Department for Transport

TAG Unit A5.4

Marginal External Costs

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Department for Transport

Transport Analysis Guidance (TAG)

https://www.gov.uk/transport-analysis-guidance-tag

This TAG Unit is guidance for the **Appraisal Practitioner**

This TAG Unit is part of the family **A5 - UNI-Modal Appraisal**

Technical queries and comments on this TAG Unit should be referred to:

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1. Introduction

1.1.1 Road decongestion benefits will arise where significant traffic reductions occur in moderate to congested conditions. In uncongested areas the effects of reduced traffic are likely to be minimal, analogous to moving along the flat part of a traditional speed/flow curve. Fully specified multi-modal models can provide robust estimates of decongestion benefits and should be used where practical and proportionate to do so.

1.1.2 However, in some instances alternative models, such as elasticity-based models, are used in forecasting, for example for the majority of rail schemes. Models of this sort are not capable of providing estimates of road decongestion benefits and this TAG Unit provides guidance on how decongestion benefits should be estimated when a multi-modal model is not used.

1.1.3 The primary method for estimating decongestion benefits in the absence of a multi-modal model is based on **marginal external costs** (MECs). The use of road vehicles incurs both private costs borne by the individual traveller (such as fuel costs and personal travel time) and external costs borne by others. These external costs include congestion, local & global air pollution, noise, infrastructure and accident costs. The MEC method is based on the change in these external costs arising from an additional (or removed) vehicle (or vehicle km) on the network. These costs have been estimated from the Department's National Transport Model and **Surface Transport Costs and Charges: Great Britain 1998**[1]. More detail on the derivation of the costs, and the definitions of road types, area types and congestion bands, are given in Appendix A.

1.1.4 The MEC method is most likely to be used when appraising rail, walking or cycling interventions, where the use of multi-modal models is less common and analysts should refer to TAG Unit A5.1 – Active Mode Appraisal and TAG Unit A5.3 – Rail Appraisal, as appropriate. The MEC method may also be applicable in other situations, for example for low cost options or where decongestion benefits are small compared to other impacts, but this should be agreed with the Department at an early stage and verified in the Appraisal Specification Report see Guidance for the Technical Project Manager).

1.1.5 The MEC method does not take into account all of the responses available to those who switch mode (for example changing destinations) or the effect of the initial change in traffic levels on costs and subsequent demand. Sensitivity testing of scheme appraisals to the results of the MEC approach will therefore be expected.

[1] Sansom, T., Nash, C., Mackie, P., Shires, J., & Watkiss, P. (2001) 'Surface Transport Costs & Charges: Great Britain 1998' Department of the Environment, Transport and the Regions, London.

1.1.6 Alternative methods for estimating decongestion benefits in the absence of a multi-modal model, but when information on highway flows or trips is available, are discussed in section 3. As above, sensitivity testing is expected of the impact on the scheme appraisal of assumptions made when using these methods.

2. Application of marginal external costs

2.1.1 Several steps need to be taken to estimate the change in the external costs of vehicle use from this information. Steps one to three calculate total changes in external costs for the opening year and the future forecast year, and then step four explains how this analysis can be extended to cover the whole appraisal period

- Step 1 – Estimate the change in vehicle kilometres
- Step 2 – Analyse the characteristics of the vehicle journeys removed
- Step 3 – Calculate marginal external costs for modelled years
- Step 4 – Discount costs over the appraisal period

2.1.2 A worked example of the method is given in Appendix B.

2.2 Step 1 – Estimate the change in vehicle kilometres

2.2.1 The first step is to estimate the change in vehicle kilometres due to the intervention in the opening year and at least one other forecast year. This will be determined by the extent to which vehicle traffic will be diverted off the roads. There will be a diversity of approaches to this assessment depending on the nature of the scheme and its size. The Department should be consulted when new approaches are used or new issues arise when estimating the change in vehicle kilometres.

2.2.2 Diversion factors for schemes can be derived from the experience of previous similar schemes, or may also be estimated from a study undertaken specifically for the scheme. A survey of the intention of road users affected by the scheme will quantify the number of journeys that may move from the road so potentially resulting in decongestion benefits.

2.2.3 Those recommended diversion factors provided in TAG (with the exception of rail factors; see below) are in terms of person kilometres, as opposed to vehicle kilometres and hence require explicit adjustment for car occupancy for the calculation of marginal external costs.

Rail diversion factors

2.2.4 See table A5.4.5 of the TAG data book for the recommended diversion factors by flow category. These diversion factors measure the expected change in car vehicle kilometres as a percentage of the change in rail passenger kilometres. For example, an increase in rail passenger kms of 100km within the London Travelcard Area can be expected to lead to a decrease in car vehicle kms of 22km. Rail diversion factors should be subject to sensitivity testing. More detail on their derivation is given in Appendix C.

2.2.5 Where possible, the change in car kilometres should be estimated using local evidence such as passenger surveys. In the absence of local evidence, diversion factors based on the Fares Conditional Elasticity study (PDFC, 2016) may be used to convert a change in rail passenger kilometres to a change in car kilometres.

2.2.6 For some schemes these national diversion factors will not be applicable, for example where long distance access trips by car are likely to be affected or where the purpose of a scheme is to encourage mode shift. All scheme appraisals will need to consider whether the nature of the scheme is likely to make the national factors inappropriate, meaning that local evidence will be required to inform the change in car kilometres.

