# Motorcycles and Congestion: The Effect of Modal Split

Department for Transport
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# 1 Introduction

## 1.1 BACKGROUND

In May 1999, the Government set up the 'Advisory Group on Motorcycling' as a means to investigate the potential of increased motorcycle use to reduce congestion and pollution. There were three primary terms of reference for the group:

- to look at the safety record of motorcyclists and agree measures that would improve safety;
- to look at the environmental impact of motorcycles and if necessary agree measures to be taken;
- to look at the role of motorcycles in integrated transport policy and to assess the scope for further enhancing their benefits through traffic management.

The Advisory Group was set up after the Government's White Paper 'A new deal for transport' recognised that motorcycling had the potential to act as a viable alternative to car travel in certain circumstances. It also recognised that this brought with it potential for easing congestion, and improving the environment, although the associated safety issues also needed to be taken into account. The Advisory Group comprises various organisations with an interest in motorcycling, including road safety groups, motoring organisations, manufacturers, training associations and action groups. Since its inception, it has set up various Task Forces to examine specific issues.

The Task Forces' remits were wide, ranging from environmental and fiscal issues of motorcycling to advice and guidance on integration and traffic management. Within this last category, DfT commissioned a 6 month study into 'Motorcycling and Congestion', carried out by Halcrow Group Ltd. The study was a first look at the effects of a possible modal shift from cars and public transport to motorcycles. To do this, Halcrow investigated the ways in which motorcycles are ridden in congested areas, and the extent to which motorcyclists benefit when compared to car or public transport travel. This was done by means of a literature review, surveys and observation of riding characteristics in congested conditions, and an efficiency assessment – the degree to which a transfer to motorcycle frees space, which in turn depends on the mode transferred from.

The Halcrow study identified a number of areas where further research was required on the impact of motorcycles on congestion. These included:

- the ways that motorcycles interact within themselves and other road users in a range of congested and uncongested conditions;
- the modes from which people will transfer when they start using motorcycles for commuting and other journeys;
- the door-to-door travel time for journeys by different modes, to determine the time savings of modal transfer;
- the adequacy of existing models (or representations) of the ways in which motorcycles affect the road network;
- the passenger car equivalent unit (pcu) value of motorcycles under different road traffic congestion circumstances;
- the space occupied by motorcycles in queues;
- the space occupied by motorcycles when parked;

- the ways in which motorcycles make efficient use of road space and the ways that these may be exploited through road infrastructure design.

## 1.2 STUDY OBJECTIVE

The aim of this current study “Motorcycles and Congestion: The Effect of Modal Shift” was to build on one particular aspect of the earlier research - the effect on congestion of modal shift *to* motorcycles; and to carry it forward by developing better methods to quantify the extent of potential mode share transfer to motorcycle. The many other impacts of increased motorcycle usage on safety and environment were outside the scope of this study.

The overall objective was to develop models to estimate the effect of modal transfer to motorcycles on congestion. At the outset, it was recognised that there were two drivers for potential transfer to motorcycle: motorcycle ownership and the decision to use it for specific journeys. Because the study was specifically interested in the relationship between motorcycle usage and congestion, it concentrated on motorcycle usage for travel in the AM peak. Therefore both motorcycle ownership and mode choice models reflecting choices between use of motorcycles and other modes were developed and these were then incorporated into existing transport models that could then be used to assess the impact of motorcycles on the road network, and their contribution to congestion relief.

In the final stage of the study, these models were used to test the effect of policy changes on motorcycle use for AM peak journeys and the resulting impact of mode shift on congestion. All relevant modes were considered in the mode choice modelling including car, bus and bicycles as well as combinations of modes such as car followed by park and ride. The test applications of these improved models were to cover London and a major town.

## 1.3 PHASES OF STUDY

The study was structured into three main phases of work:

- Phase 1 – Estimation of motorcycle ownership and mode choice models
- Phase 2 – Implementation of mode choice model
- Phase 3 – Policy testing

The first phase of work involved analysing existing data sets on motorcycle ownership and specifying and collecting data on motorcycle usage. Statistical models were then developed for both motorcycle ownership and usage. In Phase 2 the models were implemented in two transport model applications for London and Cambridge then a range of policy tests were carried out to complete Phase 3 of the study.

## 1.4 STUDY TEAM

The study has been undertaken by a team of consultants bringing a range of expertise to the different elements of the study.

- WSP’s Policy and Research team led the study and implemented the mode choice models developed within two test applications for London and Cambridge. They specified and completed the policy testing.

- Rand Europe led the development of the motorcycle ownership and usage modelling, including the design of Stated Preference (SP) surveys used to estimate the statistical models of mode choice.
- Accent Marketing and Research carried out the fieldwork for the study, undertaking both revealed and stated preference surveys by telephone and via the Internet to provide the necessary data on motorcycle owners and their travel decisions.
- Marcus Wigan of Oxford Systematics, Australia, provided expert technical input to the data collection, the development of the models and guidance on the implementation of the models for policy testing and the associated issues.  Marcus also provided a link to a number of motorcycle organisations including the British Motorcycle Federation (BMF), Motorcycle Action Group (MAG) and Motor Cycle Industry Association (MCIA), all of whom provided valuable input to the data collection, through piloting the surveys prior to their wider use.

# 2 Phase 1 - Estimation of motorcycle ownership and usage models

## 2.1 SCOPE

There are two important choices that determine potential motorcycle use: motorcycle ownership and choice of motorcycle for travel. Both of these were addressed in this study in order to predict the impact of policy initiatives on motorcycle use and the related impact on road congestion. Because motorcycle owners form a small fraction (2.4%, according to NTS) of the population, significant reductions in traffic congestion will come about only if that level of ownership increases.

Phase 1 of the research project therefore included the development of both the motorcycle ownership and mode split models. Initially the level, patterns and trends in motorcycle ownership were analysed. An ownership model was then developed from existing data sets. Insufficient data existed for the development of the motorcycle usage model from existing sources and therefore the specification and execution of surveys to obtain appropriate data on motorcycle usage formed a key part of this study. Statistical techniques were applied to the survey data to develop the mode choice models, which were then implemented in existing transport models to assess motorcycle usage under different circumstances and the resulting impact on congestion.

