6Cs Congestion Management Study

Project Report

April 2008

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Project Report

Version 1.3
April 2008

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EXECUTIVE SUMMARY

This Project Report describes the work undertaken within the 6Cs Congestion Management Study and its results and conclusions. The study was led by the 6Cs partnership of Leicestershire County Council, Derby City Council, Derbyshire County Council, Leicester City Council, Nottingham City Council and Nottinghamshire County Council, with support from the Highways Agency, East Midlands Development Agency (emda), the Government Office for the East Midlands and the Department for Transport.

The overall aims of the 6Cs Congestion Management Study were:

- To investigate the extent and severity of traffic congestion in the 3 Cities sub-region of the East Midlands over the next 10 to 20 years and the effects that it may have on the local economy and on local people; and
- To research how, in the medium to long term future, congestion could be managed and reduced across the sub-region.

A major congestion survey carried out within the study confirmed that congestion is a problem in the 3 Cities sub-region at some times of day and on some important roads, but is not spread across the whole road network. It found that the areas worst affected by congestion are the radial routes running in and out of the three main cities of Derby, Leicester and Nottingham and on city ring roads, where delays are at their most severe in the peak periods. Research commissioned on economic costs of traffic congestion estimated that traffic delays currently cost the 3 Cities sub-region at least £½ billion per year, with around half of that cost loaded onto employers and the business community.

Initial consultations with business and other stakeholder groups confirmed that traffic congestion is widely recognised as a problem in the 3 Cities sub-region at certain times of day and in certain places – particularly within the three main conurbations. Unreliability of journey times is of particular concern to business stakeholders.

A conclusion reached from the investigations of current congestion problems is that efforts to tackle urban congestion should be concentrated primarily on the three main city conurbations, but that other towns and key road links in the area should also continue to receive attention.

The amount of road travel within the 3 Cities sub-region is likely to increase significantly over the next 10 to 20 years, without significant intervention. This is partly because of increasing car ownership per head of population (which is forecast by Government to continue throughout the next 20 years), and partly because of plans for increasing economic activity and growth in population in the study area. The transport modelling activities undertaken within the study took account of these plans and confirmed that this will all place significant extra pressure on the transport system.

Study investigations included development and investigation of alternative strategy scenarios to tackle congestion in the future – looking at 2016 as a medium term target year and at 2026 for the longer term future. A Current Strategy Continuation Scenario was defined by the study team members to be one in which funding levels available to the 6Cs local authorities would continue approximately in line with current and recent past figures. The strategy for tackling congestion

under this scenario would be broadly a continuation of the current 5-year Local Transport Plans and longer term strategies within the study area. An Innovative Package Scenario was developed by the study team to include both a congestion charging element and a number of other complementary transport measures. Under this scenario, the revenue raised from the congestion charging element would (together with anticipated Government funding from the Transport Innovation Fund) be invested in funding the complementary transport measures, which would include major transport system improvements, reduction of peak period bus fares and an intensive programme of "smarter choices" measures that encourage and facilitate behavioural change by motorists.

The overall conclusion reached from the study investigations of the alternative scenarios is that an Innovative Package including congestion charging and a range of other complementary transport measures could more effectively tackle future congestion and produce better economic net benefits than continuing with the current strategy under the usual public sector funding constraints.

It is recognised that the Innovative Package Scenario tested within this study is by no means viewed as being the "best of its kind" for the area. Rather, it is seen as representing one possible example of what could be done. The initial nature of the study means that there is a need for significant further investigation, development, refinement and appraisal of alternatives. This would need to be included within a detailed business case investigation before any decision could be reached on whether to move forward towards implementation, and the precise nature of proposals for implementation.

1 INTRODUCTION

1.1 This is the overall Project Report for the 6Cs Congestion Management Study. The study was led by a partnership of three city councils and three county councils from the East Midlands, collectively known as the 6Cs, and took place between February 2007 and March 2008. The 6Cs local authorities who led the study were Leicestershire County Council, Derby City Council, Derbyshire County Council, Leicester City Council, Nottingham City Council and Nottinghamshire County Council. The 6Cs were supported in the study by the Highways Agency, East Midlands Development Agency (emda), the Government Office for the East Midlands and the Department for Transport.

1.2 The 6Cs Congestion Management Study was financially supported by the Department for Transport (DfT) through "pump-priming" funding provided from the Transport Innovation Fund (TIF). It looked at the extent and severity of traffic congestion over the next 10 to 20 years and the effects that congestion may have on the local economy and on local people. The study then researched how, in the medium to long term future, congestion could be managed and reduced across the sub-region.

1.3 Following this introduction, chapter 2 of the report sets out the scope of the study and chapter 3 describes its context. Chapter 4 then describes the current situation with respect to congestion in the study area, including levels of congestion being experienced, economic costs of congestion, current plans to tackle the problem, future trends, and initial stakeholder views on congestion issues.

1.4 Chapter 5 of the report describes work undertaken in the study on transport model development, while Chapter 6 presents the alternative future transport scenarios that were developed and investigated in the study. Chapter 7 sets out the results of testing and investigation of these alternative scenarios, and Chapter 8 draws conclusions from these results. The report is completed by Chapter 9, which outlines further work that would be needed to take the 6Cs Congestion Management initiative further.

2 PROJECT SCOPE

Aims and objectives

2.1 The overall aims of the 6Cs Congestion Management Study were:

- To investigate the extent and severity of traffic congestion over the next 10 to 20 years and the effects that it may have on the local economy and on local people; and
- To research how, in the medium to long term future, congestion could be managed and reduced across the sub-region.

2.2 Within this overall framework, the key project objectives were to:

- Explore current congestion levels in the 6Cs study area through data collection and analysis;
- Identify locations in the 6Cs study area where traffic congestion is a problem;
- Project the likely changes in levels of traffic congestion in the 6Cs area over the coming 20 years using transport models;
- Identify the scale and extent of traffic congestion in the future, and research the impact upon businesses and economic growth in the 6Cs;
- Explore and assess a range of transport measures, including congestion charging, that could be implemented in order to tackle the issue of traffic congestion and limit its future impact;
- Engage with businesses, local political interests and other key stakeholders to gather a range of views on traffic congestion in the 6Cs study area; and
- Weigh all of the evidence collected in order to enable an informed decision to be made on whether or not to move forward into full appraisal and business case development for one or more congestion management strategy options.

The study area

2.3 The 6Cs Congestion Management Study area is the “3 Cities sub-region” of the East Midlands. This includes the Derby, Leicester and Nottingham conurbations, together with other congested areas of Leicestershire, South Nottinghamshire and Southern Derbyshire. The primary focus was on the urban road network, although some key inter-urban roads that form important transport links between the urban areas were also considered. Figure 2.1 illustrates the 6Cs Congestion Management Study area.

Work programme

2.4 The work programme for the study was divided into a number of strands, including:

- Project management;
- Scenario development and testing;
- Congestion data collection using a GNSS satellite survey; and
- Stakeholder engagement.

2.5 Within each of these strands, a number of technical activities were undertaken, which were coordinated and linked through the project management work strand. Figure 2.2 shows a simplified version of the project work programme.

Study participants

2.6 The project was steered by a Project Board with representation from all six local authorities, emda, the Highways Agency, Government Office for the East Midlands and the Department for Transport. The Project Board was chaired by Leicestershire County Council as Project Sponsor; Derby City Council was the Deputy Project Sponsor. The following specific roles were allocated:

- Project manager – Leicestershire County Council
- Scenario development workstream leader – Leicester City Council
- Congestion survey workstream leader – Nottingham City Council
- Stakeholder engagement workstream leader – the 6Cs secretariat within Nottingham City Council
- Social impacts research leader – Nottinghamshire County Council

2.7 A number of specialist consultant organisations were engaged to undertake various technical activities within the project, as follows:

- Stakeholder engagement – Integrated Transport Planning, in association with Armadillo PR and Transport & Travel Research.
- Technical coordination on modelling and scenario development issues - ACS Transport Consultants.
- Modelling and appraisal of strategy scenarios – Scott Wilson, the MVA Consultancy and WSP.
- Cost estimation for cordon charging schemes - Integrated Transport Planning.
- Social impact focus groups - Integrated Transport Planning.
- Business impact case studies - Integrated Transport Planning.

Source materials

2.8 Several detailed technical reports were prepared during the course of the study on work undertaken within the individual study workstreams. These are available through the study website www.6cscongestionmanagement.co.uk. In addition, a number of technical notes were prepared on various aspects of the transport modelling and appraisal process. This report draws on the information contained within all these documents.

Financial values

2.9 Much of the initial scheme research and appraisal work for the study was undertaken using transport models working at 2002 values and prices. It should therefore be noted that all financial values quoted in this report are in 2002 prices, except where otherwise stated.

Figure 2.1 – The study area

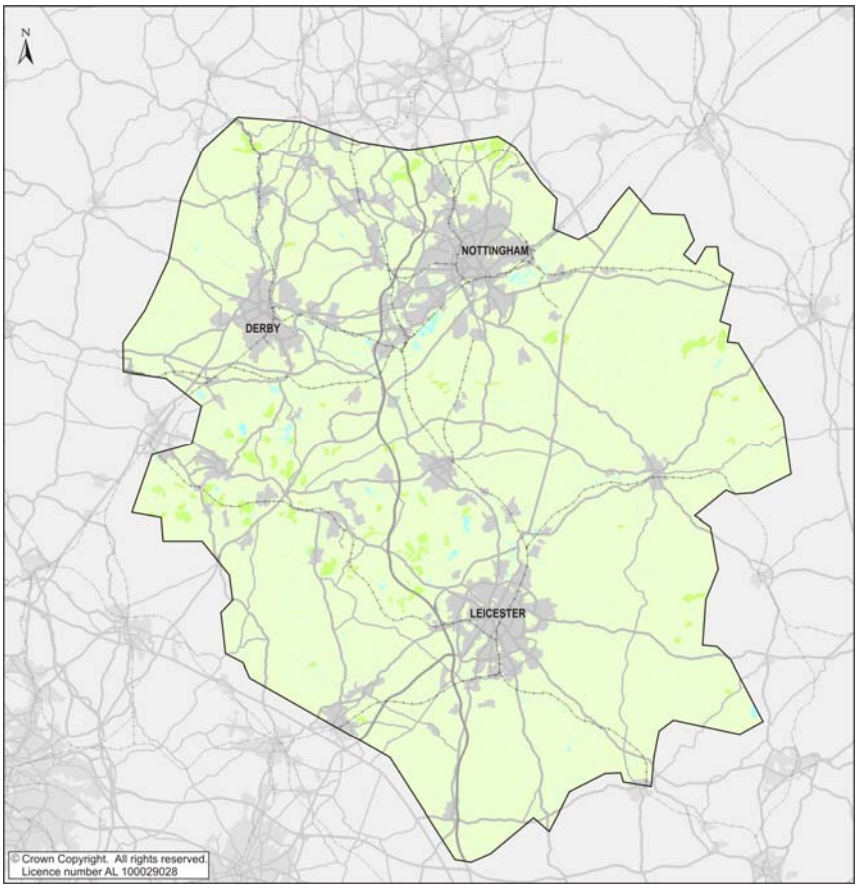
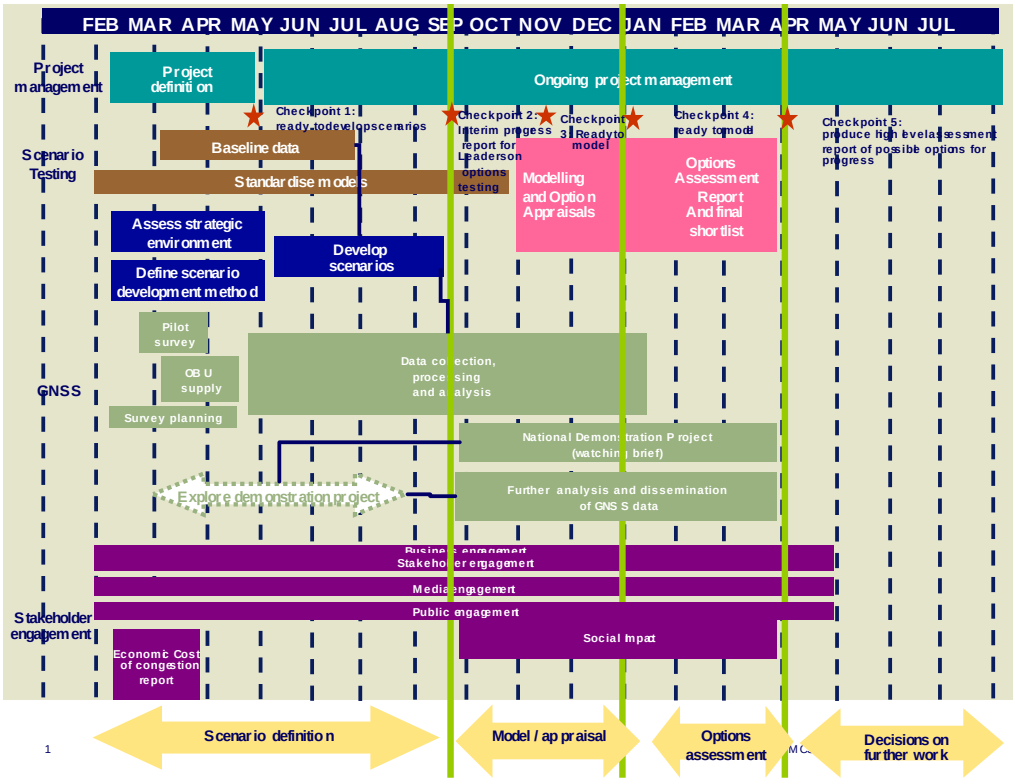


Figure 2.2 Work programme



3 CONTEXT

The sub-regional context

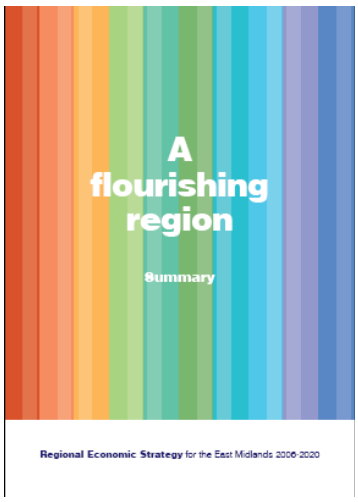
The Regional Economic Strategy

3.1 The Regional Economic Strategy (RES) for the East Midlands ('A Flourishing Region') stretches the region's ambitions beyond 2010 and towards 2020. It wants the East Midlands to be a prosperous region, and one in which people want to live and work.

3.2 From a transport perspective the RES highlights:

- The three cities sub-region's key role as an important driver of economic growth;
- The importance of reliable, high quality transport infrastructure and networks to help the region achieve its objectives of sustainable economic growth;
- The importance of good intra-regional connectivity; and
- The negative impact of road congestion on the regional and national economy and competitiveness.

3.3 A strong message from the business community within the RES is that "the reliability of journey time is often more of an issue than seeking to reduce journey time. Businesses and investors require a degree of certainty over how long journeys will take in order to be able to plan and manage supply chains, to distribute goods and people, and to meet customer expectations and commitments. Uncertainty over journey times requires them to plan for considerably longer journey times, and this can impose additional costs".



