UNIVERSITY OF WESTMINSTER

Modelling policy measures and company initiatives for sustainable urban distribution

Final Technical Report

A research project funded by the EPSRC/DfT as part of the Future Integrated Transport Programme

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CONTENTS

Page number

1. INTRODUCTION AND EXPLANATION OF THE PROJECT

1.1 Introduction

Urban goods distribution has an important role to play in the context of urban life: it is fundamental to the economic vitality and competitiveness of industrial, trade and leisure activities that are essential to wealth generation (Ogden, 1992). An efficient distribution system plays a significant role in the competitiveness of an urban area and is in itself an important element of the urban economy, both in terms of the income it generates and the employment levels it supports. Rapid and reliable goods distribution also helps to support urban lifestyles, in the retailing, tourism, entertainment and leisure sectors. However these goods distribution activities are contributing to road traffic and environmental impacts in urban areas (such as adding to congestion levels, pollution, noise, fossil fuel use etc. – Civic Trust et.al., 1990). Freight transport and distribution activities are an important factor in the consideration of urban sustainability: they facilitate and support the economic life of an urban area, but are also responsible for a number of social and environmental impacts that threaten its environmental sustainability.

After approximately twenty years of receiving little research or policy consideration in the UK, urban freight transport and distribution has recently begun to be recognised as an important activity by academics, policy makers, companies and those living and working in UK towns and cities. During this period the UK central government published or said little about freight transport in general, and in particular about *urban* freight transport.

Renewed interest in urban distribution issues among policy makers was indicated by the establishment of a Freight Distribution and Logistics Unit in the Department of Environment, Transport and the Regions (DETR) (now known as the Department for Transport or DfT), and the publication of the 1998 Transport White Paper "A New Deal for Transport: Better for Everyone" (DETR, 1998a) and the daughter document to the White Paper entitled "Sustainable Distribution" (DETR, 1999). These documents outlined the UK government's determination to recognise and address the problems both faced and caused by urban distribution activities.

The urban freight transport and distribution considerations of local authorities in the UK have traditionally tended to take place as a reaction to problems, usually arising from complaints made by residents and other road users. Most local authorities with an urban remit have not developed coherent freight transport policies to the same extent that they have their public transport policies. However, local authorities are now being encouraged by central Government to focus greater attention on freight transport and to include consideration of urban distribution and its sustainability in their Local Transport Plans. The Department for Transport is also encouraging local authorities to include Freight Quality Partnerships (FQPs) in their Local Transport Plans (DETR, 1998b).

Freight Quality Partnerships (FQPs) are an idea launched by the Freight Transport Association (FTA) in 1996. The FTA initiative brought together industry, local government and representatives of local and environmental interest groups to pursue the following agenda (Freight Transport Association, 1998):

- To identify problems perceived by each interest group relating to the movement and delivery of goods in their city;
- To identify measures within the group's competence to resolve or alleviate such problems;

- To identify best practice measures and principles for action by local government and industry to promote environmentally sensitive, economic and efficient delivery of goods in towns and cities.

FQPs can facilitate improved dialogue about urban freight transport issues between local authorities, freight transport companies, retailers, manufacturers and other businesses, local residents and other interested parties.

Environmentalists and non-freight road users have become increasingly concerned about urban freight transport activity and its environmental consequences in recent years (for example see World Wildlife Fund, 1995). At the same time companies performing urban distribution operations and manufacturers, retailers and other commercial premises in urban areas receiving and despatching goods, are becoming ever-more concerned about the efficiency, reliably and cost of distribution services as road traffic levels continue to grow and more stringent vehicle restrictions are imposed in towns and cities (for example see Freight Transport Association, 1998).

In order to better understand current patterns of goods flow and goods vehicle activity, in 1998/1999 the University of Westminster carried out an exploratory project entitled "A framework for considering policies to encourage sustainable urban freight traffic and goods/service flows" which was funded by the EPSRC as part of the Sustainable Cities Programme (Grant reference number: GR/L 77201) (Allen et. al., 2000) Through conducting face-to-face interviews and discussion groups with a wide range of participants (retailers, manufacturers, wholesalers, freight transport companies and policy makers) it was possible to: (i) gain detailed insight into current distribution operations in urban areas, (ii) examine the problems experienced by freight transport companies in urban areas, and (iii) identify many transport policy measures and company initiatives that could potentially help to make freight distribution in urban areas more environmentally and/or economically sustainable. The approach was used in Norwich and parts of London. The research framework developed in the project has also recently been applied in Winchester by the University of Southampton (Cherrett et. al., 2002).

The project reported on in this document, entitled "Modelling policy measures and company initiatives for sustainable urban distribution", has built on our earlier project, further developing the research into policy measures and company initiatives that could help to make distribution operations in urban areas more sustainable. It has received DfT and EPSRC funding as part of the Future Integrated Transport programme (Department for Transport, 2002).

1.2 Aims and objectives of the project

Recent research in urban distribution has adopted several research approaches. In France, the emphasis has been on large-scale data collection exercises (such as the quantitative and qualitative survey work carried out in Bordeaux, Dijon, Marseille – described in Ambrosini et.al., 2001). In Germany emphasis has been placed on piloting city logistics schemes in which several distribution companies work together in order to make better use of their capacity (for example see Kohler, 1999), as well as modelling commercial traffic flows (for example see Meimbresse and Sonntag, 2000). Meanwhile in Japan the research focus has been on investigating the use of computer routeing and scheduling systems in conjunction with dynamic flow simulation to improve the efficiency of operations (Thompson and Taniguchi, 2000).

While the recent growth of research into urban distribution taking place is encouraging, little of this work has been concerned with examining the likely impact of policy measures on goods vehicle operations. Few previous studies have attempted to investigate the relationship

between: (i) policy measures, (ii) likely company action in response to the measure (in terms of distribution activity), (iii) the effect on operating costs, and (iv) the change in environmental impact.

The main aim of the project reported on here has been to investigate the extent to which policy measures and company initiatives are likely to result in changes in patterns of goods flows and goods vehicle activity in different types of urban distribution operation. Policy measures tested include Low Emission Zones, congestion charging, weight and access time restrictions.

Analysis has been carried out into how these changes in goods vehicle collection and delivery patterns will affect the cost and efficiency of the goods collection/delivery operation, and the social and environmental impacts.

Consideration has also been given to whether the policy measures examined are likely to lead to similar outcomes for a range of urban distribution operations carried out in the three urban areas studied.

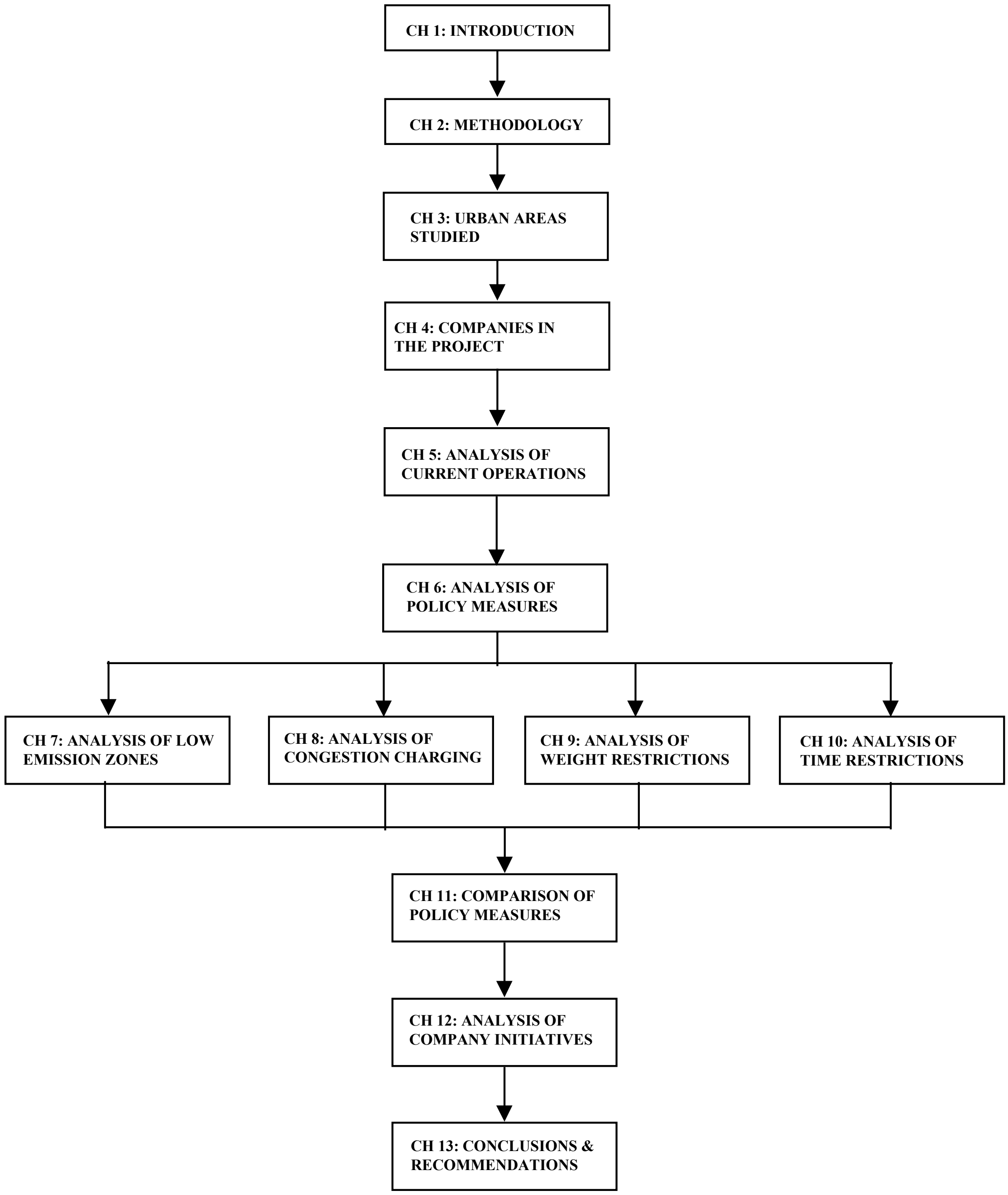
Therefore the intention of the project has been to:

- Show how distribution operations vary for the same company in three different urban areas;
- Make comparisons between different types of operations in the same urban area;
- Indicate how distribution operations and performance may change if new policy measures were introduced;
- Indicate whether the same policy measures are likely to result in the same or different outcomes in the three urban areas.

1.3 Layout of the report

Figure 1.1 shows the content of the chapters in the report.

Figure 1.1: Layout of the report



2. PROJECT METHODOLOGY

2.1 Overview of approach taken in the research

The research approach adopted in the research has comprised the following four main components:

i. Devising a suitable assessment approach for examining the relationships between policy measures/company initiatives, activity/behaviour and environmental/economic impacts.

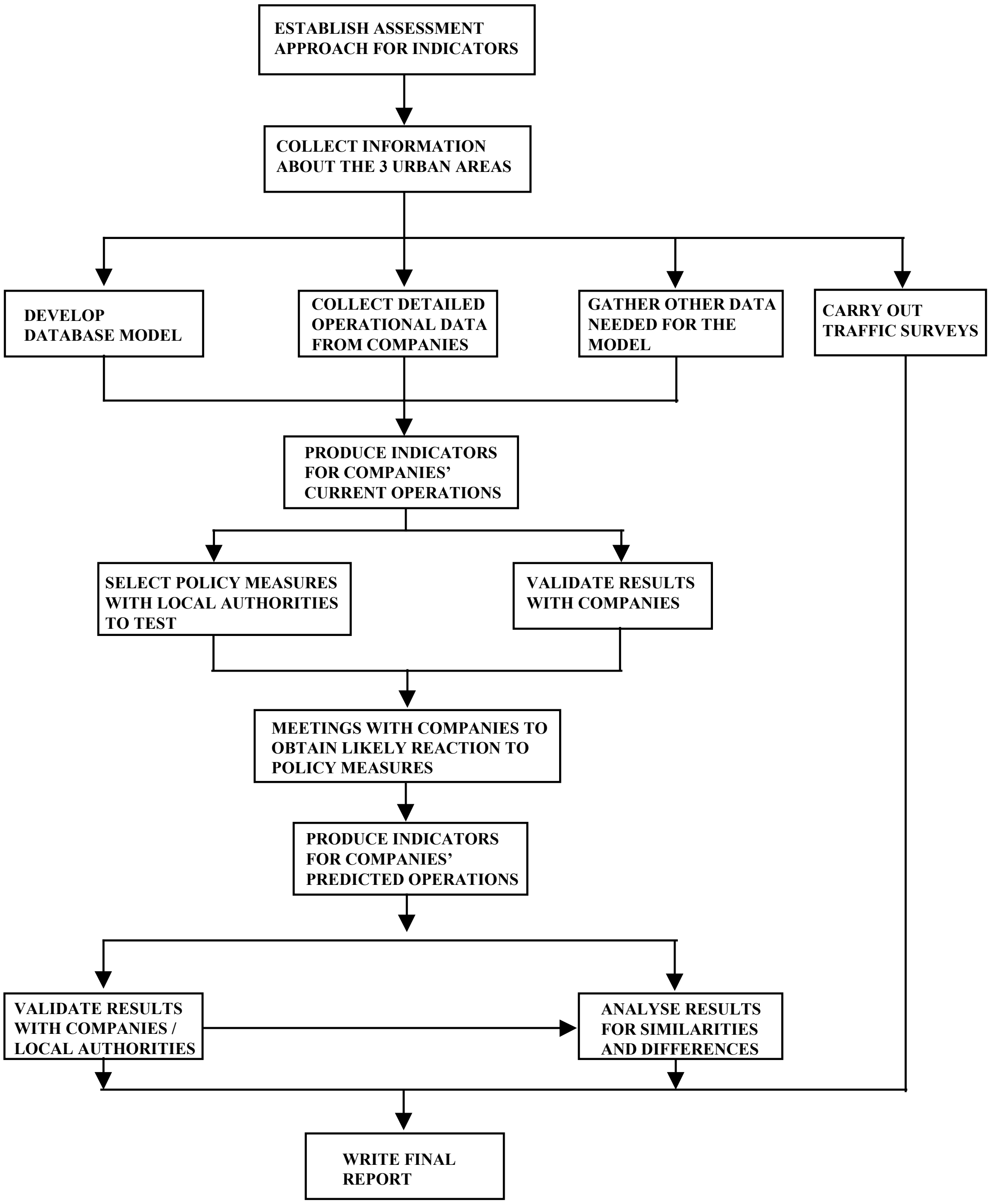
ii. Development of a database model that can be used to reflect the relationships discussed in (i) above. This model has been used to calculate operational, financial and environmental indicators of companies' current distribution operations. The database model has also been used to reflect the change in these indicators caused by likely alterations to distribution operations resulting from potential policy measures/initiatives.

iii. Working closely with distribution companies that carry out urban collections and deliveries in order to firstly, understand and document their existing goods flow and vehicle activity patterns. And secondly, to ascertain how these companies and their customers would expect these patterns of operation to change as a result of the introduction of specific policy measures and company initiatives that appear to have the greatest merit. Details of current operations have been obtained by interviews with the companies and joint data collection efforts. Likely changes to distribution operations as a result of policy measures have been obtained through meetings with representatives from the companies.

iv. Evaluation of the similarities and differences between the distribution operations and the three urban areas studied in the project in terms of: (i) the current pattern of goods collections and deliveries of the distribution companies, (ii) the likely change in the goods collection and delivery operations in response to potential policy measures and initiatives, and (iii) the extent of change in the operational, financial and environmental indicators as a result of the new pattern of goods collection and delivery operations.

Figure 2.1 shows the different activities in the project and how they relate to each other.

Figure 2.1: Relationship between different activities in the project



2.2 Range of companies participating

Distribution companies participating in the project represented a broad range of: (i) goods flows, (ii) types of premises visited, and (iii) patterns of urban distribution operation that take place in urban areas. The only obvious omission was a company carrying out full load food deliveries to supermarkets.

Further information about the distribution companies can be found in chapter 4.

2.3 Data collection methods for company operational data

The project involved collecting a significant amount of data from companies about their distribution operations in the three urban areas studied. The data collected from companies can be divided into two categories:

- A three-day detailed survey of vehicle rounds in the three areas;
- A more general survey of the depot from which these vehicles operate.

Each of these categories are described in the following two sections.

2.3.1 Three-day detailed survey of vehicle rounds

We required very detailed information about vehicle rounds in the three urban areas. It was decided to collect this data for a three-day period. This timespan was felt to be a suitable compromise between the effort involved in collecting the data and the need for sufficient data to ensure that it was representative. All data was collected for a Wednesday to Friday period to help reduce the impact of fluctuations in activity that take place during the working week.

It was originally planned that the data would be collected for the same three-day calendar period in each distribution company. However this ultimately proved not be possible due to company workloads. However, all data was collected within an eight-week calendar period.

Four of the companies collected the data themselves in a format designed by the University of Westminster. However, three of the companies were unable to collect the data themselves. This was due to the fact that their vehicles performed multi-drop work with many collections and deliveries on each round. Asking their drivers to document the required information during the vehicle round would affect their performance. This would therefore potentially affect customer service and would also bias the results. For these three companies it was necessary for University of Westminster researchers to accompany the drivers in the vehicles and record the necessary information during the round. The three-day period of data capture for each company and details of whether the company or the University collected the data is shown in Table 2.1.

Table 2.1: Data collection period at each company

	Three-day data collection period	Organisation collecting data
Company A	26-28 September 2001	Company
Company B	10-12 October 2001	Company
Company C	3-5 October 2001	University of Westminster
Company D	10-12 October 2001	Company
Company E	17-19 October 2001	University of Westminster
Company F	Basingstoke: 17-19 October 2001 Birmingham: 26-28 September 2001 Norwich: 3-5 October 2001	University of Westminster
Company G	14-16 November 2001	Company

For the five companies that performed a relatively small number of vehicle rounds in the three urban areas over the three-day period it was possible to capture data about all these rounds. However, in the case of two of the companies that performed many rounds in the urban areas each day it was necessary to study only a sample of these rounds. These companies selected rounds that were representative of the total vehicle rounds performed (i.e. to include both city centre vehicle rounds and also vehicle rounds outside the city centre).

In the case of the operations that University of Westminster researchers collected data about directly by accompanying the drivers in the vehicles, an additional data collection tool was used. A global positioning system (GPS) was used in the vehicles to record the vehicle routeing. Using this system it was possible to capture the location and time of arrival at each delivery and collection point and the vehicle speed between these points.

In the case of vehicle rounds which included travel outside of the three urban areas studied the entire round data was collected and analysed. Only capturing data about work done by the vehicles in the three urban areas would have rendered the analysis meaningless, as in order to express results per vehicle round, or per delivery it is necessary to study the entire round. However it is important to bear this in mind when consulting the results as not all the activity on each vehicle round took place wholly within the three urban areas. This is especially true of companies participating in the study that operate from distribution centres located a significant distance from the three urban areas.

The detailed information about each vehicle round studied over this three-day period included the following overall information:

- Date of delivery round;
- Time vehicle left depot;
- Time vehicle returned to depot;
- Odometer reading at end of trip;
- Odometer reading at start of trip;
- Vehicle age and specification;
- Vehicle fill at start of round.

For every delivery and collection or stop for any other reason on each vehicle round the following information was recorded:

- Start time of journey to next stopping point;
- Arrival time at next stopping point;
- Distance travelled in vehicle between stopping points;
- Whether stop was for a delivery, collection, both or another reason;
- Name & address of delivery/collection point;
- Quantity of goods delivered or collected;
- Where vehicle was parked during delivery/collection (i.e. on-street, off-street, or in shopping centre);
- Time taken for each delivery or collection;
- Any problems experienced during journey between each delivery/collection point or during delivery/collection.

The data collection sheet used to capture this information is shown in Appendix 1.

In addition, details about the vehicle used for the rounds studied was collected (see Appendix 2). This comprised details of:

- Vehicle age;
- Make and type of vehicle;
- External size of vehicle;
- Internal load space (volume);
- Gross weight of vehicle;
- Maximum payload;
- Fuel type used;

- Vehicle fuel consumption rate.

Vehicle utilisation data for the vehicles studied over the three-day period was also collected (see data collection sheet in Appendix 3). This captured how the vehicles had been used over during the 72-hour period. Time utilisation results were grouped into three headings:

- Time idle (empty) at home depot;
- Time vehicle is out on collection or delivery work;
- Time vehicle is (un)loading or waiting at depot, or rest period.

2.3.2 General survey of the depot

In addition to the detailed study of vehicle rounds over a three-day period in each company, it was also felt necessary to capture additional data about the entire activity at the depot so that it would be possible to put the vehicle rounds studied in context. Therefore the following information was collected for each of the company depots:

- Total vehicle fleet at the depot by type of vehicle;
- Total work performed by the entire depot fleet during the survey week;
- Total work performed by the entire depot fleet during the preceding 12 months.

The data collection sheets used to gather this information can be found in Appendices 2-4.

2.4 Other data sources used in the study

In addition to the data collected from the distribution companies it was also necessary to collect other data for the purposes of the proposed analysis. This additional data is described in the following sections.

2.4.1 Vehicle operating costs

It was decided that for reasons of confidentiality and also to make comparisons between companies it would be best not to use companies' actual vehicle operating costs. Instead running and standing costs were calculated by the University of Westminster for each vehicle type. Necessary cost data for vehicle acquisition, insurance, licences, tyres and maintenance were taken from Motor Transport Cost Tables (Motor Transport, 2001). Drivers wage data was based on data from the Manager's Guide to Distribution Costs (Freight Transport Association, 2002).

These industry standard vehicle operating costs were shown to the distribution companies to check differences with actual costs. Companies confirmed that these vehicle operating costs were not substantially different from their actual costs.

2.4.2 Vehicle emissions data

In order to be able to calculate vehicle emissions with the level of detail required for the project it was necessary to use emissions data sources that provided emissions rates in grammes per kilometre for:

- several different weights of goods vehicle;
- several different weights of goods vehicle for different Euro engine standards;
- the vehicle travelling at different speeds;
- for several different pollutants.

Two sources were identified and used for goods vehicle emission data in the project:

- For goods vehicles over 3.5 tonnes gross vehicle weight, emissions data was taken from the NERA Report on Lorry Track and Environmental Costs (NERA, 2000). This report contained emissions factors for a range of pollutants for 33 types of goods vehicles over 3.5 tonnes gross vehicle weight driving at a range of speeds for all engine standards up to Euro IV. AEA Technology Environment produced these tables for the NERA Report using base emission factors for heavy goods vehicles (Hickman, 1997) and scaling factors for different Euro standards (Ahlvik et al., 1997).

- For goods vehicles up to 3.5 tonnes gross vehicle weight (i.e. vans), emissions data provided by the Department for Transport was used. These speed/emission tables supplied by the Department were those used in the National Atmospheric Emissions Inventory to calculate emission factors. These tables contain data for all engine standards up to Euro IV.

The pollutants used in the project were carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_x) and particulate matter (PM10). All of these with the exception of CO_2 are part of the Objectives for National Air Quality Standards because of their impact on human health and the wider environment.

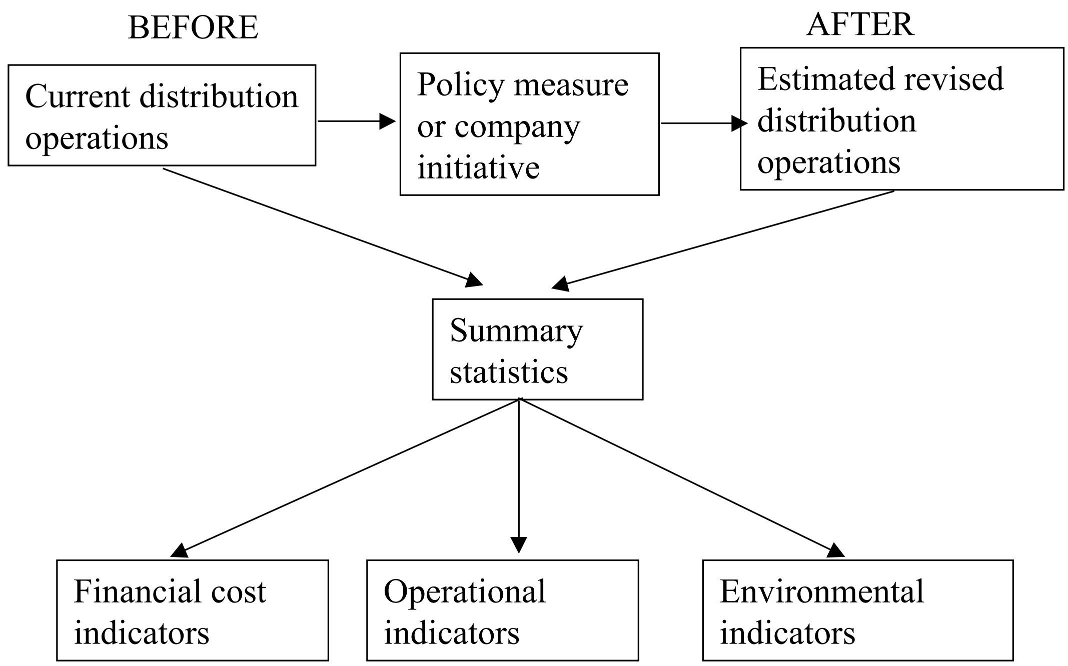
2.4.3 Vehicle fuel consumption

Most companies were able to provide detailed fuel consumption data for the vehicle studied in the project. However, in those cases where such information was not available manufacturers data and trade press vehicle test reports were used.

2.5 Database model and data analysis

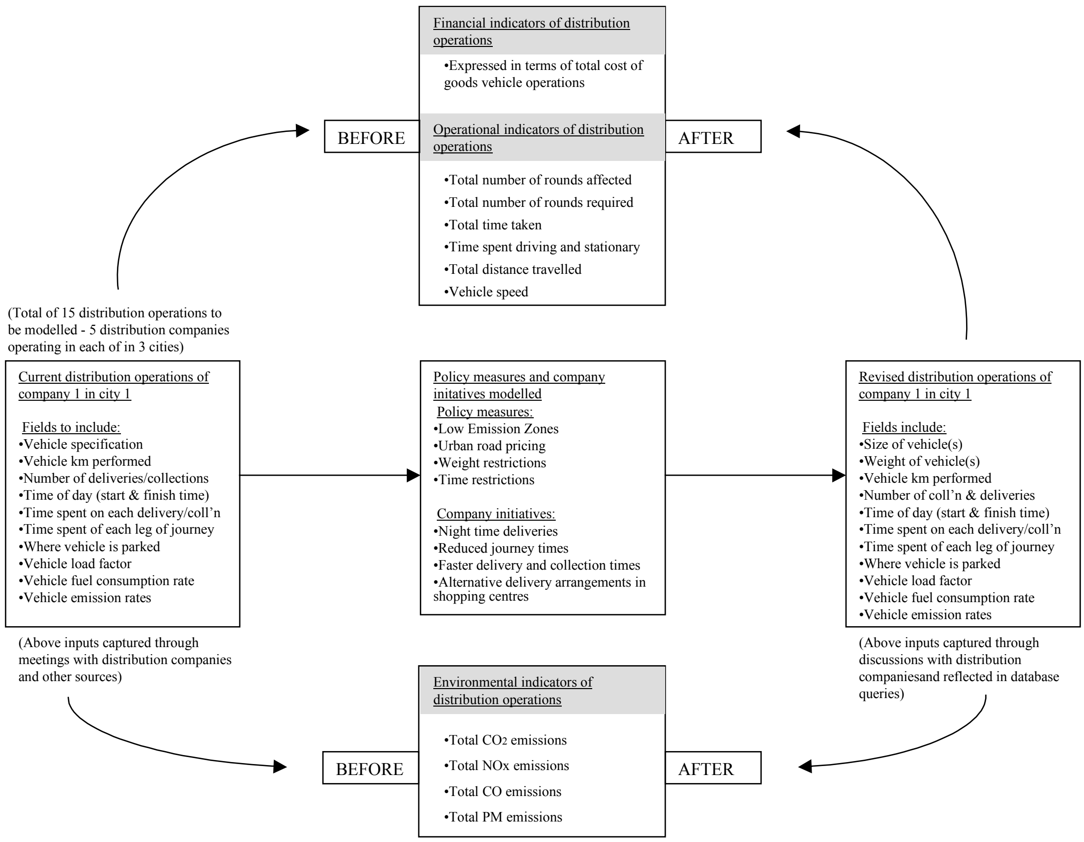
The database designed in the project had to be capable of handling all the current distribution data detailed in Section 2.3. It also had to be designed so as to be capable of manipulating this data to reflect how operations may change as a result of policy measures and company initiatives in accordance with the views expressed by companies. Figure 2.2 shows a conceptual outline of the activities, interventions and outputs for which the database model was required.

Figure 2.2: Activities, interventions and outputs represented in the database model



It was decided to develop the database model in Microsoft Access. Figure 2.3 shows a more detailed outline of data handling required in the database model.

Figure 2.3: Data handling in the database model



The data in the database was organised into several tables. These tables are listed below together with a brief description:

- *Rounds* – contains overall data about each of the 120 vehicle rounds studied (in detail);
- *Rounds (delivery and collection data)* – contains operational information about each of the 120 vehicle rounds studied in detail;
- *Trucks* – contains details of the vehicles used on the rounds studied (in detail);
- *Trucks (Activity)* – contains details of the total work done during the study week and during the year by the entire truck fleet operated from the depot;
- *Trucks (Fleets)* – contains details of the entire truck fleet operated from the depot.

A summary table was generated from collected vehicle round data within the database in order to produce the operational, financial and environmental indicators for each company's current operations in each urban area.

To produce revised operational, financial and environmental indicators to reflect the changes in the 120 vehicle rounds likely to result from policy measures and company initiatives two different approaches were used:

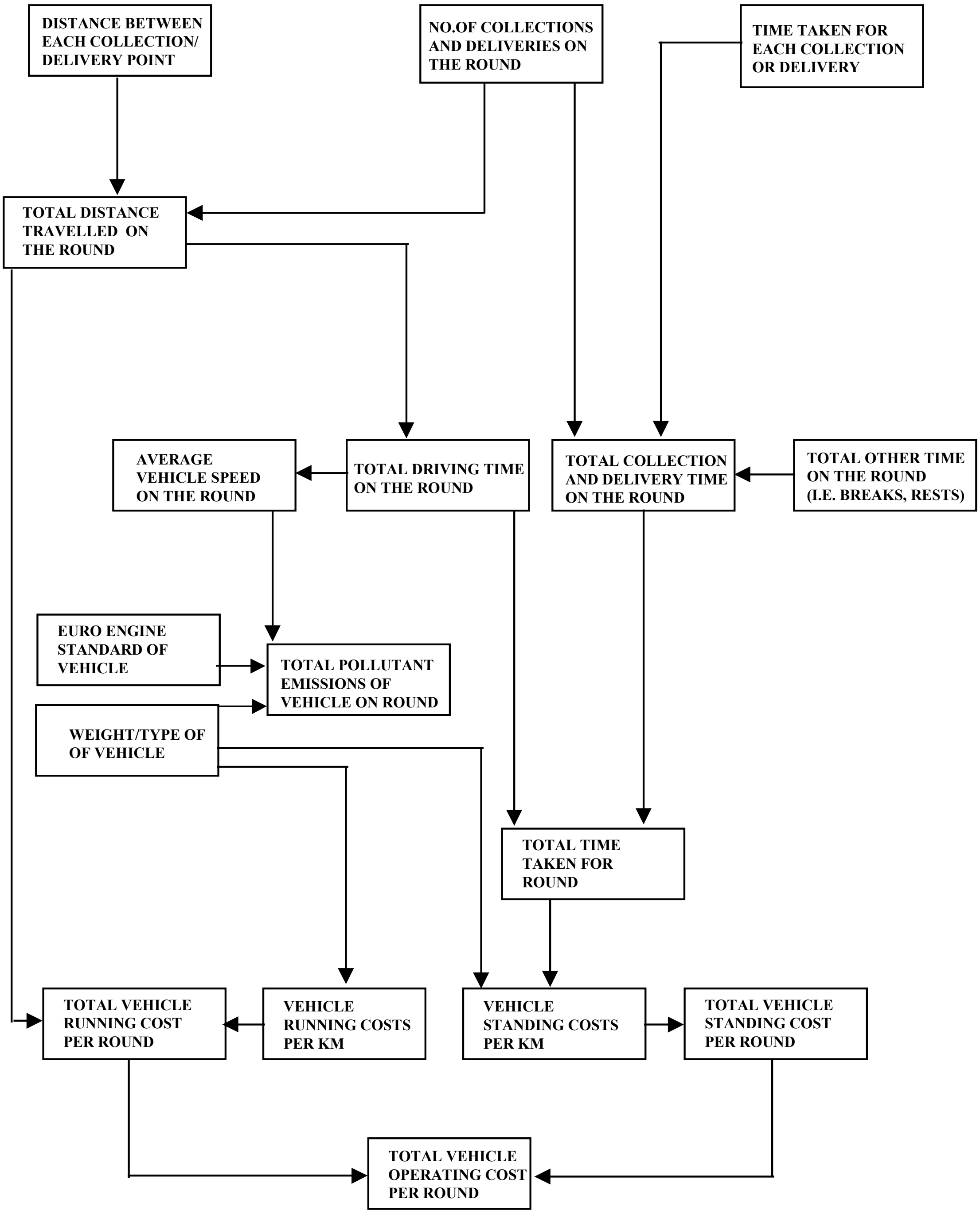
- In cases in which the number of rounds remained the same despite the implementation of a policy measure (including urban road pricing and Low Emission Zones) it was necessary to write queries that applied changes to those rounds that were affected by the policy measures;

- In cases in which the number of rounds increased as a result of the implementation of a policy measure (including changes to weight and time restrictions) it was necessary to duplicate the current 120 rounds and then amend the affected rounds, splitting them into more than one round where appropriate. (This was carried out in a Microsoft Excel spreadsheet and then fed back into the database to help ease data manipulation).