## 2.2 PATTERNS AND TRENDS IN MOTORCYCLE OWNERSHIP

The National Travel Survey and Family Expenditure Survey were used to analyse the levels of motorcycle ownership for different types of people in different parts of the country. This analysis showed that:

- ownership of one motorcycle peaks at individuals aged 35-39
- types of people identified as more likely to own a motorcycle are:
  - those living alone
  - those without children
  - males
  - households with one car
- types of people identified as less likely to own a motorcycle are:
  - those with income <£9,000
  - those in professional or managerial socio-economic groups
  - those living in Scotland, with a smaller effect for those living in Metropolitan areas, and smaller again for those in London
- two or more motorcycles are:
  - more likely to be owned by males
  - more likely to be owned by those with an income >£15,000
  - less likely to be owned by those under 25 years of age
  - less likely to be owned by those living in Scotland, with a smaller effect for those living in Metropolitan areas and London.

Trends in motorcycle ownership by engine size and region were also reviewed using data from the Vehicle Information Database (VID) between 1993 and 2001, where it was observed that the motorcycle stock increased by 36% between 1993 and 2001.

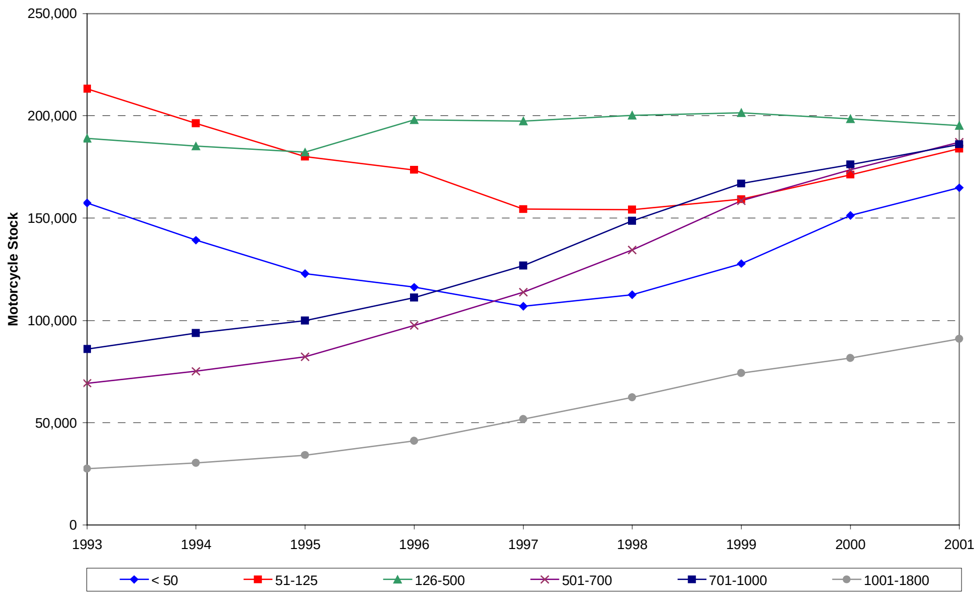


**Figure 1: Trends in Motorcycle Stock by Engine Size, 1993-2001**

The growth in ownership varied considerably by engine size as shown in Figure 1. The stock of the smaller engined motorcycles declined initially but has grown again more recently. The stock of the largest motorcycles has grown steadily although they remain the smallest group.

The rate of growth has been greatest in the London Region, with the Rest of the South (South East, South West and East Anglia) growing at a similar rate to Great Britain. The growth of motorcycle stock for the County of Cambridgeshire was less than in Great Britain.

**Table 1: Motorcycle ownership levels by Region**

| Region | 1993 | 2001 | % change |
|---|---|---|---|
| GB | 743,071 | 1,009,511 | 36% |
| London | 68,936 | 110,328 | 60% |
| Cambridgeshire | 12,939 | 15,481 | 20% |
| South | 317,313 | 410,418 | 29% |
| Rest of GB | 356,822 | 488,765 | 37% |

The 2001 London stock represents 10.9 % of the total GB stock levels while the 2001 Cambridgeshire stock represents 1.5 % of the total GB stock levels.

## 2.3 OWNERSHIP MODEL

The motorcycle ownership model predicts personal motorcycle ownership, including the number of motorcycles owned and the engine sizes of these motorcycles, depending on the characteristics of the person and the average purchase cost of a motorcycle. The ownership model has been estimated from two data sets: 1992 to 2001 National Travel Survey (NTS) data, which provides information on both personal motorcycle ownership and engine size, and the 2000 Family Expenditure Survey (FES), which provides information on personal motorcycle ownership only. The NTS data was necessary in order to be able to model choice of engine size. However, because of the small fraction of motorcycle owners in the NTS sample, even when data were aggregated across years, it did not provide enough data for development of the ownership models. The inclusion of the FES data was therefore important to boost the volume of more recent ownership data. For implementation, the models were calibrated against information on the total number of motorcycles registered, segmented by engine size and area.

The structure of the motorcycle ownership model is a disaggregate hierarchical logit model, with structural parameters to measure the sensitivity of choice of engine size relative to motorcycle ownership. Proper account is taken of differences in unexplained error between the NTS and FES data sets. The models contain a number of important explanatory variables describing motorcycle ownership, including age, gender, personal income, family structure, car ownership, location of residence and motorcycle purchase cost.

Because of the small number of observed motorcycle owners, the ownership models were estimated from a sample of households from 1992 to 2001. The VID trend analysis revealed significant changes in stock over this period, and differential patterns of growth by engine size band and region. Consequently the models were recalibrated so that they replicated the engine band shares in the 2001 VID data.