3.4 One of the three "priority actions" in the area of transport and logistics within the RES is travel demand management. The aim is to "support regional competitiveness by improving transport efficiency and reducing road congestion by developing innovative approaches to behavioural change, travel demand management, and integration, including exploring measures of congestion charging and measures to realise economic, wellbeing and environmental benefits".

The Regional Spatial Strategy

3.5 The regional spatial strategy for the East Midlands (RSS8) highlights that as in other regions, pressure is growing on transport infrastructure as travel demand increases. The main north-south road routes are increasingly congested, whilst additional investment is required in rail and other forms of public transport. Poor east-west links remain a key issue and combined statistics show that traffic is set to grow in the East Midlands at around 1% per annum for the next 20 years. At the wider Midlands scale the poor quality of these links and infrastructure is also recognised in the Smart Growth: Midlands Way initiative.

The Transport Innovation Fund

3.6 The Department for Transport (DfT) published the White Paper, 'The Future of Transport', in July 2004, in which it set out the Government's intention to establish the Transport

Innovation Fund (TIF). The TIF represents a new approach by the DfT to the allocation of some of its budget. Through the TIF, DfT is directing resources towards the achievement of two very high priority key objectives - specifically tackling congestion and improving productivity. The first of these objectives is particularly relevant to the 6Cs Congestion Management Study, which has been shaped by the provision of TIF funding for the 6Cs local authorities.

3.7 The TIF offers local authorities an avenue for developing innovative local and regional transport solutions to traffic congestion. It provides a mechanism to fund a series of 'pump-priming' studies by UK Local Authorities to investigate potential local solutions to managing congestion – of which the 6Cs Congestion Management Study is one.

3.8 The TIF also offers much larger amounts of funding (up to £200m per year is available from the TIF for a number of years) to Local Authorities who wish to progress innovative congestion management solutions including some form of road user charging. To gain a share of this funding, a detailed business case needs to be put forward to the DfT for implementing such a solution. The 6Cs Local Authorities will only decide whether to move forward to detailed business case preparation once the results of the 6Cs Congestion Management Study are known.

3.9 The 6Cs Congestion Management Study was financially supported by the DfT from the TIF pump-priming fund. The study was one of ten areas in England where studies and feasibility work were supported by DfT. The other areas are Greater Manchester; the West Midlands; Cambridgeshire; Durham; the Greater Bristol area; Tyne and Wear; Reading; Shrewsbury; and Norwich.

4 THE CURRENT SITUATION

Congestion in the 6Cs area

4.1 Before the start of the Congestion Management Study, the 6Cs local authorities were already well aware from previous local data collection and analysis activities that congestion is a problem in the study area at some times of day and on some important roads. Congestion causes delays to people and goods moving around the area and imposes significant costs on businesses and the local economy. It also causes pollution and affects the quality of life of people living and working in the area.

4.2 However, it was important within the context of the study that the six local authorities enhanced their evidence-base to obtain a consistent and comparable picture of levels of congestion across the study area. This would provide an appropriate starting point to inform development and assessment of future options for tackling congestion. Two activities were undertaken to meet this need:

- A major congestion survey; and
- A "base year" problem analysis using transport model outputs.

Congestion survey

4.3 The congestion survey was undertaken using surveyors' cars fitted with Global Positioning System (GPS) satellite tracking equipment to enable journey times to be measured on different road sections. Journeys were made using these vehicles in both typical peak and inter peak period traffic and in free flow conditions late at night. Traffic delays due to congestion were then calculated by comparing journey times during different periods of the day with those achieved at night.

4.4 The network surveyed comprised the main radial and orbital routes in the urban areas and towns within the study area. Over 70 different routes were surveyed and over 50,000 runs were made in both directions on the overall network, making the survey one of the largest ever undertaken in the UK outside London. Data collection and analysis was coordinated by Nottingham City Council's Surveys and Data team with support and contributions from teams in each of the six authorities and the Highways Agency.

4.5 Additional data from the Highways Agency HATRIS database was also brought into the survey analysis for the trunk roads in the area. Information from the survey runs and the HA database were processed in exactly the same manner to ensure consistency.

4.6 The results of the congestion survey for the morning peak hour (8am to 9am) are shown in Figure 4.1 in terms of delay per mile on each of the routes covered. The survey found that the areas worst affected by congestion are the radial routes running in and out of the three main cities of Nottingham, Leicester and Derby and on city ring roads, where delays are at their most severe in the peak periods.

Figure 4.1 Morning peak hour delays per mile as measured by the congestion survey

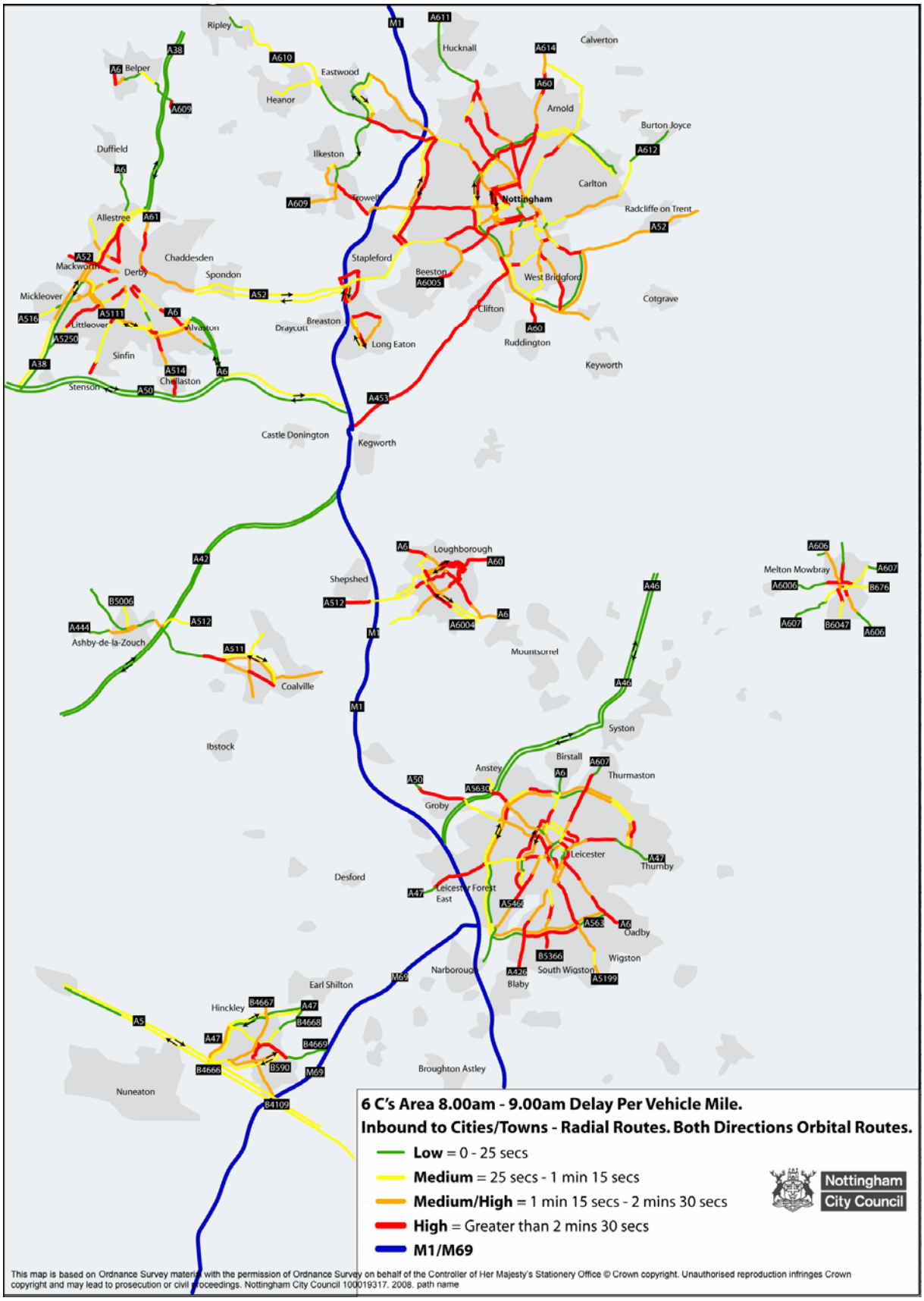


Table 4.1 presents a summary of the average level of delay incurred during the morning peak hour (8am – 9am). This shows that the conurbations of Nottingham, Leicester and Derby experience very similar levels of peak hour delay – just over 2 minutes per mile travelled during the morning peak compared with free-flow traffic conditions.

Table 4.1 Summary of delays by area – morning peak hour (8am-9am)

Area	Morning peak hour 8am to 9am Average delay per mile
Derby conurbation all routes	**2 min 6 secs**
Derby conurbation radial routes	2 min 18 secs
Derby conurbation orbital routes	1 min 28 secs
Leicester conurbation all routes	**2 min 7 secs**
Leicester conurbation radial routes	2 min 40 secs
Leicester conurbation orbital routes	1 min 41 secs
Nottingham conurbation all routes	**2 min 4 secs**
Nottingham conurbation radial routes	2 min 5 secs
Nottingham conurbation orbital routes	2 min 2 secs

4.7 The results also show that there are congestion problems in a number of other towns in the study area. In Leicestershire the worst affected is Loughborough, where delays per mile are comparable with those in Leicester, although the shorter journeys mean that the impact on overall journey times is not usually as bad. In Derbyshire, Ripley, Belper and Ilkeston suffer appreciable congestion, even if generally rather less severe than in the conurbations.

4.8 Due to major road works being undertaken on the A52 between Derby and Nottingham, congestion levels during the survey period were likely to have been affected by displaced traffic on the main radial routes between Derby and Nottingham. Measured congestion levels on the A52, A453, A6005, A609, A6002, A610 therefore need to be viewed in this context. These locations are likely to be the subject of additional future survey work to explore the findings in more detail.

Model-based problem analysis

4.9 An analysis of current congestion problems was also undertaken based on the outputs of transport models covering the three main conurbations. The modelled year used for this exercise was 2006, which was taken to broadly approximate the current situation. The measure of congestion used in this analysis was the Marginal External Cost of Congestion (MECC). **MECC is the change in total traffic delay (in seconds) on a road section imposed on all traffic by the addition or subtraction of one vehicle to that section.**

4.10 In each of the three conurbations, the problem analysis suggested that significant congestion occurs in specific locations at present but is not spread across the whole network. This aligns with previous knowledge. As also indicated by the congestion survey results, modelled congestion problems appear at least as bad on the arterial routes into the cities and on parts of the ring roads as in the city centres themselves.

The economic costs of congestion

4.11 A partner in the 6Cs initiative, East Midlands Development Agency (emda), commissioned a study into the economic costs of congestion across the East Midlands region which reported in the summer of 2007. This estimated the total economic cost of road traffic congestion to

the East Midlands region at £935 million per annum. This includes direct economic costs due to traffic delays and wider economic costs arising from limitations on agglomeration, impacts of imperfect competition, and impacts on the labour market.

4.12 The study looked at the distribution of economic costs by sub-region within the East Midlands, including the 3 Cities sub-region that corresponds to the 6Cs Congestion Management Study area. The 3 Cities sub-region was found to incur easily the highest cost of congestion – some £500m per year including direct and indirect impacts. It should be noted that this excludes congestion costs incurred on the East Midlands region's strategic road network (including some motorways and trunk roads within the study area) – which amounted to a further £185m per year. The total vehicle delays (and consequent costs) were estimated by the study to be highest in the two largest urban areas of Greater Nottingham and Central Leicestershire, with significant delays and costs also incurred in Derby.

4.13 The study found that more than half of the total economic cost of congestion is loaded onto the business community, through delays to business users of the road network and wider economic impacts.

Current plans to tackle congestion

4.14 The local authorities involved in the 6Cs Congestion Management Study already have their second five-year Local Transport Plans (for 2006-11) in place to tackle congestion, which aim to make best use of financial resources available to them. Uniquely in England, the three contiguous Local Transport Plans that have been prepared by the authorities concerned have all been rated as Excellent by central Government. These include a full programme of initiatives within the available funding including:

- Bus priority measures
- Public transport infrastructure improvements
- Increased Park & Ride facilities
- Urban traffic control, traffic management and real time information improvements
- Bus quality improvements
- Tram network extension (Greater Nottingham)
- Highway improvements at key locations
- Smarter Choices measures – including travel plans and marketing campaigns
- Parking control
- Land use policies

Future trends and pressures

4.15 All three cities within the 6Cs study area have major physical regeneration, business growth and retail development plans.

4.16 The '3 Cities' and counties are also planning for high levels of growth in housing and successfully submitted a joint Sustainable Communities Growth Point bid to the Government, based upon a new projection to increase housing stock by 121,950 dwellings for the '3 Cities' Sub-area in the period 2006-21. This is approximately 24,900 dwellings or 25% above the levels in the adopted Structure and Regional plans from 2003. Furthermore,

there are possibilities for new Eco Towns in the sub-region. A Local Employment Growth Initiative (LEGI) bid is also being developed to stimulate business growth in deprived areas and to link the unemployed in such areas to opportunities on employment growth sites such as East Midlands Airport (EMA).

4.17 In addition to all of this, predictions for EMA by 2030 are that:

- Employment will increase by 295%;
- Annual passenger numbers will grow from 4.5 million today to between 12 million and 14 million;
- Annual cargo will increase from 290,000 tonnes today to around 2.5m tonnes; and
- Annual regional income generated by EMA-related employment will rise by approximately £1.2bn (583%).

4.18 All this growth will clearly have a major impact locally, regionally and nationally on transport demand and ultimately congestion.

Initial stakeholder views on congestion issues

4.19 Views of key stakeholder groups on current congestion issues were sought as part of a first wave of engagement events running from May 2007 to January 2008. This included engagement events with business organisations and with other non-business stakeholder groups. During the first wave of stakeholder engagement events, study team members presented the study's objectives and scope, information about current congestion in the area, and an overview of the sorts of measures that were under consideration within the study for a future package of measures to tackle congestion. Discussion sessions were then included that enabled attendees to air their views on attitudes to traffic congestion, impacts of current traffic congestion and initial views on potential solutions.

Business views

4.20 Initial business engagement events were organised in association with the following business organisations – Federation of Small Businesses (Derby and Nottingham branches), the Nottinghamshire and Derbyshire Chambers of Commerce, Leicestershire Chamber of Commerce, the Institute of Directors, the Confederation of British Industry, Leicestershire Business Voice, the East Midlands Business Forum and the Institute of Chartered Accountants in England and Wales.

4.21 Key business perceptions of the traffic congestion problem expressed through these events were as follows:

- Traffic congestion is widely recognised as a problem in the 6Cs sub-area – at certain times of day and in certain places. It is not perceived as just a city centre problem, because it occurs on the main radials outside city centres and on orbital routes. Congestion is particularly bad where busy radials meet busy orbital routes, but also hinders sub-regional movements and through-traffic.
- Specific locations within the 6Cs sub-area identified as congestion hotspots included the roads outside of the Derby, Leicester and Nottingham city centres. The strategic links from motorway junctions (particularly on roads serving the business parks around Junction 21 of the M1, but also at Junctions 24, 25 and 26),

the A453, A38, A42, A46, A52 (particularly on the Nottingham Ring Road north from Queens Medical Centre) and the roads through Melton Mowbray were noted as locations with particularly acute traffic congestion at peak times.

