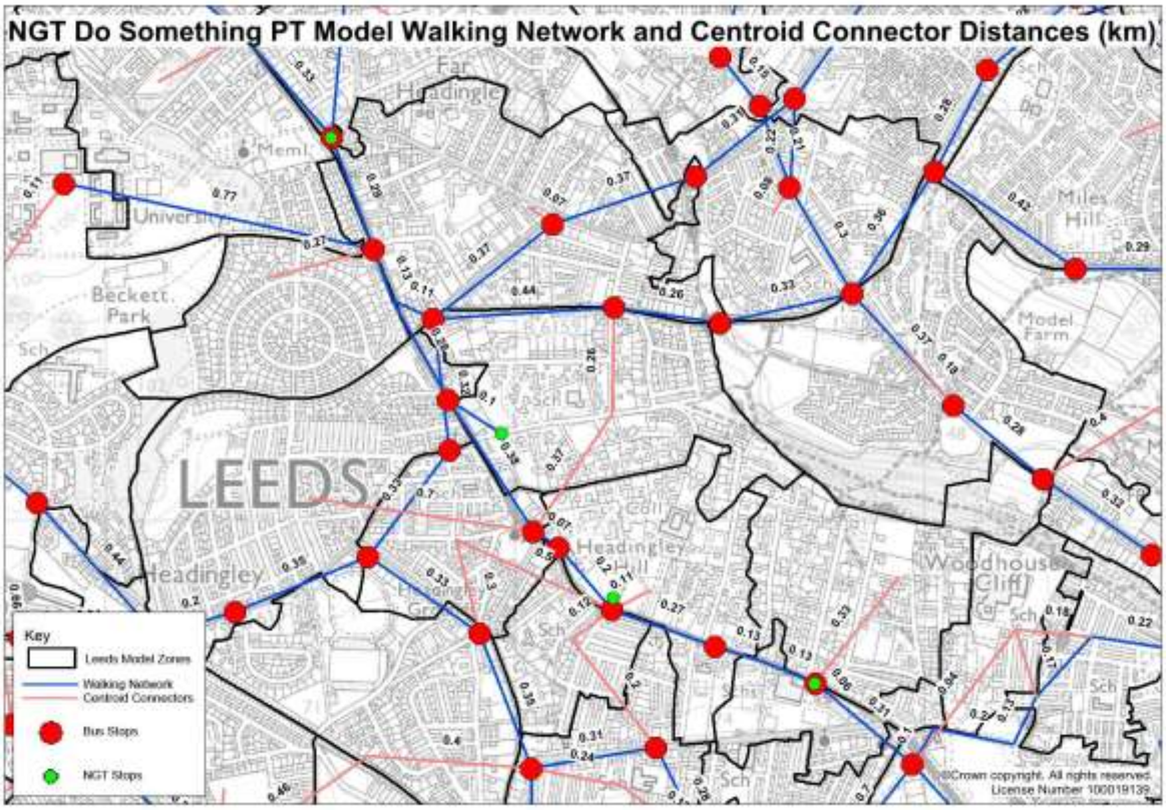
A32. An aspiration (a WYLTP key indicator, quoted in Table 7.3 in section 7.11 of Document C-1) was that NGT would achieve a modal shift in favour of public transport. However, we note that, compared to the Do Minimum scenario:

i. The proposals are predicted to result in a reduction in overall public transport passenger kms (Table 9 in Document C-1-9 gives annualised predicted passenger kms for all public transport modes in 2031 and shows that the figure for NGT (1,212,556) is lower than that for the NBA(1,217,491) and than that for the LCA (1,233,825). No figure is given for the Do Minimum case but, given that the DM buses are predicted, e.g. in Document C-1-13, to have the same journey times as the LCA but will offer a higher frequency service at any given stop, we can assume that public transport in the DM scenario would be at least as attractive as in the LCA and so we can assume the reduction in total public transport passenger kms to be even greater when compared with the Do Minimum scenario).
ii. The proposals are predicted to result in an increase in total car kms (see table 58 of document C-1-8).
iii. The majority of the predicted Trolleybus patronage is simply transferred from public transport (from table 12.4 in document C-1 it can be seen that, after weighting for the number of hours in each time period, over 75% of NGT users are predicted to have transferred from public transport).

A33. The fourth objective for NGT listed in Table 3.8 of Document C-1 was to '*Improve efficiency of city's Public transport and Road networks*'. The Promoters claim to have interpreted efficiency as if it were the same thing as the "*conventional DfT value for money"* but what they actually report in Table 7.2 of Document C-1 (where they assess the NGT scheme against the efficiency objective) falls far short even of that because it only reports the public transport passenger journey time benefits (which, by their definition, include perceived quality improvements), revenue surplus and perceived punctuality benefits - it takes no account at all of costs or of disbenefits to other road users!