It was then possible to generate a summary table to produce the operational, financial and environmental indicators for each company's operations in each urban area after the introduction of each policy measure.

Figure 2.4 shows the relationship between data items in the database used for producing indicators before and after the application of policy measures and company initiatives.

Figure 2.4: Relationship between data in the database



2.6 Indicators used

In order to reflect the sustainability of the urban distribution operations studied it was necessary to use indicators that reflected:

- Operational factors (indicators reflecting the distribution operation);
- Financial factors (indicator reflecting the vehicle operating costs to the distribution companies);
- Environmental impacts (indicators reflecting the environmental impact of the vehicles).

In deciding on suitable indicators reference was made to the Key Performance Indicator (KPI) studies in the food distribution sector carried out by Heriot-Watt University as part of the Energy Efficiency Best Practice Programme (1999). This study used five KPIs:

- Vehicle fill;
- Empty running;
- Time utilisation;
- Deviations from schedule;
- Fuel consumption.

It was felt that it would be helpful to use as many of these existing indicators as feasible in the urban distribution project to assist consistency between projects. However after discussion with the companies and local authorities, it was decided that ‘empty running’ was not a particularly appropriate indicator for urban rounds as: (i) levels of empty running were relatively low for the companies concerned, and (ii) some vehicles performing multi-drop rounds become empty and then loaded again several times during the course of a vehicle round. ‘Deviations from schedule’ was also felt to be inappropriate as not all the companies delivered or collected goods to an agreed schedule. It was also felt that vehicle pollutant emissions would represent a better indicator than fuel consumption.

The project team also added several additional indicators that were felt to be relevant to urban distribution operations, and which would be necessary in considering sustainability from operational, financial and environmental perspectives. The indicators used in the project for analysing companies’ current distribution operations were:

- **Operational indicators**
  - Number of collections and deliveries per round;
  - Time taken (per round and per collection/delivery);
  - Vehicle fill at start of round;
  - Time utilisation of the vehicle;
  - Driving time and stationary time as % of total round time;
  - Speed per round (including and excluding stops);
  - Distance travelled;
  - Proportion of deliveries on-street and off-street.

- **Financial indicators**
  - Vehicle operating cost to distribution company of the vehicle rounds.

- **Environmental indicators**
  - CO emissions;
  - CO_2 emissions;
  - NOx emissions;
  - PM10 emissions.

Several of the operational indicators (such as ‘distance travelled’, and ‘time taken’) are also environmental indicators as impacts such as disturbance, visual intrusion, and safety are closely related to them.

For the purposes of analysing how the sustainability of companies’ urban distribution operations may change as a result of policy measures it was necessary to produce a reduced list of indicators. This was necessary for two reasons: (i) in some cases there was insufficient data about how operational data would change or about the relationships between operations and some other factor to produce the indicator, and (ii) due to the number of scenarios run for

each policy measure it was important not to produce too many indicators so as to make the results relatively straightforward to interpret.

The following indicators were used to reflect companies' likely urban distribution operations after the implementation of policy measures:

- **Operational indicators**
  - Number of rounds;
  - Number of rounds affected;
  - Total time taken;
  - Driving time and stationary time as % of total round time;
  - Speed per round (including and excluding stops);
  - Distance travelled.

- **Financial indicators**
  - Vehicle operating cost to distribution company of the vehicle rounds.

- **Environmental indicators**
  - Total CO emissions;
  - Total CO_2 emissions;
  - Total NO_x emissions;
  - Total PM10 emissions.

Most of the results provided in this report for indicators of urban distribution operations after the introduction of a policy measure or company initiative are expressed as the percentage difference compared with the rounds before the implementation of the measure. It therefore shows the extent of change in the indicators as a result of the policy measure or initiative rather than absolute numbers (see section 6.1 for further details).

2.7 Selecting policy measures to test

The task of determining which policy measures to test in the project was carried out in conjunction with the local authority partners from Birmingham City Council, Hampshire County Council, and Norfolk County Council.

A meeting was held in order to commence this selection process. Three basic principles were agreed with respect to the selection process:

- In order to make comparisons possible it would be necessary to test the same policy measures in each urban area;
- That the policy measures selected should be widespread approaches to goods vehicle management in an urban area, rather than localised measures in a particular street;
- Measures should be selected that were thought to be the types of approach that policy makers may take with respect to UK urban areas in the next five years (i.e. policy measures that may be implemented in the medium term).

The starting point at this meeting involved the discussion of a list of possible measures for inclusion in the project. It was also agreed that a maximum of four policy measures could be studied in detail. Four policy measures were selected at this meeting:

- Low Emission Zones;
- Congestion charging;
- Vehicle weight restrictions;
- Vehicle access time restrictions.

It is important to note that these four policy measures selected for inclusion in the project are in no way a statement of policy measures that these local authorities intend to implement in future. Instead they simply reflect those measures that were felt by the project team to be the kind of measures that may well be considered by policy makers in the UK in the medium term (i.e. the next five years). It was therefore considered to be worthwhile to study these particular measures in detail in order to improve understanding of their likely effects on the sustainability of distribution operations.

It was then necessary to develop a range of scenarios for each of the four measures in each urban area. The issues that needed consideration included:

- **Low Emission Zones**
  - the geographical area over which it could apply;
  - the times at which it is in force;
  - the types of vehicles affected by the LEZ;
  - the engine standards which the affected vehicles have to meet.

- **Congestion Charging**
  - the geographical area over which it could apply;
  - the times at which it is in force;
  - the types of vehicles that have to pay the congestion charge;
  - the level and type of charge that is applied.

- **Vehicle weight restrictions**
  - the geographical area over which it could apply;
  - the times at which it is in force;
  - the weight of vehicles affected by the limit.

- **Vehicle access time restrictions**
  - the geographical area over which it could apply;
  - the times at which the restriction is in force;
  - the type of vehicles affected by the time restriction.

The scenarios developed for each of the four policy measures were developed in conjunction with the local authority representatives. The scenarios used for each policy measure are explained in Chapters 7-10.

2.8 Obtaining companies' views on the effect of policy measures and company initiatives

Once the four policy measures to be tested in detail had been agreed and a range of scenarios had been developed for each (see section 2.7), it was then necessary to determine how the distribution companies expected these measures to affect their operations in each of the three urban areas.

A meeting was held with each of the distribution companies at which the company representatives were:

- presented with an explanation of each of the policy measures and the different scenarios for that measure;
- asked to comment on and discuss the likely company response to each measure in general;
- requested to comment on the likely company response to the specific scenarios for each measure.

This proved to be a very worthwhile exercise with the representatives managing to describe likely changes that the company would make in order to meet the specific scenarios put to them.

For vehicle rounds affected by policy measure scenario, companies were asked to describe how they expected their company to deal with this scenario in operational terms and the likely supply chain and customer service effects of altering the operation in this way.

It was then possible for the project team to take these company responses and apply these to the vehicle rounds in the database in order to produce a new set of operational, financial and environmental indicators that could be compared with the results produced from companies' current operations (see section 2.5).

It is important to note that not all vehicle rounds operated by the companies would be affected by each of the policy scenarios developed. Whether a round would be affected by a particular scenario is dependent on the precise detail of the scenario developed and the features of the current vehicle round. For example, a weight restriction on vehicles over 7.5 tonnes gvw would not affect a vehicle round currently using a 3.5 tonne vehicle. Queries were set up in the database to determine which of the 120 vehicle rounds in the database were affected by each of the scenarios modelled.

At these meetings, company representatives were also asked about any initiatives that they were considering implementing in the short to medium term that would have a bearing on the efficiency and financial cost of their urban distribution operations, as well as its environmental impact. Companies expressed a common interest in actions that would results in:

- Reduced collection and delivery times (i.e. the time that the vehicle is parked while the driver is making collections and/or deliveries. This could be achieved, for example, by staff at the receiving premises helping the driver to unload the vehicle).
- Reduced driving times and distances travelled (i.e. by reducing the distance travelled on a vehicle round and thereby the time that the vehicle is being driven between the depot and all the collection/delivery points. This could be achieved, for example, by using routeing and scheduling systems linked to traffic information).

Therefore, the effects of reductions in collection and delivery times and driving times on companies' urban distribution operations were also investigated using the database.

2.9 On-street survey work with local authorities

At one of the project meetings early in the study it was agreed that the it would be worthwhile to carry out some traffic survey work in September/October 2001 to help inform the project team about the interactions between goods vehicles, other road users and pedestrians in the three urban areas studied. It was felt that collecting data about total freight vehicle activity in a selected location in each of the three urban areas could: (i) provide insights into the composition of freight vehicle activity in the chosen location, and (ii) help to better understand some of the environmental impacts of freight vehicle activity (in terms of interaction with pedestrians and other road users) in that location. Survey work carried out by the local authorities in each of the urban areas consisted of:

- A one-day manual traffic count on a selected road or roads with a high proportion of retail frontages in or near the centre of the urban area. The count aimed to identify as wide a range of different goods vehicle types as possible including vans;

- Video capture of the freight activity on one of the roads on which the count takes place on the same day. The video provided images of as much of the road being counted as possible (rather than close up video of a particular part of the street). The video was then used to assess interactions between freight vehicles (both mobile and stationary) other road users, and pedestrians and also showed any interactions between freight vehicles.

The project team was responsible for carrying out analysis of these surveys.

In addition, a survey of goods vehicle drivers and premises on the selected street was carried by Norfolk County Council in Norwich. Vehicle access is permitted at all times in this narrow, one lane street, despite the fact that it has the appearance of a pedestrianised street. A voluntary delivery ban is in operation in the street between 12:00-15:00. The survey was carried out in order to:

- identify the characteristics of freight deliveries, collections and servicing arrangements in the area;
- identify problems experienced, by whom, and the degree of severity;
- put forward a range of possible solutions for further investigation which could potentially form the basis of a Freight Quality Partnership.

The project team helped to carry out analysis of these survey results.

Although not specified as part of the original project, this on-street survey work has proved very helpful in providing insight into interactions between goods vehicles and other road users and pedestrians.

Further details and results of all the on-street survey work can be found in Appendix 5.

2.10 Issues and problems

Several issues and problems emerged during the project that are worth discussing at this point.

2.10.1 Data collection method

At the start of the project it was felt by the project partners that the distribution companies would be able to provide all the data required without too much difficulty. However, as the project proceeded it became apparent that some of the companies did not collect some of the data required as part of their day-to-day operation. In addition, because of the nature of their operations, it was not possible for companies with multi-drop operations involving many deliveries and collections per round to ask their drivers to gather this information during their work (as this would have affected their performance and also biased the results). It was therefore necessary for researchers to accompany drivers on the vehicle rounds to gather this data. This is a time-consuming and expensive data collection method. It is hoped that if a similar exercise is repeated in future much of the data could be obtained using systems that automatically record vehicle location and activity using global positioning system data (such as, for example, ISOTRAK and TRACKER).

2.10.2 Changes in personnel in the distribution companies

Several changes in personnel in the distribution companies participating in the project caused delays in data provision at some stages in the project. This also makes continuity very

difficult over a two-year project as each new company representative has to be briefed on the purpose of the project and the nature and timing of their company's input.

It should also be noted that the project team were pleased to be able to encourage more distribution companies to participate in the project than had been originally signed up to it when it began. This helped to extend the range of distribution operations studied in the project from three companies in each urban area to five companies in each. However, this was not budgeted for in the original proposal and resulted in increasing the workload for each activity in the project.

2.10.3 Different units of measures

The seven companies in the project use different units of measures for the goods that they distribute. Some of the companies record the weight of collections and deliveries, while the majority record the number of different items. The different measures of deliveries and collection used by participants include:

- Kilogrammes
- Packages
- Bags
- Cases
- Pallets
- Roll cages
- Loose items

This made comparisons between companies by weight or volume delivered/collected impossible. Instead the only possible means of comparing current operations between companies were:

- By expressing results per vehicle round (but obviously vehicle rounds vary significantly between companies in terms of factors such as distance travelled and time taken);

- By expressing results per collection/delivery (but obviously a collection/delivery made by one company can be very different to a collection/delivery made by another).

For the purposes of comparing the extent to which policy measures are likely to result in changes to the indicators measured, it was decided best to compare totals for all vehicle rounds studied for each company before and after the imposition of the measures (for example, total distance travelled, total time taken, total CO_2 pollutants emitted etc.). Using this approach aided the comparison of results between companies.

3. URBAN AREAS STUDIED IN THE PROJECT

The project has involved collaboration with Birmingham City Council, Hampshire County Council and Norfolk County Council.

The local authorities were responsible for selecting the urban area under their control that they would like to include in the project. Two criteria were used for selecting the urban areas studied in the project:

- Policy and treatment of distribution activity was being reviewed by the local authority;

- The chosen urban areas should exhibit different features in terms of geographical scale and urban form so that it would be possible to study the extent to which similar distribution tasks are operated in similar or different ways in the urban areas.

After consultation with the local authority partners, distribution operations in three urban areas were examined in the project:

- Birmingham;
- Basingstoke;
- Norwich.

3.1 Birmingham

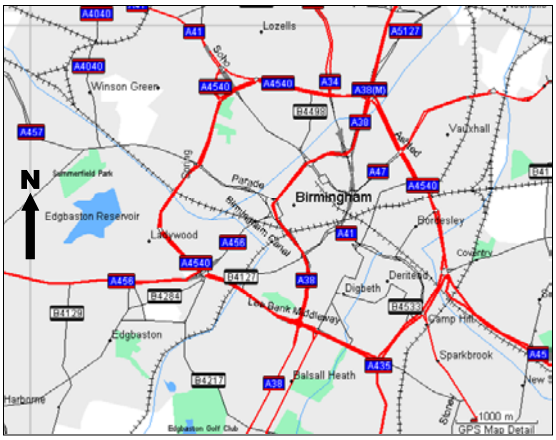
3.1.1 Overview of the urban area

Birmingham is the second largest city in the UK. The city has a population of approximately one million people. It lies within a large manufacturing region, and the service sector within Birmingham and the surrounding region has experienced rapid growth in recent years.

The city is a major retailing centre. In the last couple of years it has been undergoing one of Europe's largest city centre retail regeneration projects (Birmingham City Council, 2000). Developments of several major new leisure complexes have also been taking place within the city.

Figure 3.1 shows a map of Birmingham and its major roads.

Figure 3.1: Birmingham and its major roads



Map generated using Garmin MapSource.

3.1.2 Goods vehicle activity and existing policy measures

Heavy goods vehicles accounted for approximately 5% of all vehicle movements between 07:00 and 18:00 in the Birmingham Cordon Survey in 1999, and 6% in the 2001 survey (this survey uses count points on the middle ring road A4540 which is approximately 1.5 to 2 km from the city centre - Birmingham City Council, 2001).

New Street and several of the streets running off of it in Birmingham city centre are pedestrianised. All vehicles are restricted from entering this area from 10:00 to 18:00. This includes goods vehicles making collections and deliveries. Many of the premises located in these pedestrianised areas have no alternative access facilities so any goods that need to be delivered to or collected from the premises must either take place before 10:00 or after 18:00, or alternatively the vehicle must be parked some way from the premises and the goods conveyed on foot.

Various time restrictions for loading and unloading exist on kerbsides in the Birmingham area, particularly in the city centre.

3.2 Basingstoke

3.2.1 Overview of the urban area

Basingstoke is located in north-east Hampshire, approximately 70 km south-west of London. During the 1960s it was transformed under the Town Development Act 1952 from a small market town into a major industrial and commercial town accommodating some of the London "overspill" (i.e. the excess population that London was struggling to accommodate).

The purpose of this Act was to "encourage town development in county districts for the relief of congestion or over-population elsewhere and for related purposes" (Butler, 1983). Prior to expansion the Town area had a resident population of 17,000 and a relatively small shopping area. The master plan aimed for a population of 76,000 by 1977 and additional employment for 25,000 people in new factories, offices and other services.

The development work in Basingstoke took place from 1962 onwards. This required the development of much new infrastructure including commercial buildings, residential dwellings, roads, car parks, and other services including gas electricity, telephone systems, water and sewage systems, and new schools. A ring road was constructed that encircled the centre of the town at a radius of about three-quarters of a mile and which connected directly to the M3 motorway junction.

The master plan resulted in the redevelopment and expansion of the town centre to provide a multi-level arrangement with an additional 500,000 square feet of shopping area at pedestrian level, and service roads providing vehicle access to shops at a lower level, together with multi-storey car parking for 3,500 cars (i.e. a traffic-free shopping area).

Recent redevelopment of the retail area in the town centre has been taking place during the last two years. This work, which was completed in Autumn 2002, provides more than one million square feet of shopping and leisure space (twice the size of the original shopping centre). It contains 165 shops, 18 restaurants, and many leisure facilities.

By 2001, the Basingstoke Town area had a population of 92,000 (Basingstoke and Deane Borough Council, 2002).

Figure 3.2 shows a map of Basingstoke and its major roads.

Figure 3.2: Basingstoke and its major roads

Map generated using Garmin MapSource.

3.2.2 Goods vehicle activity and existing policy measures

By developing roads at more than one level it was possible to for goods vehicles to access the new town centre shops from underneath. There are several loading and unloading areas that are accessible from the service roads that goods vehicles can enter and then the driver can access the shops directly from these areas. Above at shop level, shoppers walk in traffic free malls, while the shoppers' cars are parked above the shops in car parks.

It was planned that the old town centre should be linked to the new by a scheme to pedestrianise the old town. In 1975 such a scheme was proposed and an exhibition staged at the central library and public meetings held to gauge traders' and the public's reactions. Some traders were concerned about the potentially negative effect of pedestrianisation of their businesses, but the proposals were generally accepted. The area including London Street, Market Place, Winchester Street, Wote Street and Church Street was pedestrianised in March 1976. As a result there is no access to these roads for goods vehicles and other traffic between 10:00 and 16:00. Loop roads and service yards were constructed to enable traffic to be diverted and so that shops and offices on Winchester Street and London Street and the surrounding roads of the old town could be served from the rear. Various time restrictions for loading and unloading exist on kerbsides in the old town.

3.3 Norwich

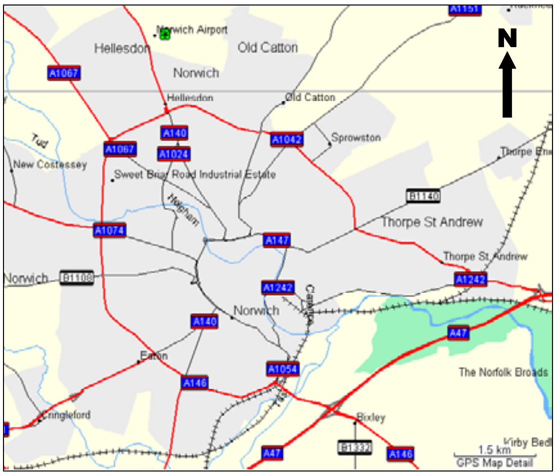
3.3.1 Overview of the urban area

Norwich is a free-standing, historic city. The old walled city is a unique historic resource with the largest and most intact medieval street pattern of any city in the country. The city contains over 1500 listed buildings, 17 Conservation Areas, 32 pre-Reformation churches, a Norman Castle and 2 Cathedrals.

Norwich is the capital of East Anglia. The built up area of Norwich has a population of 195,000 (Norfolk County Council, 2000) As a regional capital the city is both a major commercial centre for various sectors, and also a retail centre. It is the largest shopping area in the region with a shopping catchment population of 500,000. There is approximately two million square feet of retail floorspace in Norwich City centre (Norwich City Council, 2000).

Figure 3.3 shows a map of Norwich and its major roads.

Figure 3.3: Norwich and its major roads



Map generated using Garmin MapSource.

3.3.2 Goods vehicle activity and existing policy measures

Servicing of premises in the city centre is made difficult by the fact that relatively few premises have off-street facilities. In addition, congestion in the city centre makes delivery reliability difficult to achieve.

Only vehicles up to 7.5 tonnes gvw are allowed to operate freely within the outer ring road in Norwich. However heavier vehicles are permitted to enter for delivery and collection purposes.

A pedestrianised area exists at the heart of the city centre. Time restrictions prevent all vehicles (including goods vehicles) from entering this area from 10:00 to 16:00. Many of the premises located in these pedestrianised areas have no alternative access facilities. Any goods deliveries or collections for these premises either take place at the times when vehicles are allowed access or are moved from vehicles parked elsewhere by foot.

Castle Meadow, a major street with shops and offices in the city centre that used to be a key route for vehicles travelling around the city centre, was closed to most road traffic in 1998. Buses and bicycles are still allowed to use the road at all times but all other categories of motorised road vehicle are permanently banned from using the road, except for access to deliver or collect goods.

Various time restrictions for loading and unloading exist on kerbsides in the Norwich area, particularly in the city centre.

4. COMPANIES PARTICIPATING IN THE PROJECT

4.1 Introduction and operating patterns among the companies

Seven logistics and distribution companies that carry out urban collections and deliveries in Birmingham, Basingstoke and Norwich have participated in the project. Four of the companies carry out operations in all three of the urban areas. The other three each only operate in one of the urban areas (with two of these companies operating as sub-contractor to the other).

Figure 4.1 on the next page show the different operational patterns used to deliver and collect goods in the urban areas by the companies participating in the project. Further details about the different vehicle round patterns of local, regional and national distribution operations observed in the project are provided in Table 4.1

Table 4.1: Type of operations and vehicle round patterns observed in the project

Type of operation	Patterns of vehicle round
Urban distribution operation (4 patterns)	• Collections/deliveries wholly within city centre; • Collections/deliveries wholly within rest of urban area (i.e. not in city centre); • Collections/deliveries in city centre and rest of urban area; • Collections/deliveries in urban area and outside urban area.
Regional distribution operation (2 patterns)	• Collections/deliveries wholly within one urban area; • Collections/deliveries in more than one urban area.
National distribution operation (3 patterns)	• Full load delivery for one destination in urban area; • Collections/deliveries wholly within one urban area; • Collections/deliveries in more than one urban area.

Information about the operating pattern used by each company is provided in Table 4.2.

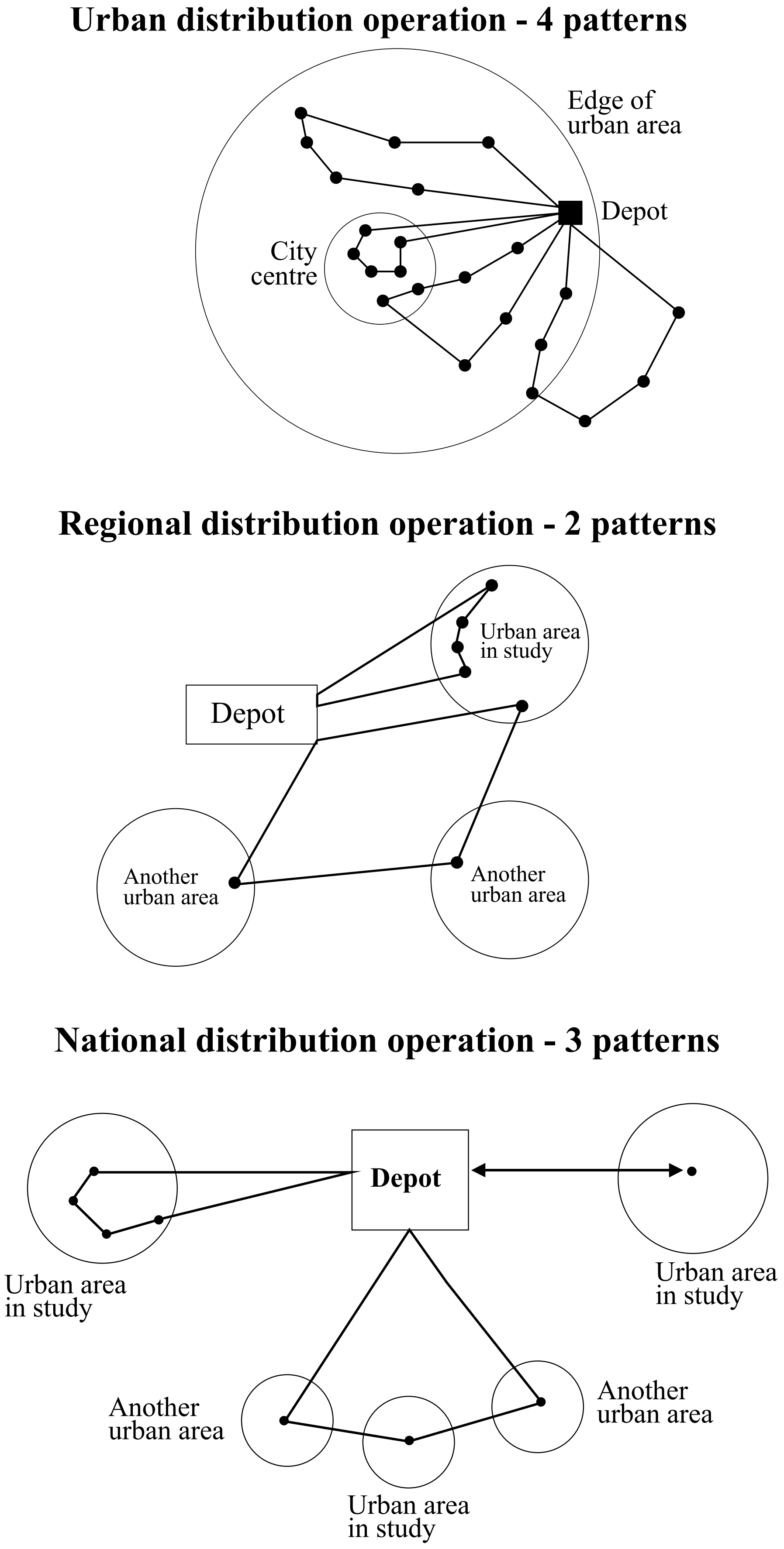
Table 4.2: Type of operations used by participating companies

Type of operation	Companies
Urban distribution operation	Company C, Company F, Company G
Regional distribution operation	Company A, Company E, Company G
National distribution operation	Company B, Company D

Table note: Company G operates an urban distribution operation in Norwich and Birmingham and a regional distribution operation for Basingstoke, and therefore appears twice in the table.

Each companies' distribution operations are explained in detail in sections 4.2 to 4.8.

Figure 4.1: Operating patterns observed in the project



4.2 Company A

A logistics company offering storage and distribution of wines and spirits. It carries out its own delivery operations in Birmingham (from a depot in Leicester) and subcontracts its deliveries in Basingstoke to company 5, and in Norwich to company 3.

Type of logistics/distribution company	**Storage and distribution of wines and spirits**
Deliveries in Birmingham?	Yes – from Leicester depot
Deliveries in Norwich?	No – Use subcontractor (company 3)
Deliveries in Basingstoke?	No – Use subcontractor (company 5)
Type of product delivered	Wines and spirits
Typical quantity of goods for each delivery address	Varies from a single case to full vehicle load.
Types of vehicle used	Vans to articulated vehicles. But mostly rigid vehicles – 7.5, 18 and 23 tonnes gross vehicle weight.
Product conveyed in/unit load	Cases and pallets
Means of conveying goods from vehicle to premises	Combination of forklift, pallet truck, trolley, and by hand.
Description/type of round	Multi-drop delivery operations in the urban areas it serves. Some delivery rounds cover the whole of the Birmingham urban area, while other rounds include deliveries to Birmingham as well as deliveries to other urban areas. The density of deliveries in Birmingham is insufficient for there to be any delivery rounds that take place wholly within the city centre.
Typical time of delivery/collection rounds	Vast majority of deliveries take place between 9am and 5pm. However, deliveries to regional distribution centres can usually take place 24 hours a day.
Days that rounds take place on	Monday to Friday, with a little work on Saturday when needed.
Frequency of delivery rounds in the urban areas studied	Daily delivery rounds to premises in Birmingham.
Is delivery/collection time prearranged?	Tends to offer customers either AM or PM delivery windows rather than an explicit delivery times. However some large customers such as cash and carry outlets and supermarkets insist on specific delivery times.
Types of premises visited on round	Wide range of commercial premises including retail premises, public houses, restaurants, hotels, offices, wholesalers and regional distribution centres. A few deliveries to residential premises.
On- or off-street deliveries at premises?	Both, but more off-street than on-street.
Location of premises visited (city centre/outer urban)	Most deliveries in outer urban area.
Collections as well as deliveries on rounds?	Yes, but deliveries tend to outweigh collections by about 90:10.
Much seasonality in delivery/collection work?	Yes
Means of communication between driver and depot	Contact with drivers is by mobile phone.
Routeing and scheduling software used?	Yes

4.3 Company B

This logistics company provides a dedicated contract distribution operation (storage and distribution) for a major non-food retailer, with shops in many UK towns and cities. Deliveries to Birmingham, Norwich and Basingstoke all take place from a regional distribution centre in Swindon. The shops tend to be located in city centre locations.

Type of logistics/distribution company	**Dedicated distribution operation from national distribution centre for non-food high street retailer**
Deliveries in Birmingham?	Yes – served from Swindon depot
Deliveries in Norwich?	Yes – served from Swindon depot
Deliveries in Basingstoke?	Yes – served from Swindon depot
Type of product delivered	Toys, games, books etc.
Typical quantity of goods for each delivery address	Between 1 pallet and full vehicle load per delivery
Types of vehicle used	Rigid (esp 17 tonne gvw) and articulated vehicles
Product conveyed in/unit load	Pallets
Means of conveying goods from vehicle to premises	Pallet trucks
Description/type of round	Vehicle delivers to urban areas from Swindon distribution centre. Usually only 1-3 deliveries per vehicle round. In some cases delivery addresses on the round are in same urban area, in some cases different urban areas.
Typical time of delivery/collection rounds	Vehicles leave the distribution centre from approximately 4am onwards and tend to make deliveries before 10am
Days that rounds take place on	Delivery rounds take place from depot Monday to Friday. Peak workloads on Monday, Thursday and Friday.
Frequency of delivery rounds in the urban areas studied	Shops in each urban area tend to receive one delivery per week.
Is delivery/collection time prearranged?	Yes
Types of premises visited on round	Shops mostly located in city centre high streets and shopping centres.
On- or off-street deliveries at premises?	Mix of on and off-street. All off-street in urban areas studied.
Location of premises visited (city centre/outer urban)	Mostly city centre, with some shopping centres.
Collections as well as deliveries on rounds?	No – except empties/returns from shops receiving deliveries.
Much seasonality in delivery/collection work?	Yes
Means of communication between driver and depot	Mobile phone
Routeing and scheduling software used?	Yes

4.4 Company C

A company offering general storage and distribution services in the Norwich and wider Norfolk area. It delivers a wide range of product on behalf of its customers. This includes fine wines and spirits delivered on behalf of company A in the Norwich area.