## 2.4 MOTORCYCLE USAGE

The level of usage of motorcycles for different trip purposes at different times of day was extracted from the National Travel Survey. The analysis confirmed that motorcycles account for only 0.5% of all person trips taking place. Just over half the motorcycle journeys are commuting trips. In the morning peak being considered in this study, this proportion increases to over 80% of motorcycle journeys being commuting trips.

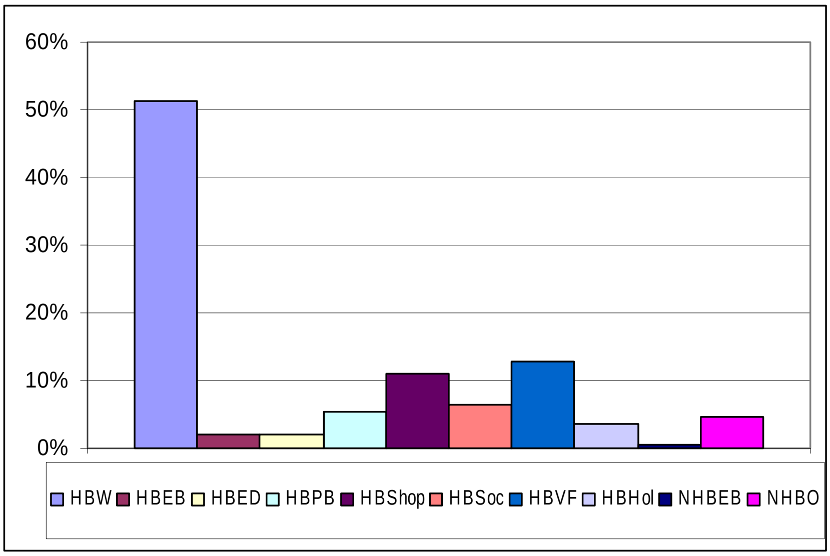


**Figure 2: Daily split of motorcycle trips for different purposes of travel**

Whilst Revealed Preference (RP) data was judged to be more appropriate given the nature of decisions for the ownership models, Stated Preference (SP) data was judged to be more appropriate for development of the usage models, on the basis that the low incidence of motorcycle ownership in the population meant that RP travel databases, such as the NTS, did not contain enough data on choices of motorcycle for AM peak hour travel. Also, SP data allowed for further evaluation of how motorcycle usage may change as a result of policy, for example, increased lane widths, provision and pricing of parking, and of other important influences, such as weather.

An SP survey was therefore conducted with 443 motorcycle owners in London, Metropolitan and other areas in the UK. Interviews were conducted by telephone and on the Internet. Respondents provided revealed preference mode choice information for a journey made in the AM peak. They then participated in two SP experiments: first a within-mode experiment to examine preferences for motorcycle travel, and second a between-mode experiment to examine trade-offs between motorcycle and another model of travel, with varying travel conditions including changes in congestion, weather, provision of motorcycle/car parking, and journey cost changes. Finally, a series of questions were asked about the respondents' personal and household characteristics in order to provide data for categorising the respondents and identifying potentially different behaviour according to background or circumstance. This included questions on age, gender, household composition, working status, socio-economic group, dress code, personal income (before tax), and membership of any motorcycling clubs.

*Which option would you prefer for your journey in the AM peak period if you had to use your motorcycle?*

| Option A | Option B |
|---|---|
| **The traffic in the general motor vehicle lanes will be subject to mild congestion**<br><br>**The general traffic lanes are not wide enough for filtering, you have no access to alternative lanes**<br><br>You have legal access to advanced stop lines | **The traffic in the general motor vehicle lanes will be freely flowing**<br><br>**The general traffic lanes are wide enough for filtering**<br><br>You have legal access to advanced stop lines |
| You will be able to park your motorcycle within 5 minutes walk of your destination<br><br>**You will be able to park at a location with no special security measures for motorcycles**<br><br>**Your motorcycle parking will cost £2 per day** | You will be able to park your motorcycle within 5 minutes walk of your destination<br><br>**You will be able to park at a location with an immovable object to lock your motorcycle to**<br><br>**Your motorcycle parking will be free** |

**Prefer Option A** ☐ **Prefer Neither** ☐ **Prefer Option B** ☐

**Figure 3: Example within-mode choice pair**

*Which option would you choose for your journey in the AM peak period?*

**You expect there to be light intermittent rain during the day**

| Motorcycle | Car |
|---|---|
| Journey takes the same time as by motorcycle now | Journey takes 5 minutes more than by car now<br><br>There are often unpredictable delays causing you to be 10 minutes late |
| You will be able to park your motorcycle within 5 minutes walk of your destination<br><br>You will not know in advance whether you will find a space with security measures | You will be able to park your car within 5 minutes walk of your destination |
| Your travel costs by motorcycle will stay at the level you reported<br><br>Your motorcycle parking will be free | Your travel costs by car will stay at the level you reported<br><br>Your car parking will be £15 per day |

**Choose Motorcycle** ☐ **Choose Neither** ☐ **Choose Car** ☐

**Figure 4: Example between-mode choice pair**

These RP and SP data were used to develop a model of mode choice from choices of motorcycle, car (driver), car (passenger), public transport and bicycle. Joint models were estimated using the SP within-mode, SP between-mode and revealed preference data, with proper scaling by data source type and mode combination.

