Inspector's questions of clarification on RTS Vision to Plan [EB/079]

5.1 Capital cost

1. How were the capital cost estimates shown in Table 5-1 calculated?

Each route option comprises a series of sections. Each section has been classified by infrastructure typology. The typologies indicate if a section is fully dedicated to RTS such as on a garden community, if it is segregated on an existing road such as a bus lane, if it includes only traffic control priority measures such bus gates, etc... The typologies are shown in Table 2.4 (page 8).

As part of the development of the typologies, cost estimates were derived based on knowledge of previous schemes in discussion with consultant ITP. These were checked with the highways engineering team at Essex Highways. This checking was also able to draw on the work of the highways team to estimate the cost of Route 1 of RTS for the Housing Infrastructure Fund bid. The estimates used are shown in the table below.

		Cost per km - lower bound (£m/km)	Cost per km - upper bound (£m/km)
Type 1	Segregated - dedicated	3.75	5.40
Type 2	Segregated - reserved	7.58	10.92
Type 3	Traffic controlled	0.75	1.08
Type 4	Place focus	1.88	2.70
Type 5	Priority	1.88	2.70
Type 6	Shared	0.50	0.72

The length of each type of infrastructure on each route option was then calculated. Using these lengths and the values in the above table, estimates of lower and upper bound costs were then derived.

As explained below Table 5.1 (page 52), the resulting average costs per kilometre were compared to benchmark average per kilometre costs from BRT schemes in Bristol and Salford. The benchmarking exercise does suggest that costs are likely to be towards the upper bound. Nevertheless, there is confidence that these estimates are sensible.

2. How were the end-to-end journey times shown in Table 5-1 calculated?

The RTS routes are coded into the transport model as a new public transport alternative. Where the RTS vehicles benefits from Type 1 – Type 5 infrastructure, it is assumed that RTS speeds will be more reliable than general traffic. Hence, travel speed is pre-defined in the model.

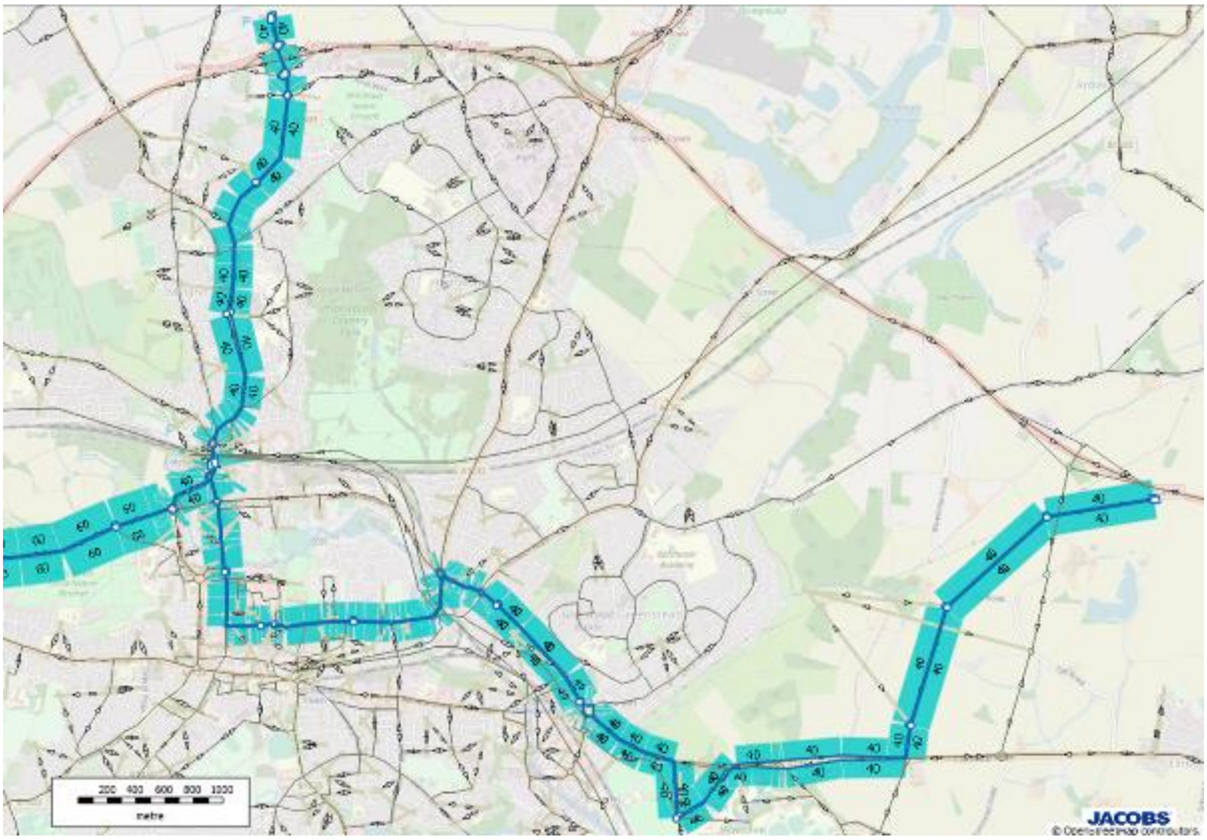
As a general rule, we set travel speed at 40 km/hr within garden communities and urban areas. Travel speed was allowed to increase to between 50-80km/hr on inter-urban sections.