Walking and cycling diversion factors

2.2.7 Diversion factors for active mode appraisal are covered in TAG Unit A5.1 active mode appraisal.

Bus diversion factors

2.2.8 See TAG data book table A.5.4.6 for bus diversion factors, broken down by geographical areas and journey type.

2.2.9 The diversion factors indicate how passenger trips on other modes would be affected if an intervention lead to an increase or decrease in bus patronage. For example if there are 100 new bus passengers, there would be 24 fewer people travelling by car using the national weighted mean diversion factor.

2.2.10 The diversion factors can be used to calculate the effect of the intervention on road congestion, and the related decongestion benefits. There is currently no guidance on how to appraise the effects of an increase in bus use on other modes such as rail or light rail.

2.2.11 Car user trips should be converted into car vehicle kilometres when these diversion factors are used to calculate decongestion benefits with MECs. The change in car kilometres due to the intervention can be calculated by dividing the total distance of passenger trips by the average car occupancy rate. Average car occupancy rates can be found in TAG data book table A.1.3.3.

2.2.12 A similar calculation can also be made for taxi journeys. Bespoke analysis of National Travel Survey data carried out by the Department for Transport found an average taxi occupancy rate of 2.4 (not including the driver) between 2002 and 2016.

2.2.13 Diversion factors vary based on the choice set of transport modes which are available. For instance if light rail is not an available alternative, diversion to bus from other modes will increase. If all the recipient/source modes listed in the table are available alternatives (even if not of interest for scheme) then the diversion factors can be read directly from TAG data book table A.5.4.6.

2.2.14 If not all recipient/source modes are available then the values can be renormalized so that all available alternatives sum to 1. For instance using the national weighted mean if rail is not a viable alternative to bus, then all other values should be divided by 0.89(=1-0.11.) Diversion to/from taxi would become 0.12(=0.11/0.89.) This method assumes that passengers are equally split across all other modes and is therefore an approximation.

2.2.15 Scheme promoters can use local evidence if it is available instead. In this case, is recommended the TAG values are used as a sensitivity test.

2.2.16 An increase in bus passenger trips is likely to lead to an increase in bus vehicle kilometres. This will directly have an impact on congestion, infrastructure costs and emissions and should be included within an appraisal of a bus intervention.

2.2.17 The diversion factors should be used for uni-modal appraisal. If more complex modelling is required see TAG guidance for modelling practitioners.

2.3 Step 2 – Analyse the characteristics of the vehicle journeys

2.3.1 In the absence of a highway model, the techniques described below assign the vehicle kilometres saved to different road types, area types and congestion levels. If feasible and proportionate to the cost of the proposed scheme, local evidence should be sought about the routes that would be used. Likely road routes can be identified using highway models or routing software, while traffic flow data for busy roads is available from the relevant highway authority. If possible an opening year estimate and at least one further forecast year estimate should be produced.

2.3.2 Local analysis of the characteristics of the traffic is likely to be most feasible for the opening year estimate. Congestion levels are expected to change over time and routes may also change if, for example, other transport schemes are built. Consideration should be given to how the assignment of traffic might change over time, but this may not be possible in some circumstances. In this case, the same pattern of traffic may be assumed in the future forecast year as the opening year. Advice from the Department should be sought if it is unclear what effort is proportionate.

2.3.3 In the absence of, or to support, local evidence, estimates of regional traffic flows derived from the NTM can be used. The proportions of traffic in each congestion level for each road type and area type vary by region and are given in the TAG data book:

A5.4.1 - Traffic by region, congestion band, area type & road type

2.3.4 Proportions of traffic are given for 2025 and five year intervals to 2060. Proportions for any intermediate year can be obtained by linear interpolation. The proportions for 2060 may be assumed if the future forecast year is beyond that date.

2.3.5 If local evidence can provide road and area types but not congestion bands, then the regional traffic tables can provide evidence on likely congestion bands. For example, if the evidence suggests that a road trip which diverts from rail in the East Midlands will use only rural roads, of which half are ’A’ and half are ‘other’, then these two columns of the table for that region can be used to derive the appropriate weights to apply to the diverted car kilometres. These weights will indicate the level of congestion typically encountered by each additional car kilometre in that region for the selected road and area type. Advice should be sought from the Department if the most appropriate method of application is unclear.

2.4 Step 3 – Marginal external costs results

2.4.1 Steps one and two should provide the change in vehicle kilometres by road type, area type and congestion level for the opening year and, usually, at least one other forecast year. These can then be used with the marginal external costs given in the TAG data book, disaggregated in the same way, to estimate the decongestion benefits in the opening and forecast year:

A5.4.2 - Marginal external costs by road type and congestion band

2.4.2 The marginal external costs are presented in pence per kilometre in real, undiscounted market prices. The results change over time as the underlying values of the impacts increase in line with Departmental methodology and factors such as fuel efficiency improve. Also presented are weighted average costs for Great Britain for each element.

2.4.3 The values for each future year should be combined with the characteristics of the predicted vehicle traffic changes to give the total external costs of those changes for the scheme opening year and the other forecast year.

2.4.4 As discussed in TAG Unit A5.3 - Rail Appraisal, the indirect tax impact of shifts from/to car use should be estimated with the indirect tax element of the marginal external costs. For public transport schemes, this should be complemented with the indirect tax impact from increased/reduced spending on public transport fares (on which VAT is not applied) and from changes in fuel use relating to public transport provision (when indirect tax is paid on that fuel). More detail is given in Appendix A of TAG Unit A5.3.

2.4.5 Care must be taken when using values in congestion band 5. In principle these are conditions where traffic flow has broken down and there is currently little evidence as to how traffic operates in such conditions. Therefore the analyst should consult the Department if considering using values in this band.

2.4.6 The method described above assumes that the alternative journeys taken in the without scheme and with scheme scenarios have the same origin and destination area types. This simplifying assumption is necessary in the absence of a trip distribution model.