The final motorcycle usage model indicates that, for journeys in the AM peak hour:

- costs are valued negatively, and are an important driver of mode choice for motorcyclists;

- journey time on motorcycles is perceived positively, but this decreases as the journey distance increases: the enjoyment is greatest for short trips (up to 20 minutes);
- time in congestion is valued more negatively by motorcyclists than time in non-congested conditions;
- journey times on other modes, i.e. car and public transport, are viewed negatively relative to motorcycle;
- we observe a distance effect, which indicates that travel by car becomes more attractive, relative to motorcycle, as journey distances increase;
- bicycle, as an alternative to motorcycle, is less attractive as journey distances increase;
- for motorcycle travel, the time spent walking from the parking location to the final destination is only valued negatively when there are no specific security measures available at the parking location: if there are security measures, then the walking time has not been found to have an impact on the utility within the range examined within the experiments;
- wide lanes are highly valued by motorcyclists, but legal access to advance stop lines is not found to be of significance in the choice process;
- the preference for motorcycle is strongly dependent on the number of months per year that a person uses his bike, possibly representing a life-style effect: the effect is biggest for commuting in London and other metropolitan areas;
- there is a negative impact on motorcycle usage for travellers living in London and other metropolitan areas, compared to ‘other’ areas, in addition to that predicted by the model, taking into account journey times, costs, etc.;
- people aged 60 and over are less likely to use their motorbike, as are those who are commuting and people whose dress code is smart or a smart uniform;
- those who perceive a higher accident risk in the morning peak compared to the rest of the day are less likely to choose to use their motorcycle;
- motorcycle owners with large motorbikes (> 900 cc) are more likely to choose to travel by motorcycle than those owning smaller motorcycles;
- motorcycle owners who own two motorbikes or more are more likely to choose to travel by motorcycle, compared to car;
- in general, motorcycle is less attractive for journeys for other purposes, compared to commuting and/or for business;
- car is more attractive to motorcycle owners in poor weather conditions; only with heavy rain is public transport preferred to motorcycle.

The resulting modal hierarchy from the model estimation process was found to be as shown in Figure 5.

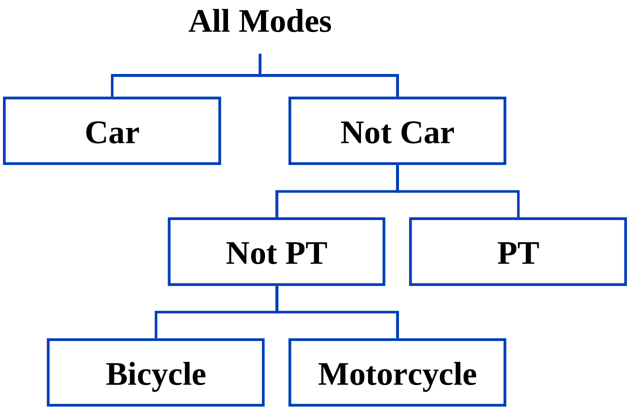


**Figure 5: Usage model hierarchy**

Because of the heterogeneous nature of the motorcycling population, mixed-logit models were developed to investigate random taste variation in the model parameters. No significant random taste variation was detected. The models indicate that there is some variation in valuation of costs across the respondents in the sample, but the model incorporating these effects was not found to give a significant improvement in model fit and has therefore not been carried forward for application.

The data collected clearly shows that motorcyclists enjoy using their motorcycles. From the models we can observe that motorcyclists are particularly sensitive to cost, and this acts as one of their primary drivers in mode choice.

# 3 Phase 2 - Implementation of mode choice models

## 3.1 APPLICATION MODELS

The ownership and usage models developed during the earlier phase of the study were incorporated into two test transport models for London and the South East Region (LASER) and the Cambridge Sub Region (MENCAM).

Both of these model applications are used to test the motorcycle ownership and usage models. They are integrated land use and transport models, incorporating trip generation, distribution, mode choice and assignment. The segment of the market being considered during this study was very small, so to minimise the variation in results due to the uncertainties associated with forecasting into the future, the work was all carried out in the base year of the models using the existing validated trip matrices. The subsequent policy testing phase of work could then consider variations in terms of mode and route choice and the subsequent impacts on congestion as a result of policy interventions.

The extension of these application models to include trip distribution, generation and land use responses to motorcycle related policies would be possible, although it was not attempted in the course of this study.

LASER (version 3.0) is a computer simulation model for planning and transport studies. It shows how changes in land use affects transport and vice versa. In particular:

- how the location of employment and households affects the demand for all modes of travel;
- how highway congestion and public transport overcrowding, in turn, affect travel and land use patterns;
- how employment changes and house building affect residential location and commuting.

The model covers **Greater London** and the Government Office Regions of the **South East** and the **East of England**, including the main ports and airports in the area. LASER has two components: a land use module based on administrative areas, and a multi-modal transport model based on networks. The model estimates:

- household and local service employment by area;
- commuting, and other journeys between areas, by car, bus, rail and walking/cycling;
- morning peak (7-10 am) travel costs, speeds, road congestion, and rail crowding;
- traffic flows on road and rail corridors.

MENCAM is an integrated land use and transport model with a structure similar to LASER. It represents travel demand in the Cambridge Sub Region and was developed as a pilot model for WSP's MENTOR land use modelling software. Public transport use is less widespread than in London and accordingly, its representation within the model is less detailed. All modes of travel are represented and the congestion on the highway and its knock on effects on the choice of route and mode are explicitly represented within the model. Because its study area is smaller, the spatial detail in MENCAM is greater than in LASER and is compatible with the zoning in Cambridgeshire County Council's SATURN model.

The strength of both LASER and MENCAM lies in their estimation of travel demand responses for different land use and transport scenarios.  Both models include a large number of demographic and socio-economic variables.  Employees and households are classified into detailed categories to capture their distinct behavioural patterns.  As a result, these models represent a wide range of travel demand responses to policy scenarios.

### 3.2 IMPLEMENTATION ISSUES

This implementation phase of work started by considering the modifications that would ideally be required to incorporate the models developed during Phase 1 into the application transport models.

A number of challenging issues were identified, that required new ways of representing network capacity to enable appropriate sensitivities to the presence and absence of motorcycles, and to present the consequent service levels that affect the mode choice behaviour of motorcyclists.  These issues are:

- Network models do not usually have provision for weather factors.
- Network models (unless based on full GIS-Transport databases) do not usually have lane width and geometric data underpinning their network link representations, which generally are more topological than spatially represented.
- Network models (again, other than detailed microsimulation models, full GIS-T systems and the hybrids now emerging of the two) do not usually include the intersection geometry, the placement of advanced stop lines, the lane width and splay layouts and all the other spatial factors that determine motorcycle behaviour in filtering and capacity pre-emption at these points.

