TFN STRATEGIC DEVELOPMENT CORRIDOR (SDC) STUDIES

FIXED SPEED ADJUSTMENT FOR URBAN AREAS

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Project:	TfN Strategic Development Corridor (SDC) Studies
Subject:	Fixed Speed Adjustment for Urban Areas
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1. INTRODUCTION

1.1.1 TfN propose to make use of the Regional Traffic Model (RTM) series of tools made available by Highways England (HE) to support their corridor based analysis on the Strategic Development Corridor (SDC) studies.

1.1.2 The RTM were commissioned in 2015 and delivered in early 2017. The RTM series of models cover five areas of England:

- North;
- Trans-Pennine South;
- Midlands;
- South East; and
- South West

1.1.3 The primary objectives of the RTM was to focus on HE scheme interventions on the Strategic Road network (SRN) and less of the focus on the urban areas.As such,detailed simulation coding was primarily focused on and adjacent to Highways England's Strategic Road Network (SRN). That means change in delays in response to flow changes was fully captured, thus would be more robust in modelling route choice and subsequently to the scheme economic appraisal.

1.1.4 In constrast to the SRN networks, the urban areas were not the primary focus of the RTM model development. As a consequence, the urban areas were coded in a form of reduced simulation with aggregated zone system and fixed speed network coding.

1.1.5 A key constraint for modelling the SDC corridors is the level of detail and the specification of the network coding (and associated zone system) in urban areas, which is:

- The coarse network density and the fixed speed coding in these urban areas mean that localised level of delay is not modelled in detail.Also this level of delay is not responsive to changes in demand. This results in the impacts of scheme improvements on the strategic road network on the reduction of travel time/congestion of the road network in the urban areas will not be accurately assessed and is likely to underestimate the benefits of the scheme improvements.
- The aggregated zone system within the urban areas would potentially result in missing benefits due to large amount of trips within the urban areas being represented as intral-zonal trips as opposed to inter-zonal trips that could benefits from the proposed schemes.

1.1.6 The different type of coding is likely to result in the misrepresentation of traffic assignment across urban areas and underestimate the journey time savings resulting from SDC interventions tested in the model.It is therefore important to allow for this constraint in option appraisal for the SDC studies.

1.1.7 The work by Atkins was always defined as being part of the Trans-Pennine Tunnel (TPT) project and if timescales and a successul outcome permitted, the outputs would potentially be fed into the SDC work.

1.1.8 It was identified that as part of this project the consultants would be required to address the absence of benefits due to the network limitation. Whilst the original study brief referenced proportional modelling, the specific mechanisms for achieving this was not prescribed. The WSP's response to the procurement clarification in August 2017 recognised the limitations of the TPS model in urban areas in terms of potential missing benefits in urban areas, this note therefore sets out the proposed adjustment that could be made to the urban coding to deliver functionality in the absence of extensive additional coding or additional software functionality.

1.1.9 The North Regional Transport Model (NRTM) and the Trans-Pennine South (TPS) RTM cover the majority of the three TfN SDC study corridors. The fixed speed coding in urban areas are only present in the TPS RTM model, this not therefore focusses on the proposed approach to deal with the fixed speed in urban areas for the forecast models to be developed for the TfN SDC corridors.

2. BACKGROUND

2.1.1 One of the challenges involves the level of coding detail available. Differing levels of coding detail offer differing opportunities and constraints.

- Positive aspects associated with a high level of coding detail
- Accuracy of supply model; and
- Responsiveness of assignment to supply side constraints.

2.1.2 Limitations on the ability to provide a high level of network coding detail include:

- Additional time availability to code in network detail;
- Additional run time (often excessive) to process flow / simulation delay for a multitude of links and nodes;
- Data availability including high quality sources of information on capacity and delay; and
- Future coding detail, requiring knowledge of localised schemes and layouts.

2.1.3 RTM platforms rely on SATURN software for traffic assignment. SATURN can be run with varying levels of detail.Simulation coding reflects the detailed junction capacity at intersections, considering saturation flows by movement, conflicts and control mechanisms. Junction delay is generated by traffic stream and demand in excess of capacity results in traffic queue which can propagate to upstream links in a process known as blocking back.SATURN can also separately or in combination apply volume delay relationships. In this mode increasing flow results in increasing delay, based on a defined “speed flow” curve. This is more commonly used for longer inter-urban links rather than dense urban network.

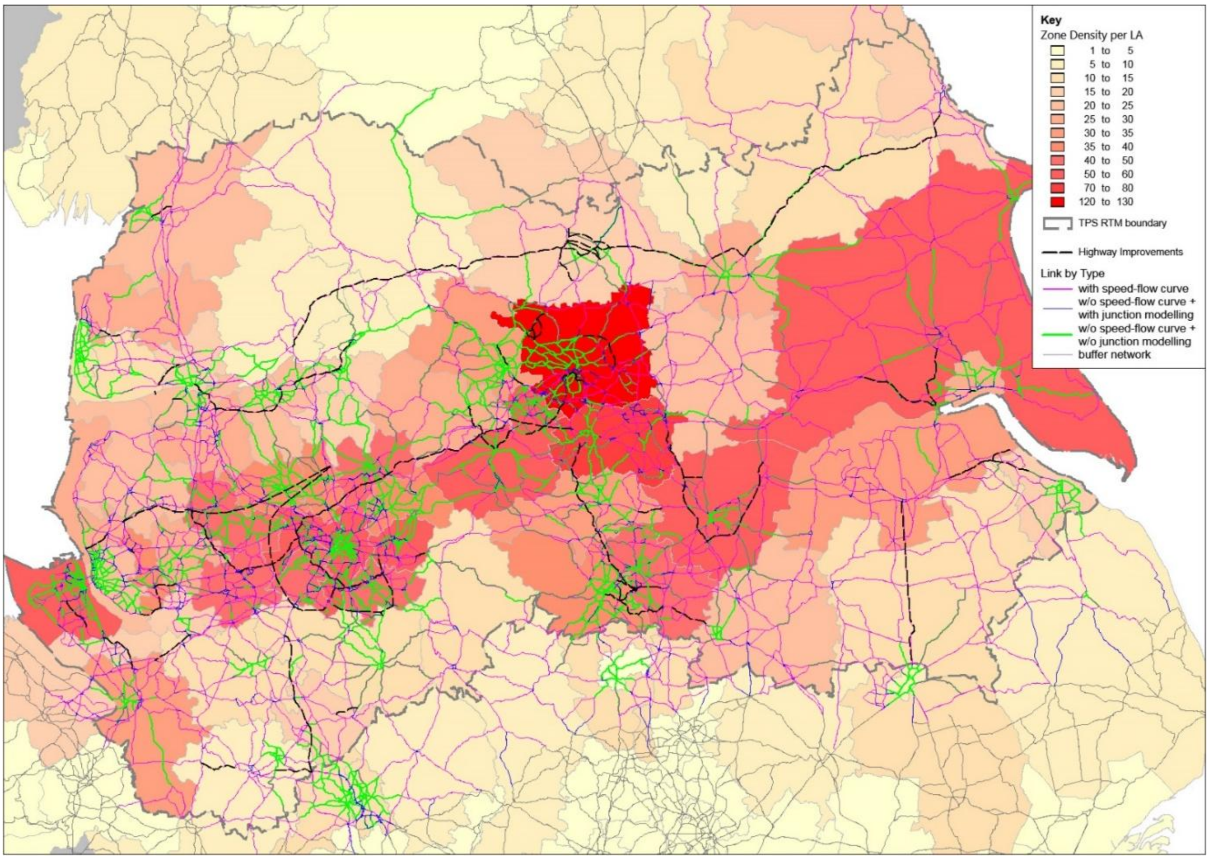
2.1.4 Fixed Speed coding represents a mechanism to cover a wider area network in a lesser amount of detail. In the RTM network speeds are taken from TrafficMaster data, derived from a sample of GPS related flow and travel time data. In the RTM, fixed speeds are commonly used for a) approach links or b) within urban areas.

2.1.5 Application a) is common within traffic modelling. Application b) is less commonly used. Its use within certain RTM reflects the focus on the SRN. Quite simply the need to model detailed urban areas such as London, Birmingham and Manchester would significantly expand the model complexity to an unacceptable level.

2.1.6 Whilst the fixed speed “shortcut” generally serves the needs of the SRN it fails to provide sufficient response in future years. In the RTM, National Travel Model (NTM) 2015 database’s speed decay has been used to provide an appropriate static speed change.

2.1.7 TfN requires fully responsive strategic corridor coverage (both SRN/Trunk routes and other traffic significant routes) across the full extent of their network area. As an example the TPS model is shown below, where fixed speed coding is demonstrated in green in Figure 1.

Figure 1 TPS Model Coding Definition



2.1.8 The green areas are otherwise unresponsive to changing traffic conditions. The fixed speed coding is focussed on areas of network coverage beyond the immediate reach of the Strategic Road network, but potentially of interest to TfN.

2.1.9 In contrast the NRTM (which covers Cumbria and the North East) does not contain fixed speed coding within the core model area. Within both Tyneside and Teesside the routes of the A1 and A19 are geographically close to the centres of Newcastle and Middlesbrough respectively. Under these circumstances the simulation coding for the SRN was expanded to cover the city centres of adjacent towns. Within the NRTM simulation network has been widely deployed with a more refined zone system and network density for urban areas, meaning that the fixed speed issue identified in the TPS model is not relevant.

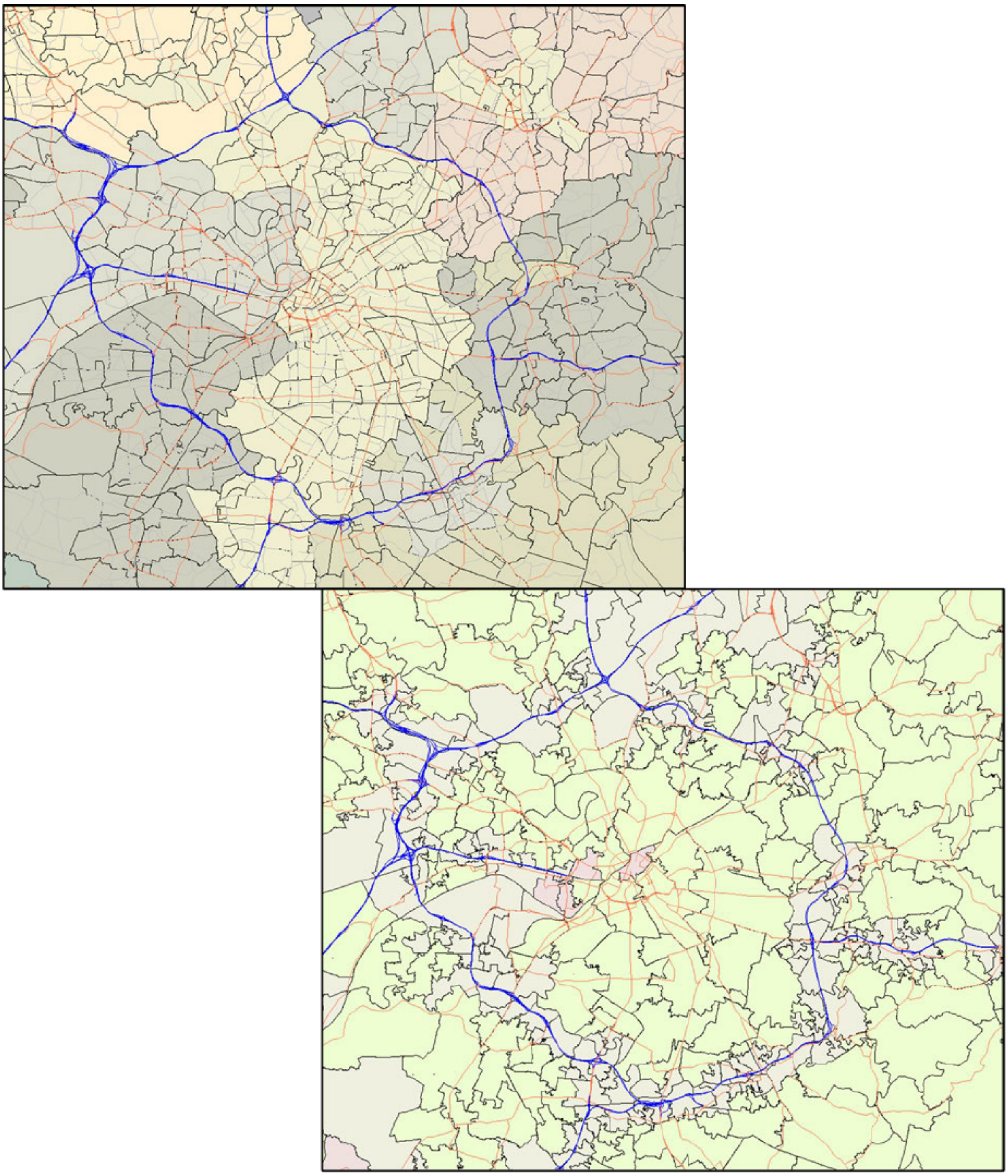
3. RTM LIMITATIONS

3.1.1 As mentioned in the previous chapter, the current network coding implemented for urban areas within the TPS RTM model includes fixed speed from TrafficMaster JT data, dummy junction coding with unlimited capacity and limited representation of junctions (i.e. number of lanes, junction layout, number of approaches to junction, etc.) and large zones with multiple zone connectors.

3.1.2 Figures 2 and 3 below show the comparison of the network coverage and zone density between the Greater Manchester (GM) model that was developed for the purpose of the M60 Smart Motorways (with fully simulated network coding) and the TPS RTM base year model.

Figure 2 Simulation Network Coding – GM Model (top) vs. TPS Model (bottom)

Figure 3 Zoning System – GM Model (top) vs. TPS Model (bottom)



3.1.3 A high level comparison of the network and zone system within the M60 Motorways between the two models show that whilst the GM model consists of about 6,800 linksand 310 zones, the TPS models only include 1,900 links with 170 zones, as summarised in Table 1 below.