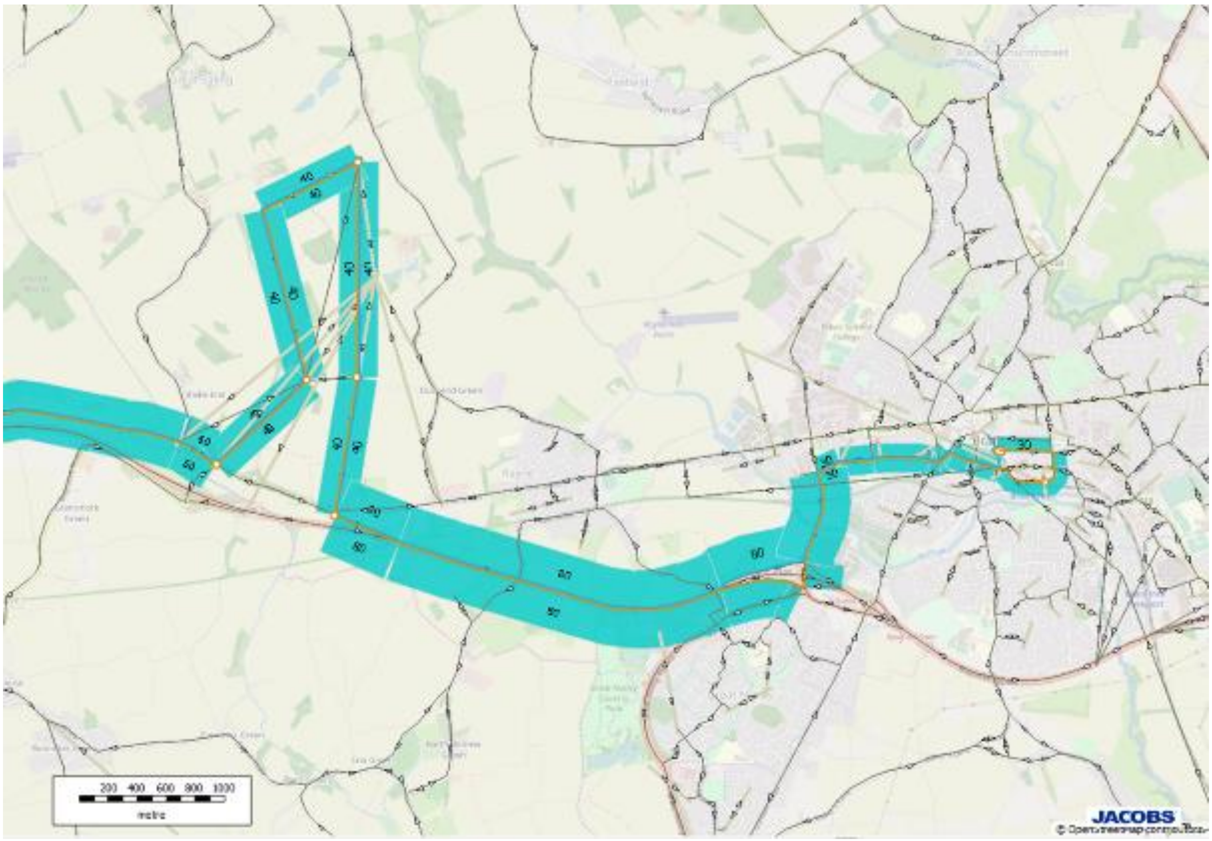
Where RTS runs with traffic, the RTS vehicle only travels as fast as general traffic. In built up areas general traffic tends to travel slower than predefined fixed RTS speeds. However, in inter-urban areas general traffic can travel faster than predefined fixed RTS speeds. This latter cased can lead to anomalies whereby RTS is faster without fixed infrastructure in the model.

