Additional traffic information to improve local emission estimates

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Executive Summary

With the introduction of the 1995 Environment Act, the estimation of road traffic emissions has become a key task for local authorities. The local air quality management process requires an assessment of emissions from traffic. Local Transport Plans must make an assessment of the impacts of proposed transport schemes on the environment. Traffic composition is known to be an important factor in estimating emissions. Whilst details of typical vehicle-mixes are available for some roads, for others national statistics are the only realistic alternative, direct measurement being costly. There can be significant differences between traffic composition on a local scale and the national average and this may not adequately describe the local situation for the purpose of accurately estimating emissions.

As part of the TRAMAQ programme of research sponsored by the Charging and Local Transport (CLT) Division of the Department of Environment Transport and the Regions (DETR), TRL was commissioned to investigate and provide a classification of traffic composition, by geographical area and location type, that could be used in local air quality assessments. This involved an analysis of the sensitivity of emission estimates to the parameters that describe traffic and the development of relationships that could describe how these parameters might be affected by road type, area type and time.

The sensitivity analysis of the parameters that affect emission estimates was carried out in two stages: the first stage sought to determine the sensitivity of emission estimates for each pollutant to the various parameters for each of the vehicle types and the second stage considered the sensitivity of total fleet emission estimates to the parameters under test. The study makes use of the methodologies adopted in the NAEI for hot emissions and COPERT III for cold start and evaporative emissions. The sensitivity analysis was carried out for each year from 1998 to 2010 inclusive. It was important to consider each year because as vehicles are scrapped they are replaced with new vehicles complying with tighter emission standards.

The effect on emission estimates of varying engine size, vehicle weight, age, average speed, trip length, ambient temperature, maximum and minimum daily ambient temperature was investigated. By changing each parameter in turn, the sensitivity of emission estimates was determined by comparison with the estimates made using a basecase. Where the difference was greater than 10%, additional local information on that parameter should be obtained.

When considering overall fleet emissions, the most important parameter is average speed. Differences of ± 30% can have a large effect on the estimate and local information on average speed would therefore be needed to assess local situations. HGV weight is also important, and local information on the split between the different categories would be required.

It is more important when considering a particular vehicle type to obtain local information and an indication is given of the data requirements for schemes that affect the proportions of vehicle types within the traffic, e.g. where there is a substantial change in the proportion of HGVs. Again, the most important parameter is average speed and local data would be required. For diesel vehicles engine size or weight are important parameters, and local information on the split between the different categories would be required. Evidence from the other types of diesel vehicle suggests that this would also be the case for buses.

Estimates of cold start emissions (for cars and LGVs only) are sensitive to the ambient temperature data used and so local data should therefore be sought. Local information on the maximum daily temperature should be sought for the estimation of evaporative emissions.

Relationships have been derived using a number of sources to describe how average speed, engine size, fuel used, trip length, vehicle age profile and HGV weight distribution vary with road type (motorway to rural B&C roads), functional area type (London inner to rural) and year (1996 to 2010). These relationships are provided as a series of tables to be used with vehicle flows that are classified according to the proportion of cars, LGVs, HGVs and buses and coaches. The relationships presented here allow the user to introduce a local dimension to estimates of emissions from road traffic by allocating traffic to defined road types and functional area types.

It is important to acknowledge the limitations in the method proposed. Firstly, although the functional area types do take account of some of the variations in traffic composition, there are also regional effects. However because of the relatively small amount of data that are available it has not been possible to disaggregate the relationships to include regional effects.

Secondly, the availability data on emissions from motorcycles, HGVs and buses are scarce. This means that the composition of HGVs and buses by weight is based on a very crude split and that motorcycles are excluded entirely.

Thirdly, there are uncertainties in the effect of the economy on vehicle purchasing and replacement and on the growth in freight, and these increase with the prediction year. Despite these limitations, the relationships described in this report allow emissions to be determined for local traffic conditions.

1 Introduction

1.1 Background to the study

1.1.1 Local air quality management

Part IV of The Environment Act 1995 requires local authorities to review and assess air quality in their areas against standards and objectives set out in the Air Quality Regulations 2000 and The Air Quality Strategy (AQS) (DETR, 2000). Where the review indicates that air quality objectives will not be met, then the local authority must designate an Air Quality Management Area (AQMA). An AQMA would then require an air quality action plan to improve air quality. Local authorities need also to have regard to the objectives of AQS when undertaking other functions such as regulating land use and drawing up development and local transport plans. The review and assessment process is a key starting point for developing a local air quality strategy that integrates air quality considerations into the policy framework, and ensures that air quality is a consideration in local authority decision making processes.

1.1.2 Traffic emissions and local air quality

In developing local air quality strategies and action plans, local authorities will need to consider the contribution that road traffic makes to air pollution. Table 1 shows that for many pollutants (notably nitrogen oxides (NO_x), carbon monoxide (CO), benzene, 1,3-butadiene and PM_{10}) road traffic contributes the most to emissions. There are exceptions, for example Middlesborough, where industry makes a large contribution to atmospheric emissions, but it is clear that estimating road traffic emissions will be a key task in the review and assessment process.

Table 1 Road traffic contribution to atmospheric emissions (%)

Area	*SO_2*	*NO_x*	*CO*	*CO_2*	*Ben -zene*	*1,3-butad -iene*	*PM_{10}*
Greater Manchester (1997)	3	63	95	21	93	96	31
London (1996)	23	75	97	29	83	97	77
West Midlands (1996)	16	85	98	43	99	97	56
Glasgow (1998)	28	76	95	29	92	98	73
Middlesborough (1998)	1	17	22	3	17	42	19
West Yorkshire (1998) (Leeds, Bradford and Kirklees)	25	73	95	17	65	98	64
Greater Belfast (1999)	2	60	75	19	89	100	17
Swansea and Port Talbot (1998)	1	28	83	17	80	92	13

Sources: Greater Manchester (Buckingham et al., 1997a); London (Buckingham et al., 1997b); West Midlands (Hutchinson and Clewley, 1996); Glasgow, Middlesborough, West Yorkshire, Swansea and Port Talbot (Buckingham et al., 1998); Greater Belfast (London Research Centre 1999).

Where hotspots of pollution result mainly from the impacts of vehicles, Government guidance suggests that traffic management be considered as a way to reduce emissions. Traffic management measures can involve a redistribution of traffic, changes in the operation of vehicles, a modal shift from private to public transport or a combination of these. The impact of any traffic management scheme on emissions and air quality may be as a result of a combination of these changes.

Local authorities need to be able to predict emissions from traffic, and in particular there is a need to estimate the effect of traffic management schemes on vehicle emissions. The direct measurement of emissions is impractical because of the large number of vehicles involved and the cost of each measurement. Emission models therefore represent a more appealing and cost-effective alternative. To determine the impact of traffic management schemes, emission models need to be able to account for detailed changes in vehicle operation and traffic composition. This study considers how traffic composition affects the accuracy of emission estimates: other ongoing studies in the TRAMAQ programme are collecting information on how traffic management affects vehicle operation and emission rates.

1.1.3 Modelling vehicle emissions

Many factors affect emissions from traffic, and these can be classed as:

- Operational factors that are influenced by driver behaviour and road conditions. These affect the way a vehicle is driven, influencing speed, rates of acceleration and deceleration and periods of idling.
- Technical factors that relate to the vehicles present in the traffic, e.g. engine size, fuel, vehicle weight, emission control technology (for which age is often a proxy).

In the calculation of the contribution of road traffic to emissions, the National Atmospheric Emission Inventory (NAEI) makes use of an average UK traffic composition obtained from vehicle registration statistics. The fleet turnover rate, based on average survival rates, new registrations in recent years and other relevant information, defines the fleet composition in future years. However, an assessment of emissions from traffic in connection with local air quality management needs to address local air quality issues, and there can be significant differences between traffic composition on a local scale and the national average. For example, buses and taxis are found predominantly in urban areas; few large lorries are found in residential locations; the age, and therefore level of emission control, of cars may vary in relation to a region’s economic performance.

This is reflected to a certain extent in the approach suggested in the draft Guidance Note on *‘Review and assessment: estimating emissions’* (DETR *et al.*, 1999). The Guidance suggests that information on local traffic is combined with the basic UK vehicle fleet statistics and projections of growth with representative factors for cold start, hot, and trip end hot soak emissions. A database of representative emission factors - the UK Emission Factors Database (UK EFD) has been assembled for use in emission inventories[1] . The database includes emission factors for cars

[1] *The UK EFD is based on numerous measurements compiled by TRL and can be found at www.London-research.gov.uk.*

(petrol and diesel), light goods vehicles (petrol and diesel), buses, motorcycles and heavy goods vehicles (small and large); speed in steps of 5 km/hr; by year; and hot (including evaporative) emissions and trip end emissions. Local authorities may have details of typical vehicle mixes on some of the roads in their area, but this will need to be supplemented by national statistics derived from, for example, the National Road Traffic Forecast (NRTF). These may not adequately describe the local situation for the purpose of accurately estimating emissions.

1.1.4 The effect of traffic composition on traffic emissions

Traffic composition has been shown in various studies to be important in determining the total emissions. Comparison of the traffic composition in central, inner and outer London shown in Table 2, and the contribution of different vehicle types to PM_{10} emissions shown in Figure 1 clearly demonstrates the disproportionate contributions to emissions by different vehicle types. In 1996 cars accounted for 65% of traffic in central London, but less than 20% of PM_{10} emissions from road traffic. In contrast, medium and heavy goods vehicles (M&HGVs) accounted for only 6% of traffic but over 35% of PM_{10} emissions. In central London, buses have a similar overall contribution to PM_{10} emissions as cars, but in outer London, and London as a whole, the contribution from cars is almost three times that of buses.

Table 2 The percentages of vehicle types in the central, inner and outer London cordons

	Within central cordon	*Within inner cordon*	*Within outer cordon*
Motorcycles	4.5	3.0	1.5
Cars	65.5	76.5	80.5
Taxis	10.0	2.0	0.5
Light Goods	11.5	11.0	10.0
Medium Goods	5.0	4.5	4.5
Heavy Goods	1.0	1.0	2.0
Buses and Coaches	2.5	2.0	1.0

Source: LPAC (1998).

Vehicle age, in terms of the applicable emissions legislation at the time of manufacture, also has a significant effect on emissions from vehicles. Figure 2 shows the relative reduction in emission limits for cars since 1970. New vehicles are constantly being introduced into the fleet and predominantly the older vehicles are being scrapped. The vehicle fleet therefore develops, with the gradual introduction of new vehicles into the fleet. For passenger cars there is a turn over of approximately 10% each year and, as such, any new emission legislation for passenger cars would take approximately 5 years to become dominant within the fleet.

These two effects, i.e. improvements in emissions from each vehicle type and their proportion in the traffic, can combine to alter the importance of different vehicle types to total emissions. In Figure 3, CO and PM emission rates are plotted against the proportion of heavy-duty vehicles (HDV) in the traffic. The data are taken from DMRB Volume 11 (Department of Transport *et al.*, 1995) and the values are normalised to a traffic composition with 8% HDV, which is the average on roads in the UK. For CO emissions, at a low proportion of HDVs in the traffic (2%), their contribution to total emissions declines with time. However for traffic with a higher proportion of HDVs (30%) their importance increases with time. For PM emissions, their contribution to total emissions is very much dependent on the proportion in the traffic, but their importance is not particularly dependent on the year.

Variations in the proportions of different vehicle types in the traffic and their age profile could significantly affect the quantities of pollutants emitted. Therefore a localised evaluation of traffic composition might be necessary to provide a realistic assessment of local air quality. The most accurate means of determining traffic composition at a local level is by direct observation: however because of the cost implications, this may not always be feasible.

1.2 Objectives of the research

The main aim of the study is to investigate and provide a classification of traffic composition, by geographical area and location type, that could be used in local air quality

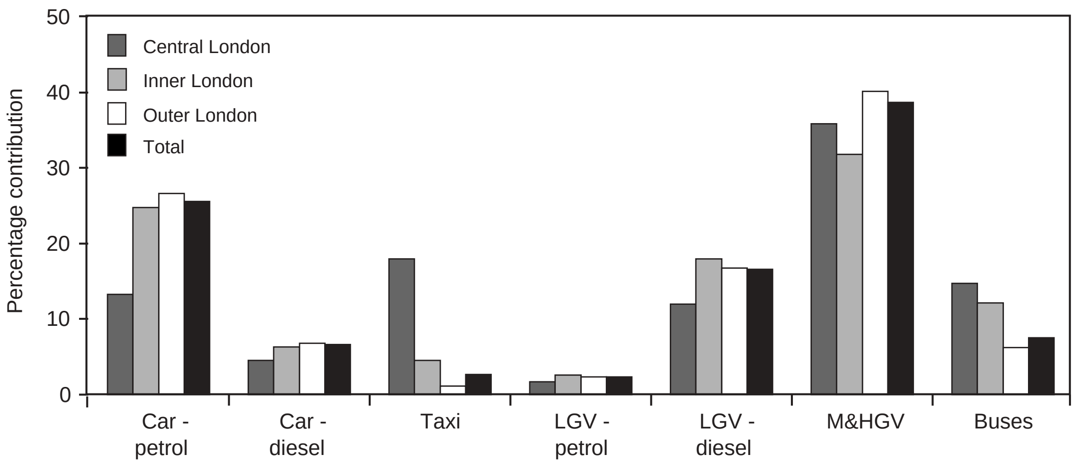

Figure 1 PM_{10} emission contributions by vehicle type (1996). (Source: Cloke *et al.*, 2000)

