GLAECONOMICS

Economic impact of traffic signals

Transport for London

LONDON DEVELOPMENT AGENCY

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Greater London Authority
November 2009

Published by
Greater London Authority
City Hall
The Queen's Walk
London SE1 2AA
www.london.gov.uk
enquiries **020 7983 4000**
minicom **020 7983 4458**

ISBN: **978-1-84781-310-7**

Paper
Printed on 9Lives 80 silk – 80 per cent recycled fibre,
20 per cent from sustainable forest management, totally chlorine free fibre.

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GLA Economics provides expert advice and analysis on London's economy and the economic issues facing the capital. Data and analysis from GLA Economics form a basis for the policy and investment decisions facing the Mayor of London and the GLA group. The unit is funded by the Greater London Authority, Transport for London and the London Development Agency.

COLIN BUCHANAN

Greater London Authority

Economic Impact of Traffic Signals

Report

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Economic Impact of Traffic Signals

Report

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Status: Final

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Executive Summary

Context

In recent years there has been a sustained debate on the role of traffic signals in London. The number of traffic signal installations has steadily increased with around 1,000 new sets being introduced since the year 2000 so that the total is now over 5,000. At the beginning of 2009 there were 2,532 signalised road junctions in Greater London. These are roughly split 50:50 between inner and outer-London with two thirds on non-Transport for London roads. Stand alone signalised pedestrian crossings make up the remaining installations (these are not addressed in this study).

This increase in traffic signals has led to a perception that there are now too many and at the margins their benefits may be outweighed by increased congestion, or at least unnecessary delays outside peak hours.

The Mayor of London is committed to tackling congestion by ensuring smoother traffic flow and Transport for London (TfL) continues to review all London traffic signals to ensure that they operate in the most efficient way in line with their own and Department for Transport standards - so traffic is stationary for shorter periods of time, whilst maintaining pedestrian safeguards. TfL has examined various options for reducing the impact of traffic signals including allowing left-turns on red and the introduction of flashing amber (this would indicate the need for caution and to possibly give-way to conflicting traffic but not necessarily having to stop). Such changes, however, require government approval which to date has not been forthcoming.

To inform the debate on the cost and benefits of traffic signals GLA Economics commissioned Colin Buchanan (CB), in 2007, to undertake an initial exploratory study which used a model of a theoretical junction to investigate whether or not it is beneficial, in economic terms, to remove traffic signal control and revert in that instance to a major / minor road priority rule.

The initial study concluded that the economic benefits and disbenefits of traffic signals are heavily dependent not only on the volumes of traffic but also traffic composition, vehicle occupancy, pedestrian volumes and time of day. The study also highlighted that any assessment of traffic signals should take into account a wider spectrum of influencing factors including safety and network management issues. Whilst a theoretical study using a simplified approach, the initial work demonstrated that there was indeed merit in considering the issue in greater detail.

For this study, further analysis was undertaken using actual traffic flows at signalised junctions in London during different times of the day. Junctions were evaluated using an assessment framework to assess the requirement for traffic signals and to define the considerations required to determine suitable alternative methods of control in place of existing traffic signals.

In appraisal of transport schemes, an assessment is made of the impacts of the scheme on the welfare of transport users. Travel is a 'cost' in the sense that an individual has to spend time and money making a journey, so a reduction in those travel costs is considered to be an economic benefit. Economists use the concept of generalised cost which combines the monetary cost of a journey (fare, petrol costs, etc.) with the time taken for the journey and various attributes associated with that journey such as crowding.

Traffic signals impact on travel costs by either increasing or decreasing journey delay depending on the journey conditions. As journey purpose, volume of trips and modal split varies by time of day and location it is necessary to explore the impacts of traffic signals taking account of these variations.

The management of London's road network is mainly the responsibility of TfL and the individual boroughs, however, the management of traffic signals is the sole responsibility of TfL. TfL's Directorate of Traffic Operations (DTO) issues guidance to the boroughs with regard to the circumstances where it is appropriate to install signals. In essence signals will be installed at a junction only if:

a) it has an accident rate equal to or greater than the average signalised junction in inner or outer-London as appropriate, and;

b) traffic flows are above a certain level, or;

c) turning traffic or pedestrian flows are above a certain level.

So traffic signals fulfil both a safety and a traffic management function. In the past the case for traffic signals was principally made on traffic conditions during weekday peak traffic periods. More recently account has also been taken of off-peak periods and weekends. The choice for junction control has, however, generally been between full time traffic signal control or conventional priority control without traffic signals, rather than also considering whether there is a case for having traffic signals operational only for particular times of day.

Methodology

In assessing the impact of traffic signals a representative sample of these 2,500 road junctions is needed. In choosing which junctions were modelled account was taken of:

- The availability of an existing and DTO approved traffic model
- The availability of all-day traffic flow data
- The location and type of junction
- Whether the junction was a stand alone junction or part of a network of junctions
- Safety (in principle there was no overriding safety reason why consideration should not be given to switching off the traffic signal)
- Junction geometry (principally linked to safety issues)

Following discussions with TfL, five junctions were chosen, namely

- A section of the Edgware Road covering seven separate junctions (all 4-arm junctions, inner-London)
- A312/B455 Target Roundabout (4-arm roundabout, outer-London)
- A13/River Road junction (3-arm junction, outer-London)
- East Barnet Road/Margaret Road (4 arm junction, outer-London)
- A215 Norwood Road/Palace Road (3-arm junction, inner-London)

These five junctions are broadly representative of two thirds of signalised junctions in London in terms of type and location, however it needs to be stressed that each junction is unique in terms of traffic volumes, composition and turning movements.

In modelling the junctions two scenarios were compared: ‘Do Minimum’, that is, the traffic signals operate as now yet with minor timing adjustments to achieve optimum performance if necessary, and ‘Do Something’ which is to remove the traffic signal control. In modelling traffic movements some assumptions are needed as to how traffic will react without signals. When the traffic signals are removed traffic is assumed to give-way to the right as normal on roundabouts, to give-way to traffic on the right on 4-arm junctions and to revert to major-minor road status for 3-arm junctions.

For each junction the model output included data on average delay per vehicle for the morning peak, inter-peak (ie the time between the morning and evening peaks), the evening peak and at night for the with and without traffic signal scenarios.

These delay figures were then converted to financial values using standard transport economic appraisal guidance from the Department for Transport. To do this account is taken of traffic composition, vehicle occupancy rates and journey purpose. This data comes from traffic counts and the London Area Transport Survey. The analysis valued the changes in time savings, vehicle operating costs and emissions between having traffic signals and no traffic signals by junction.

Modelling Assumptions

Transport modelling tools were used to develop computer simulations of real-life junctions where individual vehicle movements were simulated using established driver behaviour and car-following theories.

These micro-simulation models are regularly used throughout the UK for assessment of traffic operations and major new traffic generators such as property developments. The DTO has developed a number of such micro-simulation models for traffic junctions in London and provides guidelines for development and use of these models.

For the purpose of the present study, micro-simulation models approved by DTO were used to analyse a number of key performance indicators at selected signalised junctions. Each of the modelled junctions was used to analyse two sets of results: the existing situation and a scenario where the traffic signals are replaced with an alternate measure of control. These model results were then input into an economic model to determine the difference in economic terms between the with and without traffic signal scenarios.

These modelling tools represent only standard traffic behaviour. They are unable to accurately predict accidents and unobserved driver behaviour. In addition, there is currently no quantitative evidence in the UK that provides data on the likely form of behavioural response from road users including pedestrians before and after a change in junction control regime to the degree envisaged by this study.

In the absence of any substantial evidence, it was therefore assumed that if traffic signals were to be switched-off for all or part of the day, drivers would behave as they would normally do under whichever alternative traffic regime scenario was put in its place. For example, at a roundabout when the signals are removed they would 'give-way to the right' as usual while at a T-junction traffic on the minor arm would give-way to traffic on the major arm. This behaviour may be different to that commonly seen when traffic signals "fail" as there is usually little guidance to drivers, cyclists or pedestrians as to who has priority. It is not known whether these assumptions represent an optimistic or pessimistic evaluation of likely traffic capacity. Based, however, on anecdotal evidence from occasions when traffic signals fail, as well as engineering judgement, it is considered a reasonable approximation to the likely overall, average performance of the junction.

The present study highlights the limitations to firmly evaluating potential benefits of traffic signals; and the need for further understanding these potential behavioural responses through appropriate case studies.

Results

The results of the individual junction analysis showed considerable variation. All the junctions showed time savings at night by the removal of signals and hence an economic benefit. Four junctions showed benefits of removing signals during the inter-peak period, but at one, the Target Roundabout, there was a significant disbenefit due to the proportion of conflicting movements taking place. In three instances there are clear benefits from traffic signals in the morning and evening peaks.

The total benefits of signals by junction vary from a disbenefit of around £10,000 a year to a benefit of over £800,000 a year. These figures do not, however, fully take into account all the relevant costs and benefits. In some cases removing traffic signals reduces the capacity of the junction meaning it could not handle all the traffic which wished to pass through it. This leads to a build up of a queue and the disbenefit to this traffic that is not able to pass through the junction is not captured by the model. In addition for reasons discussed below the results do not take account of the impact on pedestrians or safety.

While there were some similarities between the results by junctions, given the small number of junctions modelled and the fact that each junction is unique in terms of traffic composition and volumes it was not felt appropriate to scale up the results to a London wide figure.

Pedestrians

The results do not take into account the benefits and disbenefits to pedestrians. This is due to a lack of data on pedestrian movements during off-peak hours and also due to a lack of validated methods of forecasting and modelling pedestrian behaviour when traffic signals are not in use.

It is apparent from the analysis that there are disbenefits from removing traffic signals during morning and evening peaks, and this generally coincides with periods when pedestrian numbers are also high. The inter-peak period is more complex; in parts of London both pedestrian and vehicle numbers are high during this time, but in other locations numbers are much reduced.

Where it has been shown that there are benefits from switching off (or introducing flashing amber) traffic signals during certain periods, it is possible that these benefits would significantly reduce if pedestrian actuation of an all-red pedestrian crossing stage was introduced, resulting in additional delay to vehicles. This is more likely to be an issue at inner-London sites and could therefore negate any benefits. At night however, traffic and pedestrian movements are lower and disbenefits to pedestrians in most parts of London are likely to be very low.

Road safety

The results also do not take into account safety issues. There are very limited studies of the impact of removing formal control at junctions on road safety, and what data there is seems to provide mixed messages. The only recent study, published by TRL and commissioned by TfL, concludes that there is not a safety case one way or other when considering ‘simplified streetscapes’ (with minimal traffic regulations, signs and lines), and so it is possible that removal of signal control would have a neutral effect on safety.

Although there is data available regarding personal injury accidents that occur when traffic signals fail, it is rarely clear whether the accident occurred as a direct result of the signal failure, or if this was a coincidence and other factors such as weather conditions or lighting were not greater contributory factors. It is possible that the lack of guidance to road users on appropriate behaviour in these situations is an important factor, which would not be the case if traffic signals are removed or switched-off with sufficient advance warning and public awareness. The use of flashing amber signals at junctions to advise users on junction behaviour is seen as a method to reduce risk where it has been adopted on the continent. The UK, however, has no experience of using flashing amber signals to warn of potential conflicting traffic movements at junctions and its use would require alterations to highways legislation.

The average cost of a personal injury accident on London’s road network is around £90,000 and an assessment would need to be made at each location where traffic signals could potentially be removed or switched-off to ascertain what, if any, are the safety risks and whether there is likely to be a net gain in economic benefits when compared to possible savings in travel time.

Conclusions and Recommendations

The study has demonstrated that on the basis of the junctions modelled there are significant benefits to road users arising from having traffic signals in London. If benefits to pedestrians were added and account taken of the higher junction capacity that signals can provide this figure would be higher. The study also shows that there are benefits of removing traffic signals in certain locations and at certain times provided safety was not compromised.

It is recommended that consideration is given to a pilot of switching off traffic signals at junctions at times when the level of traffic does not justify such controls subject to a safety audit. There is present Department for Transport guidance as to the level of daily traffic that justifies particular types of traffic control. Based on this guidance it is possible to determine the hourly level of traffic below which formal control is not necessarily appropriate and therefore junctions which could be piloted. (The actual traffic numbers depend on the flows on each arm of the junction so is not a single number.)

In the UK legislation does not allow for the use of switching all signals at a junction to flashing amber at less busy times, a measure which is commonplace in a number of European countries. We recommend discussions should take place with the appropriate European traffic authorities to obtain evidence and ascertain their views on the impact that such traffic control methods have on safety, vehicle and pedestrian movement.