Table 1 Network Density Comparison between GM and TPS Model

Road Class	No. of Links		Total Length (km)	
	GM Model	TPS Model	GM Model	TPS Model
Motorways	478	336	265.1	197.2
A Road	2,903	1,354	513.1	508.7
B Road	779	168	186.9	162.3
C/U Road	2,570	4	736.6	3.8
Total	**6,730**	**1,862**	**1,701.7**	**872.1**

3.1.4 As can be seen, in comparison with the TPS model, the GM model shows significantly higher number zones and simulated links and nodes within the Greater Manchester area with more accurate representation of various junction coding types. In constrast, the majority of the junctions within the urban areas were coded as 'dummy' type coding with unlimted capacity and fixed speed.

3.1.5 With fixed speed coding and less detailed network coverage in the TPS model, it is anticipated that the level of delays within urban areas will not be accurately modelled. Therefore there is a need to enhance detailed modelling within the urban areas to capture accurately delays and routeing for the purpose of TfN SDC models.

3.1.6 Recent experience exists in the use of fixed speed network coding in number of projects:

- Assessment of Trans-Pennine tunnel study with TPS RTM model: the fixed speed coded for the Manchester urban areas using the TrafficMaster JT data applied a reduction using the National Transport Model (NTM) speed forecast database; and
- Assessment of the A19 Norton to Wynyard scheme: fixed speed coded on the A1 (competing route from the A19) in the base year applied a speed reduction from the NTM database.

3.1.7 The assessment of these schemes revealed that:

- For the TPT study, traffic used Manchester city centre route as opposed to the M60 network to travel to / from the tunnel as a result of increasing congestion on the M60 compared to no increase in delays for the Manchester city centre routes. Select link analysis on the TPT shows that 9% (4,300 vehicles AADT) of traffic travelling on the TPT is from M62 west, of which 50% (2,200 vehicles AADT) of the traffic routes via Manchester city centre route as opposed to travelling on the M60 ring road (illustrated below). This appears to be an improbable route.

- For the A19 improvement scheme, the effects of the fixed speed coding on the A1 resulted in traffic using the A1 instead of the A19, therefore resulting in underestimation of the delays on the A19, and consequently underestimating improvement benefits. Due to the time scale, no further work was carried out to assess the impacts of the issue and only flagged up as a recognised underestimate to the benefits of the scheme.However, putting this in the context of the TfN SDC studies, comparing Reference Case (RC) and Strategic Outline Programme (SOP), traffic flows and thus delays on competing routes will not be accuratly assessed, again due to improbable assignment routing.

4. METHODOLOGY

4.1.1 The treatment of the fixed speed network coding within urban areas was initially discussed at the Senior Modelling Group meeting with TfN in November 2017. TfN informed the consultancy teams that Atkins (the software developer) has been asked to produce a method to deal with the fixed speed network coding within urban areas to reflect delays as a result of flow increase in the forecasting. However, the proposal is being prepared to investigate the loss of benefits for the Trans-Pennine Tunnel (TPT) studies and will not apply for the purpose of the three SDC corridors at this stage.

4.1.2 The ideal solution is to refine the TPS RTM model with detailed junction coding simulation for all the urban areas within the coverage of the TPS model. However, given the timescale of the project, and that Atkins may not be able to provide a mechanism before the delivery of the SDC schemes, this section outlines our proposed approach for the treatment of fixed speed coding within the urban areas to overcome the issue.

4.1.3 The application of the fixed speed coding adjustment will only be applied for the forecast models as the fixed speeds that were derived from the TrafficMaster Journey Time (JT) data are already calibrated for the base year 2015 model.

4.1.4 A summary of the methodology is indicated below, using an empirically derivedequation provided below.

$$V_{new} = A + B * \left(2 - e^{(\lambda(\frac{NF}{RF}-1))}\right)$$

Subject to	Speed	$V_{ref} > V_{new} > V_{min}$	
Where:	*SD*	=	*Speed decay*
	NF	=	*New Flow (i.e. forecast flow)*
	RF	=	*Reference Flow (i.e. base year flow)*
	A, B and λ	=	*sensitivity parameters 'calibrated' from a 'donor' model*

4.1.5 The speed decay curve above was based on the flow-delay curves that is implemented within SATURN, however with simplification as follows:

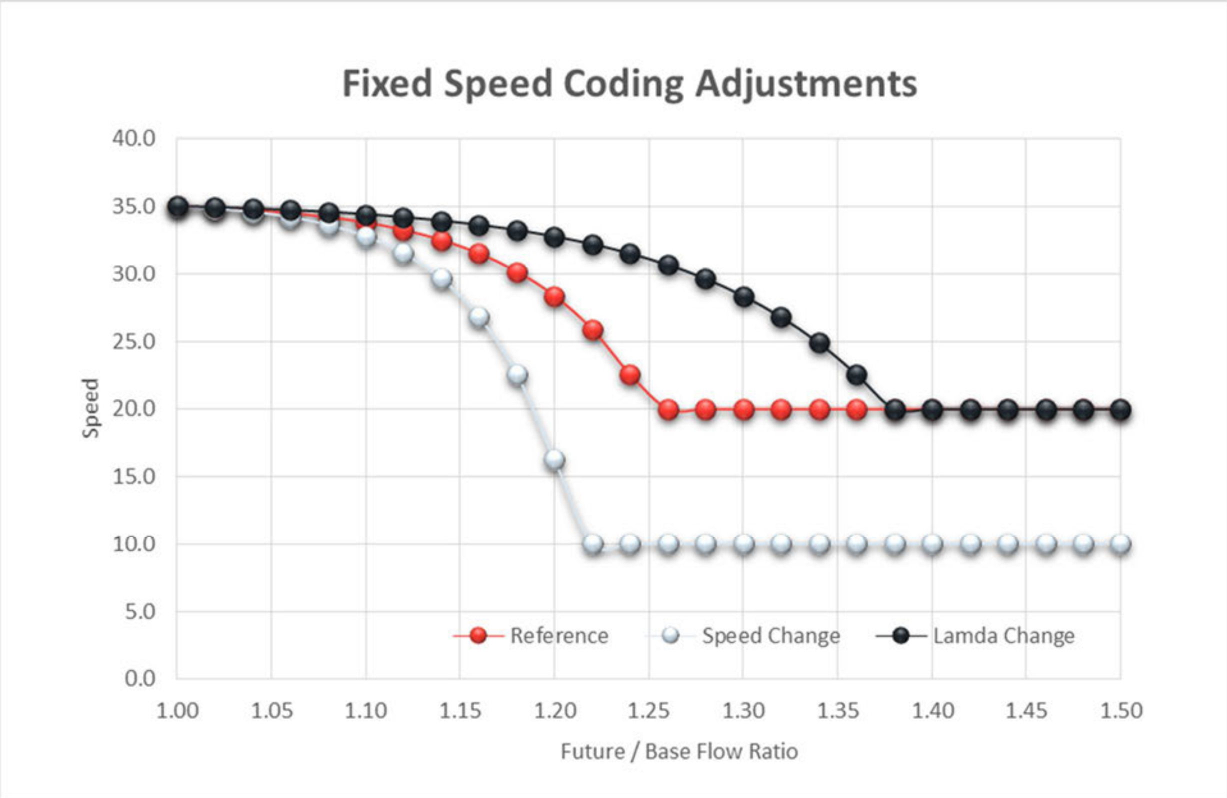
- To accurately produce change in delays as a result of flow increase, there is a need to understand the current Voume over Capctity (V/C) of each individual links within the network as the degree of change in delay would be heavily dependent on the increase in flow relative to the existing V/C. For example, if the existing V/C is only 50% then an extra 20% increase in flow would only result in 20% increase in delays. However, if the existing V/C is already near its capacity, let say, 85%, then a small increase in flow would result in significant increase in delays;and
- Due to the limited level of network coding (e.g. unlimited capacity at junctions, dummy node coding, etc.), it is not possible to calculate the existing V/C at individual link level. Furthermore, the lack of detailed coding in urban areas would mean the model is not sensitive to routes that may be unattractive, irrelevant or relatively inaccessible, therefore the curve would not be able to capture

delay at an individual link level. Instead, the curve will be derived at an aggregate level, i.e. area based. The assumption is that if the V/C exceeds capacity on one link then traffic would divert to other under-capacity roads to avoid delays. Therefore, at an aggregate level, the overall change in delays would still be accurately reflected.

4.1.6 The following example diagram (Figure 4) starts with a reference curve and illustrates the impact of adjusting the lambda (λ) value, leading to a greater or lesser convex profile, and adjusting the minimum speed which changes the minimum speed and the point at which constant speed is achieved.

4.1.7 In this way the profile of the curve will be able to mimic that of a typical speed flow profile, whereby speed impacts of increased flow are minimal up to the point where flow breakdown occurs.

Figure 4 Speed Decay – Impacts of Parameter Changes



4.1.8 The ability to shape the curve will be instrumental in identifying appropriate calibration parameters with λ and V_{min}. For simplicity a model-wide factor will be preferred.

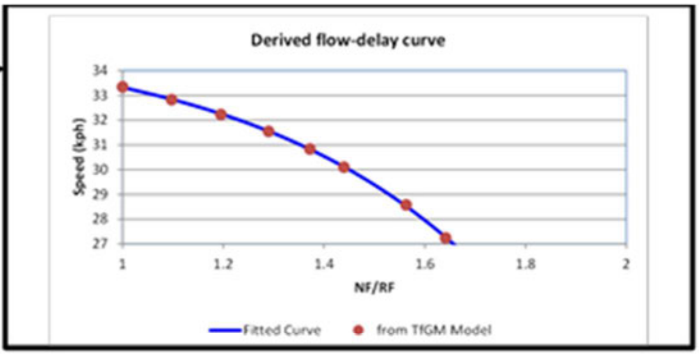
4.1.9 The method of implementation will be as follows.

- § Initial assignments to be carried out, assigning forecast demand matrices on initial SATURN network prior to fixed speed coding adjustment to produce forecast flows on the network;
- § An application written in python script to:
  - Ø call $SATDB routines to import initial assignments and calculate speed change as a result of flow increase against the base year flow, using speed decay curves that are derived from the calibration of the speed decay curves from the GM models;
  - Ø calculate extra delays and write as delay penalty to section 44444 and create new SATURN network;
- § Carry out post-fixed speed adjustment assignments on the forecast demand matrices above and the newly created SATURN networks to produce forecast assignments.

4.1.10 The process of deriving and apply the speed decay curves from a 'donor' model to the TfN SDC forecast models can be summarised in 3 stages below. For the derivation of the speed decay curves, the GM 2013 Present Year validated model was utilised. Detail of each stage is provided in the next chapter.

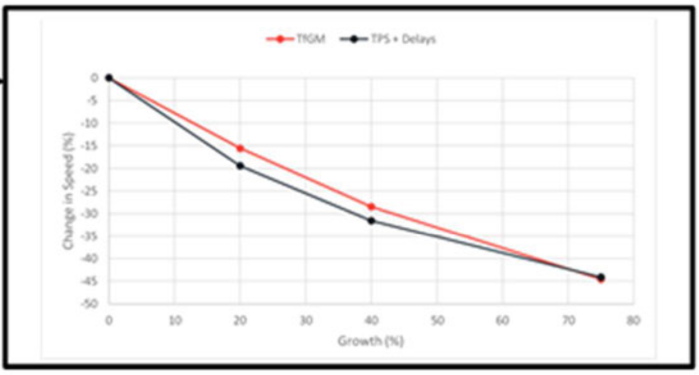
Stage 1: Derivation of speed decay curves

- GM 2013 base year models
- Different demand growth



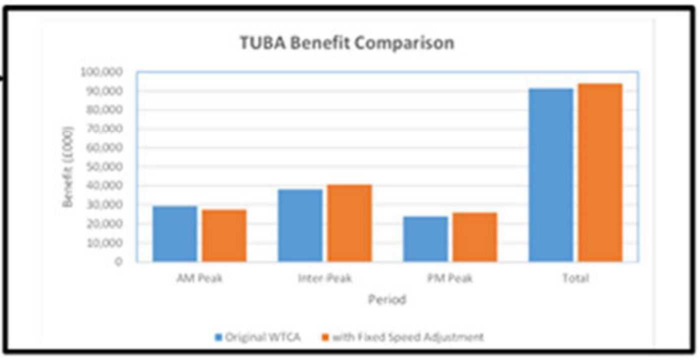
Stage 2a: Realism Test on TPS RTM 2015 Base models

- Verify speed decay curves
- Change in speeds from Base



Stage 2b: TUBA tests on WTCA models

- 2041 forecast year
- Calculate change in TUBA benefits



Stage 3: application on TfN CP models

- Initial assignment
- Final assignment

5. IMPLEMENTATION AND RESULTS

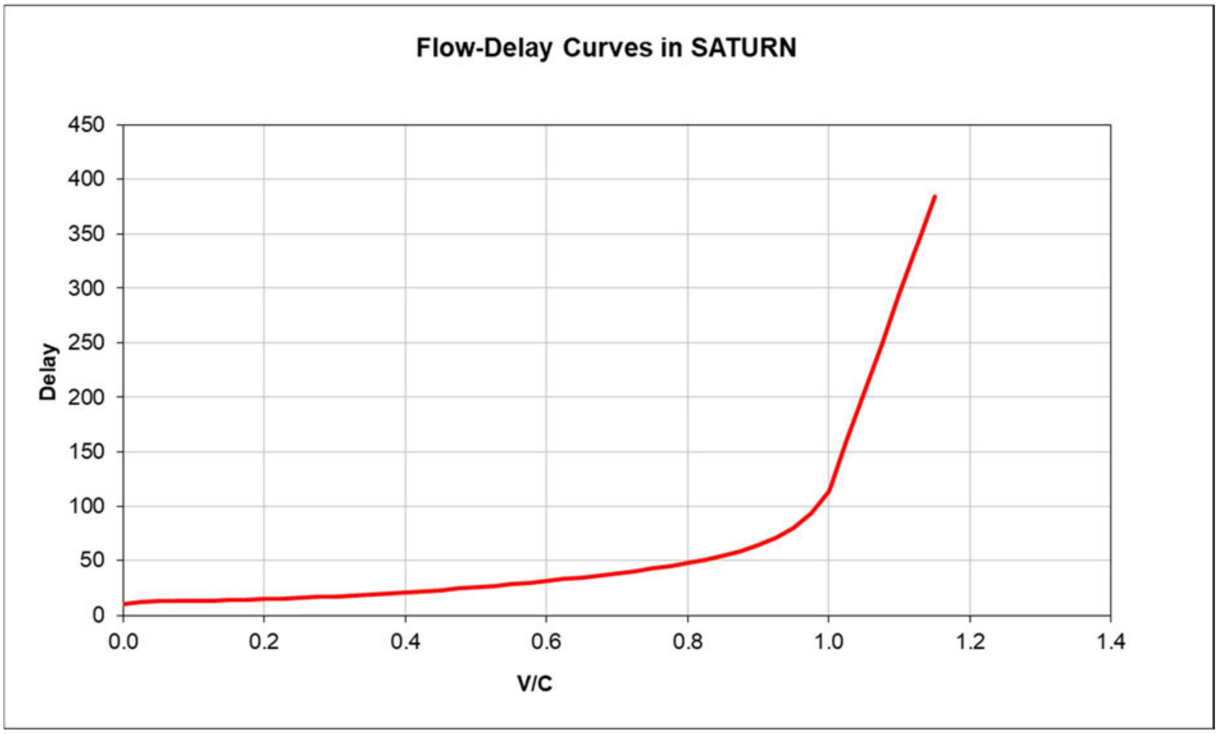
5.1. Overview

5.1.1 This chapter describes in more detail the steps that have been carried out for the fixed speed coding adjustment and its current outcomes.