The transport model also forces each RTS vehicle to stop for 30 seconds at each stop (which was a period discussed and agreed with the public transport advisor Go-Ahead as sensible). Therefore the average speed of RTS is slower than the fixed speeds or general traffic speeds.

The transport model is then used to calculate the time taken to travel along a route. This provides the end to end journey times shown in Table 5.1.

For information, the plots below show assumptions on RTS speeds in the 2033/51 best case scenario on Routes 1, 2 and 3. Where no speeds are shown it is assumed that RTS travels at the speed of general traffic.





5.2 Revenue forecast

The first paragraph under this heading reads:

Revenue forecasts have been developed using outputs from a multi-modal transport model. It should be noted that these revenue forecasts are linked to the higher investment and lower investment scenarios, and not to the phasing described above in 5.1.1. Thus, the journey times inherent in that phased approach to capital may result in lower demand and revenue than that presented here in 2033.

And the first bullet point under 5.4 Commercial viability says:

[…] *The number of trips generated is linked to provision of the entire RTS system (with the exception of route 4 in 2033) and it cannot therefore be assumed that the same number of trips would occur if only one route section were provided;*

3. Do these two statements mean that the revenue forecasts which appear in Table 5-10 for 2026 and 2033 are based on Routes 1, 2 & 3 being complete, as they would be in at the end of the total capital spend programme in 2051? And that the same applies to the operating surplus / deficit forecasts in Table 5-15?

The answer for 2026 is no. The only assumed route in 2026 is a lower investment in Route 1.

For 2033, however, the table provides two alternative scenarios for the level of investment attained by 2033 on Routes 1, 2 and 3. The lower bound is based on a floor level of investment related closely to the expected level of investment by 2033. The upper bound is based on the aspiration for a higher level of investment. The extent of investment in routes 1, 2 and 3 is likley to lie between the upper and lower bounds.

This is also explained further in Scetion 5.5 of the report.

The sixth bullet point under 5.4 Commercial viability says:

these operational viability estimates are not explicitly linked to the capital cost phasing described in 5.1.1, with the exception of the higher investment, 2051 values.

4. Is this sixth bullet point making a different statement from the first bullet point? If so please clarify what it means.

No, it is making the same point. It is felt that the high investment scenario in 2051 is the point being aimed for.

5. Table 5-9 shows total annual demand for the RTS in 2026, 2033 and 2051 (factored up from AM peak hour demand as shown in Table 5-8). From the modelling, is it possible to say what percentage mode share that represents for journeys originating in the proposed garden communities?

The transport model considers car trip and public transport trips between origins and destinations represented by model zones. The transport model does not consider cycling or walking trips. So while the model can provide a car/PT split, this does not equate to a modal split including other modes. This modal share reports considers this and uses additional assumptions to provide a modal split.

Nevertheless, recognising that the PT/car split is not the same as a full modal split, tables are provided below showing the PT/car split in the garden communities and in the wider districts. In developing the model these were used to check that shift to RTS was not unrealistically high, or conversely, unrealistically low.

It is noted that a later question asks for information on how the PT/car split is calculated in the transport model. Hence this explanation will be left till Question 9. Nevertheless, it is worth noting that the PT/car split is not defined externally by setting it to a target level. Rather it reflects the journey times in the transport model. Thus the PT/car split in the model is less than the target mode share. This is considered more prudent since we wish to establish the likely feasibility. As the modal share report explains, continued investment across a range of measures over many years will be required to meet the mode share targets.