- The variability of congestion on certain roads in the sub-area, at certain times of day, was identified as a key cause of unreliable journey times and is of particular concern to business stakeholders.
- The falling cost of motoring (in real terms) was identified as one factor driving greater demand for road space. It was also observed that there was an increase in "white vans" using the roads.

4.22 Views on impacts on businesses of current levels of traffic congestion included:

- There was a widespread recognition that congestion costs are incurred by businesses. Congestion delays result in increased costs of running freight transport and haulage operations in the region. Since 90% of goods are transported by road, any increases in costs are largely passed on to the consumer through price-inflation.
- Some stakeholders expressed concern about the growth of road freight transport and its impact on congestion in the 6Cs sub-area. It was felt that the growth of freight movements should be taken into account by any future congestion management strategy as well as the need to ensure that freight operators can continue to access city centres.
- Congestion in the 6Cs sub-area has a particular impact on staff movements to and from out of town business parks in close proximity to motorway junctions (e.g. Junction 21 of the M1). Past planning policies to generate developments in these locations were criticised by some and it was suggested that urban regeneration policies should be a future priority. Transport was identified as one of the key considerations for businesses when they locate. Business stakeholders feel there is a need for urban renewal to be supported by high quality public transport systems, in order to provide suitable business locations.

Views of other stakeholder organisations

4.23 The first wave of engagement events with other stakeholder organisations included a breakfast event organised by the Institution of Civil Engineers and the Charging or Choice conference organised by Travelwatch East Midlands. A specific stakeholder workshop event was organised and hosted by the 6Cs study team in Derby in September 2007. A wide range of stakeholder organisations were invited and 16 organisations participated.

4.24 Perceptions of traffic congestion problems expressed through these events were very similar to those expressed through the business engagement events, indicating a common perception of the current congestion issues. In particular, participating stakeholder organisations generally shared the business sector view that traffic congestion in the 6Cs study area is a problem at certain times of day and in certain places. They also felt that congestion is a particular problem on main radial routes outside the city centres, on city ring roads and where these two meet.

4.25 A consensus view expressed at the stakeholder workshop was that car use was the prime issue to be addressed to tackle congestion rather than car ownership. Through traffic was also seen as contributing to the congestion problem in cities.

4.26 On impacts of congestion, a "congestion" breakout discussion group at the Travelwatch East Midlands event chaired by a member of the 6Cs team suggested that local economic well-being should be the driving force for trying to address congestion, although it was recognised that there could be important "spin-off" environmental benefits. The 6Cs stakeholder workshop also raised air pollution as an important impact of congestion.

4.27 A particular issue raised in the stakeholder workshop (and also in some of the business engagement events) is that congestion causes significant problems for bus operators in delivering punctual and reliable services. Delays can not be recovered on short bus runs and delays caused by traffic congestion lead to less predictable journey times, which are bad for bus operators, commuters and the travelling public in general. If congestion is allowed to increase, it will mean bus operators have to use more resources (drivers, vehicles) to deliver bus services, which will increase costs, which will raise fares, which will make public transport less attractive – a vicious circle. Unpredictability of journey times was also seen as a key issue – both for bus operators and for members of the travelling public.

5 THE TRANSPORT MODELLING SYSTEM

The role of the transport modelling system

5.1 A key part of the 6Cs Congestion Management Study involved testing and investigation of alternative scenarios for future congestion management in the study area. A large part of this testing and investigation was undertaken using a transport modelling system. This modelling system was assembled for the project by making best use of existing models previously created within the 6Cs organisations and recognising the "initial investigation" nature of the study. Enhancements to the existing models were implemented to make them as internally consistent and as "fit for purpose" as possible within the study time and budget constraints.

5.2 While this modelling system was seen by the study team as being adequate for the level of investigation being undertaken by this initial study on congestion management options, it is recognised that it does not fully meet Department for Transport (DfT) model requirements for more detailed appraisal of options that would be needed as part of preparation of a full business case for any future congestion management strategy. Substantial further transport model development would therefore be needed if the 6Cs congestion management initiative was taken forward beyond this initial study, in order to ensure that appraisals based on modelling are sufficiently robust to satisfy both Government and local scrutiny.

The 6Cs study transport modelling system

5.3 The modelling system developed and used within the study consists of the following elements:

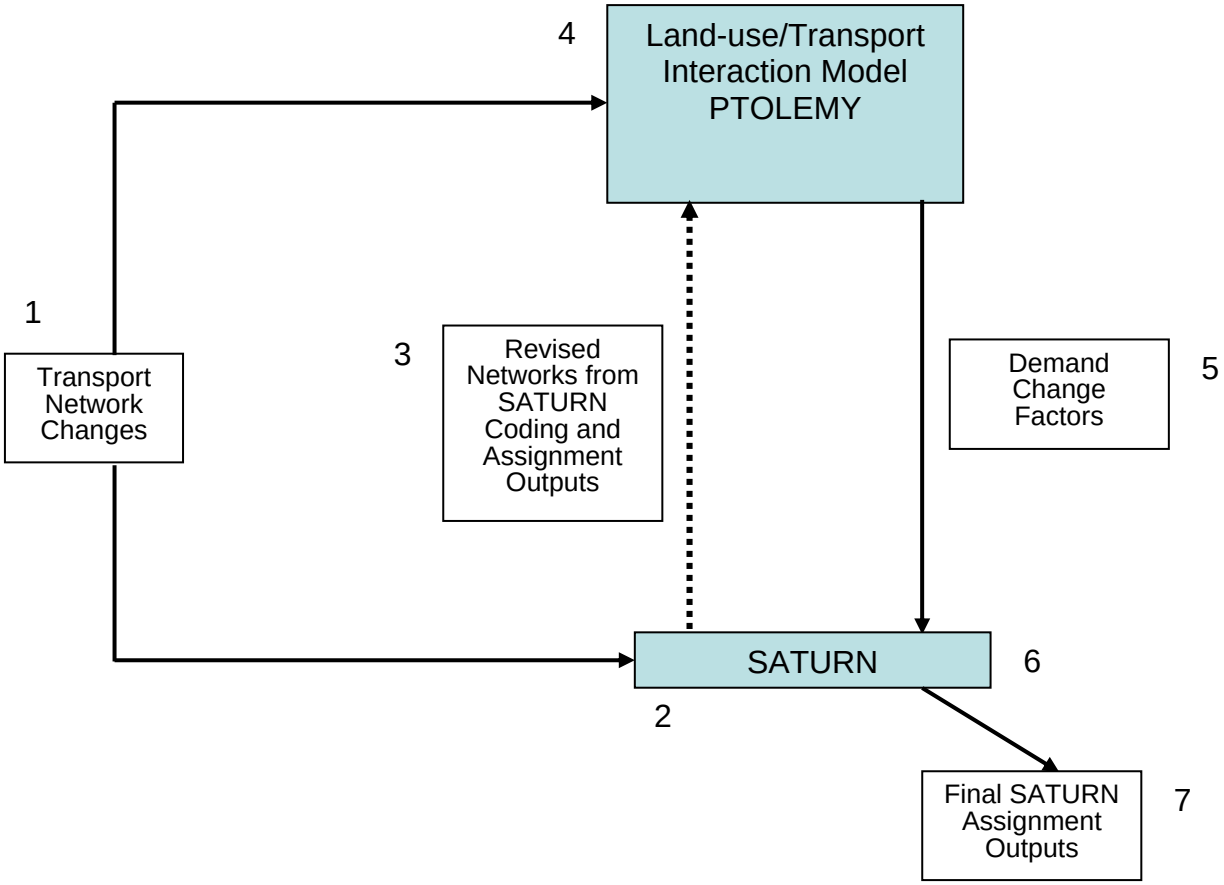
- Core modelling system
  - PTOLEMY: a transport/land-use interaction model for the 3 Cities Sub-Region, developed by WSP using MEPLAN software and representing morning peak, inter-peak and afternoon peak time periods.
  - Road traffic assignment models for each of the conurbations of Derby, Leicester and Nottingham, developed using SATURN software for three time periods.
- Supplementary models
  - SATEASY (elastic assignment) versions of the SATURN models for the three conurbations.
  - Derby demand model: a comprehensive travel demand/supply model developed using MVA's TRAM (Traffic Restraint Analysis Model) software.

Core modelling system

5.4 The structure of the core modelling system is set out in Figure 5.1. Travel demand in the core models is segmented by income level to reflect willingness to pay charges. This is a hierarchical system under which travel demand changes estimated using PTOLEMY (which takes account of a range of demand responses that could occur as a result of a change in travel costs) are applied to the SATURN trip matrices. The SATURN models are then

operated on a fixed matrix basis. There is no public transport assignment equivalent of the SATURN models - public transport modelling takes place entirely within PTOLEMY.

Figure 5.1 The core modelling system (PTOLEMY / SATURN)



5.5 Following the numbered boxes in Figure 5.1, the operation of the core modelling system for a particular model run (modelling a particular scenario) is as set out below.

5.6 The process begins with Box 1, definition of network revisions for the new model run. Wherever possible, highway network changes are made first in SATURN (Box 2) and from this the simplified link-based network coding required by PTOLEMY is derived (Boxes 3 and 4). However, in many cases it is necessary to have entirely separate network coding at the two levels in the hierarchy. Public transport schemes are coded directly into PTOLEMY, with bus speeds in PTOLEMY being responsive to changes in highway speeds.

5.7 Appropriate land-use and economic assumptions are input to PTOLEMY for the year under consideration, using the land-use modelling functionality of PTOLEMY. Within the modelling investigations of alternative scenarios and options within the project, the land-use patterns used were kept consistent for any given year. Land-use responses were not modelled (although though changes in trip end totals resulting from movement of household and person types within fixed levels of housing stock are permitted) because it was felt that with variable land-use an incomplete and potentially misleading picture of the impacts of the scheme could be captured. Sensitivity tests with variable land-use modelling could, however, be undertaken at a later stage if required.

5.8 A run of PTOLEMY results in a revised set of travel demands. Zone based origin to destination growth factors can then be developed to apply to the relevant SATURN matrices (Box 5). SATURN matrices were developed for six user classes (employers business, three other car-based groups, light goods vehicles and other goods vehicles), and growth factors were available from PTOLEMY for each of these. In applying PTOLEMY derived growth factors it was normally assumed that peak period (PTOLEMY) to peak hour (SATURN) growth factors are unchanged from the base year. It was considered that the evidence for peak spreading in the three city conurbations is not decisive, and that the modelling approaches available for this are both time consuming and uncertain in their effects.

5.9 The SATURN models are then run on a fixed matrix basis (Box 6). SATURN assignment outputs (Box 7) provide the basis for appraisal of future year problems and for appraisal of specific scenario options. Appraisal is also undertaken at the PTOLEMY level, in particular in relation to public transport.

Supplementary models

SATEASY models

5.10 The PTOLEMY model has very long run times, and so the opportunity for multiple runs of the core modelling system is very limited. This was a problem in terms of the investigation of cordon charging options, where the number of possible cordon locations, charging patterns and levels of charging is very large. Own cost[1] elastic assignment versions of the individual city conurbation models were therefore created using the SATEASY facility within SATURN, to sift a broad range of charging locations and price levels. This pragmatic approach for this particular application is felt to be reasonable and in line with DfT modelling guidance, which suggests that simple elasticity models may be used to narrow down scheme options before a full variable demand model is used to establish more detailed effects.

Derby demand model

5.11 The core modelling system has a number of limitations in respect of the investigation of demand management measures, relating to the functionality of PTOLEMY. These relate primarily to modelling of shifts in the timing of car trips in response to demand management measures, and the relationship between demand management and car parking in city centres. The Derby demand model (based on TRAM[2] software) operates with nine time periods, and has a time of day choice facility and a comprehensive parking demand/supply model. As part of the current project it was revised to include income segmentation based upon PTOLEMY estimates. Outputs from this model were therefore used to check on the sub-region wide forecasts produced using the core modelling system.

[1] Own cost means that only changes to highway costs and demands are considered, and inter-relationships with other modes such as bus and walking are not explicitly considered.
[2] Traffic Restraint Analysis Model.

6 ALTERNATIVE FUTURE SCENARIOS

6.1 Alternative strategy scenarios for congestion management in the future were developed and tested as a major part of the study. This section of the report outlines the overall process of scenario development and testing and describes the alternative scenarios tested and investigated within the study.

6.2 At an early stage in the project, the team responsible for scenario development within the study defined the transport planning objectives for the scenarios as follows:

6.3 "To tackle congestion problems throughout the study area in order to provide support for the economic development of Derby, Leicester and Nottingham together with sub-regional centres such as Loughborough and Long Eaton, whilst promoting social inclusion for the whole area."

Development and testing of scenarios

6.4 The study aimed to define and test three main future scenarios:

- Do Nothing Scenario
- Current Strategy Continuation Scenario
- Innovative Package Scenario

6.5 These would be compared with each other within the study for the target appraisal year of 2016. In addition, some attention was given to potential longer term impacts, through the creation of a 2026 Scenario, based on an assumption of no transport changes after 2016, but reflecting anticipated demographic and income changes.

Do Nothing Scenario

6.6 The Do Nothing Scenario was defined as a useful hypothetical baseline with which other scenarios could be compared, although it was recognised that this is an unlikely scenario in the real world. It refers to a scenario in which no further public sector investment is made in the transport system after 2006 other than schemes under construction. Committed schemes funded by developers were included in the Do Nothing Scenario (including those schemes that have more significance than simply the connecting of a new development into the existing highway system).

Current Strategy Continuation Scenario

6.7 For the Current Strategy Continuation Scenario the approach was to define a realistic set of additional schemes and measures that are likely to be in place by 2016 given:

- Likely funding constraints from conventional sources (in the light of current and past levels);
- Acceptability constraints; and
- The transport objectives and longer term transport strategies of the relevant authorities.

6.8 In this sense this scenario constitutes the 'most likely' scenario given present understanding of problems to be addressed and funding constraints. By comparing the Do Nothing and the 'most likely' it was possible to benchmark the effectiveness of a combination of conventional

transport measures and historic levels of funding as a means of addressing the transport problems and objectives for the area.

6.9 The schemes and measures to be included in this scenario were defined by officers from the six local authorities and the Highways Agency, working in conjunction with a team of transport modellers supplied by a consortium of consultants. These are summarised in Table 6.1.

Innovative Package Scenario

6.10 The Innovative Package Scenario was developed as an example of a combination of some form of congestion charging scheme with a range of other complementary transport measures. This is the sort of package that could potentially be eligible for significant financial support from DfT's Transport Innovation Fund, if it was found to be appropriate as a solution to the sub-region's congestion problems and a robust business case could be made for the package.

6.11 Development of the Innovative Package Scenario was a significant task within the 6Cs Congestion Management Study. It involved initial testing of a wide range of possible congestion charging scheme options for the study area, sifting and refinement of those options, and combination of a promising option with a package of other measures that would complement and reinforce the charging scheme in achieving congestion reduction and other objectives.

Testing of congestion charging scheme options

Time-distance-place (TDP) charging

6.12 One of the first charging options to be tested on its own within the study was time-distance-place (TDP) charging covering the study area. TDP charging essentially charges the road user according to the time of travel, distance travelled on a particular road link and the place of travel. Charging according to distance travelled generally requires an onboard unit (OBU) with a vehicle positioning capability (e.g. through the Global Positioning System (GPS)).