The study assumes that when traffic signal control is disabled, traffic behaviour would revert to some form of conventional priority control, which might even be stipulated through analysis of traffic demand and turning patterns and the use of advance signing. It is possible, however, that junctions could operate without any imposition of regulated traffic controls, with the expectation that road users would behave appropriately. This form of behaviour cannot, at present, be modelled – yet it is recommended that scope for this form of uncontrolled arrangement is also investigated. This can only be achieved through live trials at a variety of sites. The results would have the potential of determining precisely how traffic would behave at ‘shared space’ type environments and could provide unparalleled knowledge in this field. Such work would also need to monitor the behaviour of pedestrians.

1 Introduction

1.1 Context

1.1.1 Over the last few years there has been a sustained debate on the role of traffic signals in London. The number of traffic signal installations has steadily increased with around 1,000 new sets being introduced since the year 2000 and there are now over 5,000. Around half of these are at junctions, the remainder being stand alone pedestrian crossings.

1.1.2 This increase in traffic signals has led to a perception that there are now too many and at the margins their benefits may be outweighed by increased congestion or delay. In 2007 the Transport Commissioner was quoted as saying "We have a problem with traffic signals. We would quite like to remove some and if we can it would make a difference. If they do not add to road safety, why have them?"[1] The majority of signals he was referring to were in relation to junctions leading to roads serving new developments.

1.1.3 Transport for London (TfL) has examined various options for reducing the impact of traffic signals including allowing left-turns on red and the introduction of flashing amber, however such changes require government approval which to date has not been forthcoming.

1.1.4 The Mayor of London is committed to tackling congestion by ensuring smoother traffic flow and TfL continues to review all London traffic signals to ensure that they operate in the most efficient way, rephasing lights in line with their own and Department for Transport standards so that traffic is stationary for shorter periods of time, whilst maintaining pedestrian safeguards. The significant extension of SCOOT (a traffic-responsive Urban Traffic Control system which adjusts traffic signal timings to meet real-time traffic conditions) will also help to maximise the effectiveness of traffic signals and minimise delays.

1.1.5 There remains, however, a desire to further reduce the impact of traffic signals on road users and a number of Local Authorites both in and outside London are reviewing the removal or switching off of traffic signals which are no-longer required/justified.

1.1.6 To inform the debate on the cost and benefits of traffic signals, GLA Economics commissioned Colin Buchanan, in 2007, to undertake an initial exploratory study which used a model of a theoretical junction to investigate whether or not it is beneficial, in economic terms, to remove traffic signal control and revert in that instance to a major / minor road priority rule.

1.1.7 The initial study concluded that the economic benefits and disbenefits of traffic signals are heavily dependent not only on the volumes of traffic but also traffic composition, vehicle occupancy, pedestrian volumes and time of day. The study also highlighted that any assessment of traffic signals should take into account a wider spectrum of influencing factors including safety and network management issues. Whilst a theoretical study using a simplified approach, the initial work demonstrated that there was indeed merit in considering the issue in greater detail.

[1] Evening Standard 27.11.07

1.2 Economic impacts

1.2.1 In the appraisal of transport schemes, an assessment is made of the impacts of the scheme on the welfare of transport users. Travel is a 'cost' in the sense that an individual has to spend time and money making a journey, so a reduction in those travel costs is considered to be an economic benefit. Economists use the concept of generalised cost which combines the monetary cost of a journey (fare, petrol costs, etc.) with the time taken for the journey and various attributes associated with that journey.

1.2.2 To turn time into a financial value, standard Department for Transport (DfT) approved values of time are used. These vary by journey purpose (that is, travel in work time, commuting to and from work and other travel reasons) and hence by mode and time of day reflecting the different use of each mode by different user types. Other attributes of a journey, such as crowding can also be turned into monetary values using standard DfT values.

1.2.3 Traffic signals impact on travel costs by either increasing or decreasing journey delay depending on the journey conditions. As journey purpose, volume of trips and modal split varies by time of day and location it is necessary to explore the impacts of traffic signals in a variety of situations.

1.3 This study

1.3.1 This study builds upon the initial exploratory study, using actual traffic flows at signalised junctions in London during different time periods. Junctions were evaluated using an assessment framework to assess the requirement for traffic signals and to define the considerations required to determine suitable alternative methods of control in place of existing traffic signals.

1.3.2 Traffic models of selected junctions were then tested for two scenarios, that is, with and without traffic signals and the results were compared to determine the net economic costs and benefits of traffic signals by location and time of day using TfL approved traffic simulation models.

1.3.3 These micro-simulation models are regularly used throughout the UK to assess traffic operations and impact of different traffic management measures. The Directorate of Traffic Operations (DTO) at TfL has developed a number of such micro-simulation models for traffic junctions in London and provides guidelines for development and use of these models.

1.3.4 For the purpose of the present study, micro-simulation models approved by DTO were used to analyse a number of key performance indicators at selected signalised junctions. Each of the modelled junctions was used to analyse two sets of results: the existing situation and a scenario where the traffic signals are replaced with an alternate method of control.

1.3.5 The models are based and calibrated on average and observed traffic behaviour and are good predictors of how traffic will respond to known conditions. They are, however, not calibrated when it comes to predicting behaviour for conditions which are not conventional. For example, traffic response to the removal or switching off of traffic signals on a four-arm junction where there is no dominant traffic flow and pedestrians are present is currently not quantifiable.

1.3.6 In the absence of any recorded evidence, the assumptions used in the model are based on how drivers are predicted to behave rather than how they have been observed to behave. For example, the models assume that at a roundabout when the signals are removed they would 'give-way to the right' as usual while at a T-junction traffic on the minor arm would give-way to traffic on the major arm. This behaviour is different to that commonly seen when traffic signals "fail" as there is usually little guidance to drivers, cyclists or pedestrians as to who has priority. It is not known what impact these assumptions have on junction capacity which is a key determinant of delay. Based, however, on anecdotal evidence from occasions when traffic signals fail, as well as engineering judgement, it is considered a reasonable approximation to the likely overall, average performance of the junction.

1.4 Report structure

1.4.1 The remainder of this reported is structured as follows:

- Chapter 2 presents an overview of traffic signals in Greater London;
- Chapter 3 discusses the study methodology for assessing the utility of traffic signals based on traffic management and safety criteria;
- Chapter 4 presents the results of the traffic modelling;
- Chapter 5 describes the methodology and results of the economic evaluations; and
- Chapter 6 presents the conclusions and recommendations from the study.

1.4.2 Full technical details of the traffic modelling used are provided in a separate appendix.

2 Traffic signals in London

2.1 Administrative setup

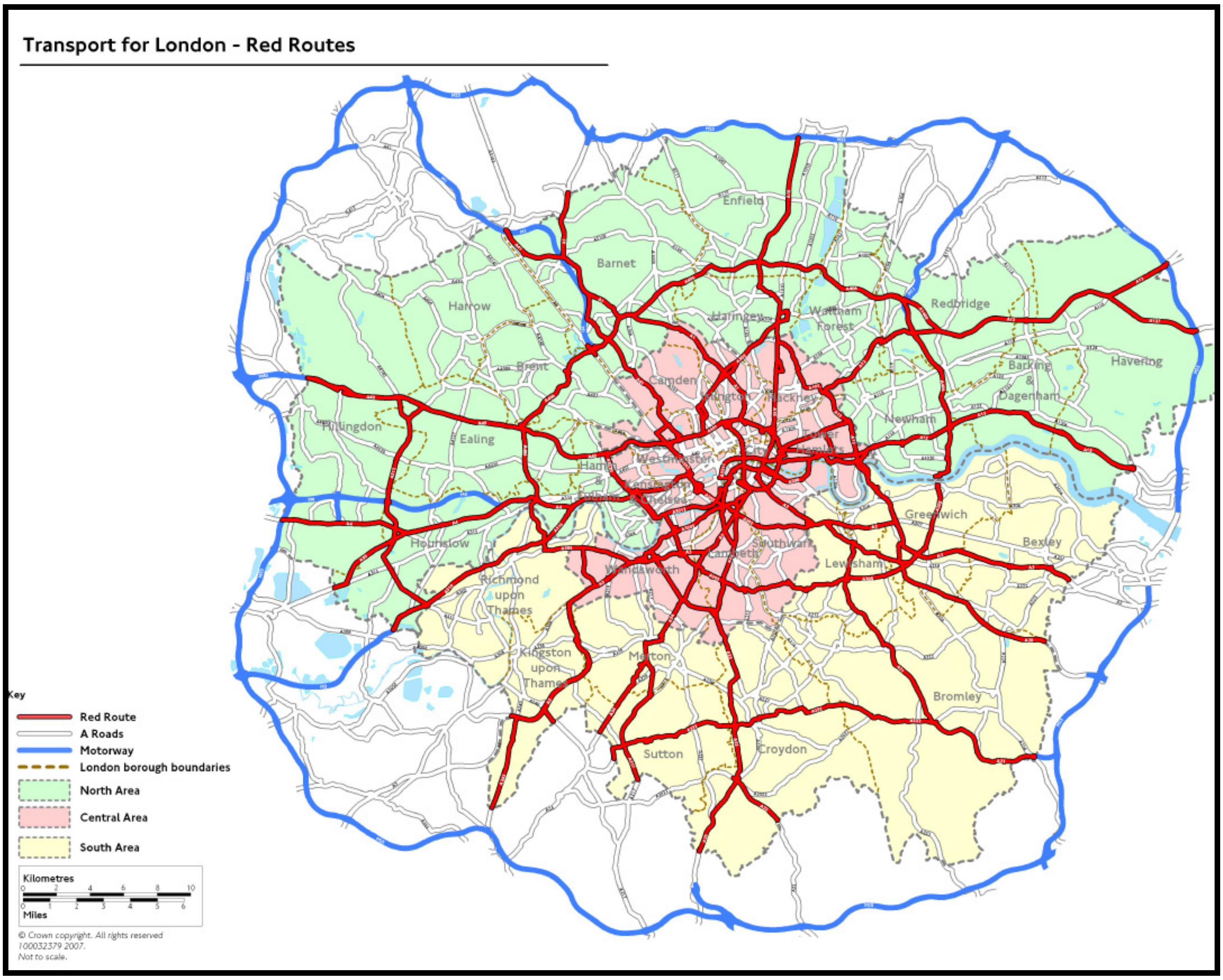
2.1.1 There is a three level hierarchy of highway authorities within Greater London:

- The Highways Agency;
- TfL; and
- The London Boroughs and Corporation of London.

2.1.2 Each highway authority is responsible for the management and maintenance of its own network, but some attributes, for example traffic signals, are the responsibility of a separate administration for the entire Greater London area.

2.1.3 London Streets, part of TfL, is responsible for managing the Transport for London Road Network (TLRN) shown in red in Figure 2.1. The TLRN accounts for about 5% of London's roads by length and carries over a third of its traffic. The roads shown in blue are the responsibility of the Highways Agency.

Figure 2.1: Greater London Road Network



2.1.4 Individual London Boroughs and the Corporation of London are responsible for the rest of the Greater London road network, including the Strategic Road Network (SRN), which has a primary function and carries considerable volumes of traffic.

2.1.5 TfL's DTO is responsible for the management and operation of all London's traffic signals and systems. Traffic signals are therefore managed by a specialised administration and not by the highway authorities directly, although the identification of the need for traffic signal control is a Borough responsibility on their own roads. The DTO issues guidance to the boroughs with regard to the circumstances where it is appropriate to install signals. In essence signals will be installed at a junction only if it has an accident rate equal to or greater than the average signal junction in inner or outer-London as appropriate, and:

- traffic flows are above a certain level; or
- turning traffic or pedestrian flows are above a certain level.

2.1.6 So traffic signals fulfil both a safety and a traffic management function. In the past the case for traffic signals was principally made on traffic conditions during the morning and evening peaks. More recently account has also been taken of off-peak periods and weekends. The option has, however, generally been between 24-hour traffic signals or no traffic signals rather than also considering whether there is a case for having traffic signals but only for particular times of day.

2.2 Greater London traffic signals statistics

2.2.1 At the beginning of 2009 there were 5,224 sets of traffic signals in Greater London. Of these 2,692 are stand alone pedestrian crossings and 2,532 are traffic junctions. Table 2.1 shows the breakdown of these traffic junctions by location (inner / outer-London), with the inner-London category subdivided into Congestion and non-Congestion Charging (CC) zones and by network (TLRN / non-TLRN).

Table 2.1: Number of signalised traffic junctions

Location	Non-TLRN	TLRN	Total
Inner-London within CC area	326	110	436
Inner-London outside CC area	427	453	880
Outer-London	924	292	1216
Total	**1,677**	**855**	**2,532**

2.2.2 Table 2.2 shows a further breakdown by:

- Number of arms (3 / 4 or more);
- Location (inner / outer-London); and
- Network (TLRN / non-TLRN).

2.2.3 These categories are used to generalise key junction types in Greater London and form the basis of our junction selection process for further analysis.