2033: “Best Possible”

Garden Community	Easton Park GC	West of Braintree GC	Col Braintree Borders GC	Tendring Colchester GC	Great Dunmow	Braintree	Chelmsford	Witham	Keveldon & Coggeshall & MarksTey	Colchester	Colchester North	Colchester South	Colchester Center
Car Trips	1000	1179	1805	1834	3781	10379	32195	7689	3288	36682	11816	16660	8206
PT Trips	168	393	434	423	598	1,510	4,903	1,632	613	7,047	2,086	2,871	2,091
Total	**1,168**	**1,572**	**2,239**	**2,257**	**4,379**	**11,889**	**37,098**	**9,321**	**3,901**	**43,729**	**13,901**	**19,531**	**10,297**
PT Share	**14.40%**	**24.99%**	**19.39%**	**18.73%**	**13.66%**	**12.70%**	**13.22%**	**17.51%**	**15.72%**	**16.12%**	**15.00%**	**14.70%**	**20.30%**

2051: “Best Possible”

Garden Community	Easton Park GC	West of Braintree GC	Col Braintree Borders GC	Tendring Colchester GC	Great Dunmow	Braintree	Chelmsford	Witham	Keveldon & Coggeshall & MarksTey	Colchester	Colchester North	Colchester South	Colchester Center
Car Trips	3866	3180	5725	4171	3459	10635	36556	7944	3307	38263	13932	16375	7957
PT Trips	992	1,123	1,676	1,303	752	1,670	5,129	1,690	650	8,610	3,161	3,167	2,282
Total	**4,858**	**4,303**	**7,401**	**5,474**	**4,211**	**12,305**	**41,685**	**9,634**	**3,957**	**46,873**	**17,093**	**19,541**	**10,239**
PT Share	**20.43%**	**26.10%**	**22.64%**	**23.80%**	**17.85%**	**13.57%**	**12.30%**	**17.55%**	**16.43%**	**18.37%**	**18.49%**	**16.20%**	**22.29%**

It is worth noting that the model does not seem to over-estimate the amount of trips on PT relative to the background level of PT use.

<u>5.3 Operating costs</u>

The third paragraph under this heading reads:

The estimate [of £225,000 for depreciation, maintenance and staffing of each RTS vehicle] is based on industry experience of the typical annual cost of operating a bus, which ranges from £160,000 to £250,000. A value towards the upper end of this range has been chosen to reflect the quality of service intended to be provided.

6. Would this annual cost provide a vehicle that meets the description in the first and fourth bullet points of section 2.2.1?

Yes, this is what was in mind. An example, it the vehicle used by the Belfast Glider, which have capital cost of £650,000. The annual £225,000 costs could be expected to be spent as follows:

Lease costs 8% x £650,000	£52,000
Staff and on costs	£100,000
Fuel	£20,000
Maintenance 8% x £650,000	£52,000
TOTAL	£224,000

<u>Appendix A</u>

The third paragraph says:

The PT model includes bus and rail networks which have been coded into EMME. The PT base matrix has been synthetically created by combining:

• NTEM data from 2014 (to provide trip ends);

• Census 2011 journey to work data, for distributing all Home Based Work trips and those Home Based Other trips on train; and

• SATURN highway base matrix for distributing Home Based Other trips on bus.

7. What percentage mode share of all trips does the total number of trips in the PT base matrix represent, and how was this mode share derived?

Please refer to the caveat explained in Question 5, that the model only considers PT and car trips, and not other modes. In answering this question, it is considered informative to provide a table in the same format as those provided in Question 5. That West of Braintree starts from a high base is a minor anomaly and not one that as of concern since the number of trips are so low.

Garden Community	Easton Park GC	West of Braintree GC	Col Braintree Borders GC	Tendring Colchester GC	Great Dunmow	Braintree	Chelmsford	Witham	Keveldon & Coggeshall & MarksTey	Colchester	Colchester North	Colchester South	Colchester Center
Car Trips	341	85	395	298	1686	8825	26881	8141	2767	31593	8768	13999	8826
PT Trips	0	61	67	52	145	949	4,536	1,457	412	4,086	882	1,530	1,675
Total	**341**	**146**	**462**	**350**	**1,831**	**9,774**	**31,417**	**9,598**	**3,179**	**35,679**	**9,650**	**15,529**	**10,501**
PT Share	**0.00%**	**41.94%**	**14.41%**	**14.74%**	**7.91%**	**9.71%**	**14.44%**	**15.18%**	**12.95%**	**11.45%**	**9.14%**	**9.85%**	**15.95%**

The fifth paragraph gives the formula for deriving PT trip rate for the future growth trip matrices:

$$PTtrip\ rate = Cartrip\ rate * [PTshare\ /\ Carshare]$$

8. What values were used for PT share and Car share in this formula?

The PT and car share values were taken from the 2011 Census as shown in the table below.