6.13 Among the range of congestion charging options available, TDP charging has significant attractions in that charges could potentially be matched most closely to actual congestion levels and amount of road use. It is therefore a potentially powerful demand management tool with a finer level of control than other options (such as cordon charging or workplace parking levy), and can also be viewed as being most equitable for the motorist. The ideal position for any road user charging scheme would be to levy charges that equate to the Marginal External Cost of Congestion (a measure of congestion severity - see Chapter 4) for each link in the road network. This is known as Marginal Social Cost (MSC) pricing and TDP, in theory at least, could come close to achieving this.

6.14 However, TDP charging is considered unlikely to be feasible as a main basis for congestion charging in the 6Cs study area by 2016. There are significant barriers to be overcome, including technological and enforcement issues, cost issues and legal issues associated with mandatory use of the technology required. There is also no existing TDP scheme experience in an urban context anywhere in the world, and reliable cost estimates could not be made for input to economic appraisal.

Table 6.1 Measures and schemes included in the Current Strategy Continuation Scenario

Derby and Derbyshire	Leicester and Leicestershire	Nottingham and Nottinghamshire

• Highway Schemes
  • T12 – A new link road to connect the new Chellaston Business Park.
  • Connecting Derby - Integrated scheme that includes a new single lane carriageway to complete the ring road, bus lanes and bus priorities.
  • HA highway improvements, including grade separated junctions on the A38/A61, A38/A52, A38/A5111.
  • HA signalisation of A38/A50 junction.
• Car Park Schemes
  • Changes to existing parking provision in and around the city centre resulting from the Connect Derby and Westfield development.
• Bus Infrastructure Scheme
  • Mixture of bus lane and signal priority measures at Burton Road, Uttoxeter Road, A6 London Road, A514 Osmaston Road.
• Park and Ride
  • Proposed locations – Boulton Moor and Derby City Hospital.
• Heavy Rail Schemes
  • Changes to existing rail services
	• Highway Schemes
	  • Improvements to highway infrastructure at: B582 Narborough Road – Whetstone; Loughborough IT; Trinity Square CP; Melton Mowbray Bypass; Lutterworth Western; and Kegworth Bypass.
	  • HA widening of M1 between J21 and J30.
	  • HA improvement to M1 J19.
	• Car Park Schemes
	  • New 2000 space off street car park at St Peters Lane to accommodate the expansion of the Shires Shopping Centre.
	• Bus Infrastructure Schemes
	  • Quality bus corridors at Saffron Lane, Melton Road, Humberstone Road, Aylestone Road, Groby Road, Welford Road, London Road and Narborough Road.
	  • Junction improvements at Abbey Lane.
	  • Conversion of traffic signals at specific locations to SCOOT to reduce delays to buses.
	  • Travel plan schemes for schools and businesses.
	  • New public transport link from Soar Valley Way to Lutterworth Road.
		• Highway Schemes
		  • Improvements to Nottingham Ring Road; and Eastside transport strategy, involving highway improvements in Nottingham City Centre, plus highway improvements to accommodate NET 2.
		  • Highway improvements at: Gedling Access Road; Hucknall Inner Relief Route; Gedling Transport Improvement Scheme.
		  • Highway realignment at Castle Market Road and Triumph Road.
		  • Junction improvements at junctions of Hucknall Road with Arnold Road and Kersall Drive.
		  • HA widening of M1 between J21 and J30.
		  • HA dualling of A453 from M1 J24 to A52 and A46 from Newark to Widmerpool.
		• Car Park Schemes
		  • Improvements including new Metro car park.
		• Bus Infrastructure Scheme
		  • Bus lanes at: Mansfield Road from Carrington to Gregory Boulevard; Nottingham Road on the approach to the Ring Road; Trent Bridge - Meadows Way/London Road approach; A612 Daleside Road.
		  • Quality bus corridor schemes at: Wollaton Road from Russell Avenue to Nottingham Ring Road; Derby Road from city boundary to city centre; A6005 Derbyshire / Nottinghamshire boundary to

Derby and Derbyshire	Leicester and Leicestershire	Nottingham and Nottinghamshire

between Nottingham and London that includes increased calls at the new East Midlands Parkway Station.	• Park and Ride
	  • Provision of three 1000 space Park and Ride facility at these locations: Enderby, Birstall and Glenfield. Headway between buses would be approximately 10 minutes.
	• Heavy Rail Schemes
	  • Changes to existing rail services between Sheffield – London and Nottingham – London that includes increased calls at East Midlands Parkway Station.
		Nottingham City boundary; Nottingham Ring Road from QMC to Mansfield Rd.
		• Park and Ride
		  • Park and Ride facilities at: Phoenix Park P&R (910 spaces), Toton P&R (1400 spaces), Clifton P&R (1000 spaces); Gamston P&R; Racecourse P&R increased from 500 to 750 spaces.
		• Heavy Rail Schemes
		  • New East Midlands Parkway Station, including a 1000 space Park and Ride facility.
		  • Changes to existing rail services between Sheffield – London and Nottingham – London that includes increased calls at East Midlands Parkway Station.
		  • London – Nottingham train service would also include a service that would call at Derby. Improved Nottingham - Sheffield train services that would include an extension to Leeds.
		• Light Rail Schemes
		  • NET Phase 2 – new tram services to serve the areas to the south and west of Nottingham.
		• Workplace Parking Levy Scheme
		  • Businesses to be charged an annual fee for workplace parking provision.
		• Other Local Transport Initiatives
		  • Pump priming improvements on off peak bus services and on weekdays from 7am – 7pm.
		  • Improvements to existing Link bus services.

6.15 Testing of TDP was therefore limited to a theoretical option, with optimal charges for each network link in each modelled time period calculated using a model-based approach to estimation of MSC prices. Only the strategic level model PTOLEMY was used for the testing of TDP, as it provided all of the necessary facilities without the complexity of use of the more detailed individual city conurbation SATURN models. As well as considering congestion costs in the calculation of MSC prices, the process took account of the marginal costs of environmental impacts using values provided by the DfT. The process of estimating MSC was iterative. PTOLEMY first calculated MECC for the starting point and set charges to these levels. Traveller responses to the prices in terms of changes in route, mode, and destination were then taken into account. MECC and revised link charges were then re-calculated and this iterative cycle continued until link prices became stable.

6.16 It should be noted that such a scenario is not fully realistic for a number of reasons – including the consideration that road users would probably find the resulting large number of different charge levels for different roads difficult to understand. The calculated impacts and benefits should therefore be viewed as an upper bound on the benefits likely to be obtainable through TDP charging - a great deal of further scheme design work would be required to convert this to a viable scheme, even once the various barriers to implementation had been overcome.

6.17 Within the process to estimate optimal TDP charges, it was assumed that:

- All vehicles would be subject to charge;
- The scheme would be applied all day from 07.00 until 19.00;
- Heavy goods vehicles would experience a charge double that for light vehicles, reflecting their greater impact on congestion;
- The charge would be zero on those links for which the current fuel duty covers the required MSC; and
- The charge would be limited to a maximum of £1 per km to avoid excessive charges on very heavily congested links.

6.18 The model estimated MSC charges would be just above 6p/km (at 2001 prices) for the study area as a whole for the morning peak. As expected, this charge would be higher (12-15p/km) in the urban areas where the road congestion levels are high, and much lower (4p/km on average) elsewhere. The MSC charges estimated for the afternoon peak were similar. For the inter-peak period, the MSC charges are a lot lower as a result of lower levels of road congestion – averaging 2.5p/km for the study area, with the urban areas incurring a charge ranging from 4-8.5p/km and under 1.5p/km outside the conurbations.

6.19 The modelled traffic and travel impacts of this TDP charging option in 2016 are summarised in Table 6.2. Throughout this table, changes in the indicator are relative to the 2016 Current Strategy Continuation scenario.

6.20 In terms of economic appraisal, the predicted resulting annual transport economic efficiency (TEE) benefits of the TDP charging option tested for the year 2016 across the study area were:

- Morning peak period £77m

- Inter-peak period £48m
- Afternoon peak period £75m
- Total (all day) £200m

6.21 These are pure benefit figures due to time savings and vehicle operating cost savings and do not take account of costs of implementing and operating a TDP scheme, which could not be estimated at this stage.

6.22 Annual revenue from the TDP charges would be around £1bn per year, evenly spread across the time periods. Again, this is a gross figure, from which scheme costs would need to be deducted.

6.23 As is evident from these results, modelling of the TDP charging scheme showed very significant potential congestion reduction benefits and transport economic efficiency benefits. However, TDP charging was not taken forward into the Innovative Package Scenario for further investigation. This is because it is considered unlikely to be feasible as a main basis for congestion charging by the year 2016 (although it could form one of a number of options within a feasible charging scheme).

Table 6.2 Modelled impacts of the TDP charging option

Indicator	Analysis
Average speeds	As a result of the MSC charges, the level of car traffic reduces significantly, resulting in car speed improvements of 10-20% in the built-up urban areas during the morning peak. Speed improvements in the conurbations' surrounding areas and on the trunk road network are generally in the 3-10% range. Afternoon peak car speed changes are of a similar magnitude. In the interpeak, there are still car speed improvements in the City areas and on the trunk roads - generally these are under 10%.
Travel by mode in the study area	During the morning peak, the total car traffic reduces by 7%. Because the car leg of park & ride trips is also charged, the average cost for park & ride trips rises by 43%, and the number of such trips falls by 14%. Bus is by far the biggest gainer, with a rise of 35% in trips and 54% in trip-kms. Train and tram both gain (by 8% and 5% respectively in number of trips). Walking and cycling also gains by 5% in trips. The afternoon peak results are similar to the morning peak. The interpeak results follow a similar pattern in terms of travel and costs though with lower magnitudes of change, except that park & ride trips rise (by 19%) rather than fall as in the morning.
Travel by destination/origin area	During the morning peak, car travel to the central business areas of the Cities falls the most (ranging from 14-24%), because of the higher charges applied to the most congested parts of the network. This is followed by trips to the other urban areas in these cities (where numbers of car trips decrease by between 11 and 15%. The afternoon peak results are similar to the morning peak. The

Indicator	Analysis
	interpeak results follow a similar pattern in terms of travel and costs
Travel by trip purpose and mode	During the morning peak, commuting travel by car reduces by 7% in trip-km, education by 14%, other private travel by 8% and employer's business by 1%. The afternoon peak modal shifts are in similar magnitude. Interpeak modal shifts also follow the same pattern though with lower magnitudes of change.

Cordon based charging options

6.24 The major part of congestion charging option development and testing focussed on cordon charging options for the three major city conurbations – Derby, Leicester and Nottingham. This included a number of single and double cordon arrangements in each conurbation, in which a charge would be levied each time a vehicle crossed a charging site on a cordon around a defined area. However, time and resource constraints did not permit the full exploration of all potential cordon charging options during this initial project.

6.25 Initial cordon locations were devised by the local authorities, based on existing measures of congestion and on perceptions of network response and practicality issues. Potential cordons were also identified based upon the distribution of high levels of MECC (a measure of congestion severity – see Chapter 4) across the network, and identification of network links through which the contributing traffic tended to pass. This method followed advice from the Institute of Transport Studies at the University of Leeds. The possible cordon locations identified in this way were explored as initial logical examples – however, they are by no means definitive and cordon location options would need further investigation if the 6Cs Congestion Management initiative is taken further beyond this initial study.

6.26 Cordon charging options were initially developed and appraised using the SATEASY element of the modelling system. A limited sub-set of the options thus developed were then tested using the PTOLEMY model. Some further investigation of effects was also undertaken using the more comprehensive Derby demand model.

6.27 A cordon charging scheme cost model was developed and applied to provide input to cordon charging scheme appraisals. This model takes as inputs cordon location and traffic flow details to derive capital and operating cost estimates. Within the cost model, it was assumed that two technical and operational solutions would be used within the cordon charging schemes examined, with road users free to select which suited their needs best:

- A solution in which the charging process is initiated by roadside beacons at charging points reading in-vehicle tags fitted by the user to their windscreens, with the charge levied against a user account. Such tags would be similar in concept to those used on the Dartford crossing, for example.
- A solution in which road users are responsible for determining that they will incur (or have recently incurred) a charge by crossing a charging site during charged hours. They then declare and pay the appropriate charge, with the payment linked to the vehicle registration number. This is similar to the main charging solution used by most users of the central London Congestion Charging Scheme.

6.28 Compliance checks with either solution would use fixed and mobile cameras with automatic number plate recognition (ANPR) technology.

6.29 In the estimation of costs for cordon charging proposals it was assumed that a similar type of charging scheme would be implemented in each of the main urban areas. This would allow a single congestion charging system to be operated as an integrated whole, with sharing of central system costs across the three city conurbations. Without this assumption, costs for individual cities would be significantly higher.

6.30 For reasons of available time and budget, a number of constraining assumptions were applied in developing and testing cordon charging scheme options. These were:

- A maximum of two cordons per conurbation;
- Peak period charging only; and
- Single direction charging only:
  - Morning peak (07.00 – 10.00) inbound charging; and
  - Afternoon peak (16.00 – 19.00) outbound charging.

6.31 For similar reasons, the initial process to identify appropriate cordon locations and charge levels took place using model based (SATEASY) tests for the morning peak only, with an assumption that a reversal would be broadly appropriate for the afternoon peak.

6.32 A number of charging cordons for each conurbation were tested initially using SATEASY – either as single cordons or in combination as double cordons. All the cordon locations initially tested for the Derby, Leicester and Nottingham conurbations are shown in Figures 6.1 to 6.3 respectively.

6.33 The results from the initial SATEASY testing and use of the cordon charging cost model suggested that the economic case for cordon charging on its own is not strong with any of the cordons tested. At best, the results suggested that economic performance of the schemes as judged from the morning peak SATEASY testing programme could be marginal, with Derby and Leicester showing small negative impacts, and Nottingham a small positive benefit.

6.34 Following completion of the initial SATEASY based testing, two cordon charging tests were carried out using the full PTOLEMY core model for the morning peak period. These were:

1. Test of the best performing cordons from the initial SATEASY appraisal for each of the three city conurbations.
2. Test of urban fringe cordons in Derby and Nottingham, with a Leicester cordon as per test 1.