Type of logistics/distribution company	**General storage and distribution services. Mix of direct contracts with goods suppliers and subcontracted work from other distribution companies.**
Deliveries in Birmingham?	No
Deliveries in Norwich?	Yes – from Norwich depot
Deliveries in Basingstoke?	No
Type of product delivered	Very wide range.
Typical size of delivery/consignment size	Wide range: 1 loose item up to several pallets.
Types of vehicle used	Vans, rigid lorries and small number of articulated lorries.
Product conveyed in/unit load	Cases, pallets, and loose items.
Means of conveying goods from vehicle to premises	Fork lift, pallet truck, trolley and by hand.
Description/type of round	Some rounds take place wholly within city centre, some wholly in outer urban area, and some covering both. Most distribution work takes place in Norwich vicinity. The majority of rounds involve multi-drop work.
Typical time of delivery/collection rounds	Deliveries start from approximately 8am onwards. Most delivery rounds completed by early afternoon, but some delivery rounds continue until approximately 5pm.
Days that rounds take place on	Monday to Friday. Very little work on Saturday and Sunday.
Frequency of delivery rounds in the urban areas studied	Many vehicle rounds per day in Norwich.
Is delivery/collection time prearranged?	Not in most cases, but arrangements for some deliveries.
Types of premises visited on round	Wide range of premises including shops, off-licences, restaurants, offices, industrial sites, and warehouses.
On- or off-street deliveries at premises?	On- and off-street.
Location of premises visited (city centre/outer urban)	All over the urban area.
Collections as well as deliveries on rounds?	Some collections take place on delivery rounds, but also separate collection rounds.
Much seasonality in delivery/collection work?	Yes
Means of communication between driver and depot	Mobile phone
Routeing and scheduling software used?	No

4.5 Company D

This logistics company provides a dedicated contract distribution operation (storage and distribution) for a major non-food retailer, with approximately 400 shops in many UK towns and cities. Deliveries to Birmingham, Norwich and Basingstoke all take place from a regional distribution centre in Redditch. Some of the shops are located in city centre high street locations, but the majority of shops are larger and located in the outer urban area, often on retail parks.

Type of logistics/distribution company	**Dedicated distribution operation from national distribution centre for non-food retailer**
Deliveries in Birmingham?	Yes – served from Redditch depot
Deliveries in Norwich?	Yes – served from Redditch depot
Deliveries in Basingstoke?	Yes – served from Redditch depot
Type of product delivered	DIY and leisure goods
Typical quantity of goods for each delivery address	Typically 2-10 roll cages, 1-5 pallets and other large loose items per delivery
Types of vehicle used	Rigid (e.g. 17 tonne gvw) and articulated vehicles
Product conveyed in/unit load	Roll cages, pallets, and others loose items
Means of conveying goods from vehicle to premises	Roll cages, pallet trucks, trolley
Description/type of round	Vehicle delivers to urban areas from Redditch distribution centre. Usually approximately 5 deliveries per vehicle round. In some cases delivery addresses on the round are in same urban area, in some cases different urban areas.
Typical time of delivery/collection rounds	Vehicles leave the distribution centre from approximately 6am onwards and return by early afternoon.
Days that rounds take place on	Delivery rounds take place from depot Monday to Friday.
Frequency of delivery rounds in the urban areas studied	Shops in each urban area tend to receive two deliveries per week.
Is delivery/collection time prearranged?	Yes
Types of premises visited on round	Some shops located in city centres but most are in outer urban area, often on retail parks.
On- or off-street deliveries at premises?	City centre deliveries can be on-street. Outer urban deliveries usually off-street.
Location of premises visited (city centre/outer urban)	Some city centre locations, mostly outer urban retail parks.
Collections as well as deliveries on rounds?	No – empties/returns from shops receiving deliveries.
Much seasonality in delivery/collection work?	Some – especially at bank holidays.
Means of communication between driver and depot	Mobile phone
Routeing and scheduling software used?	Yes

4.6 Company E

A company offering general storage and distribution services in Hampshire (including Basingstoke) and the surrounding counties. It delivers a wide range of product on behalf of its customers. This includes fine wines and spirits delivered on behalf of company A in the Basingstoke area.

Type of logistics/distribution company	**General storage and distribution services. Mix of direct contracts with goods suppliers and subcontracted work from other distribution companies.**
Deliveries in Birmingham?	No
Deliveries in Norwich?	No
Deliveries in Basingstoke?	Yes – from Andover depot
Type of product delivered	Very wide range.
Typical quantity of goods for each delivery address	Wide range: 1 loose item up to several pallets.
Types of vehicle used	Rigid and articulated lorries.
Product conveyed in/unit load	Cases, pallets, and loose items.
Means of conveying goods from vehicle to premises	Fork lift, pallet truck, trolley and by hand.
Description/type of round	All vehicle rounds are multi-drop, usually involved approximately 5-10 deliveries. Most rounds cover a large geographical area involving several towns in Hampshire.
Typical time of delivery/collection rounds	Vehicle rounds usually start from depot at approximately 7.30am. Vehicles often stay out all day making deliveries and collections and return to depot at about 4.30pm.
Days that rounds take place on	Monday to Friday. Very little work on Saturday and Sunday.
Frequency of delivery rounds in the urban areas studied	Only usually 1 vehicle round including Basingstoke per day.
Is delivery/collection time prearranged?	Not in most cases, but arrangements for some deliveries.
Types of premises visited on round	Wide range of premises including shops, off-licences, restaurants, offices, industrial sites and warehouses.
On- or off-street deliveries at premises?	Majority of deliveries take place off-street
Location of premises visited (city centre/outer urban)	All over the urban area.
Collections as well as deliveries on rounds?	Yes – usually at end of round on return to depot
Much seasonality in delivery/collection work?	Yes
Means of communication between driver and depot	Mobile phone
Routeing and scheduling software used?	No

4.7 Company F

Parcels carrier providing collection and delivery services on a national basis in the UK. The company makes deliveries in Birmingham, Basingstoke and Norwich. It has a depot within a few miles of the centre of each of these urban areas.

Type of logistics/distribution company	Parcels carrier
Deliveries in Birmingham?	Yes – from Birmingham depot
Deliveries in Norwich?	Yes – from Norwich depot
Deliveries in Basingstoke?	Yes – from Basingstoke depot
Type of product delivered	Wide range of products but unknown to carrier.
Typical quantity of goods for each delivery address	Ranges from 1 parcel to 100 parcels. Most deliveries between 1 and 10 parcels.
Types of vehicle used	Mostly 3.5 – 7.5 tonne gross vehicle weight (i.e. vans and small lorries)
Product conveyed in/unit load	Mostly parcels. Also bags and some larger packaged items.
Means of conveying goods from vehicle to premises	By trolley and by hand.
Description/type of round	Some rounds take place wholly within city centre, some wholly in outer urban area, and some covering both. Total distance on many rounds tends to be relatively low due to depot locations and density of drops. Deliveries to several addresses often made without moving the vehicle, especially in city centre. All rounds are multi-drop with as many as 100 deliveries/collections on some rounds.
Typical time of delivery/collection rounds	Delivery rounds tend to take place between
Days that rounds take place on	Mostly Monday to Friday. Small amount of work on Saturday.
Frequency of delivery rounds in the urban areas studied	Many vehicle rounds every day.
Is delivery/collection time prearranged?	No – but try to make deliveries at approximately same time to receivers. Deliveries tend to take place between approximately 08.30 and 12.30, collections take place between 14.30 and 18:00 (i.e. all work takes place during the working day).
Types of premises visited on round	Virtually all types of premises in the urban area, including some residential deliveries.
On- or off-street deliveries at premises?	Both
Location of premises visited (city centre/outer urban)	Entire urban area covered by rounds from the depots.
Collections as well as deliveries on rounds?	Some rounds comprise only deliveries, some round comprise only collections, while some rounds include both.
Much seasonality in delivery/collection work?	Yes – especially at Easter and Christmas.
Means of communication between driver and depot	Mobile phone.
Routeing and scheduling software used?	No

4.8 Company G

This company is involved in the storage and delivery of beer and other drinks. The company makes deliveries in Birmingham, Basingstoke and Norwich. Birmingham and Norwich are served by depots based on the outskirts of the cities, while Basingstoke is served by a depot in Southampton. Vehicles are usually sent out with two-person crews. The weight of the product delivered is a constraint in planning the rounds.

Type of logistics/distribution company	**Storage and delivery of beers and other drinks from either local or regional distribution centres.**
Deliveries in Birmingham?	Yes, from depot in Birmingham
Deliveries in Norwich?	Yes, from depot in Norwich
Deliveries in Basingstoke?	Yes, from depot in Southampton
Type of product delivered	Delivery of beer and other drinks.
Typical quantity of goods for each delivery address	Deliveries between approx.100 kg up to a full vehicle load. Often 500kg to 3000 kg.
Types of vehicle used	5, 10 and 23 tonne gvw
Product conveyed in/unit load	Barrels, kegs, crates and cases
Means of conveying goods from vehicle to premises	By trolley, by hand.
Description/type of round	Multi-drop rounds usually involving 2 to 15 deliveries per round. Birmingham and Norwich are served from local depots in the urban area. Basingstoke is served by from a regional depot based in Southampton.
Typical time of delivery/collection rounds	Vehicle rounds usually start from depots at approximately 5.30am onwards. Most rounds commence AM, with some starting early PM. Vehicles on short rounds may only take a few hours, while other vehicles stay out all day making deliveries and return to depot by about 4.30pm.
Days that rounds take place on	Mostly Monday to Friday.
Frequency of delivery rounds in the urban areas studied	Several rounds per day in each urban area.
Is delivery/collection time prearranged?	Yes – time window for delivery.
Types of premises visited on round	Public houses, night clubs, off-licences, restaurants, industrial premises
On- or off-street deliveries at premises?	Both
Location of premises visited (city centre/outer urban)	All over the urban area
Collections as well as deliveries on rounds?	No – except for empties.
Much seasonality in delivery/collection work?	Yes.
Means of communication between driver and depot	Mobile phone.
Routeing and scheduling software used?	Yes.

5. ANALYSIS OF CURRENT OPERATIONS

5.1 Comparison of results by company

Table 5.1 contains information about all the current vehicle rounds studied in each of the companies. In total, 120 vehicle rounds were studied. A total of 2286 collections and deliveries were made on these rounds. The analysis presented in sections 5.1.1 to 5.1.4 is based on the analysis of all vehicle rounds studied at each company.

Table 5.1: Information about all vehicle rounds studied by company

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds studied	8	5	12	5	4	41	45
Total coll'ns & deliveries on rounds studied	64	8	212	21	28	1803	150
Weight of vehicles on rounds (gross weight in tonnes)	7.5/18/23	17 & 32	3.5/7.5/12	32/35/38	7.5 & 17	3.5/6.5/7.5	5/10/23
Earliest start time of round	04:16	03:30	07:40	04:35	07:26	07:55	05:07
Latest start time of round	08:55	06:45	12:45	07:15	14:55	14:20	14:07
Earliest finish time of round	13:55	11:15	09:45	12:10	14:26	10:34	07:11
Latest finish time of round	17:50	17:30	17:45	19:30	16:37	18:25	16:29

As can be seen from table 5.1, the total number of vehicle rounds studied varied between companies. For those companies that performed a relatively small number of vehicle rounds in the three urban areas over the three-day study period it was possible to capture data about all these rounds. However, in the case of companies that performed many rounds in the three urban areas each day it was necessary to study only a sample of these rounds. These companies selected rounds that were representative of the total vehicle rounds performed.

The mix of vehicle weights operated by companies also varied widely depending on the nature of the distribution operation.

5.1.1 Analysis of time taken and collections/deliveries by company

Table 5.2 contains analysis of the average number of collections and/or deliveries per vehicle round, the time taken per round by company, and the time taken for deliveries and collections. As can be seen the average number of collections and/or deliveries vary significantly between companies. This is related to the distribution operations of the companies. As would be expected, the parcels carrier (company F) has a far higher average than the other companies. By contrast, the two companies involved in dedicated distribution operations from a single national distribution centre for retailers (companies B and D) have, on average, only 2 and 4 deliveries per round, while the company delivering beers and other drinks (company G) has, on average, only 3 deliveries per round. These companies are delivering far more product (in terms of weight and volume) at each delivery point than company F.

It should be noted that our definition of a "vehicle round" refers to any trip or series of linked trips by a vehicle from a depot to make collections and/or deliveries, which then returns to the depot, regardless of whether that vehicle round consists of 1 or 100 collections and/or deliveries.

Our definition of a "delivery" is every address at which goods are delivered by a driver. A "collection" is every address from which goods are collected by a driver. The quantity of goods delivered or collected at each address can obviously vary. If a driver parks a vehicle and then makes deliveries to four different addresses without moving the vehicle between

each delivery, this is counted as four deliveries. Deliveries (and collections) obviously vary substantially in terms of the quantity of goods delivered at each address.

The vehicle rounds studied in the project consist of far more deliveries than collections (1916 deliveries compared with 317 collections), as most of the companies are primarily involved in the delivery of goods rather than the collection of goods in the urban areas studied.

The average time taken per vehicle round refers to elapsed time between when the vehicle departs the depot and then returns to the depot after making all its collections/deliveries. The average time per round differs substantially between companies. During data capture we subdivided the time taken per round into two categories:

- Driving time – time when the vehicle is being driven between the depot and all the collection/delivery points;
- Stationary time – time when the vehicle is parked while the driver is making collections or deliveries, or when the driver is taking a rest break.

Table 5.2 shows the proportion of total time per round accounted for by driving time and stationary time. The results reflect that the companies delivering goods over quite long distances to relatively few delivery points (i.e. companies A, B, D and E) tend to spend the majority of their time driving. Meanwhile vehicle involved in many local deliveries (i.e. company E) or delivering heavy products (company G) spend a greater proportion of their time stationary while the driver makes deliveries.

The average time taken per delivery (i.e. the time it takes the driver to take the goods to each delivery point and then return to the vehicle and commence driving again) various widely between companies. This is reflection of the type and quantity of products delivered by each company.

Table 5.2: Analysis of time taken and collections/deliveries by company

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Average no. of coll'ns/ deliveries per round	8	2	18	4	7	44	3
Average time taken per round (mins)	553	548	247	592	376	276	157
Ave driving time as % of total round time	68%	65%	53%	68%	69%	41%	38%
Ave stationary time as % of total round time	32%	35%	47%	32%	31%	59%	62%
Ave time taken per delivery (mins)	17	111	7	36	15	3	45
Ave time taken per collection (mins)	8	n/a	9	n/a	n/a	6	n/a
Coll'ns/deliveries on-street (% of total)	Not available	0%	41%	10%	14%	58%	Not available
Coll'ns/deliveries off-street (% of total)	Not available	100%	59%	90%	86%	42%	Not available

Table notes:
"n/a" - Average time taken per collection not applicable as only deliveries made on these companies' rounds.

Table 5.2 also shows the proportion of total collections and deliveries that take place on-street (i.e. the vehicle is parked on a public road) compared with off-street (i.e. the vehicle is parked in a private parking area, a private loading bay or a private shopping centre loading area). The

results reflect that the parcel carrier is the only company with a greater proportion of collections/deliveries in which the vehicle is parked on-street rather than off-street.

5.1.2 Analysis of distance travelled and vehicle speed by company

Table 5.3 contains analysis of the average distance travelled expressed in two ways: (i) per vehicle round, and (ii) per collection/delivery. The distance travelled per round varies between companies depending on:

- The distance between the depot at which the vehicle is based and the urban areas;
- The distance between the collection/delivery addresses on the vehicle round.

Companies operating from a single national distribution centre (companies B and D) or a regional distribution centre (companies A and E) can be seen to have far longer average distances per vehicle round than the other companies.

The average distance travelled per collection/delivery in Table 5.3 reflects the density of addresses served on the vehicle round. This is well illustrated in the case of companies B, C and D. All three companies have similar average distances per vehicle round. However, company G has a far higher average distance per collection/delivery due to the lower delivery density on its rounds, and hence the greater distance between addresses served.

In table 5.3, average speed per vehicle round has been expressed in two ways:

- Average speed per round excluding stops – this is the average speed of the vehicle while it is driving;
- Average speed per round including stops – this is the average speed of the vehicle taking into account the time it spends stationary making deliveries/collections and during rest breaks as well as while driving. This speed is therefore less than the average speed excluding stops.

The average speed excluding stops achieved by the companies varies depending on the geography of the vehicle rounds and hence the types of roads used. For companies C and F with depots and virtually all collections/deliveries in the urban area, their average speed is far lower than companies using motorways and "A" roads outside the urban area on the round.

The average speed including stops can be seen far lower than the speed excluding stops. This is explained by the total amount of time spent making collections/deliveries on a round, which varied between companies (see average time spent stationary per round in Table 5.2).

Table 5.3: Analysis of distance travelled and vehicle speed by company

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Average distance travelled per round (km)	285	371	41	361	208	46	45
Average distance travelled per coll'n/delivery (km)	37	279	3	87	30	1	23
Ave speed per round (excl. stops) km/hour	46	60	21	50	53	23	45
Ave speed per round (incl. Stops) km/hour	31	39	11	34	36	9	18

5.1.3 Analysis of vehicle fill and vehicle time utilisation by company

Table 5.4 contains analysis of vehicle fill and time utilisation. Vehicle fill refers to how full the vehicle was when it departed from the depot on a delivery round. Some of the companies

vehicle fill has been measured by weight while others have been measured by volume, depending on the most appropriate measure for each company. Collection rounds on which the vehicle depart from the depot empty were omitted from this analysis.

The time utilisation of the vehicles refers to how the vehicles examined over the 72-hour study period were used. Three categories of use were applied to the vehicles:

- Time spent idle and empty at home depot;
- Time spent away from depot on collection or delivery;
- Time spent (un)loading or waiting at depot, or rest period.

Therefore, the three rows dealing with "average vehicle utilisation" in Table 5.4 should be studied jointly. Together they sum to 100%, thereby reflecting how the vehicles' time was spread across these three categories during the study period.

Table 5.4: Analysis of vehicle fill and vehicle time utilisation by company

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Ave vehicle utilisation: time idle (empty) at home depot	Not available	22%	51%	58%	31%	55%	Not available
Ave vehicle utilisation: time vehicle out on coll'n/delivery	Not available	35%	34%	38%	40%	36%	Not available
Ave vehicle utilisation: time (un)loading or waiting at depot, or rest period	Not available	43%	15%	4%	29%	9%	Not available
Average vehicle fill at start of round (%)*	Not available	79%	61%	74%	43%	63%	61%

Table notes:
** - Vehicle fill measured in either volume or weight depending on measurement appropriate to company. Collection rounds excluded from this analysis.*
Not available – data unavailable.

5.1.4 Analysis of vehicle operating costs by company

Table 5.5 contains analysis of the average cost of performing: (i) vehicle rounds, and (ii) each collection/delivery by company. It should be noted that these costs are not actual vehicle operating costs supplied by the companies. Instead industry standard vehicle operating costs were calculated for each vehicle type (see section 2.4.1).

As would be expected the average cost per vehicle round varies substantially between companies depending on the size of vehicle, duration and distance involved. Similarly, the average cost per delivery/collection also ranges widely between companies, based on the number of collections and deliveries per round.

It is important to bear in mind that the quantity of goods delivered in each delivery by companies B, D and G is far greater than for instance companies C and F.

Table 5.5: Analysis of vehicle operating costs by company

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Average operating cost per round (£)	200.65	274.33	62.17	344.97	136.53	65.01	93.54
Average operating cost per coll'n/delivery (£)	25.86	207.77	4.28	82.54	18.56	1.75	45.77

5.2 Comparison of results in the three urban areas by company

Four of the seven companies that participated in the study operated in all three of the urban areas (companies B, D, F and G). Therefore in the case of these companies it was possible to provide separate results for their operations in Basingstoke, Birmingham and Norwich.

Tables 5.6 to 5.9 contain analysis of a selection of the items presented in section 5.1. Each table comprises the results for all vehicle rounds carried out by the company in the first column (i.e. the same results as presented in section 5.1), followed by the results for Basingstoke, Birmingham and Norwich vehicle rounds. Some companies performed a small number of rounds in each urban area during the 72-hour study period, this is shown in the tables.

As explained in section 5.1, it is important to note that not all vehicle activity took place within the three urban areas studied. Some vehicle rounds including collections and/or deliveries outside the study areas. Also, in the case of companies without depots located in the three study areas, the distance travelled between the depot and the study area did not by definition take place within the urban area. The results presented in Tables 5.6 to 5.9 comprise the entire vehicle round, including the collections/deliveries and distance travelled outside Basingstoke, Birmingham and Norwich.

Table 5.6: Current results for company B

	All rounds	Basingstoke	Birmingham	Norwich
Total number of rounds studied	5	1	3	1
Total coll'ns & deliveries on rounds studied	8	2	5	1
Average no. of coll'ns/ deliveries per round	2	2	2	1
Average vehicle fill at start of round (%)	79%	100%	70%	86%
Average time taken per round (mins)	548	385	505	840
Ave driving time as % of total round time	65%	70%	63%	67%
Ave stationary time as % of total round time	35%	30%	37%	33%
Ave speed per round (excl. stops) km/hour	60	50	61	70
Ave speed per round (incl. Stops) km/hour	39	35	38	47
Ave time taken per delivery (mins)	111	58	103	185
Ave time taken per collection (mins)	n/a	n/a	n/a	n/a
Average distance travelled per round (km)	371	227	323	661
Average distance travelled per coll'n/delivery (km)	279	114	207	661
Average operating cost per round (£)	274.33	146.19	226.76	545.18
Average operating cost per coll'n/delivery (£)	207.77	73.09	140.19	545.18

Table note:
"n/a" - Average time taken per collection not applicable as only deliveries made on these rounds.

The results for company B are presented in Table 5.6. Company B makes weekly deliveries to retail outlets. This explains the limited number of rounds captured during the study period. The difference in the time taken per round for the three urban areas is explained by the fact that all vehicle rounds are made from a single national depot.

Table 5.7 contains the results for company D. This company is similar to company B in that it carries out dedicated vehicle rounds to all three urban areas from a single distribution centre. The company make twice-weekly deliveries to retail outlets.

Table 5.7: Current results for company D

	All rounds	Basingstoke	Birmingham	Norwich
Total number of rounds studied	5	2	2	1
Total coll'ns & deliveries on rounds studied	21	8	8	5
Average no. of coll'ns/ deliveries per round	4	4	4	5
Average vehicle fill at start of round (%)	74%	70%	78%	78%
Average time taken per round (mins)	592	763	318	800
Ave driving time as % of total round time	68%	72%	62%	74%
Ave stationary time as % of total round time	32%	28%	38%	26%
Ave speed per round (excl. stops) km/hour	50	54	42	56
Ave speed per round (incl. Stops) km/hour	34	39	26	42
Ave time taken per delivery (mins)	36	43	32	33
Ave time taken per collection (mins)	n/a	n/a	n/a	n/a
Average distance travelled per round (km)	361	490	136	555
Average distance travelled per coll'n/delivery (km)	87	122	38	111
Average operating cost per round (£)	344.97	454.25	162.77	490.82
Average operating cost per coll'n/delivery (£)	82.54	113.56	43.71	98.16

Table note:
"n/a" - Average time taken per collection not applicable as only deliveries made on these rounds.

Table 5.8 shows the results by urban area for the parcels carrier (company F). The higher cost per collection/delivery is explained by the fact that the vehicle fleet at the Birmingham depot includes heavier vehicles than at the other depots. Travel speeds (excluding stops) can be seen to be higher in Basingstoke than in Birmingham and Norwich. This is due to the easier traffic conditions (both in terms of traffic levels and access to the centre of Basingstoke).

Collections take approximately twice as long as deliveries. This is due to the fact that more administration is involved and customers do not always have goods ready for despatch when the driver arrives.

Basingstoke vehicle rounds have a greater average distance than rounds in Birmingham and Norwich. This is due to the fact that Basingstoke has a smaller population and is less built-up, both of which result in greater distances between delivery points.

There is a far greater proportion of deliveries and collections during which the vehicle is parked off-street or in a shopping centre in Basingstoke than in the other two urban areas. This reflects the more recent development of Basingstoke (with the explicit aim of designing covered, segregated underground delivery areas for servicing the majority of retailers in the town centre) plus the lower density of development (which has allowed a greater proportion of premises to have off-street parking areas).

Table 5.8: Current results for company F

	All rounds	Basingstoke	Birmingham	Norwich
Total number of rounds studied	41	9	17	15
Total coll'ns & deliveries on rounds studied	1803	339	819	645
Average no. of coll'ns/ deliveries per round	44	38	48	43
Average vehicle fill at start of round (%)	63%	49%	62%	71%
Average time taken per round (mins)	276	280	294	253
Ave driving time as % of total round time	41%	40%	43%	39%
Ave stationary time as % of total round time	59%	60%	57%	61%
Ave speed per round (excl. stops) km/hour	23	31	20	21
Ave speed per round (incl. Stops) km/hour	9	13	9	8
Ave time taken per delivery (mins)	3	3	3	3
Ave time taken per collection (mins)	6	5	6	7
Coll'ns/deliveries on-street (% of total)	58%	62%	70%	28%
Coll'ns/deliveries off-street (% of total)	34%	33%	27%	50%
Coll'ns/deliveries in shopping centre (% of total	8%	5%	3%	22%
Average distance travelled per round (km)	46	72	43	32
Average distance travelled per coll'n/delivery (km)	1	2	1	1
Average operating cost per round (£)	65.01	65.43	71.89	56.96
Average operating cost per coll'n/delivery (£)	1.75	1.75	2.04	1.41

Table 5.9 shows the results for the distribution company delivering beers and other drinks (company G). Basingstoke is served by a depot located approximately 50 kilometres away, while Birmingham and Norwich are served by local depots located within the urban area. This explains the greater average distance travelled per round and per delivery in Basingstoke. It also explains the higher average speed achieved on Basingstoke rounds, as the vehicle is using faster categories of road (i.e. motorway and "A" roads).

The time taken per delivery is greatest in Birmingham. This is explained by the fact that Birmingham vehicle rounds involve a greater average size of delivery than Basingstoke and Norwich. This is reflected in the greater average cost of delivery in Birmingham.

Table 5.9: Current results for company G

	All rounds	Basingstoke	Birmingham	Norwich
Total number of rounds studied	45	4	27	14
Total coll'ns & deliveries on rounds studied	150	20	75	55
Average no. of coll'ns/ deliveries per round	3	5	3	4
Average vehicle fill at start of round (%)	61%	67%	72%	34%
Average time taken per round (mins)	157	218	169	117
Ave driving time as % of total round time	38%	59%	37%	34%
Ave stationary time as % of total round time	62%	41%	63%	66%
Ave speed per round (excl. stops) km/hour	45	65	48	33
Ave speed per round (incl. Stops) km/hour	18	39	18	11
Ave time taken per delivery (mins)	45	22	57	29
Ave time taken per collection (mins)	n/a	n/a	n/a	n/a
Average distance travelled per round (km)	45	132	43	23
Average distance travelled per coll'n/delivery (km)	23	43	27	8
Average operating cost per round (£)	93.54	161.46	98.15	65.22
Average operating cost per coll'n/delivery (£)	45.77	46.81	56.38	25.01

Table note:
"n/a" - Average time taken per collection not applicable as only deliveries on these rounds.

5.3 Geographical coverage of the rounds studied

We also analysed each companies' vehicle rounds in terms of their geographical coverage within each of the three urban areas. This was necessary as some of the companies' vehicle rounds visit the city centre while other companies' rounds only visit the outskirts of the urban area.

We therefore defined three geographical areas within each of the three urban areas studied. We referred to these areas in the following ways:

- Inner area;
- Outer area;
- Elsewhere in urban area (i.e. urban area beyond the inner and outer area).

The coverage of these geographical areas differ in each urban area studied. Our definition of these geographical areas in Birmingham, Basingstoke and Norwich are shown in Table 5.10.

Table 5.10: Definition of the geographical areas

	Definition of geographical coverage
Birmingham	
Inner area	Area within the inner ring road (which encloses the city centre).
Outer area	Area between the inner ring road and the middle ring road (A4540 – approx. 1.5 to 2 km from city centre).
Elsewhere in urban area	Urban area outside the middle ring road (A4540).
Norwich	
Inner area	Area within the inner ring road (A147 which encloses the city centre).
Outer area	Area between the inner ring road (A147) and the outer ring road (A140/A1042 – approx. 2 to 3 km from city centre).
Elsewhere in urban area	Urban area outside the outer ring road (A140/A1042).
Basingstoke	
Inner area	Area within the ringway (A30/A339/A340 which encloses an area of approx. 2.5 km from the town centre).
Outer area	Industrial and commercial area which lies 500m around the outside of the ringway (this is not shown in Figure 5.3).
Elsewhere in urban area	Urban area outside the outer area defined above.

Figures 5.1 to 5.3 show the inner and outer areas we have defined for Birmingham and Norwich and the inner area for Basingstoke. These inner and outer areas are used for the analysis of policy measures reported in Chapters 6 to 11.

Figure 5.1: Birmingham inner and outer areas

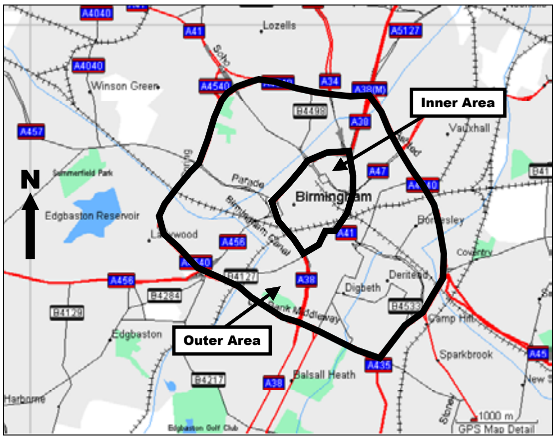


Figure 5.2: Norwich inner and outer areas

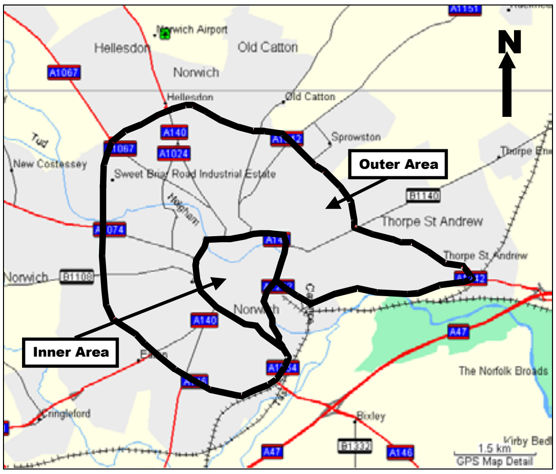
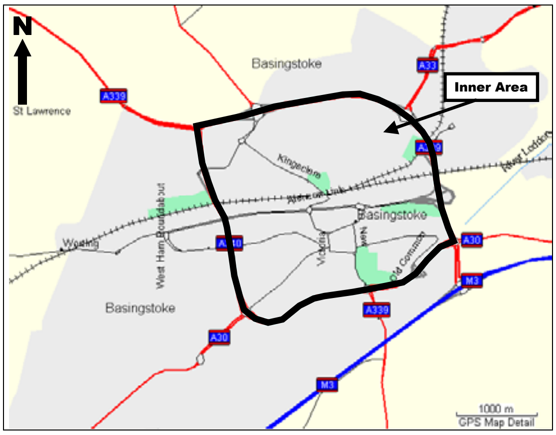


Figure 5.3: Basingstoke inner area



Maps generated using Garmin MapSource.