5.2. Stage 1: Derivation of the Speed Decay Curves Using GM Models

5.2.1 The initial form of the speed decay curve was derived from the flow-delay curve as implemented within SATURN with the form as illustrated in Figure 5 below.

Figure 5 Flow-Delay Curve in SATURN



5.2.2 To accurately model delays for links / junctions, detailed simulation should be coded to provide the V/C of links approaching junctions. For the TPS RTM model with fixed speed and unlimited capacity coding in the urban areas:

- it is not possible to determine junction capacity and therefore V/C of links approaching junctions to accurately produce delays or increase in delays as flow increases;
- since the network is coded with fixed speed urban delay response to flow change is missing ; and
- the urban scope of network is insufficient (i.e.the network does not truly reflect alternative routes, number of lanes or number of approaches to a junction) and the calculation of junction V/C is therefore not possible.

5.2.3 To be able to represent speed decay as a result of flow increase, an inverse function of the flow-delay curve was adopted with some simplification, in particular excluding V/C elements at either link or junction due to lack of information on capacity.

5.2.4 An equation of the form was adoped, as below:

$$V_{new} = A + B\left(2 - \exp\left(\lambda\left(\frac{\mathrm{NF}}{\mathrm{RF}} - 1\right)\right)\right)$$

where:

- A, B and λ are parameters that could be adjusted in order to best fit the modelled data.
- NF is the new flow (forecast flow) and RF is the reference (or base) flow.
- $A + B = V_{RF}$ where V_{RF} is the speed at reference flow (base year speed).

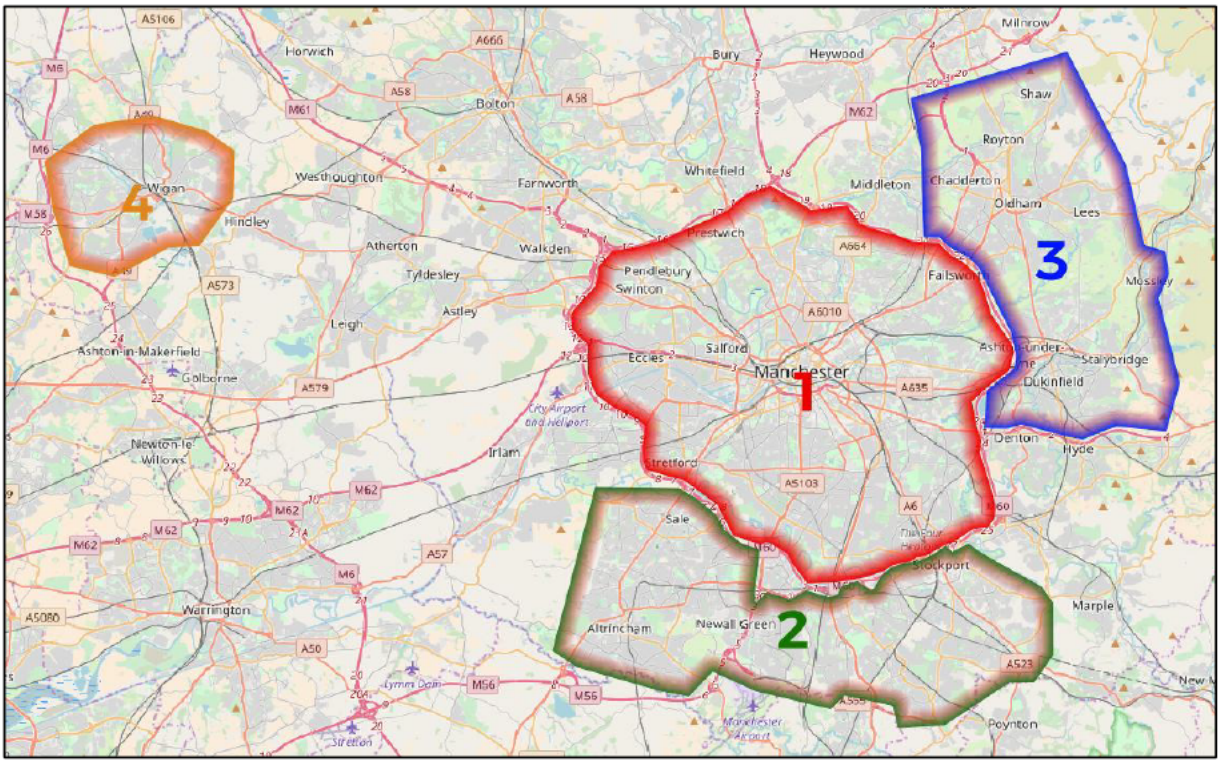
5.2.5 To calibrate the speed flow curves the GM 2013 base year model with full simulation coding for Greater Manchester area was used. The trip matrix was multiplied by factors of 1.1, 1.2, 1.3, 1.4, 1.5, 1.75 and 2.0 in order to simulate increasing traffic up to an extreme limit.

5.2.6 In order to represent speed decay for different types of urban areas where fixed speed coding was implemented, 4 areas were selected to represent 4 distinct characteristics:

- (1) The core area, reflecting major urban area with moderate or high congestion;
- (2) A higher income area with expected significant growth in demand in future;
- (3) A lower income area with potential for growth; and
- (4) A free standing town distinct from the continuous conurbation.

5.2.7 The map of the 4 areas simulated within the GM model is shown in Figure 6 below.

Figure 6 Four Distinct Areas Used for Speed Decay Curves



5.2.8 For all the links that fall within each of the 4 selected areas, the following selection criteria were applied:

- $V/C > 0.1$;
- Non zero flow;
- Free flow speed not equal to congested speed; and
- Free flow speed below 50 kph

5.2.9 The first three criteria were chosen in order to make sure that links for which the speed flow curve was calculated had traffic on and had delays of some description. The 50kmph limit was chosen to exclude roads that have a speed limit greater than 30 mph. Only links that met the criteria across all the growth assignments were used in the calculation. Weighted averages of the congested speed across all the links and the actual flow were found using the following equations. For speed:

$$\mathrm{V}_{ave} = \frac{\sum_i^N V_i F_i d_i}{\sum_j^N F_j d_j}$$

5.2.10 Where V_i is the congested speed, F_i is the actual flow, andd_i is the distance of link i. Similarly the weighted average for the flow across all links is calculated below:

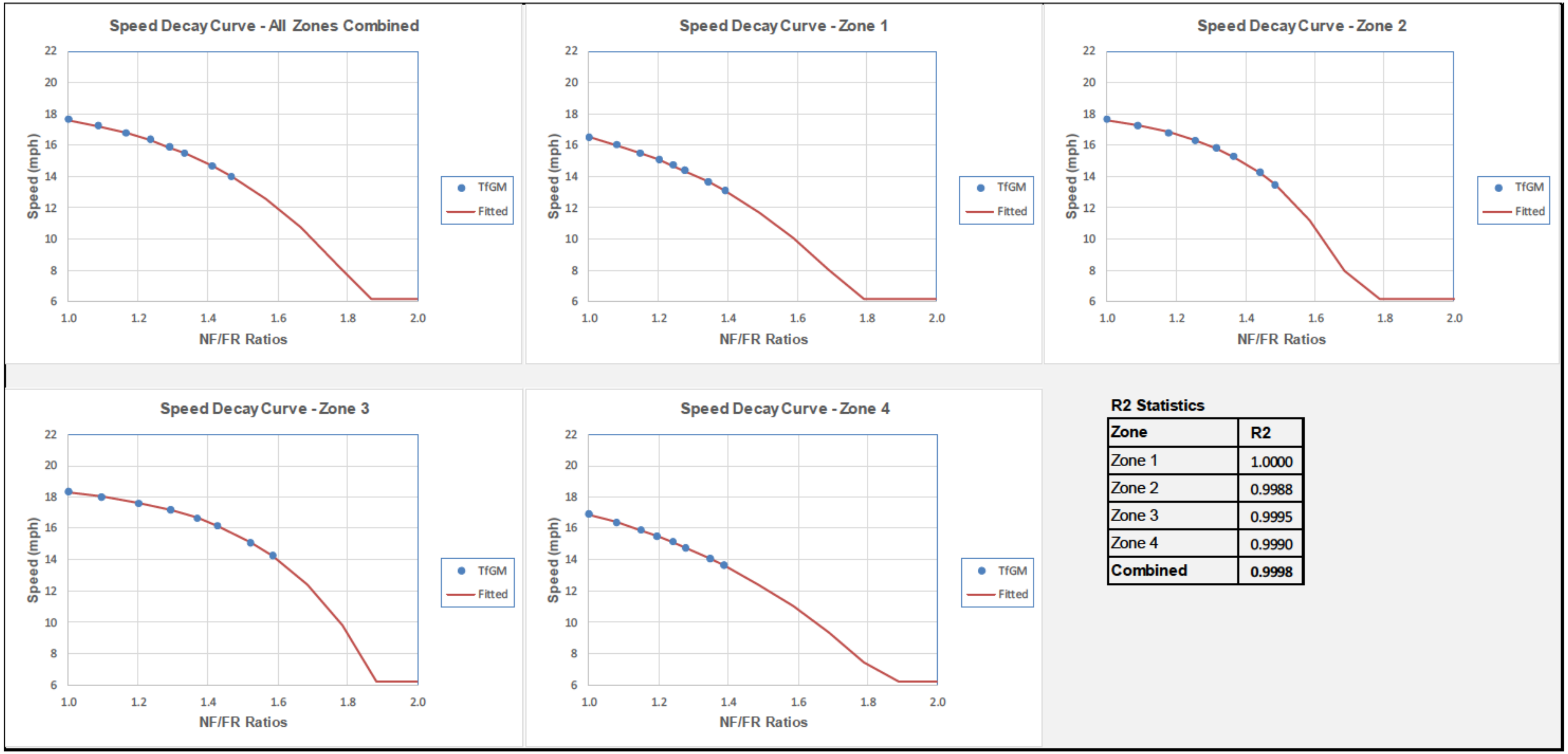
$$F_{ave} = \frac{\sum_j^N F_i d_i}{\sum_j^N d_j}$$

5.2.11 The equation was fitted using average speed and flows calculated for each area by time period and for each demand growth point. Table 2 below summarises the parameters for each area on its own and also for the 4 areas combined. Figures 7 to 9 show the speed decay shapes for each of the three modelled periods (AM, IP and PM) that was produced by applying different demand growth to represent increase in traffic flow for the aggregated 4 areas overall.