2.4.7 In some instances, particularly some rail interventions which are aimed at a particular time of day, it is more practical to classify changes in car kilometres by time of day and region, rather than road type and congestion band. The TAG data book also contains proportions of traffic and marginal external costs disaggregated in this way:

A5.4.3 - Car traffic shares by time of day

A5.4.4 - Marginal external costs by region and time of day

2.4.8 Proportions of traffic are given for 2025 and five-year intervals to 2060. Proportions for any intermediate year can be obtained by linear interpolation. The proportions for 2060 may be assumed if the future forecast year is beyond that date.

2.4.9 The values in Table A5.4.4 relate only to transport economic efficiency (time and vehicle operating cost) impacts. Therefore, where these values are used to calculate decongestion benefits, values from Table A5.4.2 should be used to estimate other impacts (such as accidents or greenhouse gas emissions). In such circumstances it may be problematic to determine the appropriate road type, congestion band etc so the weighted average values for Great Britain should be used.

2.4.10 The choice of which level of disaggregation to use should be based on what is most practicable in view of the scheme and the requirements of the analysis. The reporting should include a justification of the external costs used and where various options are considered (potentially including different modes) it is expected that a consistent approach will be taken.

2.5 Step 4 – Calculation of discounted external costs of vehicle use for whole appraisal period

2.5.1 Steps 1-3 will have provided total undiscounted external costs of changes in vehicle use for the scheme opening year and, usually, at least one other forecast year.

2.5.2 Interpolation and extrapolation can be used to derive individual values for all other future years to the end of the appraisal period. Analysts should have regard to the advice in TAG Unit A1.1 - Cost Benefit Analysis on interpolation and extrapolation of benefits. See Annual Parameters in the TAG data book for data used to inform extrapolation interpolation and extrapolation.

2.5.3 It is recognised that defining reasonable growth profiles for traffic may be difficult for many schemes, particularly those that have used the regional traffic proportions provided above. In the absence of other evidence, road demand (and its allocation to the area and road types/congestion levels) in the final year of the appraisal period may be assumed to be the same as in the last modelled year. The standard assumptions about growth in factors such as values of time and fuel efficiency should be assumed to continue to grow over time and these values applied to the last year of the appraisal period. The congestion, accident, air quality and noise components should be extrapolated in line with value of time growth. Infrastructure and indirect tax costs should be held constant in real terms for the remainder of the appraisal period. Greenhouse gas costs should be grown in line with the non-traded greenhouse gas values in TAG data book table A3.4.

2.5.4 The profile of benefits between the last modelled year and the end of the appraisal period may then be estimated by interpolation between the benefits estimated in the last modelled year and the end of the appraisal period.

2.5.5 These results should then be discounted to the Department's standard base year using the standard discount rate starting at 3.5%. This should be applied across all components, including those impacts on life and health. These air quality, noise and accident components have been uprated by 2% in their preparation by the Department, to approximate the effect of the lower health discount rate when combined with the standard discount rate, avoiding the need for separate treatment of health- and non-health impacts. TAG Unit A1.1 contains further advice on discounting.

2.6 Step 5 – Calculation of external costs for vehicles under different scenarios

2.6.1 Steps 1-4 have provided the total discounted external costs of changes in vehicle use for the scheme opening year and further forecast years. This step is a further optional step to re-assess steps 1-4 using different scenarios in line with those published in the National Road Traffic Projections 2022, and reflected in the TAG Common Analytical Scenarios (CAS). This step is optional for scheme promoters but will give an indication about the sensitivity of the MEC impacts to different levels of traffic forecasts.

2.6.2 In scheme appraisal, it is important to assess a range of scenarios which might impact the MEC valuations. The resulting range of values should be to provide a range around the estimated MEC impacts of the scheme. The marginal external costs for each Common Analytical Scenario are given in the Common Analytical Scenarios data book, for 2025 and five-yearly intervals to 2060.

3. Alternative approaches

3.1.1 Where a highway model is available it can be used to estimate decongestion benefits without using the external costs estimated by the NTM. The alternative approaches below still require an initial estimate of the reduction in vehicle kilometres (Step 1 – Estimate the change in vehicle kilometres) but Step 2 – Analyse the characteristics of the vehicle journeys and Step 3 – Marginal external costs results can be replaced by:

- manual reduction of flows on the affected highway links. As this is a simple link-based approach, the output can be analysed to determine the average cost per vehicle at different flow levels. This approach should only be used where the number of highway trips removed is small and the routing of highway trips can be assumed to be unaffected;
- manual reduction of trips for the affected cells of the highway trip matrix. Following this, a highway assignment model should be applied, and benefits can be assessed using TUBA. This method should be used where re-routing of highway trips is expected, but secondary induced traffic effects can be ignored; or
- where changes in highway journey times are significant and these benefits become a significant proportion (say, about 10%) of the transport economic efficiency benefits, induced traffic should be considered via an augmented application of the method discussed in the preceding bullet. Trips in affected cells of the highway trip matrix may be manually reduced. However, when applying the highway assignment model, elasticities should be included to cater for induced traffic. Further guidance on the use of elasticities to estimate induced traffic is given in TAG Unit M2 - Variable Demand Modelling. The TUBA software programme should be used to assess the decongestion benefits.

4. Presentation of results

4.1 Appraisal tables

4.1.1 The results of this analysis should be presented in the standard Transport Economic Efficiency, Public Accounts and Analysis of Monetised Costs and Benefits tables. Results should be reported as follows:

- The estimated change in congestion costs should be entered in TEE table as a change in consumer travel time for cars, LGVs and goods vehicles. It should be noted that the calculation of 'congestion' cost includes an estimate of vehicle operating cost changes.
- The estimated changes in greenhouse gases, local air quality, noise and accident costs should be entered in the relevant boxes of the AMCB table.