Table 2.2: Greater London junctions by number of arms, location & network

Junction type	Number of junctions	% of the total number of junctions
3 arms – inner-London – non-TLRN	538	21%
3 arms – inner-London – TLRN	387	15%
3 arms – outer-London – non-TLRN	638	25%
3 arms – outer-London – TLRN	220	9%
4 and more arms – inner-London – non-TLRN	215	8%
4 and more arms – inner-London – TLRN	176	7%
4 and more arms – outer-London – non-TLRN	286	11%
4 and more arms – outer-London – TLRN	72	3%
Total	**2,532**	**100%**

3 Methodology

3.1 Overview

3.1.1 As noted earlier, this study follows on from an initial exploratory study which modelled a hypothetical junction to test whether there is a tipping point in terms of the level of traffic, taking into account its composition and journey purpose, at which it is beneficial in economic terms to switch-off[2] the traffic signals.

3.1.2 The aim of this study was to advance our understanding of the economic impacts of traffic signals across London taking on board the key issues arising from the initial study.

3.1.3 To do this required us to consider a range of different junction types:

- In both inner and outer-London;
- On and off the TLRN giving a wide range of traffic volumes and differing traffic compositions;
- At different times of day;
- That are stand alone and part of a wider network.

3.1.4 In addition we need to take account of pedestrian issues and safety.

3.1.5 To identify representative junctions an assessment framework was developed as a means to identify factors that influence the decision whether to signalise a junction or not and to determine suitable alternative methods of control in place of existing traffic signals.

3.2 Framework for assessment

3.2.1 In the past most junction appraisals which led to the installation of traffic signals evaluated peak traffic flow conditions and generalised the use of signals over the complete day, week, month and year. This approach however, although comprehensive in evaluating the impact of traffic signals on safety and traffic flow in general, failed to differentiate the operational requirements and benefits during other times of the day. Extending the analysis to different times of day is a key parameter that has been taken into account in this study.

3.2.2 Traffic signals are used to control traffic movement through:

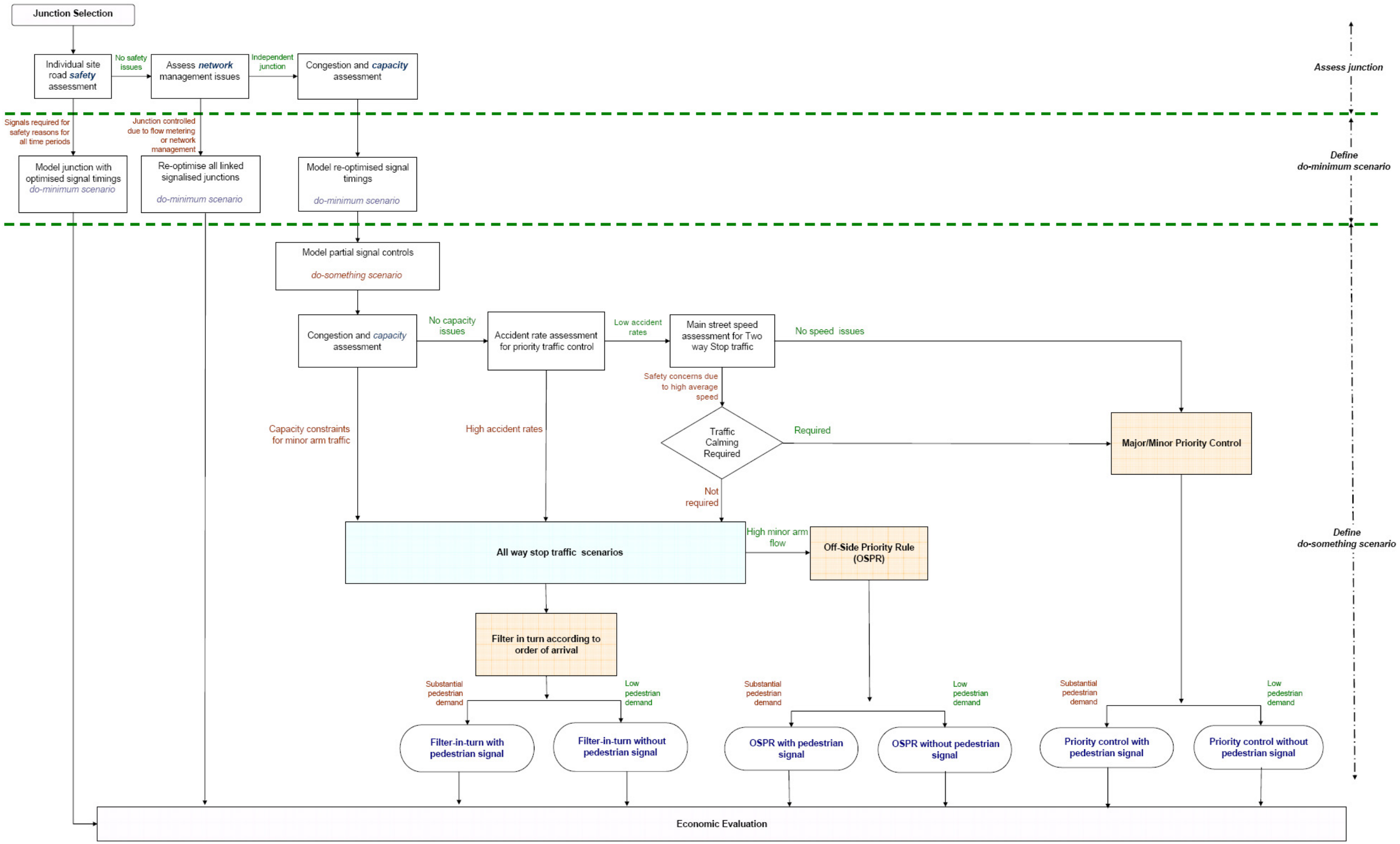
- Improved road safety;
- Major reductions in congestion and delay; and
- Specific strategies which regulate the use of the road network.

3.2.3 These factors have been taken into consideration in selecting junctions for analysis and reviewing alternative methods of control in the case where traffic signals are switched-off for complete or partial time periods in the day.

3.2.4 The assessment methodology is shown in Figure 3.1.

[2] The term "switch off" is used as a short hand to suggest an alternative method of control at a junction. It may not literally be the switching off of the traffic signals.

Figure 3.1: Methodology for assessment of traffic signals



3.3 Key assessment criteria

3.3.1 Key assessment criteria include safety, network management and capacity issues.

Individual site road safety

3.3.2 Road safety analysis needs to be specific to the site and time of day. Consideration of the safety issues which could arise and which should be considered prior to any formal decision-making include:

- The ratio of pedestrians and cyclists to motorised vehicles
- Carriageway widths
- Junction layout and geometry
- Pedestrian and cyclist provision
- Characteristics of traffic, including
  - Approach speeds
  - Through speeds
  - Proportion of goods vehicles
- Collision history.

Road network management

3.3.3 The use of traffic signals is, in parts of the road network, dictated by traffic management imperatives over local congestion or road safety considerations. The following key assessments are required:

- Is the traffic signal part of any strategic network, eg TLRN?
- Is the signal used for enforcing flow metering?
- Is the signal part of a group of inter-connected or synchronised signals?

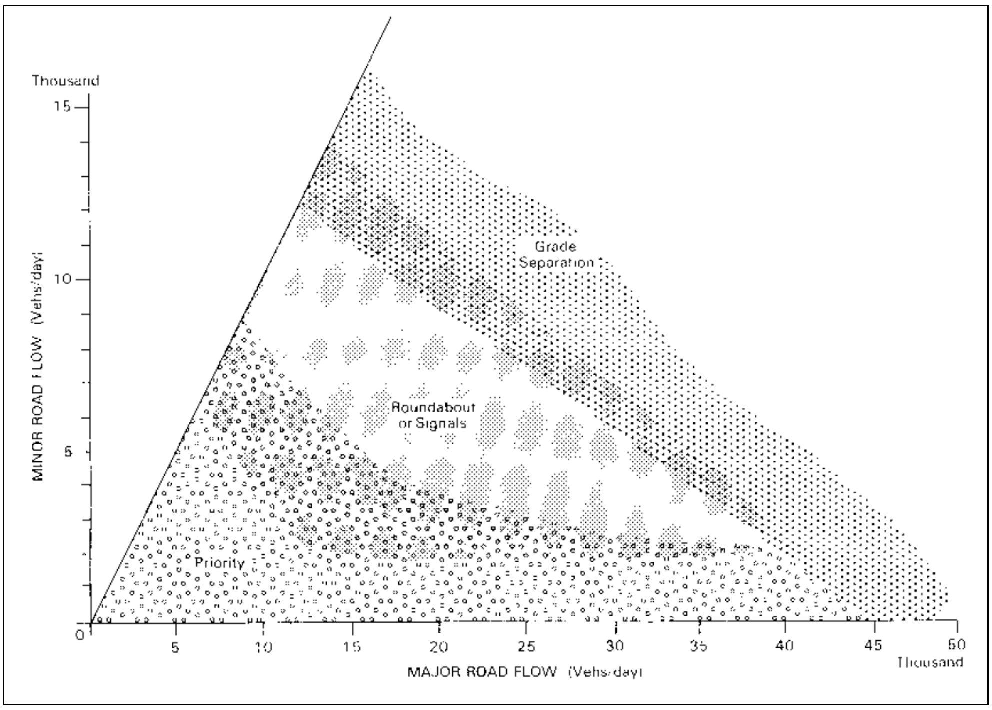
Congestion and capacity assessment

3.3.4 The positive or negative impact of traffic signals on congestion will be assessed through:

- The degree of saturation (that is, the degree to which the traffic through the junction exceeds its capacity);
- Traffic throughput and reserve capacity;
- Vehicle delay;
- Delay to passengers and other street users;
- Scope for further signal timing optimisation; and
- Requirements during different times of the day.

3.3.5 Figure 3.2 shows the conventional approach to choosing junction control methods based on the simple relationship between traffic flows on major / minor roads, using average daily traffic demand. This diagram does not compare the type of junction to time of the day, but it gives a good indication of possible alternatives. It does not, however, take into account the economic value of people and goods travelling on the network where these may be markedly different by time of day or even by each arm of the junction.

Figure 3.2: Junction type appropriate for different traffic flows on major / minor roads



Source: Transport in the Urban Environment

3.4 Junctions selected for study

3.4.1 To provide economic results for Greater London, junctions were selected which are representative of the characteristic mix of junctions present in London.

3.4.2 As discussed in Section 2.2, road junctions can be categorised by the following key attributes:

- Number of arms (3 / 4 or more);
- Location (inner / outer-London); and
- Network (TLRN / non-TLRN).

These categories form the basis of grossing up the modelling results to a London wide assessment. Signalised pedestrian crossings, eg PELICANs and PUFFINs, are excluded from the analysis.

3.4.3 In selecting junctions suitable for analysis account was taken of:

- The availability of DTO compliant traffic models;
- The availability of all-day traffic flow data;
- The type and location of junction, to ensure a representative sample;
- Safety (in principle there were no overriding safety reasons why consideration should not be given to switching off the traffic signal);
- Junction geometry (principally linked to safety issues).

3.4.4 A long list of possible junctions was reviewed with DTO against these criteria leading to the agreed short listed junctions shown in Table 3.1.

Table 3.1: List of selected junctions

Junction location	Key arms and intersections	Type of junction (no. of arms)	Peak major arm traffic flow (morning peak)	Location
A5 Edgware Road (inter-connected traffic signals)	Edgware Road/ Harrow Road/ Marylebone Road	4-arm	615	inner-London
	Edgware Road/ Praed Street/ Chapel Street	4-arm	910	
	Edgware Road/ Sussex Garden/ Old Marylebone Road	4-arm	884	
	Edgware Road/ Burwood Place/ Harrowby Street	4-arm	941	
	Edgware Road/ George Street/ Kendal Street	4-arm	907	
	Edgware Road/ Connaught Street/ Upper Berkeley Street	4-arm	952	
	Edgware Road/ Seymour Street	4-arm	987	
Church Road	(A312/B455)-Target roundabout	Roundabout	1475	outer-London
A13/ River Road	River Road - Bastable Avenue	3-arm (T-junction)	884	outer-London
East Barnet	East Barnet Road / Margaret Road	4-arm	640	outer-London
West Norwood	A215 Norwood Road - Palace Road	3-arm (T-junction)	888	inner-London

3.4.5 These five sets of junctions together represent about 67.5% of signalised junctions in London as shown below in Table 3.2.