Figure 6.1 Example charging cordons tested for Derby

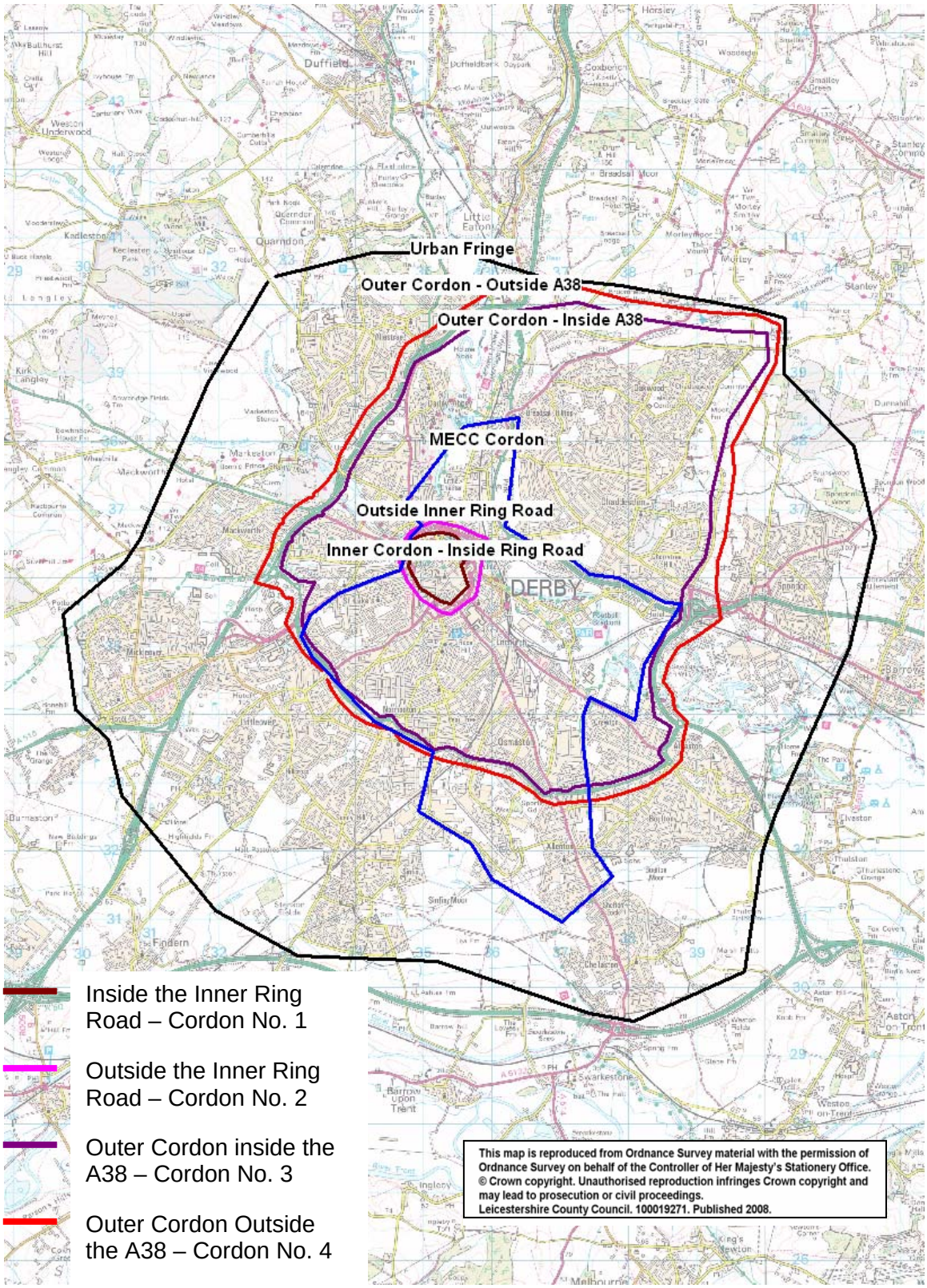
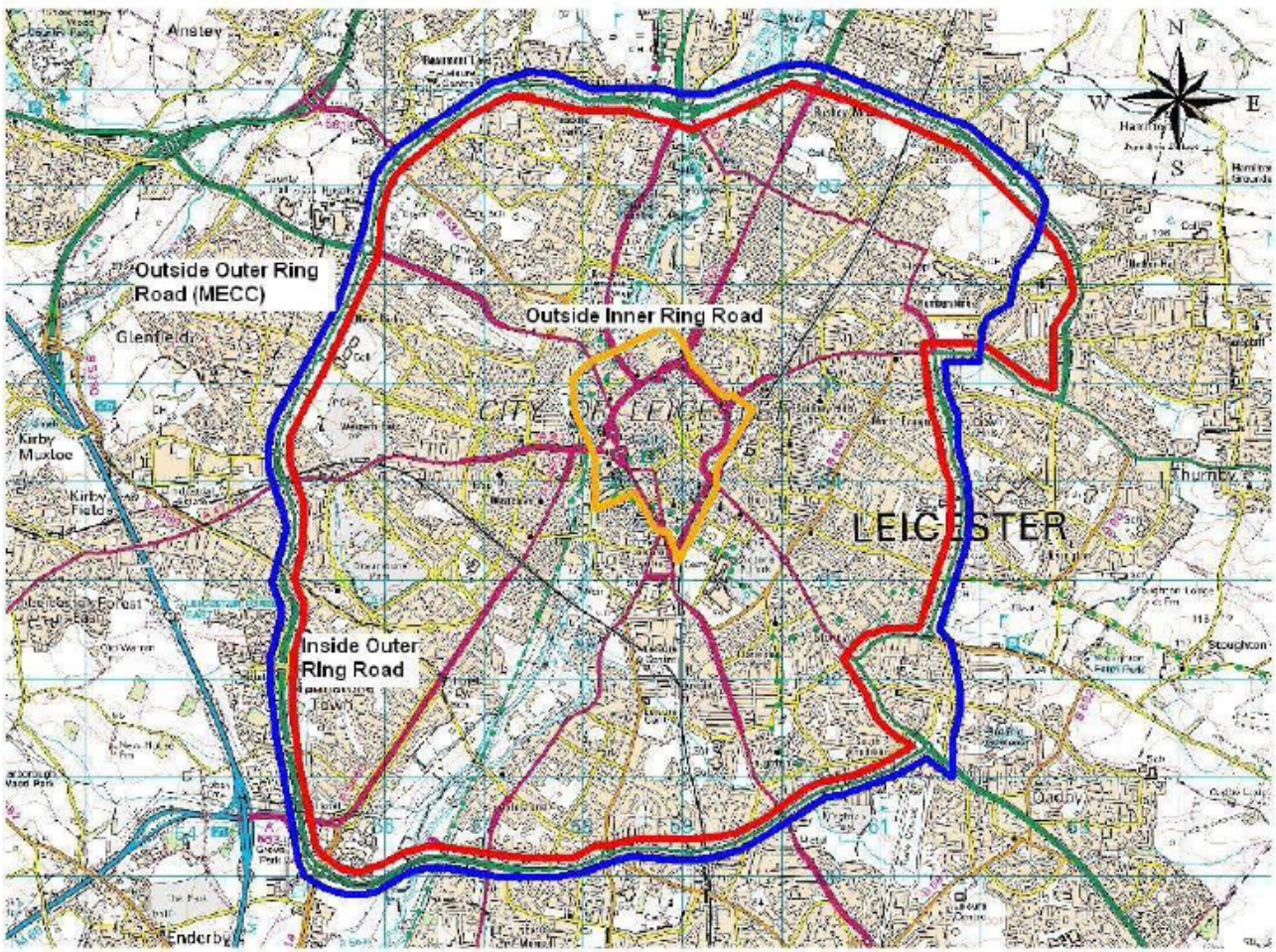
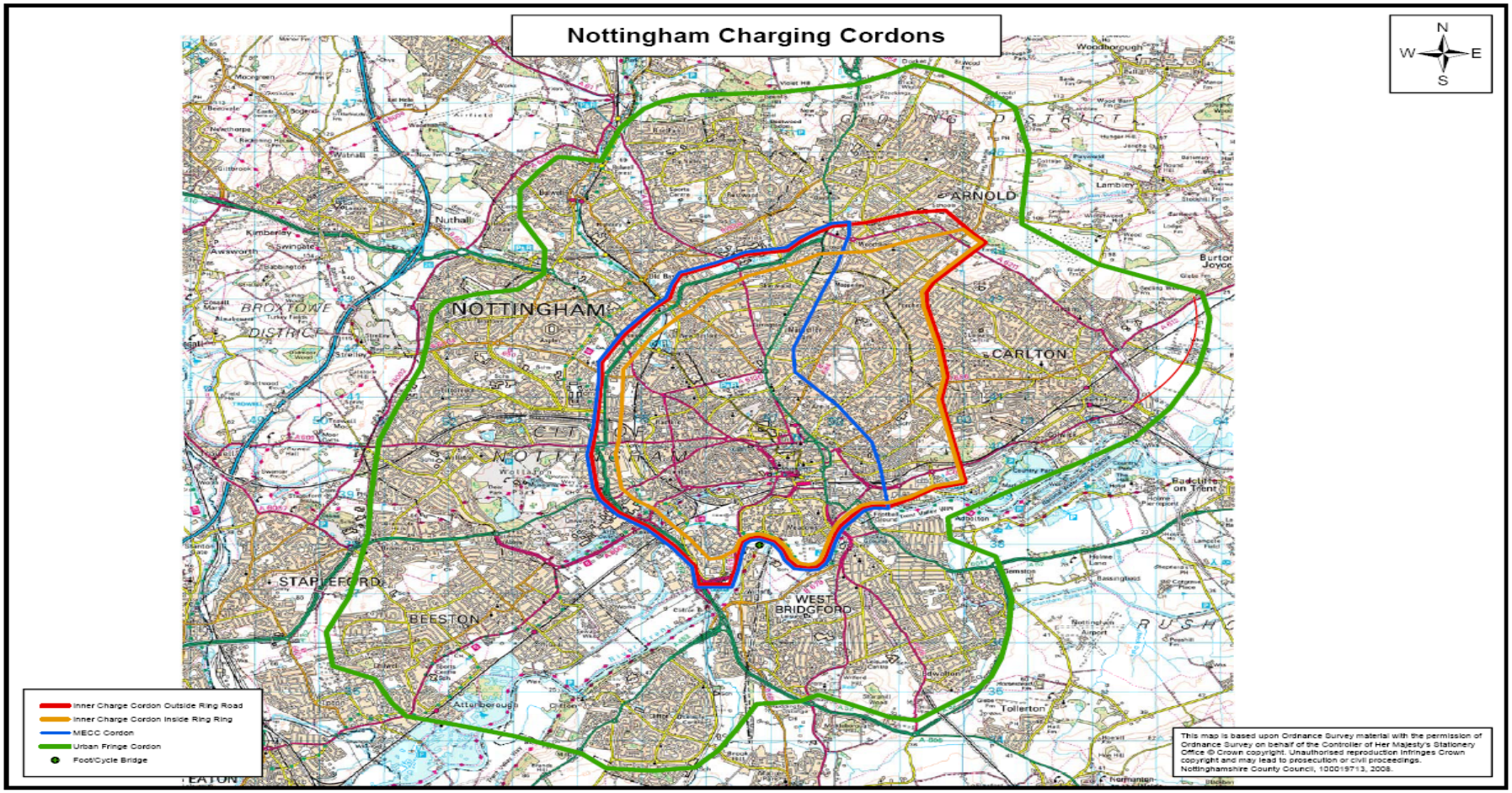


Figure 6.2 Example charging cordons tested for Leicester



- Outside Inner Ring Road –Cordon No. 1
- Inside Outer Ring Road – Cordon No. 2
- Outside Outer Ring Road (MECC Cordon) – Cordon No. 3

Figure 6.3 Example charging cordons tested for Nottingham



Inner Charge Cordon Inside Ring Road – Cordon No. 1

Inner Charge Cordon Outside Ring Road – Cordon No. 2

MECC Cordon – Cordon No. 3

Urban Fringe – Cordon No. 4

6.35 The locations of the cordons for these tests can be seen in Figures 6.1 to 6.3. The charges applied to each crossing of the cordons (inbound in the morning peak and outbound in the afternoon peak) were each of the order of £2 as shown in Table 6.3. The exact values used in the tests were selected on the basis of economic modelling for the particular cordon locations – it should be noted, however, that these charges would need to be revisited, refined as appropriate and balanced between the three city conurbations should the 6Cs Congestion Management initiative be taken forward into a more detailed investigation and business case preparation phase.

6.36 Test 1 was run for both morning and afternoon peak periods in 2016, while Test 2 was run for the morning peak period only.

Table 6.3 Cordons and charge levels tested using PTOLEMY

Test 1 – SATEASY best performing cordons	Test 2 – Urban fringe cordons
Derby: Inside outer ring road - £1.75 *(Figure 6.1 Cordon No. 3)*	Derby: Urban fringe - £1.75 *(Figure 6.1 Cordon no. 5)*
Leicester: Inside outer ring road – £2.00 *(Figure 6.2 Cordon No. 2)*	Leicester: Inside outer ring road – £2.00 *(Figure 6.2 Cordon No. 2)*
Nottingham: Outside ring road - £1.60 *(Figure 6.3 Cordon No. 2)*	Nottingham: Urban fringe - £2.00 *(Figure 6.3 Cordon No. 4)*

6.37 The traffic and travel impact outputs from the two PTOLEMY tests of alternative cordon charging schemes are summarised in Table 6.4 by key indicator. Throughout this table, changes in the indicator are relative to the 2016 Current Strategy Continuation scenario.

6.38 Transport economic appraisal results showed an annual benefit of £19.2 million for the morning peak period for Test 1, and £16.7 million for the afternoon peak. The urban fringe cordon option (Test 2) gave an annual benefit of £19.9 million for the morning peak period. This compares with an estimated annualised cost for setting-up and operating the charging scheme under the Test 1 option (the Test 2 option cost was assumed to be similar) of £34.4 million.

6.39 Total scheme revenue (before deduction of operating costs) was calculated to be £161 million for the Test 1 option. Deducting the annualised cost would leave net annual revenue of around £127m in 2016. Because the urban fringe cordon option (Test 2) was only modelled for the morning peak, an equivalent net revenue figure was not calculated – however, it would be likely to be of the same order of magnitude.

6.40 From these results it can be seen that the performance of the two cordon charging schemes fully tested using the PTOLEMY model are very similar in terms of impacts, transport economic benefits and revenue generation.

Table 6.4 Summary of results for PTOLEMY tests on cordon charging options

Indicator	Test 1 - SATEASY best performing cordons	Test 2 – Urban fringe cordons
Average speeds	As a result of the cordon charges, car traffic volumes drop for trips going into the 3 city conurbations, resulting in speed improvements in the range 3%-10% during the morning peak period. The cordons have negligible effect on the traffic speed in the rural areas outside the city conurbations. The afternoon peak results show slightly less speed improvements, though geographic patterns are similar.	As a result of the urban fringe cordon charges, car traffic drops for in-bound trips into the 3 city conurbations, resulting in speed improvements of 3%-20% during the morning peak period. The cordons have negligible effect on the traffic speed in the rural areas.
Travel by mode in the study area	During the morning peak, average perceived car operating cost across the study area rises by 25%, and the total number of car trips reduces by 3% across the study area. For all other modes the volume of trips increases across the study area (23% for Park and Ride, 17% for bus, 6% for train, 5% for tram and 1% for cycling and walking). For bus, Park and Ride and tram the transfer of car users to these modes increases the average journey lengths. For train use, the transfer of car trips reduces the average journey length.	During the morning peak, average perceived car operating cost in the entire study area rises by 25%, and the total car traffic reduces by 3%. For all other modes the volume of trips increases (29% for Park and Ride, 14% for bus, 6% for train, 4% for tram and 1% for cycling and walking). For bus, Park and Ride and tram the transfer of car users to these modes increases the average journey lengths. For trains, the transfer of shorter distance car trips reduces the average journey length.
Travel by destination / origin area	Car usage to the central zones of the cities drops by between 11% and 15%, with the number of car trips to the urban areas falling by between 5% and 7%. The location of Park and Ride sites has a marked effect on the usage of the facility: in Derby where two of the Park and Ride sites are located within the cordon boundary, there is a significant drop in ridership (20% reduction to the central zones, and 15% to the urban zones). There is a large increase in P&R patronage in Nottingham and Leicester (17% to central Nottingham, and 67% to central Leicester). Bus ridership sees a large increase, with Derby experiencing the largest growth with a 61% increase to the central Derby zones.	Car usage to the city central zones drops by 8% in Nottingham, 4% in Derby and 15% in Leicester, with the number of car trips to the urban areas falling by 5% in Nottingham and Leicester and 3% in Derby. Park and Ride experiences a large increase in patronage in Nottingham and Leicester (31% rise in the number of trips to central Nottingham, and 64% to central Leicester), although for Derby, where all Park and Ride sites are located inside the urban fringe charging cordon, the patronage falls by 39%. Bus ridership increases in all areas, with the average distance of bus journeys to the central areas increasing by between 5% and 16%. The number of train journeys increase, with the average journey lengths increasing except within Leicester where trip lengths to the central and urban area reduce.