There are a number of strategies available to address the shortfalls in the ability of traditional network models to represent road movements that encompass motorcycles and other vehicle types.  Each such simplification raises problems in ensuring that the appropriate patterns of network performance are presented to the mode choice and overall demand models.  This is because some of the factors that affect the motorcycle traveller may be being progressively deleted from consideration due to the successive simplifications and aggregations imposed in the attempt to represent motorcycles as a single aggregate mode which effectively behaves the same as a car but with slightly different speed and capacity impacts.

The probability of filtering behaviour is affected by the fraction of heavy vehicles in the traffic stream, the weather conditions, and the lane widths. Of these the lane widths are probably the most critical, followed by the junction geometry in the network.

The route structures affected by limited filtering, and the effects of access to or non access by motorcycles to bicycle and or bus lanes, will be important features for strategic analysis, especially as most field trials to date have indicated that in a wide range of circumstances both motorcycle access to bus lanes and advanced bicycle stop lines, are generally appropriate in terms of traffic and safety performance.

The integration of a detailed GIS version of the TfL road network into the LASER model was initially considered.  However, it soon became clear that this would have been a major task to implement, which would have pre-empted resources from many of the other aspects of this study..  The identification of bus lanes and cycle routes was however implemented in the Cambridge model because the smaller size of its study area made this a feasible task.

The acceleration/deceleration characteristics of a motorcycle is a small contributing factor to the driving cycle within the enveloping traffic stream, but this has as yet not been the subject of experimental measurement, and so values cannot be attributed to this aspect with any great confidence at this stage.

The available measured capacity pre-emption equivalents for motorcycles vary from as high as 0.9 in some constrained circumstances to zero in congested or overloaded critical intersections. Clearly the heroic assumption for a minimal strategic network model will necessarily assume a range of options. These can defensibly include zero capacity pre-emption by motorcycles (even if their mode share is increased substantially in some scenarios by the mode choice model).

Where necessary simplifications to the original model structures were proposed to resolve some of the issues identified above.

## 3.3 IMPLEMENTATION OF OWNERSHIP MODEL

The ownership model developed in Phase 1 of the study was used indirectly within the LASER and MENCAM models. The base year person trip matrices (segmented by purpose and household car availability, and for LASER by income) were split into trips by motorcycle owners and those by non-owners, and the models were extended to explicitly represent these two categories of the population separately.

The division of the matrices into motorcycle owners and non-owners was achieved by applying the ownership model to population data from the 2001 Census. This gave the probability at the home end of each trip segment being made by a motorcycle owner, taking account of the variation in the population profiles in different areas by age, gender, car availability and household composition.

The differentiation of motorcycle ownership by size of bike was omitted from the implementation.

Although changes in the structure of the population were not investigated further within this study, the approach adopted could be used directly to look at alternative land use scenarios.

## 3.4 IMPLEMENTATION OF USAGE MODEL

Motorcycle was introduced in both the LASER and MENCAM models, as a mode available for use by the motorcycle owners only. The characteristics of motorcycle travel implemented in the models were:

- Monetary cost of motorcycle use – fuel costs
- Speed of travel relative to cars on different types of road
- Parking was assumed to be free for all trip purposes in all areas
- Parking search times
- Capacity / road space requirements
- Occupancy.

The values were selected to be as consistent as possible with the Phase 1 work and published research.  With more extensive data to support assumptions, a number of improvements could be made on the representation of motorcycles in the models.

In the MENCAM model, the presence of bus lanes and cycle routes in the transport network was identified and motorcycles were prohibited from using this network capacity.

For the non-motorcycle owners the existing mode choice models in LASER and MENCAM were unaltered.  For the owners the motorcycle usage models developed in Phase 1 were implemented as closely as possible to their original form.

The enhanced models were then run and the results compared with the original model results to determine the scale of the changes in the pattern of mode shares.  This process highlighted the differences between the application models and the statistical models developed in Phase 1.  The main differences occurred due to the inclusion of short trips in the application models – a large number of which are made on foot.  The SP surveys had focused on a specific journey that respondents, i.e. motorcycle owners, made by motorcycle, car, public transport or bicycle, in the AM peak.  Respondents who indicated that they had walked, were considered out of scope.  This effectively excluded any consideration of short trips by foot, since these are not very likely to switch to motorcycle.  Some further modifications were made to the mode specific constants in order to minimise the overall change from the mode split in the original model.

**Table 2: Mode split in MENCAM model before and after enhancements**

| Mode | Original Model | Enhanced model with motorcycles | | |
|---|---|---|---|---|
| | | Non Owner | MC owner | All |
| Car | 61% | 63% | 35% | 62% |
| Cycle | 14% | 11% | 1% | 11% |
| Walk | 9% | 8% | 4% | 8% |
| Bus | 15% | 16% | 6% | 15% |
| Rail | 2% | 3% | 3% | 3% |
| M/C | | 0% | 52% | 2% |
| Total | 100% | 100% | 100% | 100% |

Introducing the ownership and usage models into MENCAM has altered the modelled behaviour slightly, altering the numbers of trips on each mode.  However the impacts are small and it was considered that the improvements made will not have undermined the original model calibration. Comparing counts of motorcycle trips on links entering Cambridge and crossing the River Cam screenline, suggested the MENCAM model was predicting higher motorcycle usage than observed (around 3% of motorised movements rather than 1% to 2%).  However the count data available was for a 12 hour period while the model focuses on the AM peak and it is not unreasonable to expect the largest proportion of motorcycle trips to take place in the peak when congestion is at its worst, particularly because the survey analysis had shown that a large proportion of motorcycle trips are for commuting purposes.

For the Cambridge area small manual adjustments to the implementation produced results that are reasonably consistent with the original model and provided a good platform for policy testing in Phase 3 of the study.

The spatial detail in the LASER model is more limited than in the Cambridge model and to compensate for this LASER includes a separate structure for intrazonal trips categorising them by different journey lengths.  This made the implementation of the usage model more complex and the resulting mode split for motorcycle owners was fairly uniform across the modes and significantly different from that in the original LASER model.