Table 2 Fitted Curve Coefficients

Zone	AM Peak			Inter-Peak			PM Peak		
	A	B	lambda	A	B	lambda	A	B	lambda
Combined	25.51	2.86	2.371	31.27	2.04	2.149	27.59	1.74	3.396
Zone 1	21.71	4.83	1.940	30.28	1.65	2.479	26.09	1.53	4.052
Zone 2	27.03	1.29	3.746	31.72	1.89	2.176	27.80	1.64	2.986
Zone 3	28.36	1.10	3.308	32.03	2.23	1.830	27.27	3.24	2.066
Zone 4	20.61	6.61	1.515	27.87	2.87	2.173	23.83	3.90	2.553

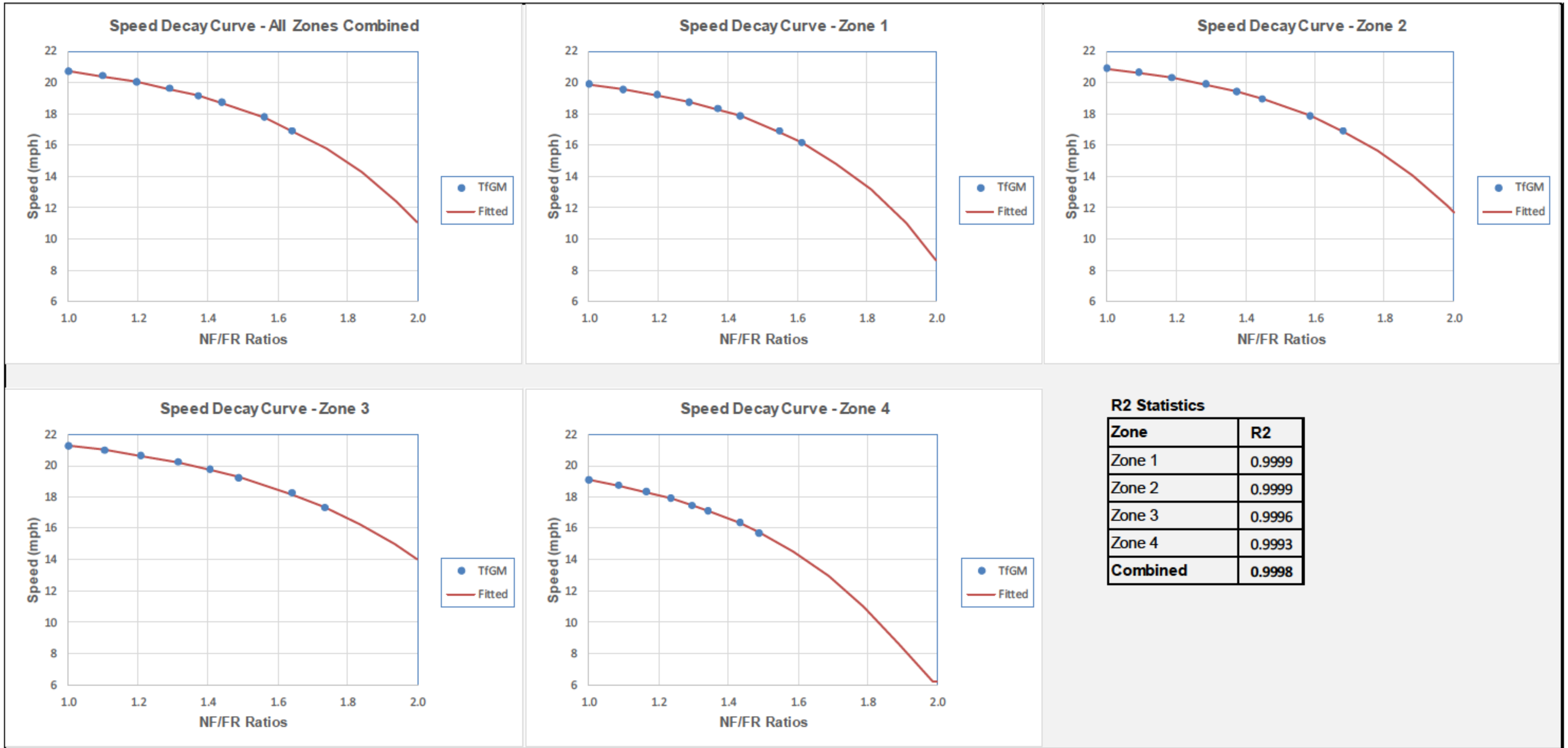
Figure 7 Fitted Curves Derived from GM Model – AM Peak



R2 Statistics

Zone	R2
Zone 1	1.0000
Zone 2	0.9988
Zone 3	0.9995
Zone 4	0.9990
Combined	0.9998

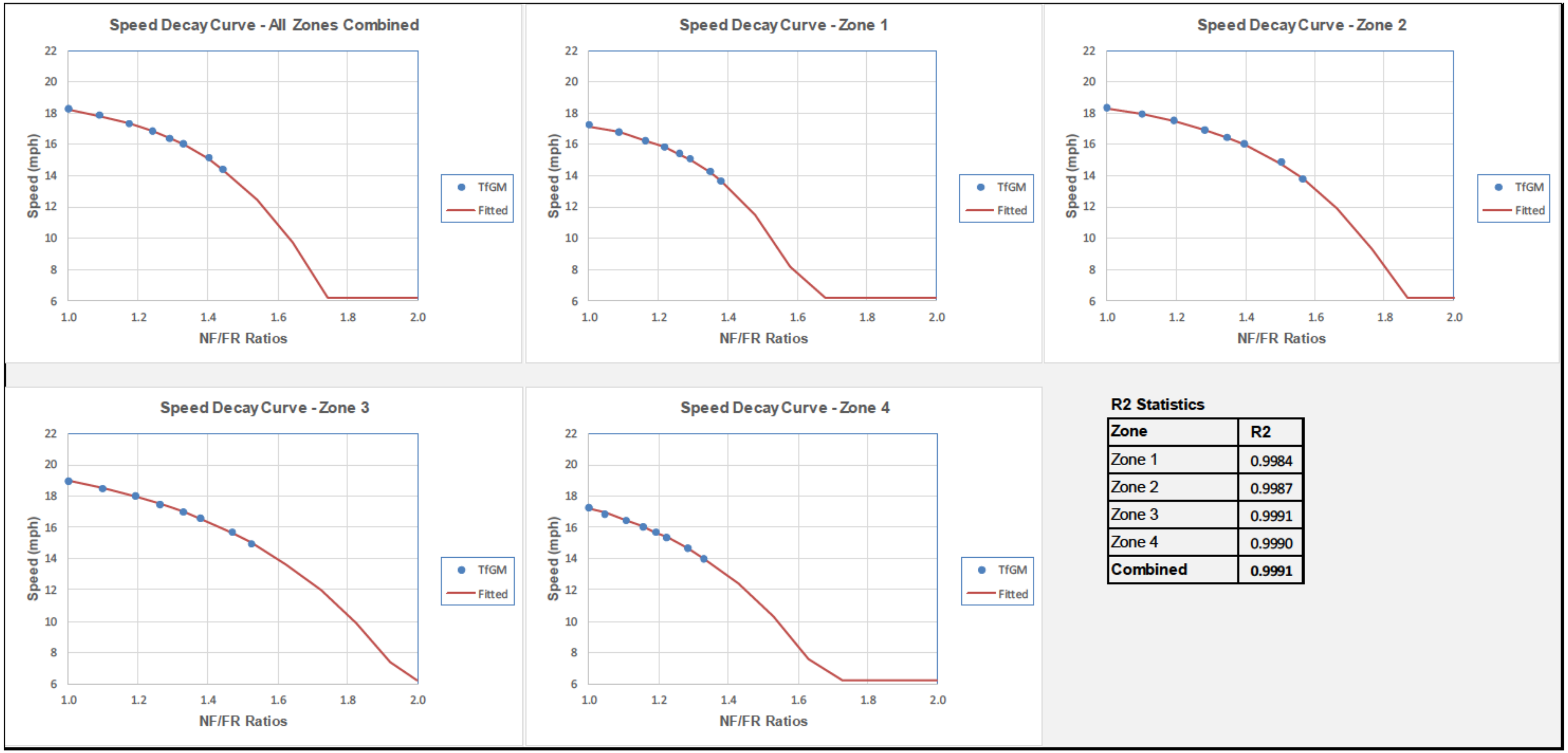
Figure 8 Fitted Curves Derived from GM Model – Inter-Peak



R2 Statistics

Zone	R2
Zone 1	0.9999
Zone 2	0.9999
Zone 3	0.9996
Zone 4	0.9993
Combined	0.9998

Figure 9 Fitted Curves Derived from GM Model – PM Peak



R2 Statistics

Zone	**R2**
Zone 1	0.9984
Zone 2	0.9987
Zone 3	0.9991
Zone 4	0.9990
Combined	0.9991

5.2.12 It can be seen that the derived flow-delay curves were able to match very well the modelled delays produced from the GM base year models for different growth across all the three time periods and at each individual area levels. It is therefore concluded that the derived speed decay curves can be used for stage 2 as describe below.

5.2.13 It is however noted that the GM models struggle to converge as the demand increases and failed to converge with poor convergence when the demand increases by 40% or higher (as provided in Table 3 below). That would mean the curves may not represent accurately the speed decays as the demand increase as a result of poor model convergence.

Table 3 GM SATURN Assignment Convergence

Statistics	With 20% Growth			With 40% Growth			With 75% Growth		
	AM	IP	PM	AM	IP	PM	AM	IP	PM
Loop	120	75	120	120	120	120	120	120	120
%Flow	98.4	98.8	95.6	94.3	96.3	96.2	89.1	95.6	91.0
%Gap	0.013	0.004	0.029	0.077	0.011	0.048	0.471	0.059	0.167

5.3. Stage 2: Realism Tests and TUBA Check

5.3.1 As the speed decay curves were calibrated from the GM Base year models for each of the zones defined, it was necessary to carry out realism tests on the TPS RTM models to:

- Verify that the application of the speed decay curves that was derived from the GM model can represent similar reduction in speed to the that from the GM model as a result of the flow increase;
- Assess whether an issue with traffic routeing through city centre as previously observed in the original TPS model has now been improved; and
- Check that TUBA benefits from applying the fixed speed adjustment to one of the TPS forecast models (TPT Option 8 + Wider Transport Connectivity Assessment schemes) shows change in benefits, particularly for areas in the vicinity of the schemes. It is anticipated that the implementation of the fixed speed adjustment in urban areas would result in increase in user benefits as, in comparison to no change in delays in urban areas without fixed speed adjustment - applied in both 'with' and 'without' improvements on the strategic road networks, delays are now responsive to change in demand in urban areas, therefore improvements that are proposed on strategic road networks would draw more traffic away from urban areas. The working assumption was that this would relieve excess urban congestion, producing extra time saving benefits. This hypothesis is to be tested.

5.3.2 To assist the realism tests and subsequently to apply to the actual TfN SDC schemes, a python script was developed to apply the fitted curves to the test models

Stage 2a: Realism Test with TPS RTM model

5.3.3 This was undertaken to verify whether applying the fitted curve to the TPS base year model with similar growth in demand as implemented to the GM model in stage 1 would result in similar reduction in travel speed. The base year 2015 TPS RTM was used as the starting point and assignments were then carried out on demand matrices with similar growth. The process was carried out in the python script, with steps as below:

- Initial assignments on TPS RTM Models with 20%, 40% and 75% growth in demand matrices;
- Extract flows from the initial assignments, compare to the base year link flows for each of the 4 areas;
- Calculate speed decay using the fitted curve for each area, then convert to equivalent delays for each link;

- Write extra delays to card 44444 of the SATURN network and carry out final assignments;
- Extract data from the final assignments, calculate overall reduction in speed and compare against the reduction in speed produced from GM model.

Refinement of the Speed Decay Curves' Parameters

5.3.4 During the realism test process, number of refinement was made to the original speed decay curve, preventing excessive increase in delays due to a) low traffic volume; and b) significant increase in forecast flows compared to the base year flow. The Ratios of NF/RF were refined by the equation below to take into account individual link flows against the area-based average flows.

$$\left(\frac{NF}{RF}\right)' = 1 + \left(\frac{NF}{RF} - 1\right)\frac{LF}{AF}$$

Where:

- LF is the base year flow on a particular link; and
- AF is the base year average flow of an area that link belongs to

5.3.5 A maximum value of $\frac{NF\prime}{RF}$ was set at 2, again, to stop excessive delays being introduced to the system.

5.3.6 The delays were then calculated using the following formula

$$Delay = T - \frac{d}{V}$$

Where:

- T is the free-flow speed travel time;
- d is link distance; and
- V is calculated using the following method.

$$V = V_{ff} - (V_{ref} - V_{SFC})$$

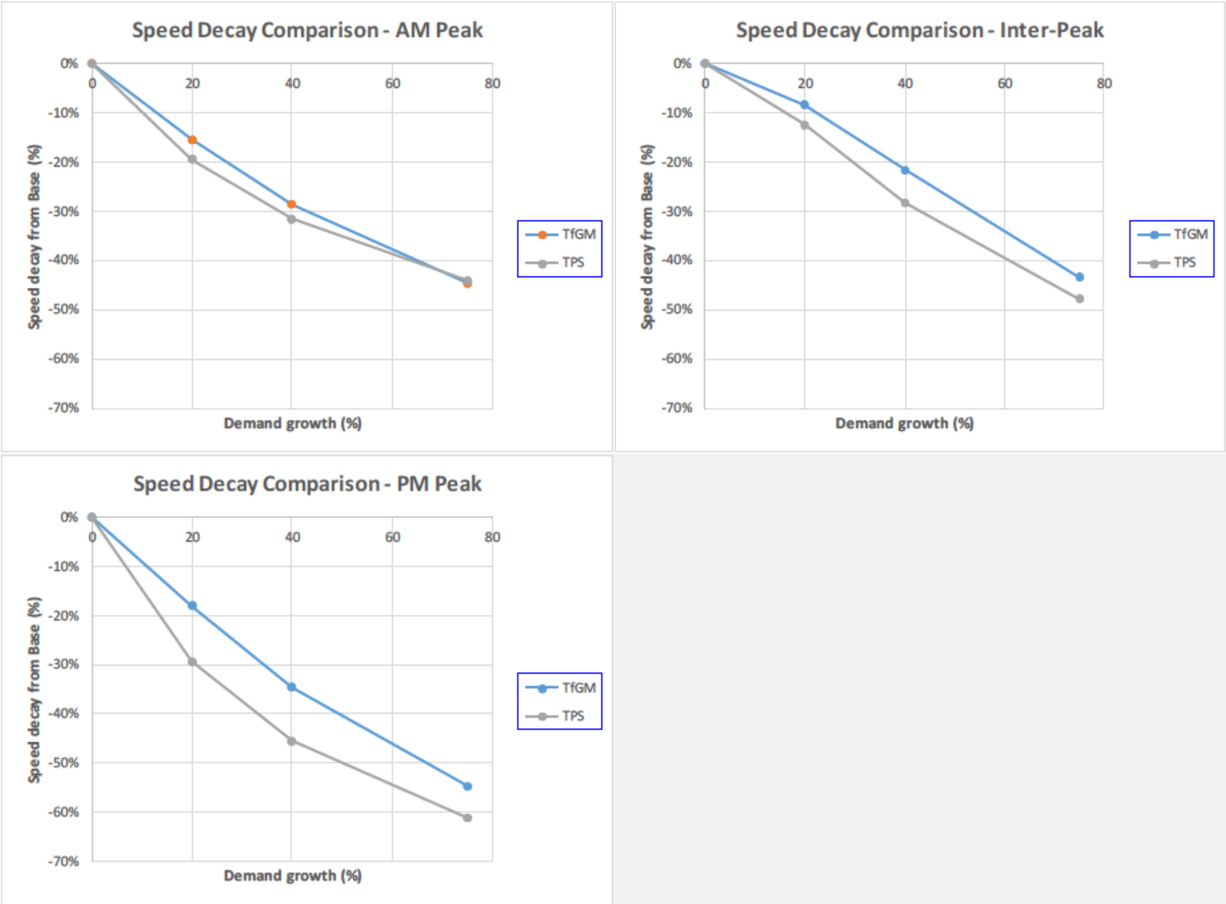
Where:

- V_{ff} is the free flow speed,
- V_{ref} is the reference speed from the speed flow curve calculated when $\frac{NF}{RF} = 1$ and
- V_{SFC} is the value calculated from the speed flow curve. A minimum speed value was used in order to prevent very low traffic speeds from occurring, this was set to 10kmph.