Indicator	Test 1 - SATEASY best performing cordons	Test 2 – Urban fringe cordons
Travel by trip purpose and mode	During the morning peak, commuting travel by car reduces by 3% in terms of trip-km, education by 4%, other private travel by 1% whilst employers business trips by car remain unchanged. P&R usage for commuters sees the largest increase with the passenger-km increasing by 74%, this is followed by bus use increasing by 41%. In Nottingham the usage of the tram for commuting increases by 13%.	During the morning peak, commuting travel by car reduces by 3% in terms of trip-km, education by 6%, other private travel by 2% whilst employers business trips by car increase by 1%. P&R usage for commuters sees the largest increase with the passenger-km increasing by 77%, this is followed by bus use increasing by 47%.
Cordon flow and demand changes	Derby experiences a drop of 28% in the number of vehicles crossing the cordon points in the morning peak period. Leicester sees a 33% drop, and Nottingham a 23% drop.	The number of vehicles crossing the cordons in the morning peak period fall in Nottingham by 31%, in Leicester by 33% and in Derby by 21%.

Supplementary testing using the Derby Demand model

6.41 Supplementary tests were carried out using the Derby Demand Model for the year 2016 to explore issues that could not be modelled in detail using the core modelling system. The cordons used in the supplementary testing were selected at an early stage - a double cordon arrangement, using cordons 2 and 3 (outside the inner ring road and inside the outer ring road) was utilised. The charges used for crossing these cordons were £1.50 and £0.75 respectively. As for all the core model and SATEASY tests the assumption made was that these cordons would operate inbound in the morning peak and outbound in the afternoon peak.

6.42 Overall, this model estimated higher economic benefits from cordon charging than were shown by tests using PTOLEMY or SATEASY. This could be due to a variety of factors, including the application of time period choice modelling, inclusion of a large number of modelled time periods and the treatment of out and return trips as a single unit. Specifically, there is some evidence that inclusion of a detailed representation of city centre parking demand and supply within the Derby TRAM model led to higher estimated benefits for cordon charging schemes - perhaps as much as 50% higher.

6.43 Charging for only one hour in the morning and afternoon peaks did not show any advantages over charging for three hour periods. Scheme capital and 'fixed' operating costs would be the same regardless of the length of charge period. Benefits and revenues for longer periods of charging would be higher, and these would probably outweigh any increase in the variable element of the scheme operating costs.

6.44 Charging only in the morning peak (and not in the afternoon) was investigated as a means of reducing scheme costs, on an assumption that charges for 'from home' trips would effect demand for trips back to homes. Morning peak only charging would mean that the need for equipment for outbound charging would be removed. However, for Derby it is clear that continued and even increased presence of through traffic in the afternoon peak, unaffected by the charges, seriously erodes scheme benefits to a degree that would outweigh any cost savings.

Other congestion charging options

6.45 A "central London-style" area licensing scheme was considered at an early stage of the study. In area licensing schemes, road users need to pay to use their vehicle during charged hours anywhere within a defined area (referred to as the Congestion Charging Zone in the London case). Enforcement checks are therefore required within the area as well as at specific points on its border.

6.46 However, it was felt that an area licensing scheme could only be enforced effectively over a relatively small area – perhaps similar in size to the London Congestion Charging Zone. Initial testing of small area charging schemes with tightly drawn zones around city centres (where area licensing might have been applicable) did not show promising results. Consideration of area licensing was therefore not taken further within the study – rather, efforts were concentrated on the cordon charging type schemes described above, covering larger areas than just city centres.

Workplace parking levy

6.47 A workplace parking levy (WPL) was given some consideration as an alternative to congestion charging as a means of directly addressing congestion and as a source of funds for investment in alternatives to car travel (which will in themselves lead to improved road travel conditions). However, WPL was not a main focus of the study (as a WPL based package would be unlikely to be eligible for TIF funding), and so the analysis was preliminary in nature and intended for initial comparative purposes only.

6.48 For Nottingham there is a proposed scheme for which a detailed specification and appraisal is available. The consideration of WPL within this study essentially involved a simple extrapolation of financial and other key considerations from this appraisal to Derby and Leicester.

6.49 Appraisal of WPL in Nottingham showed the following characteristics, which could also be expected in the other two cities for a similarly specified WPL scheme:

- A relatively low direct impact on congestion;
- Encouragement of employers to participate in 'Smarter Choices' type activities, particularly workplace travel plans; and
- Generation of modest funds for an investment in package of alternatives to car travel that would be expected to have an impact in reducing congestion (in Nottingham's case, these would be used in particular for the local contribution to funding which will unlock the benefits of Nottingham Express Transit Phase 2).

6.50 The result of the financial extrapolation process was that the expected net annual income (after deduction of scheme administration costs) for each of the cities in 2014 (at 2007 prices) for a WPL scheme similar to that specified for Nottingham is:

- Nottingham - £9.7m
- Derby - £5.9m
- Leicester - £8.5m
- Total – £24.1m

6.51 The predicted net income is therefore relatively modest compared with that from the cordon based road user charging schemes described earlier, although the implementation and operating costs are also much lower. The implications of higher levels of WPL charges were not considered. However, it is expected that the impact upon levels of congestion would continue to be comparatively modest even if charges were raised substantially. It can also be expected that any negative impacts of the scheme upon business and investment would rise with increasing charge levels.

Charging option taken forward into Innovative Package Scenario

6.52 Following the definition, testing and investigation of different options, the charging scheme option taken forward to form part of the Innovative Package Scenario was the scenario

tested under Test 1 with the PTOLEMY core model[3]. This includes single charging cordons in Derby, Leicester and Nottingham (cordon 3 in Figure 6.1, cordon 2 in Figure 6.2, cordon 2 in Figure 6.3 respectively) with a congestion charge of around £2 payable each time the cordon is crossed travelling towards the city centre during the morning peak (07.00 to 10.00) or travelling away from the city centre during the afternoon peak (16.00 to 19.00).

6.53 It should be noted that this option is not viewed as an optimal cordon charging scheme at this stage – merely as an example of one of the more promising of the options tested to date for addressing congestion. Extensive further work would be needed on design and testing of charging scheme options as part of any extension of the 6Cs congestion management initiative, looking at other options and using more comprehensive modelling tools.

Complementary measures

6.54 An example package of complementary measures was defined and tested that would seek to reinforce the effects of the charging scheme and provide travel alternatives to use of the private car in particular. Complementary measures should also help mitigate any undesirable impacts of a charging scheme. The measures included within the Innovative Package Scenario for testing comprised three main sets:

- Core measures – These are primarily concerned with significantly improving bus services and mass transit schemes. The individual "core measures" included are summarised in Table 6.5.
- Public transport fare reduction – The set of complementary measures tested included a 30% reduction in peak period bus, tram and Park & Ride fares, on the assumption that such reductions could be implemented under new regulatory arrangements allowed by current legislation.
- Smarter choices – This would involve implementing a high intensity programme of interventions to encourage and enable people to make travel choices other than use of the private car. This would include major increases in investment in areas that have been shown by DfT-sponsored research to be highly cost-effective in inducing changes in travel habits – including, in particular, personal travel planning (PTP), workplace travel plans, and school travel plans.

6.55 These measures would be in addition to those included in the Current Strategy Continuation Scenario. They represent an initial attempt to define a sensible set of complementary measures, but this is an area that would need significant further research and investigation in any future stages of the 6Cs congestion management initiative.

6.56 Initial appraisal was undertaken of the three sets of measures on their own before they were taken forward into testing and appraisal within the complete Innovative Package Scenario. Key headline appraisal results are given below.

- Core measures (excluding the possible Leicester personalised rapid transit scheme):
  - £14.5m per year morning peak period benefits (before costs).

[3] If a congestion charging scheme was introduced as part of a package of measures in Nottingham, the City Council has stated its intention to withdraw its WPL scheme. This was not taken into account within appraisal of the Innovative Package Scenario, but would need to be considered in any further work.

- £37m per year all day benefits (before costs).
- Economic benefits relatively evenly spread across the three conurbations, but with a slightly higher proportion for Greater Nottingham.
- Total capital costs £1,110m[4] (Derby / Derbyshire elements - £146m; Leicester / Leics elements - £199m; Nottingham / Notts elements - £764m).
- Annual operating costs £16.5m.

❑ Public transport fare reduction:

- £17m per year morning peak period benefits (before deduction of subsidy cost).
- £7m per year morning peak period fare subsidy cost.
- Morning peak period benefit to cost ratio of around 2.5.

❑ Smarter choices:

- 4% morning peak traffic reduction (after taking account of induced traffic effects).
- £64m per year morning peak period benefits.
- Costs estimated at £19.2m per year.

[4] Cost estimates for core measures and smarter choices include allowance for optimism bias.

Table 6.5 Core complementary measures included in the Innovative Package Scenario

Derby and Derbyshire	Leicester and Leicestershire	Nottingham and Nottinghamshire

• A number of highway improvements to reduce delays to buses (in particular) and other traffic.
• Bus priority measures:
  • Alfreton Road bus only corridor with restricted access for general traffic;
  • A52 corridor between new P & R site and Pentagon Island;
  • A516 bus priorities onto Uttoxeter Road from P&R site, including a dedicated junction and signals for buses only; and
  • A6 approaches to London Road and A6/A6 (T) junctions.
• Bus route enhancements along A6005 Nottingham Road.
• Bus rapid transit along key corridors including that linking the city with Mickleover and Mackworth.
• A new free city centre shuttle bus service operating on a 5 minute frequency throughout the day from 7:00am to 7:00pm.
• Bus stops to be brought up to 'red carpet' standards throughout City and improvements to be implemented in the rest of the County.
• All local residential bus services to be at least every 10 minutes between 7:00am and
	• Highway improvements:
	  • Conversion where practicable of radial routes to 'Red Routes' which will keep radial routes clear of stationary vehicles and improve journey time and reliability.
	  • Measures to reduce bus delays at signalised junctions and crossings
	  • High-quality radials for buses and bus corridors to improve journey times by 5%
	  • Improved pedestrian crossings along the Inner Ring Road.
	• Bus priority measures to be, as far as possible, capacity neutral (in terms of total vehicle capacity). Bus progression to be facilitated by GPS-based vehicle tracking and using active intervention strategies to minimise delays.
	• Bus services at five minute headways on all main radials, with improvements and extensions to the bus network for journeys which do not commence or terminate in the City Centre. On two city orbital bus routes, services at 10 min headways. In addition, improved off peak and Sunday services.
	• A personalised rapid transit system (PRT) for Leicester City Centre – possibly an on demand driverless ultra light urban railway to offer personalised transport with minimal waiting times
		• Highway capacity improvements through improvements in the areas' Urban Traffic Control (SCOOT) system.
		• Bus priority measures for:
		  • A612 Daleside Road;
		  • A609 Wollaton Road;
		  • A52 Derby Road;
		  • A611 Hucknall Road; and
		  • Thane Road.
		• Improvements to existing bus services and some new services
		• Light rail (Nottingham Express Transit) schemes including:
		  • NET1 extensions to Linby and Kimberley; and
		  • NET3 to West Bridgford and Gedling.
		• Park and ride schemes that integrate car parking facilities with bus and NET services into the city centre as well as local rail services:
		  • Leapool - bus P&R;

Derby and Derbyshire	Leicester and Leicestershire	Nottingham and Nottinghamshire

7:00pm, and every 30 minutes off peak.
 	
• Interurban bus services to be at least every 15 minutes between 7:00am and 6:30pm, and at least every 30 minutes in off-peak from 5.30am and up to 11.30pm... To include services to Hilton, Willington, Melbourne and Long Eaton.
 	
• A1 Skylink service to East Midlands Airport frequency to be increased to every t0 minutes.
 	
• A new outer orbital service with a 15 minute frequency from 7:00am-7:00pm and a half-hourly service in the off peak.
 	
• Park and ride schemes:
  • City Hospital (extension of 650 additional spaces with possible construction of a multi storey car park);
  • Boulton Moor (new provision of 1500 spaces to potentially include a decked car park);
  • A61 (Morrisons - additional 1000 spaces in the form of a decked structure); and
  • A52 (proposed new site with provision for 2000 spaces).
  • Bus interchanges for inter service transfer in the City and throughout the county.
 	
• A City Centre terminus for P&R routes from Boulton Moor and the City Hospital.
 	
• Improved ticketing for public transport using smartcard or other proven technology, to promote the greater use of public transport and encourage the purchase of tickets 'off-bus'.
	and transports passengers non stop to their destination. Given the uncertainties over this scheme, it was excluded from the appraisal process at this stage – further investigation would be needed.
	
	• New park and ride schemes for:
	  • Leicester Forest East;
	  • Enderby;
	  • Birstall;
	  • Glenfield;
	  • Oadby;
	  • A47 Thurnby; and
	  • Blaby.
	
	• All city centre bus terminals upgraded to quality bus station standards. New purpose built interchanges at orbital/radial intersections. 'Timed' interchanges equipped with comprehensive information systems and direct bus-to-bus transfer.
	
	• A new 'flagship' bus station located in the city centre which would provide the terminus for all city centre services.
	
	• Comprehensive review of bus stop provision. High standards of provision and maintenance. Product branding and publicity to accentuate a 'network-wide' identity.
		• Gedling - NET P&R; and
		
		• Bingham - bus & local rail services.
		
		• New bus interchanges are proposed at:
		  • Bulwell;
		  • Sherwood; and
		  • Clifton.
		
		• Bus accessibility and security to be enhanced by provision of real time displays at stops and on buses and CCTV at 700 bus stops.
		
		• Improved public transport ticketing, including the introduction of smartcard ticketing.
		
		• Free bus travel for people under 16 years of age during the school term.

7 RESULTS OF SCENARIO TESTING AND INVESTIGATION

Traffic and travel impacts

7.1 The Current Strategy Continuation Scenario and the Innovative Package Scenario were tested using the core modelling system for three time periods (morning peak, inter-peak and afternoon peak) for the year 2016. The Innovative Package Scenario was also tested for the morning peak period for the later year of 2026, to provide a benchmark of how benefits from the package change with the rise in levels of congestion anticipated between 2016 and 2026.

7.2 The measures included under each of the scenarios tested were as described in the previous chapter. The Leicester personal rapid transit possibility was excluded from the modelling and appraisal work on the Innovative Package Scenario, as the concept required a level of development before it could be modelled that was not possible within the study timeframe. For the morning peak test undertaken at 2026, the charge levels tested under the Innovative Package Scenario were increased in line with the average value of time increase from 2016 to 2026.

7.3 When average speeds were compared between the hypothetical Do Nothing Scenario for 2016 and the Current Strategy Continuation Scenario, the modelling results showed average speeds across the study area road network were about 4% higher on average under the Current Strategy Continuation Scenario. This suggests that it would be significantly better at addressing traffic delays than Do Nothing.