Due to the differences in the structures of the statistical usage model developed in Phase 1 and the mode choice models in both LASER and MENCAM, it was inevitable that the results obtained from the two phases of work would not be entirely consistent for the group of motorcycle owners. For the LASER model the complexity and the segmentation detail of the original model calibration made it difficult to obtain results for motorcycle owners that matched closely to the original model calibration.  While the models could be made more consistent with one another the process is largely manual and the size of the LASER model made this impossible to consider in this phase of work. In any case, the SP survey provides grounds for belief that the motorcycle owners in London do not necessarily make travel choices that are typical of the population as a whole, which is the group whose mode split was calibrated within LASER.

# 4 Phase 3 - Policy testing

## 4.1 SPECIFICATION OF POLICY TESTS

The ownership and usage models developed for this study are capable of testing a wide range of policy tests. The policy testing phase of the study was designed to demonstrate the robustness of the models and to consider the subsequent impacts on congestion of policies that encourage car travellers to switch instead to use motorcycles. The models could equally be used to test policies encouraging more sustainable travel through increased public transport use or shortening journey lengths with increases in walking and cycling.

The range of potential model runs considered for this phase included the effects of:

- Trip end related policies affecting the end (normally the destination) of the journey – eg parking costs / times, security and capacity;
- Road / Route related policies affecting particular links in the network and thus the journey time / choice of route, etc. – eg Congestion charging, motorcycle access to bus lanes, cycle lanes, advanced stop lines;
- Ownership related – different ownership patterns or levels and how these impact on travel;
- Other issues which can be investigated through sensitivity testing - eg weather.

From the statistical analysis carried out in the development of the mode choice models during Phase 1 of the study, it was established that cost is the best variable for influencing mode choice rather than changes in travel time and security. However the current levels of motorcycle usage are relatively low and the scale of change that would be required to make significant differences in congestion levels was likely to be difficult to achieve.

From the range of possible tests, five were selected and carried out using the Cambridge model as follows:

- Permitting motorcycles to use the limited number of bus lanes on the radial routes approaching Cambridge;
- Increasing the cost of car parking by 50% for the motorcycle owners – these have the opportunity to consider motorcycle or other modes as an alternative;
- Introducing a global road user charge of 10p per mile (in 2003 prices) for car travel by motorcycle owners – as again this group have the potential to change mode to reduce travel costs;
- Increasing the level of motorcycle ownership by 50%. The existing patterns of owners are retained so the areas with low numbers of resident motorcyclists will continue to be lower than average;
- Combining the introduction of road user charging as in test 3 with the increased motorcycle ownership investigated in test 4. Increasing the cost of car travel is expected to lead to an increase in motorcycle owners, as more travellers seek more cost effective means of travel.

In practice the parking and road user charging policies would be expected to increase car travel costs for *all* travellers, which would then lead to significant changes in mode and destination choice across the board. The majority of these effects would inevitably be associated with the large number of non-motorcycle owners, which would then swamp the effects we wished to analyse on the smaller number of persons who would switch to use motorcycles and the associated knock on effects on other modes. The impact of these policies is also likely to be at least as great on motorcycle ownership as on motorcycle usage. Since the ownership modelling is indirectly included in LASER and MENCAM, applying the policy only to the motorcycle owners was considered the most efficient modelling strategy to produce informative results and to understand the impact of policies on motorcycle usage.

Weather impacts are significant for motorcyclists in the same way as they affect the likelihood of travellers choosing to use bicycles and to a lesser extent to walk. While these effects are not policy effects and have not been tested here, the weather plays a significant role in efficient operation of the transport system for all modes of travel.

### 4.2 POLICY RESULTS

The change in trips by mode *for motorcycle owners* is shown in the Table below. The model considers the impact of the policies on all modes of transport, including public transport, walking and cycling, even though the policies tested were more focused on the relationship between motorcycle and car use.

The first two tests were found to have very limited impacts on the choice of mode. Both policies are focused on a very limited number of trips and thus the impact is, not surprisingly, limited. The unexpected small decrease in motorcycle trips in the Bus lanes policy test was due to the decrease in travel time not being beneficial for short trips of less than 20 minutes, for which the fixed hassle factors, associated with parking and dressing appropriately, outweigh time savings. Similarly, increasing the motorcycle ownership levels does little to affect the travel conditions, and the movement between modes is thus limited. The road user charging is the one policy that produces a significant switching from car on to other modes. Motorcycle is the main beneficiary within the motorcycle owning subgroup of the population, in terms of volumes of trips, although the percentage increase in the small number of rail trips by this group of travellers is large. Combining road user charging and increased motorcycle ownership reinforces the usefulness of motorcycle as an alternative mode of travel and produces the greatest reduction in car trips of all policies tested.

**Table 3: Percentage change from 2001 Base run in trips by mode for motorcycle owners**

| Mode | M/Cs in Bus Lanes | Parking costs (car + 50%) | RUC (car 10p/mile) | Ownership +50% | Ownership & RUC | Ownership & RUC *relative to Ownership only* |
|---|---|---|---|---|---|---|
| Car | 0.3% | -0.5% | -10.8% | 52.1% | 34.8% | -11.8% |
| Cycle | 0.6% | 0.6% | 0.4% | 50.7% | 50.1% | 0.3% |
| Walk | 0.5% | 0.7% | 0.4% | 50.6% | 50.1% | 0.3% |
| Bus | 0.6% | 0.3% | 4.9% | 52.5% | 57.2% | 3.4% |
| Rail | -0.8% | 0.4% | 10.9% | 48.9% | 57.1% | 5.9% |
| M/C | -0.3% | 0.2% | 6.2% | 49.6% | 60.4% | 7.5% |
| **Total** | **0.0%** | **0.0%** | **0.0%** | **50.7%** | **50.7%** | **0.0%** |

The impact on the amount of motorcycle travel on different types of road in the highway network was fairly limited as shown in the Table below. Allowing motorcycles access to bus lanes appears to lead to some rerouting in order to make some use of the less congested links. In the table below the bus lanes are included with the urban single carriageway A roads. Parking costs and global increases in ownership have little effect. Road user charging leads to proportionately more motorcycle travel on motorways and dual carriageways, as more of the longer journeys switch to motorcycles.