District	Car	Train	Bus
Braintree	85%	11%	3%
Colchester	81%	11%	8%
Tendring	90%	7%	3%
Uttlesford	86%	12%	2%

The paragraph headed "Mode choice" explains how the incremental mode choice model was used:

An incremental mode choice model was included to capture modal shift as public transport improves (due to the RTS) relative to the highway. It is calibrated based on the behaviour of the base model. It works by altering the share of public transport trips if there is a change in the PT generalised cost relative to highway generalised cost.

9. Please give more details of how the incremental mode choice model works. In particular, how are the PT and highway generalised costs calculated, and how do any changes in such costs translate into changes in mode share?

The transport model has over 500 zones denoted by the centroid markers in the plot below.

For each zone the number of PT and car 'trip ends' are known along with distributional information on the destination and origin of these trips. This information on trips is also classified by vehicle type and trip purpose.

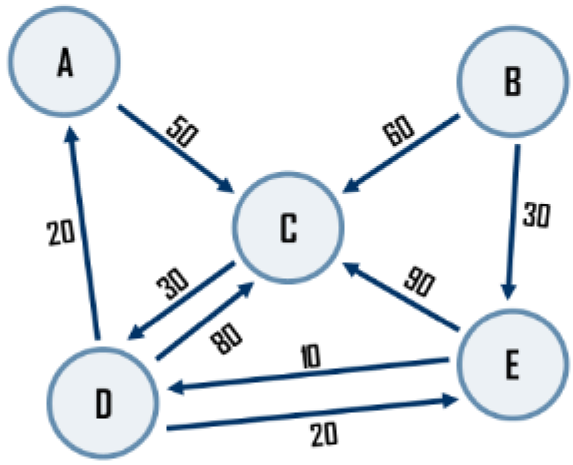
This information is used to form a set of trip matrices. Each model year has a different set of trip matrices. But each scenario in the same model year commences the modelling process with the same trip set of trip matrices. Although the model will change the matrices based on (a) alterations to the distribution due to the creation of garden community settlements in greenfield sites and (b) mode choice decisions where some trip can switch between car and PT modes.

We have matrices for:

- Car commuting
- Car other trips
- Car business trips (which is different from a community trip to work)
- PT commuting
- PT other trips
- LGV trips
- HGV trips

The figure below shows a simplified matrix.

Spatial Interactions



O/D Matrix

	A	B	C	D	E	Ti
A	0	0	50	0	0	50
B	0	0	60	0	30	90
C	0	0	0	30	0	30
D	20	0	80	0	20	120
E	0	0	90	10	0	100
Tj	20	0	280	40	50	**390**

The assignment model that takes the matrices and assigns the trips to the highway network or PT network. The assignment to the highway network takes into account congestion effects, so trips are not always added to the most direct route. The PT trips are similarly assigned although crowding is not taken into account. Hence, we now know the route each trip takes to its destination.

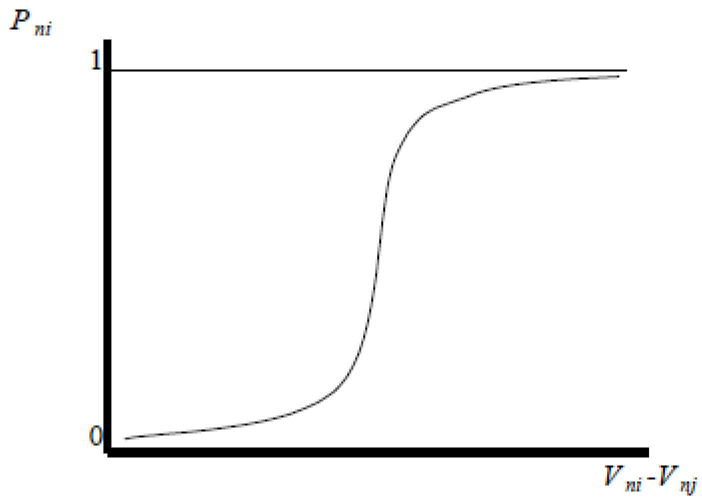
However, given the effect of congestion and if a scenario makes improvements to the PT network (such as introducing a new route), we would expect that some car drivers might switch to PT. Similarly, if an improvement is made to the highway network we would expect that some PT users might switch to car use. [Note that this is a simplification of reality as we are not taking into account choices such as multi-mode journeys (using car and PT) or decisions not to travel (such as working from home).]