7.4 The test results from modelling and comparison of the two main scenarios of interest are summarised in Table 7.1. All results shown in this table state the forecast impacts in 2016 of the Innovative Package Scenario in comparison with the Current Strategy Continuation Scenario. Figure 7.1 illustrates travel mode shares in 2016 for each scenario during the morning peak period.

7.5 The results of morning peak period testing for 2026 showed similar patterns of results but with slightly greater magnitude impacts, as projected untreated congestion levels in 2026 would be worse.

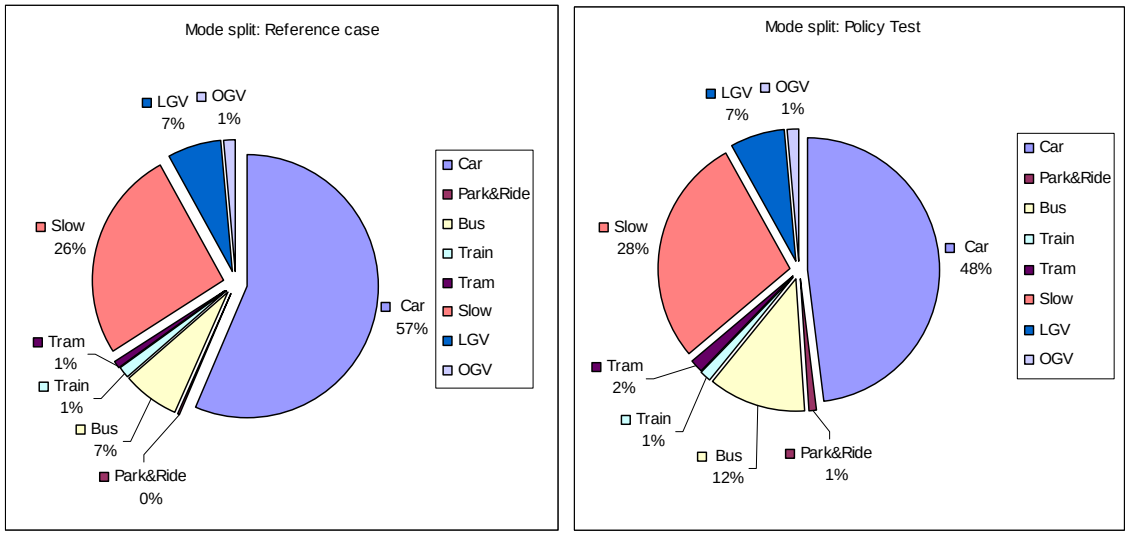
Table 7.1 Impacts of the Innovative Package Scenario versus the Current Strategy Continuation Scenario (2016)

Indicator	Analysis
Average speeds	Within the morning and afternoon peak periods there are significant increases in the average highway speed within each of the 3 Cities. A significant number of zones in the built-up area see speed increases in the range 10 to 20%. The inter-peak period sees very little change in road speed, however, as no cordon charge is present for this time period.
MECC (a measure of congestion severity)	There are significant reductions in the number of network links in each conurbation with severe congestion where MECC exceeds 250 seconds. In the morning peak for Derby there was a fall in occurrences of such links from 6% of the total to 3%. The equivalent

Indicator	Analysis
	figures for Leicester and Nottingham are 5%/4% and 9%/5% respectively.
Travel by mode in the study area	In the morning peak the combination of measures combines to produce some significant modal shift by comparison with the Current Strategy Continuation Scenario. The number of car trips reduces by 15%. The average distance of the car trips increases by 9%, suggesting that it is the shorter trips that are transferring to alternative modes. Park and Ride usage sees an increase of 172%, with the reduced bus fares leading to an overall reduction of 25% in the average cost of P&R trips. Bus usage sees a 70% increase in ridership, with the average journey length by bus extending by 6%. Tram sees a 67% increase in ridership with the reduced fares and the opening of NET3. Train and walking/cycling modes both see an increase of around 7-8% in number of trips The afternoon peak sees a similar pattern of change to the mode share. In the inter-peak when there are no cordon charges, there is still a 7% shift away from the car mode, with park and ride, bus and tram picking up a large increase in patronage.
Travel by destination/origin area	During the morning peak the central zones within each city see a significant drop in car traffic: by 38% in Nottingham, 33% in Leicester and 30% in Derby. Park and Ride patronage rises to the central city zones. In Nottingham and Leicester, where the park and ride sites are outside the cordon boundary the average cost of each trip falls, but within Derby because the park and ride sites are within the cordon the average cost of using park and ride rises. The reduced bus fares lead to considerably increased bus patronage; in addition, the average distance per bus trip rises by 16% to central Nottingham, 6% to central Leicester and 20% to central Derby. Train use to central Nottingham falls by 4%, with a 5% reduction to the Nottingham urban zones, as the tram patronage rises by 67%. In Leicester and Derby the use of the train increases - Leicester seeing a 12% increase in patronage. During the inter-peak period there are still significant shifts away from car (14% to 17%) for trips to the city centres, as a result of improved public transport services and Smarter Choices measures. During the afternoon peak there are similar effects to the morning peak, with a large drop in car usage in the city centres and significant modal shift to public transport and walking/cycling.
Travel by trip purpose and mode	During the morning peak, as might be expected, the employers business trips by car fall by only 3% with a few travellers transferring to bus, train and tram. Personal business trips also see a modest fall of 5%. For personal trips there is a large increase in Park and

Indicator	Analysis
	Ride and bus usage, but rail use falls by 20% reflecting the impact of the reduced bus fares. Trips to school or college see a drop in 38% of car trips, with the travellers again transferring to bus and tram. The train sees a 13% reduction in use. Commuting sees a 13% reduction in car use, with the workers transferring to all the other modes including the train where the speed of the train outweighs the benefit of the reduced costs of the bus. There is also a large rise (20%) in walking/cycling for commuter journeys, as a result of the Smarter Choice measures. The patterns of change in the afternoon are similar to the morning peak, while the changes in the inter-peak are more modest.
Cordon crossing changes	In the morning peak a reduction of between 32% and 39% is forecast in the number of cars crossing the cordons in each conurbation. In the afternoon peak there is a reduction of between 33% and 48%. The difference is attributed to the different traveller profiles in each of the periods, with the afternoon peak having a larger number of non-work trips included.
Changes in car vehicle-km on the road network – by geographic area	The analysis shows that during the morning peak, car vehicle-km reduces by around 16%-20% in the 3 major urban areas. The impact on the network outside the urban areas is smaller, although still substantial. The overall car vehicle-km reduction is 3% in the overall study area, after allowing for the effects of induced traffic, and redistribution of car traffic away from the urban areas. During the inter-peak and afternoon peak, the patterns of traffic change are similar to the morning peak, although the magnitude of change during the inter-peak period is smaller.

Figure 7.1 2016 Morning peak period mode share under the Current Strategy Continuation Scenario (left) and the Innovative Package Scenario (right)



Transport economic appraisal

7.6 Economic appraisal was undertaken targeted on the possible first year of implementation of the full package – 2016. The economic appraisal results showed total annual benefits of implementing the Innovative Package Scenario (rather than the Current Strategy Continuation Scenario) of £106 million for the morning peak period, £115 million for the inter-peak and £80 million for the afternoon peak period in 2016. This gave a total annual benefit of £301 million in 2016. For 2026, in terms of economic performance there was calculated to be a significant but not huge benefit increase over the 2016 position, with net annual morning peak benefits of £118m rather than £106m.

7.7 The annual costs of implementing and operating the Innovative Package Scenario (above those of the Current Strategy Continuation Scenario) in 2016 were also estimated for comparison. For this exercise, the capital costs associated with implementing the core complementary measures were converted into an annual debt repayment sum. The estimated costs are shown below[5].

- Core complementary measures capital repayment costs £100m pa
- Core complementary measures operating costs £16.5m pa
- Smarter Choices costs £19.2m pa
- Charging scheme annualised capital and operating costs £34.4m pa
- Total annual costs £170.1m

7.8 Comparing the calculated benefits with the estimated costs gives a benefit / cost ratio of around 1.8 for 2016.

Financial analysis

7.9 Revenue from the congestion charging element of the Innovative Package was estimated to be approximately £139m per year in 2016. This would be put towards meeting the costs shown above. As can be seen, Government funding (from TIF in particular) would also be needed to support the overall package and make it financially viable. In particular, grant funding from TIF towards the capital costs of complementary measures and the congestion charging system would reduce the debt repayment sums and could bring the available revenue into line with costs.

Environmental impacts

7.10 Likely noise impacts were considered within the initial appraisal of alternative scenarios. With the implementation of the Innovative Package Scenario a significant number of links would experience a flow reduction by comparison with the Current Strategy Continuation Scenario. This would translate into noise reductions for each conurbation. In terms of the impact in relation to noise nuisance, it is worth noting that the noise benefits of the Package are most apparent on secondary and tertiary links in the road hierarchy, which are those closest to populated areas.

7.11 Analysis of the air quality and greenhouse gas impact of the Innovative Package Scenario versus the Current Strategy Continuation Scenario was undertaken for carbon monoxide,

[5] The cost of the fare reduction intervention is more than offset by fare revenue from the increased patronage experienced as a result of the total package of measures, so this is not included.

carbon dioxide, nitrogen dioxide and particulates (PM_{10}). The Innovative Package Scenario was forecast to bring about a significant reduction in all indicators other than the PM_{10} indicator, of a scale greater than the difference between the 2016 Reference Case and the 2016 Do-Nothing. Most of the benefits would occur either along trunk roads or secondary and tertiary roads in the road hierarchy. The main radial routes into the city centres would benefit less from emission reductions as traffic re-routes away from alternative routes that were only attractive when the radials suffered from higher levels of congestion.

Safety impacts

7.12 Traffic flow reductions resulting from the Innovative Package Scenario were forecast to bring about a reduction in accidents by comparison with the Current Strategy Continuation Scenario. Fatal and serious injury accidents were forecast to be 2-6% lower in 2016 under the Innovative Package Scenario.

Social impacts

7.13 Previous research on the potential social impacts of alternative future congestion management strategies was reviewed at an early stage of the study. This provided valuable background information and confirmed that the main potential social impacts of concern that should be considered include:

- Changes in accessibility (including spatial, temporal, financial, psychological and physical aspects of accessibility) to key facilities and services for different community sectors; and
- Changes in how external impacts of traffic (noise, air pollution, accident risk) bear on different community sectors.

7.14 Full appraisal of these impacts would require a combination of quantitative analyses and qualitative research, and further work would be required on social impacts beyond the scope of this study.

7.15 One piece of model-based quantitative analysis undertaken within the study looked at the impact of the alternative strategies on non-car-owning households using public transport modes. This found that, under the Innovative Package, as the road speeds improve, the generalised cost of travel would be substantially lower on bus, tram and Park & Ride modes than under the Current Strategy Continuation Scenario. For non-car-owning, low income households the generalised cost for commuting journeys would reduce by up to 28% during the morning peak period. The speed improvements would be more significant for the longer distance bus trips, expanding the labour catchment area by bus to the main employment centres.

7.16 Initial accessibility modelling with overlay of data on to social deprivation indices is also being progressed by the local authorities beyond the end of the 6Cs Congestion Management Study, and the results will be reported separately.

7.17 The main research on social impacts undertaken within the study involved undertaking qualitative research through a series of focus groups. These were undertaken with people from sectors of society who had been identified in previous research as being potentially vulnerable to social exclusion under congestion management strategies that involve

congestion charging in particular. Nine focus groups were undertaken in total, at various locations spread across the study area.

7.18 The primary aim of the focus group research was to gain an in-depth understanding of the pertinent issues for vulnerable social groups arising from possible alternative future congestion management strategies for the 6Cs study area. The nine focus groups were undertaken with:

- Young people from low income households;
- Older people from low income households and disabled people;
- People of Asian ethnicity from low income households;
- People of Afro-Caribbean ethnicity from low income households;
- People with caring responsibilities;
- Low income parents with dependent children;
- Low income unemployed people;
- Low income shift workers; and
- Rural residents from low income households.

7.19 Each focus group followed an agreed topic guide which initially explored the impact of traffic on participants' lives and current travel choices and constraints to travel for different trip purposes. Participants were then presented with two 'transport futures', broadly corresponding to the Current Strategy Continuation Scenario and the Innovative Package Scenario – information from early modelling was used to present a picture of the conditions that might be found in the future under these scenarios.

7.20 Key outputs from the focus groups were:

- Throughout all areas and across all groups, congestion was viewed as a serious issue that impacts on travel decisions on a daily basis. Many participants currently adapt their travel behaviour accordingly.
- In the young persons focus group, there was a strong aspiration expressed to own and drive a car. However, cost was seen as a key constraint to travel and the view was expressed that traffic and congestion affects where people choose to work.
- In the groups undertaken in Leicester, parking by city visitors in local neighbourhoods was perceived as a key issue, with knock-on effects on congestion, safety, noise and air pollution.
- Perceived barriers to bus travel were highlighted by many participants in the focus groups. In Derby / Derbyshire and Leicester / Leicestershire, these included lack of service provision outside of peak times and the quality and cleanliness of vehicles in certain areas. Across all areas, high bus fares were cited as a barrier to public transport use. There was particularly strong dissatisfaction among the Afro-Caribbean group participants about bus services, with participants attaching a stigma to using public transport. These barriers would all need to be overcome for a future congestion management strategy to be fully effective.

- Shift workers felt that congestion has less of an impact on how they travel because they often travel outside of peak hours. However, as a result of travelling outside of the peak, there is a lack of public transport services and a fear of using public transport during hours of darkness.
- People with caring responsibilities felt that congestion affects their lives, causing stress when they need to travel to places for specific times. For low income parents with dependent children cost is a key barrier to travel.
- The future situation under the Current Strategy Continuation Scenario was viewed as unsurprising but undesirable by participants in most of the focus groups. In groups undertaken in Leicester, predicted future traffic congestion problems were not as bad as some participants expected.
- When the Innovative Package Scenario was presented to the focus groups, many participants initially reacted negatively to the principle of a congestion charge. Some participants became much more positive towards the scenario when the complementary measures and the actual impacts on their own lives were discussed. Some participants were, however, sceptical of whether many of the complementary measures would actually be implemented, highlighting the importance of these measures being implemented before or at the same time as any charging commenced.
- The Innovative Package Scenario was seen as generally beneficial by the young persons group, provided the complementary measures served areas outside the main cities, such as Ilkeston where the group took place. If they were implemented, it was felt that it would lead to greater access to jobs and services and would negate, for some, the need to own a car.
- Unemployed focus group participants were pragmatic in their views on the Innovative Package Scenario, believing that a congestion charge would be unlikely to affect them directly, yet recognising that the complementary measures would benefit them directly, particularly the reduction in bus fares.
- In the rural residents focus group the Innovative Package Scenario was well received in terms of its complementary measures, particularly the extension to the Nottingham tram network, the reduction in bus fares and the proposed park and ride sites. There was an initial 'knee jerk' reaction against congestion charging – although many then conceded that it would not impact directly on the participants themselves.
- The complementary measures in the Innovative Package Scenario were viewed in a positive light in the groups undertaken in Leicester, particularly a reduction in bus fares. The personal rapid transit (PRT) possibility for Leicester city centre was felt to be unnecessary - an innovative mode serving the whole of Leicester would be preferred.
- In the two ethnic minority groups, many car users said that they would continue using their car if a charging scheme was implemented under the Innovative Package Scenario, although there was recognition of the benefits of the complementary measures, with improvements to bus services being welcomed.