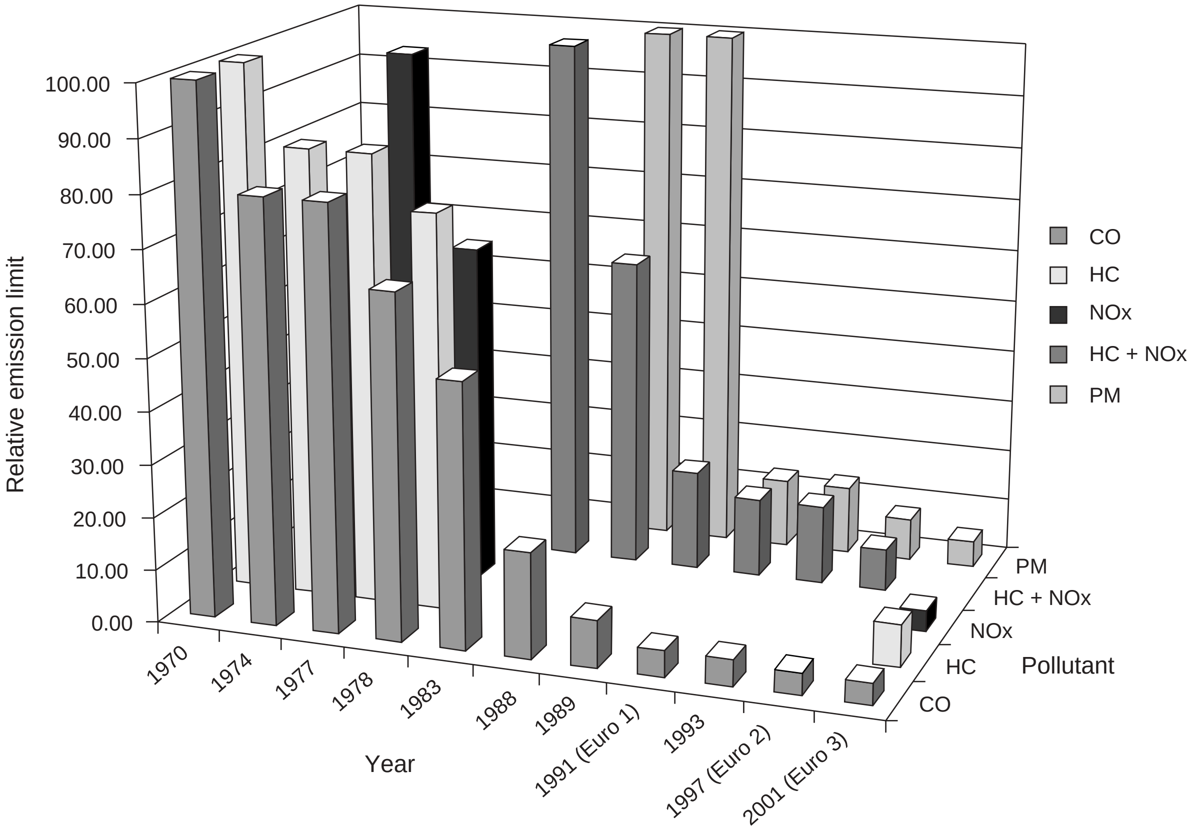

Figure 2 The relative reductions in allowable emissions from passenger cars

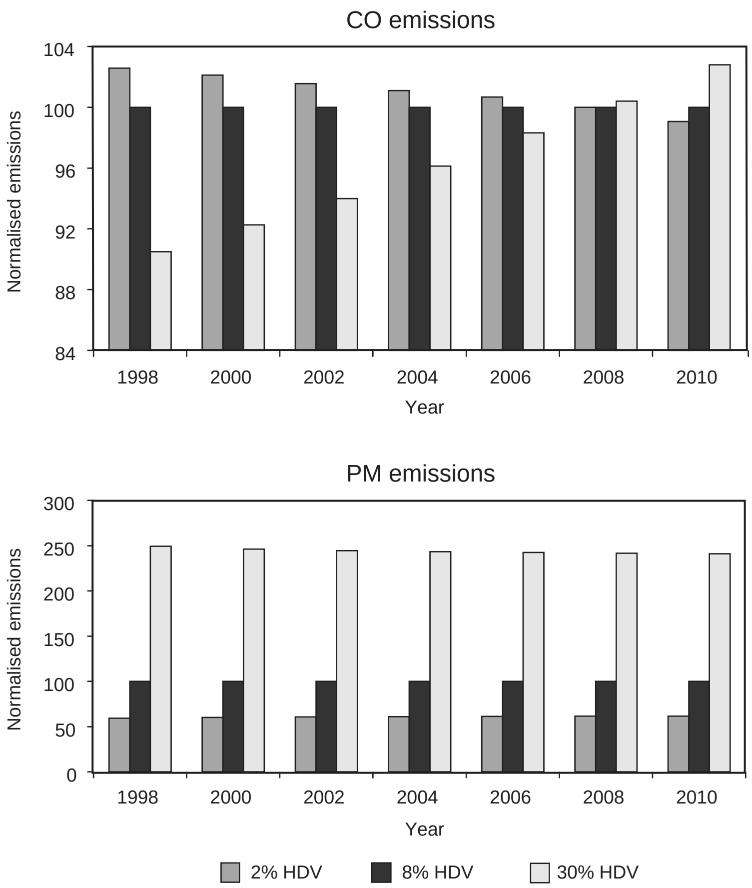

Figure 3 Effect on emissions of % HDV and year

assessments. Because local authorities need to predict traffic emissions in the future (2005 and beyond) the classification will need to consider changes in fleet composition with time.

The specific objectives of the study are:

1 To undertake a sensitivity analysis to determine the effects of differences in traffic composition on vehicle emissions.

2 To define the level of detail required in obtaining the localised traffic data.

3 To review the information used and the assumptions made in compiling the National Road Traffic Forecasts.

4 To determine and undertake other additional investigations, within the budget constraints for this project, that might be required to achieve robust results.

5 To develop a classification of traffic composition by geographical area and type of location in England.

1.3 Scope of the report

This Final Report describes the traffic information that can be used to determine vehicle and fleet emissions for future scenarios.

In Chapter 2, the sensitivity of emission estimates to changes in parameters describing traffic is summarised. The two main sources of forecasts for traffic and vehicles, the National Road Traffic Forecasts and the Vehicle Market Model, are described in Chapter 3. Using the sensitivities as a guide, a method to determine and forecast traffic composition is developed in Chapter 4.

2 Sensitivity of emission estimates to traffic composition

2.1 Introduction

Figures 1, 2 and 3 demonstrate that for each pollutant, emission estimates vary according to vehicle type and age. But what other traffic parameters are estimates sensitive to and how important are those sensitivities? This chapter summarises an earlier report on sensitivity tests of the effect of various traffic parameters on emission estimates (Cox *et al*., 1999).

The sensitivity analysis was carried out in two stages. The first determined the sensitivity of emission estimates for each pollutant to the various parameters for each of the vehicle types. Each vehicle type contributes a certain proportion to the total emissions for the fleet, and this also depends on pollutant type. The second stage took, for each vehicle type in turn, the results of the first stage and considered the sensitivity of total fleet emission estimates to the parameters under test. Estimates of hot, cold start and evaporative emissions were considered.

For hot emissions, this study makes use of the method and emission factors used in the NAEI. Emission factors are combined with annual vehicle kilometres to provide a total emission. In the NAEI, kilometres travelled by a vehicle type are used as an indication of the proportion of those vehicles present in the fleet. The emission factors for each pollutant are based on the relationship between emission rates and average speed according to vehicle type, legislation class, and size (engine size for cars and weight for goods vehicles) and were those used in the NAEI. Hickman (1998) supplied the average speeds assigned to each road type.

Upon starting a vehicle, and for a period of time afterwards, the engine will not be operating at its maximum efficiency and emissions will be elevated: this period is known as the cold start. The method in the European Environment Agency’s road transport emission model, COPERT III (Ntziachristos and Samaras, 1999) was used to estimate cold start emissions. Emission factors are only available for petrol, diesel and LPG passenger cars. It was assumed in this study that cold start emissions from LDVs can be estimated in the same way as for passenger cars.

Hydrocarbon emissions also arise by evaporation from the fuel system, especially of petrol vehicles. Evaporative emissions depend on the volatility of the fuel and the variations in temperature, both ambient and in the fuel system during a journey. Three types of evaporative loss can occur:

- diurnal losses, as a result of the expansion and contraction of the contents of the fuel tank during the daily temperature cycle;
- hot soak emissions due to the evaporation of fuel after the engine is switched off;
- running losses due to the evaporation of fuel during operation of the vehicle.

The method described in COPERT III was used in this study.

In the sensitivity analysis, a basecase of total UK hot emissions was calculated using the annual vehicle-kilometres used in compiling the NAEI. The vehicle classes for which estimates are made are shown in Table 3. Road type is classed as urban, rural or motorway. Traffic composition is predicted to change year-on-year because of vehicle scrappage and their replacement with new, cleaner vehicles. In addition traffic growth for each vehicle type will differ. Because of this, the sensitivity analysis was carried out for each year from 1998 to 2010 inclusive. By changing each of the parameters described below, the sensitivity of emission estimates to these could be determined through comparison with the estimates made for the basecase. In order to validate the method of estimating emissions, a comparison with the road transport portion of the NAEI (DETR, 1998) was made for 1996.

It should be noted that there are a wide range of vehicle weights for HGVs and currently very limited emissions data. The work presented here is based on a crude split between articulated and rigid vehicles. As more emissions data become available, for example through Project UG216 (Latham *et al*., 2000), they may indicate that it is necessary to have local information on HGV weights.

Motorcycles were not included in the analysis due to the scarcity of reliable emission factors. Motorcycles make up the smallest proportion of the vehicle fleet, but this does not necessarily mean that their importance is small.

Table 3 Breakdown of vehicle classes

Vehicle class *Fuel type*	*Engine size/ weight*	*Legislation*
Passenger cars		
Petrol	<1.4l 1.4-2.0l >2.0l	Pre-Euro 1 Euro 1 Euro2 Euro 3 Euro 4
Diesel	<2.0l >2.0l	Pre-Euro 1 Euro 1 Euro2 Euro 3 Euro 4
Light Goods Vehicles (LGVs)		
Petrol	Small Medium Large	Pre-Euro 1 Euro 1 Euro2 Euro 3 Euro 4
Diesel	Small Medium Large	Pre-Euro 1 Euro 1 Euro2 Euro 3 Euro 4
Heavy Goods Vehicles (HGVs)		
Diesel	Rigid Articulated	Pre-Euro 1 Euro 1 Euro2 Euro 3 Euro 4
Buses and Coaches		
Diesel	All	Pre-Euro 1 Euro 1 Euro2 Euro 3 Euro 4

2.1.1 Parameters tested

For each year from 1998 and 2010 inclusive, hot emissions were calculated for a basecase traffic composition. For cold start and evaporative emissions the analysis was carried out for the years 1998, 2001, 2004, 2007 and 2010 for summer and winter. In this way the basecase reflects the changing fleet over time and the difference in ambient temperature during the year. It was assumed that half of the trips were carried out in the summer i.e. on 182.5 days.

The effect on the emission estimates of varying the parameters listed below was investigated:

- engine size;
- vehicle weight;
- vehicle age;
- average speed;
- trip length;
- ambient temperature;
- maximum and minimum daily ambient temperature.

Emissions of PM were not included in the sensitivity analysis for petrol cars or LGVs as there are few data on which to base emission factors.

2.1.1.1 Engine size

The sensitivity of emission estimates to engine size was tested for passenger cars only: emission factors for buses, HGVs and LGVs are not disaggregated according to engine size.

Table 3 gives the engine size categories used for petrol cars. The effect of engine size was tested by including all the vehicle-kilometres in the 1.4 –2.0 l category. For diesel cars, the vehicle kilometres were included in the <2.0 l category and then in the >2.0 l category.

2.1.1.2 Vehicle weight

The sensitivity of emission estimates to vehicle weight and configuration was tested for HGVs and LGVs: emission factors for passenger cars and buses are not disaggregated according to weight.

Table 3 gives the weight categories used for LGVs and HGVs. For LGVs, the effect of vehicle weight was tested by including all the vehicle-kilometres in the medium size category. For HGVs, all the vehicle-kilometres were included in the rigid or the articulated category.

2.1.1.3 Vehicle age

As shown in Figure 2, the introduction of the Euro 1 legislation for cars manufactured from 1993/4 dramatically reduced emission limits of CO, HC and NO_x, and for diesel vehicles, PM. This trend has continued with the introduction of Euro 2 and Euro 3 cars in 1996and 2000 and further reductions will occur as a result of the Euro 4 legislation, albeit at a less dramatic rate.

The sensitivity of emission estimates to vehicle age was determined by examining the error that would arise if the percentage of vehicles in the dominant emission legislation class were altered. For example, using the 1998 basecase, all the vehicle-kilometres travelled were included in the Euro 1 vehicle class and the emissions were subsequently recalculated by including 10%, then 15% and 20% of the fleet as pre-Euro 1. The procedure was carried out on Euro 1 to Euro 4 assuming a certain percentage of the fleet was in the legislative class below and above. This procedure should give a good indication of the sensitivity of emissions estimates to vehicle age against a continually changing fleet composition.

2.1.1.4 Average speed

The effect of average speed was calculated independently for each of the road types, urban, rural and highway, and then for all roads in combination. To do this it was necessary to create a basecase of emissions for each road type, assuming that all the vehicle-kilometres were driven on that road type. For the ‘all roads’ scenario the basecase was the same as the standard basecase calculated for each year. The speeds were then varied by ±30% for each road type. For cold start emissions, only emissions estimates of post-Euro 1 petrol vehicles were included in the tests.

2.1.1.5 Trip length

The sensitivity of emissions estimates to trip length was tested by varying the average trip length of 8.4km by ±10%.

2.1.1.6 Temperature

The sensitivity of emissions estimates to temperature was tested by varying in turn the ambient, maximum and minimum daily temperature by ± 2, 4 and 6 ^{o}C.

2.1.2 Assessment criteria

The calculated emissions were compared against the relevant basecase and the percentage difference was compared with sensitivity criteria. The criteria were based on the premise that traffic management schemes may lead to a 5-10% change in emissions on implementation: an accuracy of 5-10% in emission estimates is therefore required in order to, for example, compare the relative benefits of a number of different schemes.

If by varying a particular parameter the results differ by greater than 5%, emission estimates were judged sensitive to that parameter. When interpreting the results in terms of the detail required to accurately predict emissions, a difference of less than 10% was considered small enough to be able to use the national vehicle fleet composition. Where the differences were greater than 10%, additional local information on that parameter should be obtained. It was also necessary to consider the pollutant under review. For example, NO_x and PM_{10} emissions are of particular concern for urban areas when evaluating the likelihood of exceeding air quality objectives.

2.2 Sensitivity of vehicle emissions estimates

2.2.1 Hot emissions

2.2.1.1 Passenger cars and engine size

For petrol cars, only estimates of CO_2 and CO emissions are sensitive to engine size, but the percentage difference is less than 10% and so using the national fleet data would provide sufficient accuracy.

For diesel cars, emissions of CO_2, NO_x, HC and PM are sensitive to engine size. Because there were differences greater than 10% in the sensitivity analysis for emissions of CO_2, HC and PM, greater detail than is provided by the national fleet composition would be required.

2.2.1.2 Goods vehicles and weight

For petrol LGVs, estimates of emissions of CO_2, NO_x and HC are sensitive to vehicle weight. The sensitivity is large for CO_2 and NO_x and so local data would be needed to provide an acceptable level of accuracy in emission estimates.

Emission estimates of CO, NO_x, HC and PM for diesel LGVs are sensitive to vehicle weight and would require local information to be able to predict emissions accurately.

In general HGV emissions of all the pollutants are sensitive to the split between articulated and rigid vehicles. Local information would be required to determine emissions of CO, CO_2, NO_x and HC accurately.

2.2.1.3 Average speed

Emission estimates are far more sensitive to average speed than to vehicle weight or engine size. For all pollutants, it is important that local information is available on speeds, particularly for estimating emissions from diesel vehicles and for schemes on roads classed as motorways.

It should be noted that for buses, the highest speeds used in the sensitivity tests are outside the range for which the emission curves are valid, so these results should be treated with some caution.

2.1.1.4 Vehicle age

The majority of the scenarios indicate that the national split will provide sufficient detail to calculate emissions with an acceptable accuracy, as the percentage changes from the basecase for all the pollutants generally fall below 10%. However there are some instances where additional local information would be required. These are:

- For petrol and diesel cars and LGVs when the UK fleet starts to be dominated by Euro 1 vehicles, i.e. around 1998.
- For HGVs, when the UK fleet starts to be dominated by Euro 2 vehicles, i.e. around 2001.
- For HGVs and buses, when the UK fleet becomes dominated by Euro 3 vehicles, i.e. around 2006.

2.2.2 Cold start emissions

2.2.2.1 Trip length

For cars and LGVs, varying the trip length by 10% would lead to an error of only 5% in the estimation of cold start emissions. Therefore it would be valid to use the national average trip length in the estimation of cold start emissions.

2.2.2.2 Ambient temperature

The estimation of cold start emissions in the summer months is particularly sensitive to the assumed ambient temperature. Differences of 2°C can lead to significant errors in the estimate of emissions of CO and HC from all LDVs and for NO_x and PM for diesel LDVs. For winter months, ambient temperature affects the accuracy of estimates of cold start emissions of diesel LDVs. It would be important therefore that local ambient temperature data be used for estimates of cold start emissions.

2.2.3 Evaporative emissions

2.2.3.1 Trip length

As with cold start emissions, varying the trip length has some effect on the accuracy of the estimates of evaporative emissions from petrol cars and LGVs, but it would be valid to use the national average trip length.

2.2.3.2 Maximum daily ambient temperature

Although varying the maximum daily temperature affects the estimate of evaporative emissions, the error would generally be below 10%. However from about 2007, this parameter becomes more important. Therefore for estimates before 2007, the national average maximum daily temperature would provide sufficient accuracy. From 2007 it would be prudent to use local maximum daily temperature data.

2.2.3.3 Minimum daily ambient temperature

Varying the minimum daily temperature has no significant effect on the accuracy of estimates of evaporative emissions. It is therefore judged that the national average maximum daily temperature would provide sufficient accuracy.

2.3 The sensitivity of fleet emission estimates

2.3.1 Comparison with fleet emissions

The contributions of each vehicle type to total hot emissions for the base case are shown in Figure 4. In this second stage of the sensitivity assessment, these values were used to weight the results obtained for each vehicle type and to determine the sensitivity of total fleet emissions to changes in traffic parameters.