Table 5.11 shows the total number of rounds performed by each company in each of these geographical areas in the study.

Table 5.11: Number of vehicle rounds performed in each geographical area by company (by location of delivery/collection addresses)

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Birmingham							
Inner area	0	1	n/a	0	n/a	10	9
Outer area	2	2	n/a	2	n/a	7	8
Inner and outer area	0	0	n/a	0	n/a	0	10
Elsewhere in urban area	6	0	n/a	0	n/a	0	0
Norwich							
Inner area	n/a	1	1	0	n/a	12	7
Outer area	n/a	0	6	0	n/a	2	4
Inner and outer area	n/a	0	5	1	n/a	1	3
Elsewhere in urban area	n/a	0	0	0	n/a	0	0
Basingstoke							
Inner area	n/a	1	n/a	2	2	6	2
Outer area	n/a	0	n/a	0	0	1	0
Inner and outer area	n/a	0	n/a	0	0	2	2
Elsewhere in urban area	n/a	0	n/a	0	2	0	0
TOTAL ROUNDS	8	5	12	5	4	41	45

Table notes:
"n/a" – not applicable as company does not operate in this urban area.

Geographical information about a sample of the vehicle rounds, including routeings, was captured using a Garmin GPS (global positioning system). This information was also used to verify speed and timing data captured by other means.

Four examples of vehicle rounds recorded using the GPS and plotted on maps generated by Garmin MapSource are shown in Figures 5.4 to 5.7.

Figure 5.4: Vehicle round carried out by company C in Norwich

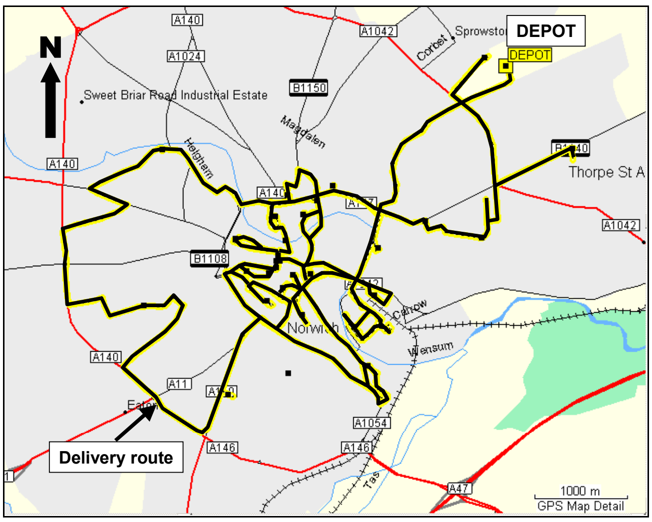


Figure 5.5: Vehicle round carried out by company F in Birmingham

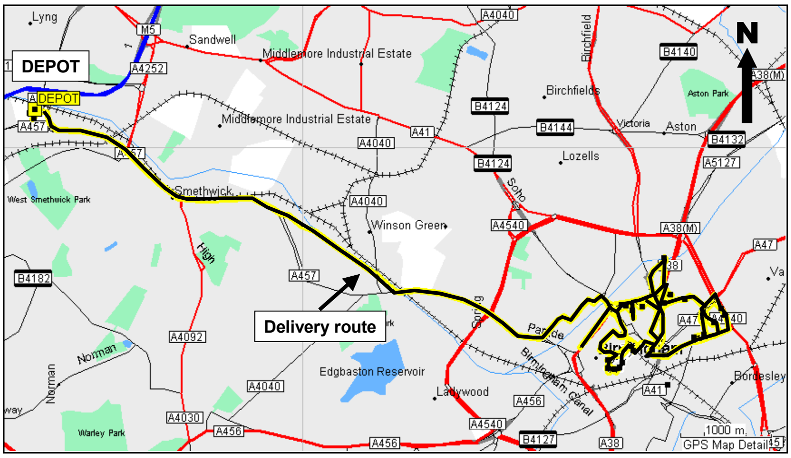


Figure 5.6: Vehicle round carried out by company E in Basingstoke and surrounding area

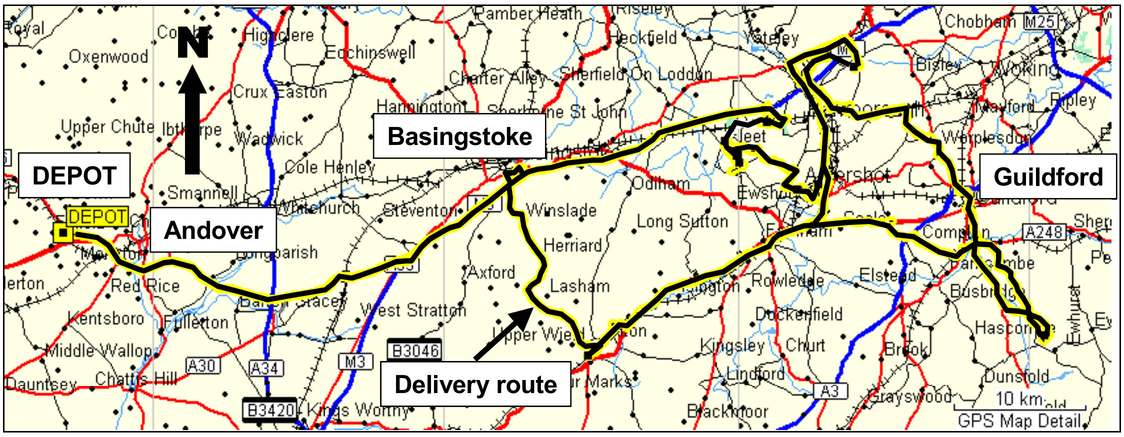
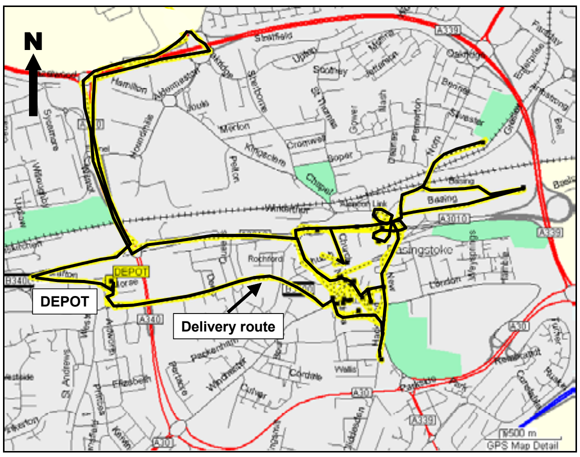


Figure 5.7 Vehicle round carried out by company F in Basingstoke



Maps generated using Garmin MapSource.

6. ANALYSIS OF POLICY MEASURES

6.1 Introduction

Section 2.7 has explained the process by which the policy measures analysed in detail in the project were selected. The four policy measures considered in detail in the project were:

- Low Emission Zones;
- Congestion charging;
- Vehicle weight restrictions;
- Vehicle access time restrictions.

The same four policy measures were analysed in each of the three urban areas.

Scenarios for each measure were applied to two geographical areas in Birmingham, Basingstoke and Norwich: (i) the inner area, and (ii) the inner and outer area (see section 5.3 for a definition of the inner and outer area in each location).

Figure 6.1 shows the relationship between data items in the database used for producing indicators before and after the application of policy measures and company initiatives.

Each policy measure is presented in a separate chapter (chapters 7 to 10). The following is provided in each chapter for the policy measure analysed:

- explanation of the policy measure;
- discussion of the policy measure;
- the specific scenarios tested for each policy measure;
- assumptions made in modelling the policy measure;
- the results of the modelling.

The indicators used to reflect the effect of these policy measures (and various scenarios for each measure) on the sustainability of the companies' vehicle rounds are shown in Table 6.1, together with an explanation.

Table 6.1: Indicators used to reflect sustainability of distribution operations as a result of introduction of policy measures

Indicator	Explanation of indicator
Operational indicators	
Number of rounds	The total number of vehicle rounds operated to make all the collections/deliveries before and after the introduction of the policy measure.
Number of rounds affected	The number of vehicle rounds affected by the policy measure compared with the total number of vehicle rounds operated.
Total time taken	The total amount of time taken to carry out all vehicle rounds before and after the introduction of the policy measure (shown as a % change)
Original driving time as % of total time taken, and New driving time as % of total time taken	Driving time as a proportion of total time taken on vehicle rounds before and after the introduction of the policy measure. (Driving time - time that the vehicle is being driven between the depot and all the collection/delivery points).
Original stationary time as % of total time taken, and New stationary time as % of total time taken	Stationary time as a proportion of total time taken on vehicle rounds before and after the introduction of the policy measure (Stationary time - time that the vehicle is parked while the driver is making collections or deliveries, or when the driver is taking a rest break).
Speed per round (excluding stops)	Average speed of vehicle rounds (when vehicle is being driven) before and after the introduction of the policy measure (shown as a % change).
Speed per round (including stops)	Average speed of vehicle rounds (including stationary time) before and after the introduction of the policy measure (shown as a % change).
Distance travelled	Total distance travelled on vehicle rounds before and after the introduction of the policy measure (shown as a % change).
Financial indicators	
Vehicle operating costs to distribution company of the vehicle rounds	Total operating cost of vehicle rounds before and after the introduction of the policy measure (shown as a % change).
Environmental indicators	
Total CO emissions	Total pollutant emissions on vehicle rounds before and after the introduction of the policy measure (shown as a % change).
Total CO_2 emissions	
Total NO_x emissions	
Total PM10 emissions	

The analysis compares the vehicle rounds that companies currently operate with the operations they would be likely to carry out after the implementation of a policy measure. Some of the indicators provided in tables in chapters 7 to 10 are expressed in absolute terms (showing the current result and the result after application of the policy measure). The other indicators are expressed in terms of percentage difference between the current situation and the situation after the application of the policy measure. For example, +30% distance travelled, means that the distance travelled by vehicles on delivery and collection rounds after the application of a policy measure is 30% greater than the distance travelled currently travelled (i.e. prior to the measure). Any indicator that does not change as a result of a policy scenario is shown as “n/c” (i.e. no change) in the results tables.

For any given policy measure only some aspects of the vehicle rounds are affected and hence only some of the indicators are affected. Table 6.2 shows for each policy measure whether or not an indicator is affected by the measure (based on whether or not the vehicle rounds performed by the companies are affected). The abbreviations used for the indicators in Table 6.2 are the same as those used in chapters 7 to 10.

Table 6.2: Effect of policy measures on the indicators

Indicator	Policy scenarios					
	Low Emission Zone	Congestion charging – no effect on driving time	Congestion charging – reductions in driving time	Weight restrictions	Time restrictions – two hour window for vehicle rounds	Time restrictions – vehicle rounds at night
Total number of rounds	X	X	X	✓	✓	X
Total time taken	X	X	✓	✓	✓	✓
Driving time as % of total	X	X	✓	✓	✓	✓
Stationary time as % of total	X	X	✓	✓	✓	✓
Speed per round (incl. Stops)	X	X	✓	X	X	✓
Speed per round (excl. stops)	X	X	✓	X	X	✓
Total distance travelled	X	X	X	✓	✓	X
Total vehicle operating costs	✓	✓	✓	✓	✓	✓
Total CO emissions	✓	X	✓	✓	✓	✓
Total CO_2 emissions	✓	X	✓	✓	✓	✓
Total NOx emissions	✓	X	✓	✓	✓	✓
Total PM10 emissions	✓	X	✓	✓	✓	✓

Table notes:
✓ - policy scenario has effect on indicator
X - policy scenario has no effect on indicator

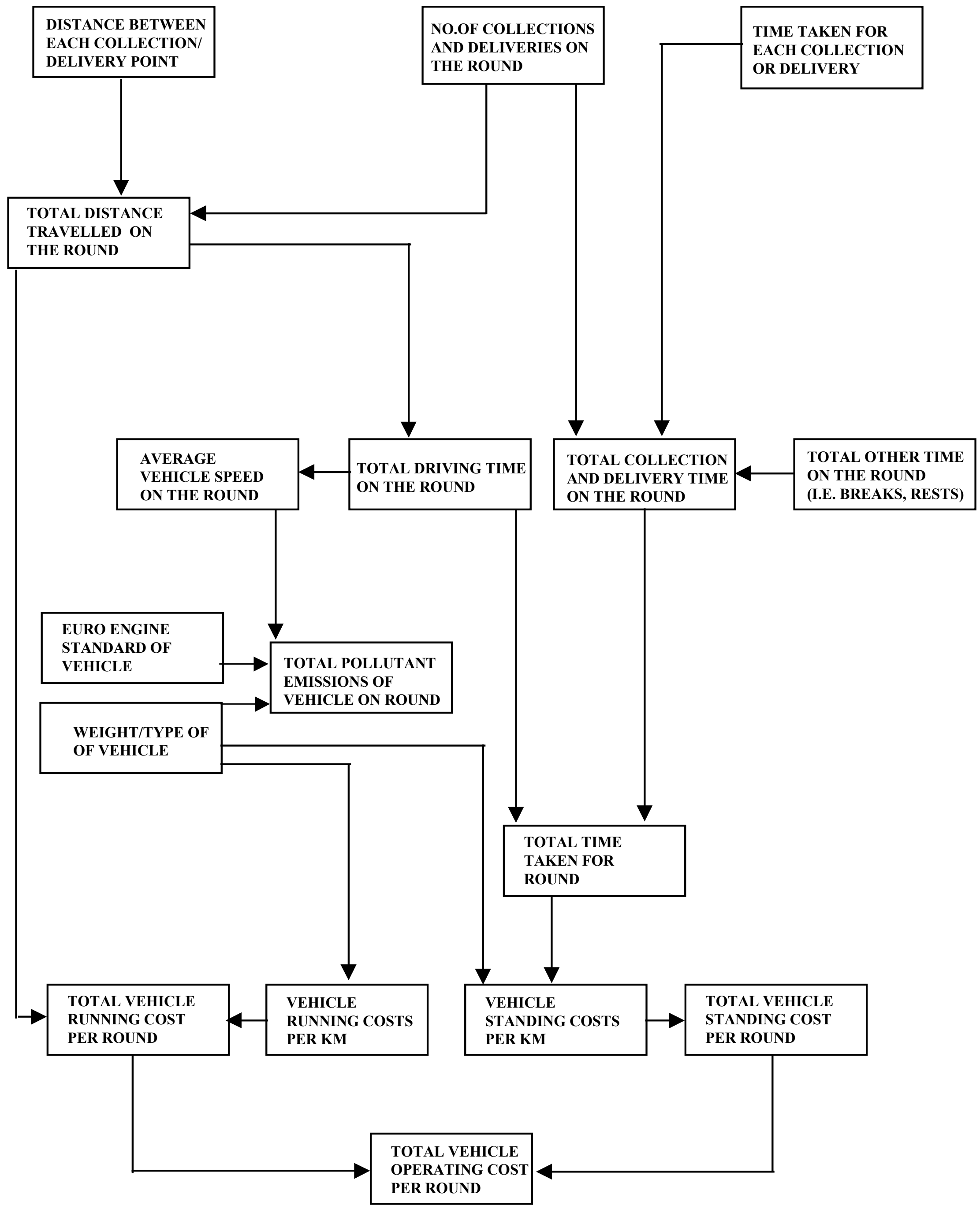
In the tables containing the results presented in chapters 7 to 10, any indicator that is not subject to change when a policy measure is implemented is shown in grey (i.e. all the indicators with crosses against them in Table 6.2).

In chapters 7 to 10, two results tables are presented for each scenario analysed (and several scenarios are analysed for each policy measure). The first results table shows the results for all vehicle rounds operated by each company. The second table shows the results by urban area irrespective of company. It should be noted that the analysis is based on all the vehicle rounds performed by five of the companies in the three urban areas during the 72-hour study period, and a representative sample of the rounds performed by two of the companies.

Appendix 6 contains results tables for the four companies that operate in all three urban areas (companies B, D, F and G). These tables show the results in each urban area for each of these four companies.

In examining the results in chapters 7 to 10, it is important to bear in mind that each scenario for the four policy measures has only been applied to a vehicle round if that vehicle round will be affected. Therefore, for any company participating in the study, this means that either none, some or all rounds can be affected by any given scenario.

Figure 6.1: Relationships between data in the database



7. ANALYSIS OF LOW EMISSION ZONES

7.1 Explanation of the Low Emission Zone measure

The aim of a Low Emission Zone (LEZ) is to improve air quality by excluding older, high-polluting vehicles from certain urban areas and encouraging the faster take up of more modern, cleaner vehicles.

7.2 Discussion of the Low Emission Zone measure

There are no LEZs currently in place in the UK. However such schemes do exist in several Sweden cities and in Amsterdam. "Environmental zones" were implemented in the central areas of Stockholm, Göteborg, Malmö, and Lund in 1996. Diesel driven trucks and buses with a gross vehicle weight of over 3.5 tonnes are only allowed to enter these environmental zones if their engines is less than 8 years old or achieves specified emissions standards (Municipality of Stockholm et al, 2002). A similar scheme exists in central Amsterdam in which vehicles over 7.5 tonnes gross weight are only allowed to enter if they meet specified emissions and size criteria and also have a load consolidation of at least 80% (PSD, 2002).

Legislation introduced in recent years in the UK is helping to ensure that air quality is monitored at a local level and, if necessary, measures put in place by local authorities to improve it (ALG/GLA, 2002):

> "Under part IV of the 1995 Environment Act, local authorities have a duty to periodically undertake a review and assessment of air quality in their area. The Air Quality Regulations 2000 prescribe air quality Objectives and the dates for meeting them. For each Objective, local authorities have to consider present and likely future air quality, and assess whether the Objectives are likely to be achieved in time.
>
> Should the review and assessment process indicate that one or more of the air quality Objectives will not be met by the prescribed date in either whole or part of the authority, and where people are exposed for the relevant averaging time, local authorities are required (after due consultation) to designate the area of pollution exceedance as an Air Quality Management Area (AQMA). They then have a duty to consult on and prepare an action plan laying out plans to work in pursuit of the Objectives."

One important measure that could help improve air quality in urban areas is the implementation of a LEZ. A feasibility study for the introduction of a LEZ in London has recently been carried out (ALG/GLA, 2002). This was jointly commissioned by the Mayor of London, the Association of London Government and two central government departments to investigate ways of improving the quality of air in London. This is in response to recent UK and European legislation that has introduced target levels for air quality in forthcoming years. If the London authorities decided to go ahead with an LEZ for London the earliest possible date it is likely to be implemented is 2005.

A range of vehicles could be subject to a LEZ including light and heavy goods vehicles, buses, coaches, taxis and cars.

7.3 Specific scenarios tested for the Low Emission Zone measure

The following four scenarios were tested for the LEZ measure:

1. Euro III engines required for all goods vehicles operating on rounds that enter inner area in 2006;

2. Euro III engines required for all goods vehicles operating on rounds that enter outer or inner area in 2006;

3. Euro IV engines required for all goods vehicles operating on rounds that enter inner area in 2010;

4. Euro IV engines required for all goods vehicles operating on rounds that enter outer or inner area in 2010.

7.4 Assumptions made in modelling the Low Emission Zone measure

The following assumptions were made in modelling the LEZ:

- The LEZ is in force 24 hours per day, 7 days per week;

- The LEZ applies to all light and heavy goods vehicles;

- That the LEZ Euro engine standard comes into force five years after the engine first becomes available (i.e. Euro III became available in 2001 and is required by the LEZ in 2006; and Euro IV is scheduled to become available in 2005 and is required by the LEZ in 2010).

We calculated the cost of compliance with the LEZ for distribution companies in two ways: (i) the cost of bringing forward the vehicle replacement cycle, and (ii) the cost of replacing vehicle engines in existing vehicles to meet the required Euro standard.

7.5 Company responses

The aim of a LEZ is to reduce pollutant emissions in an urban area due to the use of cleaner engines. In the scenarios we have modelled, for companies that have vehicle replacement cycles of five years or less no new costs would be incurred as a result of the introduction of a LEZ.

However, companies with replacement cycles of more than five years would have to either retrofit existing vehicles to meet the standards or bring forward their replacement programme. These companies would therefore be expected to incur costs as a result of the LEZ.

Large companies with national operations may be able redeploy newer vehicles to the urban area with the LEZ in order to meet the standards at no additional cost. However, this would only be possible if LEZ were introduced in a small number of urban locations. If instead LEZs were introduced at a similar point in time in many or all UK urban areas this redevelopment strategy would not be possible. Within the analysis it has been assumed that redeployment is not possible.

Four of the companies participating in the project would be unaffected in terms of additional by the introduction of a LEZ due to their existing vehicle replacement cycle. However three companies would experience increased vehicle operating costs (companies C, D and G).

7.6 Results of the modelling of the Low Emission Zone measure

Table 7.1 shows the effects of the introduction of a LEZ on vehicle rounds and the related impact on the indicators analysed.

Table 7.1: Effects of LEZ and impact on indicators

Effect on vehicle rounds	Impact on indicators
Euro engine standards improved on vehicle rounds where necessary	Lower total pollutant emissions
Increased vehicle operating costs per km on some rounds (where companies have to take action to meet LEZ standards)	Increased vehicle operating costs

None of the vehicles used by companies on the 120 vehicle rounds studied in the project had Euro III engines. Vehicle being used all had either Euro I or Euro II engines.

Table 7.2 shows the total number of vehicle rounds affected by the different LEZ scenarios (i.e. the number of vehicle rounds that do not currently use a vehicle with a Euro III or IV engine). However, as already explained four companies, assuming their current vehicle replacement cycle continues in future, will already be operating a vehicle with Euro III engine by 2006, or a vehicle with Euro IV engine by 2010. Therefore, although these companies' vehicles would enter the LEZ they would not need to take any action to meet the vehicle requirements and would not experience increased costs.

Not all 120 vehicle rounds would be affected by the LEZ policy measure as some of the vehicle rounds studied do not enter either the inner or outer areas.

Table 7.2: Number of vehicle rounds affected by each LEZ scenario

Scenario	Vehicle rounds affected
1. Euro III engines required for all goods vehicles operating on rounds that enter inner area in 2006.	63% (76/120)
2. Euro III engines required for all goods vehicles operating on rounds that enter outer or inner area in 2006.	91% (109/120)
3. Euro IV engines required for all goods vehicles operating on rounds that enter inner area in 2010.	63% (76/120)
4. Euro IV engines required for all goods vehicles operating on rounds that enter outer or inner area in 2010.	91% (109/120)

7.6.1 Results of the Low Emission Zone scenarios by company

Tables 7.3-7.6 show the impact of scenarios 1-4 on the operational, financial, and environmental indicators on all vehicle rounds carried out by each company.

The results for each company in each of the three urban areas can be found in Appendix 6.

Table 7.3: Results of LEZ scenario 1 by company
(Euro III engines required for all goods vehicles operating on rounds that enter inner area in 2006)

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	0 / 8	3 / 5	6 / 12	1 / 5	2 / 4	31 / 41	33 / 45
Total time taken							
Orig. driving time as % of total Orig. stationary time as % of total							
New driving time as % of total New stationary time as % of total							
Speed per round (incl. Stops)							
Speed per round (excl. stops)							
Total distance travelled							
Total vehicle operating costs	n/c	n/c	+3%	+1%	n/c	n/c	+4%
Total CO emissions	n/c	-10%	-9%	n/c	n/c	-12%	n/c
Total CO_2 emissions	n/c	n/c	n/c	n/c	n/c	-2%	n/c
Total NOx emissions	n/c	-33%	-36%	-9%	-19%	-16%	-25%
Total PM10 emissions	n/c	-49%	-32%	-6%	-19%	-19%	-23%

Table 7.4: Results of LEZ scenario 2 by company
(Euro III engines required for all goods vehicles operating on rounds that enter outer or inner area in 2006)

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	2 / 8	3 / 5	12 / 12	4 / 5	2 / 4	41 / 41	45 / 45
Total time taken							
Orig. driving time as % of total Orig. stationary time as % of total							
New driving time as % of total New stationary time as % of total							
Speed per round (incl. Stops)							
Speed per round (excl. stops)							
Total distance travelled							
Total vehicle operating costs	n/c	n/c	+5%	+3%	n/c	n/c	+5%
Total CO emissions	-3%	-10%	-19%	-6%	n/c	-18%	n/c
Total CO_2 emissions	n/c	n/c	-1%	n/c	n/c	-2%	n/c
Total NOx emissions	-12%	-33%	-43%	-34%	-19%	-28%	-31%
Total PM10 emissions	-14%	-49%	-42%	-40%	-19%	-31%	-28%

Table 7.5: Results of LEZ scenario 3 by company
(Euro IV engines required for all goods vehicles operating on rounds that enter inner area in 2010)

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	0 / 8	3 / 5	6 / 12	1 / 5	2 / 4	31 / 41	33 / 45
Total time taken							
Orig. driving time as % of total Orig. stationary time as % of total							
New driving time as % of total New stationary time as % of total							
Speed per round (incl. Stops)							
Speed per round (excl. stops)							
Total distance travelled							
Total vehicle operating costs	n/c	n/c	+3%	+1%	n/c	n/c	+4%
Total CO emissions	n/c	-61%	-63%	-21%	-54%	-43%	-73%
Total CO_2 emissions	n/c	-2%	-2%	-1%	-2%	-4%	-2%
Total NOx emissions	n/c	-44%	-49%	-15%	-31%	-29%	-41%
Total PM10 emissions	n/c	-71%	-67%	-20%	-57%	-46%	-68%

Table 7.6: Results of LEZ scenario 4 by company
(Euro IV engines required for all goods vehicles operating on rounds that enter outer or inner area in 2010)

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	2 / 8	3 / 5	12 / 12	4 / 5	2 / 4	41 / 41	45 / 45
Total time taken							
Orig. driving time as % of total Orig. stationary time as % of total							
New driving time as % of total New stationary time as % of total							
Speed per round (incl. Stops)							
Speed per round (excl. stops)							
Total distance travelled							
Total vehicle operating costs	n/c	n/c	+5%	+3%	n/c	n/c	+5%
Total CO emissions	-21%	-61%	-83%	-80%	-54%	-74%	-90%
Total CO_2 emissions	-1%	-2%	-5%	-3%	-2%	-6%	-3%
Total NOx emissions	-15%	-44%	-61%	-50%	-31%	-52%	-51%
Total PM10 emissions	-22%	-71%	-85%	-77%	-57%	-80%	-85%

7.6.2 Discussion of results of the Low Emission Zone scenarios by company

- Four of the companies experience no effect on operating costs as a result of the LEZ policy scenarios. This is because their fleet replacement cycle would have resulted in them acquiring compliant vehicles anyway.
- The results suggest that the three companies that would experience increased operating costs due to the need to acquire compliant vehicles would incur operating cost increases of up to 5%.
- The results indicate that the LEZ would be likely to result in significant reductions in pollution levels on the vehicle rounds that enter the inner and outer areas.

- Scenarios in which the LEZ is implemented in the outer and inner area (scenarios 2 and 4) produce greater reductions in pollutant emissions compared with scenarios only applied to the inner area (scenarios 1 and 3) due to the greater number of rounds that are affected when the geographical area of the zone is extended.

- The results indicate that the introduction of Euro IV engines in conjunction with a LEZ would be likely to result in significant reductions in pollution from distribution operations compared with current levels. However it should be noted that scenario 4 would not take effect until 2012 (which is a longer time scale than the other policy measures and scenarios being examined).

7.6.3 Results of the Low Emissions Zone scenarios by urban area

Tables 7.7-7.10 show the impact of scenarios 1-4 on the operational, financial, and environmental indicators on all vehicle rounds studied in the three urban areas.

Table 7.7: Results of LEZ scenario 1 by urban area
(Euro III engines required for all goods vehicles operating on rounds that enter inner area in 2006)

	Basingstoke	Birmingham	Norwich
Total number of rounds			
Number of rounds affected	15 / 20	30 / 57	31 / 43
Total time taken			
Orig. driving time as % of total Orig. stationary time as % of total			
New driving time as % of total New stationary time as % of total			
Speed per round (incl. Stops)			
Speed per round (excl. stops)			
Total distance travelled			
Total vehicle operating costs	+1%	+2%	+2%
Total CO emissions	-3%	-1%	-10%
Total CO2 emissions	n/c	n/c	n/c
Total NOx emissions	-12%	-9%	-38%
Total PM10 emissions	-13%	-10%	-43%

Table 7.8: Results of LEZ scenario 2 by urban area
(Euro III engines required for all goods vehicles operating on rounds that enter outer or inner area in 2006)

	Basingstoke	Birmingham	Norwich
Total number of rounds			
Number of rounds affected	18 / 20	48 / 57	43 / 43
Total time taken			
Orig. driving time as % of total Orig. stationary time as % of total			
New driving time as % of total New stationary time as % of total			
Speed per round (incl. Stops)			
Speed per round (excl. stops)			
Total distance travelled			
Total vehicle operating costs	+2%	+2%	+3%
Total CO emissions	-8%	-3%	-13%
Total CO2 emissions	n/c	n/c	n/c
Total NOx emissions	-34%	-19%	-40%
Total PM10 emissions	-39%	-21%	-47%

Table 7.9: Results of LEZ scenario 3 by urban area
(Euro IV engines required for all goods vehicles operating on rounds that enter inner area in 2010)

	Basingstoke	Birmingham	Norwich
Total number of rounds			
Number of rounds affected	15 / 20	30 / 57	31 / 43
Total time taken			
Orig. driving time as % of total Orig. stationary time as % of total			
New driving time as % of total New stationary time as % of total			
Speed per round (incl. Stops)			
Speed per round (excl. stops)			
Total distance travelled			
Total vehicle operating costs	+1%	+2%	+2%
Total CO emissions	-44%	-24%	-79%
Total CO2 emissions	-2%	-1%	-3%
Total NOx emissions	-21%	-13%	-55%
Total PM10 emissions	-37%	-21%	-80%

Table 7.10: Results of LEZ scenario 4 by urban area
(Euro IV engines required for all goods vehicles operating on rounds that enter outer or inner area in 2010)

	Basingstoke	Birmingham	Norwich
Total number of rounds			
Number of rounds affected	18 / 20	48 / 57	43 / 43
Total time taken			
Orig. driving time as % of total Orig. stationary time as % of total			
New driving time as % of total New stationary time as % of total			
Speed per round (incl. Stops)			
Speed per round (excl. stops)			
Total distance travelled			
Total vehicle operating costs	+2%	+2%	+3%
Total CO emissions	-78%	-47%	-86%
Total CO2 emissions	-3%	-2%	-4%
Total NOx emissions	-51%	-28%	-57%
Total PM10 emissions	-80%	-46%	-87%

7.6.4 Discussion of results of the Low Emissions Zone scenarios by urban area

- A greater proportion of the vehicle rounds studied in Norwich and Basingstoke (approximately 75% of vehicle rounds) would be affected by scenarios 1 and 3 (inner area) than in Birmingham (52% of vehicle rounds). This is because more of the rounds studied in Norwich and Basingstoke enter the inner area than in Birmingham. This is due to the greater geographical area of Birmingham. There are a greater proportion of vehicle rounds in Birmingham that either only enter the outer area, or which enter neither the inner or outer area.

- The same is true to a lesser extent in scenarios 2 and 4 (inner and outer area), with approximately 85% of vehicle rounds being subject to the LEZ in Birmingham, compared to all vehicle rounds in Norwich.

- The results suggest that the LEZ scenarios would have more impact in terms of pollutant reduction on the vehicle rounds studied in Norwich than in the other urban areas. This is due to: (i) there being a greater proportion of Euro I vehicles currently operated by the companies in the project in Norwich than in the other two urban areas, and (ii) the distance travelled on Norwich vehicle rounds (especially by companies using a national distribution centre).