**Table 4: Percentage change in motorcycle kilometres by road type**

| Road Type | M/Cs in Bus Lanes | Parking costs (car + 50%) | RUC (car 10p/mile) | Ownership +50% | Ownership & RUC |
|---|---|---|---|---|---|
| Motorways | 2% | 1% | 38% | 51% | 107% |
| Dual Carriageways | -1% | 1% | 22% | 51% | 83% |
| Non urban Single Carr. A road | -1% | 0% | 16% | 51% | 75% |
| Non urban B and minor roads | -1% | 0% | 15% | 51% | 73% |
| Urban B and minor roads | -5% | 1% | 5% | 52% | 57% |
| Urban Single Carr. A roads *(including Bus lanes)* | 18% | 1% | 9% | 51% | 65% |
| All roads | 0% | 0% | 17% | 51% | 75% |

The congestion benefits of the potential switch to motorcycle use are varied. Access to bus lanes appears to make little difference to the amount of time lost due to congestion. However, Cambridge where this case was tested has fairly limited bus lanes. The impacts in larger conurbations and London would be expected to be more significant. The reduction in car travel from the other policies leads to some reduction in time lost to congestion. The most effective policies are: encouraging increased motorcycle ownership (and hence use), and the charging of car trips.

**Table 5: Change in lost time for all road vehicles (minutes) by road type compared with Base run**

| | M/Cs in Bus Lanes | Parking costs (car + 50%) | RUC (car 10p/mile) | Ownership +50% | Ownership & RUC | Ownership & RUC *relative to Ownership only* |
|---|---|---|---|---|---|---|
| Motorway | 53 | 125 | 494 | 259 | -245 | -504 |
| Dual Carriageway. | -140 | -9731 | -2025 | -7963 | -8204 | -241 |
| NonUrb A Sing Carr | 1034 | -6366 | -85909 | -62930 | -20065 | 42865 |
| NonUrb B & minor | 64 | 1540 | 9133 | 8864 | -5459 | -14322 |
| Urban B & Minor | 336 | 757 | 7262 | -4987 | -835 | 4152 |
| Urban A Sing Carr | -731 | -2151 | -3979 | -4231 | -1081 | 3150 |
| **All road types** | **617** | **-15826** | **-75025** | **-70989** | **-35888** | **35101** |

As can be seen from the change in lost time, the greatest congestion relief tends to occur on the non-urban single carriageway A roads. The Figure below shows how these savings are spread over the network in the case of introducing road pricing. It can be seen that immediately to the North West of Cambridge there are increases in lost time (red) with savings (in blue) further from the city centre and to the south. Thus despite a significant movement from car to motorcycle for the owners, the impacts on congestion in and around Cambridge are limited, due to the relatively small number of existing motorcycle owners.

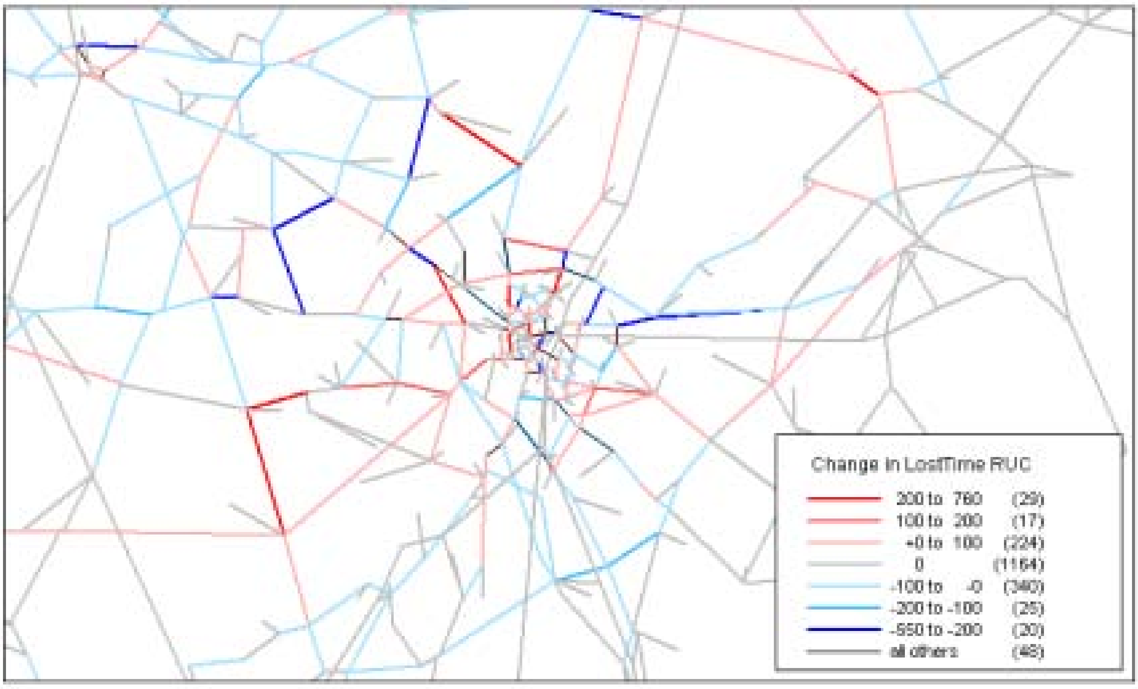


**Figure 6: Change in lost time per link on introduction of road user charging**

The congestion benefits from increased motorcycle ownership and decreased highway travelling through road user charging are however not cumulative with much lower savings from the two measures combined than individually.

In summary, the most effective means of encouraging a switch from car to motorcycle usage is through increasing the number of motorcycle owners and hence the size of the population that have the option available.  Increasing the cost of travel on other modes will encourage owners to make more motorcycle trips so that there are likely to be resultant savings in congestion.