When considering the effect of altering a parameter, for example, the vehicle age profile, for each vehicle type in turn the emission estimate was substituted into the appropriate total fleet emissions. These two values (i.e. the fleet basecase and that with the age profile altered) were then compared against the sensitivity criteria. The sensitivity of fleet evaporative and cold start emission estimates was determined in a similar manner, i.e. the effect of changing each parameter was calculated by substituting the new emissions into the basecase and comparing the two totals.

It was not possible to separate the sensitivity by season as the hot emissions are calculated for the year as a whole.

2.3.2 Fleet hot emissions

2.3.2.1 Passenger cars and engine size

When the contribution to total emissions by vehicle type is considered, only CO emissions from petrol cars are sensitive to engine size. The percentage difference is less than 10% and so using the national fleet data would provide sufficient accuracy.

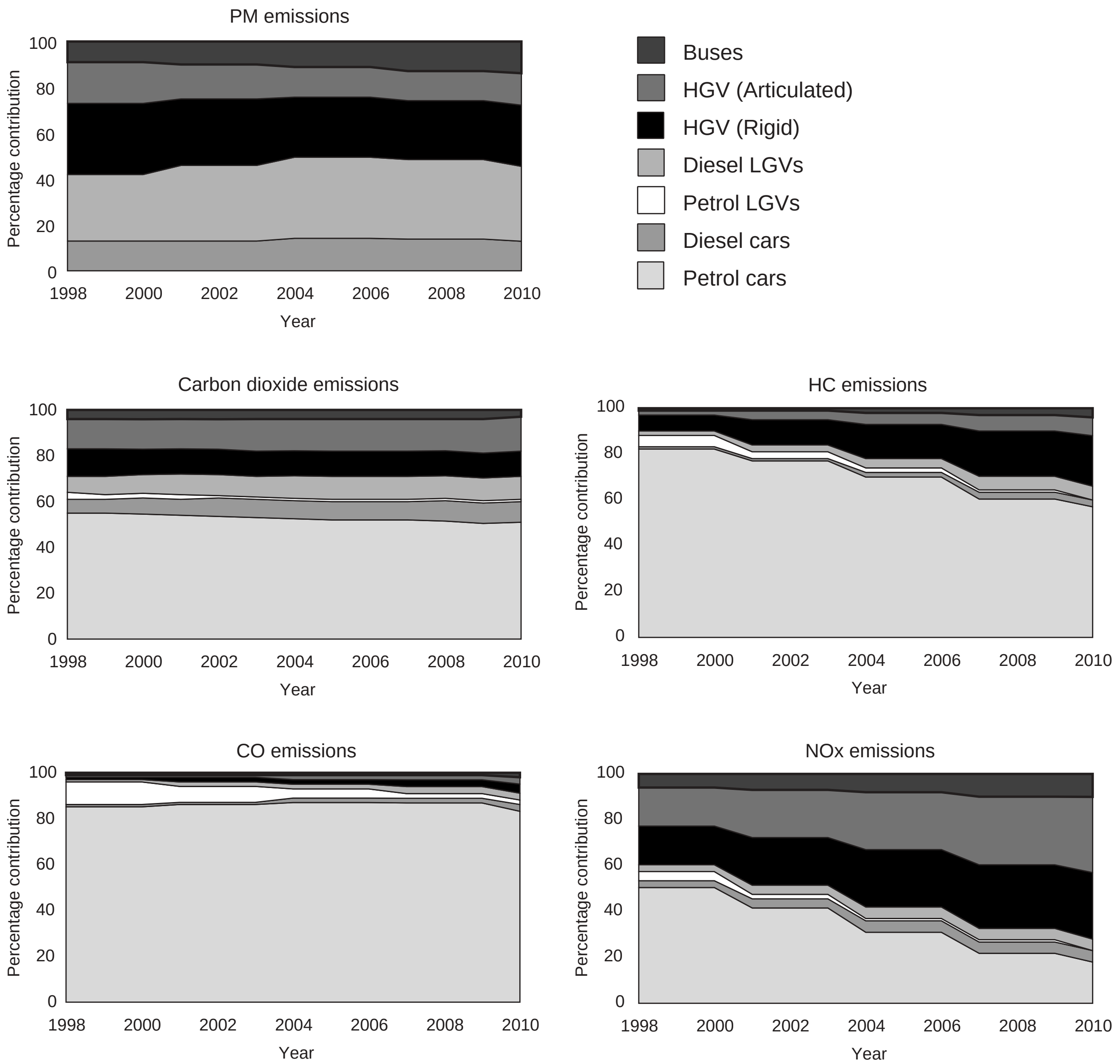

Figure 4 Contribution to total fleet emissions for each vehicle type

2.3.2.2 Goods vehicles and weight

For petrol LGVs, emission estimates are not sensitive to vehicle weight. Therefore using the national fleet statistics would provide an acceptable level of accuracy. Fleet emission estimates of CO_2, NO_x and PM are sensitive to diesel LGV and HGV vehicle weight, particularly the split between articulated and rigid HGVs. Local information is recommended to provide the required accuracy for NO_x emissions.

2.3.2.3 Average speed

Emission estimates are more sensitive to average speed than vehicle weight or engine size. For petrol cars, diesel LGVs and HGVs it is important that local information is available on speeds. For the other vehicle types national information is adequate.

2.3.2.4 Vehicle age

The majority of the scenarios indicate that the national split would be adequate to calculate emissions with an acceptable accuracy. However, at the point where Euro 1 cars become dominant over pre-Euro 1 cars (about 1998), it is important to have local information because of the large difference in emission rates between these groups.

2.3.3 Cold start emissions

2.3.3.1 Trip length

For cars and LGVs, varying the trip length by 10% would lead to an error of less than 5% in the estimation of fleet cold start emissions. Therefore it would be valid to use the national average trip length in the estimation of cold start emissions.

2.3.3.2 Ambient temperature

The estimation of fleet cold start emissions is not particularly sensitive to the assumed ambient temperature when the total fleet emissions are considered. However, as local information is likely to be readily available on temperature, this should be used.

2.3.3.3 Average speed

Estimates of cold start emissions from diesel vehicles are not dependent on average speed and so the analysis concentrates only on petrol cars and LGVs. Varying the speed by +/-30% leads to errors of less than 5% therefore it is valid to use national information on speeds. However, as local data is needed for fleet hot emissions it should be used for cold start emissions also.

2.3.4 Evaporative emissions

2.3.4.1 Trip length

Varying the trip length has little effect on the accuracy of the estimates of fleet evaporative emissions from petrol cars and LGVs and therefore it would be valid to use the national average trip length.

2.3.4.2 Maximum and minimum daily ambient temperatures

Varying the maximum or minimum daily temperature affects the estimate of fleet evaporative emissions by less than 5%. Therefore, the national average maximum and minimum daily temperatures would provide sufficient accuracy.

2.4 Summary of the sensitivity analysis

2.4.1 For each vehicle type

The results of the sensitivity analysis for each vehicle type show that potentially large errors in estimates of emissions can occur when inappropriate values are assigned to parameters that describe vehicle characteristics, average speed and temperature. Table 4 summarises the results of the sensitivity tests and recommends the detail required for each vehicle type.

For all vehicle types, the most important parameter for hot emissions is average speed, where differences of ± 30% can have a large effect on the estimate. This is true also for cold start emissions from petrol vehicles. The largest errors would be seen for estimates of CO from petrol cars and LGVs. For all vehicle types and all pollutants greater accuracy than using the national average speed would be required to assess local situations.

Hot emissions from petrol cars and LGVs are not particularly sensitive to engine size or vehicle weight, and so for these vehicles, national fleet characteristics would provide sufficient detail. For diesel vehicles engine size or weight are important parameters, and local information on the split between the different categories would be required. Buses are not distinguished by size in the emission database and so the effect has not been tested. The evidence from the other types of diesel vehicle suggest that there may be significant effects.

Although emission rates for all vehicles are sensitive to age/legislation class, the national split would provide sufficient detail in most instances. However there are some years e.g. 1998, 2001 and 2006, where additional information on the vehicle age profile would be required.

Cold start emissions can only be reliably calculated for passenger cars and LGVs. Estimates of cold start emissions are sensitive to the ambient temperature data used and this will be of particular importance in areas of the country where there is a greater than 2 °C difference from the UK mean. Local data on ambient temperature should therefore be sought.

The UK average trip length of 8.4km is shown to be adequate for the estimation of both cold start and evaporative emissions.

The function for estimating evaporative emissions is only applicable to petrol passenger cars, but it is likely that the conclusions will apply to petrol LGVs also. Estimates of evaporative emissions become sensitive to the maximum daily temperature by 2007. Therefore for estimates from 2007 onwards, local temperature data should be sought.

Table 4 Summary of important parameters for emissions from individual vehicle types

	Vehicle type					
Parameter	*Petrol cars*	*Diesel cars*	*Petrol LGVs*	*Diesel LGVs*	*HGVs*	*Buses*
Speed	Local information required	Local information required	Local information required	Local information required	Local information required	Local information required
Size and weight	Mainly national data adequate	Local information required	Local information required	Local information required	Local information required	
Age	Mainly national data adequate	Mainly national data adequate	Mainly national data adequate	Mainly national data adequate	Mainly national data adequate	Mainly national data adequate
Ambient temperature	Local information required	Local information required	Local information required	Local information required		
Trip length	Mainly national data adequate	Mainly national data adequate	Mainly national data adequate	Mainly national data adequate		
Maximum daily temperature	Local information required					

2.4.2 For the fleet as a whole

Although the discrepancies will be lower than for the individual vehicles, significant errors can still occur, particularly for average speed. Table 5 summarises the results of the sensitivity tests and recommends the detail in the fleet composition that would be required.

The most important parameter for hot emissions is average speed, where differences of ± 30% can have a significant effect on the estimate. The largest errors would be seen as a result of petrol cars (CO), but also diesel LGVs and HGVs (PM_{10} and NO_x). Local information on average speed would therefore be needed to assess local situations.

Hot emissions from petrol cars and LGVs are not particularly sensitive to engine size or vehicle weight, and so for these vehicles, national fleet characteristics would provide sufficient detail. For HGVs the configuration is an important parameter, and local information on the split

Table 5 Summary of important parameters for fleet emissions

	Vehicle type					
Parameter	*Petrol cars*	*Diesel cars*	*Petrol LGVs*	*Diesel LGVs*	*HGVs*	*Buses*
Speed	Local information required	Mainly national data adequate	Mainly national data adequate	Local information required	Local information required	Mainly national data adequate
Size and weight	Mainly national data adequate	Mainly national data adequate	Mainly national data adequate	Mainly national data adequate	Local information required	
Age	Mainly national data adequate	Mainly national data adequate	Mainly national data adequate	Mainly national data adequate	Mainly national data adequate	Mainly national data adequate
Ambient temperature	Mainly national data adequate	Mainly national data adequate	Mainly national data adequate	Mainly national data adequate		
Trip length	Mainly national data adequate	Mainly national data adequate	Mainly national data adequate	Mainly national data adequate		
Maximum daily temperature	Mainly national data adequate					

between the different categories would be required.

Although for the different vehicle types, emission estimates are sensitive to age/legislation class, when the whole fleet is considered, the national age distribution would provide sufficient accuracy.

Cold start emissions can only be reliably calculated for passenger cars and LGVs. The estimation of fleet cold start emissions is not particularly sensitive to the assumed ambient temperature. However, as local information is likely to be readily available on temperature, this should be used.

3 Forecasting traffic composition

3.1 Introduction

The current forecasting of traffic and its composition within the UK is undertaken by a series of linked models. These models, most of which contribute to the National Road Traffic Forecasts (NRTF) (DETR 1997), are shown in Figure 5. This figure shows how both the data and the spatial scale at which they operate, link the various models. The emphasis is on forecasting car traffic since much of the research and modelling effort has gone into this vehicle class. The forecasting processes for other vehicle classes, whilst following the same pattern, tend to be much simpler. Any attempt to forecast the composition of traffic at a local level will need to consider all these models. The figure also shows the relationship between current developments being undertaken to improve the local forecasts of the NRTF that are pertinent to the objectives of this project.

The emphasis in the description of the various models and processes is on the inputs and outputs and their disaggregation, rather than on a description of the derivation of the relationships involved.

3.2 National road traffic forecasts

3.2.1 Forecasting car ownership and vehicle stock

At the heart of the NRTF process is the National Car Ownership model for estimating the ownership of cars and their use. In the current NRTF process, the ownership of cars and their annual useage are estimated separately. The National Car Ownership model estimates the proportion of households that have varying numbers of cars available. Generally, four levels of availability are distinguished: zero, one, two and three or more. The car ownership model distinguishes eight types of households (based on size and number of workers) and five area types. The model is based on historic cross-sectional data from the Family Expenditure Survey and relates ownership to income and the trend in the holding of driving licences. Thus, car ownership forecasts are sensitive to changes in GDP (through the effect on income), and changes in the number and type of households. The forecasts are not influenced by the costs of ownership or use.

National forecasts of car ownership act as a control for a similar model, TEMPRO, described in Section 3.4. TEMPRO forecasts car ownership at a much more local level. These forecasts can be made for areas down to electoral ward level, but district level forecasts are published by DTLR within the TEMPRO database.

Forecasts from the National Car Ownership model provide a control mechanism through the total number of vehicles for the Vehicle Market Model (VMM), which forecasts the composition of the vehicle (car) stock and is described in Section 3.3.

In contrast to the sophistication of the car ownership forecasting process there is no formal forecasting of LGVs, HGVs, or buses and coaches. For these classes the emphasis is on forecasting the annual vehicle-kilometres directly as described in Sections 3.2.2.2 - 3.2.2.4.

3.2.2 Forecasting vehicle traffic

3.2.2.1 Cars

The second set of models involved in the forecasting of levels of national car traffic are the vehicle use models. In the case of cars, the models assume that the annual distance travelled per vehicle is a function of the costs of motoring, in particular the type of fuel used, and the use of company cars. The models again distinguish the same household and area types as the Car Ownership model but do not distinguish the type or age of car. These forecasts multiplied by those from the National Car Ownership model form the basis of the NRTF.

3.2.2.2 HGVs

Forecasts of vehicle kilometres are built up from separate forecasts of road tonnes transported, length of trip, and vehicle use for 15 sectors of the economy based on relationships for each sector over the last 21 years. These forecasts are sensitive to GDP and freight costs.

3.2.2.3 LGVs

The forecasts of vehicle-kms by LGVs are determined only by the HGV forecasts, by way of an elasticity of LGV traffic to HGV traffic.

3.2.2.4 Buses and coaches

The forecasts of bus and coach traffic are split into two types. Local bus traffic forecasts are assumed to decline with increasing car ownership whilst the forecasts of coach traffic are assumed to increase with increasing GDP.