- Road related infrastructure costs will generally accrue to the Highways Agency or Local Government and should therefore appear in the PA table under the central or local government investment costs headings.
- A note should be added to all tables to explain that the methodology in this unit has been applied.

4.1.2 All values estimated using this method should also be included in the Appraisal Summary Table with a note to explain how they were estimated.

4.2 Spreadsheet of results

4.2.1 It is anticipated that the above method will require the use of spreadsheet software to calculate the total external cost change estimate. A clear spreadsheet of all calculations, assumptions and results must be submitted with any scheme that uses this methodology. The separate totals for each category of benefit calculated using this methodology (e.g. congestion, greenhouse gases, etc.) should be stated clearly in scheme documentation.

5. References

ITS (2016) ‘Fares Conditional Elasticity study’, conducted for PDFC, available via the PDFC website: https://www.raildeliverygroup.com/pdfc.html.

Sansom, T., Nash, C., Mackie, P., Shires, J., & Watkiss, P. (2001) ‘Surface Transport Costs & Charges: Great Britain 1998’ Department of the Environment, Transport and the Regions, London.

Sloman, L., Cairns, S., Newson, C., Anable, J., Pridmore, A. & Goodwin, P. (2010) ‘The Effects of Smarter Choice Programmes in the Sustainable Travel Towns’, Report to the Department for Transport, London.

6. Document Provenance

Marginal External Congestion Costs

This TAG Unit forms part of the restructured WebTAG guidance, taking the ‘in draft’ October 2013 versions of TAG units 3.9.5 – MSA – Decongestion Benefits and 3.13.2 – Guidance on Rail Appraisal – External Costs of Car Use as its basis. This includes adjustments to the decongestion element of the marginal external costs as a result of changes to the values of travel time savings.

Unit 3.9.5 was based on Annex E of **Major Scheme Appraisal in Local Transport Plans: Part 1 Detailed Guidance on Public Transport and Highway Schemes** (DfT, 2003). It was updated in 2007, when rail specific guidance in Unit 3.13.2 was also introduced. Both units were updated again in August 2012.

Minor changes were made to this TAG Unit in November 2015, to clarify the calculation of indirect tax impacts when the marginal external cost method has been used.

In July 2017, Section 2.2 of this unit was updated to reflect new diversion factors.

In January 2020 this unit was updated to reflect updated MEC estimates from the Department’s National Transport Model.

In May 2023 this unit was updated to reflect updated MEC estimates from the Department’s National Transport Model, as well as the introduction of MECs for the Common Analytical Scenarios.

Appendix A: Appendix A MECS and the National Transport Model

A.1 Derivation of MECs from the National Transport Model

A.1.1 This section describes how marginal external costs have been calculated using the National Transport Model (NTM). It is a multi-modal model which includes 6 modes of transport - car driver, car passenger, rail, bus, walk and cycle. The model is composed of a series of sub-models, three of which are applied in iteration to produce the main model outputs. More information on the NTM is available on the DfT's website[2].

A.1.2 The NTM calculates the marginal costs of congestion using a set of speed-flow curves. These are used to represent the relationship between the volume of traffic on a particular link and the speed of the traffic. Congestion is modelled as non-linear. When a link is relatively free of congestion, an additional vehicle will not have a large impact on speed. As the link becomes more congested, an additional vehicle will have a much larger impact upon average speed.

A.1.3 Within the NTM, congestion is defined as time lost relative to free flow conditions. The speed at free flow conditions is set at the speed limit, adjusted for junctions. As a link becomes congested (and therefore traffic will be travelling at less than free-flow speed) the implied time penalty is modelled.

A.1.4 The external costs associated with the time penalty firstly consists of the value of journey time increases due to congestion. The NTM combines the modelled delay of a marginal vehicle with the recommended TAG values of time (TAG Data Book) and then sums these across all users of a road to give the cost of delay of an additional vehicle kilometre.

A.1.5 In addition, the change in vehicle operating costs are taken into account. The addition of a single car will result in a small change in vehicle operating costs per vehicle caused by a small reduction in average speed for all the vehicles already on the link. Adding these costs to the time costs of delay gives the marginal external congestion costs.

A.1.6 Estimates of the external costs of accidents, noise, infrastructure damage, local air quality and greenhouse gases (in the form of carbon in carbon dioxide) are calculated in addition to the congestion costs. These are taken from Sansom et al. (2001) which gives these marginal external costs by vehicle-type, road-type and area-type for 1998. Values are adjusted away from Samson et al. (2001) to reflect updated subsequent guidance.

A.1.7 Overall, both NTM results on congestion and other external costs originating from Sansom et al. are valued in the future given:

- Values of time extrapolated according to TAG Data Book table 1.3.2;

- BEIS guidance on the current and future cost of a tonne of CO2 with the NTM accounting for improvements in fuel efficiency;
- DEFRA guidance on the current cost of NOx and PM10 (the latter by area type);
- Current and future fuel duty and VAT from HM Treasury;
- Accidents, local air pollution, noise and infrastructure costs are all assumed to grow in line with GDP per capita reflecting increases in people's willingness to pay. The NTM accounts for tighter vehicle emissions standards in line with DEFRA guidance.