Table 3.2: Percentage representation of selected junctions

Junction type	Number of junctions	% of the total number of junctions
3 arms – inner-London – non-TLRN	**538**	**21.2%**
3 arms – inner-London – TLRN	387	15.3%
3 arms – outer-London – non-TLRN	**638**	**25.2%**
3 arms – outer-London – TLRN	220	8.7%
4 and more arms – inner-London – non-TLRN	215	8.5%
4 and more arms – inner-London – TLRN	**176**	**7.0%**
4 and more arms – outer-London – non-TLRN	**286**	**11.3%**
4 and more arms – outer-London – TLRN	**72**	**2.8%**
Total number of traffic junctions	**2,532**	**100.0%**
Percentage represented by selected junctions		**67.5%**

3.4.6 In terms of traffic flow at these junctions they are broadly in line with London as a whole. Table 3.3 shows data from CELLO, which is a strategic transport model for CEntraL London covering most of the junctions in inner-London and major junctions in outer-London. So the figures are broadly in line for inner-London while in outer-London the study figures are lower but this is due to CELLO not covering the large number of smaller junctions in this area.

Table 3.3: Average traffic flows at London junctions

		Selected Junctions		All Junctions in CELLO Model	
		3 arm	**4 arm**	**3 arm**	**4 arm**
Roundabout	Outer		4532		3299
Signalised	Inner	2324	2484	1968	2216
	Outer	1784	1471	2346	2751

3.5 Pedestrians

3.5.1 While there was ready access to traffic flow data there is no consistent and comprehensive data available for pedestrian movements at junctions. The previous theoretical analysis modelled different levels of pedestrian flows as if a ZEBRA crossing was installed at the previous signalised junction. As this exercise was using actual traffic flow data it was not felt appropriate to introduce theoretical pedestrian data. The implications of not modelling pedestrians are discussed in Section 5.4.

3.6 Safety

3.6.1 A key reason for traffic signals is to manage conflicts at junctions which can in turn bring about safety benefits. It was envisaged that safety benefits/disbenefits would be assessed in this study, however, on the advice of our road safety experts we have used a scenario approach to assess the safety impacts. This is due to conflicting evidence about the impacts of removing traffic signals on safety and due to the wide variation at present in accident rates at signalised junctions in London. This issue is addressed in Section 5.5.

3.7 Alternative traffic control regimes

3.7.1 Traffic signals are one of a number of measures that can be used to manage conflicting movements at junctions. Traditionally traffic signal installations tend to operate 24 hours a day. The signal timing strategy will normally vary throughout the day, either using pre-set plans based on traffic demand measurements or (as in an increasing number of cases) using adaptive systems to reflect changing traffic flows. The simplest form of control is vehicle actuation (VA), where the signal remains green for the major road until a vehicle is detected approaching or waiting on the minor road, or a pedestrian pushes a demand button.

3.7.2 A detailed review of existing measures and provisions within the legislation to provide for alternatives to current junction design has been conducted. These include:

- Part–time signal control;
- Use of flashing amber signals to traffic during certain times;
- Optimising the signal settings for all periods of day where not already done.

3.7.3 Part-time signal control is currently in limited use in the UK, mainly at roundabouts, although the number of sites has diminished in recent years due to safety and design concerns. Traffic signals are switched-off for most of the day but if the entry arms suffer long queues, the traffic signals are automatically switched on to regulate conflicts. This method is also considered at standard crossroads and T-junctions.

3.7.4 There are no specific regulations relating to the use of part-time traffic signal control. DfT Traffic Advisory Leaflet 1/06 *General Principles of Traffic Control by Light Signals (Part 2)* states that:

"In most situations, there is no need for part-time operation and if used there may be an increase in accident potential. If the junction is working efficiently on vehicle actuation during off-peak periods, unnecessary delays are minimised and the advantages of control, especially for the more vulnerable users, retained."

3.7.5 Under the DTO *Design Standards for Signal Schemes in London (SQA-0064)* there is no mention at all of part-time signal control, or indeed any statement that traffic signal control should be 24-7.

3.7.6 This clearly infers that use of part-time signals is not contrary to any DfT or DTO standards even though DfT state that it 'may' be more hazardous. Because 'part-time' is not defined at all, by omission this could mean part-time over a monthly/ annual basis (where signals may be turned off for days/ weeks at a time) as easily as it could mean for periods of the day. Coupled with the DfT advice in *Manual for Streets* and LTN *1/08 Traffic Management and Streetscape* that there is no statutory requirement for any form of priority or traffic control regulations, it means that switch-off is perfectly legitimate. It is logical, however, that flashing amber arrangements might be preferred.

3.7.7 Presenting a flashing amber signal to traffic at a road junction does not currently constitute a possible alternative in the UK, but is supported by the Vienna Convention and is common within continental Europe and across the World. The DfT could not currently authorise use of a flashing amber other than at PELICAN crossings, yet with these increasingly being replaced with PUFFIN and TOUCAN crossings facilities in the UK, there would seem to be scope to re-evaluate use of the flashing amber signal.

3.7.8 It is very difficult to predict what road-user response and behaviour would be during a traffic signal switch-off. The closest condition in the UK, save for a very few sites that have had no technical evaluation of behaviour, is that which occurs during a signal failure. Attempts to standardise modelling/ forecasting techniques of this condition have, to date, not been particularly successful. This study considers a range of responses and possible methods of simplifying the assessment of these responses.

3.7.9 Table 3.4 presents the closest approximation to alternative conventional methods of control, or road-user responses, envisaged in the absence of formal traffic signal arrangements with the traditional green, red and amber signal. The two approaches used in this study have been the off-side priority rule (as at a roundabout) and major-minor priority control where traffic on the minor road gives way to traffic on the major road. Where traffic is moving very slowly on the major road it is assumed that drivers move to an almost filter in turn type arrangement letting traffic out of the side road as is commonly observed in reality.

Table 3.4: Alternative traffic control regimes

	Traffic Management Regime	Anarchic			Filter-in-turn (FiT)			Off-Side Priority Rule (OSPR)			Major/minor Priority Control		
	Degree of control	None	Regulated	Partial Control	None	Regulated	Partial Control	None	Regulated	Partial Control	None	Regulated	Partial Control
Control Regime	Vehicle to vehicle control regulations	None			Filter-in-turn according to order of arrival			Give way to vehicles approaching from the right (as if mini-roundabout)			Minor road traffic gives way to major road traffic (as if conventional major/minor priority junction)		
	Traffic signal regime	Switched off or flashing amber	Switched off or flashing amber	Flashing amber with all-red pedestrian crossing stage	Switched off or flashing amber	Switched off or flashing amber	Flashing amber with all-red pedestrian crossing stage	Switched off or flashing amber	Switched off or flashing amber	Flashing amber with all-red pedestrian crossing stage	Switched off or flashing amber	Switched off or flashing amber	Flashing amber with all-red pedestrian crossing stage
	Vehicle to pedestrian control regulations	None	Pedestrians have priority (presumed that crossings revert to zebra)	Vehicles must stop at red signal to allow pedestrians to cross	Filter-in-turn according to order of arrival	Pedestrians have priority (presumed that crossings revert to zebra)	Vehicles must stop at red signal to allow pedestrians to cross	None	Pedestrians have priority (presumed that crossings revert to zebra)	Vehicles must stop at red signal to allow pedestrians to cross	None	Pedestrians have priority (presumed that crossings revert to zebra)	Vehicles must stop at red signal to allow pedestrians to cross
Modelled User Behaviour	Driver behavior	No premeditated order, completely random	No premeditated order, completely random	No premeditated order, completely random, until pedestrian forces controlled crossing stage	Drivers judge priority according to order of arrival	Drivers judge priority according to order of arrival, but must give priority to pedestrians	Drivers judge priority according to order of arrival, until pedestrian forces controlled crossing stage	Drivers judge whether gap is sufficient to accord with off-side priority rule	Drivers judge whether gap is sufficient to accord with off-side priority rule, but must give priority to pedestrians	Drivers judge whether gap is sufficient to accord with off-side priority rule, until pedestrian forces controlled crossing stage	Drivers judge whether gap is sufficient to accord with conventional major/minor priority rule	Drivers judge whether gap is sufficient to accord with conventional major/minor priority rule, but must give priority to pedestrians	Drivers judge whether gap is sufficient to accord with conventional major/minor priority rule, until pedestrian forces controlled crossing stage
	Pedestrian behavior	No premeditated order, completely random	Pedestrians assume priority through presence on crossing	Pedestrians cross in gaps or force controlled crossing stage	Pedestrians judge priority according to order of arrival	Pedestrians assume priority through presence on crossing	Pedestrians cross in gaps or force controlled crossing stage	Pedestrians cross in gaps	Pedestrians assume priority through presence on crossing	Pedestrians cross in gaps or force controlled crossing stage	Pedestrians cross in gaps	Pedestrians assume priority through presence on crossing	Pedestrians cross in gaps or force controlled crossing stage

Note* Traffic signals switched off will normally require hooding or advance signal failure warning sign (could be VMS)

Traffic signals on flashing amber will require alteration to Road Traffic Regulation Act

Priority to pedestrians under flashing amber already covered by RTRA and Highway Code

4 Junction assessment

4.1 Micro-simulation modelling

4.1.1 Traffic data collected from junction sites is used to develop traffic models of the existing conditions. These base scenario models can then be modified to create a proposed scenario model. A number of proposed scenario models can then be used to evaluate the best possible option based on traffic and economic comparisons.

4.1.2 For the purpose of the present study, DTO approved VISSIM models were used to analyse a number of key performance indicators at signalised junctions. Each of the modelled junctions was used to analyse two sets of results: the existing situation and a scenario where the traffic signals are replaced with the alternate measures of control discussed previously. The VISSIM model results were then input into an economic model.

4.1.3 It was assumed that if traffic signals were to be switched-off for all or part of the day, drivers would behave as they would normally do under whichever alternative traffic regime scenario was in place. For example, at a roundabout when the signals are removed they would give-way to the right as usual while at a T-junction traffic on the minor arm would give-way to traffic on the major arm. This behaviour is different to that commonly seen when traffic signals "fail" as there is usually little guidance to drivers as to who has priority, yet it is considered likely that the average results in terms of journey time, delay and queues is similar. This, however, requires further research to verify this assumption.

4.1.4 The following sections present model results for the two scenarios ('Base' - the same as Do Minimum – and 'Do Something') for each of the selected junctions. Charts showing impacts on the following are provided:

- Average delay – a reduction in the Do Something relative to the Base means that there is a benefit from switching off traffic signals;
- Average speed – an increase in the Do Something relative to the Base means that there is a benefit from switching off traffic signals;
- Total number of vehicles crossing the junction – this will generally be similar in the Base and Do Something scenarios, but any major differences can indicate distortions in the model results (usually an indication of gridlock) and are explained in the following sections.

4.2 Edgware Road

4.2.1 The stretch of road modelled consists of seven separate junctions, located within the City of Westminster. This is a busy stretch of road with large numbers of shops and restaurants, offices and high density housing. The level of traffic going through these individual junctions is in the order of 7-10,000 vehicles in both the three-hour morning and evening peaks. Traffic levels remain high in the inter-peak and late into the evening. Pedestrian activity is high throughout the day and evening.