3.2.3 Forecasts by area and road type

Whilst the forecasts produced by the process outlined in Section 3.2.2 provide some measure of disaggregation by household type and area of residence (where applicable), they do not provide forecasts of traffic by road type or by area of the country. To do this a database of national road traffic statistics has been set up. This takes data from the rotating traffic census, car journey purposes from the National Travel Survey (NTS), and descriptions of road types and urban and rural areas and combines them into a database. This database can then provide road type/area type traffic tables disaggregated into various sub-categories represented by:

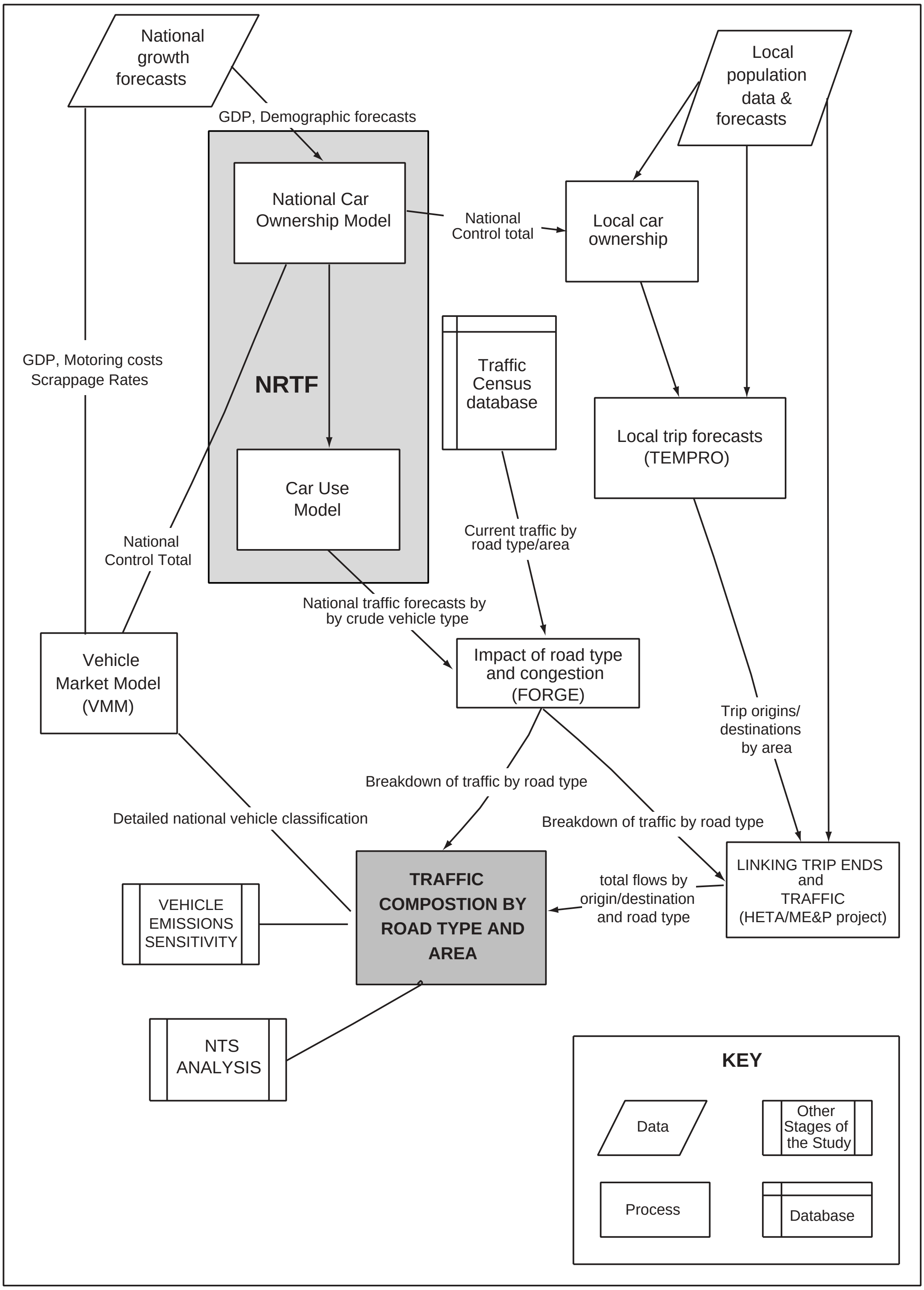

Figure 5 Forecasting traffic composition – a schematic framework

- NRTF vehicle types.
- Time periods.
- Car journey purposes.
- NRTF urban and rural area types.
- NRTF road types.

3.2.3.1 NRTF Vehicle types

The vehicle types considered are:

- Cars (including taxis and minibuses with 8 seats or less).
- Light goods vehicles (less than 30 cwt unladen weight).
- Rigid body goods vehicles (referred to as rigids).
- Articulated goods vehicles (referred to as artics).
- Buses and coaches.

3.2.3.2 Time periods

Nineteen time periods (shown in Table 6) have been distinguished based on data from the core census of automatic traffic counts from 120 randomly chosen sites that cover all classes of road in Great Britain. From this census, two quantities are stored: the proportion of traffic flow for each vehicle type that occurs in the 19 time periods and the proportion of the all vehicle flow in the busy direction by time period, road and area type.

Table 6 Time periods

Period number	*Day*	*Time*
1	Mon-Fri	00:00-06:00
2	Mon-Fri	06:00-07:00
3	Mon-Fri	07:00-08:00
4	Mon-Fri	08:00-09:00
5	Mon-Fri	09:00-10:00
6	Mon-Fri	10:00-16:00
7	Mon-Fri	16:00-17:00
8	Mon-Fri	17:00-18:00
9	Mon-Fri	18:00-19:00
10	Mon-Fri	19:00-22:00
11	Mon-Fri	22:00-24:00
12	Saturday	00:00-0900
13	Saturday	09:00-14:00
14	Saturday	14:00-20:00
15	Saturday	20:00-24:00
16	Sunday	00:00-10:00
17	Sunday	10:00-15:00
18	Sunday	15:00-20:00
19	Sunday	20:00-24:00

3.2.3.3 Car journey purposes

Data from NTS and roadside interview sites are used to provide estimates of the breakdown of car traffic by six journey purposes. The percentage of car traffic in each category is disaggregated by road type and area type. These categories are shown in Table 7.

3.2.3.4 NRTF urban and rural area types

Having disaggregated traffic by vehicle type and by time-period, and car traffic by journey purpose, each census site was allocated to a NRTF functional area type. In the original work there were 11 NRTF area types classified by the size of the urban area. These are to be replaced by the classification defined by population size and district boundaries as shown in Table 8. Disaggregation in this way forms the basis of the traffic composition tables developed in Chapter 4.

Table 7 Purposes of car journeys

Home based	*Non home-based*
Work	Work and employers business
Employers business	Other
Essential other	
Discretionary other	

Table 8 Area type classification

Area type	*Code*	*Number of zones*	*1991 Popu -lation (mill -ions)*	*Typical zonal popu -lation density (per hectare)*
London Central	LC	7	0.15	68
London Inner	LI	28	2.35	79
London Outer	LO	36	3.91	43
London Fringe	LF	18	0.84	24
London Rural	LR	9	0.27	10
Conurbation Centre	CC	7	0.09	30
Conurbation Main	CM	15	3.51	33
Conurbation Secondary	CS	18	2.58	24
Conurbation Urban	CU	57	4.59	21
Conurbation Rural	CR	39	1.65	5
Urban Small (Population 10-25k)	US	191	2.92	13
Urban Medium (Population 25-100k)	UM	202	10.26	29
Urban Large (Population 100-250k)	UL	25	3.32	46
Urban Big (Population >250k)	UB	14	3.24	55
Fringe Urban	FU	12	0.38	17
Fringe Big	FB	31	1.67	24
Rural	R	483	13.55	1.6
Total		1192	55.28	

Source: National Road Traffic Forecasts (1997)

3.2.3.5 NRTF road types

The following descriptions are used within the database:

Within rural areas	*Within urban areas*
Motorways	Motorways
Class A road dual-carriageways	Class A roads
Other class A roads	Class B & C roads
Class B roads	Unclassified
Other roads (class C or unclassified)	

3.2.3.6 Regional effects

The functional area types in the NRTF process give a geographical perspective to traffic forecasts which will allow local authorities to make an assessment of traffic emissions within their areas, taking account of the different vehicle types. However, after allowing for these functional area types, there are known to be differences on a regional level. For example Figure 6 shows the proportions of

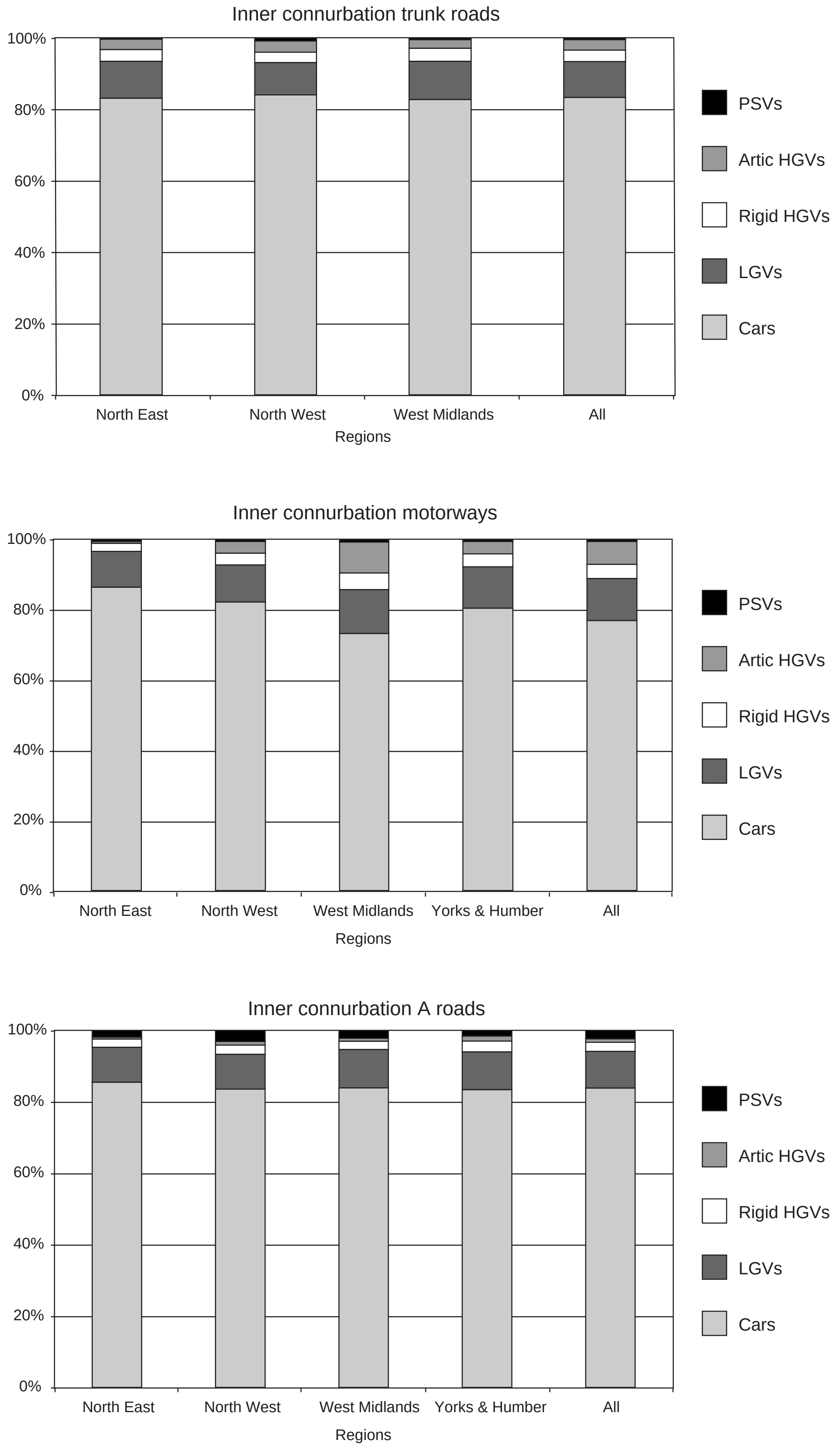

Figure 6 Proportions of vehicle types by region and road type for the inner conurbation area type

different vehicle types by region for the functional area type 'Inner Conurbation' (Conurbation Centre and Conurbation Main combined). Whilst the proportions are generally similar, there are proportionately more PSVs on trunk roads and A roads in the North-West; there are proportionately more LGVs and HGVs on motorways in the West Midlands; there are proportionately more on A roads in the North-West.

Disaggregation to obtain this finer detail would be based on very few core census sites and the observed quantities for any particular road in a particular area may vary widely from these figures. Therefore it is proposed that the estimates of vehicle types by area type, road type, and time period for use in emissions calculations be forecast on the basis of the existing NRTF process.

3.3 Estimating the effects of congestion

The disaggregation of road traffic forecasts described in Section 3.2.3 takes no account of the likely impact of future congestion. The future incidence of congestion, as is the case now, will not be uniform in its extent or impact. A 'fitting on' process has been developed by HETA Division of DETR, to estimate the impact of congestion on traffic by road and area type (NRTF, 1997).

This process known as FORGE, has two important implications on this study. It will alter the forecasts of traffic in general by road type, and it will alter the speed at which traffic travels by area and road type. Using estimates of the level of congestion by road type in each area type, the responses of users to increasing congestion are categorised as follows:

- Reassignment. As congestion on a particular type of road increases, the average speed drops and journey times increase. Drivers will increasingly choose routes using other types of roads. Traffic is assumed to reassign to less congested sections of the same road type. If none are available the traffic reassigns to a lower order road type. For example, motorway (or rural dual carriage-way) traffic will reassign to A roads. The amount of reassignment is governed by given elasticities according to journey time.
- Time switching. As journey times increase, some road users will choose to change the start time of their journey. Time switching in the 'fitting on' process takes place between fixed categories of the time periods given in Table 6.
- Mileage suppression. As journey times increase by a sufficient margin the generalised costs of undertaking a journey may exceed the benefits associated with the journey. Through given elasticities some traffic is suppressed and not made on the network.

3.4 Vehicle Market Model

3.4.1 Description

The original Vehicle Market Model (VMM) was developed jointly by the Universities of Leeds and Liverpool in 1996 for the Department of Transport (Dodgson and Kirby, 1996). This model forecast the composition of the vehicle market for cars, HGVs, private and light goods vehicles (PLGs) and public service vehicles (PSVs). The breakdown is most comprehensive for cars where the vehicle market is split by age, fuel type and ownership (private and company car). For the other vehicle types the breakdown is much less comprehensive.

The model has subsequently been revised by Napier University, and has been named VMM-98 (HETA, 1999).

3.4.2 Cars

The model disaggregates the fleet by:

- nine engine sizes;
- two fuel types (petrol or diesel);
- two categories of ownership (company and private);
- sixteen ages of car.

The model also estimates the annual distance travelled by each type of vehicle and the fuel consumption. These estimates can be split into up to six types of road (the splits are pre-specified by the user). The vehicle composition and kilometres driven were validated against 1994 figures.

Forecasts by engine size, fuel type and ownership type in a given year are estimated as follows:

A Inputs to the model relating to forecasts of total car ownership are provided by the NRTF for that year. The original VMM was based on a 1994 uprating of the NRTF but VMM-98 is based on 1996 data and the 1997 version of NRTF.

B The number of cars (by engine size and fuel type) that survive from the previous year to the current one is estimated by a set of survival relationships, where survival is dependent on age, engine size, relative price of new cars of that type. VMM-98 includes the effect of Vehicle Excise Duty (VED) on survival rates such as the effect of reduced VED rates for passengers cars <1.4l.

C The difference between (A) and the total of (B) provides an estimate of total new car purchases.

D.These new cars (C) are then split into engine sizes, fuel type and ownership type based on costs of ownership, running costs and the difference between private costs and fleet costs to which VMM-98 has added VED.

E The cars that survive from the previous year, (B), are split once more by ownership type.

F Average annual kilometrage is forecast by engine size, fuel type and ownership type through a relationship that includes GDP, fuel price, and the cost of travel by six public transport modes. This can be split by road type using pre- determined splits. However, VMM-98 incorporates the effects of variations from the FORGE fitting-on process (see Section 3.3).

G Fuel consumption of new cars is forecast either by an econometric model that represents past underlying trends, or by incorporating the effects of different technology scenarios. These models have been greatly modified within VMM-98.

3.4.3 Heavy goods vehicles

The HGV model disaggregates the HGV fleet by six vehicle types:

- rigid vehicles under 7.5 tonnes gross vehicle weight;
- rigid vehicles between 7.5 and 17 tonnes gross vehicle weight;
- rigid vehicles between 17 and 26 tonnes gross vehicle weight;
- rigid vehicles over 26 tonnes gross vehicle weight;
- articulated vehicles under 33 tonnes gross vehicle weight;
- articulated vehicles over 33 tonnes gross vehicle weight.

Stocks are not forecast directly but inferred from the annual kilometrage and the 1994 vehicle stock for the vehicle type and 16 vehicle ages.

Kilometrage forecasts are made by the following steps:

A Inputs to the model relating to the forecasts of annual total tonne.kilometrage are derived from NRTF.

B The total of tonne-kilometres at (A) is split between six vehicle types using projections based on splits observed in the annual Continuing Survey of Road Goods Transport (CSRGT) (Government Statistical Service, 1998a).

C The result of (B) is divided by average load factor for each of the six vehicle types, to give the annual total kilometrage (using projections based on average load factors in the CSRGT).