A.2 NTM road and area types

A.2.1 This section contains information and tables explaining the definitions of terms used in FORGE (Fitting On of Regional Growth and Elasticities) and the marginal external cost outputs. Table A1 shows the codes assigned to different area and road types used in TAG Data Book tables A5.4.1 and A5.4.2. All motorways outside conurbations are assumed to be in rural areas for the purposes of the model.

Table A1 Specification of Conurbations, Other Urban, Rural, Motorways, A roads and B&C roads in terms of FORGE area and road type codes

FORGE Area Type	**Conurbations 1 to 5**			**Other Urban 6 to 9**			**Rural 10**		
FORGE Road Type	Motor ways	A roads	Other roads	Motor ways	A roads	Other roads	Motor ways	A roads	Other roads
Code	1	2 to 5	6 & 7	n/a	2 to 5	6 & 7	1	2 to 5	6 & 7

A.2.2 Table A2 shows the FORGE area type codes and a detailed definition of the FORGE area types.

Table A2 FORGE area types

1. Central London	City of London, Westminster south of Westway, and a few adjacent wards of neighbouring boroughs
2. Inner London	Remainder of: Westminster, Camden, Islington, Kensington & Chelsea, Lambeth, Southwark. All of: Hackney, Hammersmith & Fulham, Haringey, Lewisham, Newham, Tower Hamlets, Wandsworth
3. Outer London	Barking & Dagenham, Barnet, Bexley, Brent, Bromley, Croydon, Ealing, Greenwich, Harrow, Havering, Hillingdon, Hounslow, Kingston-upon-Thames, Merton, Redbridge, Richmond upon Thames, Sutton, WalthamForest.
4. Inner Conurbation	Cities of Birmingham, Manchester, Liverpool, Sheffield, Leeds, Newcastle Upon Tyne and Glasgow
5. Outer Conurbation	Remainder of former Metropolitan counties: i.e. rest of West Midlands, rest of Greater Manchester, rest of Merseyside, rest of South Yorkshire, rest of West Yorkshire, rest of Tyne & Wear and the Greater Glasgow area (including Kirkintilloch, Airdrie, Wishaw, East Kilbride, Paisley, Erskine and Milngavie)
6. Urban Big (>250,000)	Blackpool, Bournemouth, Brighton, Bristol, Cardiff, Edinburgh, Hull, Leicester, Middlesbrough, Nottingham, Plymouth, Portsmouth, Southampton, Stoke
7. Urban Large (>100,00)	Aberdeen, Basildon, Blackburn, Cheltenham, Colchester, Derby, Dundee, Gloucester, Ipswich, Luton, Milton Keynes, Newport(Gwent) Northampton, Norwich, Oxford, Peterborough, Preston, Reading, Slough, Southend, Swansea, Swindon, Telford, Torbay, Warrington
8. Urban Medium (>25,000)	Abbots Langley, Abingdon, Accrington, Aldershot & Farnborough, Alfreton & Heanor, Amersham & Chesham, Ashford, Ashtead, Aylesbury, Ayr, Banbury, Banstead, Bargoed & Newbridge, Barnstaple, Barrow, Barry, Basingstoke, Bath, Bedford, Bedworth, Belper & Duffield, Bexhill, Billericay, Bishop Auckland, Bishop's Stortford, Blyth & Cramlington, Bognor Regis, Boston, Bracknell, Bradford & Trowbridge, Braintree, Brentwood, Bridgend, Bridgwater, Bridlington, Bromsgrove, Buckhaven & Leven ,Burnley & Padiham, Burton upon Trent, Bury St Edmunds, Bushey Heath, Camberley & Frimley, Camborne & Redruth, Cambridge, Cannock, Canterbury, Canvey Island, Carlisle, Caterham & Warlingham, Chatham, Chelmsford, Chertsey, Chester, Chesterfield, Chippenham, Chipping Sodbury, Chorley, Clacton/Frinton/Walton, Cleethorpes, Clevedon & Backwell, Codsall & Wombourne, Congleton, Consett & Stanley, Conwy & Llandudno, Corby, Crawley, Crewe & Nantwich, Cumbernauld, Cwmbran, Darlington, Dartford, Deal, Dover, Dumbarton & Alexandria, Dunfermline, Durham, East Grinstead, Eastbourne, Eastleigh, Egham, Ellesmere Port, Epping/Loughton/Chigwell, Epsom & Ewell, Exeter Exmouth, Falkirk & Grangemouth, Falmouth, Farnham, Fleet, Gillingham, Glenrothes, Glossop, Grantham, Gravesend, Grays & Ockenden, Great Malvern, Great Yarmouth, Greenock & Port Glasgow, Grimsby, Guildford,, Hailsham & Polegate, Harlow, Harpenden, Harrogate, Haslingden & Rawtenstall, Hassocks & Burgess Hill, Hastings, Hatfield & Welwyn, Hartlepool, Haywards Heath, Hemel Hempstead, Hereford, Herne Bay & Whitstable, High Wycombe, Hinckley, Hitchin/Letchworth/Baldock,