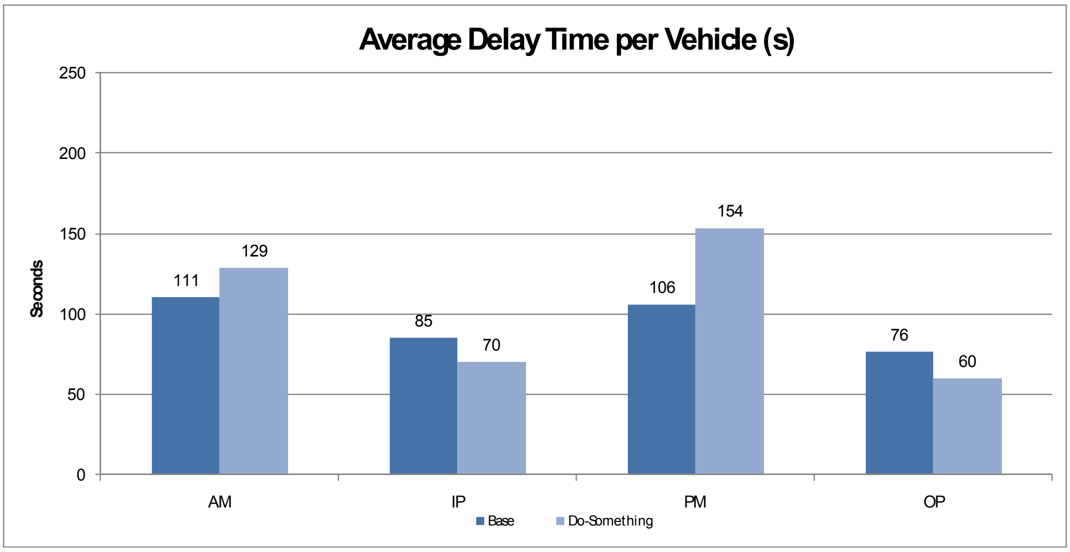
4.2.2 The existing (slightly revised) A5 VISSIM models were used for the morning (07:00 - 08:00), inter-peak (12:00 - 13:00), evening (17:00 - 18:00) and off-peak (22:00 - 01:00) periods for the existing traffic signal regime. The alternative regime modelled assumed that priority control is given to traffic approaching from the right with signals switched-off at the following locations (as shown in Figure 4.1);

- Edgware Road / Marylebone Road / Harrow Road junction
- Edgware Road / Praed Street / Chapel Street junction
- Edgware Road / Sussex Gardens / Old Marylebone Road junction
- Edgware Road / Burwood Place / Harrowby Street junction
- Edgware Road / Kendal Street / George Street junction
- Edgware Road / Seymour Street junction

Figure 4.1: Location of junctions with switched-off signal control

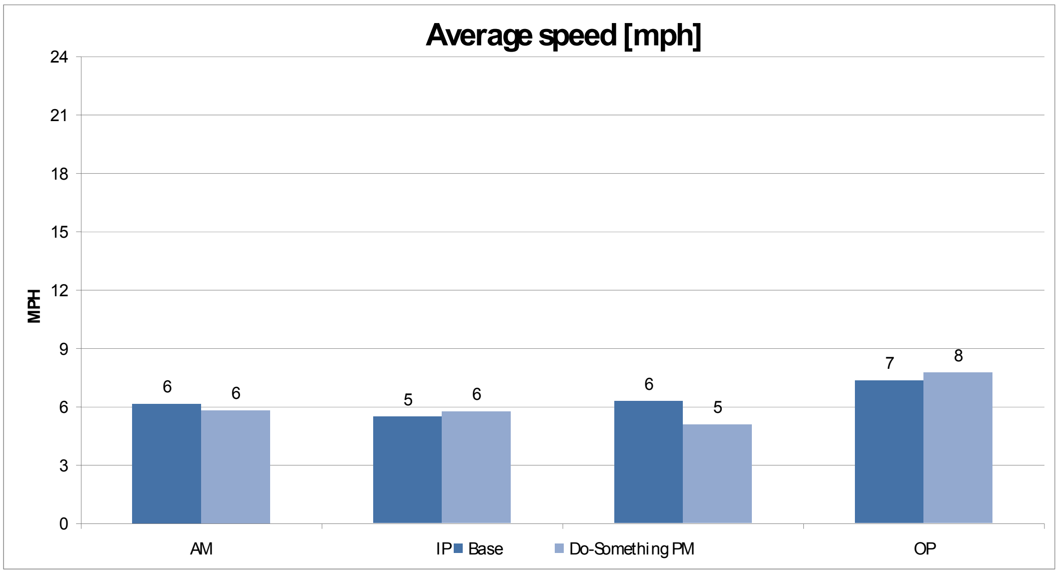
4.2.3 The key results of the analysis are summarised in the figures below.

Figure 4.2: Average delay time (s) per vehicle at Edgware Road



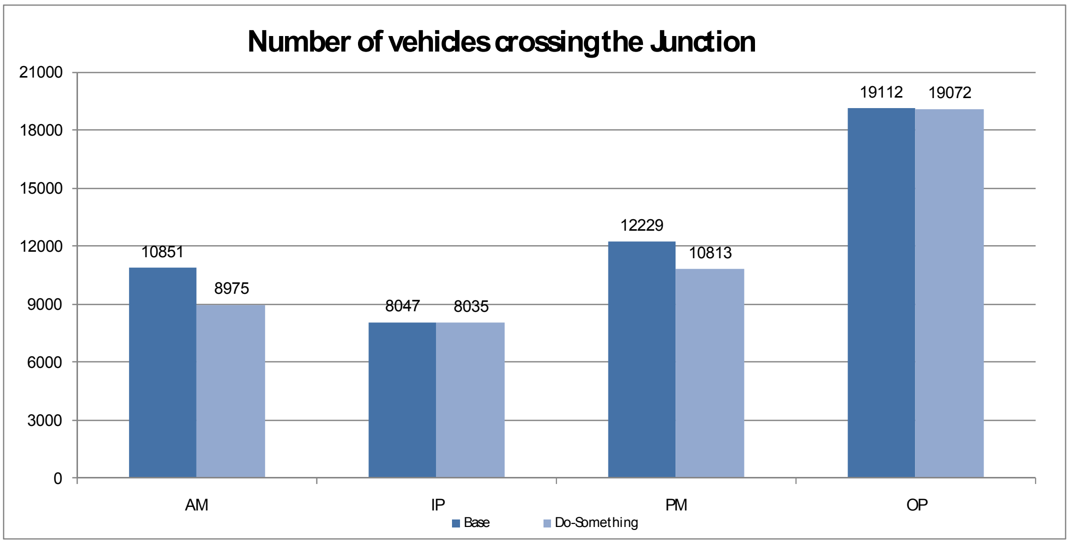
4.2.4 As Figure 4.2 illustrates, the average delay time per vehicle decreases in the inter-peak and off-peak periods without traffic signals and increases during the morning and evening peaks due to heavy traffic flow during these periods.

Figure 4.3: Average speed (mph) at Edgware Road



4.2.5 Change in average delay is reflected in associated changes in average speeds, as shown in Figure 4.3. In the without signal scenario average speeds in the inter-peak are virtually the same as the morning peak showing that traffic volumes remain fairly constant throughout the day.

Figure 4.4: Total number of vehicles crossing the junction at Edgware Road



4.2.6 The total traffic numbers in both scenarios should be broadly the same subject to some minor fluctuations in the modelling. Where the numbers are markedly different, eg in the morning and evening peaks in Figure 4.4, it is an indication that there is severe congestion or gridlock at certain times and not as many vehicles can travel through this section of road in the without signals scenario. The implication is that the economic benefits of traffic signals are higher than the modelling shows in this instance.

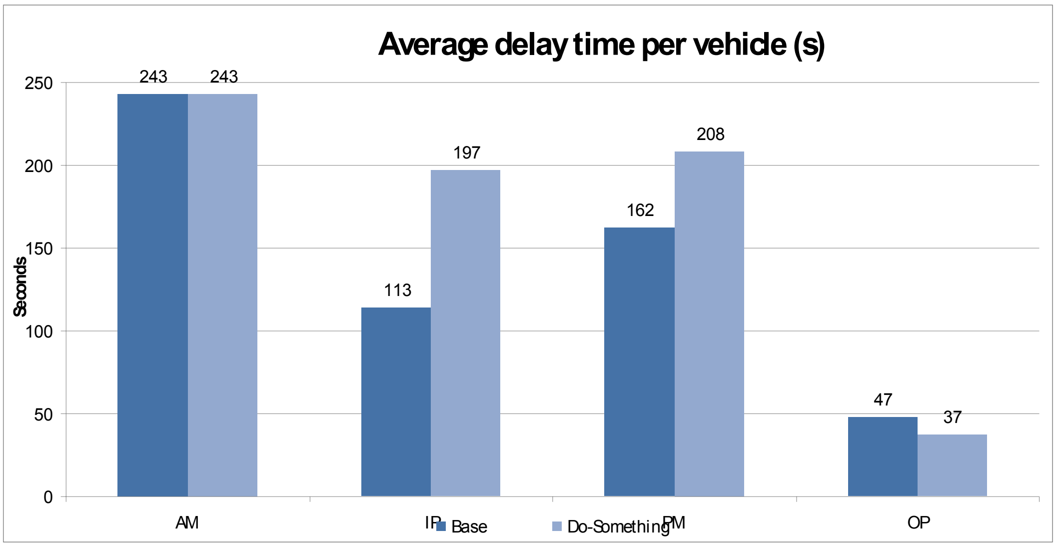
4.3 Target Roundabout

4.3.1 Target Roundabout on the A312 is located in the London Borough of Ealing in an area that is mostly residential in character, with schools, parks and golf courses located nearby. The volume of traffic using the roundabout is around 14,000 vehicles in both the morning and evening three-hour peaks.

4.3.2 The existing A312 Church Road corridor VISSIM models were used for the present signalised junction. The alternative modelling was for the usual priority to the right expected at a roundabout.

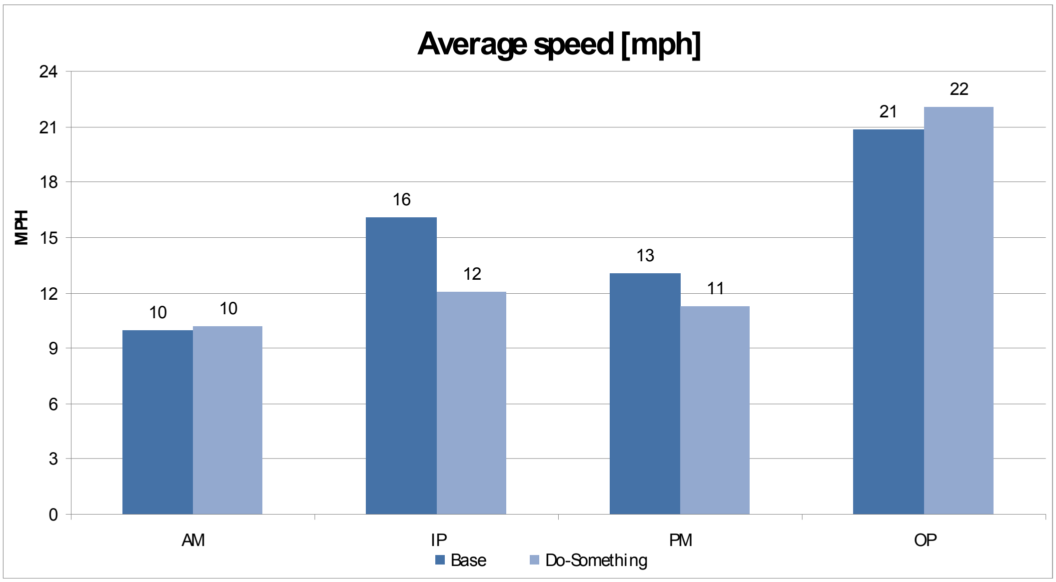
4.3.3 The results for average delay time per vehicle, average speed and number of vehicles leaving the network are shown in Figures 4.5 to 4.7.

Figure 4.5: Average delay time (s) per vehicle at Target Roundabout



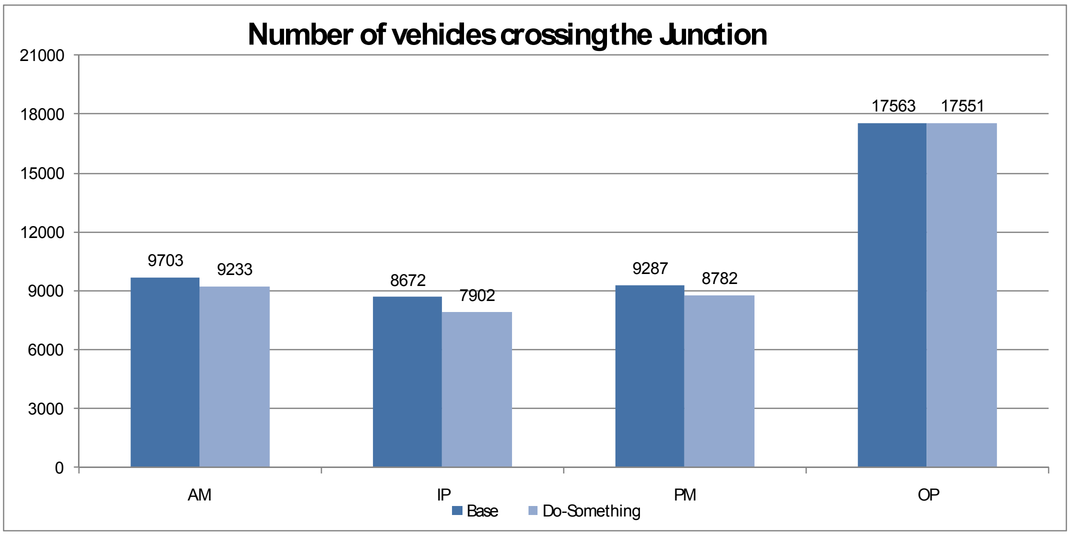
4.3.4 The average delay time per vehicle increases in the inter-peak and evening peak periods without traffic signals. This is due to the large proportion of conflicting movements taking place. There is no difference in the morning peak and a slight benefit at night from removing signals.

Figure 4.6: Average speed (mph) at Target Roundabout



4.3.5 The average speed increases for the off-peak when traffic signals are switched-off, reflecting low traffic volumes. For the other times of day, however, it remains the same or decreases. This is due to heavy traffic flows during the day hours.