The challenge is to bring about sufficient change to produce noticeable effects for the travelling population as a whole, as the number of motorcyclists compared with other travellers is very small.  At the margin, changes can bring immediate short term relief to congestion in urban areas.  However it is clear from the responses to the surveys undertaken in Phase 1 of the study and the form of the usage model developed, that motorcyclists, like cyclists, are strongly influenced by weather conditions.  Consequently the effects of a wet wintry day could offset benefits gained through policies promoting motorcycle use.

# 5 Summary and recommendations

## 5.1 SUMMARY

This study has advanced both the understanding and measurement of motorcycle usage. The recognition of the importance of motorcycle ownership and the development of an ownership model is a major step forward in the process of estimating motorcycle use. The subsequent implementation of the ownership model using data from the 2001 Census of Population provides a methodology that could be extended to study areas other than the Cambridge and London and South East areas considered in this study.

The identification of a suitable population sample in which to survey travel choices and demand responses was challenging, given the small motorcycle owning population in the UK. Car is the most common alternative mode of transport for motorcyclists, making the allocated quotas for those trading between public transport and motorcycle more difficult to achieve.

The revealed and stated preference surveys provided a valuable data set both for this study and potentially for further work on understanding motorcycling behaviour. The sample sizes were sufficient to estimate models of mode choice. In general we would have hoped to have seen more trading between modes in the SP experiment, but the results suggested that many of those currently using their motorcycle are not particularly responsive to the policy changes that were examined. It is important to remember that all of the respondents participating in these exercises owned a motorcycle and therefore had an inclination towards this mode already, albeit not always for AM peak hour trips.

The practical implementation of the ownership and usage models that were developed raised a number of issues of how to transfer the model parameters and their level of behavioural detail across to be incorporated into typical transport models, and into LASER and MENCAM in particular. These two applications used to test the usage and ownership models benefited from already containing a detailed segmentation of travel demand, the representation of all modes of travel and the equilibration of mode and route choice in a manner that takes account of changing congestion levels. More detailed analysis of the policy impacts of changing levels of motorcycle use on congestion could be undertaken using more traditional pure assignment models such as SATURN or with micro simulation. Such models are however typically highway models without any representation of mode choice.

The practical implementation of the ownership and usage models produced reasonable levels and patterns of motorcycle usage for the motorcycle owners. The structural differences between the LASER model and the mode choice model developed for the shorter journeys, made the implementation more complex and resulted in a less good validation of the motorcycle owners usage of modes. This could be improved through further work enhancing the LASER model and bringing the two structures closer together. The results from the MENCAM model for Cambridge were encouraging and provided a good basis for testing a range of policies.

Following the findings of the surveys undertaken, it was clear that policies affecting the monetary cost of journeys would have more significant impacts than other measures. Significant modal shifts were obtained through the introduction of road user charging and increasing car parking charges. The overall impact on congestion was small due to the relatively small number of motorcycle owners in the country.

## 5.2 RECOMMENDATIONS

This study has restricted itself to investigating the propensity of existing motorcycle owners to change their travel behaviour. More demographic analysis and investigation into the types of user and typical motorcycle journeys could identify those groups who could assist congestion reduction through more targeted policies.

A further area of interest would be to investigate mode switching to motorcycle by those that are not currently motorcyclists, this would require an ownership model that included travel quality variables as well as demographic variables. In addition a clearer understanding of the positive and negative effects on the transport system of attracting travellers from modes other than car needs further investigation.

In the ownership models, there is currently no linkage between motorcycle ownership and travel quality variables, such as increased congestion. It was not possible to easily obtain information on usual congestion levels for journeys made by travellers in the NTS or FES samples, and ideally the model would benefit from network accessibility information. It may be possible to investigate such a linkage in London, say, through LATS, where there may be enough motorcycle owners sampled and where detailed information on journeys made is collected, such that detailed travel conditions could be approximated.

Additional benefits may be obtained from incorporating retail prices into the motorcycle ownership models, rather than the industry costs. An attempt was made in this study, but the data did not become available over the course of the project.

In the mode-choice component, the revealed preference models at present rely on self-reported level of service information for the current and alternative modes in the model. This was a practical approach as the survey was already being used to collect the stated preference data. However, practical restrictions make it difficult to collect data on more than two modes within such an instrument. Whilst the data collected has allowed revealed preference information to be incorporated within the model and allows binary choice models for motorcycle against the next best mode, there could be potential benefits from estimating a model using network level of service data. This would also lift the practical restrictions of the existing survey and would allow more modes to be considered. Combined with availability information, this would provide the basis for a simultaneous mode choice model covering all available modes. This would require a sample of respondents who used motorcycle for an AM peak hour journey for whom the level of service for a range of available modes, including motorcycle, could be obtained. Again we recommend LATS as a potential data source.

In the design of the survey a number of psychometric scales were investigated in an effort to obtain an indirect measure of risk acceptance/avoidance. A number of potential scales were identified but they were found to be inappropriately worded for the context of the current study and were found to place an undue burden on the respondents. As a result the decision was taken not to pursue such an approach in the main survey, although this may be an area that merits further examination in the design of future studies of motorcyclist behaviour.

The study has also identified a number of gaps that need to be filled to treat motorcycles appropriately in transport models. More detailed representation of cycle, bus lanes and lane widths are now beginning to be needed to manage large areas strategically as the measures that can be applied are now a cocktail of capacity and demand management.

The available measured capacity pre-emption equivalents for motorcycles vary from as high as 0.9 in some constrained circumstances to zero in congested or overloaded critical intersections.  Further research into the variation in capacity equivalents for motorcycles under different traffic conditions would be beneficial to the improved representation of motorcycles in transport models.  Similarly further research into motorcycle issues associated with its parking cost and availability, movement in traffic, queuing at junctions, safety and cost issues would be of interest.

The MENCAM model used to test responses to a range of policy initiatives in this study, has the option of being linked to Cambridgeshire County Council's SATURN model. Further analysis of policy responses on congestion and junction performance could therefore be undertaken through linking the extended mode choice model to the SATURN model.