D For existing vehicles, the annual total vehicle kilometrage in each class is estimated by (a) estimating the numbers of vehicles in the previous year's fleet that survive to current year in each class; and (b) multiplying these by the annual average kilometrage for that class. This gives the annual total kilometrage of surviving vehicles for each class.

E Subtraction of (D) from (C) yields the forecast of the kilometrage by new vehicles in each class.

New vehicle stock is estimated by the division of the new-vehicle forecast of kilometrage (obtained at (E) above) by the annual average kilometrage of new vehicles in the forecast year in each of the six HGV categories.

3.4.4 Private and light goods vehicles

The model is based on the data obtained for PLGs in the 1992/93 Survey of Small Commercial Vehicles and covers goods vehicles in the Private and Light Goods vehicle (PLG) taxation class. This class is disaggregated as:

- PLG (light vans).
- PLG (HGV).
- Fuel type.

Reliable forecasts of this vehicle type are much more difficult to make and no age breakdown is possible since these data were not collected in the base survey and, as explained under the NRTF model, the forecasts of this category are very simplistic compared with other vehicle classes. No vehicle stock forecasts are made and changes in kilometrage are simply the NRTF growth-rates.

3.4.5 Public service vehicles

The public service vehicle model is disaggregated into three main types of bus/coach:

- Minibus (up to 35 seats).
- Single deck bus or coach (36 seats or more).
- Double deck bus.

In addition, the model was disaggregated by area and type of service as follows:

- Local bus services in London.
- Local bus services outside London.
- Other (non-local) services.

There are also two other types of vehicle:

- Non-hackney buses and coaches
- Hackney taxation (i.e. allowed to ply for hire): non bus. body types: cars & taxis (these are mainly 'black' taxis).

Base year derived vehicle-km splits are defined, as defaults, splitting minibus, single and double-deck kilometrage into London-local, Non-London Local, Other (non-local) and Non Hackney classes. Forecasts of vehicle stock are not made.

For local bus services, total bus passenger-km and vehicle-km are estimated from a model driven by assumptions concerning GDP, fuel price and public transport fares elasticities.

For non-local bus services, non-hackney bus and hackney taxis, it is assumed that vehicle-km remain constant.

3.5 Current work on traffic forecasts

Figure 5 shows the sequence of forecasting local changes in car-ownership and trip making. Forecasts of trips are produced in the TEMPRO databases and are made at a district level and take account of relatively local changes in population and employment. But the relationship to local changes in traffic is very nebulous and in previous versions of NRTF, nationally derived factors for equating forecasts of trip changes to changes in traffic were used, based on base year ratios between national estimates of car traffic and car trip making. This factor was assumed to represent increases in trip length over time. However, this gave no indication of where any increases in trip making were being made in terms of road type or area.

HETA Division of the DETR are developing a more robust linkage between trip-end and traffic forecasts, with the intention to provide forecasts of the behaviour of trips generated in a particular area type, in terms of where they are going, on what roads and through what type of area. The work is on-going.

4 A method to determine traffic composition in England and Wales

4.1 Introduction

Earlier in this report, the sensitivity of emission estimates to traffic parameters was discussed. In this Chapter, relationships are developed to describe how these parameters change according to road type, area type and time. In Section 4.2, the sources of data, the analysis performed and the relationships derived are presented. How this information should then be used is described in Section 4.3.

Because of the level of information available, it has been necessary to combine some of the functional area types described in Table 8 as follows:

- London inner: London Central, London Inner.
- London outer: London Outer, London Fringe, London Rural.
- Conurbation inner: Conurbation Centre, Conurbation Main.
- Conurbation outer: Conurbation Secondary, Conurbation Urban, Conurbation Rural.
- Urban big: Urban Big, (Population >250k), Fringe Urban, Fringe Big.
- Urban large: Urban Large (Population 100-250k).
- Urban medium: Urban Medium (Population 25-100k).
- Urban small: Urban Small (Population 10-25k).
- Rural: Rural.

4.2 Data sources and analysis

4.2.1 Average speed

Using FORGE data for the years 1996 and 2010, a linear model was assumed where average speed was directly proportional to the year, i.e.

$$\text{Speed in year } Y = m(Y - 1996) + c) \quad (1)$$

Where *Y* is the year of interest (up to 2010), *c* is the speed in 1996 and *m* is the rate at which average speed reduces over time.

The relationships between average speed and year for a range of road and area types are shown in Table 9 to Table 11.

4.2.2 Engine size and trip length of passenger cars

The National Travel Survey is designed to provide a database of personal travel information for Great Britain and collates data on the use of cars by households. The NTS classifies light duty vans and privately owned lorries as cars, but excludes those vehicles that are not for household use. Data for the surveys between 1994 and 1998 were used to estimate the linear relationship between year and the proportions of petrol and diesel cars within each engine size range or average trip length. The relationships obtained are shown in Table 12 to Table 14.

4.2.3 Age profile

The DETR routinely carries out surveys of vehicles in use on roads in the UK, in order to assess the scale of the evasion of Vehicle Excise Duty (DETR 2000b). The roadside surveys involve recording the registration mark of almost a million vehicles across 256 sites. There are 24 motorway sites, 53 built-up major road sites, 53 built-up minor road sites, 53 major road non built-up sites and 53 minor non built-up road sites. At each site, data are collected for one twelve hour period on a weekday and one six hour period at the weekend. The registration marks collected in this way are then sorted and matched with information on taxation transactions collected by the Driver and Vehicle Licensing Agency.

For the purposes of this report, the 236 sites in Britain (20 sites of the survey sites are in Northern Ireland and so were not included in the analysis) were each assigned to a road and area type as in Section 4.1. Data on vehicle type and age for each of the sites from the 1999 survey were obtained from Ledger (2000) and allocated to the road and area types. The main assumption is that the distribution of vehicle ages seen in 1999 will be the same year-on-year. This assumes that the rate of entry of new vehicles into the fleet is not affected e.g. by economic shocks.

By examining each combination of area type and road type, a distribution was developed according to:

$$\text{Percentage of vehicles of age } R = A\left(R^2 - (R+1)^2\right) + B \quad (2)$$

Where B is the proportion of new vehicles each year and A is related to the rate at which these are scrapped.

The age at which a vehicle disappears from a particular area type and road type is given by:

$$\text{Age of vehicle} = \frac{1}{2}(B / A - 1) \quad (3)$$

The remaining percentage of vehicles after substituting the integer obtained into Equation 2 should be assigned to an ‘older than’ category.

The relationships obtained are shown in Table 15 to Table 21.

Data from NTS can also be used to look at the age of cars by road type, area type and region. The regional effect appears to be greater than the functional area type as shown in Table 22. For example, in Urban Areas (>250,000) the average proportion of newer cars (defined here as registration number prefix J onwards) was about 39%, but with a range of 24% in Greater London to 60% in Scotland. Similarly for Urban Areas (3000 to 10,000), the average proportion of newer vehicles was 42% with a range of 33% (North-East England) to 50% (West Midlands and Scotland).

However, these percentages are based on small sample sizes (in some cases less than 10 cars), and whilst it is acknowledged that regional effects are important, at this stage there are insufficient data either in the NTS or the vehicle tax evasion surveys to recommend such disaggregation.

4.2.4 Weight categorisation of HGVs

The split between articulated and rigid HGVs was obtained for 1999 using the data obtained from Ledger (2000). This was then combined with projected growth rates taken from *Focus on Freight* (Government Statistical Service, 1998) to produce the expected proportion of HGVs that are articulated. The relationships obtained are shown in Table 23.

Table 9 Relationship between average speed (km/h) and year (1996 to 2010) for passenger cars

	Motorway	*Urban A roads or rural dual carriageways*	*Urban B&C roads or rural single carriageways*	*Urban unclassified or rural B&C roads*	*All types*
London inner	-0.59x(*Y*-1996)+64	-0.14x(*Y*-1996)+27	-0.18x(*Y*-1996)+31	-0.07x(*Y*-1996)+25	-0.13x(*Y*-1996)+28
London outer	-0.64x(*Y*-1996)+50	-0.12x(*Y*-1996)+31	-0.14x(*Y*-1996)+40	-0.07x(*Y*-1996)+27	-0.14x(*Y*-1996)+32
Conurbation inner	-0.89x(*Y*-1996)+52	-0.12x(*Y*-1996)+32	-0.11x(*Y*-1996)+37	-0.09x(*Y*-1996)+21	-0.15x(*Y*-1996)+27
Conurbation outer	-0.50x(*Y*-1996)+58	-0.01x(*Y*-1996)+40	-0.08x(*Y*-1996)+39	-0.07x(*Y*-1996)+39	-0.11x(*Y*-1996)+42
Urban big	–	-0.15x(*Y*-1996)+40	-0.01x(*Y*-1996)+39	-0.06x(*Y*-1996)+39	-0.07x(*Y*-1996)+39
Urban large	–	-0.17x(*Y*-1996)+42	-0.06x(*Y*-1996)+42	-0.09x(*Y*-1996)+44	-0.11x(*Y*-1996)+43
Urban medium	–	-0.14x(*Y*-1996)+48	-0.05x(*Y*-1996)+43	-0.03x(*Y*-1996)+47	-0.09x(*Y*-1996)+47
Urban small	–	-0.13x(*Y*-1996)+47	-0.01x(*Y*-1996)+46	-0.04x(*Y*-1996)+45	-0.06x(*Y*-1996)+46
Rural	-0.54x(*Y*-1996)+106	-0.13x(*Y*-1996)+91	-0.17x(*Y*-1996)+69	-0.03x(*Y*-1996)+63	-0.08x(*Y*-1996)+76
All areas	-0.36x(*Y*-1996)+89	-0.02x(*Y*-1996)+49	-0.06x(*Y*-1996)+58	-0.08x(*Y*-1996)+47	-0.03x(*Y*-1996)+54

Table 10 Relationship between average speed (km/h) and year (1996 to 2010) for LGVs

	Motorway	*Urban A roads or rural dual carriageways*	*Urban B&C roads or rural single carriageways*	*Urban unclassified or rural B&C roads*	*All types*
London inner	-0.62x(*Y*-1996)+65	-0.14x(*Y*-1996)+27	-0.18x(*Y*-1996)+31	-0.07x(*Y*-1996)+25	-0.12x(*Y*-1996)+28
London outer	-0.64x(*Y*-1996)+50	-0.13x(*Y*-1996)+31	-0.14x(*Y*-1996)+40	-0.07x(*Y*-1996)+27	-0.12x(*Y*-1996)+32
Conurbation inner	-0.89x(*Y*-1996)+52	-0.12x(*Y*-1996)+32	-0.11x(*Y*-1996)+37	-0.09x(*Y*-1996)+21	-0.16x(*Y*-1996)+28
Conurbation outer	-0.51x(*Y*-1996)+58	-0.01x(*Y*-1996)+40	-0.08x(*Y*-1996)+39	-0.07x(*Y*-1996)+39	-0.09x(*Y*-1996)+43
Urban big	–	-0.15x(*Y*-1996)+40	-0.01x(*Y*-1996)+39	-0.06x(*Y*-1996)+39	-0.08x(*Y*-1996)+39
Urban large	–	-0.17x(*Y*-1996)+42	-0.06x(*Y*-1996)+42	-0.09x(*Y*-1996)+44	-0.11x(*Y*-1996)+43
Urban medium	–	-0.14x(*Y*-1996)+48	-0.05x(*Y*-1996)+43	-0.03x(*Y*-1996)+47	-0.09x(*Y*-1996)+47
Urban small	–	-0.13x(*Y*-1996)+47	-0.01x(*Y*-1996)+46	-0.04x(*Y*-1996)+45	-0.06x(*Y*-1996)+46
Rural	-0.54x(*Y*-1996)+106	-0.13x(*Y*-1996)+91	-0.17x(*Y*-1996)+69	-0.03x(*Y*-1996)+63	-0.07x(*Y*-1996)+76
All areas	-0.55x(*Y*-1996)+88	-0.03x(*Y*-1996)+50	-0.15x(*Y*-1996)+59	-0.12x(*Y*-1996)+49	-0.07x(*Y*-1996)+56

Table 11 Relationship between average speed (km/h) and year (1996 to 2010) for HGVs, buses and coaches

	Motorway	*Urban A roads or rural dual carriageways*	*Urban B&C roads or rural single carriageways*	*Urban unclassified or rural B&C roads*	*All types*
London inner	-0.45x(*Y*-1996)+61	-0.18x(*Y*-1996)+26	-0.21x(*Y*-1996)+31	-0.08x(*Y*-1996)+25	-0.14x(*Y*-1996)+28
London outer	-0.66x(*Y*-1996)+49	-0.18x(*Y*-1996)+31	-0.14x(*Y*-1996)+40	-0.07x(*Y*-1996)+27	-0.16x(*Y*-1996)+33
Conurbation inner	-0.98x(*Y*-1996)+48	-0.15x(*Y*-1996)+31	-0.12x(*Y*-1996)+37	-0.13x(*Y*-1996)+20	-0.25x(*Y*-1996)+31
Conurbation outer	-0.54x(*Y*-1996)+55	-0.09x(*Y*-1996)+39	-0.09x(*Y*-1996)+39	-0.09x(*Y*-1996)+39	-0.19x(*Y*-1996)+46
Urban big	–	-0.19x(*Y*-1996)+41	-0.02x(*Y*-1996)+38	-0.08x(*Y*-1996)+38	-0.13x(*Y*-1996)+40
Urban large	–	-0.21x(*Y*-1996)+42	-0.06x(*Y*-1996)+41	-0.11x(*Y*-1996)+44	-0.15x(*Y*-1996)+43
Urban medium	–	-0.17x(*Y*-1996)+47	-0.03x(*Y*-1996)+45	-0.03x(*Y*-1996)+45	-0.13x(*Y*-1996)+46
Urban small	–	-0.17x(*Y*-1996)+86	-0.01x(*Y*-1996)+69	-0.04x(*Y*-1996)+64	-0.09x(*Y*-1996)+81
Rural	-0.25x(*Y*-1996)+96	-0.07x(*Y*-1996)+86	-0.20x(*Y*-1996)+69	-0.04x(*Y*-1996)+64	-0.02x(*Y*-1996)+81
All areas	-0.43x(*Y*-1996)+82	0.038x(*Y*-1996)+57	-0.16x(*Y*-1996)+64	-0.14x(*Y*-1996)+50	-0.04x(*Y*-1996)+64

Table 12 Percentages of petrol passenger cars in each engine capacity class, 1996 - 2010

	Year														
Engine capacity	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
<1.4 l	45.1	44.3	43.5	42.6	41.7	40.7	39.6	38.4	37.1	35.7	34.2	32.5	30.7	28.6	26.3
1.4-2.0 l	49.7	50.4	51.0	51.7	52.4	53.1	54.0	54.9	56.0	57.0	58.2	59.5	60.9	62.5	64.3
>2.0 l	5.2	5.3	5.5	5.7	5.9	6.2	6.4	6.7	6.9	7.3	7.6	8.0	8.4	8.9	9.4

Table 13 Percentages of diesel passenger cars in each engine capacity class, 1996 - 2010

	Year														
Engine capacity	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
<1.4 l	4.5	4.0	3.6	3.3	3.0	2.8	2.6	2.5	2.3	2.2	2.1	1.9	1.9	1.8	1.7
1.4-2.0 l	86.3	87.7	88.9	89.9	90.7	91.4	92.0	92.5	93.0	93.3	93.7	94.1	94.3	94.6	94.8
>2.0 l	9.2	8.3	7.5	6.8	6.3	5.8	5.4	5.0	4.7	4.5	4.2	4.0	3.8	3.6	3.5

Table 14 Average trip length (km) for petrol and diesel passenger cars, 1996 - 2010

Year	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
Petrol cars	7.6	7.7	7.7	7.8	7.8	7.9	7.9	8.0	8.0	8.0	8.1	8.1	8.2	8.2	8.3
Diesel cars	12.4	12.1	11.8	11.5	11.2	11.0	10.7	10.4	10.1	9.8	9.5	9.3	9.0	8.7	8.4