- Reductions in pollutant emissions would be expected to be significantly greater for vehicle rounds in Basingstoke and Birmingham (scenarios 1 and 3) if the LEZ was implemented in the inner and outer area rather than only in the inner area (scenarios 2 and 4).

- The results indicate that increases in vehicle operating costs as a result of a LEZ would be similar in the three urban areas. An increase of 1-2% of total vehicle operating costs for all the distribution activity studied would be expected if the LEZ was implemented in the inner area, and 2-3% increases in total vehicle operating costs for all the distribution activity if the LEZ was implemented in the inner and outer area. However, it needs to be borne in mind that not all companies would be subject to a vehicle operating cost increase, as some companies would already be operating compliant vehicles. In the project, only three out of the seven companies would be expected to experience cost increases.

- The implementation of a LEZ in 2010 that required Euro IV engines (scenarios 3 and 4) can be seen to produce far greater reductions in pollutant levels on vehicle rounds in the three urban areas than a LEZ based on Euro III engines in 2006 (scenarios 1 and 2).

8. ANALYSIS OF CONGESTION CHARGING

8.1 Explanation of the congestion charging measure

Congestion charging refers to a scheme in which vehicle drivers (or the companies responsible for the vehicles) have to pay a charge in order to enter a particular geographical area at a particular time. The aim of such a scheme is to reduce road traffic levels in the urban area and also to reduce traffic pollutant emissions. Such a scheme may also generate a profit which can be used to provide improved public transport services.

8.2 Discussion of the congestion charging measure

Although congestion charging does not currently exist in any urban areas in the UK, it is due to be implemented in London in February 2003. The Mayor of London intends to introduce a congestion charging scheme in central London in which vehicles will pay £5 per day to enter central London between 07:00 and 18:30 from Monday to Friday.

Goods and service vehicles working in central London will be subject to this charge. The Mayor anticipates that the congestion charge will reduce traffic levels in London, and that freight and service companies will benefit in terms of shorter and more reliable journey times.

It was originally proposed in the London scheme that goods vehicles should pay £15 per day. The freight industry was critical of this charge. The proposed charge was subsequently reduced to £5 per day for all vehicles.

Transport for London note that congestion charging will result in substantial decreases in traffic (TfL, 2002):

- Inside the zone:
    - traffic would be reduced by 10 - 15%;
    - queues would be reduced by 20 - 30%;
    - traffic speeds would be increased by 10 - 15%.
- Outside the zone:
    - traffic may increase on orbital routes by up to 5%;
    - traffic would be reduced on radial routes by 5 - 10%;
    - overall reduction in traffic by 1 - 2%.

Clearly, reductions in traffic could lead to greater reliability for the journey times of goods vehicles. Increased reliability would off-set some or all of the additional costs but there remains some uncertainty about the likely impacts. In addition, while it is argued that traffic would fall in the congestion charging area it has also been claimed that congestion would be worse around the edge of the zone. This in turn would reduce the level of benefits to be expected from more reliable delivery and service trips in the central area.

8.3 Specific scenarios tested for the congestion charging measure

Different scenarios were tested that included: (i) different geographical coverage of the scheme, (ii) different daily charges, and (iii) different assumptions about the effect on traffic speed.

The following five scenarios were tested for the congestion charging measure:

1. £5 daily fee for all goods vehicles operating on rounds that enter inner area between 07:00 and 18:30 – no effect on driving time;

2. £5 daily fee for all goods vehicles operating on rounds that enter inner area between 07:00 and 18:30 – driving time in inner area reduces by 15%;

3. £15 daily fee for all goods vehicles operating on rounds that enter inner area between 07:00 and 18:30 – driving time in inner area reduces by 15%;

4. £5 daily fee for all goods vehicles operating on rounds that enter inner or outer area between 07:00 and 18:30 – no effect on driving time;

5. £5 daily fee for all goods vehicles operating on rounds that enter inner or outer area between 07:00 and 18:30 – driving time in inner and outer area reduces by 15%.

8.4 Assumptions made in modelling the congestion charging measure

The scenarios and the assumptions made in the modelling are largely based on the proposed London congestion charging scheme. £5 is the fee proposed for the London scheme for goods vehicles. Previously a charge of £15 for goods vehicles had been proposed.

The timings of the scheme (07:00 to 18:30) are identical to those proposed for London.

A reduction in driving time of 15% is assumed in some scenarios (this is based on predictions for the London scheme).

For vehicles that perform two vehicle rounds per day in the congestion charging zone, a charge of £2.50 has been applied to each round.

For vehicle rounds on which the vast majority of the total distance travelled takes place outside the congestion charging zone it has been assumed that these rounds will not experience an improvement in traffic speed on the round as a whole.

8.5 Company responses

All of the companies felt that the timing and organisation of distribution operations would carry on unaffected if any of the congestion charging scheme scenarios were implemented in the three urban areas. They all felt that the possibility of making collections and deliveries after 18:30 or before 07:00 would be unacceptable to their customers.

None of the operators would consider altering the times at which their vehicle rounds take place in order to avoid the charge.

Most companies were of the opinion that they would only consider changing the times at which they make collections and deliveries if: (i) the congestion charging scheme was far higher than in the scenarios modelled, (ii) it was not possible to pass this cost onto customers, and (iii) the benefits of congestion charging in terms of improved speeds were very low. It is therefore unlikely that the types of congestion charging schemes being considered by policy makers are likely to have much, if any, effect on the number and timings of urban deliveries and collections.

However, all companies were concerned about having to bear the financial costs of the congestion charging scheme. They were concerned about whether the scheme would in fact deliver improvements in traffic speed that were sufficient to outweigh the congestion charge.

Some of the companies mentioned that they would be prepared to pay more than £5 if the traffic speed and potential journey reliability improvements were sufficiently large.

8.6 Results of the modelling of the congestion charging measure

Table 8.1 shows the effects of the introduction of a congestion charging scheme on vehicle rounds and the related impact on the indicators analysed.

Table 8.1: Effects of congestion charging and impact on indicators

Effect on vehicle rounds	Impact on indicators
Need to pay congestion charge each day	Increased total cost per round
Possible faster vehicle speeds	Reduction in standing cost per round Change in pollutant emissions per round

Table 8.2 shows the total number of vehicle rounds affected by the different congestion charging scenarios.

Not all 120 vehicle rounds would be affected by the congestion charging scheme. There are two reasons why a vehicle round may not be affected by a congestion charging scenario:

- the round does not enter the congestion charging area (i.e. either the inner or outer area);
- the round takes place outside the times that the congestion charging scheme is in force.

Table 8.2: Number of vehicle rounds affected by each congestion charging scenario

Scenario	Vehicle rounds affected
1. £5 daily fee for all goods vehicles operating on rounds that enter inner area between 07:00 and 18:30 – no effect on driving time.	62% (74/120)
2. £5 daily fee for all goods vehicles operating on rounds that enter inner area between 07:00 and 18:30 – driving time in inner area reduces by 15%.	62% (74/120)
3. £15 daily fee for all goods vehicles operating on rounds that enter inner area between 07:00 and 18:30 – driving time in inner area reduces by 15%.	62% (74/120)
4. £5 daily fee for all goods vehicles operating on rounds that enter inner or outer area between 07:00 and 18:30 – no effect on driving time.	89% (107/120)
5. £5 daily fee for all goods vehicles operating on rounds that enter inner or outer area between 07:00 and 18:30 – driving time in inner and outer area reduces by 15%.	89% (107/120)

8.6.1 Results of the congestion charging scenarios by company

Tables 8.3-8.7 show the impact of scenarios 1-5 on the operational, financial, and environmental indicators on all vehicle rounds carried out by each company.

The results for each company in each of the three urban areas can be found in Appendix 6.

Table 8.3: Results of congestion charging scenario 1 by company
(£5 daily fee for all goods vehicles operating on rounds that enter inner area between 07:00 and 18:30 – no effect on driving time)

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	0 / 8	3 / 5	6 / 12	1 / 5	2 / 4	31 / 41	31 / 45
Total time taken	n/c	n/c	n/c	n/c	n/c	n/c	n/c
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was:.65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was:.69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	n/c	n/c	n/c	n/c	n/c	n/c	n/c
Speed per round (incl. Stops)	n/c	n/c	n/c	n/c	n/c	n/c	n/c
Speed per round (excl. stops)	n/c	n/c	n/c	n/c	n/c	n/c	n/c
Total distance travelled							
Total vehicle operating costs	n/c	+1%	+3%	n/c	+2%	+5%	+2%
Total CO emissions	n/c	n/c	n/c	n/c	n/c	n/c	n/c
Total CO_2 emissions	n/c	n/c	n/c	n/c	n/c	n/c	n/c
Total NOx emissions	n/c	n/c	n/c	n/c	n/c	n/c	n/c
Total PM10 emissions	n/c	n/c	n/c	n/c	n/c	n/c	n/c

Table 8.4: Results of congestion charging scenario 2 by company
(£5 daily fee for all goods vehicles operating on rounds that enter inner area between 07:00 and 18:30 – driving time in inner area reduces by 15%)

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	0 / 8	3 / 5	6 / 12	1 / 5	2 / 4	31 / 41	31 / 45
Total time taken	n/c	n/c	-4%	n/c	n/c	-3%	-4%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was:.65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was:.69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	n/c	n/c	Now: 51% Now: 49%	n/c	n/c	Now: 38% Now: 62%	Now: 36% Now: 64%
Speed per round (incl. Stops)	n/c	n/c	+5%	n/c	n/c	+4%	+5%
Speed per round (excl. stops)	n/c	n/c	+8%	n/c	n/c	+12%	+11%
Total distance travelled							
Total vehicle operating costs	n/c	+1%	-1%	n/c	+2%	+2%	-1%
Total CO emissions	n/c	n/c	-8%	n/c	n/c	-4%	-1%
Total CO_2 emissions	n/c	n/c	-5%	n/c	n/c	-3%	-4%
Total NOx emissions	n/c	n/c	-8%	n/c	n/c	-5%	-4%
Total PM10 emissions	n/c	n/c	-8%	n/c	n/c	-4%	-4%

Table 8.5: Results of congestion charging scenario 3 by company
(£15 daily fee for all goods vehicles operating on rounds that enter inner area between 07:00 and 18:30 – driving time in inner area reduces by 15%)

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	0 / 8	3 / 5	6 / 12	1 / 5	2 / 4	31 / 41	31 / 45
Total time taken	n/c	n/c	-4%	n/c	n/c	-3%	-4%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was:.65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was:.69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	n/c	n/c	Now: 51% Now: 49%	n/c	n/c	Now: 38% Now: 62%	Now: 36% Now: 64%
Speed per round (incl. Stops)	n/c	n/c	+5%	n/c	n/c	+4%	+5%
Speed per round (excl. stops)	n/c	n/c	+8%	n/c	n/c	+12%	+11%
Total distance travelled							
Total vehicle operating costs	n/c	+3%	+4%	+1%	+5%	+11%	+4%
Total CO emissions	n/c	n/c	-8%	n/c	n/c	-4%	-1%
Total CO_2 emissions	n/c	n/c	-5%	n/c	n/c	-3%	-4%
Total NOx emissions	n/c	n/c	-8%	n/c	n/c	-5%	-4%
Total PM10 emissions	n/c	n/c	-8%	n/c	n/c	-4%	-4%

Table 8.6: Results of congestion charging scenario 4 by company
(£5 daily fee for all goods vehicles operating on rounds that enter inner or outer area between 07:00 and 18:30 – no effect on driving time)

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	2 / 8	3 / 5	12 / 12	4 / 5	2 / 4	41 / 41	43 / 45
Total time taken	n/c	n/c	n/c	n/c	n/c	n/c	n/c
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was:.65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was:.69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	n/c	n/c	n/c	n/c	n/c	n/c	n/c
Speed per round (incl. Stops)	n/c	n/c	n/c	n/c	n/c	n/c	n/c
Speed per round (excl. stops)	n/c	n/c	n/c	n/c	n/c	n/c	n/c
Total distance travelled							
Total vehicle operating costs	+1%	+1%	+6%	+1%	+2%	+6%	+3%
Total CO emissions	n/c	n/c	n/c	n/c	n/c	n/c	n/c
Total CO_2 emissions	n/c	n/c	n/c	n/c	n/c	n/c	n/c
Total NOx emissions	n/c	n/c	n/c	n/c	n/c	n/c	n/c
Total PM10 emissions	n/c	n/c	n/c	n/c	n/c	n/c	n/c

Table 8.7: Results of congestion charging scenario 5 by company
(£5 daily fee for all goods vehicles operating on rounds that enter inner or outer area between 07:00 and 18:30 – driving time in inner and outer area reduces by 15%)

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	2 / 8	3 / 5	12 / 12	4 / 5	2 / 4	41 / 41	43 / 45
Total time taken	n/c	n/c	-7%	n/c	n/c	-5%	-5%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was:.65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was:.69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	n/c	n/c	Now: 51% Now: 49%	n/c	n/c	Now: 38% Now: 62%	Now: 36% Now: 64%
Speed per round (incl. Stops)	n/c	n/c	+9%	n/c	n/c	+5%	+6%
Speed per round (excl. stops)	n/c	n/c	+18%	n/c	n/c	+15%	+16%
Total distance travelled							
Total vehicle operating costs	+1%	+1%	-1%	+1%	+2%	+1%	-1%
Total CO emissions	n/c	n/c	-12%	n/c	n/c	-8%	-3%
Total CO_2 emissions	n/c	n/c	-7%	n/c	n/c	-5%	-6%
Total NOx emissions	n/c	n/c	-8%	n/c	n/c	-10%	-7%
Total PM10 emissions	n/c	n/c	-9%	n/c	n/c	-9%	-6%

8.6.2 Discussion of results of the congestion charging scenarios by company

- The results indicate that the effect of congestion charging will differ between companies, depending on: (i) the level of the charge, (ii) the geographical area in which the scheme is implemented, and (iii) whether or not the scheme results in speed improvements.

- If there is no improvement in vehicle speeds, and hence driving times, as a result of congestion charging then the only indicator that will change is vehicle operating costs. There would be no effect on operational or environmental indicators (see scenarios 1 and 4).

- The results indicate that the effect of inner area congestion charging with no speed improvements (scenario 1) is likely to result in some differences in vehicle operating cost changes between companies, with one company experiencing a 5% increase in costs, while others are unaffected. The company forecast to receive the highest cost increase has the greatest proportion of vehicle rounds in the inner area of all participating companies.

- Improvements in vehicle speed for goods vehicles (as a result of reductions in traffic levels) can be seen to reduce, and in some cases outweigh, the congestion charge for companies (see scenarios 2, 3 and 5). This illustrates the importance of generating time savings to ensure that congestion charging does not have a detrimental economic effect, and also in helping to increase acceptability among companies.

- Improvements in vehicle speed as a result of congestion charging would also be expected to generate small reductions in pollutant emissions among the companies (see scenarios 2, 3 and 5).

- The results indicate that, for some companies, the congestion charge in the inner area (scenario 2) or the inner and outer area (scenario 5) could be offset, or more than offset, by a 15% reduction in driving time.

- The geographical area covered by a congestion charging scheme is likely to have an important bearing on its economic impact on some companies. The results suggest that for one of the participating companies (company C) costs would be 6% higher if the scheme was implemented in the outer and inner area (scenario 4), compared with only 3% in the inner area (scenario 1) if there were no time savings.

- The results suggest that a charge of £15 in the inner area, even with improved vehicle speeds in the urban area (scenario 3), would be likely to result in cost increases of up to 11% for the companies. This reflects the likely importance of the level of the charge to company attitudes towards a congestion charging scheme.

- Obviously a congestion charging scheme that leads to reduction in car traffic (thereby leading to faster journeys for those paying the charge) will produce wider benefits in an urban area in terms of less traffic, less pollution etc. This is not reflected in the results tables above.

8.6.3 Results of the congestion charging scenarios by urban area

Tables 8.8-8.12 show the impact of scenarios 1-5 on the operational, financial, and environmental indicators on all vehicle rounds studied in the three urban areas.

Table 8.8: Results of congestion charging scenario 1 by urban area
(£5 daily fee for all goods vehicles operating on rounds that enter inner area between 07:00 and 18:30 – no effect on driving time)

	Basingstoke	Birmingham	Norwich
Total number of rounds			
Number of rounds affected	15 / 20	28 / 57	31 / 43
Total time taken	n/c	n/c	n/c
Orig. driving time as % of total Orig. stationary time as % of total	Was: 54% Was: 46%	Was: 46% Was: 54%	Was: 43% Was: 57%
New driving time as % of total New stationary time as % of total	n/c	n/c	n/c
Speed per round (incl. Stops)	n/c	n/c	n/c
Speed per round (excl. stops)	n/c	n/c	n/c
Total distance travelled			
Total vehicle operating costs	+2%	+2%	+3%
Total CO emissions	n/c	n/c	n/c
Total CO2 emissions	n/c	n/c	n/c
Total NOx emissions	n/c	n/c	n/c
Total PM10 emissions	n/c	n/c	n/c

Table 8.9: Results of congestion charging scenario 2 by urban area
(£5 daily fee for all goods vehicles operating on rounds that enter inner area between 07:00 and 18:30 – driving time in inner area reduces by 15%)

	Basingstoke	Birmingham	Norwich
Total number of rounds			
Number of rounds affected	15 / 20	28 / 57	31 / 43
Total time taken	-1%	-2%	-4%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 54% Was: 46%	Was: 46% Was: 54%	Was: 43% Was: 57%
New driving time as % of total New stationary time as % of total	Now: 53% Now: 47%	Now: 44% Now: 56%	Now: 40% Now: 60%
Speed per round (incl. Stops)	+2%	+2%	+4%
Speed per round (excl. stops)	+6%	+8%	+11%
Total distance travelled			
Total vehicle operating costs	+1%	n/c	n/c
Total CO emissions	n/c	-1%	-3%
Total CO2 emissions	-1%	-1%	-1%
Total NOx emissions	-1%	-1%	-2%
Total PM10 emissions	-1%	-1%	-4%

Table 8.10: Results of congestion charging scenario 3 by urban area
(£15 daily fee for all goods vehicles operating on rounds that enter inner area between 07:00 and 18:30 – driving time in inner area reduces by 15%)

	Basingstoke	Birmingham	Norwich
Total number of rounds			
Number of rounds affected	15 / 20	28 / 57	31 / 43
Total time taken	-1%	-2%	-4%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 54% Was: 46%	Was: 46% Was: 54%	Was: 43% Was: 57%
New driving time as % of total New stationary time as % of total	Now: 53% Now: 47%	Now: 44% Now: 56%	Now: 40% Now: 60%
Speed per round (incl. Stops)	+2%	+2%	+4%
Speed per round (excl. stops)	+6%	+8%	+11%
Total distance travelled			
Total vehicle operating costs	+5%	+3%	+6%
Total CO emissions	n/c	-1%	-3%
Total CO2 emissions	-1%	-1%	-1%
Total NOx emissions	-1%	-1%	-2%
Total PM10 emissions	-1%	-1%	-4%

Table 8.11: Results of congestion charging scenario 4 by urban area
(£5 daily fee for all goods vehicles operating on rounds that enter inner or outer area between 07:00 and 18:30 – no effect on driving time)

	Basingstoke	Birmingham	Norwich
Total number of rounds			
Number of rounds affected	18 / 20	46 / 57	43 / 43
Total time taken	n/c	n/c	n/c
Orig. driving time as % of total Orig. stationary time as % of total	Was: 54% Was: 46%	Was: 46% Was: 54%	Was: 43% Was: 57%
New driving time as % of total New stationary time as % of total	n/c	n/c	n/c
Speed per round (incl. Stops)	n/c	n/c	n/c
Speed per round (excl. stops)	n/c	n/c	n/c
Total distance travelled			
Total vehicle operating costs	+3%	+3%	+4%
Total CO emissions	n/c	n/c	n/c
Total CO2 emissions	n/c	n/c	n/c
Total NOx emissions	n/c	n/c	n/c
Total PM10 emissions	n/c	n/c	n/c

Table 8.12: Results of congestion charging scenario 5 by urban area
(£5 daily fee for all goods vehicles operating on rounds that enter inner or outer area between 07:00 and 18:30 – driving time in inner and outer area reduces by 15%)

	Basingstoke	Birmingham	Norwich
Total number of rounds			
Number of rounds affected	18 / 20	46 / 57	43 / 43
Total time taken	-1%	-3%	-5%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 54% Was: 46%	Was: 46% Was: 54%	Was: 43% Was: 57%
New driving time as % of total New stationary time as % of total	Now: 53% Now: 47%	Now: 43% Now: 57%	Now: 39% Now: 61%
Speed per round (incl. Stops)	+2%	+4%	+6%
Speed per round (excl. stops)	+6%	+12%	+16%
Total distance travelled			
Total vehicle operating costs	+2%	n/c	n/c
Total CO emissions	n/c	-3%	-4%
Total CO2 emissions	-1%	-3%	-2%
Total NOx emissions	-1%	-3%	-2%
Total PM10 emissions	-1%	-3%	-4%

8.6.4 Discussion of results of the congestion charging scenarios by urban area

- The impact of congestion charging scenarios that do not produce time savings on the cost of distribution operations is broadly similar in all three urban areas. Congestion charging in the inner area would be expected to result in increases in the total vehicle operating costs of 2-3% for all the distribution activity studied (scenario 1) and 3-4% if congestion charging was implemented in the inner and outer area (scenario 4).

- The results suggest that an inner area congestion charge of £5 that resulted in time savings of 15% (scenario 2) would result in a broadly neutral economic effect for the total distribution activity studied in each of the three urban areas.

- The results are similar for an inner and outer area congestion charge of £5 that resulted in time savings of 15% (scenario 5) in Birmingham and Norwich. However in Basingstoke

the total operating cost for all distribution activity studied would be expected to increase by 2%.

- An inner area congestion charge of £15 that resulted in time savings of 15% (scenario 3) would be likely to result in vehicle operating cost increases in all of the urban areas. The results indicate that cost increases would be higher in Norwich (6%) than in Birmingham (3%). This is due to the proportion of vehicle rounds affected in each urban area.

- If congestion charging were to result in driving time savings then this would be expected to lead to reductions in pollutant emissions due to improved engine performance. This is reflected in scenarios 2, 3 and 5. The results suggest that pollutant reductions of between 1% and 5% would be expected in the urban areas.

8.6.5 Sensitivity analysis – level of the congestion charge

Sensitivity analysis was carried out to further explore the effect of different driving time reductions on operating costs if a £5 daily congestion charge was introduced in the inner area (i.e. further analysis of scenarios 1 and 2). These scenarios were selected for more detailed analysis as they are the most similar to the scheme proposed in London.

The results show that for some companies the financial effect of a congestion charging scheme are likely to be closely related to the level of speed improvement that the scheme results in. For companies C and G, a 10% driving time reduction outweighs the additional cost of paying the congestion charge, leading to a net benefit.

However for companies such as B that distribute goods over a long distance from a national depot, the time savings in the urban area are likely to have a very small effect on total journey time. Therefore for companies with this type of operating pattern the scope for mitigating the charge through time savings in the urban area is greatly reduced.

8.6.6 Sensitivity analysis - times at which the congestion charge is in force

In the five scenarios modelled, it was assumed that the congestion charge was in force between 07:00 and 18:30 on weekdays. However further work was conducted to examine the number of vehicle rounds that would be affected if the congestion charging scheme started later than 07:00. The results for an inner area congestion charging scheme are shown in Table 8.13, and for an inner and outer area scheme in Table 8.14.

Table 8.13: Number of vehicle rounds affected by different inner area congestion charging times

Time	Coverage of congestion charging scheme	Rounds affected
07:00 - 18:30	Inner area	62% (74/120 rounds)
08:00 - 18:30	Inner area	58% (69/120 rounds)
09:00 - 18:30	Inner area	55% (66/120 rounds)
10:00 - 18:30	Inner area	50% (60/120 rounds)

Table 8.14: Number of vehicle rounds affected by different inner and outer area congestion charging times

Time	Coverage of congestion charging scheme	Rounds affected
07:00 - 18:30	Inner and outer area	89% (107/120 rounds)
08:00 - 18:30	Inner and outer area	85% (102/120 rounds)
09:00 - 18:30	Inner and outer area	80% (96/120 rounds)
10:00 - 18:30	Inner and outer area	73% (88/120 rounds)

The results show that the proportion of vehicle rounds in the study that are affected by congestion charging falls by approximately 5% for every hour that the start time of the scheme is put forward (between 07:00 and 10:00).

9. ANALYSIS OF VEHICLE WEIGHT RESTRICTIONS

9.1 Explanation of the vehicle weight restriction measure

Vehicle weight restrictions were investigated for the three urban areas. In this policy measure only vehicles up to a certain gross vehicle weight would be allowed to enter a specific geographical area within the urban area to make collections and deliveries during a large period of the working day (10:00 to 16:00).

The aim of such a measure would be to reduce the number of large goods vehicles entering the chosen area when pedestrians and other road users are present and thereby overcoming the impacts that it is commonly perceived that these vehicles cause, such as pollution, intimidation, safety concerns, vibrations and noise.

9.2 Discussion of the vehicle weight restriction measure

In many French towns and cities freight vehicles above a certain size or weight are banned at certain times of day. The same is true in some German towns and cities such as Heidelberg (Schmidt, 1996). Banning heavy lorries can potentially reduce the environmental impacts that they cause (such as noise, vibration, visual intrusion and safety problems).

There are several ways in which companies affected could theoretically respond to the vehicle weight restriction measure analysed. These include:

- Continue to carry out deliveries and collections at the same time, using lighter vehicles. This would result in the company performing more vehicle rounds in total;
- Changing the times at which the rounds are performed (i.e. use the same vehicle but perform the rounds either before 10:00 or after 16:00);
- For companies dispatching vehicles from a distribution centre based a long way from the urban area, they could retain the same delivery and collection times. However, instead of operating a greater number of lighter vehicles from the distribution centre to the urban area, they could use the existing heavier vehicle from the depot to the edge of the restricted area and then tranship the goods onto lighter vehicles which make deliveries in the urban area between 10:00 and 16:00.

By preventing heavier vehicles from entering a particular part of the urban area for much of the working day, if the current collection and delivery times need to be maintained, this work would have to be conducted by lighter vehicles, which are only capable of carrying a proportion of the goods that a heavy lorry can carry on each trip. Therefore the use of smaller vehicles would be expected to lead to increases in the total number of vehicle rounds and total vehicle kilometres.

9.3 Specific scenarios tested for the vehicle weight restriction measure

Different scenarios were tested that included: (i) different geographical coverage of the scheme, and (ii) two different weight restrictions.

The following four scenarios were tested for the vehicle weight restriction measure:

1. No vehicles over 7.5 tonnes (gvw) allowed in inner area between 10:00 and 16:00;

2. No vehicles over 12 tonnes (gvw) allowed in inner area between 10:00 and 16:00;

3. No vehicles over 7.5 tonnes (gvw) allowed in outer and inner area between 10:00 and 16:00;

4. No vehicles over 12 tonnes (gvw) allowed in outer and inner area between 10:00 and 16:00.

All the four scenarios tested prevented vehicles from entering the restricted area between 10:00 and 16:00. This time period was chosen as it is the time period used in pedestrianised areas in many urban areas in the UK.

9.4 Assumptions made in modelling the vehicle weight restriction measure

In order to model the effects of the scenarios for this measure it was necessary to derive factors by which the total time taken and distance travelled on a current vehicle round would be expected to increase if lighter vehicles were used and therefore the number of vehicle rounds increased.

This was achieved by calculating the number of vehicle rounds that would be required and then allocating the delivery and collection work to these rounds. These new vehicle rounds were input into the GPS mapping system so that the total distance travelled on these new rounds could be calculated. In this way it was possible to derive distance conversion factors for each company based on the number of vehicles required when the restriction was in force.

It was assumed that vehicle speeds after the introduction of weight restriction measures would remain the same as prior to the measure. It was therefore possible to also apply the distance conversion factors to the driving time of the new rounds in order to calculate the total driving time for all the vehicle rounds carried out by each company.

For company B it was assumed that, given the distance between their depot and the urban areas served, rather than operate several lighter vehicles from their national depot to each urban area, on any rounds affected by the weight restriction scenarios they would continue to use a heavy vehicle between the depot and the edge of the urban area and then tranship the goods onto lighter vehicles for delivery in the urban area. However, the costs calculated in this case do not include the costs of a transhipment centre, only the costs of the vehicles and drivers. Therefore, these costs are an underestimate.

9.5 Company responses

The companies participating in the study were of the opinion that this measure would be difficult to cope with and would have significant operational and economic impacts on their business.

All of the companies felt that the scenarios would be likely to result in them carrying out more vehicle rounds to make the same number of collections and deliveries each day. The companies did not expect to be able to alter the time at which they make collections and deliveries as the current times are operated to meet the needs of the senders and receivers. As would be expected, those companies operating the heaviest vehicles and/or making a high proportion of collections and deliveries in the city centre were most concerned about the implications of this measure.

Representatives of the two distribution operations carried out from a single national distribution centre were especially concerned about this measure. They felt that they would initially consider despatching vehicles from the depot earlier in the morning, so that they could make deliveries and leave the restricted area before the restriction came into force. However, they believed that the scope for this would be limited by: (i) the distance between

the depot and the urban areas served, and (ii) the earliest time that receivers would accept deliveries. Using lighter vehicles from the depot would be considered but, given the distance driven to the urban areas, this would be likely to result in very large cost increases that would be unacceptable. If the costs of using a greater number of lighter vehicles from the depot were too high, it would be necessary to adopt a system of transhipment on the edge of the urban areas, in which goods transported by heavy vehicles from the depot were unloaded onto lighter vehicles (either operated by the company or a local sub-contractor).

In addition they were of the opinion that if the time restriction was the entire working day (i.e. longer than the 10:00 to 16:00 tested in the scenarios) it may be necessary to consider changing the nature of the distribution operation from a national operation to a system with either regional of local depots far closer to the urban areas.

9.6 Results of the modelling of the vehicle weight restriction measure

Table 9.1 shows the effects of the introduction of the vehicle weight restriction measure on vehicle rounds and the related impact on the indicators analysed.

Table 9.1: Effects of weight restrictions and impact on indicators

Effect on vehicle rounds	Impact on indicators
Greater number of vehicle rounds required using lighter vehicles to make the same number of collections and deliveries in each urban area.	Increase in total number of vehicle rounds
	Increase in total distance travelled
	Increase in total time taken
	Change in total vehicle operating costs
	Change in total pollutant emissions

Table 9.2 shows the total number of vehicle rounds affected by the different weight restriction scenarios. Not all 120 vehicle rounds would be affected by the weight restriction scenarios. There are three reasons why a vehicle round may not be affected by a weight restriction scenario:

- the round does not enter the weight restriction area (i.e. either the inner or outer area);
- the round takes place outside the times that the congestion charging scheme is in force;
- the vehicle is below the restricted weight limit.

Table 9.2: Number of vehicle rounds affected by each weight restriction scenario

Scenario	Vehicle rounds affected
1. No vehicles over 7.5 tonnes (gvw) allowed in inner area between 10:00 and 16:00.	18% (22/120)
2. No vehicles over 12 tonnes (gvw) allowed in inner area between 10:00 and 16:00.	15% (18/120)
3. No vehicles over 7.5 tonnes (gvw) allowed in outer and inner area between 10:00 and 16:00.	28% (34/120)
4. No vehicles over 12 tonnes (gvw) allowed in outer and inner area between 10:00 and 16:00.	23% (28/120)

9.6.1 Results of the weight restriction scenarios by company

Tables 9.3-9.6 show the impact of scenarios 1-4 on the operational, financial, and environmental indicators on all vehicle rounds carried out by each company.

The results for each company in each of the three urban areas can be found in Appendix 6.