Figure 4.7: Total number of vehicles crossing the Target Roundabout



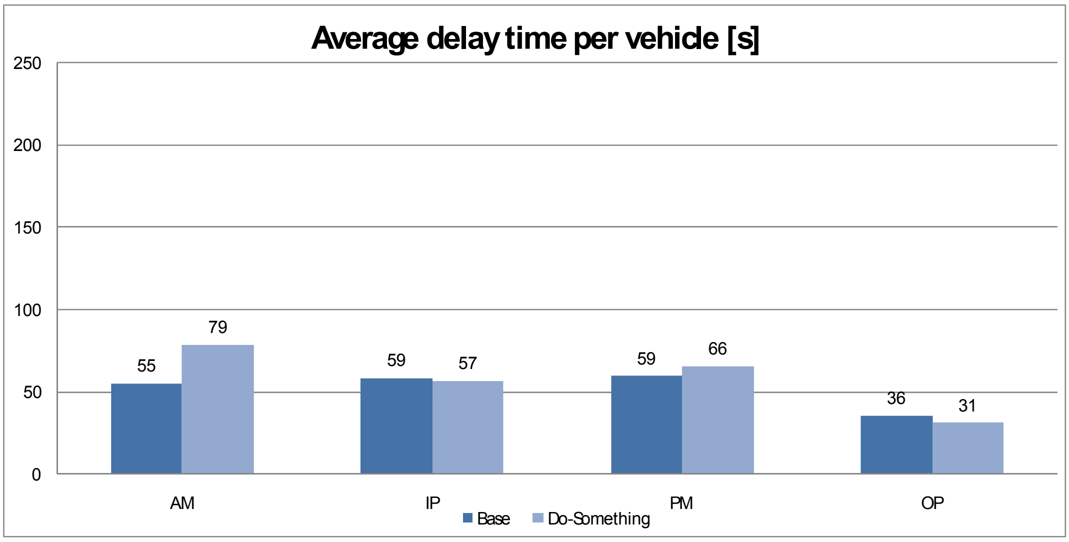
4.3.6 The marked reduction in traffic numbers in the inter-peak period reflects the high level of congestion during that time period.

4.4 River Road

4.4.1 The River Road/ Bastable Avenue junction is located in the London Borough of Barking and Dagenham. The area is both residential and commercial in character with the Lyon Business Park located north of Bastable Avenue. The junction is used by around 5,000 vehicles over a three-hour time period incorporating the morning, evening and inter-peak periods.

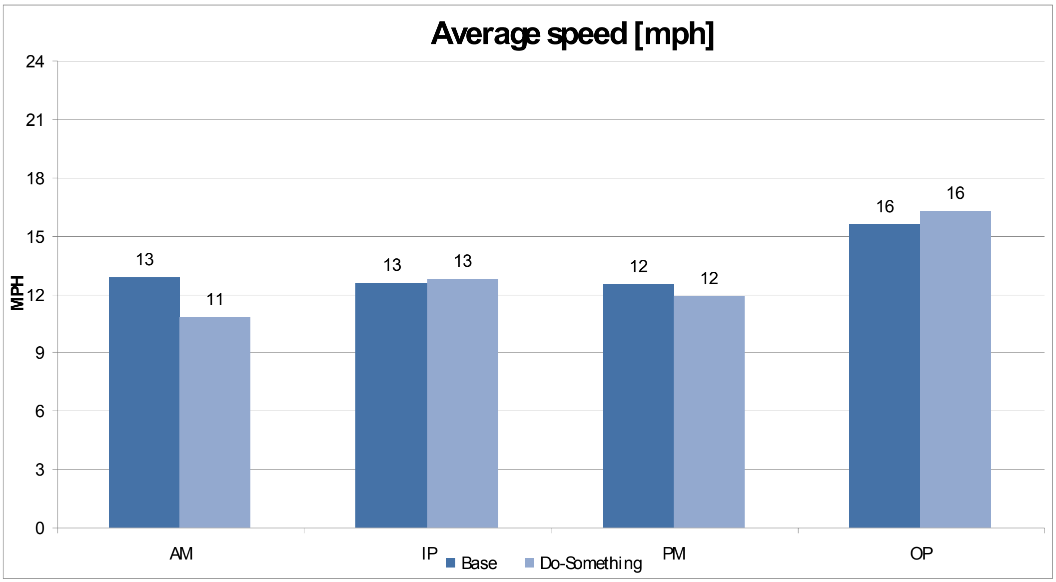
4.4.2 Existing VISSIM models for the A13 were used for the with signals scenario. In the without signal scenario the junction was treated as having a major/ minor priority control with River Road having the priority over Bastable Avenue.

Figure 4.8: Average delay time (s) per vehicle at A13 River Road junction



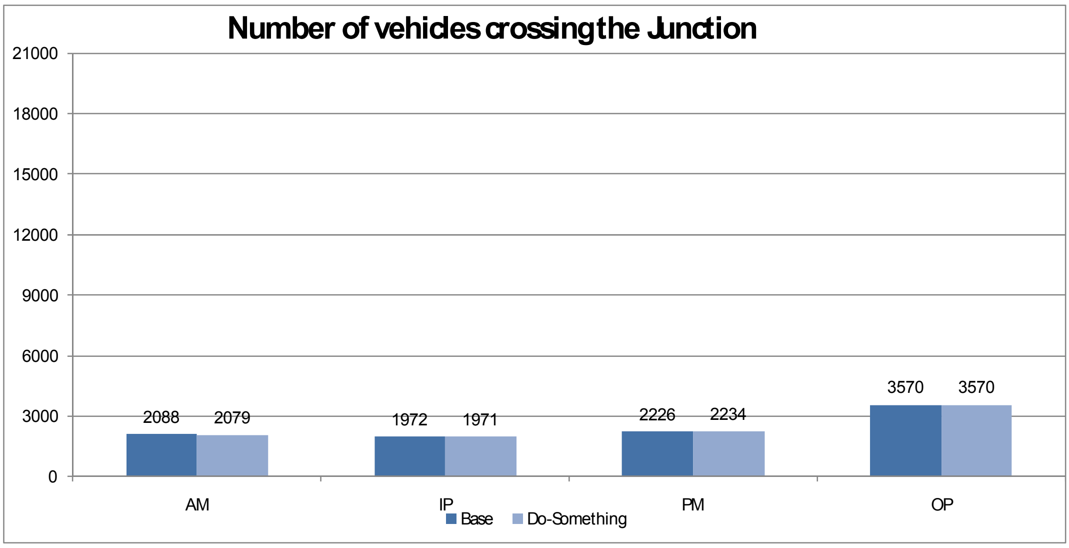
4.4.3 The results are what might typically be expected - disbenefits of switching off signals during the morning and evening peaks in terms of additional delay, with marginal time savings in the inter-peak and off-peak periods.

Figure 4.9: Average speed (mph) at A13 River Road junction



4.4.4 With traffic signals the average speed in the morning and evening peaks is kept at the level of the inter-peak. Average speeds are improved slightly at night when the signals are switched-off.

Figure 4.10: Total number of vehicles crossing at the A13 River Road junction



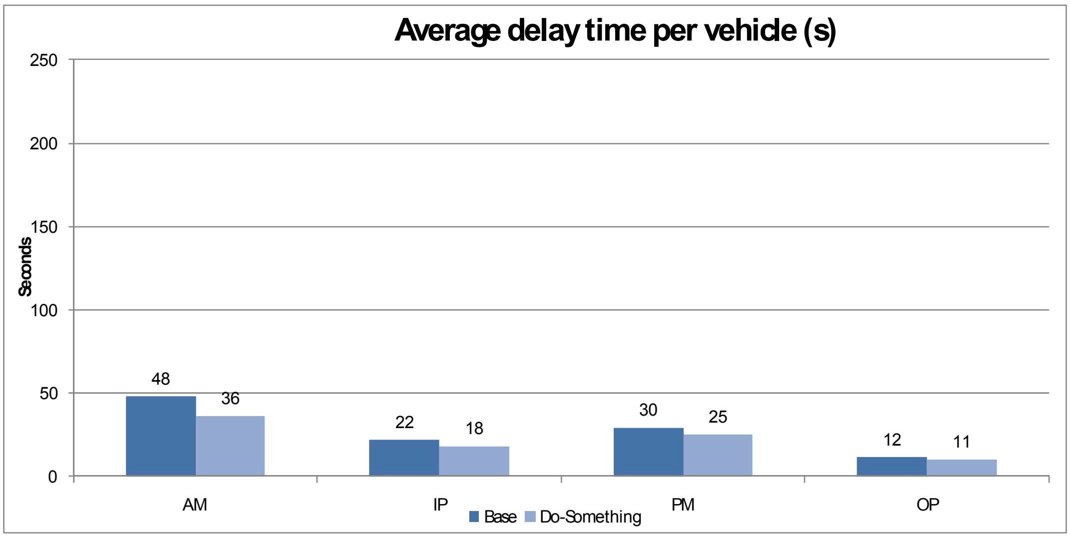
4.4.5 The total number of vehicles in both scenarios is the same illustrating that the junction can handle the volume of traffic presented with no traffic signals.

4.5 East Barnet Road/Margaret Road

4.5.1 The East Barnet Road/Margaret Road junction is located within the London Borough of Barnet forming part of the northern outskirts of Greater London with a largely residential character. The junction is used by around 4,000 vehicles in the morning and evening peaks.

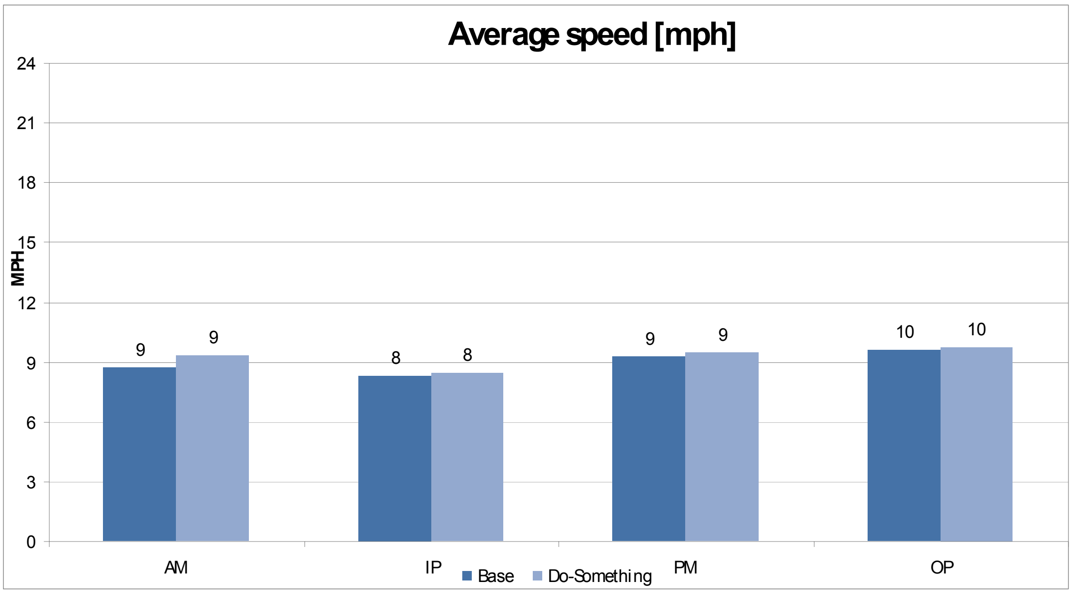
4.5.2 The existing New Barnet VISSIM model was used for the with signals scenario. In the without signal scenario, priority was given to vehicles coming from the right.

Figure 4.11: Average delay time (s) per vehicle at East Barnet junction



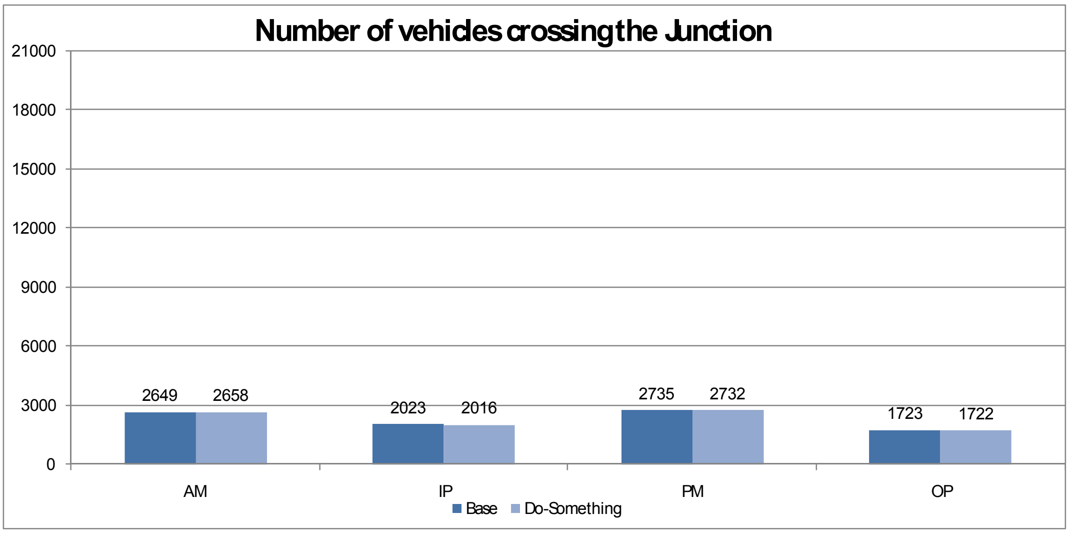
4.5.3 The average delay time per vehicle is reduced in each time period in the without traffic signal scenario.