The correct way to measure transport system efficiency is to consider the total inputs (traveller time, vehicle operating costs, public transport operating costs, infrastructure costs and the costs of externalities such as accidents, noise and pollution) per unit output (e.g. per trip made). The inclusion of intangible ("perceived") benefits is acceptable provided that perceived disbenefits are also included. Revenues and taxes are a transfer and should not be included in the calculation of system efficiency. Unfortunately the figures required to calculate this measure have not been released but, since the NGT proposals are predicted to result in an increase in private vehicle trip lengths and an increase in congestion (as measured by average highway speeds detailed in table 7 of Document C-1-9) there is prima-facie evidence of reduced efficiency in the highway network. Also, even according to the unduly optimistic figures in Tables 17.1 and 17.4, the £701m in public transport passenger travel time savings over the appraisal period needs to be reduced by at least £440m (to remove the value of the perceived boarding penalty – see *A12*), by £274m of investment, by £120m of increased public transport operating costs, by £14.7m of increased private vehicle operating costs, by £12.2m of increased private vehicle occupant travel time and by £25.4m increased accident costs. The result, less £6.4m in reduced GHG, is a negative £178.9m. In other words, the NGT scheme causes <u>a reduction in system efficiency</u>.

A34. Map of Centroid connectors and walk links in the Headingley area (supplied by AECOM in response to a data request by P Bonsall to the NGT Team)


NGT Do Something PT Model Walking Network and Centroid Connector Distances (km)
Key
Leeds Model Zones
Walking Network
Centroid Connectors
Bus Stops
NGT Stops
LEEDS
Far Headingley
Beckett Park
University
Headingley
Headingley Hill
Woodhouse Cliff
Miles Hill
Model Farm
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A35. Recalculation of journey times from Bodington to the city

The table below starts with the journey times quoted in Appendix A of the Run Time Assessment Report (Document C-1-13). The comparison is then progressively improved, firstly by effecting three corrections:

1. To provide times to the first bus/NGT stops encountered after entering the City Centre (the original figures were times to City Square but this is inappropriate because buses are required to take a tortuous route via The Headrow in order to reach City Square and because most passengers from Bodington will not wish to travel all the way to City Square. The Arena and Merrion Centre stops provide a fairer comparison.
2. To add the walk time to and from bus/NGT stops (assuming an average walking distance at each end of 300 metres for bus and 360 metres for NGT – the extra 60 metres for NGT is due to the wider spacing of stops – I have assumed that the additional walk distance is 25% of the average difference in spacing)
3. To add in the waiting times (based on half the headway – the same assumption as is made in other NGT modelling work).

At which point we see that, in the am peak, the NGT advantage is reduced from 13 minutes to 8 minutes while in the interpeak NGT's advantage of seven minutes has been reduced to 2 minutes.

We then add weightings for walking and waiting (using the values used elsewhere in the NGT analysis) and for time spent standing on the bus or NGT vehicle (adding a very conservative 0.5 to the normal weighting of 1.0 - work in the rail industry could be taken to support a doubling of the normal weighting).

At which point we see that, in the am peak, the NGT advantage of 13 minutes been reduced to less than 2 minutes while, in the interpeak (which is far more important in terms of numbers of passengers carried), NGT's advantage of 7 minutes has become a disadvantage of 5 minutes.

Note that this comparison is based on data in Doc C-1-13 and does not allow for the fact that bus boarding times could be improved or that the delay to buses caused by the diversion via Blackman Lane could easily be reduced.

Bodington to city	mins			
	Am peak southbound		Interpeak southbound	
	NGT	DM	NGT	DM
Output from runtime model in app A of c.1.13	19.63	32.5	20.64	27.89
Corrections:				
Improve comparability– delete times shown in Appendix A of Doc C-1-13 as being incurred after arrival at Arena/Merrion stops	*-2.83* 16.8	*-5.42* 27.09	*-2.83* 17.81	*-5.42* 22.47
Add walk time (assuming average walk speed of 2mph)	*+ 6.7* 23.5	*+5.6* 32.69	*+6.7* 24.51	+5.6 28.07
Add wait time (assume 50% of headway)	*+3.0* 26.50	*+1.5* 34.16	*+3.0* 27.51	*+1.5* 29.57
Weightings:				
Apply standard weightings for walk (1.3) and wait (2.85 am 2.48 IP)	*+2.01+5.55* 34.06	*+1.68+2.78* 38.62	*+2.01+4.35* 33.87	+1.68+2.18 33.43
Apply reasonable weighting for standing. In the am peak we assume 66% stand in NGT (0.66x0.5=0.33) while 20% stand in bus (0.5x0.5= 0.25). In the interpeak we assume 50% stand in NGT none in bus (0.2x0.5=0.1)	*+16.8x.33* *= + 5.54* 39.60	*+27.09x.1* *= +2.71* 41.33	*+17.81x.25* *= +4.45* 38.32	+ 22.47 x0 = + 0 33.43