Table 9.3: Results of weight restriction scenario 1 by company
(No vehicles over 7.5 tonnes (gvw) allowed in inner area between 10:00 and 16:00)

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds	Was: 8 Now: 8	Was: 5 Now: 11	Was: 12 Now: 14	Was: 5 Now: 5	Was: 4 Now: 5	Was: 41 Now: 41	Was: 45 Now: 77
Number of rounds affected	0/8	1/5	2/12	0/5	1/4	0/41	18/45
Total time taken	n/c	+1%	+2%	n/c	+19%	n/c	+26%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was: 65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was: 69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	n/c	Now: 64% Now: 36%	Now: 54% Now: 46%	n/c	Now: 60% Now: 40%	n/c	Now: 45% Now: 55%
Speed per round (incl. Stops)							
Speed per round (excl. stops)							
Total distance travelled	n/c	+2%	+4%	n/c	+9%	n/c	+76%
Total vehicle operating costs	n/c	-2%	+1%	n/c	+15%	n/c	+12%
Total CO emissions	n/c	+1%	+4%	n/c	+8%	n/c	+29%
Total CO_2 emissions	n/c	+1%	+2%	n/c	+7%	n/c	+15%
Total NOx emissions	n/c	+1%	n/c	n/c	+8%	n/c	+19%
Total PM10 emissions	n/c	+2%	+4%	n/c	+12%	n/c	+110%

Table 9.4: Results of weight restriction scenario 2 by company
(No vehicles over 12 tonnes (gvw) allowed in inner area between 10:00 and 16:00)

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds	Was: 8 Now: 8	Was: 5 Now: 8	Was: 12 Now: 12	Was: 5 Now: 5	Was: 4 Now: 5	Was: 41 Now: 41	Was: 45 Now: 61
Number of rounds affected	0/8	1/5	0/12	0/5	1/4	0/41	16/45
Total time taken	n/c	-1%	n/c	n/c	+19%	n/c	+17%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was: 65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was: 69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	n/c	Now: 62% Now: 38%	n/c	n/c	Now: 60% Now: 40%	n/c	Now: 44% Now: 56%
Speed per round (incl. Stops)							
Speed per round (excl. stops)							
Total distance travelled	n/c	+1%	n/c	n/c	+9%	n/c	+52%
Total vehicle operating costs	n/c	-2%	n/c	n/c	+16%	n/c	+6%
Total CO emissions	n/c	n/c	n/c	n/c	+8%	n/c	+19%
Total CO_2 emissions	n/c	n/c	n/c	n/c	+8%	n/c	+10%
Total NOx emissions	n/c	n/c	n/c	n/c	+10%	n/c	+18%
Total PM10 emissions	n/c	+1%	n/c	n/c	+13%	n/c	+92%

Table 9.5: Results of weight restriction scenario 3 by company
(No vehicles over 7.5 tonnes (gvw) allowed in outer and inner area between 10:00 and 16:00)

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds	Was: 8 Now: 9	Was: 5 Now: 11	Was: 12 Now: 15	Was: 5 Now: 12	Was: 4 Now: 5	Was: 41 Now: 41	Was: 45 Now: 91
Number of rounds affected	1/8	1/5	3/12	2/5	1/4	0/41	26/45
Total time taken	+9%	+1%	+3%	+54%	+19%	n/c	+34%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was: 65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was: 69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	Now: 66% Now: 34%	Now: 64% Now: 36%	Now: 54% Now: 46%	Now: 73% Now: 27%	Now: 60% Now: 40%	n/c	Now: 49% Now: 51%
Speed per round (incl. stops)							
Speed per round (excl. stops)							
Total distance travelled	+5%	+2%	+5%	+44%	+9%	n/c	+99%
Total vehicle operating costs	+7%	-2%	+1%	+27%	+15%	n/c	+15%
Total CO emissions	+5%	+1%	+5%	+38%	+8%	n/c	+39%
Total CO_2 emissions	+4%	+1%	+2%	+18%	+7%	n/c	+20%
Total NOx emissions	+5%	+1%	-1%	+18%	+8%	n/c	+25%
Total PM10 emissions	+7%	+2%	+5%	+51%	+12%	n/c	+144%

Table 9.6: Results of weight restriction scenario 4 by company
(No vehicles over 12 tonnes (gvw) allowed in outer and inner area between 10:00 and 16:00)

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds Total number of rounds	Was: 8 Now: 9	Was: 5 Now: 8	Was: 12 Now: 12	Was: 5 Now: 9	Was: 4 Now: 5	Was: 41 Now: 41	Was: 45 Now: 68
Number of rounds affected	1/8	1/5	0/12	2/5	1/4	0/41	23/45
Total time taken	+9%	-1%	n/c	+39%	+19%	n/c	+23%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was: 65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was: 69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	Now: 66% Now: 34%	Now: 62% Now: 38%	n/c	Now: 72% Now: 28%	Now: 60% Now: 40%	n/c	Now: 46% Now: 54%
Speed per round (incl. stops)							
Speed per round (excl. stops)							
Total distance travelled	+5%	+1%	n/c	+31%	+9%	n/c	+67%
Total vehicle operating costs	+8%	-2%	n/c	+21%	+16%	n/c	+8%
Total CO emissions	+5%	n/c	n/c	+28%	+8%	n/c	+25%
Total CO_2 emissions	+5%	n/c	n/c	+13%	+8%	n/c	+14%
Total NOx emissions	+6%	n/c	n/c	+15%	+10%	n/c	+24%
Total PM10 emissions	+7%	+1%	n/c	+40%	+13%	n/c	+120%

9.6.2 Discussion of results of the weight restriction scenarios by company

- The companies are affected very differently by the weight restriction policy measures.

- Companies D and G are worst affected by the weight restriction scenarios. The environmental impacts of their operations increase significantly as a result of the increase in distance travelled and pollutant emissions.

- Company F is completely unaffected by all weight restriction scenarios, despite the fact that it operates many rounds in the inner area. This is because the vehicle weight used by company G is below the restriction.

- If a vehicle round is affected by these weight restriction scenarios, then this collection/delivery work will have to be carried out using lighter vehicles. Therefore, the work that was previously done on one vehicle round, would require more than one vehicle round, and this would result in increases in distance travelled and pollutant emissions. However, this assumes that companies continue to operate diesel-powered vehicles. By switching to the use of electric vehicles or other alternatively fuelled vehicles it would be possible to reduce the total pollutants emitted despite the increase in distance. However the use of electric vehicles is only likely to be possible when vehicles are operating from a relatively local depot.

Scenario 1 (inner area, 7.5 tonnes)

- In scenario 1 the original 120 vehicle rounds become 161 vehicle rounds.

- The results of scenario 1 indicates that the effect of such a weight restriction would have differing impacts on the companies. Worst affected in company G with their vehicle rounds increasing from 45 to 77. The total distance travelled by company G would increase by approximately 80%, resulting in a significant increase in pollutant emissions on the rounds.

- Company F is completely unaffected by scenario 1, despite the fact that it operates many rounds in the inner area. This is because the vehicle weight used by company F is below the restriction.

- For companies affected by scenario 1, total time taken, distance travelled and pollution can be seen to increase. However the overall effect on most companies is relatively small as only a small proportion of their rounds are affected.

- The economic impact of scenario 1 on company B is underestimated, as it is assumed that in this case goods are transhiped onto larger on the edge of the urban area for the affected vehicle round. However the cost of the transhipment centre are not included in the estimated vehicle operating costs. Taking this into account, costs would be expected to increase rather than fall.

Scenario 2 (inner area, 12 tonnes)

- As would be expected the effects of this scenario are less pronounced than for the 7.5 tonne restriction in scenario 1.

- The original 120 vehicle rounds become 140 vehicle rounds in scenario 2.

- Only companies B, E and G have any rounds affected by scenario 2, and for company E only one round is affected.

Scenario 3 (inner and outer area, 7.5 tonnes)

- As would be expected scenario 3 (outer and inner area, 7.5 tonne restriction) affects more vehicle rounds than any other weight restriction scenario. Companies D and G are worst affected. The environmental impacts of their operations increase significantly as a result of the increase in distance travelled and pollutant emissions.

- The original 120 vehicle rounds become 184 vehicle rounds in scenario 3.

Scenario 4 (inner and outer area, 12 tonnes)

- The original 120 vehicle rounds become 152 vehicle rounds in scenario 4.

Comments on company B

As explained in the assumptions (see section 9.3) in the case of company B it was assumed that, given the distance between their depot and the urban areas served, rather than operate several lighter vehicles from their national depot to each urban area, on any rounds affected by the weight restriction scenarios they would continue to use a heavy vehicle between the depot and the edge of the urban area and then tranship the goods onto lighter vehicles for delivery in the urban area.

The results were also calculated in which it was assumed that vehicles that met the weight restrictions for each scenario operated from the depot to the urban areas. As would be expected, this produced much worse results both from a company and an environmental perspective.

The difference in results depending on the distribution operation used by company B is summarised in Table 9.7.

However, it should be noted that the costs calculated in first solution described above do not include the costs of a transhipment centre, only the costs of the vehicles and drivers. Therefore the costs in the right hand column of Table 9.7 (and in Table 9.3) are an underestimate.

Table 9.7: Results of weight restriction scenario 1 for all rounds performed by company B

	Scenario 1	
	Lighter vehicles from depot to urban area	**Existing heavy vehicle to urban edge and lighter vehicles for final delivery**
Total time taken	+95%	+1%
Total distance travelled	+164%	+2%
Total vehicle operating costs	+75%	-2%
Total CO emissions	+119%	+1%
Total CO_2 emissions	+84%	+1%
Total NOx emissions	+82%	+1%
Total PM10 emissions	+161%	+2%

9.6.3 Results of the weight restriction scenarios by urban area

Tables 9.8-9.11 show the impact of scenarios 1-4 on the operational, financial, and environmental indicators on all vehicle rounds studied in the three urban areas.

Table 9.8: Results of weight restriction scenario 1 by urban area
(No vehicles over 7.5 tonnes (gvw) allowed in inner area between 10:00 and 16:00)

	Basingstoke	Birmingham	Norwich
Total number of rounds	Was: 20 rounds	Was: 57 rounds	Was: 43 rounds
Total number of rounds	Now: 27 rounds	Now: 75 rounds	Now: 59 rounds
Number of rounds affected	4/20	10/57	8/43
Total time taken	+13%	+6%	+4%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 54% Was: 46%	Was: 46% Was: 54%	Was: 43% Was: 57%
New driving time as % of total New stationary time as % of total	Now: 56% Now: 44%	Now: 49% Now: 51%	Now: 44% Now: 56%
Speed per round (incl. Stops)			
Speed per round (excl. stops)			
Total distance travelled	+23%	+14%	+7%
Total vehicle operating costs	+11%	+4%	n/c
Total CO emissions	+12%	+6%	+3%
Total CO2 emissions	+7%	+4%	n/c
Total NOx emissions	+8%	+4%	n/c
Total PM10 emissions	+32%	+14%	+8%

Table 9.9: Results of weight restriction scenario 2 by urban area
(No vehicles over 12 tonnes (gvw) allowed in inner area between 10:00 and 16:00)

	Basingstoke	Birmingham	Norwich
Total number of rounds	Was: 20 rounds	Was: 57 rounds	Was: 43 rounds
Total number of rounds	Now: 24 rounds	Now: 66 rounds	Now: 50 rounds
Number of rounds affected	4/20	9/57	5/43
Total time taken	+11%	+4%	+1%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 54% Was: 46%	Was: 46% Was: 54%	Was: 43% Was: 57%
New driving time as % of total New stationary time as % of total	Now: 55% Now: 45%	Now: 48% Now: 52%	Now: 44% Now: 56%
Speed per round (incl. Stops)			
Speed per round (excl. stops)			
Total distance travelled	+17%	+9%	+3%
Total vehicle operating costs	+9%	+2%	-2%
Total CO emissions	+9%	+4%	n/c
Total CO2 emissions	+6%	+3%	-1%
Total NOx emissions	+8%	+4%	n/c
Total PM10 emissions	+28%	+12%	+5%

Table 9.10: Results of weight restriction scenario 3 by urban area
(No vehicles over 7.5 tonnes (gvw) allowed in outer and inner area between 10:00 and 16:00)

	Basingstoke	Birmingham	Norwich
Total number of rounds	Was: 20 rounds	Was: 57 rounds	Was: 43 rounds
Total number of rounds	Now: 28 rounds	Now: 92 rounds	Now: 64 rounds
Number of rounds affected	5/20	18/57	11/43
Total time taken	+24%	+17%	+4%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 54% Was: 46%	Was: 46% Was: 54%	Was: 43% Was: 57%
New driving time as % of total New stationary time as % of total	Now: 56% Now: 44%	Now: 52% Now: 48%	Now: 45% Now: 55%
Speed per round (incl. Stops)			
Speed per round (excl. stops)			
Total distance travelled	+33%	+32%	+8%
Total vehicle operating costs	+20%	+12%	n/c
Total CO emissions	+21%	+19%	+3%
Total CO2 emissions	+13%	+12%	n/c
Total NOx emissions	+17%	+14%	n/c
Total PM10 emissions	+48%	+37%	+9%

Table 9.11: Results of weight restriction scenario 4 by urban area
(No vehicles over 12 tonnes (gvw) allowed in outer and inner area between 10:00 and 16:00)

	Basingstoke	Birmingham	Norwich
Total number of rounds	Was: 20 rounds	Was: 57 rounds	Was: 43 rounds
Total number of rounds	Now: 25 rounds	Now: 75 rounds	Now: 52 rounds
Number of rounds affected	5/20	16/57	7/43
Total time taken	+21%	+11%	+1%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 54% Was: 46%	Was: 46% Was: 54%	Was: 43% Was: 57%
New driving time as % of total New stationary time as % of total	Now: 56% Now: 44%	Now: 50% Now: 50%	Now: 44% Now: 56%
Speed per round (incl. Stops)			
Speed per round (excl. stops)			
Total distance travelled	+27%	+21%	+4%
Total vehicle operating costs	+18%	+7%	-2%
Total CO emissions	+19%	+13%	n/c
Total CO2 emissions	+13%	+8%	-1%
Total NOx emissions	+19%	+12%	n/c
Total PM10 emissions	+46%	+29%	+6%

9.6.4 Discussion of results of the weight restriction scenarios by urban area

- The results suggest that the weight restriction scenarios would results in some differences in the three urban areas in terms of: (i) the proportion of vehicle rounds affected by each scenario, (ii) the proportional increase in vehicle rounds that would be necessary to carry out the same amount of collection and delivery work, and (iii) the effect of each scenario on the total distribution costs, time taken, distance travelled and pollutant emission levels.

- Scenario 1 (inner area, 7.5 tonnes) would affect approximately the same proportion of vehicle rounds in all three urban areas (approximately 20%).

- Scenario 2 (inner area, 12 tonnes) would affect approximately 10% of the vehicle rounds studied in Norwich, 15% in Birmingham and 20% in Basingstoke.

- Scenario 3 (inner and outer area, 7.5 tonnes) would affect approximately 25-30% of vehicle rounds in each of the urban areas.

- Scenario 4 (inner and outer area, 12 tonnes) would affect 25-30% of vehicle rounds in Basingstoke but only approximately 15% of vehicle rounds in Norwich.

- In terms of the effects of the scenarios on total distribution activity in the urban areas, the results suggest that the impact would be greatest in Basingstoke, and least in Norwich (in terms of increases in vehicle operating costs, time taken, distance travelled, and pollutant emissions).

- The results suggest that the weight restriction scenarios would be expected to result in increases in the environmental impacts of the companies' distribution activity in each of the urban areas.

- It should be noted that in the case of company B it was assumed that, given the distance between their depot and the urban areas served, rather than operate several lighter vehicles from their national depot to each urban area, on any rounds affected by the weight restriction scenarios they would continue to use a heavy vehicle between the depot and the edge of the urban area and then tranship the goods onto lighter vehicles for delivery in the urban area. The operating costs calculated for this company do not include the costs of a transhipment centre, only the costs of the vehicles and drivers. Therefore these costs are an underestimate. (see section 9.3 for further details). Only one vehicle round operated by company B was affected by the weight restriction scenarios and this round takes place in Norwich (this round was affected by all four scenarios). Therefore the results showing the effect of each the scenarios on vehicle operating costs in Norwich will be underestimated.

9.6.5 Sensitivity analysis - weight of vehicles to which restrictions apply

In the four scenarios modelled, it was assumed that the weight restrictions would affect vehicles either over 7.5 tonne (gvw) or over 12 tonnes (gvw). However further work was conducted to examine the number of vehicle rounds that would be affected if the weight restriction was only applied to vehicles over 18 tonnes (gvw). The results for inner area weight restrictions are shown in Table 9.12. Inner and outer area weight restrictions are shown in Table 9.13.

Table 9.12: Number of vehicle rounds affected by different inner area weight restrictions

Vehicle weight	Coverage of weight restrictions	Rounds affected
Not above 7.5t	Inner area	18% (22/120 rounds)
Not above 12t	Inner area	15% (18/120 rounds)
Not above 18t	Inner area	14% (17/120 rounds)

Table 9.13: Number of vehicle rounds affected by different inner and outer area weight restrictions

Vehicle weight	Coverage of weight restrictions	Rounds affected
Not above 7.5t	Inner and outer area	28% (34/120 rounds)
Not above 12t	Inner and outer area	23% (28/120 rounds)
Not above 18t	Inner and outer area	23% (27/120 rounds)

The results indicate that if the weight restriction was 18 tonnes rather than the 12 tonne restriction modelled in scenarios 2 and 4, the total number of vehicle rounds affected would be almost identical. This is because few vehicles between 12 and 18 tonnes were being used by the companies in the project. Therefore the impact of a 12 tonne and 18 tonne weight restriction would very similar outcomes for the vehicle rounds studied in the three urban areas.

10. ANALYSIS OF VEHICLE ACCESS TIME RESTRICTIONS

10.1 Explanation of the vehicle access time restriction measure

Vehicle access time restrictions were also analysed for the three urban areas. In this policy measure no goods vehicles would be permitted to enter a specific geographical area within the urban area to make collections and deliveries during a large period of the working day.

The aim of such a measure would be to prevent goods vehicles of any weight entering the chosen area when pedestrians and other road users are present. This could help to reduce the impacts that it is commonly perceived that goods vehicles cause, such as pollution, intimidation, safety concerns, vibrations and noise.

10.2 Discussion of the vehicle access time restriction measure

There has been a significant increase in the number and size of pedestrianised areas in the UK in the last ten years, especially in high streets and retailing areas. It is believed that pedestrians' experience of these areas is improved by removing vehicles (through a reduction in pollution, noise, vibration, visual intrusion, mobility and safety).

Such time restrictions tend to prevent all vehicles (including goods vehicles) from entering the area in question for a major part of the working day, often from 10:00 to 16:00. Many of the premises located in these pedestrianised areas have no alternative access facilities so any goods or services that need to be supplied to or collected from the premises must either be provided at the times when vehicles are allowed access or supplied on foot. This can cause particular problems for freight transport. Pedestrianised areas already exist in a small number of streets in the centres of Norwich, Basingstoke and Birmingham.

It should be noted that in this time restriction policy measure, we are testing a geographical area (which we have defined as the inner area) that is far greater than current pedestrianised areas in most UK towns and cities.

Vehicle access time restrictions reduce the times during the working day that vehicles can enter designated areas to carry out freight work. Coupled with time restrictions imposed by customers and receivers, this can result in distribution companies having very little time in which to perform their work and placing their operations under significant strain.

There are only a few options available to companies when facing access time restrictions across a relatively large geographical area in a town or city:

i. Attempt to continue delivering and collecting goods during the working day. This could be achieved by compressing the time in which collections and deliveries take place, by operating a greater total number of vehicle rounds. These could take place, for instance, between 08:00–10:00 and/or 16:00-18:00;
ii. Deliver and collect goods in the restricted urban area during the night;
iii. The company could continue to operate vehicle rounds at its current times and then drivers would park the vehicles on the edge of restricted area and deliver the goods on foot;
iv. The company could deliver goods destined for the restricted area to a bicycle delivery company based on the edge of the restricted area. The goods could be delivered from this depot during the day using bicycles. This option has not been modelled in the report.

The first option listed above would help to minimise the impact of the access time restrictions on senders and receivers of goods. In this approach, goods would still be delivered within

most companies' working day and would therefore result in relatively few operational implications for receivers or senders. Also receivers would be likely to have staff present at these times so would incur no additional staff costs for receiving goods. However this solution is likely to increase distribution costs.

The second option listed above of delivering out-of-hours (i.e. during the night) would require co-ordination and agreement between distribution companies and the senders and receivers of the goods. Many premises receiving deliveries or requiring collections of goods do not currently allow this activity to take place outside of their normal working hours. The main reasons for this are that they are either: (i) do not have facilities to ensure the security of their premises if their staff are not present at the time of delivery, (ii) are worried about the accuracy of deliveries if their staff are not present, or (iii) do not want to have to pay to have their staff present during the night.

There are three possible solutions to their concerns about the security of their premises if receiving out-of-hours deliveries:

- employ staff to be present at the premises at the time of the delivery;
- provide door keys to the premises to the delivery company and make changes to their premises so that the keys only provide access to a delivery/collection area inside the front or back door rather than to the whole premises;
- install some type of lockable box or receptacle outside the premises or attached to the premises into which goods can be delivered to or collected from.

None of these solutions are widely used by receivers as they are all perceived as costing more than their current delivery arrangements (either in terms of the labour requirements, the cost of changing the layout of the premises or the cost of a depository box).

By delivering at night it would be possible to continue with similar vehicle rounds in terms of the number of deliveries on the round and the size of vehicle used, except that they would take place at a different time (i.e. during the night). This may also lead to some benefits including faster and more reliable journey times. However driver wages may well increase (i.e. night wages) and it presents a delivery problem.

The third and fourth options (of delivery by foot) are unlikely to prove attractive to distribution companies on a large scale. It already happens to some extent in existing urban operations where a particular shop is difficult to reach by vehicle, or where an emergency delivery is required by a shop in a pedestrianised area. However to introduce this as a solution on a wider scale would be likely to significantly increase the time taken to make collections and deliveries, and hence also to significantly increase total distribution costs. Some products would be completely unsuited to this approach. Also, this approach would only be likely to be operationally feasible for parcels and other small, relatively light-weight deliveries.

Some companies already operate rounds that are either unaffected because of the times at which they take place or the company could easily cope with the time restriction by making a minor modification to the round (by either altering the delivery sequence or sending out the vehicles a few minutes earlier). There is no need to alter these rounds.

10.3 Specific scenarios tested for the vehicle access time restriction measure

The following four scenarios were tested for the access time restriction measure:

1. No goods vehicles of any size/weight (including light goods vehicles) are allowed in inner area between 10:00 and 16:00. Instead collection and delivery work on affected rounds is still carried out but either at the beginning or end of the working day;

2. No goods vehicles of any size/weight (including light goods vehicles) are allowed in inner area between 10:00 and 16:00. Instead collection and delivery work on affected rounds is carried out during the night. Driving times are 15% lower in the urban area and 5% lower on motorways and "A" roads due to working at night, drivers' wages remain the same;

3. No goods vehicles of any size/weight (including light goods vehicles) are allowed in inner area between 10:00 and 16:00. Instead collection and delivery work on affected rounds is carried out during the night. Driving times are 15% lower in the urban area and 5% lower on motorways and "A" roads due to working at night, drivers' wages are 20% higher (i.e. same as scenario 2 except driver wages 20% higher);

4. All goods vehicles of any size/weight (including light goods vehicles) are allowed in inner area at any time (i.e. all existing restrictions in force in the three urban areas are removed - such as current time restrictions in pedestrian areas).

It was decided by the project team that it was inappropriate to model scenarios that covered the outer area as well as the inner area, as such a policy measure is unlikely to be implemented over such a large area. Therefore only scenarios concerned with the inner area were analysed.

10.4 Assumptions made in modelling the vehicle access time restriction measure

In scenario 1 it was assumed that companies have a two-hour morning and afternoon window in which to carry out their delivery and collection work (i.e. 08:00-10:00 and 16:00-18:00). This is based on the earliest time from which most companies accept deliveries (08:00) and when the restriction takes affect (10:00). The afternoon window is based on when the restriction ends (16:00) and when most companies stop accepting deliveries at present (18:00). We then calculated how many vehicle rounds the company would need to operate in the inner area in the two-hour window in order to satisfy all their collections/deliveries. In some cases this remained at one vehicle round, in other cases more than one vehicle round would be required. If companies needed to increase the number of vehicle rounds they perform in the inner area, they may well be able to reduce the size/weight of the vehicles they use. Changes to the weight of vehicles used by companies in the inner area have been made in the modelling in such cases.

In scenario 1 the outcome for affected companies is to produce more vehicle rounds than were originally operated. The same distance and driving time conversion factors were used as in the weight restriction measure (see section 6.4.4).

As in the weight restriction scenarios, any rounds operated by company B that were affected by scenario 1 of the time restrictions measure were treated differently than other companies. It was assumed that, given the distance between their depot and the urban areas served, rather than operate several lighter vehicles from their national depot to each urban area, on any rounds affected by the weight restriction scenarios they would continue to use a heavy vehicle between the depot and the edge of the urban area at night and then tranship the goods onto lighter vehicles for delivery in the urban area during the two-hour window in the morning.

However, the costs calculated in this case do not include the costs of a transhipment centre, only the costs of the vehicles and drivers. Therefore the costs are an underestimate.

If vehicle rounds affected by the time restrictions were carried out at night rather than during the day, travel speeds would be likely to improve. However, it may also be necessary to pay increased drivers wages for night work. Therefore scenario 2 assumes reductions in driving times of 5% on vehicle rounds with the majority of their distance on "A" roads and motorways, and 15% on vehicle rounds that take place wholly within an urban area. Drivers' wages were assumed to remain unchanged in this scenario.

In scenario 3 the same assumptions were made about reductions in driving time, but drivers' wages were assumed to increase by 20% when working at night (FTA, 2002).

Reductions in driving time were based on consulting comparisons of night and day time traffic speed data in Britain (DfT, 2001).

Receivers would also have higher costs for accepting goods at night but this has not been included in the modelling.

10.5 Company responses

The companies felt that this policy measure would be the most problematic of all the measures for them to cope with. They predicted that it would cause them significant operational problems, and were very concerned about its likely impact on customer service.

When discussing the access time measure in general several of the companies struggled to see how they could offer a satisfactory service at an affordable price.

The companies carrying out dedicated distribution operations from a single national distribution centre felt that a scenario that only provided them with a very small delivery window (and which would therefore force them to despatch a large number of lighter vehicles) would be likely to result in very large cost increases that would be unacceptable. If the costs of using more vehicles from the existing national depot were too high, it would be necessary to fundamentally alter the distribution network. This may involve establishing depots closer to the urban areas and using a completely different fleet of vehicles.

The companies felt that it would be possible to get most senders and receivers of goods to accept collections and deliveries between 08:00-10:00 and 16:00-18:00. However they felt that as things currently stand, it would not be possible to get a large proportion of senders and receivers to accept night collections and deliveries (even though this may well be preferable to them as distribution companies).

All of the companies felt that a removal of any existing time restrictions in the three urban areas (scenario 4) would help to some extent to relieve current pressures on their operations. However, they did not think that it would necessarily result in them being able to improve their efficiency, and hence may not lead to cost savings for them. This was due to the fact that they would still continue to offer the same service level in their operations, and this would leave the operation largely unaffected. Also, in the case of dedicated distribution operations it is not possible to carry out more delivery or collection work in the urban area as the delivery/collection points are fixed. Some of the companies felt that it is possible that a vehicle may be able to carry out slightly more collection and delivery work on a round if existing time restrictions were lifted, as long as the vehicle was not already full when despatched.

10.6 Results of the modelling of the vehicle access time restriction measure

Table 10.1 shows the effects of the introduction of the access time restriction measure on vehicle rounds and the related impact on the indicators analysed.

Table 10.1: Effects of access time restrictions and impact on indicators

Effect on vehicle rounds	Impact on indicators
Scenario 1: making collections & deliveries in a smaller time window Greater number of vehicle rounds required to make the same number of collections and deliveries in each urban area	Increase in total number of vehicle rounds Increase in total distance travelled Increase in total time taken Change in total operating costs Change in total pollutant emissions
Scenarios 2 and 3: making collections and deliveries at night Higher driver wages Faster and more reliable journeys	Change in total operating costs
Scenario 4: all existing time restrictions removed According to companies, vehicle rounds would not change in this scenario	No effect

In total 55 vehicle rounds are affected by scenarios 1, 2 and 3 (i.e. 46% of all vehicle rounds). In some cases it is possible for companies to adjust the start time of an affected round to take between 08:00-10:00 or 1600-18:00, so that although the time of the round changes everything else remains the same.

On other existing vehicle rounds it takes longer than two hours to make all the collections and deliveries in the inner area. In these cases one existing vehicle round would have to become more than one vehicle round for all the collections and deliveries to take place within a two-hour window.

10.6.1 Results of the access time restriction scenarios by company

Tables 10.2-10.4 show the impact of scenarios 1-3 on the operational, financial, and environmental indicators on all vehicle rounds carried out by each company.

The results for each company in each of the three urban areas can be found in Appendix 6.

Table 10.2: Results of time restriction scenario 1 by company
(No goods vehicles of any size/weight (including light goods vehicles) are allowed in inner area between 10:00 and 16:00. Instead collection and delivery work on affected rounds is still carried out but either at the beginning or end of the working day)

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds Total number of rounds	Was: 8 Now: 8	Was: 5 Now: 7	Was: 12 Now: 20	Was: 5 Now: 5	Was: 4 Now: 5	Was: 41 Now: 59	Was: 45 Now: 54
Number of rounds affected	0/8	1/5	5/12	0/5	1/4	29/41	19/45
Total time taken	n/c	-2%	+11%	n/c	+19%	+10%	+9%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was: 65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was: 69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	n/c	Now: 61% Now: 39%	Now: 56% Now: 44%	n/c	Now: 60% Now: 40%	Now: 46% Now: 54%	Now: 41% Now: 59%
Speed per round (incl. Stops)							
Speed per round (excl. stops)							
Total distance travelled	n/c	n/c	+18%	n/c	+9%	+21%	+20%
Total vehicle operating costs	n/c	-3%	+4%	n/c	+12%	+7%	+1%
Total CO emissions	n/c	n/c	-4%	n/c	+4%	n/c	+7%
Total CO_2 emissions	n/c	n/c	-6%	n/c	+4%	n/c	+3%
Total NOx emissions	n/c	n/c	-23%	n/c	+1%	-32%	+5%
Total PM10 emissions	n/c	n/c	-13%	n/c	+4%	-15%	+30%

Table 10.3: Results of time restriction scenario 2 by company
(No goods vehicles of any size/weight (including light goods vehicles) are allowed in inner area between 10:00 and 16:00. Instead collection and delivery work on affected rounds is carried out during the night. Driving times are 15% lower in the urban area and 5% lower on motorways and "A" roads due to working at night, drivers' wages remain the same)

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	0 / 8	1 / 5	5 / 12	0 / 5	1 / 4	29 / 41	19 / 45
Total time taken	n/c	-1%	-4%	n/c	-1%	-3%	-3%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was: 65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was: 69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	n/c	n/c	Now: 52% Now: 48%	n/c	Now: 68% Now: 32%	Now: 38% Now: 62%	Now: 37% Now: 63%
Speed per round (incl. stops)	n/c	+1%	+3%	n/c	+1%	+4%	+4%
Speed per round (excl. stops)	n/c	+1%	+6%	n/c	+1%	+12%	+7%
Total distance travelled							
Total vehicle operating costs	n/c	-1%	-4%	n/c	-1%	-3%	-2%
Total CO emissions	n/c	n/c	-6%	n/c	n/c	-4%	-2%
Total CO_2 emissions	n/c	n/c	-3%	n/c	n/c	-3%	-5%
Total NOx emissions	n/c	n/c	-5%	n/c	n/c	-5%	-5%
Total PM10 emissions	n/c	n/c	-5%	n/c	n/c	-4%	-4%

Table 10.4: Results of time restriction scenario 3 by company
(No goods vehicles of any size/weight (including light goods vehicles) are allowed in inner area between 10:00 and 16:00. Instead collection and delivery work on affected rounds is carried out during the night. Driving times are 15% lower in the urban area and 5% lower on motorways and "A" roads due to working at night, drivers' wages are 20% higher (i.e. same as scenario 2 except driver wages 20% higher))

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	0 / 8	1 / 5	5 / 12	0 / 5	1 / 4	29 / 41	19 / 45
Total time taken	n/c	-1%	-4%	n/c	-1%	-3%	-3%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was: 65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was: 69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	n/c	n/c	Now: 52% Now: 48%	n/c	Now: 68% Now: 32%	Now: 38% Now: 62%	Now: 37% Now: 63%
Speed per round (incl. Stops)	n/c	+1%	+3%	n/c	+1%	+4%	+4%
Speed per round (excl. stops)	n/c	+1%	+6%	n/c	+1%	+12%	+7%
Total distance travelled							
Total vehicle operating costs	n/c	+1%	+3%	n/c	+3%	+4%	+3%
Total CO emissions	n/c	n/c	-6%	n/c	n/c	-4%	-2%
Total CO_2 emissions	n/c	n/c	-3%	n/c	n/c	-3%	-5%
Total NOx emissions	n/c	n/c	-5%	n/c	n/c	-5%	-5%
Total PM10 emissions	n/c	n/c	-5%	n/c	n/c	-4%	-4%

10.6.2 Discussion of results of the time restriction scenarios by company

Scenario 1 (collections and deliveries in inner area carried out between 08:00-10:00 and 16:00-18:00)

- The original 120 vehicle rounds become 159 vehicle rounds in scenario 1.