Table 15 Distribution of vehicle age for petrol cars

	Motorway	*Urban A roads or rural dual carriageways*	*Urban B&C roads or rural single carriageways*	*Urban unclassified or rural B&C roads*	*All roads*
London inner	0.23% x $(R^2-(R+1)^2)$ + 9.4%	0.19% x $(R^2-(R+1)^2)$ + 8.5%	Insufficient data	0.17% x $(R^2-(R+1)^2)$ + 8.1%	0.17% x $(R^2-(R+1)^2)$ + 8.1%
London outer	0.32% x $(R^2-(R+1)^2)$ + 11.1%	0.22% x $(R^2-(R+1)^2)$ + 9.2%	0.22% x $(R^2-(R+1)^2)$ + 9.3% *	0.16% x $(R^2-(R+1)^2)$ + 7.9%	0.23% x $(R^2-(R+1)^2)$ + 9.4%
Conurbation inner	Insufficient data	0.27% x $(R^2-(R+1)^2)$ + 10.2%	Insufficient data	0.24% x $(R^2-(R+1)^2)$ + 9.7%	0.25% x $(R^2-(R+1)^2)$ + 9.8%
Conurbation outer	0.37% x $(R^2-(R+1)^2)$ + 12.1%	0.25% x $(R^2-(R+1)^2)$ + 9.9%	0.22% x $(R^2-(R+1)^2)$ + 9.2%	0.28% x $(R^2-(R+1)^2)$ + 10.5%	0.26% x $(R^2-(R+1)^2)$ + 10.1%
Urban big	Insufficient data	0.23% x $(R^2-(R+1)^2)$ + 9.5%	Insufficient data	Insufficient data	0.20% x $(R^2-(R+1)^2)$ + 8.8%
Urban large	Insufficient data	0.23% x $(R^2-(R+1)^2)$ + 9.5%	0.16% x $(R^2-(R+1)^2)$ + 7.9%	0.16% x $(R^2-(R+1)^2)$ + 7.8%	0.22% x $(R^2-(R+1)^2)$ + 9.3%
Urban medium	Insufficient data	0.22% x $(R^2-(R+1)^2)$ + 9.2%	0.16% x $(R^2-(R+1)^2)$ + 7.9%	0.11% x $(R^2-(R+1)^2)$ + 6.5%	0.21% x $(R^2-(R+1)^2)$ + 9.0%
Urban small	Insufficient data	0.20% x $(R^2-(R+1)^2)$ + 8.7%	0.16% x $(R^2-(R+1)^2)$ + 7.8%	0.21% x $(R^2-(R+1)^2)$ + 9.0%	0.20% x $(R^2-(R+1)^2)$ + 8.7%
Rural	0.38% x $(R^2-(R+1)^2)$ + 12.2%	0.29% x $(R^2-(R+1)^2)$ + 10.6%	0.25% x $(R^2-(R+1)^2)$ + 9.9%	0.21% x $(R^2-(R+1)^2)$ + 9.0%	0.29% x $(R^2-(R+1)^2)$ + 10.7%
Total	0.36% x $(R^2-(R+1)^2)$ + 11.8%	0.24% x $(R^2-(R+1)^2)$ + 9.7%	0.22% x $(R^2-(R+1)^2)$ + 9.2%	0.20% x $(R^2-(R+1)^2)$ + 8.7%	0.26% x $(R^2-(R+1)^2)$ + 10.0%

Table 16 Distribution of vehicle age for diesel cars

	Motorway	*Urban A roads or rural dual carriageways*	*Urban B&C roads or rural single carriageways*	*Urban unclassified or rural B&C roads*	*All roads*
London inner	0.40% x $(R^2-(R+1)^2)$ + 12.5%	0.38% x $(R^2-(R+1)^2)$ + 12.1%	0.33% x $(R^2-(R+1)^2)$ + 11.3%	0.34% x $(R^2-(R+1)^2)$ + 11.5% *	0.37% x $(R^2-(R+1)^2)$ + 12.0%
London outer	0.44% x $(R^2-(R+1)^2)$ + 13.1%	0.39% x $(R^2-(R+1)^2)$ + 12.4%	0.38% x $(R^2-(R+1)^2)$ + 12.2% *	0.34% x $(R^2-(R+1)^2)$ + 11.6%	0.39% x $(R^2-(R+1)^2)$ + 12.3%
Conurbation inner	Insufficient data	0.41% x $(R^2-(R+1)^2)$ + 12.6%	Insufficient data	0.38% x $(R^2-(R+1)^2)$ + 12.3%	0.39% x $(R^2-(R+1)^2)$ + 12.3%
Conurbation outer	0.45% x $(R^2-(R+1)^2)$ + 13.3%	0.39% x $(R^2-(R+1)^2)$ + 12.4%	0.37% x $(R^2-(R+1)^2)$ + 12.1%	0.40% x $(R^2-(R+1)^2)$ + 12.6%	0.40% x $(R^2-(R+1)^2)$ + 12.6%
Urban big	Insufficient data	0.37% x $(R^2-(R+1)^2)$ + 12.1%	0.30% x $(R^2-(R+1)^2)$ + 10.8%	0.22% x $(R^2-(R+1)^2)$ + 9.3%	0.35% x $(R^2-(R+1)^2)$ + 11.8%
Urban large	Insufficient data	0.37% x $(R^2-(R+1)^2)$ + 12.1%	0.36% x $(R^2-(R+1)^2)$ + 11.8%	0.35% x $(R^2-(R+1)^2)$ + 11.6%	0.38% x $(R^2-(R+1)^2)$ + 12.2%
Urban medium	Insufficient data	0.37% x $(R^2-(R+1)^2)$ + 12.1%	0.35% x $(R^2-(R+1)^2)$ + 11.7%	0.32% x $(R^2-(R+1)^2)$ + 11.1%	0.38% x $(R^2-(R+1)^2)$ + 12.2%
Urban small	Insufficient data	0.36% x $(R^2-(R+1)^2)$ + 11.9%	0.35% x $(R^2-(R+1)^2)$ + 11.6%	0.37% x $(R^2-(R+1)^2)$ + 12.0%	0.37% x $(R^2-(R+1)^2)$ + 12.0%
Rural	0.46% x $(R^2-(R+1)^2)$ + 13.5%	0.43% x $(R^2-(R+1)^2)$ + 13.0%	0.39% x $(R^2-(R+1)^2)$ + 12.4%	0.37% x $(R^2-(R+1)^2)$ + 12.1%	0.41% x $(R^2-(R+1)^2)$ + 12.7%
Total	0.45% x $(R^2-(R+1)^2)$ + 13.3%	0.40% x $(R^2-(R+1)^2)$ + 12.4%	0.39% x $(R^2-(R+1)^2)$ + 12.4%	0.36% x $(R^2-(R+1)^2)$ + 11.9%	0.39% x $(R^2-(R+1)^2)$ + 12.3%

** the relationship is based on less than 1000 observations.*
*** the relationship is based on less than 100 observations.*

Table 17 Distribution of vehicle age for petrol LGVs

	Motorway	*Urban A roads or rural dual carriageways*	*Urban B&C roads or rural single carriageways*	*Urban unclassified or rural B&C roads*	*All roads*
London inner	0.34% x $(R^2-(R+1)^2)$ + 11.5% *	0.31% x $(R^2-(R+1)^2)$ + 11.0%	0.27% x $(R^2-(R+1)^2)$ + 10.3% *	0.33% x $(R^2-(R+1)^2)$ + 11.4% *	0.31% x $(R^2-(R+1)^2)$ + 11.0%
London outer	0.36% x $(R^2-(R+1)^2)$ + 11.9%	0.29% x $(R^2-(R+1)^2)$ + 10.7%	0.30% x $(R^2-(R+1)^2)$ + 10.7% **	0.22% x $(R^2-(R+1)^2)$ + 9.2%	0.30% x $(R^2-(R+1)^2)$ + 10.9%
Conurbation inner	Insufficient data	0.35% x $(R^2-(R+1)^2)$ + 11.6%	Insufficient data	0.34% x $(R^2-(R+1)^2)$ + 11.4% *	0.35% x $(R^2-(R+1)^2)$ + 11.7%
Conurbation outer	0.39% x $(R^2-(R+1)^2)$ + 12.4% *	0.32% x $(R^2-(R+1)^2)$ + 11.2%	0.22% x $(R^2-(R+1)^2)$ + 9.2% *	0.38% x $(R^2-(R+1)^2)$ + 12.2% *	0.32% x $(R^2-(R+1)^2)$ + 11.2%
Urban big	Insufficient data	0.33% x $(R^2-(R+1)^2)$ + 11.3%	0.15% x $(R^2-(R+1)^2)$ + 7.5%	0.20% x $(R^2-(R+1)^2)$ + 8.7%	0.30% x $(R^2-(R+1)^2)$ + 10.7%
Urban large	Insufficient data	0.33% x $(R^2-(R+1)^2)$ + 11.3%	0.30% x $(R^2-(R+1)^2)$ + 10.9%	0.28% x $(R^2-(R+1)^2)$ + 10.4% *	0.31% x $(R^2-(R+1)^2)$ + 11.0%
Urban medium	Insufficient data	0.29% x $(R^2-(R+1)^2)$ + 10.7%	0.22% x $(R^2-(R+1)^2)$ + 9.2% *	0.26% x $(R^2-(R+1)^2)$ + 10.2% *	0.28% x $(R^2-(R+1)^2)$ + 10.5%
Urban small	Insufficient data	0.28% x $(R^2-(R+1)^2)$ + 10.5%	0.25% x $(R^2-(R+1)^2)$ + 9.9% *	0.29% x $(R^2-(R+1)^2)$ + 10.6% *	0.29% x $(R^2-(R+1)^2)$ + 10.5%
Rural	0.41% x $(R^2-(R+1)^2)$ + 12.7%	0.37% x $(R^2-(R+1)^2)$ + 12.0%	0.31% x $(R^2-(R+1)^2)$ + 11.0%	0.26% x $(R^2-(R+1)^2)$ + 10.1%	0.35% x $(R^2-(R+1)^2)$ + 11.7%
Total	0.40% x $(R^2-(R+1)^2)$ + 12.6%	0.32% x $(R^2-(R+1)^2)$ + 11.2%	0.30% x $(R^2-(R+1)^2)$ + 10.7%	0.27% x $(R^2-(R+1)^2)$ + 10.2%	0.32% x $(R^2-(R+1)^2)$ + 11.2%

Table 18 Distribution of vehicle age for diesel LGVs

	Motorway	*Urban A roads or rural dual carriageways*	*Urban B&C roads or rural single carriageways*	*Urban unclassified or rural B&C roads*	*All roads*
London inner	0.47% x $(R^2-(R+1)^2)$ + 13.6% *	0.44% x $(R^2-(R+1)^2)$ + 13.2% *	0.38% x $(R^2-(R+1)^2)$ + 12.2% *	0.46% x $(R^2-(R+1)^2)$ + 13.4% **	0.44% x $(R^2-(R+1)^2)$ + 13.1%
London outer	0.47% x $(R^2-(R+1)^2)$ + 13.6% *	0.44% x $(R^2-(R+1)^2)$ + 13.1%	0.41% x $(R^2-(R+1)^2)$ + 12.6% **	0.40% x $(R^2-(R+1)^2)$ + 12.5% *	0.43% x $(R^2-(R+1)^2)$ + 13.0%
Conurbation inner	Insufficient data	0.44% x $(R^2-(R+1)^2)$ + 13.2% *	Insufficient data	0.45% x $(R^2-(R+1)^2)$ + 13.2% *	0.44% x $(R^2-(R+1)^2)$ + 13.1% *
Conurbation outer	Insufficient data	0.42% x $(R^2-(R+1)^2)$ + 12.9%	0.40% x $(R^2-(R+1)^2)$ + 12.5% *	0.47% x $(R^2-(R+1)^2)$ + 13.6% *	0.43% x $(R^2-(R+1)^2)$ + 13.0%
Urban big	Insufficient data	0.44% x $(R^2-(R+1)^2)$ + 13.1%	0.41% x $(R^2-(R+1)^2)$ + 12.7% *	0.39% x $(R^2-(R+1)^2)$ + 12.4% *	0.43% x $(R^2-(R+1)^2)$ + 12.9%
Urban large	Insufficient data	0.43% x $(R^2-(R+1)^2)$ + 13.1%	0.44% x $(R^2-(R+1)^2)$ + 13.1% *	0.40% x $(R^2-(R+1)^2)$ + 12.6% *	0.42% x $(R^2-(R+1)^2)$ + 12.8%
Urban medium	Insufficient data	0.43% x $(R^2-(R+1)^2)$ + 12.9%	0.38% x $(R^2-(R+1)^2)$ + 12.2% *	0.42% x $(R^2-(R+1)^2)$ + 12.8% *	0.41% x $(R^2-(R+1)^2)$ + 12.7%
Urban small	Insufficient data	0.41% x $(R^2-(R+1)^2)$ + 12.8%	0.43% x $(R^2-(R+1)^2)$ + 12.9% *	0.44% x $(R^2-(R+1)^2)$ + 13.1% *	0.42% x $(R^2-(R+1)^2)$ + 12.9%
Rural	Insufficient data	0.46% x $(R^2-(R+1)^2)$ + 13.5%	0.43% x $(R^2-(R+1)^2)$ + 13.0%	0.39% x $(R^2-(R+1)^2)$ + 12.3%	0.46% x $(R^2-(R+1)^2)$ + 13.5%
Total	0.49% x $(R^2-(R+1)^2)$ + 13.9%	0.43% x $(R^2-(R+1)^2)$ + 13.0%	0.42% x $(R^2-(R+1)^2)$ + 12.9%	0.42% x $(R^2-(R+1)^2)$ + 12.8%	0.44% x $(R^2-(R+1)^2)$ + 13.2%

** the relationship is based on less than 1000 observations.*
*** the relationship is based on less than 100 observations.*

Table 19 Distribution of vehicle age for rigid HGVs

	Motorway	*Urban A roads or rural dual carriageways*	*Urban B&C roads or rural single carriageways*	*Urban unclassified or rural B&C roads*	*All roads*
London inner	0.28% x $(R^2-(R+1)^2)$ + 10.3% *	0.32% x $(R^2-(R+1)^2)$ + 11.3% *	0.32% x $(R^2-(R+1)^2)$ + 11.2% *	0.28% x $(R^2-(R+1)^2)$ + 10.4% **	0.30% x $(R^2-(R+1)^2)$ + 10.9% *
London outer	0.32% x $(R^2-(R+1)^2)$ + 11.2% *	0.21% x $(R^2-(R+1)^2)$ + 9.0% *	0.23% x $(R^2-(R+1)^2)$ + 9.4% **	0.29% x $(R^2-(R+1)^2)$ + 10.5% *	0.25% x $(R^2-(R+1)^2)$ + 9.9%
Conurbation inner	Insufficient data	0.34% x $(R^2-(R+1)^2)$ + 11.6% *	Insufficient data	0.23% x $(R^2-(R+1)^2)$ + 9.4% **	0.33% x $(R^2-(R+1)^2)$ + 11.3% *
Conurbation outer	0.27% x $(R^2-(R+1)^2)$ + 10.3% *	0.29% x $(R^2-(R+1)^2)$ + 10.5%	0.26% x $(R^2-(R+1)^2)$ + 10.0% *	Insufficient data	0.30% x $(R^2-(R+1)^2)$ + 10.8%
Urban big	Insufficient data	0.30% x $(R^2-(R+1)^2)$ + 10.9%	0.25% x $(R^2-(R+1)^2)$ + 9.8% *	0.34% x $(R^2-(R+1)^2)$ + 11.6% *	0.29% x $(R^2-(R+1)^2)$ + 10.6%
Urban large	Insufficient data	0.28% x $(R^2-(R+1)^2)$ + 10.3%	0.24% x $(R^2-(R+1)^2)$ + 9.7% *	0.20% x $(R^2-(R+1)^2)$ + 8.7% *	0.26% x $(R^2-(R+1)^2)$ + 10.1%
Urban medium	Insufficient data	0.28% x $(R^2-(R+1)^2)$ + 10.5%	0.13% x $(R^2-(R+1)^2)$ + 7.1% *	0.19% x $(R^2-(R+1)^2)$ + 8.6% *	0.26% x $(R^2-(R+1)^2)$ + 10.1%
Urban small	Insufficient data	0.25% x $(R^2-(R+1)^2)$ + 9.9%	0.19% x $(R^2-(R+1)^2)$ + 8.5% *	0.21% x $(R^2-(R+1)^2)$ + 9.1% *	0.23% x $(R^2-(R+1)^2)$ + 9.4%
Rural	0.32% x $(R^2-(R+1)^2)$ + 11.2%	0.29% x $(R^2-(R+1)^2)$ + 10.6%	0.24% x $(R^2-(R+1)^2)$ + 9.6%	0.25% x $(R^2-(R+1)^2)$ + 9.8%	0.26% x $(R^2-(R+1)^2)$ + 10.1%
Total	0.33% x $(R^2-(R+1)^2)$ + 11.3%	0.28% x $(R^2-(R+1)^2)$ + 10.4%	0.23% x $(R^2-(R+1)^2)$ + 9.3%	0.24% x $(R^2-(R+1)^2)$ + 9.8%	0.27% x $(R^2-(R+1)^2)$ + 10.2%