5.3.7 Once these delays were calculated they were written into the 44444 card of the Saturn .DAT file and implemented in an assignment run.

5.3.8 Figure 10 below shows the comparison in terms of speed reduction between the GM model and the TPS RTM Model, in response to similar demand growth.

Figure 10 Speed Decay Comparison GM vs. TPS RTM



5.3.9 The TPS RTM models show similar reduction in speed compared to the GM in response to the similar demand growth. The TPS models however show larger degree of decay as the demand increase compared to GM. It is anticipated as:

- The GM base year model was 2013 whereas the TPS RTM base year was 2015, i.e. lower demand compared to the TPS RTM models; and
- Network coverage within the GM is denser compared to the TPS. This gives a higher number of route choices in the GM compared to TPS in order to avoid congestion.

5.3.10 It is also noticed that the difference in speed decays in the PM peak is larger than that for the AM and Inter-Peak. Investigation of the TPS AM peak, Inter-Peak and PM peak models with growth in demand assignments show that the models did not converge with the demand growth, as summarised in Table 4 below.

Table 4 TPS SATURN Assignment Convergence

Statistics	With 20% Growth			With 40% Growth			With 75% Growth		
	AM	IP	PM	AM	IP	PM	AM	IP	PM
Loop	61	119	120	108	120	120	120	120	120
%Flow	97.8	98.1	95.1	98.2	95.0	93.2	96.1	94.8	94.0
%Gap	0.029	0.014	0.054	0.010	0.021	0.052	0.021	0.041	0.122

5.3.11 As can be seen, the TPS assignments did no converge well, particularly for the PM peak with the growth in demand of 50% and 75%. That resulted in significant change in delays/costs that consequently affects the analysis.

Stage 2b: TUBA Check

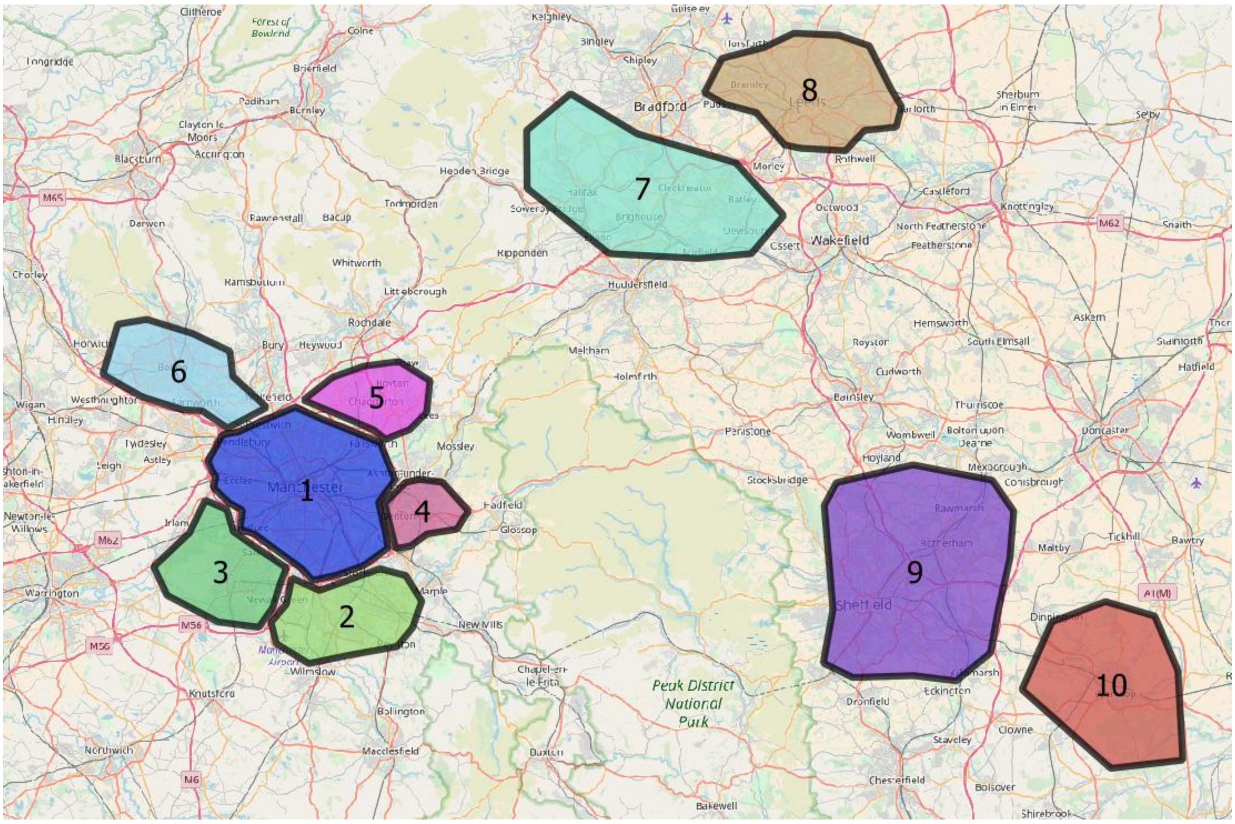
5.3.12 The process was applied to the Trans-Pennine tunnel + Wider Transport Connectivity Assessment schemes to provide an indication of change in TUBA benefits with the inclusion of extra delays using the derived speed decay curves.

5.3.13 The previous works on the TPT+WTCA using the local models (GM models for Manchester side and South Yorkshire Strategic Traffic Model (SYSTM+) for Sheffield side) to assess the benefits of the tunnel + wider connectivity schemes produced signficant benefits for Manchester and Sheffield, which was not fully captured in the TPS RTM models. The work however did not provide the scale of benefits accrued from the two local models compared to those produced from the TPS RTM models. The comparison of the benefits from the TPS RTM and the two local models specifically for Manchester and Sheffield urban areas is currently being prepared for the purpose of the TPTS+ project.

5.3.14 For this purpose, the 2041 forecast models were run with extra delays added in for both Do-Minimum and Do-Something networks for AM, IP and PM periods. The model outputs from this test were extracted for TUBA calculation and compared against the TUBA benefits without extra delays added in.

5.3.15 Figure 11 below shows the areas that have been chosen for the fixed speed adjustment for the TPT+WTCA models.

Figure 11 Zones to apply Fixed Speed Adjustment



5.3.16 With each of the zones correspond to one of the 4 distinct flow-delay curve areas as summarised in Table 5 below.

Table 5 Zones and Corresponding Index

Zone	Index Used	Flow-Delay Curve Area's Description
1, 8 and 9	1	Core metropolitan areas, reflect major urban area with moderate or high congestion
2 and 3	2	High income area with expected significant growth in demand in future
4, 5, 7 and 10	3	Lower income area with potential for growth
6	4	Free standing town

5.3.17 This test differentiates the application of the curves based on the calibration areas described above. In the event that the general area-wide relationship is applied it is likely that the result would vary slightly from the current outcome. Table6 below provides a quick summary of TUBA benefits between the 'original' TPT+WTCA (i.e. without fixed speed adjustment) and the 'revised' TPT+WTCA schemes (with fixed speed adjustment), with the overall TUBA benefits increase by about 3% for the 'revised' networks.

Table 6 TUBA Benefit Comparison (£000s)

Period	Travel Time	Fuel VOC	Non-Fuel VOC	Indirect Tax	Total
Original - without Fixed Speed Adjustment					
AM Peak	28,282	-139	-1,485	2,683	**29,341**
Inter-Peak	38,084	-1,572	-3,877	5,491	**38,126**
PM Peak	24,224	-181	-2,961	2,941	**24,023**
Total	**90,590**	**-1,892**	**-8,323**	**11,115**	**91,490**
Revised - with Fixed Speed Adjustment					
AM Peak	26,409	-183	-1,486	2,709	**27,449**
Inter-Peak	40,584	-1,498	-3,895	5,448	**40,639**
PM Peak	25,835	4	-2,745	2,842	**25,936**
Total	**92,828**	**-1,677**	**-8,126**	**10,999**	**94,024**
Difference					
AM Peak	-1,873	-44	-1	26	**-1,892**
Inter-Peak	2,500	74	-18	-43	**2,513**
PM Peak	1,611	185	216	-99	**1,913**
Total	**2,238**	**215**	**197**	**-116**	**2,534**
%Difference					
AM Peak	-7%	32%	0%	1%	**-6%**
Inter-Peak	7%	-5%	0%	-1%	**7%**
PM Peak	7%	-102%	-7%	-3%	**8%**
Total	**2%**	**-11%**	**-2%**	**-1%**	**3%**

5.3.18 The AM Peak is showing a reduction in benefits of 6% while the IP and PM show similar increase in benefits of about 7-8%. The curve shown in Figure 7 shows that the AM speed decay is similar to the GM model and is far smaller than the inter-peak and PM peaks.

5.3.19 The small increase in TUBA benefits in the 'revised' TPT+WTCA from the 'original' TPT+WTCA forecast models is anticipated as the 'original' TPT+WTCA models already applied speed reduction from the NTM database, whereas the fixed speed adjustment to the TPT+WTCA network applies the speed reduction to the base year model's speeds. That resulted in the speed in the 'revised' TPT+WTCA models being higher than in the 'original' TPT+WTCA models for number of links, thus producing a lower increase or even a reduction in TUBA benefits. This application of the adjustment, therefore, effectively shows the net increase in the benefits compared to the speed reduction using the NTM database.

5.3.20 In order to check actual the increase in TUBA benefits where the fixed speed adjustment was applied to the forecast year speeds instead of the base year speeds, another test was carried out. Table 7 below shows the increase in TUBA benefits as a result of this test.

Table 7 TUBA Benefit with Fixed Adjustment to the Forecast Network's Speed (£000s)

Period	Travel Time	Fuel VOC	Non-Fuel VOC	Indirect Tax	Total
Original - without Fixed Speed Adjustment					
AM Peak	28,282	-139	-1,485	2,683	**29,341**
Inter-Peak	38,084	-1,572	-3,877	5,491	**38,126**
PM Peak	24,224	-181	-2,961	2,941	**24,023**
Total	**90,590**	**-1,892**	**-8,323**	**11,115**	**91,490**
Revised - with Fixed Speed Adjustment applied to Forecast Network's Speed					
AM Peak	29,412	-21	-1,364	2,631	**30,658**
Inter-Peak	40,763	-1,650	-3,705	5,540	**40,948**
PM Peak	26,620	54	-2,767	2,826	**26,733**
Total	**96,795**	**-1,617**	**-7,836**	**10,997**	**98,339**
Difference					
AM Peak	1,130	118	121	-52	**1,317**
Inter-Peak	2,679	-78	172	49	**2,822**
PM Peak	2,396	235	194	-115	**2,710**
Total	**6,205**	**275**	**487**	**-118**	**6,849**
%Difference					
AM Peak	4%	-85%	-8%	-2%	**4%**
Inter-Peak	7%	5%	-4%	1%	**7%**
PM Peak	10%	-130%	-7%	-4%	**11%**
Total	**7%**	**-15%**	**-6%**	**-1%**	**7%**

5.3.21 With this test, TUBA benefits show an overall increase of 7% compared to 'without' fixed speed adjustment.

5.3.22 Table 8 below provides SATURN assignment convergence for the tests with fixed speed adjustment applied.

Table 8 TPT+WTCA SATURN Assignment Convergence

Statistics	DM 2041			DS 2041		
	AM	IP	PM	AM	IP	PM
Loop	91	120	120	80	120	120
%Flow	97.5	98.2	97.1	97.8	98.1	97.8
%Gap	0.013	0.014	0.020	0.011	0.014	0.025

5.3.23 It can be seen that the models converged reasonably well within in terms of %flow and %gap criteria.

5.3.24 In addition to TUBA benefits, the flow difference between the 'original' and the 'revised' models were produced to show that traffic routing issues have now been improved. Figures 12 and 17 below shows the flow difference between the original and the revised models for the Do-Minimum and Do-Something respectively.

5.3.25 For both Do-Minimum and Do-Something models, across all three modelled periods, the adjustment of fixed speed in urban areas resulted in more using the motorway rather than routing through the urban areas, for example, on the M60 in Manchester and on M1 near Sheffield. The extra traffic travelling on the motorway network compared to the 'without fixed speed adjustment' explain why the benefits produced do not increase an initially anticipated. This was due to the fact that extra traffic correctly routed via motorways results in more delays on the network, thus reducing the benefits claimed for the WTCA schemes.