	Hoddesdon/Cheshunt, Horsham, Hucknall, Hythe/Folkestone, Ilkeston, Inverness, Kettering, Kidderminster, Kilmarnock, King's Lynn, Kirkcaldy, Lancaster, Lancing, Leatherhead, Leighton Buzzard, Leyland, Lichfield, Lincoln, Littlehampton,, Livingston, Llanelli, Loughborough, Lowestoft, Lymington/New Milton, Macclesfield, Maidenhead, Maidstone, Mansfield, Margate, Marske/Saltburn/Brotton, Merthyr Tydfil, Mold/Buckley, Neath, Nelson/Colne, Newark, Newbiggin/Bedlington, Newbury, Newhaven & Seaford, Newton Abbot, Northwich, Nuneaton, Ormskirk/Skelmersdale, Penarth, Perth, Peterhead, Peterlee, Pontypridd, Port Talbot, Radlett/Elstree/Borehamwood, Rainham/Wigmore, Ramsgate/Broadstairs, Rayleigh/Rochford, Redditch, Reigate, Rhyl/Prestatyn, Rickmansworth, Rochester, Rugby, Runcorn, Salisbury, Sandown & Ventnor, Scarborough, Scunthorpe, Seaham, Sheerness, Shildon/Newton Aycliffe, Shrewsbury, Sittingbourne, South Oxhey, Spennymoor/Coxhoe, St Albans, St Neots, Stafford, Staines/Sunbury, Stanford-le-Hope, Stevenage, Stirling, Stroud/Nailsworth, Sutton/Kirkby, Swadlincote, Tamworth, Taunton, Tonbridge, Tunbridge Wells, Waltham Abbey, Walton/Weybridge/Esher, Warwick & Leamington Spa, Watford, Wellingborough, Weston-super-mare, Weymouth & Portland, Whitehaven, Widnes, Wilmslow, Winchester, Windsor, Winsford, Witham, Woking, Wokingham, Worcester, Worksop, Worthing, Wrexham, Yateley, Yeovil, York
9. Urban Small (>10,000)	
10. Rural	

A.2.3 Table A3 gives a description of the FORGE road type codes.

Table A3 FORGE road codes

Road Type	London and Conurbations	Other Urban	Rural
1	Motorway	N/A	Motorway
2	N/A	N/A	Trunk Dual A
3	N/A	N/A	Principal Dual A
4	Trunk A	Trunk A	Trunk Single A
5	Principal A	Principal A	Principal Single A
6	B and C Roads	B and C Roads	B Roads
7	Unclassified	Unclassified	C & Unclassified

A.3 NTM congestion bands

A.3.1 The congestion bands used in the external costs spreadsheets reflect the volume to capacity ratio of a traffic link. The volume (v) is the actual traffic flow and the capacity (c) is the theoretic maximum traffic flow. These can be expressed in terms of vehicle (or PCU (passenger car unit)) per time period per road (or lane) length. Table A4 shows how the congestion bands relate to the ratios.

Table A4 Congestion Bands in terms of volume over capacity

Congestion band	Volume / Capacity
1	v/c < 0.25
2	0.25 < v/c < 0.5
3	0.5 < v/c < 0.75
4	0.75 < v/c < 1
5	v/c > 1

A.3.2 When assigning traffic to the v/c bands the process assumes “average network” lane capacities. However, depending on local conditions, the actual capacity of a link may be somewhat more or less than the capacity assumed at the site. In some cases actual flows may exceed the theoretical capacity of a link and lead to v/c ratios in excess of 1.

A.3.3 Appraisals should seek to identify the capacities of roads that are used as substitutes for rail, if possible and proportionate for the size of the scheme. In the absence of more local knowledge, Tables A5 and A6 contain suggested capacities for roads in rural and urban areas respectively. Table A7 shows the PCU factors for different vehicle types.

Table A5 Suggested average capacities (PCU per lane km per hour) for rural roads

Road Type	Motorway	Trunk & Principal Dual	Trunk & Principal Single	B Roads	C & Unclassified Roads
Capacity Flow (PCU)	2330	2100	1380	1150	1050

Table A6 Suggested average capacities (PCU per lane km per hour) for urban roads

Road Type	Area Type	Capacity Flow (PCU)
Motorway	1,2&4	2000
	3 & 5	2330
A Road	1,2&4	700
	3	1100
	5	1100
	6,7,8 & 9	1100
B&C Road	1	550
	2	550
	3	790
	4	550
	5 & 6	790

	7 to 9	1050
Unclassified Road	1	550
	2	550
	3	790
	4	550
	5 & 6	790
	7 to 9	1050

Table A7 PCU Factors by Vehicle Type

Vehicle Type	PCU Factor
Car	1.0
Light Goods Vehicle	1.0
Rigid Goods Vehicle	1.9
Artic Goods Vehicle	2.9
Public Service Vehicle	2.5

Appendix B: Marginal External Cost worked example

B.1.1 This appendix provides a worked example of how to calculate the benefits of reduced car kilometres resulting from mode switch using the Marginal External Cost (MEC) method. The example is based on the cycling and walking case study of improvements to a canal towpath serving a large industrial estate in London.

B.1.2 The example follows the four-step process described in the main body of this Unit:

- Step 1 – Estimate the change in vehicle kilometres
- Step 2 – Analyse the characteristics of the vehicle journeys removed
- Step 3 – Calculate marginal external costs for modelled years
- Step 4 – Discount costs over the appraisal period

B.2 Step 1 – Estimate the change in vehicle kilometres

B.2.1 Forecast demand for walking and cycling kilometres as a result of the scheme are forecast on the basis of before and after intervention trip counts from a comparative study and assumptions about average trip distance. Removed car kilometres are based on user surveys from the comparative study which indicated that 27.3% of users had a car available for the trip but chose not to use it. The length of car trips removed is assumed to be equal to the walking and cycling trips they are replaced with, meaning car kilometres removed are 27.3% of the forecast increase in walking and cycling kilometres.