Table 20 Distribution of vehicle age for articulated HGVs

	Motorway	*Urban A roads or rural dual carriageways*	*Urban B&C roads or rural single carriageways*	*Urban unclassified or rural B&C roads*	*All roads*
London inner	0.25% x $(R^2-(R+1)^2)$ + 9.9% **	0.28% x $(R^2-(R+1)^2)$ + 10.0% **	Insufficient data	Insufficient data	0.25% x $(R^2-(R+1)^2)$ + 9.8% **
London outer	0.28% x $(R^2-(R+1)^2)$ + 10.5% *	0.30% x $(R^2-(R+1)^2)$ + 10.9% *	Insufficient data	Insufficient data	0.29% x $(R^2-(R+1)^2)$ + 10.7% *
Conurbation inner	Insufficient data	0.21% x $(R^2-(R+1)^2)$ + 8.7% **	Insufficient data	Insufficient data	0.19% x $(R^2-(R+1)^2)$ + 8.4% **
Conurbation outer	0.25% x $(R^2-(R+1)^2)$ + 9.8% **	0.18% x $(R^2-(R+1)^2)$ + 8.3% *	Insufficient data	Insufficient data	0.17% x $(R^2-(R+1)^2)$ + 8.1% *
Urban big	Insufficient data	0.19% x $(R^2-(R+1)^2)$ + 8.6% *	Insufficient data	Insufficient data	0.19% x $(R^2-(R+1)^2)$ + 8.6% *
Urban large	Insufficient data	0.24% x $(R^2-(R+1)^2)$ + 9.7% *	Insufficient data	Insufficient data	0.24% x $(R^2-(R+1)^2)$ + 9.7% *
Urban medium	Insufficient data	0.29% x $(R^2-(R+1)^2)$ + 10.6% *	0.21% x $(R^2-(R+1)^2)$ + 8.9% **	Insufficient data	0.29% x $(R^2-(R+1)^2)$ + 10.6% *
Urban small	Insufficient data	0.29% x $(R^2-(R+1)^2)$ + 10.7% *	Insufficient data	Insufficient data	0.26% x $(R^2-(R+1)^2)$ + 10.1% *
Rural	0.30% x $(R^2-(R+1)^2)$ + 10.8%	0.31% x $(R^2-(R+1)^2)$ + 10.9%	0.31% x $(R^2-(R+1)^2)$ + 11.1%	0.11% x $(R^2-(R+1)^2)$ + 6.5% *	0.31% x $(R^2-(R+1)^2)$ + 10.9%
Total	0.31% x $(R^2-(R+1)^2)$ + 10.9%	0.29% x $(R^2-(R+1)^2)$ + 10.6%	0.29% x $(R^2-(R+1)^2)$ + 10.6%	0.13% x $(R^2-(R+1)^2)$ + 6.9% *	0.28% x $(R^2-(R+1)^2)$ + 10.5%

* the relationship is based on less than 1000 observations.

*** the relationship is based on less than 100 observations.*

Table 21 Distribution of vehicle age for buses and coaches

	Motorway	*Urban A roads or rural dual carriageways*	*Urban B&C roads or rural single carriageways*	*Urban unclassified or rural B&C roads*	*All roads*
London inner	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
London outer	Insufficient data	0.15% x $(R^2-(R+1)^2)$ + 7.7% **	Insufficient data	Insufficient data	0.26% x $(R^2-(R+1)^2)$ + 10.1% *
Conurbation inner	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
Conurbation outer	Insufficient data	Insufficient data	Insufficient data	Insufficient data	0.17% x $(R^2-(R+1)^2)$ + 8.0% *
Urban big	Insufficient data	0.18% x $(R^2-(R+1)^2)$ + 8.2% *	Insufficient data	0.19% x $(R^2-(R+1)^2)$ + 8.7% *	0.16% x $(R^2-(R+1)^2)$ + 8.0% *
Urban large	Insufficient data	0.22% x $(R^2-(R+1)^2)$ + 9.1% *	0.18% x $(R^2-(R+1)^2)$ + 8.3% **	Insufficient data	0.16% x $(R^2-(R+1)^2)$ + 7.8% *
Urban medium	Insufficient data	0.24% x $(R^2-(R+1)^2)$ + 9.2% *	Insufficient data	Insufficient data	0.21% x $(R^2-(R+1)^2)$ + 8.7% *
Urban small	Insufficient data	0.18% x $(R^2-(R+1)^2)$ + 8.2% *	0.14% x $(R^2-(R+1)^2)$ + 7.4% **	Insufficient data	0.20% x $(R^2-(R+1)^2)$ + 8.8% *
Rural	Insufficient data	0.28% x $(R^2-(R+1)^2)$ + 10.3% *	0.29% x $(R^2-(R+1)^2)$ + 10.7% *	Insufficient data	0.25% x $(R^2-(R+1)^2)$ + 9.6%
Total	Insufficient data	0.19% x $(R^2-(R+1)^2)$ + 8.5%	0.17% x $(R^2-(R+1)^2)$ + 8.2% *	0.12% x $(R^2-(R+1)^2)$ + 6.7% *	0.19% x $(R^2-(R+1)^2)$ + 8.5%

* the relationship is based on less than 1000 observations.
** the relationship is based on less than 100 observations.

Table 22 The proportion of cars with the registration number prefix J onwards

	Metropolitan built-up areas	*Other urban (> 250K)*	*Other urban (25K to 250K*	*Other urban (10K to 25K)*	*Other urban (3K to 10K; from 1996)*	*Small urban (3k to 25k pre-1996)*	*Rural*	*Total*
North East	48%	53%*	52%*	44%*	33%*	–	69%*	50%
North West & Merseyside	47%	44%	44%	55%*	38%*	–	43%*	45%
Yorkshire & Humberside	46%	43%	36%	43%*	43%*	–	37%*	41%
East Midlands	–	38%	38%	30%*	45%*	50%**	34%	38%
West Midlands	39%	36%	45%	33%*	50%**	–	36%*	39%
Eastern	–	41%*	42%	49%*	36%	–	37%	40%
Greater London	–	24%*	35%*	–	–	–	–	35%
South East	–	34%	37%	38%	46%	–	45%	39%
South West	–	32%	31%	34%*	40%	–	29%	33%
Wales	–	48%*	43%	55%*	36%*	–	28%*	40%
Scotland	52%*	60%*	44%	60%*	50%	71%**	35%*	48%
All regions	45%	39%	40%	43%	42%	62%*	37%	40%

** based on less than 100 observations*
*** based on less than 10 observations*

Table 23 Proportion of HGVs that are articulated

	Motorway	*Urban A roads or rural dual carriageway*	*Urban B&C roads or rural single carriageway*	*Urban unclassified or rural B&C roads*	*All types*
Observed : 1999					
London inner	11%*	3%*	1%*	0%**	5%*
London outer	21%*	10%	0%**	0%*	12%
Conurbation inner	Insufficient data	3%*	Insufficient data	1%**	3%*
Conurbation outer	25%*	9%	5%*	0%*	9%
Urban big	Insufficient data	8%	6%*	2%*	6%
Urban large	Insufficient data	8%	2%*	3%*	7%
Urban medium	Insufficient data	13%	5%*	1%*	12%
Urban small	Insufficient data	4%*	0%**	0%**	3%*
Rural	27%	24%	16%	5%	20%
All areas	26%	14%	13%	3%	14%
Forecast : 2004					
London inner	12%*	4%*	1%*	0%**	5%*
London outer	23%*	11%	0%**	0%*	13%
Conurbation inner	Insufficient data	4%*	Insufficient data	2%**	3%*
Conurbation outer	28%*	10%	5%*	0%*	10%
Urban big	Insufficient data	9%	6%*	2%*	7%
Urban large	Insufficient data	9%	2%*	4%*	8%
Urban medium	Insufficient data	14%	5%*	1%*	13%
Urban small	Insufficient data	4%*	0%**	0%**	3%*
Rural	29%	27%	18%	5%	22%
All areas	28%	15%	15%	4%	16%
Forecast : 2010					
London inner	13%*	4%*	1%*	0%**	6%*
London outer	25%*	12%	0%**	0%*	14%
Conurbation inner	Insufficient data	4%*	Insufficient data	2%**	4%*
Conurbation outer	30%*	11%	6%*	0%*	11%
Urban big	Insufficient data	10%	7%*	2%*	8%
Urban large	Insufficient data	10%	2%*	4%*	9%
Urban medium	Insufficient data	16%	6%*	1%*	14%
Urban small	Insufficient data	5%*	0%**	0%**	4%*
Rural	32%	29%	19%	6%	24%
All areas	30%	16%	16%	4%	17%

* the relationship is based on less than 1000 observations.
** the relationship is based on less than 100 observations.

4.2.5 Fuel categorisation for passenger cars

The NAEI road transport emission model uses a projection of the proportion of cars and LGVs in the UK fleet that are diesel and this is included in Table 24. The projection is made using DETR data on vehicle survival rates, new car sales (VMM) and mileage rates.

The information collated by DETR to assess the scale of the evasion of Vehicle Excise Duty also gives information on the proportion of vehicles that use diesel fuel according to road type and functional area type. However, there appears to be a sampling bias towards diesel fuelled vehicles. This may arise because the surveys seek to include some of the more unusual vehicle types (Ledger 2000) which may be more likely to be diesel fuelled. What the data do show, is that across all the road and functional area types there is little difference in the proportion of passenger cars that are diesel fuelled. It is therefore acceptable to use the average figures supplied in Table 24.

4.3 Using the method

4.3.1 Data requirements

Tables 9 to 24 can be used to provide additional local information on: average speed, engine capacity of passenger cars, the average trip distance of passenger cars, the proportion of HGVs that are articulated and rigid, an age profile for each of the vehicle types and the proportion of cars and LGVs that are diesel fuelled. All the user of the method needs to provide are vehicle flows classified according to car, LGV, HGV and buses and coaches. The classification of flows can either be achieved through measurements (automatically by axle counts or manually by on-site identification) or from the NRTF (DETR, 1997).

The following examples show how the tables can be used to give additional information on traffic on a B road in an inner conurbation in 2005 and on an inner conurbation motorway in 2010. A spreadsheet-based model that incorporates the tables is included on a CD-ROM with this report. Figure 7 illustrates the calculation procedure as a flow diagram.

Emission functions such as those developed for the NAEI (as provided by TRL) and COPERT III (1999) can then be used to estimate emissions.

4.3.2 An inner conurbation B road in 2005

Average speeds

From Table 9 and Table 10 it can be seen that cars and LGVs have the same relationship between average speed and year, i.e.

$$\begin{aligned}\text{Average speed} &= -0.11 \times (Y - 1996) + 37\\ &= -0.11 \times (2005 - 1996) + 37\\ &= 36 \text{ km/h}\end{aligned}$$

For HGVs, coaches and buses:

$$\begin{aligned}\text{Average speed} &= -0.12 \times (Y - 1996) + 37\\ &= 36 \text{ km/h}\end{aligned}$$

Fuel used, engine capacities and trip length for passenger cars

From Tables 12 and 13, the engine size distributions for petrol and diesel cars can be found.

	Diesel cars	*Petrol cars*
Engine capacities <1.4 l	2.2%	35.7%
Engine capacities 1.4-2.0 l	93.3%	57.0%
Engine capacities >2.0 l	4.5%	7.3%
Total	100.00%	100.00%

The average trip length for petrol and diesel passenger cars will be 8 km and 9.8 km respectively as shown in Table 14.

The proportion of passenger cars and LGVs that will be diesel in 2005 will be 18.1% and 88.2% respectively.

Proportion of HGVs that are articulated

Insufficient data were available for this particular road type to estimate the proportion of HGVs that are articulated and so the value for all roads i.e. 4% should be used.

Vehicle age profile

In Tables 15 to 21 there is no specific information on the age profile for any of the vehicle types on inner conurbation B roads. Therefore, the profile for all inner conurbation roads must be used, except for Buses and Coaches where the profile for all types of road must be used, because of the lack of any other information. Table 25 shows the distribution of year of registrations for each of the vehicle types. The shaded values represent the proportion of vehicles that are not accounted for within the model e.g. 4% of petrol cars on this road type are 20 or more years old, but there is insufficient information to break this down further.

It is interesting to note that on inner conurbation B roads petrol vehicles are on average older than their diesel equivalents. Articulated HGVs, buses and coaches tend to be the oldest vehicles on these roads.

4.3.3 An inner conurbation motorway in 2010

Average speeds

From Table 9 and Table 10 it can be seen that cars and LGVs have the same relationship between average speed and year, i.e.

Table 24 Average proportion (%) of diesel passenger cars and LGVs, 1996-2010

Fuel	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
Cars	9.9	10.7	12.2	13.4	14.5	15.5	16.3	17.0	17.6	18.1	18.3	18.5	18.7	18.8	18.9
LGVs	61.7	66.2	67.8	72.9	77.4	81.0	83.8	85.8	87.2	88.2	88.9	89.3	89.6	89.8	89.9

Table 25 Percentage of vehicles in each year on inner conurbation B roads

Year of registration	*Age of vehicle*	*Petrol car*	*Diesel car*	*Petrol LGV*	*Diesel LGV*	*Rigid HGV*	*Articulated HGV*	*Coaches and buses*
2005	0	9.55	11.91	11.35	12.66	10.97	8.21	8.31
2004	1	9.05	11.13	10.65	11.78	10.31	7.83	7.93
2003	2	8.55	10.35	9.95	10.9	9.65	7.45	7.55
2002	3	8.05	9.57	9.25	10.02	8.99	7.07	7.17
2001	4	7.55	8.79	8.55	9.14	8.33	6.69	6.79
2000	5	7.05	8.01	7.85	8.26	7.67	6.31	6.41
1999	6	6.55	7.23	7.15	7.38	7.01	5.93	6.03
1998	7	6.05	6.45	6.45	6.5	6.35	5.55	5.65
1997	8	5.55	5.67	5.75	5.62	5.69	5.17	5.27
1996	9	5.05	4.89	5.05	4.74	5.03	4.79	4.89
1995	10	4.55	4.11	4.35	3.86	4.37	4.41	4.51
1994	11	4.05	3.33	3.65	2.98	3.71	4.03	4.13
1993	12	3.55	2.55	2.95	2.1	3.05	3.65	3.75
1992	13	3.05	1.77	2.25	1.22	2.39	3.27	3.37
1991	14	2.55	0.99	1.55	0.34	1.73	2.89	2.99
1990	15	2.05	0.21	0.85	2.5	1.07	2.51	2.61
1989	16	1.55	3.04	0.15		0.41	2.13	2.23
1988	17	1.05		2.52		3.27	1.75	1.85
1987	18	0.55					1.37	1.47
1986	19	0.05					0.99	1.09
1985	20	4					0.61	0.71
1984	21						0.23	0.33
1983	22						7.16	4.96

Shaded values refer to the percentage that are that age or older.

Average speed = -0.89 x (Y - 1996) + 52
= -0.89 x (2010 - 1996) + 52
= 39 km/h

For HGVs, coaches and buses:

Average speed = -0.98 x (Y - 1996) + 48
= 34 km/h

Engine capacities for passenger cars

From Tables 12 and 13, the distribution of engine sizes for petrol and diesel cars can be found.