- Companies are affected very differently by scenario 1. While the scenario has no effect on two companies and little effect one other, three companies experience relatively large changes to their operations (companies C, F and G). The results suggest that for one of these companies (G), their environmental impact would increase as both their total distance travelled and pollution levels would increase. However, for two of these companies (C and F) the environmental impact would be less certain. This is because the total distance that they travel would increase due to the need to carry out more vehicle rounds but some of their pollutant levels would decrease due to their use of lighter vehicles. This outcome is due to the relationship between vehicle weight and emission levels for various pollutants in the NERA Report (2000). This emissions data shows significant differences in NOx and CO_2 pollution levels for 3.5-7.5 tonne (gvw) vehicles and 7.5-12 tonne (gvw) vehicles. Therefore if, as in this scenario, a company switched from using vehicles with a gross weight of 7.5-12 tonnes to vehicles with a gross weight of 3.5–7.5 tonnes, even though total distance travelled may increase, according to the data in the emissions tables, the overall emission levels for certain pollutants could fall.

- Compressing vehicle rounds into a shorter period of the working day in order to comply with time restrictions is likely to result in some companies operations becoming more expensive as well as more environmentally damaging.

Scenarios 2 and 3 (collections and deliveries in the inner area during the night)

- If, as in scenario 2, drivers' wages remain the same, the results indicate that carrying out the rounds at night would lead to time savings and reductions in operating costs for all of

the companies with affected rounds. However, to perform the rounds at night would require agreement from customers and receivers and may well cause them greater costs.

- Scenario 3 shows that if drivers' wages were to increase by 20% when working at night, this would more than outweigh the value of the time savings for all the companies, resulting in higher vehicle operating costs for companies.

- The results indicate that carrying out vehicle rounds at night in order to meet time restrictions is likely to have environmental benefits in terms of reduced pollution (due to improved speed). Whether or not operating at night would lead to more or less expensive distribution operations depends on the relationship between the level of time savings and the increase in drivers' wages.

- In addition collections and deliveries at night would require agreement from senders and receivers of goods in the case of third party distribution. It would incur additional costs at the receiving premises either in terms of labour or the capital costs of equipping the premises with secure deposit facilities.

- Our previous research findings suggest that one of the main factors preventing receivers from accepting out-of-hours deliveries is this additional cost that this would incur them in (Allen et al., 2000). Another difficulty is that some sites are unable to receive deliveries at night due to planning restrictions. It is therefore necessary for distribution companies and receivers to find a way to share any cost saving made by the distribution company to help compensate the receiver for the additional costs they have to bear.

- In addition, introducing night collection and delivery work is only likely to be operationally and commercially feasible from many distribution companies' perspectives if a sufficient number of receivers accept deliveries at these times. Otherwise distribution companies will have to operate rounds during the working day as well as rounds at night.

Scenario 4 (lifting of all existing vehicle access time restrictions in the inner area)

- In this scenario all goods vehicles of any size/weight (including light goods vehicles) are allowed in the inner area at any time (i.e. all existing restrictions in force in the three urban areas are removed - such as current time restrictions in pedestrian areas).

- None of the companies felt that scenario 4 would result in changes to their distribution operations even though it would relieve some of the current pressures on their operations. It was therefore expected that vehicle rounds would continue unaltered. Therefore no results table has been included for this scenario.

10.6.3 Results of the access time restriction scenarios by urban area

Tables 10.5-10.7 show the impact of scenarios 1-3 on the operational, financial, and environmental indicators on all vehicle rounds studied in the three urban areas.

Table 10.5: Results of time restriction scenario 1 by urban area
(No goods vehicles of any size/weight (including light goods vehicles) are allowed in inner area between 10:00 and 16:00. Instead collection and delivery work on affected rounds is still carried out but either at the beginning or end of the working day)

	Basingstoke	**Birmingham**	**Norwich**
Total number of rounds	Was: 20 rounds	Was: 57 rounds	Was: 43 rounds
Total number of rounds	Now: 25 rounds	Now: 69 rounds	Now: 65 rounds
Number of rounds affected	10/20	21/57	24/43
Total time taken	+17%	+5%	+10%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 54% Was: 46%	Was: 46% Was: 54%	Was: 43% Was: 57%
New driving time as % of total New stationary time as % of total	Now: 55% Now: 45%	Now: 49% Now: 51%	Now: 46% Now: 54%
Speed per round (incl. Stops)			
Speed per round (excl. stops)			
Total distance travelled	+15%	+8%	+15%
Total vehicle operating costs	+10%	+2%	+2%
Total CO emissions	+7%	+1%	+1%
Total CO2 emissions	+5%	+1%	-1%
Total NOx emissions	+1%	-1%	-6%
Total PM10 emissions	+9%	+2%	n/c

Table 10.6: Results of time restriction scenario 2 by urban area
(No goods vehicles of any size/weight (including light goods vehicles) are allowed in inner area between 10:00 and 16:00. Instead collection and delivery work on affected rounds is carried out during the night. Driving times are 15% lower in the urban area and 5% lower on motorways and "A" roads due to working at night, drivers' wages remain the same)

	Basingstoke	**Birmingham**	**Norwich**
Total number of rounds			
Number of rounds affected	10 / 20	21 / 57	24 / 43
Total time taken	-2%	-1%	-4%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 54% Was: 46%	Was: 46% Was: 54%	Was: 43% Was: 57%
New driving time as % of total New stationary time as % of total	Now: 53% Now: 47%	Now: 44% Now: 56%	Now: 41% Now: 59%
Speed per round (incl. Stops)	+3%	+2%	+3%
Speed per round (excl. stops)	+6%	+6%	+8%
Total distance travelled			
Total vehicle operating costs	-1%	-1%	-3%
Total CO emissions	n/c	-1%	-2%
Total CO2 emissions	-2%	-1%	-1%
Total NOx emissions	-2%	-1%	-2%
Total PM10 emissions	-1%	-1%	-3%

Table 10.7: Results of time restriction scenario 3 by urban area
(No goods vehicles of any size/weight (including light goods vehicles) are allowed in inner area between 10:00 and 16:00. Instead collection and delivery work on affected rounds is carried out during the night. Driving times are 15% lower in the urban area and 5% lower on motorways and "A" roads due to working at night, drivers' wages are 20% higher (i.e. same as scenario 2 except driver wages 20% higher))

	Basingstoke	Birmingham	Norwich
Total number of rounds			
Number of rounds affected	10 / 20	21 / 57	24 / 43
Total time taken	-2%	-1%	-4%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 54% Was: 46%	Was: 46% Was: 54%	Was: 43% Was: 57%
New driving time as % of total New stationary time as % of total	Now: 53% Now: 47%	Now: 44% Now: 56%	Now: 41% Now: 59%
Speed per round (incl. Stops)	+3%	+2%	+3%
Speed per round (excl. stops)	+6%	+6%	+8%
Total distance travelled			
Total vehicle operating costs	+2%	+2%	+3%
Total CO emissions	N/c	-1%	-2%
Total CO2 emissions	-2%	-1%	-1%
Total NOx emissions	-2%	-1%	-2%
Total PM10 emissions	-1%	-1%	-3%

10.6.4 Discussion of results of the access time restriction scenarios by urban area

Scenario 1 (collections and deliveries in inner area carried out between 08:00-10:00 and 16:00-18:00)

- Scenario 1 would affect a greater proportion of vehicle rounds in Norwich (55%) and Basingstoke (50%) than in Birmingham (37%). This is because a smaller proportion of the companies' rounds enter the inner area in Birmingham. This is explained by the comparative geographical size of the three urban areas.

- In order to carry out all the collection and delivery work in a two-hour window the total number of vehicle rounds would be expected to increase by 51% in Norwich, 38% in Birmingham, and 25% in Basingstoke. The increase in the proportion of vehicle rounds is lowest in Basingstoke as the time these rounds spend in the inner area tends to be less than rounds in Birmingham and Norwich. Therefore in Basingstoke it is more likely that a single vehicle round could carry out the necessary collections and deliveries in a two-hour window than in the case of rounds in Norwich and Birmingham (where it would more commonly be necessary to operate additional vehicle rounds to ensure that all the work was completed).

- Vehicle operating costs are however expected to increase most in Basingstoke. This is due largely to the impact of the scenario on company E. This company would have to despatch additional vehicle rounds from its regional depot which would only visit Basingstoke in order to meet the two-hour window. It currently serves Basingstoke as part of multi-drop rounds that cover a large area of southern England.

- It should be noted that, as with the weight restriction scenarios, the increase in vehicle operating costs in Norwich are an underestimate. This is because the costs of a transhipment centre have not been included in the costs of company B's affected vehicle rounds in Norwich (see section 9.3 for further details).

Scenarios 2 and 3 (collections and deliveries in the inner area during the night)

- As with scenario 1, scenarios 2 and 3 would affect a greater proportion of vehicle rounds in Norwich and Basingstoke than in Birmingham due to the greater geographical size of the latter.

- If drivers' wages are unchanged (scenario 2), the results indicate that carrying out the rounds at night would lead to relatively similar time savings and reductions in operating costs in each of the urban areas.

- If drivers' wages were to increase by 20% due to night working (scenario 3), this would be expected to result in higher total vehicle operating costs in all three urban areas.

- The results indicate that carrying out vehicle rounds at night in order to meet time restrictions is likely to have environmental benefits in terms of slightly reduced pollution (due to improved speed) on vehicle rounds in all the urban areas.

Scenario 4 (lifting of all existing vehicle access time restrictions in the inner area)

- In this scenario all goods vehicles of any size/weight (including light goods vehicles) are allowed in the inner area at any time (i.e. all existing restrictions in force in the three urban areas are removed - such as current time restrictions in pedestrian areas).

- None of the companies felt that scenario 4 would result in changes to their distribution operations even though it would relieve some of the current pressures on their operations. It was therefore expected that vehicle rounds would continue unaltered. Therefore no results table has been included for this scenario.

10.6.5 Sensitivity analysis - times at which the vehicle access restrictions are in force

In the four scenarios modelled, it was assumed that the vehicle access time restriction was in force between 10:00 and 16:00. However further work was conducted to examine the number of vehicle rounds that would be affected if the access time restrictions continued for longer than 16:00. The results for inner area access time restrictions are shown in Table 10.8. Inner and outer area access time restrictions are shown in Table 10.9.

Table 10.8: Number of vehicle rounds affected by different inner area access time restrictions

Time	Coverage of weight restrictions	Rounds affected
10:00 - 16:00	Inner area	46% (55/120 rounds)
10:00 – 17:00	Inner area	46% (55/120 rounds)
10:00 – 18:00	Inner area	46% (55/120 rounds)

Table 10.9: Number of vehicle rounds affected by different inner and outer area access time times

Time	Coverage of weight restrictions	Rounds affected
10:00 - 16:00	Inner and outer area	73% (88/120 rounds)
10:00 – 17:00	Inner and outer area	73% (88/120 rounds)
10:00 – 18:00	Inner and outer area	73% (88/120 rounds)

The results indicate that if the access time restriction was extended to 17:00 or 18:00 (rather than 16:00 as modelled in the four scenarios) this would affect exactly the same number of vehicle rounds as 16:00 in the inner area. This is because no vehicle rounds operated by the companies in the study commence their work in any of the three urban areas after 16:00. If vehicle access time restrictions were applied to the inner and outer area then 73% of the rounds studied would be affected, regardless of whether the end time of the restriction was 16:00, 17:00 or 18:00.

11. COMPARISON OF RESULTS OF ALL POLICY MEASURES

In chapters 7-10 the results for the four policy measures considered in the project (and for several scenarios for each measure) have been presented.

The main points that have emerged from the analysis in terms of: (i) operational and financial impacts, and (ii) environmental impacts are considered in sections 11.1 and 11.2.

Appendix 7 contains graphs showing the results for the four policy measures (and all scenarios of each measure) for each company by indicator.

11.1 Operational and financial impacts

11.1.1 Low Emission Zone policy measure

The introduction of Low Emission Zones would be likely to have an impact on the vehicle operating costs of some companies. However, our results indicate that, even for those companies affected, vehicle operating costs are unlikely to rise by more than 5%.

Companies that replace their vehicles on a relatively frequent basis (such as every five years or more frequently) would be unlikely to experience any additional costs as a result of this policy measure. Three out of the seven companies in the project would be subject to additional costs in our analysis.

It is relatively unlikely that a LEZ would result in any operational changes within companies. The only possible effect indicated by the companies is that if LEZs were initially introduced in only a few urban areas, large companies with a national fleet may choose to redeploy their newer vehicles to these urban areas and use the older vehicles in areas without a LEZ. This could result in improved air quality in the urban area that had introduced the LEZ, while air quality in other areas deteriorated.

Companies with small fleets have far less opportunity to redeploy their vehicles in this way. Also, firms operating their entire fleet in one urban area (which tend to be small companies) would not have the opportunity to redeploy their fleet if a LEZ was introduced in that area. Small firms and firms with a significant proportion of their vehicles operating in the urban area with a LEZ may therefore be disproportionately affected by a LEZ in terms of the fleet changes they will have to make in order to comply.

11.1.2 Congestion charging policy measure

Congestion charging schemes that fail to bring about reductions in traffic levels (and therefore result in no improvement in traffic speeds) will have a negative effect on the operating cost of distribution companies. Our results indicate that a £5 daily charge in the inner area is likely to produce increases in vehicle operating costs of between 1% and 5% for companies with vehicle operations in this area. A £5 in a larger geographical area (i.e. the inner outer area) is likely to result in increases in slightly higher vehicle operating cost increases as more vehicles would be affected.

With a daily charge of £5 per vehicle, if there are no improvements in traffic speeds as a result of congestion charging then companies would be likely to organise their distribution operations in exactly the same way as they did before the scheme was introduced. The only possible change is that companies would ensure that they did not send vehicles into the congestion charging zone unnecessarily. However, a far higher charge (maybe in the order of £30 to £50 per vehicle per day) would be likely to result in significant changes in the way urban distribution work was carried out, especially if distribution companies were unable to

pass these costs onto their customers. In such a situation more distribution companies would be likely to operate outside the hours that the charging scheme is in force (i.e. during the night).

If congestion charging did produce improvement in traffic speeds (and hence journey times) this would offset some of the costs of the scheme for distribution companies. Our results show that a 15% reduction in journey time (with a £5 per day charge) would actually result in an overall cost reduction for some companies (assuming that they could use the saved time to do additional paid work). However, a higher daily charge of £15 per vehicle would result in cost increases of up to 11% for companies even with a 15% reduction in journey time.

If congestion charging did result in reduced journey times then companies would have to reorganise their distribution operations to make use of this additional time. Collection and delivery rounds would have to be reorganised as a greater number of collections and deliveries could now be carried out on each vehicle round.

11.1.3 Weight restriction policy measure

The weight restriction policy measures would be likely to have the most significant operational and financial impacts of the four measures studied for those companies affected. These impacts would include significant increases in the total number of vehicle rounds, vehicles and drivers, time taken, and distance travelled to perform their collection and delivery work. These operational impacts would be likely to also result in higher vehicle operating costs.

Companies likely to be worst affected by these policy measures are those who either operate national or regional urban distribution operations (i.e. deliver to the urban area from depots located significant distances from the urban area) and/or companies using heavy vehicles. The two companies in the project that operate urban deliveries from national distribution centres told us that if a significant proportion of their rounds were affected by scenarios such as those analysed in the project, it would be necessary for the companies to reconsider their entire urban distribution strategy. These companies felt that it may be necessary to completely restructure their delivery systems under these conditions, by introducing depots closer to urban areas.

11.1.4 Access time restriction policy measure

Our results indicate that if vehicle access time restrictions of 10:00-16:00 were implemented in the inner area, and distribution companies were unable to persuade receivers to accept deliveries at night, then the policy measure would be likely to have even greater operational and financial impacts than weight restriction. This is because companies collecting and delivering goods in the inner area would be affected regardless of their vehicle weight. Operational impacts would be similar to those caused by weight restrictions described above. Our results suggest that vehicle operating costs could increase by between approximately 10-20% for distribution companies in this scenario (this is likely to be far greater in the case of a company with a single national distribution centre that had to introduce local depots as a result). In addition, queuing at receivers' premises could also increase as more delivery and collection activity would have to take place in a shorter period of time (however this has not been modelled).

However, if receivers could be persuaded to accept night deliveries and collections, financial impacts are likely to be far less marked. Our results indicate that, depending on the trade-off between increases in wages necessary for night work and the improvement in speeds, vehicle operating costs could actually fall. But for night deliveries and collections to be acceptable to

senders and receivers, negotiations would be required with distribution companies in order to develop safe systems that do not result in far greater expense for these parties.

11.2 Environmental impacts

11.2.1 Low Emission Zone policy measures

The LEZ scenarios analysed can be seen to result in significant reductions in vehicle pollution. Euro IV engines will have an even larger impact on pollution levels than Euro III engines.

Besides the reduction in pollution levels, all other aspects of the vehicle rounds (in terms of vehicle weight, number of vehicle rounds, time of operation, time taken, distance travelled etc.) that have environmental implications would be expected to remain the same if a LEZ was introduced in the three urban areas.

11.2.2 Congestion charging policy measure

A congestion charging scheme that fails to bring about reductions in traffic levels will not produce any environmental benefits for an urban area. If traffic levels (of cars and other private transport) were reduced in such a scheme then, although the vehicle rounds carried out by distribution companies would be likely to continue in the same number using the same vehicles as before the introduction of the scheme, there would be a reduction in their environmental impacts. Improved speed would lead to: (i) reduced driving time by goods vehicles in the urban area (as less time would be needed to drive between collections and deliveries), and (ii) reductions in pollutant levels (as fewer pollutants would be emitted at higher driving speeds).

Our results indicate that if driving times were reduced by 15%, the reduction in pollutant levels for companies experiencing the improvement in traffic speeds would be in the region of 5-10%. The pollution reductions are therefore far less than for the LEZ policy measure. However, these two policy measures could be used jointly to bring about even greater reductions in pollution level.

As explained in section 11.1, improved speeds would obviously also be of benefit to companies.

11.2.3 Weight restriction policy measure

The weight restriction policy measure would obviously have the effect of preventing vehicles above certain weights from entering the urban area at those times of day when cyclist and pedestrian flows are relatively high. This would therefore be expected to reduce the environmental impacts associated with heavier vehicles such as noise, vibration and intimidation.

However, as the results indicate, distribution companies affected by this measure would be likely to operate more vehicle rounds using lighter vehicles during the restricted hours in order to make their deliveries and collections, rather than using the existing heavier vehicles outside the restricted hours. This is due to the customers' needs for deliver and collection work to continue at its current times of day.

Therefore, the weight restriction measure would be likely to result in more vehicle hours being operated within the urban area during the working day, as well as an increase in the total distance travelled within the urban area. This would be likely to add to traffic

congestion, have safety implications for cyclists and pedestrians, and would be expected to increase the total pollution caused by goods vehicles.

11.2.4 Access time restriction policy measure

The analysis suggests that if distribution companies responded to new time restrictions in urban area by trying to compress all of their work into a shorter period of the working day (scenario 1) then the outcomes will be the similar to weight restrictions measures only greater (as more companies and more vehicle rounds would be affected).

However, if companies responded to time restrictions by operating vehicle rounds at night, then this would be likely to result in a reduction in accident levels involving goods vehicles, less intimidation for pedestrians and cyclists, and reduction in driving time and pollution levels in the urban area (due to improved speeds). As already explained (see section 11.1.4) urban distribution at night would also bring operational advantages for companies, but would be viewed less positively by senders and receivers.

Of course, night deliveries would not be lead to environmental benefits in all cases, and consideration would need to be given to night delivery and collection work in residential areas.

11.3 Impact of policy measures on different companies / types of operation

In this section we examine the effects of each of the policy measures on the seven companies participating in the project.

11.3.1 Low Emission Zone policy measure

The financial impact of a low emission zone on companies that do not have compliant vehicles may differ between companies depending on the geography of each company's vehicle rounds in each urban area and the geographical coverage of a LEZ scheme. Three companies (C, D and G) would experience increased operating costs as a result of a LEZ.

In the case of company G the predicted increase in vehicle operating costs is very similar in all three urban areas for both inner and inner/outer scenarios (4% increase compared with 5% increase). This is because the geography of their vehicle rounds is similar in each urban area (in terms of the proportion of inner area and inner/outer area rounds).

However, company D would be expected to incur greater vehicle operating cost increases if the LEZ was implemented in the inner and outer area (3% increase) than if it was only implemented in the inner area (1% increase). This is because relatively few of their vehicle rounds enter the inner area (only 1 out of 5 vehicle rounds). The same is true for company C. All 12 of this companies vehicle rounds would be affected by a LEZ in the inner and outer area, compared with only 6 out of 12 rounds if the LEZ was only implemented in the inner area.

Differences in the reductions in the total quantity of the four pollutants emitted by the companies as a result of the four LEZ scenarios depend on: (i) the weight, age and speed of vehicles used on the current vehicle rounds, and (ii) the number of rounds affected in the case of companies with vehicle replacement cycles of more than five years. For example in scenario 1 (inner area), company D achieves fewer reductions in pollutants than the other companies because only one of its five rounds takes place in the inner area, and the other four vehicle rounds would continue to use older vehicles.

The LEZ policy measures tested in this project are unlikely to affect the vehicle operating costs of companies in particular sectors of the distribution market more than others. The impact on vehicle operating costs will depend on two main factors: (i) the company's vehicle replacement cycle, and (ii) the geographical profile of a company's collection and delivery work compared with the geographical coverage of a LEZ scheme.

However, as mentioned in section 11.1.1, if LEZ schemes were only implemented in a small number of urban areas in the UK, large companies with a national fleet may be able to redeploy their newer vehicles to these urban areas and use the older vehicles in areas without a LEZ. Locally-based companies with small fleets and long vehicle replacement cycles would be unable to redeploy their vehicles in this way. The latter may therefore be disproportionately affected by a LEZ scheme in terms of the fleet changes they will have to make in order to comply.

11.3.2 Congestion charging policy measure

The results suggest that some of the companies in the project will be worse affected than others by particular congestion charging scenarios. There are very few vehicle rounds which avoid the congestion charge due to completing their work in the congestion charging area before, or starting their work after, the charge comes into force. However, like the LEZ policy measures, differences in the impact on companies are due to the proportion of a company's vehicle rounds that take place in the geographical area in which the scheme is implemented.

In our analysis, if a congestion charge was implemented in the inner area (scenario 1) then companies F and G would have a very high proportion of affected rounds (31 out of 41 rounds, and 41 out of 45 rounds respectively).

Company F, the parcels carrier, would be expected to experience a far greater increase in vehicle operating costs than company G in scenario 1 with no time savings (11% compared with 4%) because a £5 daily charge would represent a greater proportion of the operating cost per round for a parcel carrier operating a relatively small vehicle, than for a drinks distributor using heavier vehicles with two-person crews.

Therefore an inner area congestion charging scheme may disproportionately affect distribution companies delivering to the city centre such as parcels carriers, companies delivering to high street shops and to pubs, bars and restaurants.

If the congestion charging scheme covers both the inner and outer area then many companies would be expected to have a high proportion of affected vehicle rounds. The only companies likely to be relatively unaffected are those predominantly making deliveries further from the centre of the urban area (i.e. more than 3km from the city centre) often to industrial premises. Such companies in the project include companies A and E.

11.3.3 Weight restriction policy measure

The results indicate that the weight restriction policy measure would be expected to affect the companies in the project very differently. Some would be totally unaffected while others would have to make significant changes to their operation, and would experience sizeable cost increases.

In scenario 1 for example (inner area, vehicle over 7.5 tonnes) , company G would be worst affected with their vehicle rounds increasing from 45 to 77. The total distance travelled by company G would increase by approximately 80%, resulting in a significant increase in pollutant emissions on the rounds. Next worst affected is company C with an increase in vehicle rounds from 12 to 14.

Three companies (A, D and F) would be completely unaffected by scenario 1. Company F would be unaffected despite the fact that it operates many rounds in the inner area. This is because the weight of the vehicles it uses is below the restricted weight. In the case of company A it is unaffected because its vehicle rounds do not take place in the inner area, while company D is unaffected because its vehicle round in the inner area is completed before the restriction comes into force at 10:00.

If the weight restriction was extended to cover both the inner and outer areas (scenarios 3 and 4) company F would remain unaffected (due to the weight of its vehicles) but all other vehicles would now be affected by the policy measure to some extent.

The primary factor in determining how severely distribution companies would be affected by such weight restriction measures is obviously the weight of vehicles currently operated by companies. Other important factors are the geography of vehicle rounds compared with the area covered by the weight restriction, and the times at which vehicle rounds take place compared with the times at which restrictions are in force.

11.3.4 Access time restriction policy measure

Companies C, F and G have a greater proportion of vehicle rounds that are affected by the time restriction scenarios modelled in the inner area than the other companies. This is due to two facts: (i) that they have a high proportion of rounds that enter the inner area, and (ii) that their many of their rounds take place during the restricted times of 10:00 to 16:00. In some cases it would be possible for the companies to simply schedule the existing vehicle round to take between 08:00-10:00 or 1600-18:00, so that although the time of the round changes everything else remains the same. However, on some existing vehicle rounds it takes longer than two hours to make all the collections and deliveries in the inner area. In these cases one existing vehicle round would have to become more than one vehicle round for all the collections and deliveries to take place within a two-hour window.

Compressing all collection and delivery work into 08:00-10:00 and 16:00-18:00 (scenario 1) is expected to increase the total distance travelled by each of these three companies by approximately 20%. Increases in vehicle operating costs vary between 1% and 7% for the three companies.

Delivering at night (scenarios 2 and 3) is expected to reduce the total time taken by companies C, F and G by approximately the same amount (a 3-4% reduction in time taken). If drivers' wages remain at their current levels (scenario 2) each of the three companies would be expected to have small reductions in vehicle operating costs (of 2-4%). However, if drivers' wages rise by 20% for night work (scenario 3) the companies would be expected to experience increases in vehicle operating costs of 3-4%.

11.4 Impact of policy measures on companies in the three urban areas

In this section we compare the effects of each of the policy measures on all vehicle rounds studied in the three urban areas.

11.4.1 Low Emission Zone policy measure

The results suggest that increases in vehicle operating costs as a result of a LEZ would be similar in the three urban areas. An increase of 1-2% in total vehicle operating costs for all the distribution activity studied would be expected if the LEZ was implemented in the inner area, and 2-3% increases in total vehicle operating costs for all the distribution activity if the LEZ was implemented in the inner and outer area.

Not all companies would be subject to a vehicle operating cost increase, as some companies would already be operating compliant vehicles. In the project, only three out of the seven companies would be expected to experience cost increases.

However, of those companies that are financially affected by a LEZ, the impact may differ in the three urban areas. This will be dependent on the geography of each company's vehicle rounds in each urban area and the geographical coverage of the LEZ scheme.

Companies D and G are expected to experience increases in vehicle operating costs as a result of the LEZ. In the case of company G the predicted increase in vehicle operating costs is very similar in all three urban areas (as a similar proportion of vehicle rounds are affected by each scenario in each urban area). Meanwhile Company D would experience differences in cost increases in each urban area if a LEZ was only implemented in the inner area. This is because they only operate an inner area vehicle round in Norwich. Therefore vehicle operating costs would be expected to increase by 3% for the Norwich round, but to remain unchanged on the Birmingham and Basingstoke rounds.

A LEZ introduced in the inner area would be likely to affect a greater proportion of vehicle rounds in Norwich and Basingstoke than in Birmingham. This is because a greater proportion of vehicle rounds in Norwich and Basingstoke enter the inner area than in Birmingham, due to the smaller geographical area of the former areas.

The results suggest that the LEZ scenarios would have more impact in terms of pollutant reduction on the vehicle rounds studied in Norwich than in the other urban areas. This is due to: (i) there being a greater proportion of Euro I vehicles currently operated by the companies in the project in Norwich than in the other two urban areas, and (ii) the distance travelled on Norwich vehicle rounds (especially by companies using a national distribution centre).

11.4.2 Congestion charging policy measure

The impact of congestion charging scenarios with a £5 daily charge that do not produce time savings on the cost of distribution operations is broadly similar in all three urban areas. Congestion charging in the inner area would be expected to result in increases in the total operating costs for all the distribution activity studied of 2-3% (scenario 1) and 3-4% if congestion charging was implemented in the inner and outer area (scenario 4).

The results suggest that an inner area congestion charge of £5 that resulted in time savings of 15% (scenario 2) would result in a broadly neutral economic effect for the total distribution activity studied in each of the three urban areas.

If congestion charging were to result in driving time savings then this would be expected to lead to reductions in pollutant emissions due to improved engine performance. This is reflected in scenarios 2, 3 and 5. The results suggest that pollutant reductions of between 1% and 5% would be expected in the urban areas.

Obviously the effect of congestion charging schemes on companies and environmental impacts would differ significantly between the urban areas if reductions in traffic levels (and hence in traffic speeds and journey times) as a result of the schemes were different in Birmingham, Basingstoke and Norwich.

11.4.3 Weight restriction policy measure

The results suggest that the weight restriction scenarios would results in some differences in the three urban areas in terms of: (i) the proportion of vehicle rounds affected by each

scenario, (ii) the proportional increase in vehicle rounds that would be necessary to carry out the same amount of collection and delivery work, and (iii) the effect of each scenario on the total distribution costs, time taken, distance travelled and pollutant emission levels.

The most severe weight restriction scenario tested (scenario 3 - inner and outer area, 7.5 tonnes) would affect approximately 25-30% of the vehicle rounds studied in each of the urban areas.

In terms of the effects of the scenarios on total distribution activity in the urban areas, the results suggest that the impact would be greatest in Basingstoke, and least in Norwich (in terms of increases in vehicle operating costs, time taken, distance travelled, and pollutant emissions).

The results suggest that the weight restriction scenarios would be expected to result in increases in the environmental impacts of the companies' distribution activity in each of the urban areas.

Companies may be more affected by weight restrictions in one urban area than another. For example, company G is likely to have a greater proportion of its rounds affected in Basingstoke than in Birmingham and Norwich. It would also experience far greater increases in vehicle operating costs on its Basingstoke rounds than on its rounds in the other two urban areas. This is because its Basingstoke rounds are performed from a regional depot located a relatively long way from Basingstoke, whereas the other two urban areas are served from depots located within the urban area.

11.4.4 Access time restriction policy measure

If vehicle access time restrictions resulted in collection and delivery work taking place in a two-hour window either early in the morning or later in the afternoon (scenario 1) then the results suggest that a greater proportion of vehicle rounds would be affected in Norwich (55%) and Basingstoke (50%) than in Birmingham (37%). This is because a smaller proportion of the companies' rounds enter the inner area in Birmingham. This is explained by the comparative geographical size of the three urban areas. This would be likely to result in a significant increase in the total number of vehicle rounds operated.