Figure 4.12: Average speed (mph) at East Barnet junction



4.5.4 The average speed increases marginally for all time periods, showing the benefit of removing signals.

Figure 4.13: Total number of vehicles crossing the East Barnet junction



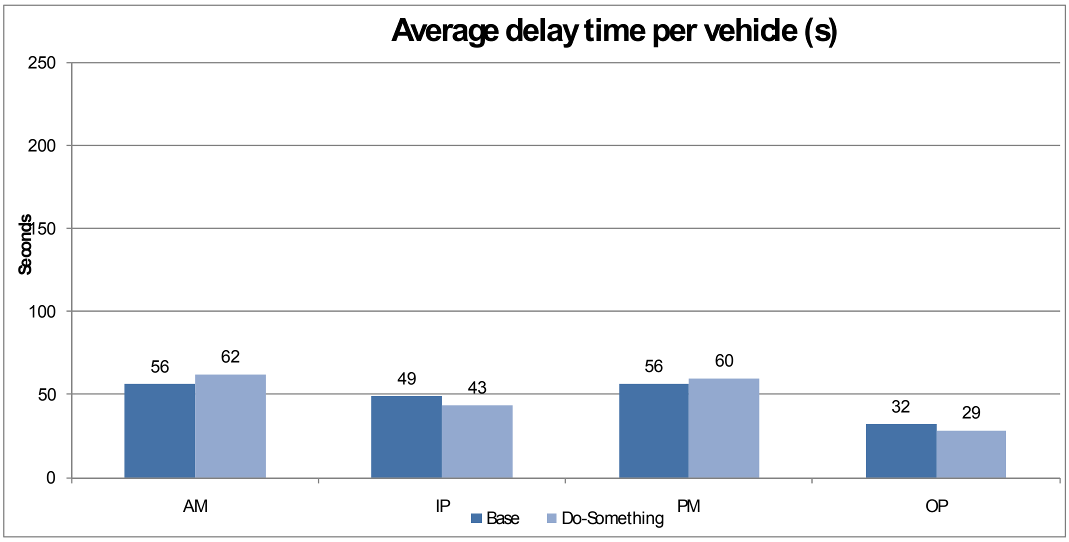
4.5.5 The total number of vehicles in the with and without scenario is the same, showing that the junction can handle the volume of traffic in the with and without scenarios.

4.6 A215 Norwood Road/Palace Road

4.6.1 The A215 Norwood Road / Palace Road junction is located within the London Borough of Lambeth. The area is largely residential in character with Tulse Hill railway station in close proximity. The junction is used by around 2,000 vehicles in both the morning and evening peaks.

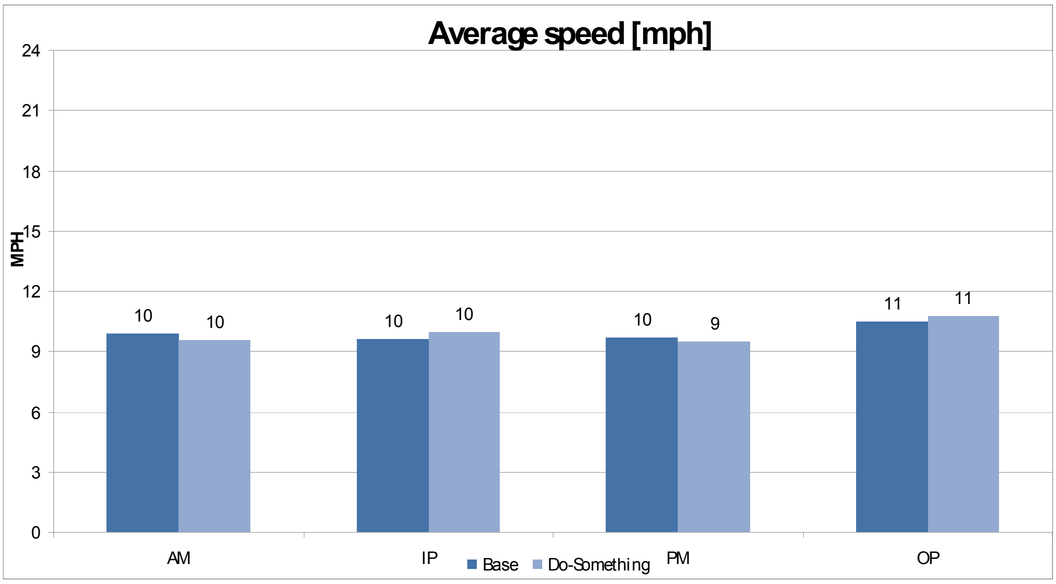
4.6.2 Existing VISSIM West Norwood models were used for the with signals scenario; in the without signal scenario the junction was modelled as a major / minor priority control, with the traffic on A215 Norwood Road having the priority over Palace Road.

Figure 4.14: Average delay time (s) per vehicle at Norwood Road junction



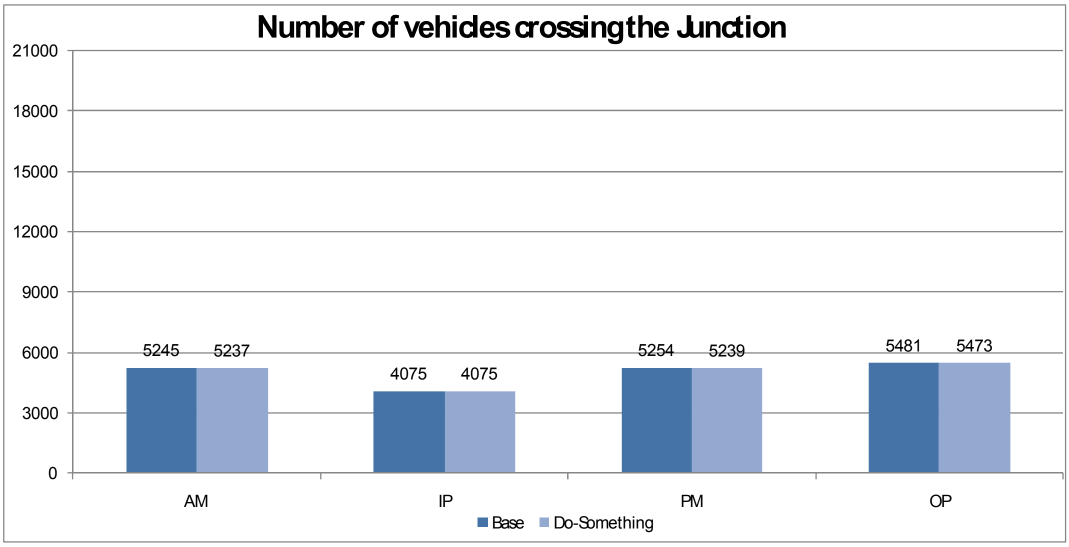
4.6.3 The average delay time per vehicle is lower without signals during the inter-peak and off-peak periods and higher during the morning and evening peaks.

Figure 4.15: Average speed (mph) at Norwood Road junction



4.6.4 The average speed decreases during the morning and evening peak time periods without signals and increases in the inter-peak and off-peak periods.

Figure 4.16: Total number of vehicles crossing the Norwood Road junction



4.6.5 The total number of vehicles in the with and without signals scenarios is the same, showing that the junction can handle the volume of traffic.

5 Economic impact analysis

5.1 Introduction

5.1.1 An economic model was developed, using the outputs from the VISSIM modelling and the economic parameters set out in the DfT's WebTAG guidance for transport appraisals. For each of the five junctions, model outputs were produced for the following time periods:

- Morning peak (8.00 – 9.00)
- Inter-peak (12.00 – 13.00)
- Evening peak (17.00 – 18.00)
- Off-peak (22.00 – 01.00)

5.1.2 The following vehicle types are covered:

- Car
- Light goods vehicle (LGV)
- High goods vehicle (HGV)
- Bus
- Taxi
- Motorbike
- Bicycle

5.1.3 Each of the modelled junctions was used to analyse two sets of results: the existing or base ('Do Minimum') scenario and a 'Do Something' scenario where the traffic signals were replaced with an alternative measure of control as discussed earlier in the report.

5.1.4 The following categories of benefit have been quantified and valued:

- Time savings;
- Vehicle operating costs (fuel);
- Vehicle operating costs (non-fuel); and
- Carbon emissions.

5.1.5 Some of the assumptions that have been used in the economic analysis are described in the next section, and a full assumptions register is provided in the Appendix to this report.

5.2 Methodology

Time savings

5.2.1 The VISSIM model outputs show the average delay time and the number of vehicles for each vehicle type / time of day / junction, thus enabling total delay time to be calculated. The difference between total delay time in the Do Minimum (existing case with optimised traffic signals) and Do Something (without traffic signal control) shows whether there is a benefit or disbenefit as a result of removing traffic signals in each case.

5.2.2 The change in delay time can be valued by applying a value of time. Standard values of time per person from the DfT's WebTAG guidance have been used. These are then converted into values of time per vehicle by applying journey purpose splits and average vehicle occupancy rates from WebTAG and the London Area Transport Survey (LATS).

5.2.3 The results for each individual time period are then scaled-up so that they represent a total for the whole year. It has been assumed that benefits can be scaled-up in proportion to the observed hourly flows at each junction. This means that if, for instance, the observed flow at a junction between 7.00 and 8.00 is 20% lower than the observed flow between 8.00 and 9.00, then the benefit / disbenefit for 7.00-8.00 is assumed to be 20% lower than the benefit calculated for 8.00-9.00 from the model results. It is not necessarily the case that there is a linear relationship between flow and benefit, although to prove otherwise would require an enormous amount of modelling to be undertaken.

Vehicle operating costs (fuel)

5.2.4 WebTAG guidance provides a formula that can be used to estimate the rate of fuel consumption by vehicles travelling at different speeds. This has been applied to the average speeds in the Do Minimum and Do Something scenarios in order to estimate differences in fuel consumption rates between the two scenarios. This in turn is then applied to the average distance travelled, that is, the distance covered by the area modelled, to calculate changes to total fuel consumption, and WebTAG values for the cost of fuel are applied to estimate the total change to fuel vehicle operating costs. The model results are factored up in the same way as the time savings to obtain an annual total.

Vehicle operating costs (non-fuel)

5.2.5 A very similar approach is used for the non-fuel operating costs – again, a WebTAG formula is used to estimate the change to non-fuel vehicle operating costs as a result of different speeds between the two scenarios and the results are scaled-up and annualised accordingly.

Emissions

5.2.6 Emissions benefits are related to fuel consumption, which is estimated as part of the vehicle operating costs. WebTAG values for carbon emissions per litre of fuel consumed are applied to calculate total emissions, and then monetised also using WebTAG values.