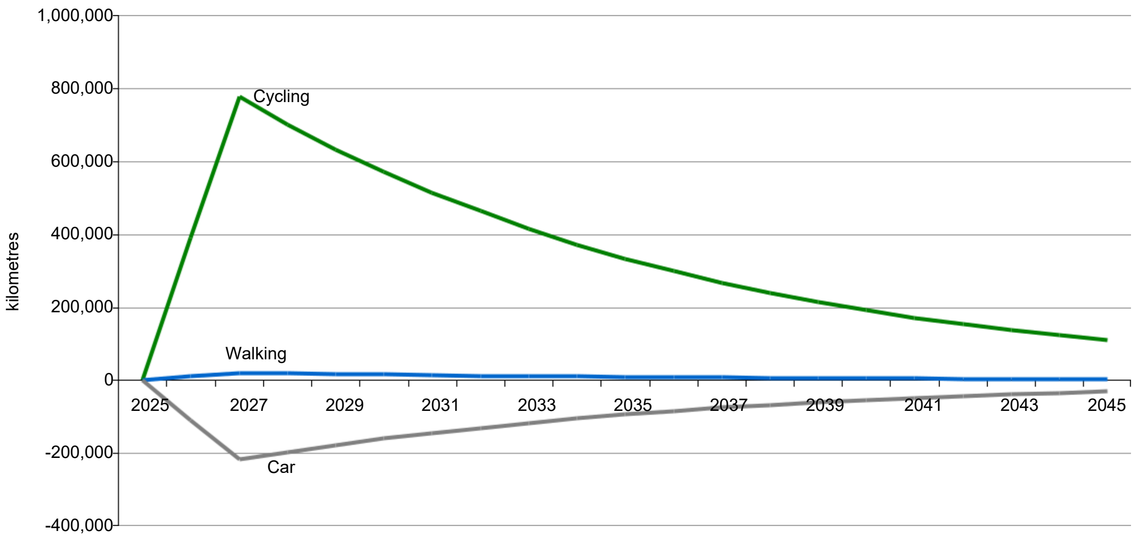

Figure B1 - Forecast increase in annual walking and cycling kilometres and reduction in car kilometres

B.3 Step 2 – Analyse the characteristics of car journeys removed

B.3.1 In the absence of specific information on the car trips being removed, average proportions of traffic by road type for London from [TAG Data Book table A5.4.1] have been used.

Table B1 Proportions of traffic by road type for London (TAG Data Book table A5.4.1)

	Motorways	A Roads	Other Roads
2025	7.8%	49.5%	42.7%
2030	7.9%	49.7%	42.4%
2035	8.0%	49.7%	42.3%
2040	8.1%	49.7%	42.2%
2045	8.2%	49.6%	42.2%
2050	8.2%	49.6%	42.2%
2055	8.2%	49.6%	42.2%
2060	8.1%	49.6%	42.2%

B.4 Step 3 – Calculate marginal external costs for modelled years

B.4.1 The MECs by road type for London, for each category of impact and year, were taken from **TAG Data Book table A5.4.2**. These were then weighted with the proportions of traffic in Table B1 to produce weighted average marginal external costs for each year and category of impact.

Table B2 Weighted average marginal external costs for all road types, London (cars, pence per kilometre, 2010 market prices)

	2030	2035	2040	2045
Congestion	72.0	84.3	97.3	107.2
Infrastructure	0.1	0.1	0.1	0.1
Accidents	3.7	4.0	4.4	4.9
Local Air Quality	0.7	0.7	0.7	0.0
Noise	0.3	0.3	0.3	0.4
Greenhouse Gases	2.6	2.1	1.8	1.8
Indirect Taxation	-1.2	-0.1	0.5	0.7
Reduction in car kms	-159,932	-93,579	-53,922	-31,042
Net impact (£)	-£124,897	-£85,524	-£56,735	-£35,718

B.4.2 The benefit in each year for which marginal external costs are provided is then calculated as the product of the MECs presented in Table B2 and the number of car kilometres forecast to be removed in that year.

B.5 Step 4 – Discount costs over the appraisal period

B.5.1 Forecast reductions in car kilometres were produced for each year of the appraisal period. Therefore the MECs for each category were interpolated between the years for which values are given in the TAG databook (for example a decongestion value of 92.1 pence per kilometre in 2038). The cost per kilometre for each category was multiplied by the number of car kilometres removed in each year of the appraisal period. The stream of benefits for each category was then discounted to a 2010 base year using the standard HMT Green Book discount rates given in **TAG Data Book table A1.1** and described in TAG Unit A1.1 – Cost Benefit Analysis.

B.5.2 The calculations are set out in Table B3 and the overall results are presented in Table B4 (the figures in Table B4 show the change in marginal external costs, so that negative values represent benefits).

Table B3 Calculation of marginal external costs

Cost (ppkm)	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**
Congestion	71.98	74.43	76.89	79.35	81.81	84.27	86.88	89.49	92.10	94.71	97.32	99.30	101.27	103.25	105.23	107.20
Infrastructure	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.14	0.14	0.14	0.14	0.14
Accident	3.65	3.73	3.80	3.88	3.95	4.03	4.11	4.19	4.27	4.36	4.44	4.53	4.62	4.72	4.81	4.90
Air Quality	0.73	0.71	0.70	0.69	0.67	0.66	0.66	0.66	0.67	0.67	0.67	0.54	0.40	0.27	0.13	0.00
Noise	0.26	0.27	0.28	0.28	0.29	0.29	0.30	0.30	0.31	0.32	0.32	0.33	0.34	0.34	0.35	0.36
GHG	2.56	2.47	2.37	2.27	2.18	2.08	2.03	1.98	1.94	1.89	1.84	1.83	1.82	1.81	1.80	1.79
Indirect Tax	-1.20	-0.97	-0.74	-0.51	-0.28	-0.05	0.05	0.16	0.27	0.38	0.49	0.53	0.56	0.60	0.64	0.67
	2030	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**
Car kms (000s)	-160	-147	-133	-120	-107	-94	-86	-78	-70	-62	-54	-49	-45	-40	-36	-31
Benefits (£000s)	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**
Congestion	-£115	-£109	-£102	-£95	-£88	-£79	-£75	-£70	-£64	-£59	-£53	-£49	-£46	-£41	-£38	-£33
Infrastructure	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0
Accident	-£6	-£5	-£5	-£5	-£4	-£4	-£4	-£3	-£3	-£3	-£2	-£2	-£2	-£2	-£2	-£2
Air Quality	-£1	-£1	-£1	-£1	-£1	-£1	-£1	-£1	-£0	-£0	-£0	-£0	-£0	-£0	-£0	£0
Noise	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0
GHG	-£4	-£4	-£3	-£3	-£2	-£2	-£2	-£2	-£1	-£1	-£1	-£1	-£1	-£1	-£1	-£1
Indirect Tax	£2	£1	£1	£1	£0	£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0	-£0
	2030	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**