Figure 12 Flow Difference between the 'Original' and 'Revised' Network – DM2041 – AM Peak

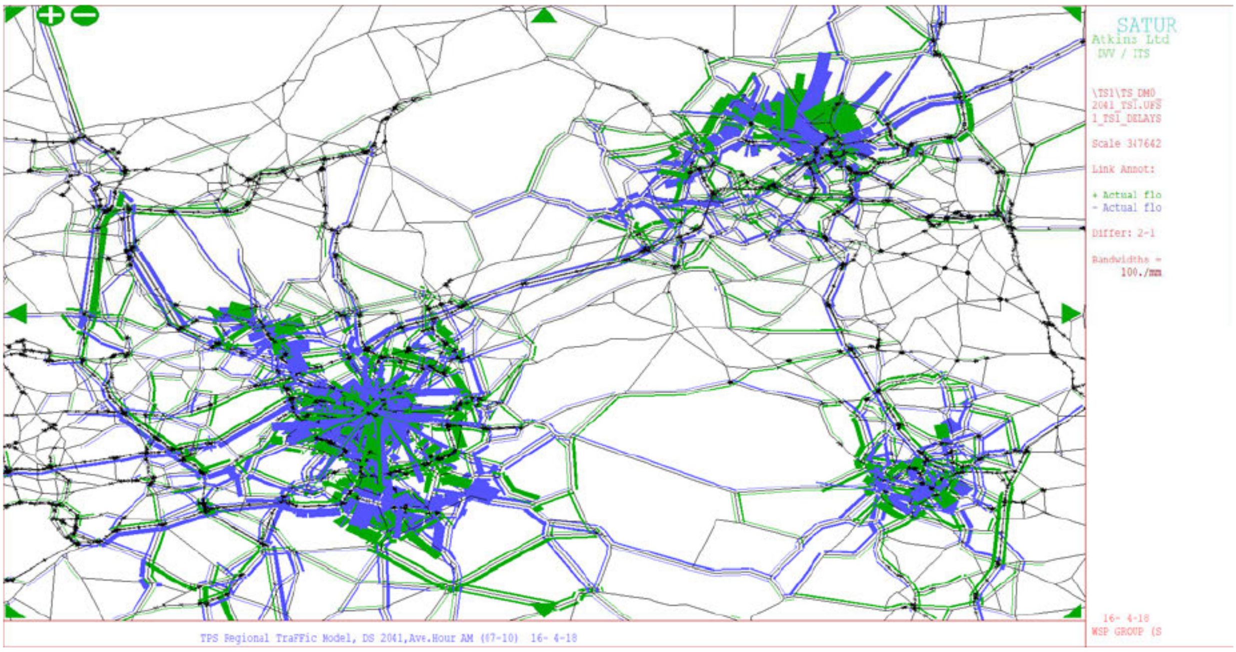


Figure 13 Flow Difference between the ‘Original’ and ‘Revised’ Network – DS2041 – AM Peak

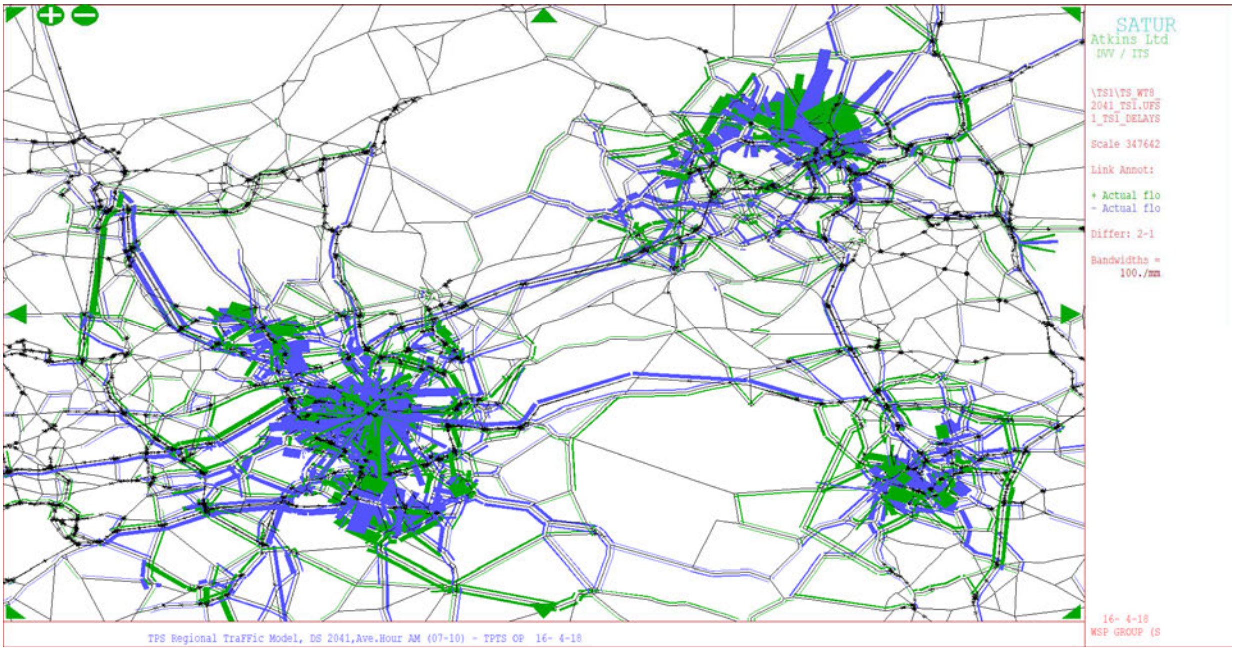


Figure 14 Flow Difference between the ‘Original’ and ‘Revised’ Network – DM2041 – Inter-Peak

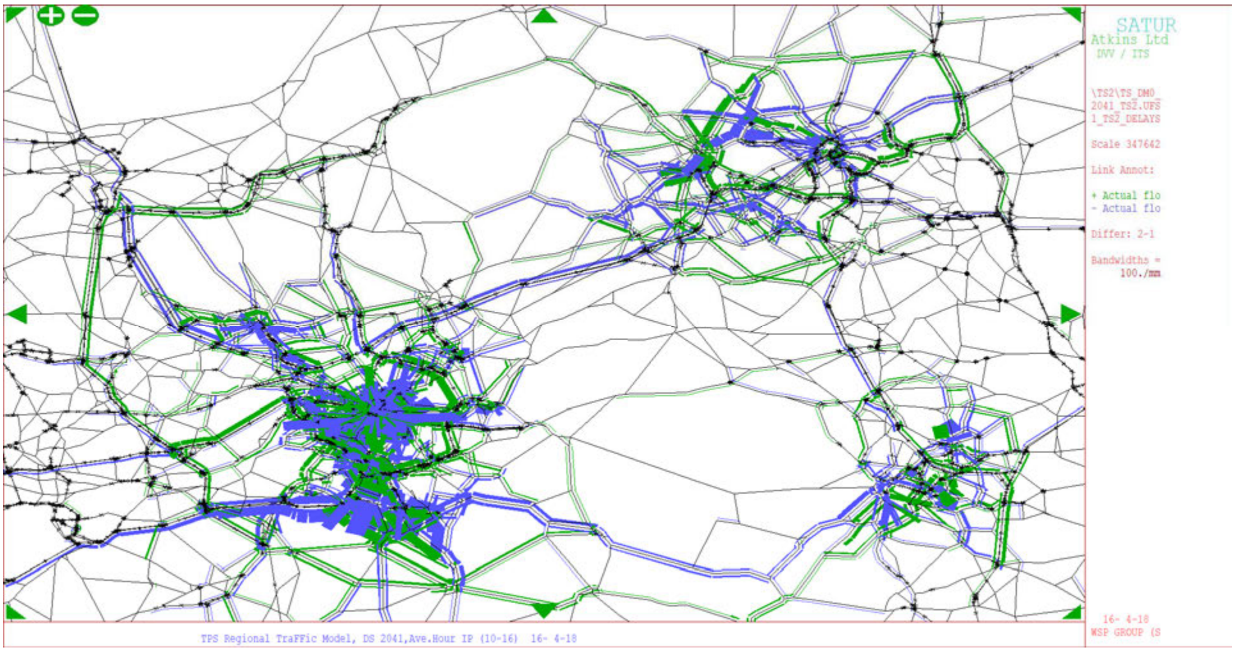


Figure 15 Flow Difference between the 'Original' and 'Revised' Network – DS2041 – Inter-Peak

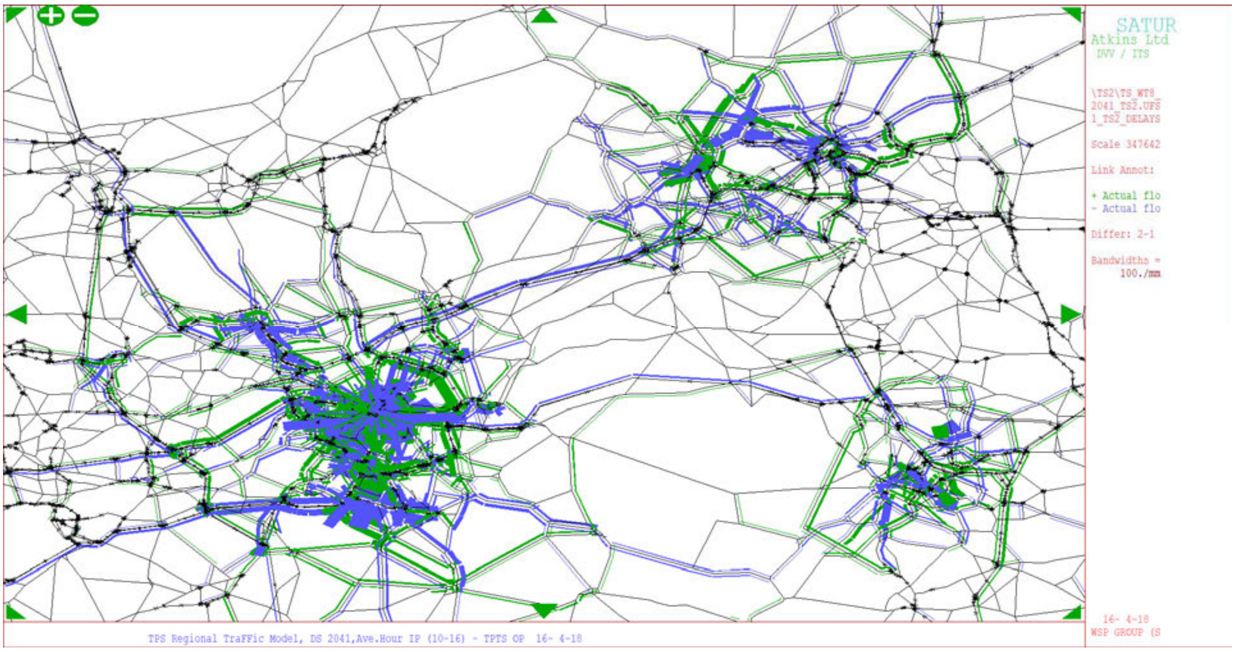


Figure 16 Flow Difference between the 'Original' and 'Revised' Network – DM2041 – PM Peak

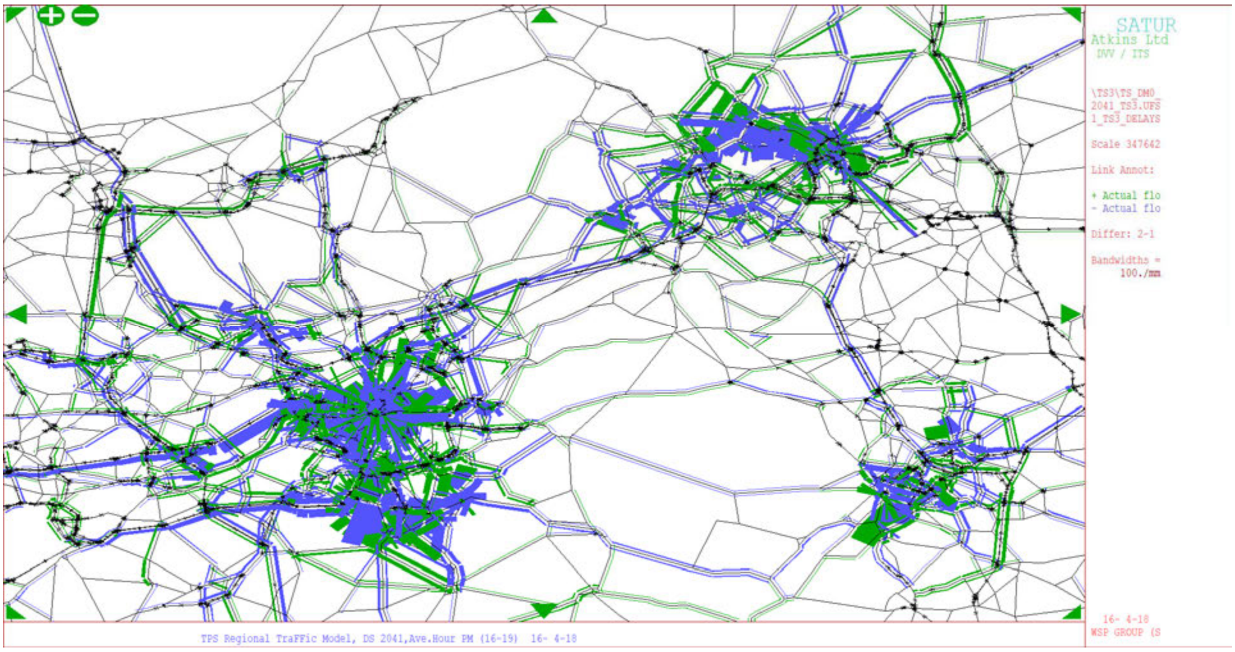
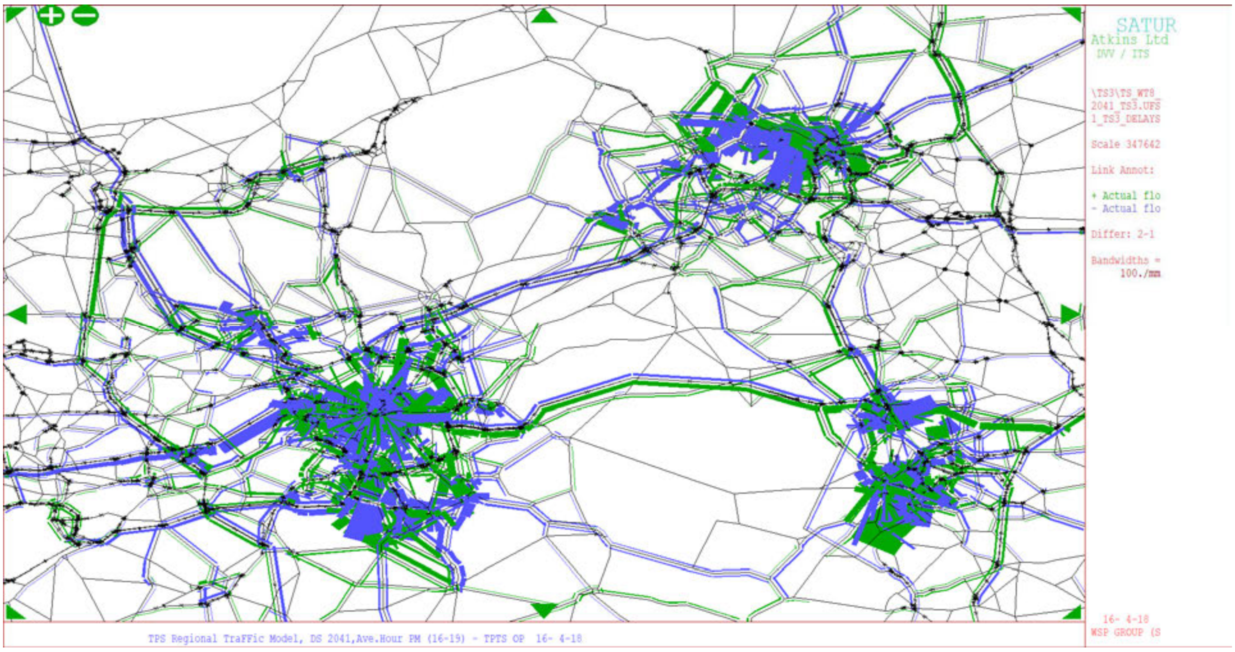