- Participants in the older and disabled people focus group felt that a peak period congestion charge would not affect them negatively, but there was concern expressed that buses could become more crowded as a result. For this group, physical barriers were felt to be the biggest constraint to travel in terms of being able to walk down the street, cross the road and board public transport vehicles.
- People with caring responsibilities and low income parents felt themselves likely to be "car captive" as a direct result of their caring responsibilities. It was felt that a congestion charge could potentially price them off the road, although it was felt that blue badge holders should receive some form of concession or exemption. Carers who are more reliant on public transport were seen to benefit from the Innovative Package Scenario.

7.21 Overall then, the group discussions revealed that (by comparison with the Current Strategy Continuation Scenario) the Innovative Package Scenario would have positive impacts on people from most of the social groups consulted because many live within low income households and are dependent on bus services. However, there are groups that are effectively "car captive" at present, such as carers or low income families, who could suffer further social exclusion from the effects of a congestion charging scheme. Measures to assist them (for example, by making use of public transport alternatives more feasible) would need consideration in any further work within the 6Cs Congestion Management initiative.

Business and wider economic impacts

7.22 Within the study, some investigation was undertaken of likely impacts of alternative future scenarios on the local economy and on businesses. However, this was restricted in scope at this stage and further investigation would be needed in any further stages of the 6Cs Congestion Management initiative. The following paragraphs bring out the key findings at this stage.

Business-related travel

7.23 Business travel by car would reap benefit from the reduced congestion and improved travel times and conditions highlighted in Table 7.1, but would be liable to pay charges on trips that crossed the charging cordons during peak periods. Detailed analysis of impacts for different trip purposes calculated that, overall, the direct time saving and vehicle operating cost benefits for business travellers (not freight) would exceed what they would pay in congestion charges. This is in contrast to other trip purposes, where the reverse is true.

7.24 Journey time reliability is a key issue for businesses and employers, as highlighted in the Regional Economic Strategy for the 3 Cities sub-region. Within the model constraints for this study, the reliability indicator selected for the initial appraisal was the average volume to capacity ratio (V/C) across the urban area road networks. The outputs from the core modelling system for this indicator are shown in Table 7.2.

7.25 It can be seen that the average V/C ratio is better (lower) under the Innovative Package Scenario than the Current Strategy Continuation Strategy. The difference is significantly greater than that between the 2016 Reference Case and 2016 Do-Nothing, indicating the Innovative Package is likely to be more successful than conventional measures at addressing reliability.

Table 7.2 Comparison of volume / capacity ratios under alternative 2016 scenarios

City network	Time period	Average volume / capacity ratio	
		2016 Current Strategy Continuation Scenario	2016 Innovative Package Scenario
Derby	Morning peak	23	19
	Inter-peak	21	20
	Afternoon peak	24	22
Leicester	Morning peak	39	37
	Inter-peak	31	30
	Afternoon peak	41	39
Nottingham	Morning peak	52	47
	Inter-peak	44	42
	Afternoon peak	44	47

City centre viability

7.26 Although there is considerable interest in the impacts of the Innovative Package Scenario on the economic viability of the city centres of Derby, Leicester and Nottingham, the modelling tools available for this study were not well suited to looking at changes in travel behaviour such as trip suppression or destination changes. This is because the PTOLEMY model operates in such a way that commuting, education and employers business trips are "doubly constrained" within the model - the total number of trips to/from each geographic zone is not allowed to vary regardless of travel costs, and so for these trip purposes any impact of congestion charges in these important areas will not be apparent.

7.27 Within PTOLEMY, home-based trips for other purposes are not so constrained. The model results for these trip types suggested that although congestion charging on its own may lead to small reductions in trip numbers to city centres, under the Innovative Package Scenario there would be around 20% more trips made to city centres than with the Current Strategy Continuation Scenario.

Business impact case studies

7.28 Following the first wave of stakeholder engagement events within the study, it was recognised by the 6Cs Project Board that there was a need for better information on the potential impacts on businesses under alternative future transport scenarios. As a result, a piece of research was commissioned by emda to carry out five business impact case studies. These involve collaboration with five businesses of different types in the 6Cs area to undertake an in-depth examination of their typical transport patterns. The modelling outputs are then being used to estimate impacts for those businesses of alternative future scenarios. These should serve as illustrative "real world" examples of potential business impacts.

7.29 The business impact case studies will be completed beyond the end of the 6Cs Congestion Management Study and will be reported separately and made available on the study website www.6cscongestionmanagement.co.uk.

Business engagement

7.30 A second wave of engagement events with business stakeholder organisations is scheduled to take place following the publication of this report. Feedback and views on the alternative scenarios and their potential impacts will be sought through these events.

8 CONCLUSIONS

8.1 The conclusions reached from the analyses and investigations undertaken in the 6Cs Congestion Management Study are set out in the following paragraphs.

Current congestion problems

8.2 The congestion survey carried out within the study confirmed that congestion is a problem in the study area at some times of day and on some important roads, but is not spread across the whole road network. It found that the areas worst affected by congestion are the radial routes running in and out of the three main cities of Derby, Leicester and Nottingham and on city ring roads, where delays are at their most severe in the peak periods. Further problem analysis using transport modelling in the Derby, Leicester and Nottingham conurbations supported this conclusion.

8.3 Research commissioned by emda on economic costs of traffic congestion estimated that traffic delays currently cost the 3 Cities sub-region at least £½ billion per year, with around half of that cost loaded onto employers and the business community.

8.4 Initial consultations with business and other stakeholder groups confirmed that traffic congestion is widely recognised as a problem in the 3 Cities sub-region at certain times of day and in certain places – particularly within the three main conurbations. Unreliability of journey times is of particular concern to business stakeholders.

8.5 A conclusion reached from the investigations of current congestion problems is that efforts to tackle urban congestion should be concentrated primarily on the three main city conurbations, but other towns and key road links in the area should also continue to receive attention. This primary focus on the three main conurbations was carried through to the study investigations of alternative future scenarios.

Future trends and pressures

8.6 The amount of road travel within the 3 Cities sub-region is likely to increase significantly over the next 10 to 20 years, without significant intervention. This is partly because of increasing car ownership per head of population (which is forecast by Government to continue throughout the next 20 years), and partly because of plans for increasing economic activity and growth in population in the study area. The transport modelling activities undertaken within the study took account of these plans and confirmed that this will all place significant extra pressure on the transport system.

Transport modelling

8.7 A significant amount of project effort was devoted to putting together a transport modelling system that was fit for purpose for the study, making best use of existing models within the 6Cs organisations and recognising the “initial investigation” nature of the study. While this modelling system was seen by the study team as being adequate for the level of investigation being undertaken by this initial study on congestion management options, it was also recognised that it had some internal inconsistencies and can not fully represent some key potential responses to complex demand management options including congestion charging. The results and study conclusions from the modelling based activities should be read in this context.

8.8 An important conclusion is therefore that substantial further transport model development would be needed if the 6Cs congestion management initiative was taken forward beyond this initial study into more detailed appraisal and business case development. This would be required to fully meet Department for Transport (DfT) model requirements for business case development and to give the 6Cs authorities sufficient confidence to take a major policy and investment decision once a business case was complete.

Definition of alternative future transport strategies

8.9 Two main future scenarios were defined, tested and investigated within the 6Cs Congestion Management Study – a Current Strategy Continuation Scenario and an Innovative Package Scenario. Within the transport modelling stream, these were tested for the year 2016 and, to a lesser degree, 2026. These were compared with each other and with a 2016 Do Nothing Scenario (no further public sector investment in transport beyond current commitments).

8.10 The Current Strategy Continuation Scenario was defined by the study team members to be one in which funding levels available to the 6Cs local authorities would continue approximately in line with current and recent past figures. The strategy for tackling congestion under this scenario would be broadly a continuation of the current 5-year Local Transport Plans and longer term strategies within the study area. This can be seen as the "most likely" scenario at present.

8.11 The Innovative Package Scenario was developed by the study team to include both a congestion charging element (with single peak period charging cordons in Derby, Leicester and Nottingham) and a number of other complementary transport measures. Under this scenario, the revenue raised from the congestion charging element would (together with anticipated Government funding from the Transport Innovation Fund) be invested in funding the complementary transport measures, which would include major transport system improvements, reduction of peak period bus fares and an intensive programme of "smarter choices" measures that encourage and facilitate behavioural change by motorists. Development of this scenario was an iterative process involving preliminary modelling of a wide range of elements and options before a combined package could be put together as an example of what might be appropriate for the 6Cs study area.

Congestion under alternative future transport strategies

8.12 The conclusions reached by the study team from the transport modelling investigations of these scenarios are:

- Under the Current Strategy Continuation Scenario, in 2016 delays due to traffic congestion are likely to be significantly worse in the Derby, Leicester and Nottingham conurbations than at present. This would impose further economic costs on the area and may hinder the economic growth, regeneration and housing plans for the area.
- The Innovative Package Scenario would give significantly better congestion reduction results in 2016 than the Current Strategy Continuation Scenario. Under the Innovative Package Scenario, the transport modelling results predict that car-kilometres travelled in the three conurbations in the morning peak period would be 16-20% lower than under the Current Strategy Continuation Scenario. A similar impact is predicted for the afternoon peak period, with a smaller effect in the inter-

peak period. A significant number of roads within the conurbations would see average speed increases of between 10 and 20%.

- The reduction in congestion and improvement in journey speeds would result from the effectiveness of the Innovative Package Scenario in encouraging people to use non-car modes in peak times. The initial modelling results predict that the number of morning peak bus trips would be 70% higher under the Innovative Package Scenario than under the Current Strategy Continuation Scenario., the number of tram trips (in Nottingham) would be 67% higher, the number of park-and-ride trips would be 172% higher, the number of train trips would be 7-8% higher, and the number of cycling or walking trips would be 7-8% higher.

Transport economic efficiency and financial viability of alternative future scenarios

8.13 The transport economic efficiency (TEE) of the Innovative Package Scenario was compared with that of the Current Strategy Continuation Scenario. TEE essentially trades off the main transport benefits against the implementation and operating costs. The result of this comparison was that the additional benefits of the Innovative Package Scenario (around £301 million per year) would significantly outweigh the additional costs (approximately £170 million per year), giving a benefit/cost ratio of 1.8. This ratio excludes consideration of several other benefit areas. The study team therefore concluded that, from a transport economic efficiency perspective, the Innovative Package Scenario would be preferable to a future scenario based on continuation of current strategies and funding levels.

8.14 In terms of financial viability, the congestion charging scheme element of the Innovative Package Scenario would generate gross revenue of £139 million per year (£105 million net, after scheme operating and implementation costs are deducted). This would be used to finance implementation and operation of the overall package, along with additional funding leveraged in from the Government's Transport Innovation Fund (TIF). The magnitude of the initial revenue and cost estimates and the funds potentially available from TIF are such that the study team concluded that the Innovative Package Scenario could be financially viable.

Wider economic and business impacts of alternative future scenarios

8.15 This study did not explicitly assess the potential wider economic impacts in the sub-region of alternative future scenarios. However, some initial indications of possible positive business impacts were drawn from the modelling activities and a small number of business impact case studies funded by emda will also shortly report their findings. This is, though, an area that would need further detailed consideration in any further work that the 6Cs may decide to undertake on the congestion management initiative.

8.16 The wider economic impacts for the Innovative Package Scenario in comparison with the Current Strategy Continuation Scenario will depend on the balance between any cost increases resulting from the charging scheme element and the potential economic benefits arising from reduced congestion and better accessibility resulting from the package as a whole. These potentially include improved access for customers and labour markets, reduced journey times, improved journey time reliability, and increased agglomeration.

Potential social impacts of alternative future scenarios

8.17 The 6Cs Congestion Management Study started to explore the potential social impacts of future congestion management scenarios. These primarily concern changes in accessibility

to key facilities and services for different community sectors, and changes in how external impacts of traffic (such as air and noise pollution, accident risk etc) bear on different community sectors.

8.18 Focus groups undertaken with people from potentially vulnerable sectors of society (particularly various low income groups) suggested that the Innovative Package Scenario could have a broadly positive social impact for many vulnerable members of society – although initial views of many participants were opposed to congestion charging in principle. Many low income households do not have access to a car and are reliant on public transport, cycling and walking – facilities for which could all be significantly improved under this package. The predictions of increasing congestion under the Current Strategy Continuation scenario were generally viewed as undesirable but unsurprising.

8.19 However, there are some people within the low income sectors of society who are strongly car-reliant – such as some carers, working mothers and residents of remote rural areas. Without measures specifically targeted at helping them (for example, by enhancing non-car alternatives for socially deprived areas), these people could potentially find themselves more socially excluded by a package that includes a congestion charge - though the fact that only a peak period charge is envisaged would provide a large measure of mitigation in this respect. This issue would need to be given specific consideration (alongside broader quantitative analyses of social impacts) in any further work on congestion management in the 6Cs area.

Overall conclusion

8.20 The overall conclusion reached from the study is that an Innovative Package including congestion charging and a range of other complementary transport measures could more effectively tackle future congestion and produce better economic net benefits than continuing with the current strategy under the usual public sector funding constraints. The congestion charging element would generate an income stream sufficient (with additional capital funding from the Government's Transport Innovation Fund) to support the complementary transport measures.

8.21 Finally, it is recognised that the Innovative Package Scenario tested within this study is by no means viewed as being the "best of its kind" for the sub-region. Rather, it is seen as representing one possible example of what could be done. The initial nature of the study means that there is a need for significant further investigation, development, refinement and appraisal of alternatives. This would need to be included within a detailed business case investigation before any decision could be reached on whether to move forward towards implementation, and the precise nature of proposals for implementation.

9 FURTHER WORK

9.1 As noted at various points throughout this report, extensive further work would need to be undertaken in terms of scheme development and testing, appraisal and business case development if the decision was taken to progress the 6Cs Congestion Management initiative beyond this initial study. This would require significant further investment of time, effort and funds and would include:

- Development of an improved transport modelling system that can better capture the full range of impacts of an Innovative Package and fully meet the Department for Transport (DfT) model requirements.
- Further work on developing and assessing options for inclusion in the package, including charging scheme options (including cordon charging and TDP) and complementary measures. This work would take account of the findings from this initial study.
- Development and costing of an outline system design for the congestion charging scheme element of the package to feed into appraisal activities.
- Rigorous full appraisal of a refined Innovative Package against alternatives, including appraisal of:
  - Transport economic efficiency;
  - Wider economic impacts and business impacts;
  - Environmental impacts;
  - Safety impacts;
  - Accessibility impacts; and
  - Social and distributional impacts.
- Consideration of delivery, governance and implementation issues, including:
  - Definition of project and programme management procedures;
  - Development of appropriate governance arrangements for implementation and operation of an Innovative Package across the 6Cs area;
  - Development of a risk management strategy; and
  - Development of a plan for monitoring and evaluating the package post-implementation.
- Development of a commercial and procurement strategy for the package.
- Development of a financial plan for implementing the package.
- Continuing engagement with a range of stakeholders, including business interest groups, other stakeholder groups and the media.
- A programme of public consultation and engagement.