Discount factor	0.49	0.47	0.46	0.44	0.43	0.41	0.40	0.38	0.37	0.36	0.34	0.33	0.32	0.31	0.30	0.29
Discounted Benefits (£000s)	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**
Congestion	-£56.5	-£51.8	-£46.7	-£42.0	-£37.2	-£32.5	-£29.6	-£26.7	-£23.8	-£20.9	-£18.0	-£16.1	-£14.6	-£12.7	-£11.3	-£9.55
Infrastructure	-£0.09	-£0.08	-£0.07	-£0.06	-£0.06	-£0.05	-£0.04	-£0.04	-£0.03	-£0.03	-£0.02	-£0.02	-£0.02	-£0.02	-£0.02	-£0.01
Accident	-£2.86	-£2.59	-£2.31	-£2.05	-£1.80	-£1.55	-£1.40	-£1.25	-£1.10	-£0.96	-£0.82	-£0.74	-£0.67	-£0.58	-£0.52	-£0.44
Air Quality	-£0.57	-£0.50	-£0.43	-£0.36	-£0.31	-£0.25	-£0.22	-£0.20	-£0.17	-£0.15	-£0.12	-£0.09	-£0.06	-£0.03	-£0.01	£0.00
Noise	-£0.21	-£0.19	-£0.17	-£0.15	-£0.13	-£0.11	-£0.10	-£0.09	-£0.08	-£0.07	-£0.06	-£0.05	-£0.05	-£0.04	-£0.04	-£0.03
GHG	-£2.01	-£1.72	-£1.44	-£1.20	-£0.99	-£0.80	-£0.69	-£0.59	-£0.50	-£0.42	-£0.34	-£0.30	-£0.26	-£0.22	-£0.19	-£0.16
Indirect Tax	£0.95	£0.68	£0.45	£0.27	£0.13	£0.02	-£0.02	-£0.05	-£0.07	-£0.08	-£0.09	-£0.09	-£0.08	-£0.07	-£0.07	-£0.06

B.5.3 The decongestion benefits form part of the Transport Economic Efficiency (TEE) impacts of the scheme and should be reported in the TEE table in the "Road" column and carried through in to the Analysis of Monetised Costs and Benefits (AMCB) table and Appraisal Summary Table (AST). The MEC approach does not distinguish between journey purposes but the decongestion benefits can be split using the default values in **TAG Data Book table A1.3.4.** The decongestion benefits represent changes in both travel time and vehicle operating costs. It should be noted in the AST that this is the case and that the benefits have been calculated with the MEC method.

B.5.4 The indirect tax impacts should be reported in the Public Accounts (PA) table, AMCB table and AST. The infrastructure impact represents a reduction in highway maintenance costs and should be included as a negative cost in the PA table, netting off the scheme costs. The accident, local air quality, noise and greenhouse gas impacts should be reported in the AMCB and AST and contribute to the scheme's Present Value of Benefits (PVB).

Table B4 Present values of marginal external costs

Category of impact	Present Value (£000s, 2010 market prices)
Decongestion	-£450
Infrastructure	-£1
Accident	-£22
Local Air Quality	-£3
Noise	-£2
Greenhouse Gases	-£12
Indirect Taxation	£2

Appendix C: Deriving rail diversion factors

C.1.1 See the TAG data book table A5.4.5 for the appropriate diversion factors by flow category.

C.1.2 Analysis carried out as part of the Fares Conditional Elasticity study (conducted by ITS Leeds for the Passenger Demand Forecasting Council (PDFC))[2] looked at the results from a ticket-type diversion technical survey from 2011, which asked people how they would divert from rail if a ticket type was unavailable. We have used the answers from this as a proxy for diverting to/from rail, for any reason.

C.1.3 The academic who undertook the survey provided results to DfT, including diversion factors for each ticket type, within each rail flow category. We have aggregated the results across ticket types, for each flow category, using ticket type and flow category data from Lennon data, to weight the aggregated results.

C.1.4 The new car diversion factors for PDFH flow categories 1 and 2 (‘London Travelcard area’ and ‘South East to London’) are somewhat lower than for other categories. For London, this is due to a high rate of bus diversion, as there is greater bus availability than in other parts of the country. For the latter car unavailability means a very high proportion of people would not attempt to make a journey into London if a train is unavailable.

[2] This report is available on the PDFC website: https://www.raildeliverygroup.com/pdfc.html.

Appendix D: Bus diversion factors

D.1.1 The diversion factors have been produced by a study carried out by RAND Europe and Systra for Department for Transport. The literature review involved searching the relevant academic and grey literature as well as making enquiries to experts in the field to identify material.