Looking at the effect on particular companies in the three urban areas, of the four companies operating in all three urban areas only companies F and G have a large proportion of vehicle affected by the time restriction measure. For both these companies, a high proportion of their vehicle rounds in Basingstoke are affected by the time restriction. If the companies were to cope with this time restriction by carrying out deliveries and collections from 08:00-10:00 and 16:00-18:00 (scenario 1) then a greater proportion of their existing rounds in Basingstoke could be rescheduled to take place in these two hour windows. In the case of vehicle rounds in Norwich and Birmingham many of the vehicle rounds take longer than two hours to complete their work in the inner area and would therefore have to be replaced by more than one vehicle round to get all the work completed to avoid the time restriction. This explains why the effects of the time restriction in scenario 1 are less pronounced in Basingstoke than in the other two urban areas.

If, in order to overcome time restrictions, companies carried out their collection and delivery rounds at night (scenarios 2 and 3) the result indicate that relatively similar time savings would be achieved on vehicle rounds to all three urban areas. This would be expected to have environmental benefits in terms of slightly reduced pollution (due to improved speed) on vehicle rounds in all the urban areas.

12. ANALYSIS OF COMPANY INITIATIVES

12.1 Introduction

Companies were asked about any initiatives that they were considering implementing in the short to medium term that would have a bearing on the efficiency and financial cost of their urban distribution operations, as well as its environmental impact. Companies expressed a common interest in the investigation of the effect on their urban distribution operations of:

- Reduced collection and delivery times (i.e. the time that the vehicle is parked while the driver is making collections and/or deliveries);
- Reduced driving times and distances travelled (i.e. by reducing the distance travelled on a vehicle round and thereby the time that the vehicle is being driven between the depot and all the collection/delivery points).

In addition, company F, which makes deliveries to, and collections from, shopping centres was very interested in finding ways in which to reduce the time taken for these specific collections and deliveries.

The companies would achieve operational and financial benefits if they could find ways in which to bring about these time savings. At the same time the environmental impact of their operations may also fall due to their vehicle spending less time in the urban area.

Reduced collection and delivery times would result in goods vehicles spending less time parked at kerbsides. Goods vehicles parked on-street while collections and deliveries take place can cause a range of environmental problems including:

- Safety issues for pedestrians crossing the road (as it obscures their vision of traffic on the road, and other road users vision of them);
- Safety issues for cyclists using the road (as it forces them further towards the middle of the road);
- Safety issues for other road users (as it reduces the available road width);
- Visual intrusion – detracting from the ambience of the urban environment;
- Physical intimidation if the vehicle is poorly parked - potentially causing pedestrians to have to walk around the vehicle;
- Noise and pollution impacts if the vehicle of the engine is left running.

Reducing the time that goods vehicles spend parked on-street would potentially help to limit all these impacts.

In addition, in our previous research some shopkeepers have also expressed concern that vehicles parked outside their shops can obscure the shop to potential customers and can negatively affect the image and appearance of the shop to potential customers, thereby affecting shop sales (Allen et.al., 2002).

Reducing driving times (by reducing the distance travelled) would lead to the following environmental improvements:

- reduced vehicle kilometres;
- reduced fuel consumption;
- reduced pollutant emissions.

The effect of these company-led changes on the operational, financial and environmental indicators are considered in the following sections.

12.2 Reduced collection and delivery times

12.2.1 Discussion of reduced collection and delivery times

Companies could consider how to reduce the time taken to make collections and deliveries (i.e. the time during which the vehicle is stationary at a collection/delivery point). Ways in which this could be achieved include:

- Receivers helping to (un)load vehicles ands carry goods;
- Receivers not checking deliveries in detail at the time of delivery;
- Deliveries only having to be made to one location within each premises rather than to several;
- Senders having goods being collected ready when the driver arrives;
- The use of technology during collections and deliveries to speed up administration and reduce the need for paperwork;
- The use of technology to pre-alert premises about the arrival of a vehicle making a collection or delivery;
- Good communication systems in place between the driver and the depot to ensure that the driver is aware of any cancelled or altered collection and delivery work;
- Receivers who operate booking-in systems for vehicles making deliveries ensuring that these are run efficiently and without queuing;
- Ensuring that appropriate handling equipment is used to convey goods from the vehicle to the premises;
- Premises allowing goods vehicles to use off-street facilities where they exist.

By reducing the time taken to make collections and deliveries on vehicle rounds more time would be made available to carry out extra work and therefore earn additional revenue.

12.2.2 Scenarios tested for reduced collection and delivery times

Three scenarios involving reduced collection and delivery times were tested:

1. 10% reduction in the time taken for each collection and delivery;
2. 20% reduction in the time taken for each collection and delivery;
3. 30% reduction in the time taken for each collection and delivery.

These scenarios were applied to all 120 vehicle rounds.

12.2.3 Assumptions made in modelling reduced collection and delivery times

Reductions in collection and delivery time were only applied to collections and deliveries that took less than three minutes to carry out. It was felt that if a delivery or collection already took less than three minutes, there would be little opportunity to reduce this further.

This assumption only has a significant impact on company F, as it has a high proportion of very short collection and delivery times.

12.2.4 Results of the modelling of reduced collection and delivery times

Table 12.1-12.3 show the effect of reduced collection and delivery times on the total time taken (i.e. driving time plus stationary time), vehicle operating costs and the other indicators affected for each company. Indicators that are not affected by a reduction in collection and delivery time are shown in grey.

Table 12.1: Collection and delivery times reduced by 10% on all vehicle rounds

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	8/8	5/5	12/12	5/5	4/4	41/41	45/45
Total time taken	-3%	-3%	-5%	-3%	-3%	-5%	-6%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was: 65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was: 69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	Now: 70% Now: 30%	Now: 67% Now: 33%	Now: 55% Now: 45%	Now: 70% Now: 30%	Now: 71% Now: 29%	Now: 43% Now: 57%	Now: 41% Now: 59%
Speed per round (incl. stops)	+3%	+3%	+4%	+3%	+3%	+5%	+6%
Speed per round (excl. stops)							
Total distance travelled							
Total vehicle operating costs	-2%	-2%	-4%	-2%	-2%	-5%	-5%
Total CO emissions							
Total CO_2 emissions							
Total NOx emissions							
Total PM10 emissions							

Table 12.2: Collection and delivery times reduced by 20% on all vehicle rounds

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	8/8	5/5	12/12	5/5	4/4	41/41	45/45
Total time taken	-5%	-6%	-9%	-5%	-7%	-10%	-13%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was: 65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was: 69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	Now: 72% Now: 28%	Now: 69% Now: 31%	Now: 58% Now: 42%	Now: 72% Now: 28%	Now: 73% Now: 27%	Now: 45% Now: 55%	Now: 43% Now: 57%
Speed per round (incl. stops)	+5%	+6%	+9%	+6%	+6%	+11%	+12%
Speed per round (excl. stops)							
Total distance travelled							
Total vehicle operating costs	-3%	-3%	-8%	-3%	-5%	-9%	-11%
Total CO emissions							
Total CO_2 emissions							
Total NOx emissions							
Total PM10 emissions							

Table 12.3: Collection and delivery times reduced by 30% on all vehicle rounds

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	8/8	5/5	12/12	5/5	4/4	41/41	45/45
Total time taken	-8%	-8%	-14%	-8%	-10%	-15%	-19%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was: 65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was: 69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	Now: 74% Now: 26%	Now: 72% Now: 28%	Now: 61% Now: 39%	Now: 74% Now: 26%	Now: 75% Now: 25%	Now: 48% Now: 52%	Now: 46% Now: 54%
Speed per round (incl. stops)	+8%	+10%	+14%	+9%	+9%	+18%	+20%
Speed per round (excl. stops)							
Total distance travelled							
Total vehicle operating costs	-5%	-5%	-13%	-5%	-7%	-14%	-16%
Total CO emissions							
Total CO_2 emissions							
Total NOx emissions							
Total PM10 emissions							

Companies with the greatest proportion of stationary time (such as C, F and G) can be seen to benefit most, with vehicle operating costs reductions of up to 5%, 10% and 15% when reducing collection and delivery time by 10%, 20% and 30% respectively.

As well as benefiting distribution companies, reducing collection and delivery times would also have beneficial environmental outcomes as vehicles would spend less time parked on-street in the urban area. As discussed in section 12.1, reductions in the time that vehicles are parked on-street could lead to safety improvements for pedestrians, cyclists and other road users, less visual intrusion, less physical intimidation. These are not reflected in the indicators in Tables 12.1 to 12.3.

The results also indicate that the effects of the three scenarios would be relatively similar in the three urban areas. For example, a 20% reduction in collection and delivery times (scenario 2) would be expected to result in reductions in the total time taken for all vehicle rounds of 7% in Basingstoke, 9% in Birmingham and 10%. This slight difference is explained by the fact that collections and deliveries account for a greater proportion of the total time taken for vehicle rounds in Norwich than the other urban areas.

Obviously, if collection and delivery times are reduced by assistance from receivers and senders, then this may result in their operating costs increasing. This is not included in the results in Tables 12.1 to 12.3 as these tables reflect the financial impact on the distribution company. This needs to be borne in mind when thinking about the overall commercial benefits of collection and delivery time reductions.

12.3 Reduced collection and delivery times in shopping centres

12.3.1 Discussion of reduced collection and delivery times in shopping centres

One of the companies participating in the project (company F) makes deliveries to retailers in shopping centres on a regular basis. At present, the driver has to park in a (usually) underground unloading area, and then convey the goods from the vehicle to the shop, which often involves a travelling a relatively long distance using lifts and corridors. A driver with a large load to deliver may have to make more than one journey to each shop. The next delivery in the shopping centre may involve driving the vehicle to another unloading area and then repeating the delivery process.

An alternative to this system would be for the shopping centre management to take more responsibility for internal distribution within their centre. The delivery drivers would make deliveries to a shopping centre employee in a single, easily accessible location, and this person would then be responsible for distributing the goods to tenants within the building. This would help to reduce the time taken by the driver to make deliveries at the shopping centre.

This type of scheme also has several possible benefits for the retailers:

- They could use it as a temporary storage space that would supplement their existing, in many cases limited, on-site storage facilities. If a shop had a lot of stock due in and could not cope with it, or did not want it all on-site at once, they could choose to leave it in the shopping centre storage area and use the centre as an emergency buffer store for a few days;
- They would have the peace of mind that comes from knowing that the deliveries have already successfully been made to a location either in the shopping centre or only a few hundred metres away from their shop (there is no risk of the delivery being delayed in traffic or adverse weather conditions);

- They would have more control over the final movement of the goods from the shopping centre storage area to the premises than they did previously. They could choose to either have the goods delivered at a suitable time or collect them themselves at any time of day they would like. Emergency deliveries could be made for the storage area to the shop at any time of day in a way that is not currently possible;
- They could reduce the storage area required in their shops and make greater use of the shopping centre storage area instead. This would allow them to increase and potentially redesign the sales area in their shop in order to increase revenue;
- They could make use of additional services at the storage area such as packaging removal, recycling, hanging of garments on rails, ticketing and tagging.

Several examples of this type of facility have recently been established in the UK:

- BAA has developed a 25,000 square feet "consolidation centre" at Heathrow Airport which is run on their behalf by Exel. The purpose of the scheme is to reduce goods vehicle movements, and to improve goods handling systems and waste packaging management in the terminals. In this scheme, goods destined for retailers with premises in terminals 1-4 are now delivered to the centre which is located away from the terminal buildings rather than directly to the shops. Five vehicles are operated by Exel to transport goods from the consolidation centre to the shops in the terminal buildings as the retailers require them. Deliveries to the consolidation centre are faster than to the shops as there is less congestion on approach roads and fewer delays in off-loading goods (Energy Efficiency Best Practice Programme, 2002).

- Meadowhall shopping centre in Sheffield is one of the largest shopping centres in the UK with 270 shops and an 11-screen cinema, with a total leasable area of 1.3 million square feet (Meadowhall Management Team, 2002). A scheme is now in operation at the shopping centre in which retailers can pool their storage capacity. Participating retailers have their deliveries made to a 50,000 square feet consolidation centre several hundred metres from the shopping centre rather than direct to their shops. The goods can be stored at this facility, services performed on them and can then be transported to the shops at the retailers' convenience using a shared delivery system. Exel are managing the shared store and delivery-to-store operation (e.logistics, 2002).

- Tibbett and Britten launched a 70,000 square feet off-site "logistics centre" at Bluewater shopping centre in Kent in November 2002. This operates in a similar manner to the Meadowhall scheme described above (Tibbett and Britten, 2002).

12.3.2 Scenarios tested for reduced collection and delivery times in shopping centres

Only company F (the parcels carrier) made a sizeable number of collections and deliveries in shopping centres on the rounds studied. This company had 20 vehicle rounds that included work in shopping centres. Therefore the scenarios tested were only applied to these 20 vehicle rounds. The following scenarios were modelled:

1. 50% reduction in collection and delivery time in shopping centres;

2. 70% reduction in collection and delivery time in shopping centres;

3. 90% reduction in collection and delivery time in shopping centres.

12.3.3 Assumptions made in modelling reduced collection and delivery times in shopping centres

Reductions in collection/delivery times were only applied to collections and deliveries that took less than 3 minutes to carry out. It was felt to be unrealistic to apply the reductions to these already quick collections and deliveries.

It should be noted that the analysis assumes that collections/deliveries are made into the (un)loading area of the shopping centre. As the vehicle arrives a shopping centre employee helps the driver to unload the vehicle. The driver and vehicle then depart while the employee makes the deliveries to retail outlets (i.e. it does not assume that the goods are stored in a remote warehouse and then delivered to the shops in another vehicle when requested by them, as operated in the Heathrow, Meadowhall and Bluewater schemes).

The results do not include the cost of the shopping centre employee.

12.3.4 Results of the modelling of reduced collection and delivery times in shopping centres

Table 12.4-12.6 show the effect of reduction in delivery and collection times in shopping centres of 50%, 70% and 90% for the 20 vehicle rounds operated by company F that include shopping centre deliveries.

Table 12.4: Collection and delivery times in shopping centres reduced by 50% on 20 vehicle rounds by company F

	All Rounds	**Basingstoke**	**Birmingham**	**Norwich**
Total number of rounds				
Number of rounds affected	20/20	6/6	8/8	6/6
Total time taken	-6%	-11%	-4%	-6%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 38% Was: 62%	Was: 32% Was: 68%	Was: 42% Was: 58%	Was: 39% Was: 61%
New driving time as % of total New stationary time as % of total	Now: 41% Now: 59%	Now: 36% Now: 64%	Now: 44% Now: 56%	Now: 41% Now: 59%
Speed per round (incl. stops)	+7%	+12%	+4%	+6%
Speed per round (excl. stops)				
Total distance travelled				
Total vehicle operating costs	-6%	-10%	-4%	-5%
Total CO emissions				
Total CO_2 emissions				
Total NOx emissions				
Total PM10 emissions				

Table 12.5: Collection and delivery times in shopping centres reduced by 70% on 20 vehicle rounds by company F

	All Rounds	Basingstoke	Birmingham	Norwich
Total number of rounds				
Number of rounds affected	20/20	6/6	8/8	6/6
Total time taken	-9%	-15%	-6%	-8%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 38% Was: 62%	Was: 32% Was: 68%	Was: 42% Was: 58%	Was: 39% Was: 61%
New driving time as % of total New stationary time as % of total	Now: 42% Now: 58%	Now: 38% Now: 62%	Now: 45% Now: 55%	Now: 42% Now: 58%
Speed per round (incl. stops)	+10%	+18%	+5%	+8%
Speed per round (excl. stops)				
Total distance travelled				
Total vehicle operating costs	-8%	-14%	-5%	-8%
Total CO emissions				
Total CO_2 emissions				
Total NOx emissions				
Total PM10 emissions				

Table 12.6: Collection and delivery times in shopping centres reduced by 90% on 20 vehicle rounds by company F

	All Rounds	Basingstoke	Birmingham	Norwich
Total number of rounds				
Number of rounds affected	20/20	6/6	8/8	6/6
Total time taken	-11%	-20%	-7%	-10%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 38% Was: 62%	Was: 32% Was: 68%	Was: 42% Was: 58%	Was: 39% Was: 61%
New driving time as % of total New stationary time as % of total	Now: 43% Now: 57%	Now: 40% Now: 60%	Now: 46% Now: 54%	Now: 43% Now: 57%
Speed per round (incl. stops)	+14%	+24%	+7%	+11%
Speed per round (excl. stops)				
Total distance travelled				
Total vehicle operating costs	-10%	-18%	-7%	-10%
Total CO emissions				
Total CO_2 emissions				
Total NOx emissions				
Total PM10 emissions				

The results in Table 12.4-12.6 indicate that operating this type of system could lead to significant cost savings for distribution companies. Benefits to the company are greatest in Basingstoke because of the greater proportion of shopping centre collections and deliveries on the Basingstoke vehicle rounds.

This concept could also be applied in a high street situation. A consolidation point located close to a number of city centre premises could be established. This centre could receive all the deliveries for those premises and then deliver them on to the premises in a single delivery. This approach could therefore potentially have both commercial and environmental benefits if carefully planned and organised.

12.4 Reduced driving times and distances travelled

12.4.1 Discussion of reduced driving times and distances travelled

Reducing driving times on vehicle rounds would make more time available to carry out extra work and therefore earn additional revenue. This could be achieved either as a result of policy measures that assist urban distribution operations, or through actions taken by companies.

We have examined reductions in driving time that are brought about by findings ways in which to reduce the total distance travelled on a vehicle round (vehicle speed is assumed to remain constant).

Companies could potentially reduce the distance travelled and hence the driving time on vehicle rounds by improve routeing and scheduling of the work their vehicles carry out. Improved routeing could be achieved through the use of: (i) automated routeing systems by distribution company planners at the depot (where these are not already used), (ii) on-board navigational aids to select optimum routes for drivers, and prevent drivers from becoming lost, and which can also make use of current traffic information. Improved scheduling of deliveries and collections can help to plan deliveries and collections to take place with the minimum geographical distance being covered (taking into account constraints about delivery times imposed by customers and receivers). Dynamic routeing and scheduling systems offer the possibility of re-routeing and/or rescheduling the vehicle round if the delivery and collection work on the vehicle round changes.

The use of information and technology has an important role to play in reducing the distance travelled and hence the driving time of vehicles. However, well-trained and -informed drivers can have a similar effect. Some companies parcels carriers and general hauliers performing large numbers of drops on each vehicle round are more reliant on the knowledge and expertise of their drivers to minimise route distance than on IT systems. This is demonstrated by the initial increase in distance and time taken when a new driver without local knowledge of road systems and the delivery and collection arrangements at premises replaces an experienced driver on a vehicle round.

12.4.2 Scenarios tested for reduced driving times and distances travelled

The following scenarios were modelled:

1. 5% reduction in distance travelled and driving time;
2. 10% reduction in distance travelled and driving time;
3. 30% reduction in distance travelled and driving time.

These scenarios were applied to all 120 vehicle rounds.

12.4.3 Assumptions made in modelling reduced driving times and distances travelled

It was assumed that vehicle speeds remain constant.

12.4.4 Results of the modelling of reduced driving times and distances travelled

Table 12.7-12.9 show the effect of reduced distance travelled and driving times on total time taken, vehicle operating costs and the other indicators affected for all 120 vehicle rounds studied by company.

Table 12.7: Distance travelled and driving time reduced by 5% on all vehicle rounds

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	8 / 8	5 / 5	12 / 12	5 / 5	4 / 4	41 / 41	45 / 45
Total time taken	-3%	-3%	-2%	-4%	-3%	-2%	-2%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was: 65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was: 69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	Now: 67% Now: 33%	Now: 64% Now: 36%	Now: 52% Now: 48%	Now: 67% Now: 33%	Now: 68% Now: 32%	Now: 39% Now: 61%	Now: 37% Now: 63%
Speed per round (incl. stops)	-2%	-2%	-2%	-2%	-2%	-3%	-3%
Speed per round (excl. stops)							
Total distance travelled	-5%	-5%	-5%	-5%	-5%	-5%	-5%
Total vehicle operating costs	-4%	-4%	-3%	-4%	-4%	-2%	-2%
Total CO emissions	-5%	-5%	-5%	-5%	-5%	-5%	-5%
Total CO_2 emissions	-5%	-5%	-5%	-5%	-5%	-5%	-5%
Total NOx emissions	-5%	-5%	-5%	-5%	-5%	-5%	-5%
Total PM10 emissions	-5%	-5%	-5%	-5%	-5%	-5%	-5%

Table 12.8: Distance travelled and driving time reduced by 10% on all vehicle rounds

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	8 / 8	5 / 5	12 / 12	5 / 5	4 / 4	41 / 41	45 / 45
Total time taken	-7%	-7%	-5%	-7%	-6%	-4%	-4%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was: 65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was: 69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	Now: 66% Now 34%	Now: 63% Now: 37%	Now: 51% Now: 49%	Now: 66% Now: 34%	Now: 66% Now: 34%	Now: 38% Now: 62%	Now: 36% Now: 64%
Speed per round (incl. Stops)	-3%	-4%	-5%	-3%	-3%	-6%	-6%
Speed per round (excl. stops)							
Total distance travelled	-10%	-10%	-10%	-10%	-10%	-10%	-10%
Total vehicle operating costs	-8%	-8%	-6%	-8%	-7%	-5%	-5%
Total CO emissions	-10%	-10%	-10%	-10%	-10%	-10%	-10%
Total CO_2 emissions	-10%	-10%	-10%	-10%	-10%	-10%	-10%
Total NOx emissions	-10%	-10%	-10%	-10%	-10%	-10%	-10%
Total PM10 emissions	-10%	-10%	-10%	-10%	-10%	-10%	-10%

Table 12.9: Distance travelled and driving time reduced by 15% on all vehicle rounds

	Company A	Company B	Company C	Company D	Company E	Company F	Company G
Total number of rounds							
Number of rounds affected	8 / 8	5 / 5	12 / 12	5 / 5	4 / 4	41 / 41	45 / 45
Total time taken	-10%	-10%	-7%	-11%	-9%	-6%	-5%
Orig. driving time as % of total Orig. stationary time as % of total	Was: 68% Was: 32%	Was: 65% Was: 35%	Was: 53% Was: 47%	Was: 68% Was: 32%	Was: 69% Was: 31%	Was: 41% Was: 59%	Was: 38% Was: 62%
New driving time as % of total New stationary time as % of total	Now: 65% Now: 35%	Now: 62% Now: 38%	Now: 49% Now: 51%	Now: 65% Now: 35%	Now: 65% Now: 35%	Now: 37% Now: 63%	Now: 35% Now: 65%
Speed per round (incl. stops)	-5%	-6%	-7%	-5%	-5%	-9%	-9%
Speed per round (excl. stops)							
Total distance travelled	-15%	-15%	-15%	-15%	-15%	-15%	-15%
Total vehicle operating costs	-12%	-12%	-8%	-12%	-11%	-7%	-7%
Total CO emissions	-15%	-15%	-15%	-15%	-15%	-15%	-15%
Total CO_2 emissions	-15%	-15%	-15%	-15%	-15%	-15%	-15%
Total NOx emissions	-15%	-15%	-15%	-15%	-15%	-15%	-15%
Total PM10 emissions	-15%	-15%	-15%	-15%	-15%	-15%	-15%

The results indicate that, as would be expected, companies that spend most time driving on vehicle rounds will experience greater reductions in vehicle operating costs than companies with a high proportion of stationary time. For example, companies D and E would be expected to experience reductions of 4% in vehicle operating costs in scenario 1 (i.e. driving time savings and reductions in distance travelled of 5%), compared with only 2% reductions in operating costs for companies F and G.

Reductions in pollutant emissions on the vehicle rounds would be expected to be proportional to the reduction in distance travelled (assuming speed remains constant).

Average speed including stops would be expected to fall as the distance travelled and driving time are reduced. This is because the stationary time during collections and deliveries (which is assumed to remain constant becomes proportionately more important as driving time is reduced.

The results also indicate that the effects of these scenarios would be similar in the three urban areas. For example, a 5% reduction in distance travelled and driving time would be expected to result in reductions in the total time taken for all vehicle rounds of 2-3%, and reductions in vehicle operating costs of 3-4% in the three urban areas.

13. CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

13.1 Current urban distribution operations of companies

The project has quantified major differences in the urban distribution operations of different companies. The companies participating in the project were selected so as to reflect the breadth of distribution activity that takes place in urban areas.

It has been possible to illustrate major differences in vehicle operations between the companies studied in terms of:

- the distance travelled on each vehicle round;
- whether the operation involves multi-drop or single drop work;
- the size and weight of vehicle used;
- the operating time of the vehicle rounds;
- the actual time taken to make collections and deliveries;
- the time taken to collect/deliver goods compared with the time taken to drive the vehicle;
- The average speed of vehicle rounds;
- the time utilisation of the vehicle;
- the vehicle fill at the start of the round.

It has been shown that these depend on factors that include: the types of product carried, the quantity of goods for each collection/delivery address, the location of the depot from which goods are despatched to the urban area, the geographical coverage of the vehicle round, and the location of deliveries and collections in the urban area.

The work has helped to demonstrate that there are many different patterns of urban distribution that need to be taken into account when thinking about suitable policy measures to bring about sustainable urban distribution. The results show that these operating patterns are affected in different ways by the various measures tested.

13.2 Current urban distribution operations in the three urban areas

The project has shown that the size and form of the urban area can have an important bearing on the distribution operations that serve that urban area. For example, average speeds in Basingstoke are higher than in Birmingham and Norwich, and the proportion of off-street and shopping centre deliveries are higher in Basingstoke (which was designed in the 1950s and 1960s to segregate and improve much of the distribution work for the city centre). Multi-drop vehicle rounds serving Basingstoke also cover greater distances than in Norwich and Birmingham as, given the population size and density, it is necessary to travel further to carry out the same amount of collection and delivery work.

Discussion with the companies together with our own analysis of each urban area has shown that existing distribution problems (both in terms of problems caused and experienced by goods vehicle) are far more acute in Birmingham and Norwich than in Basingstoke.

13.3 Policy measures and company initiatives analysed

The four policy measures analysed shown to have different likely effects on distribution operations in terms of: (i) impact on the distribution operation and its cost to the company, and (ii) on the environmental impact of the distribution activity.

The results indicate that Low Emission Zones will have the least impact of the four policy measures on the organisation and operation of distribution activities, but would have a

potentially significant impact on pollutant levels. Three of the seven companies would be expected to experience vehicle operating cost increases of up to 5% due to the need to acquire compliant vehicles.

Our work has demonstrated that the effect of congestion charging will differ between companies, depending on: (i) the level of the charge, (ii) the geographical area in which the scheme is implemented, and (iii) whether or not the scheme results in speed improvements. The results demonstrate that improvements in the average speed of goods vehicles (as a result of reductions in traffic levels) can reduce, and in the case of some companies outweigh, the congestion charge. This illustrates the importance of generating time savings to ensure that congestion charging does not have a detrimental economic effect, and also in helping to increase acceptability among companies.

The companies studied would be affected very differently by weight restriction policy measures. In the scenarios we have examined, those companies operating light goods vehicles would be completely unaffected while those companies operating heavy goods vehicles with a gross weight of 12 tonnes or more would have to make significant changes to their distribution patterns in order to comply that would result in significant increases in total vehicle operating costs. The environmental impact the vehicle rounds performed by those companies worst affected by the weight restriction scenarios, would also be likely to increase significantly as a result of the increase in total distance travelled, time taken and pollutant emissions.

Time restrictions could lead to distribution activities being compressed into a shorter period of time at the start or end of the working day. If this were to happen the results suggest that, like weight restrictions, this would have negative impacts on the distribution operations of companies affected in terms of increases in vehicle rounds, total distance travelled and could also result in more queuing at receivers' premises. The environmental impact of vehicle activity would also be expected to increase if companies responded to time restrictions in this manner.

However, if time restrictions resulted in more distribution companies operating at night then the results indicate that this could be beneficial from both a commercial and environmental perspective. The commercial benefits would depend on the trade-off between improved driving speeds and higher drivers' wages. For this approach to become more commonplace it will be necessary for senders and receivers of goods to accept night work. They will potentially experience higher reception/despatch costs and may have concerns about the safety of their premises if staff were not present. Therefore negotiations between supply chain partners would be necessary to make night collections and deliveries in urban areas possible for more distribution companies.

The company initiatives examined have demonstrated that there is potential for both commercial and environmental improvements if distribution companies together with their supply chain partners could identify ways in which to either: (i) reduce the distance travelled and driving times (through for example the use of IT, internal planning or supply chain co-operation), or (ii) reduce collection and delivery times (through closer working relationships with senders and receivers).

13.4 Success of approach used

The project has helped in providing a better understanding of the:

- Different patterns of urban distribution operations currently taking place;
- Likely effect of different policy measures on various distribution operations;
- Relationship between policy measures and their environmental and commercial/operational impact on these various distribution patterns;
- Impact of policy measures on distribution activities in three different urban areas;
- Possible environmental and commercial benefits that could be achieved through company actions to reduce distance travelled and time taken.

The analysis of the likely effects of four policy measures on urban distribution operations has demonstrated:

- the likely impact of several scenarios for each policy measure considered (the results reflect that the various scenarios modelled for each policy measure could produce very different outcomes);
- the extent to which the vehicle rounds of the seven companies participating in the project would be affected differently by these four policy measures in terms of: (i) distribution operations, (ii) vehicle operating costs, and (iii) environmental impacts;
- the extent to which the companies' operations would be affected differently in the three urban areas;
- the overall effect on the total distribution activities carried out by the seven companies in each of the urban areas (i.e. comparisons of results between the three urban areas);
- that an understanding of different patterns of urban distribution is necessary when investigating the likely effect of policy measures intended to bring about sustainable urban distribution.

Even with the relatively small number of companies participating in the project and the amount vehicle round data we were able to capture, it has been possible to obtain much insight into the likely company reactions to, and effects of, different policy measures and company initiatives. This work will add to the current discussion about policy making for urban distribution.

The database developed and used in the project proved to be a very effective tool for analysing the distribution data collected. It was also suited to the task of applying changes to this data to reflect how operations may change as a result of policy measures and company initiatives in accordance with the views expressed by companies. The use of a database also made the task of producing results in several ways relatively straightforward (i.e. by company, by urban area, by company by urban area).

By developing a set of indicators it was possible to reflect the sustainability of these distribution operations before and after the application of the policy measures and company initiatives in operational, financial and environmental terms.

The involvement of local authorities and distribution companies in the project has helped to ensure that the policy measures selected for investigation and the likely responses of companies to these measures are as realistic as possible.

13.5 Future research

Data collection and data entry proved to be very time consuming tasks in the project. However, now that it the merits of the project have been demonstrated it is possible to consider how to reduce the data collection and entry effort required when using the approach in future. This would be especially important if a larger number of companies were to participate in a future project.

There is scope to use electronic means of data capture rather than manual data collection for gaining information about companies' current vehicle rounds. The project team did make use of a portable global positioning system to collect some data during the project and feel that this approach is viable. Systems that automatically record vehicle location and activity using global positioning system data have become available in the last couple of years mean that much of the data required by this project could be automatically captured. Each vehicle round could then be downloaded onto a personal computer for analysis. Other systems now available are capable of recording every time vehicle doors are opened for a collection or delivery and linking this to the vehicle location systems. However, to collect the full range of vehicle round data used in this project it would be necessary to combine the automatic data capture of a vehicle location system with some manual inputs by the driver (e.g. to record whether a collection or delivery is taking place when the vehicle is stationary, or to record why the vehicle has been parked if a collection or delivery is not taking place). This could be achieved by the driver inputting a status code into a dashboard-mounted computer and this information can be linked to the vehicle location system data.

Developing this type of data collection approach would potentially revolutionise goods vehicle activity surveys, allowing data to be captured for many vehicle movements at relatively low cost.

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