	Diesel Cars	*Petrol cars*
Engine capacities <1.4 l	1.7%	26.3%
Engine capacities 1.4-2.0 l	94.8%	64.3%
Engine capacities >2.0 l	3.5%	9.4%
Total	100.00%	100.00%

The average trip length for petrol and diesel passenger cars will be 8.3 km and 8.4 km respectively as shown in Table 14.

The proportion of diesel fuelled cars and LGVs in 2010 will be 18.9% and 89.9% respectively.

Proportion of HGVs that are articulated

The proportion of HGVs that are articulated will be 32% in 2010.

Age profile

In Tables 15 to 21 there is no specific information on the age profile for any of the vehicle types. The profile for all motorways was used for all vehicles except for buses and coaches where the profile for all types of road was used. Table 26 shows the distribution of year of registrations for each of the vehicle types. Again, the shaded values represent the vehicles that are not accounted for within the model e.g. 1.75% of diesel cars are 15 years or older, but there is insufficient information to break this down further.

It is interesting to note that vehicles on inner conurbation motorways are newer than those on B roads in the same areas.

5 Summary

The main aim of this study was to investigate and provide a classification of traffic composition, by geographical area and location type, that could be used in local air quality assessments. This involved an analysis of the sensitivity of emission estimates to the parameters that describe traffic and the development of relationships that could describe how these parameters might be affected by road type, area type and time.

5.1 Sensitivity of emission estimates to traffic parameters

The sensitivity analysis of the parameters that affect emission estimates was carried out in two stages: the first stage sought to determine the sensitivity of emission estimates for each pollutant to the various parameters for each of the vehicle types and the second stage considered the sensitivity of total fleet emission estimates to those

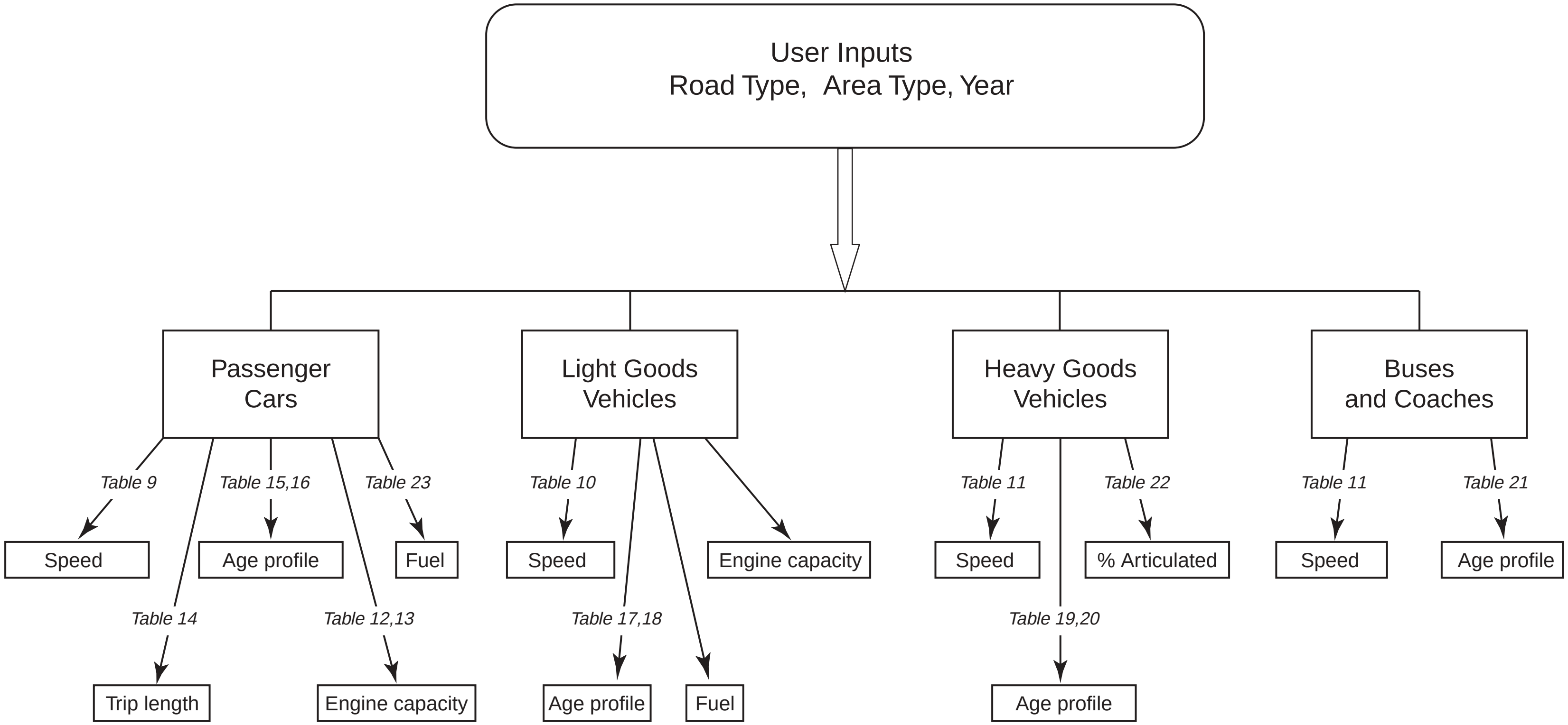

Figure 7 Procedure for estimating the composition of traffic by road type, area type and year

Table 26 Percentage of vehicles on inner conurbation motorways within each year of registration

Year of registration	*Age of vehicle*	*Petrol car*	*Diesel car*	*Petrol LGV*	*Diesel LGV*	*Rigid HGV*	*Articulated HGV*	*Coaches and buses*
2005	0	11.44	12.85	12.2	13.41	10.97	10.59	8.31
2004	1	10.72	11.95	11.4	12.43	10.31	9.97	7.93
2003	2	10	11.05	10.6	11.45	9.65	9.35	7.55
2002	3	9.28	10.15	9.8	10.47	8.99	8.73	7.17
2001	4	8.56	9.25	9	9.49	8.33	8.11	6.79
2000	5	7.84	8.35	8.2	8.51	7.67	7.49	6.41
1999	6	7.12	7.45	7.4	7.53	7.01	6.87	6.03
1998	7	6.4	6.55	6.6	6.55	6.35	6.25	5.65
1997	8	5.68	5.65	5.8	5.57	5.69	5.63	5.27
1996	9	4.96	4.75	5	4.59	5.03	5.01	4.89
1995	10	4.24	3.85	4.2	3.61	4.37	4.39	4.51
1994	11	3.52	2.95	3.4	2.63	3.71	3.77	4.13
1993	12	2.8	2.05	2.6	1.65	3.05	3.15	3.75
1992	13	2.08	1.15	1.8	0.67	2.39	2.53	3.37
1991	14	1.36	0.25	1	1.44	1.73	1.91	2.99
1990	15	0.64	1.75	0.2		1.07	1.29	2.61
1989	16	3.36		0.8		0.41	0.67	2.23
1988	17					3.27	0.05	1.85
1987	18						4.24	1.47
1986	19							1.09
1985	20							0.71
1984	21							0.33
1983	22							4.96

Shaded values refer to the percentage that are that age or older.

parameters under test. The study makes use of the methodologies adopted in the NAEI for hot emissions and COPERT III for cold start and evaporative emissions. The sensitivity analysis was carried out for each year from 1998 to 2010 inclusive. It was judged important to consider each year because as vehicles are scrapped they are replaced with new vehicles complying with tighter emission standards.

The effect on emission estimates of varying the parameters listed below was investigated:

- engine size (passenger cars);
- vehicle weight (HGVs, buses);
- vehicle age;
- average speed;
- trip length;
- ambient temperature;
- maximum and minimum daily ambient temperature.

By changing each of the parameters in turn, the sensitivity of emission estimates to these could be determined through comparison with the estimates made using a basecase. The sensitivity criteria were based on the premise that traffic management schemes may lead to a 5-10% change in emissions on implementation. Where the sensitivity of the emission estimates was greater than 10%, additional local information on that parameter should be obtained. It was also necessary to consider the pollutant under review. For example, NO_x and PM_{10} emissions are of particular concern for urban areas when evaluating the likelihood of exceeding air quality objectives.

The analysis showed that important errors can occur when estimating emissions from the fleet as a whole, particularly for average speed. Table 5 recommends the detail in the fleet composition that would be required.

The most important parameter for hot emissions is average speed. Differences of ± 30% can have a significant effect on the estimate and so local information on average speed would therefore be needed to assess local situations. For HGVs engine size or weight are also important parameters, and local information on the split between the different categories would be required.

Cold start emissions can only be reliably calculated for passenger cars and LGVs. The estimation of fleet cold start emissions is not particularly sensitive to the assumed ambient temperature but, as local information is likely to be readily available, this should be used.

It is more important when considering a particular vehicle type to obtain local information and Table 4 recommends the level of detail that would be required to provide acceptable accuracy in the emission estimates. Table 4 can be used to inform the data requirements for schemes that influence the proportions of vehicle types within the traffic, e.g. where a new development increases substantially the amount of HGVs, then local information on average speed and weight should be determined for these vehicles.

For all vehicle types, the most important parameter for hot emissions is average speed: for petrol vehicles, speed is also important in determining cold start emissions Local speed data would be required to assess local situations. For diesel vehicles engine size or weight are important parameters, and local information on the split between the different categories would be required. Evidence from the other types of diesel vehicle suggest that this would be the case for buses also.

Estimates of cold start emissions are sensitive to the ambient temperature data used and so local data should therefore be sought. Local information on the maximum daily temperature should be sought for the estimation of evaporative emissions.

5.2 A method to derive traffic composition

Relationships have been derived using a number of sources to describe how average speed, engine size, trip length, vehicle age profile and HGV weight distribution vary with road type (motorway to rural B&C roads), functional area type (London inner to rural) and year (1996 to 2010). These sources include:

- the FORGE process that forecasts the incidence of congestion and the response of road users;
- the NTS which collates data on the use of cars by households;
- data on vehicle type and age from the 1999 survey of the evasion of Vehicle Excise Duty; and
- *Focus on Freight* (Government Statistical Service, 1998) which provides growth rates for freight.

These relationships are provided as a series of tables to be used with vehicle flows that are broken down according to the proportion of cars, LGVs, HGVs and buses and coaches.

One of the aspirations of this study was to provide a classification for specific sites such as a shopping centre. It has not been possible to derive relationships for specific situations because of the scarcity of empirical data. However, by using Table 4 to inform the data requirements for particular vehicle types, the relationships presented here can be used to add a local perspective to emission estimates.

5.3 Uncertainties in the method

It is acknowledged that although the functional area types do take account of some of the variations in for example the proportions of vehicle types and the age profile of the traffic, there are also regional effects. However, because of the relatively small amount of data that are available it has not been possible to disaggregate the relationships to include regional effects.

There are insufficient data or prediction tools to provide additional information on the types of fuel used by vehicles, except for the information already available through the NAEI forecasts. Aggregated values are available for passenger cars and LGVs and it can reasonably be assumed that almost all HGVs and buses will use diesel.

Motorcycles were not included in the study due to the scarcity of reliable emission factors. Motorcycles make up the smallest proportion of the vehicle fleet but it is not necessarily true that their importance may be small. As additional data become available on motorcycles, then their effect on traffic emissions should be investigated further.

Similarly, emissions of PM from petrol cars or LGVs were not included in the study as there are few data on which to base emission factors.

There is a wide range of weights for HGVs and buses, and currently very limited emissions data and the work presented here is based on a very crude split. As more emissions data become available they may indicate that it is necessary to increase the number of categories and include more local information.

There are also uncertainties in the relationships derived and these increase with the forecast year. In particular there are uncertainties in the effect of the economy on vehicle purchasing and replacement and on the growth in freight.

Despite these limitations the relationships presented here do allow the user to introduce a local dimension to estimates of emissions from road traffic by assigning the traffic to road types and functional area types.

6 References

Buckingham C, Forrest G, Sadler L, Shah S and Wickham L (1997a). *Atmospheric emissions inventory for Greater Manchester.* London: London Research Centre.

Buckingham C, Clewley L, Hutchinson D, Sadler L and Shah S (1997b). *London atmospheric emission inventory.* London: London Research Centre.

Buckingham C, Sadler L, Shah S, Forrest G, Jenkins N and Spence E (1998). *Atmospheric emissions inventories Glasgow, Middlesborough and West Yorkshire (Leeds, Bradford and Kirklees).* London: London Research Centre.

Cox J A, Griffiths P I J, Emmerson P and Cloke J (1999). *Traffic composition and emission estimates: draft interim report.* Project Report PR/SE/613/99. Crowthorne: TRL Limited. (*Unpublished report available on direct personal application only*)

Cloke J, Cox J A, Hickman A J, Ellis S E, Ingrey M and Buchan K (2000). London Low Emission Zone. TRL Report TRL431. Crowthorne: TRL Limited.

Department of the Environment, Transport and the Regions (DETR) (1997). *National road traffic forecasts (Great Britain) 1997.* London: The Stationery Office.

Department of the Environment, Transport and the Regions (DETR) (1998). *Digest of environmental statistics no 20.* London: The Stationery Office.

Department of the Environment, Transport and the Regions (DETR) (1999). *Review and assessment: Estimating emissions. LAQM TG2 (00).* London: The Stationery Office.

Department of the Environment, Transport and the Regions (DETR) (2000a). *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland*. London: The Stationery Office.

Department of the Environment, Transport and the Regions (DETR) (2000b). *Vehicle Excise Duty Evasion 1999: Statistical Bulletin (00)13.* London: The Stationery Office.

Department of Transport, Scottish Office, Welsh Office and Department of the Environment for Northern Ireland (1995). Environmental assessment. *Design Manual for Roads and Bridges, Volume 11*. London: The Stationery Office.

Dodgson J S and Kirby H R (1996). *Structure of the Vehicle Market Model. Technical Note 393.* Institute for Transport Studies. University of Leeds. April 1996. Unpublished.

Government Statistical Service (1998a). *Transport of goods by road: Annual report of the continuing surveys of road goods transport.* London: The Stationery Office.

Government Statistical Service (1998b). *Focus on freight.* London: The Stationery Office.

HETA (1999). Personal Communication to Paul Emmerson. Crowthorne: TRL Limited.

Hickman A J (1998*)*. *Methodology for calculating transport emissions and energy consumption.* MEET Deliverable 22. Project Report PR/SE/491/98. Crowthorne: TRL Limited. (*Unpublished report available on direct personal application only*)

Hutchinson D and Clewley L (1996). *Atmospheric emissions inventory, West Midlands.* London: London Reseaerch Centre.

Latham S, Cloke J and Eastlake A (2000). *Inception report for UG216 - Emission measurements.* Project Report PR/SE/192/00. Crowthorne: TRL Limited. (*Unpublished report available on direct personal application only*)

Ledger (2000). *Personal communication to N Paulley.* Crowthorne: TRL Limited.

London Research Centre (1999). Greater Belfast emission inventory. http/www.london-research.gov.uk

LPAC (1998). *Developing road traffic reduction targets for London.*

TRL Limited (no date). *UK road transport emission data.* www.trl/env_emissions.htm.

Ntziachristos L and Samaras Z (1999). *COPERT III. Methodology and Emission Factors.* Draft Final Report.

Abstract

Estimating road traffic emissions is an increasingly important part of a local authority's duties. For example, the local air quality management process requires an assessment of emissions from traffic and Local Transport Plans must make an assessment of the impacts of proposed transport schemes on the environment. Traffic composition is an important factor in estimating emissions, but whilst details of typical vehicle-mixes are available for some roads, for others national statistics are the only realistic alternative. The national 'average' may not adequately describe the local situation for the purpose of accurately estimating emissions.

This report describes a study to investigate and provide a classification of traffic composition, by geographical area and location type, that could be used in local air quality assessments. Relationships have been derived using a number of sources to describe how average speed, engine size, fuel type, trip length, vehicle age profile and HGV weight distribution vary with road type (motorway to rural B&C roads), area type (London inner to rural) and year (1996 to 2010). These relationships are then provided as a series of tables to be used with vehicle flows that are classified according to the proportion of cars, LGVs, HGVs and buses and coaches.

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