Figure 17 Flow Difference between the ‘Original’ and ‘Revised’ Network – DS2041 – PM Peak



5.3.26 Select link analysis of traffic travelling on the TPT between the ‘original’ and the ‘revised’ model assignments show that traffic that travels through the urban areas have been improved in the ‘revised’ model as compared to the ‘original’ model. Figure 18 shows the comparison of the select link analysis for the AM peak , zoomed in to Manchester city centre.

5.3.27 As can be seen, the issue with traffic travelling through Manchester city centre from A580 and M62 have been improved in the ‘fixed speed adjustment’ models, with about 50% less traffic using the city centre routes compared to the ‘without fixed speed adjustment’ applied.

Figure 18 Select Link Analysis Comparison – 'Original' Model (top) vs. 'Revised' Model (bottom)

5.3.28 Analysis shows that the increase in benefits in the models with the fixed speed adjustment for urban areas applied are deemed to be acceptable. The more important aspect to note is that the results of the tests show that the routeing are more sensible compared to 'without fixed speed adjustment' in urban areas, paritularly in terms of routeing of traffic through the urban areas as opposed to using motorway networks.

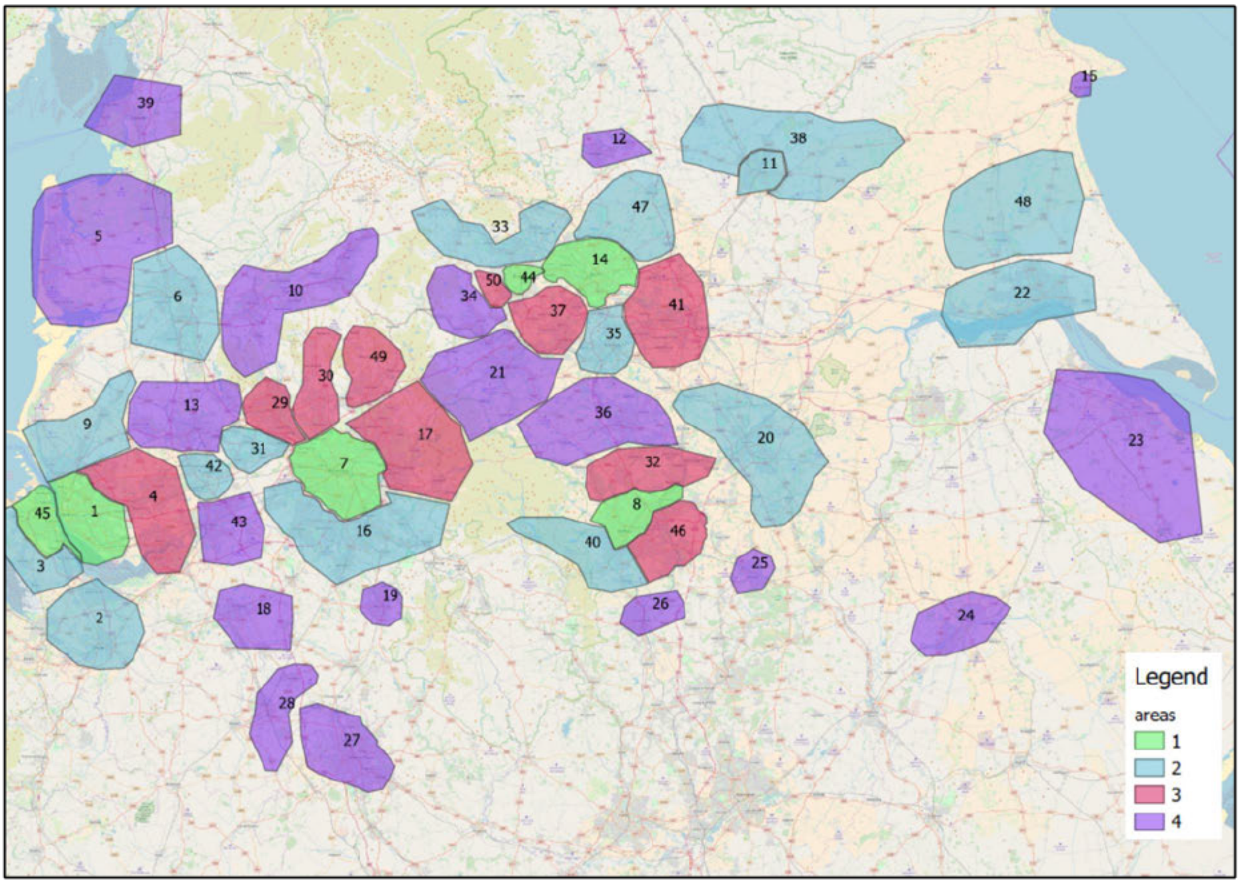
5.4. Stage 3: Application of the Speed decay curves to TfN SDC Schemes

5.4.1 Once the method has been agreed, the application of the fixed speed adjustment using the derived curves from stage 1 will be used for the TfN SDC schemes.

5.4.2 Prior to implementing the fixed speed adjustment for urban areas in the context of the TfN SDC models, a series of tests have been carried out on the Central Pennine SDC modelReference Case 2035 networks to check whether the process would result in plausible outcomes.

5.4.3 The first tasks was to define urban areas with appropriate index so that fixed speed adjustment process can be applied to. Figure 19 below shows the boundaries defined for urban areas in the Central Pennine models with colour coded representing one of the 4 area indices described in chapter 5.

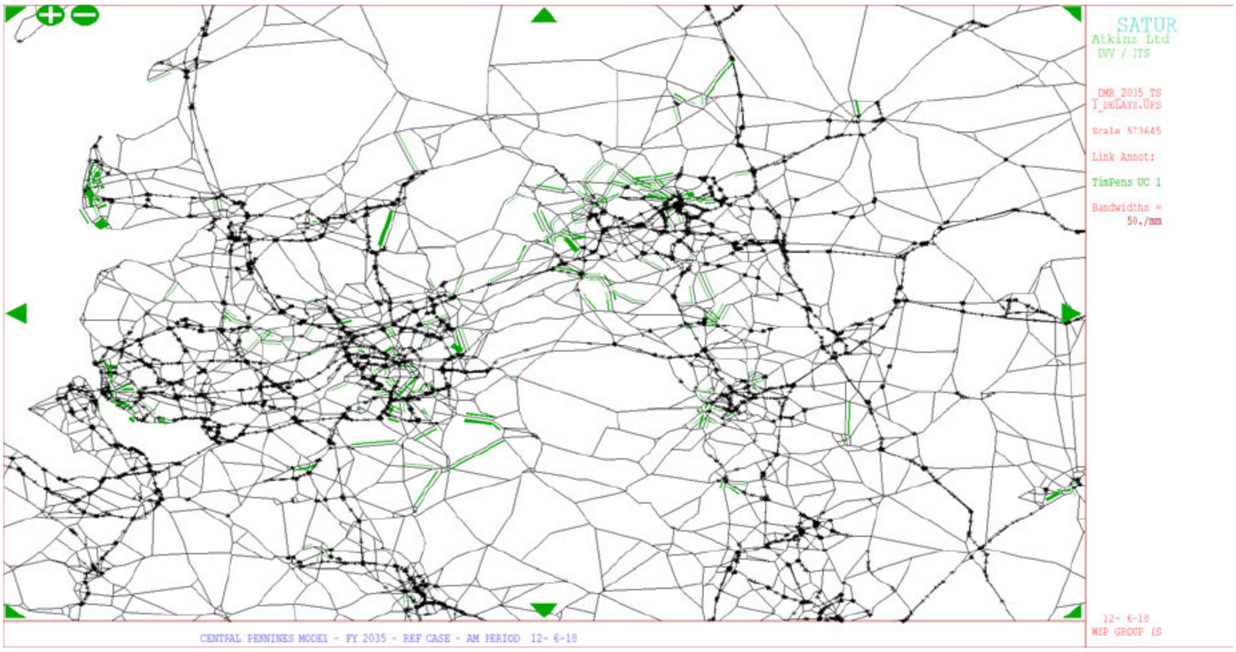
Figure 19 Urban Areas Defined for Central Pennine SDC



5.4.4 The urban areas defined above were used with the reference case 2035 fixed demand assignments to produce additional delays to create a 'revised' networks. Initial checks were carried out to ensure extra delays added as a result of the fixed speed adjustment process is plausible. Figure 20 below shows the 'revised' network with extra delays added in for urban areas.

5.4.5 With exception of a few links (in Blackpool and Ashton-under-Lyne, where significant increase in link flows against the base year), the extra delays added in to the Reference case network seems plausible and proportionate to the increase in flows against the base year.

Figure 20 Added Delays to the Reference Case Network



5.4.6 Table 9 below shows the convergence summary of the Reference case 2035 assignments between 'with' and 'without' fixed speed adjustments in urban areas.

Table 9 Reference Case 2035 SATURN Convergence

Statistics	Without Fixed Speed Adjustment			With Fixed Speed Adjustment		
	AM	IP	PM	AM	IP	PM
Loop	41	43	49	42	56	75
%Flow	97.9	98.9	98.2	97.7	98.8	97.9
%Gap	0.0150	0.0110	0.0140	0.0110	0.0036	0.0190

5.4.7 It can be seen the 'with fixed adjustment' networks would produce similar level of convergence in terms of flow and gap compared to the 'without fixed speed adjustment' networks although it requires longer runtime until convergence.

5.4.8 Figure 19 shows the difference between the 'revised' network assignment and the reference case assignment. It can be seen flow differences occur in the urban areas where the fixed speed adjustment was applied. The difference looks plausible with more traffic being drawn to the strategic road network as opposed to the urban areas, a few example are provided below in Figures 21 to 24.

5.4.9 It is noted that there are number of short links where it show significant difference between the 'revised' and the Ref.case network. As mentioned, the fixed speed adjustment process is a simplified process that calculates extra delays mainly using the ratios of the forecast flows over base year flows, whilst it produces plausible change in delays on the majority of the network, it still has a limitation of not being able to accurately apply to all the links, particularly short links where slightly change in delays would result in significant change in flows.