From the base year transport model we know the number of trips on the highway network and the number of trips. Specifically we know the number of trip ends at each origin and destination and how they are assigned onto the highway and PT networks. We have also been able to check that the assignment is realistic. i.e. that the amount of traffic on links or trip assignment to bus or train service is close to reality. During the calibration process there are methods that are used to help the transport model get closer to predicting this current reality. (So even though we necessarily make simplification and assumptions on of travel behaviour the model predicts the current state well.)

From the base model we develop a mode choice model, which has the general form:

$$P_{ij}^{1} = \frac{\exp\left(-\lambda C_{ij}^{1}\right)}{\exp\left(-\lambda C_{ij}^{1}\right) + \exp\left(-\lambda C_{ij}^{2}\right)} = \frac{1}{1 + \exp(-\lambda(C_{ij}^{2} - C_{ij}^{1})}$$

To understand this equation, however, it is worth considering the shape of the curve it produces. This is shown below for some different values of lambda.



The formula is telling us the probability of choosing to travel by one mode compared to another mode based on the difference in costs between the two modes. The key to a good mode choice model is ensuring a sensible parameter lambda is chosen so there is a realistic level of response. In our case we also introduced a damping factor to avoid long trips (>30km) changing modes – further improving realism as we didn't expect RTS would have a big impact on long distance trips.

So now we have a realistic base model and a mode choice model. This is used as the basis for the forecast tests as follows:

1. Set up forecast network

2. Set up the forecast trip matrices

3. Assign the trips to a network

4. Produce a matrix showing the generalised cost between each OD pair

5. Use the mode choice model to predict a new mode split between PT and car (not applied to external trips of the main area). The output are new trip matrices.

6. Run the model again with the new trip matrices to produce the final assignment.

In step 5 we exclude external trips and identify the change from the base model. Hence, we call the approach incremental as we are making an incremental change to the base model rather than an absolute change to the entire trip matrix.

In Step 4, we obtain generalised costs from the model. In the case of car trips, between each origin and destination we know the route (or routes) that a car trip takes, which the assignment model has found. The assignment model also calculates the speed and time take along each link, thus taking into account congestion effects. Thus we are able to extract a 'skim' matrix from the transport model of the journey time between each origin and destination.

We then adjust this matrix to add values such as walk time. We also make a further adjustment to take into account vehicle operating costs, value of time and the number of passengers. This is combined to provide a generalised cost or car travel. This is different between each origin and destination. Thus in each matrix we have over 250,000 different values for generalised cost (500*500).

We perform a similar exercise for PT trip to produce a generalised cost between each origin and destination for travel by PT.

With this information we are able to use the formula for predicting the mode split between cars and PT between each origin and destination.

The paragraph headed "Assignment" reads:

The EMME model has a highway component and a public transport component. It assigns a fixed number of highway trips and a fixed number of PT as calculated in the mode choice model. (It does not assign trips between the highway and PT networks.) Highway trips are assigned to the highway network through an optimisation procedure which considers the generalised cost of journeys.

Mr Johnstone criticises the way that the EMME model has been used in his Matter 6 hearing statement. His response to the Inspector's Q23 says:

Jacobs state […] for the NEA RTS at Para 5.2 of EB/079 that:-

> *"…A multimodal transport model has been developed using EMME transport modelling software.....that combines Highway and a Public Transport (PT) models."*
>
> *"…Revenue forecasts have been developed using outputs from a multimodal transport model."*

EMME however has not actually been used in full as is suggested above and that is the issue. This fact should now be fully disclosed and the shortcomings inherent with the cut-down approach actually adopted by Jacobs accepted and brought to everyone's attention. EB/079 reinforces this assertion, since it is stated by Jacobs on Page 70 that EMME, as actually used on the WoBGC:-

> *"…assigns a fixed number of highway trips and a fixed number of PT as calculated in the mode choice model. It does not assign trips between the highway and PT networks."*

The "mode choice model" referred to here is just a manual spreadsheet, so this clearly is contra to how a true multi-modal model should be set-up and deployed. The EMME work presented by Jacobs in EB/079 is in fact just a hand *calculation and does not consider congestion, which is a fundamental part of making a selected transport choice as a resident of (say) WoBGC or CBBGC. If the journey by bus to Stansted or Colchester is as slow as that by car, then why travel by bus? The EMME model, it would seem, is not capable of making this distinction and this aspect now needs to be properly considered by Jacobs and a full and coherent written explanation provided as to exactly how and why EMME has been used, particularly as it underpins the mode-share targets provided within EB/080.*

10. What is the NEAs' response to this specific criticism of the way that the EMME model has been used?

"The EMME model has a highway component and a public transport component. It assigns a fixed number of highway trips and a fixed number of PT as calculated in the mode choice model. (It does not assign trips between the highway and PT networks.)"

As explained in Q9, this is incorrect. We do assign trips between highway and PT networks.

"EMME however has not actually been used in full as is suggested above and that is the issue. This fact should now be fully disclosed and the shortcomings inherent with the cut-down approach actually adopted by Jacobs accepted and brought to everyone's attention."

This is incorrect. Information on the amount of forecast trips, and hence revenue, is obtained directly from the Emme transport model. This process for this is described in Question 9.

"EB/079 reinforces this assertion, since it is stated by Jacobs on Page 70 that EMME, as actually used on the WoBGC:-

> *"…assigns a fixed number of highway trips and a fixed number of PT as calculated in the mode choice model. It does not assign trips between the highway and PT networks."*

The "mode choice model" referred to here is just a manual spreadsheet, so this clearly is contra to how a true multi-modal model should be set-up and deployed."

This is a misunderstanding, we believe, by Mr Johnstone. It is true that it is a fixed trip model which does not vary the total demand. However, as described in Question 9, the Emme model most certainly alters the balance of trips between highway and PT matrices. While more sophisticated transport models will include more iterations, the method we have used is entirely consistent with usual practice and the multi-modal modelling methodology.

The mode choice model is intricately and seamlessly linked to the assignment model through a series of macros within Emme. In would be incorrect to describe this as a manual spreadsheet. It would also be unfeasible to operate a manual spreadsheet since across matrices we have over 1,000,000 calculations per scenario to perform as described in Question 9.

It should be borne in mind that city regions often have a range of model packages available, which are expensive to upkeep. It is unreasonable to expect an area like North Essex to have such as suite of models. We have therefore taken a proportionate approach applicable to the strategic plan making stage of a scheme.

"The EMME work presented by Jacobs in EB/079 is in fact just a hand calculation and does not consider congestion, which is a fundamental part of making a selected transport choice as a resident of (say) WoBGC or CBBGC."

This is incorrect. As described in Question 9, congestion effects are considered and do inform mode choice.

"If the journey by bus to Stansted or Colchester is as slow as that by car, then why travel by bus?" The EMME model, it would seem, is not capable of making this distinction and this aspect now needs to be properly considered by Jacobs and a full and coherent written explanation provided as to exactly how and why EMME has been used, particularly as it underpins the mode-share targets provided within EB/080."

The mode choice model, as described in Question 9, makes reasonable predictions using established and proven modelling techniques based on the changes between generalised costs of travel by car or PT. PT will never be a alternative for some people for some journeys, however, by putting in a significant new RTS route with faster journey times than current bus services this will suit some people for some trips. Accordingly, transport model realistically identifies a proportion of trips that could be attracted to PT modes.

It follows that we disagree with the conclusions of Mr. Johnstone. The current transport modelling has been proportionate and appropriate to the strategic planning stage. As we move into detailed design, transport models are being enhanced to have a more sophisticated approach. This is part of the iterative development of major schemes. We disagree with Mr Johnstone that such sophisticated transport models should be available at a strategic planning stage.