Figure 21 Flow Difference – Revised Network vs. Ref.Case Network – CP Corridor

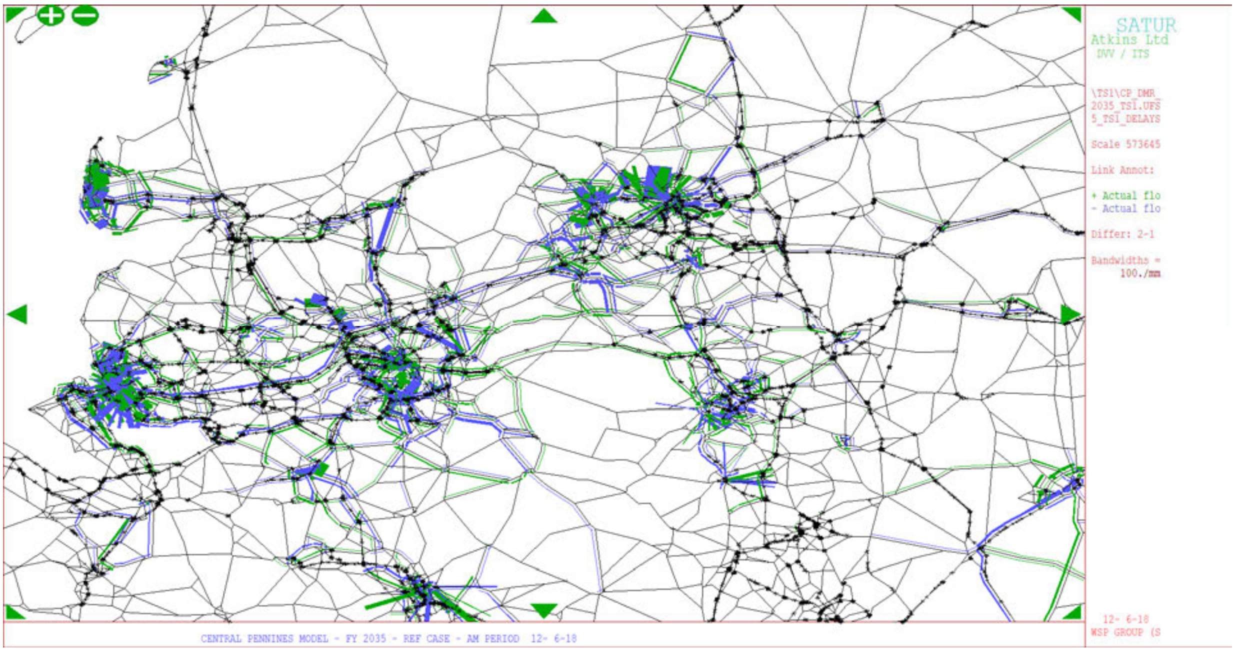


Figure 22 Flow Difference – Revised Network vs. Ref.Case Network - Manchester

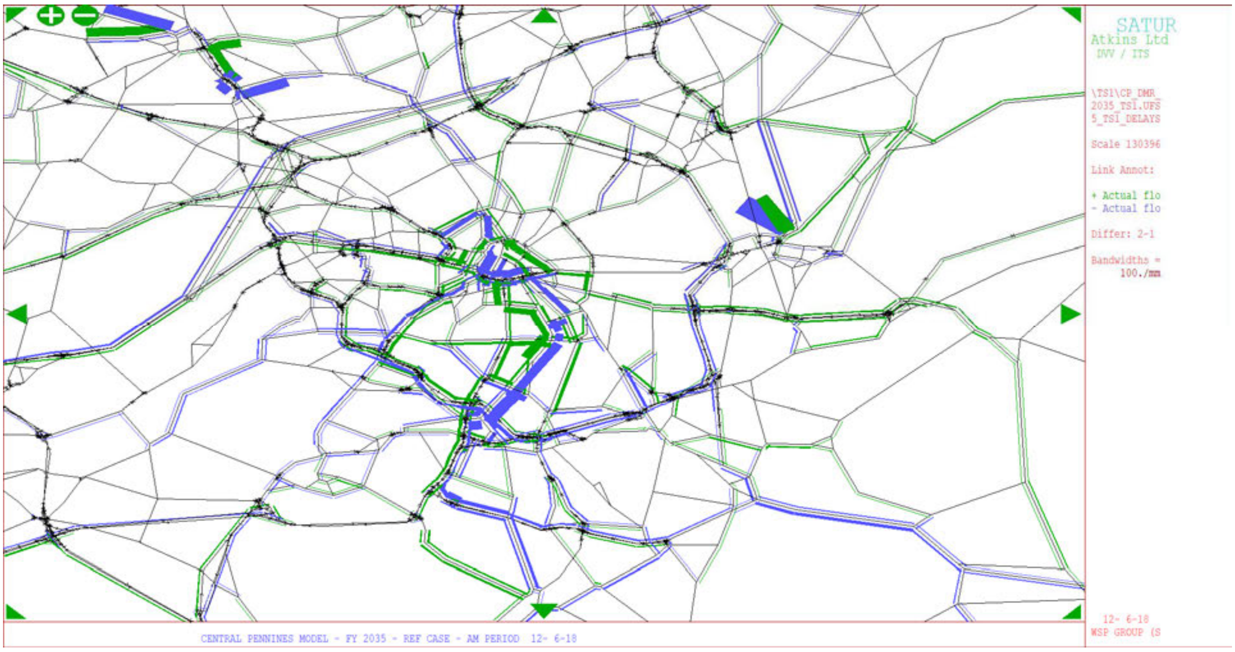


Figure 23 Flow Difference – Revised Network vs. Ref.Case Network – Leeds/Bradford

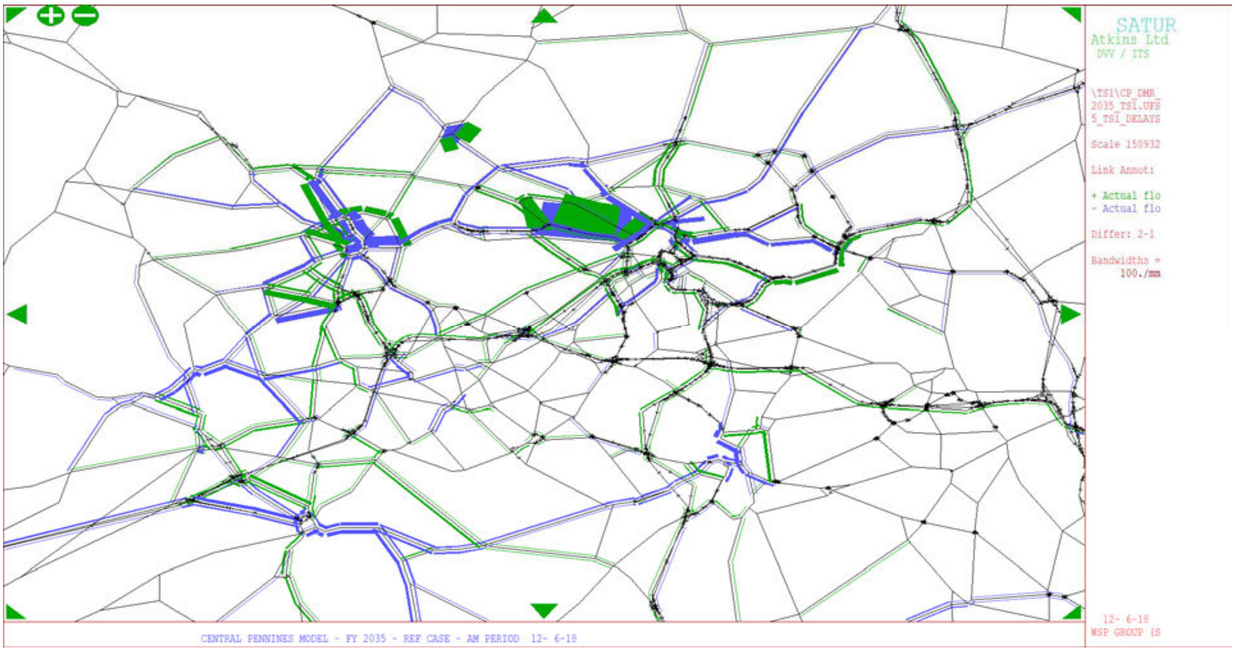
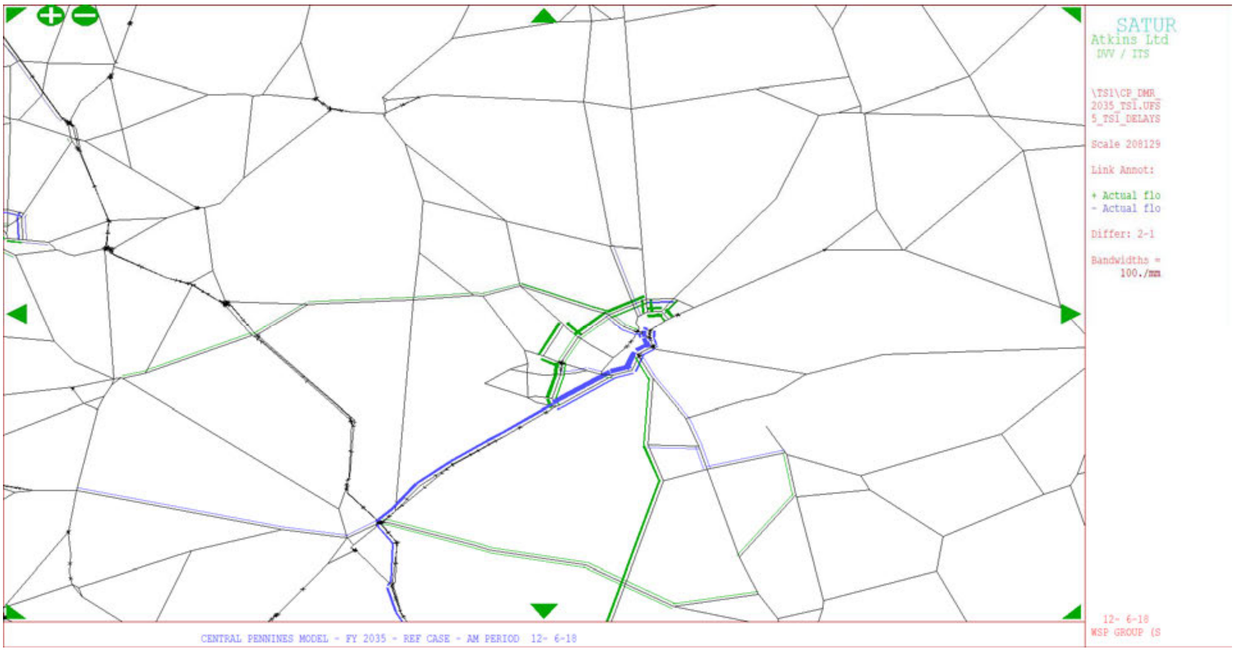


Figure 24 Flow Difference – Revised Network vs. Ref.Case Network - Lincoln



5.5. Proposed Approach to TfN SDC schemes

5.5.1 Overall, WSP view is that the fixed speed adjustment generally produces plausible outcomes in terms of routeing, with exception of number of short links (slip roads, double merges etc.) where slight change in delays would result in significant change in flow) and recommend to adopt the fixed speed for the purpose of the TfN SDC Central Pennine models.

5.5.2 Two options are proposed to apply the fixed speed adjustments in urban areas for the purpose of the Central Pennine and West and Wales SDC models, as below:

Option 1: apply fixed speed adjustment prior to VDM. The following steps demonstrate the application:

§ Carry out initial assignments on the forecast SDC networks, using fixed forecast demand matrices provided by TfN and MDST, to produce forecast assignments;
§ Run the python scripts to calculate extra delays as a result of flow increases and produce a 'revised' forecast networks; and
§ Use the 'revised' networks for full VDM runs.

Option 2: apply fixed speed adjustment post-VDM.

§ Carry out VDM with the 'without fixed speed adjustment'
§ Use the final assignments and demand matrices produced from VDM as a starting point, run python script to calculate extra delays to create a 'revised' networks; and
§ Assignment the post-VDM demand matices onto the 'revised' networks to produce post-VDM assignments.

5.5.3 With option 1, there are number of risks associated with delivery as below:

§ Additional time to create fixed demand matrices to carry out assignment to apply fixed speed adjustment;
§ Definition of appropriate urban areas in which fixed speed to be applied may need refining, thus result in repeated works if the VDM results come out not as anticipated, thus risk in delivery of the project;
§ Possible additional assignment run-times due to extra delays added in the 'revised' networks, thus result in longer runtime during the VDM process.
§ It is not possible to compare the assignments results and TUBA benefits between 'with' and 'without' fixed speed adjustment.

5.5.4 WSP proposes the option 2, which to apply the fixed speed adjustment to the post-VDM assignments.This approach can offer:

§ Little loss in additional time required to setup initial fixed demand assignments to implement fixed speed adjustment
§ Reduced risks of repeated works, thus keeping up with delivery of the projects; and
§ Ability toprovide comparison of the assignments between 'with' and 'without' fixed speed adjustment in terms of model results and TUBA/WITA benefits if required.

5.6. Further Improvements of the Speed Decay Curves

5.6.1 The objective of the TfN is to assess each SDC corridor in the context of transformational growth strategy, thus the current speed decay approach derived from the GM models was developed to primarily deal with the reduciton in speed as a result of flow increases. The process does not, however, capture the other end of the curve, i.e. increase in speed as a result of flow decrease. The process would therefore potentially result in some missing benefits when, for example, the proposed scheme under the National Trip End Model (NTEM) growth strategy would result in reduced traffic within the urban areas, thus reduce congestions and would be able to claim extra benefits for the urban areas.

5.6.2 The refinement of the speed decay curves to account for the speed increase as a result of flow reduction is proposed to be implemented for the TPT study.

6. SUMMARY

6.1.1 A key issue with the TPS SDC model is that urban areas networks have been coded in less detail, with fixed speed and unlimited capacity. This results in the model not being able to represent accurately delays within the urban areas as flow increase, thus affecting the routeing in the vicinity of the TfN SDC schemes.

6.1.2 The WSP proposed approach to resolve this has been to develop an application utilising a ‘donor’ model (GM) to derive best fit speed decay curves from assigning increased demand to the GM network. The outcome of the test generated a set of curves that were then used for the TfN SDC scheme assessment.

6.1.3 A number of realism tests were carried out on the TPS RTM models to check the fitness of the derived curves against the GM model. TUBA analysis was also conducted on the TPT+WTCA models to provide an indication of increase in benefits as a result of the fixed speed adjustment to the urban areas.

6.1.4 The outcome from these tests show that the fitted curves produced plausible speed decays leading to improved routingcompared to the original model assignments, paricularly in terms of traffic routeing through the urban areas. The outcome has also demonstrated modest additional economic benefit. Although by virtue of the process adopted there are some risks around assurance to suit WebTAG style analysis the technique provides a plausible and proportionate approach.

6.1.5 Tests were carried out on the Central Pennine reference case 2035 networks to ensure the process would produce a plausible results prior to applying to the TfN SDC forecasts.The tests overall show more plausible routeing compared with ‘without fixed speed adjustment’ assignments, with more traffic being drawn to strategic road networks as opposed to travelling via urban routes.

6.1.6 WSP proposes to adopt option 2: applying the fixed speed adjustment to post-VDM assignments to help reduce risks and provide extra information where applicable.The proposed option offers reduced risks of repetitive works, loss of additional time required to setting up model runs, thus keeping up with the planned devilvery of the projects. Furthermore, it also offers potential comparison of economic appraisal results between ‘with’ and ‘without’ fixed speed adjustments to the urban areas.

6.1.7 WSP recognises that the current approach still have some limitation, i.e. not being able to capture speed change as a result of flow decrease, thus potentially missing benefits associated with flow reduction in the Do-something compared to the Do-Minimum. The work will be further improved for the purpose of the TPTS+ projects.