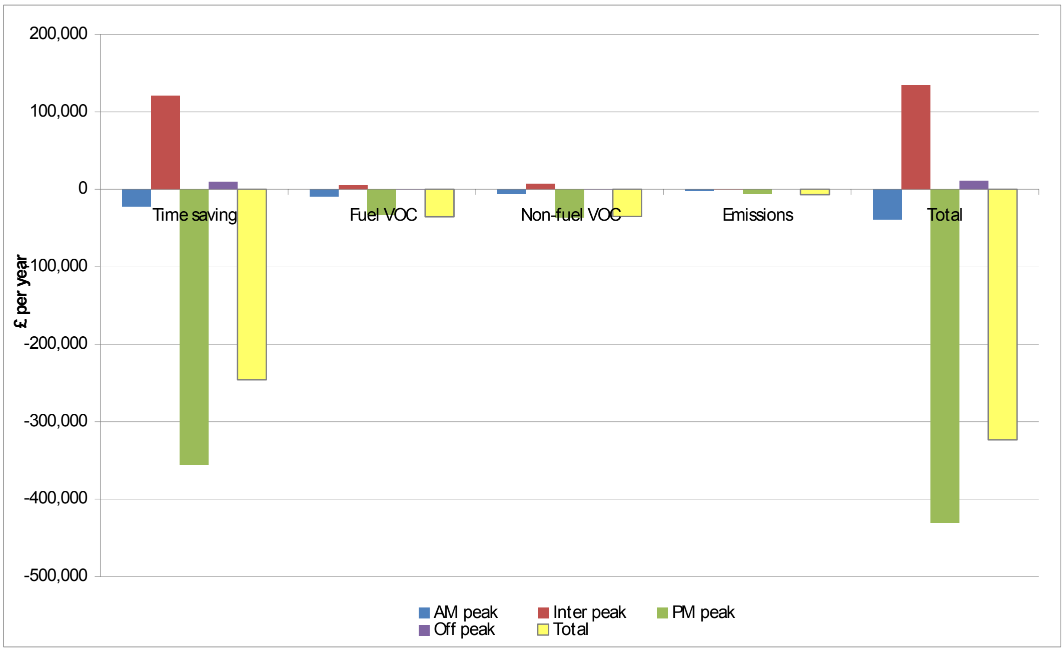
5.3 Results

Individual junctions

5.3.1 The charts in this section are based on the results for the individual junctions, ie they do not represent a total benefit / disbenefit for all London. Figures 5.1 to 5.5 below show the results for each of the five junctions that were modelled, split by benefit type and time period.[3]

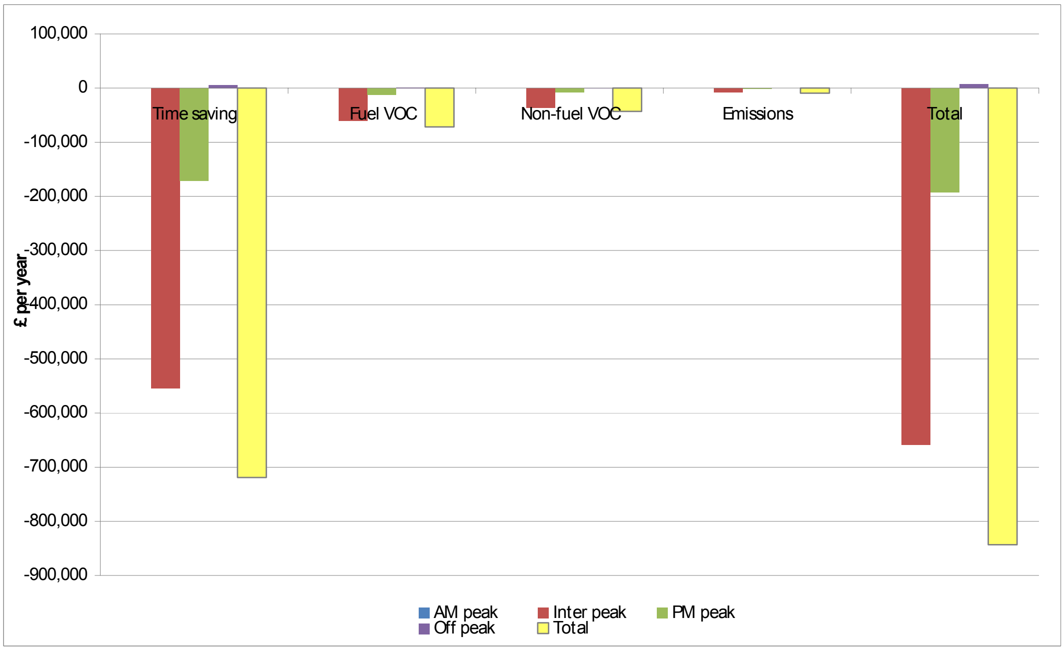
[3] It should be noted that the scale of the y-axis is different for each chart, as the benefits / disbenefits for some junctions are much larger than others

Figure 5.1: Impact of removing traffic signals on Edgware Road



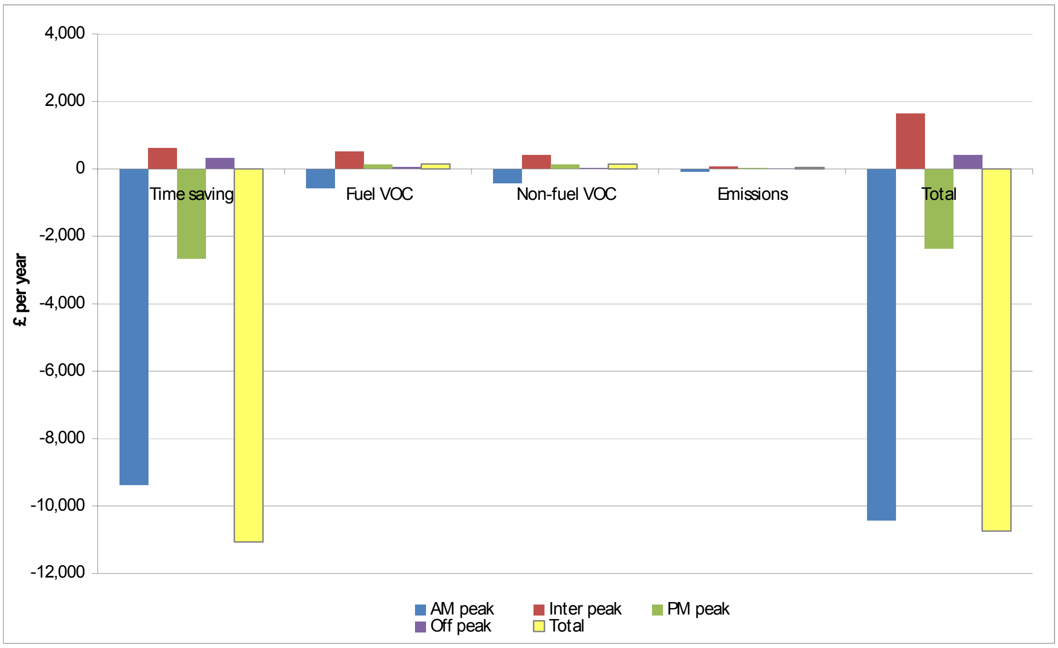
5.3.2 The results for Edgware Road show a disbenefit from removing traffic signals in the morning and evening peak periods. In the case of the evening peak the disbenefits are substantial - over £400k a year - reflecting a high traffic flow. There is a benefit from removing traffic signals during the inter-peak of over £100k a year, and a slight benefit in the off-peak.

Figure 5.2: Impact of removing traffic signals at Target Roundabout



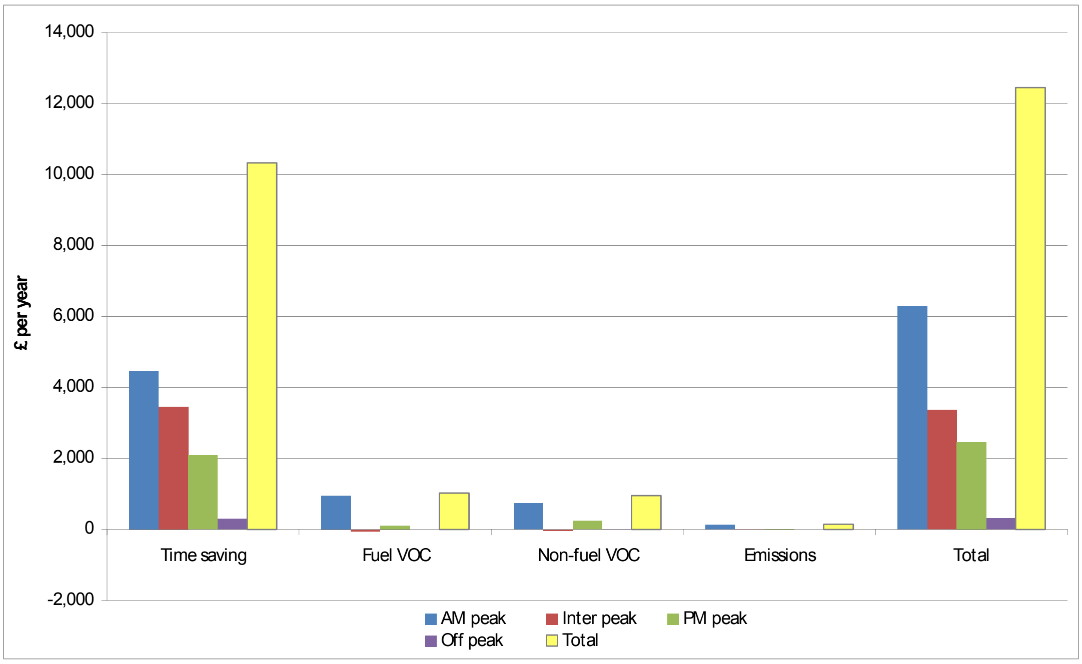
5.3.3 Figure 5.2 indicates that there would be a significant disbenefit (approximately £660k a year) from removing traffic signals during the inter-peak at the Target Roundabout, and to a lesser extent during the evening peak (disbenefit of approximately £190k a year). There would be a slight benefit from removing traffic signals in the off-peak, with a neutral impact in the morning peak since the level of gridlock is such that the signalling system does not influence delay time. Overall the total for the whole day shows a large disbenefit. It should be noted that roundabouts are peculiar examples of traffic junctions where the delay for individual arms and that for overall traffic is highly dependent on the balance of flows and available gaps for major traffic movements. Unbalanced flows, for instance in the inter-peak scenario, can result in higher delay for all traffic but can be easily minimised by introducing demand operated traffic signals.

Figure 5.3: Impact of removing traffic signals, A13 River Road



5.3.4 As shown in Figure 5.3, the A13 River Road has similar results to Edgware Road, albeit on a smaller scale, as there would be disbenefits from removing traffic signals during the morning and evening peak and a benefit during the inter-peak and off-peak. These are in line with the results that would be expected, with traffic signals required at busier times of day to regulate flows but less necessary at times when flows are lower.

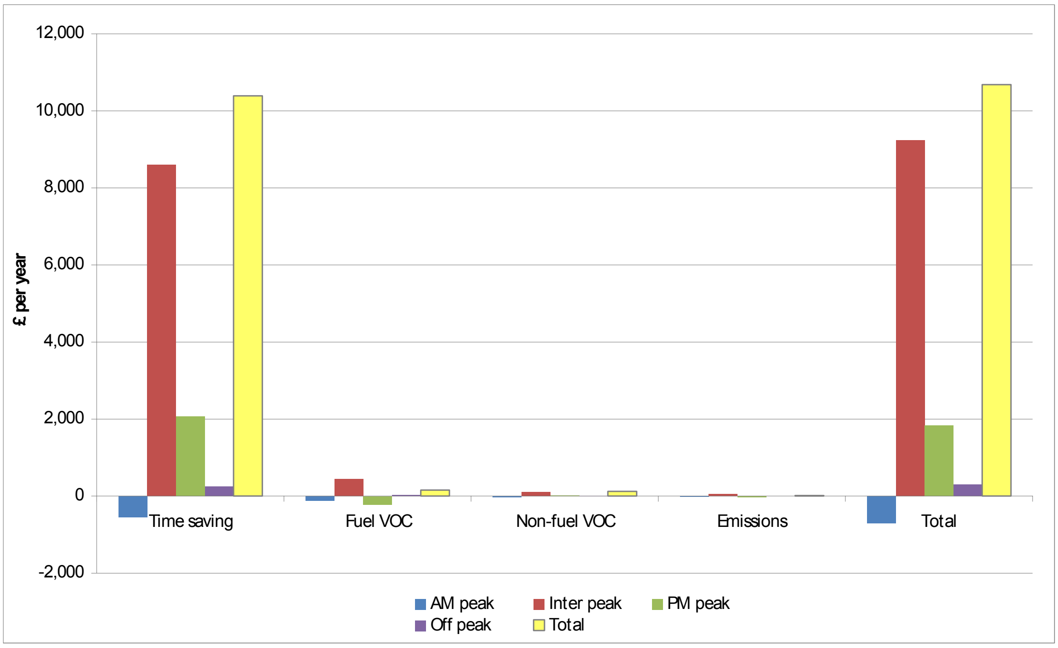
Figure 5.4: Impact of removing traffic signals at East Barnet junction



5.3.5 As shown in

Figure 5.4, the East Barnet junction benefits from the removal of traffic signals at all times of day, with the largest benefit occurring during the morning peak. Again, the size of flow is an important factor in determining whether there is a benefit – the flows at this junction are relatively low throughout the day therefore traffic signals are less necessary to regulate flows.

Figure 5.5: Impact of removing traffic signals at Norwood Road junction



5.3.6 West Norwood has an overall benefit from removing traffic signals of approximately £11k a year, as shown in Figure 5.5. This is on a smaller scale than the benefits at some of the other junctions. There would be a slight disbenefit from removing traffic signals during the morning peak.

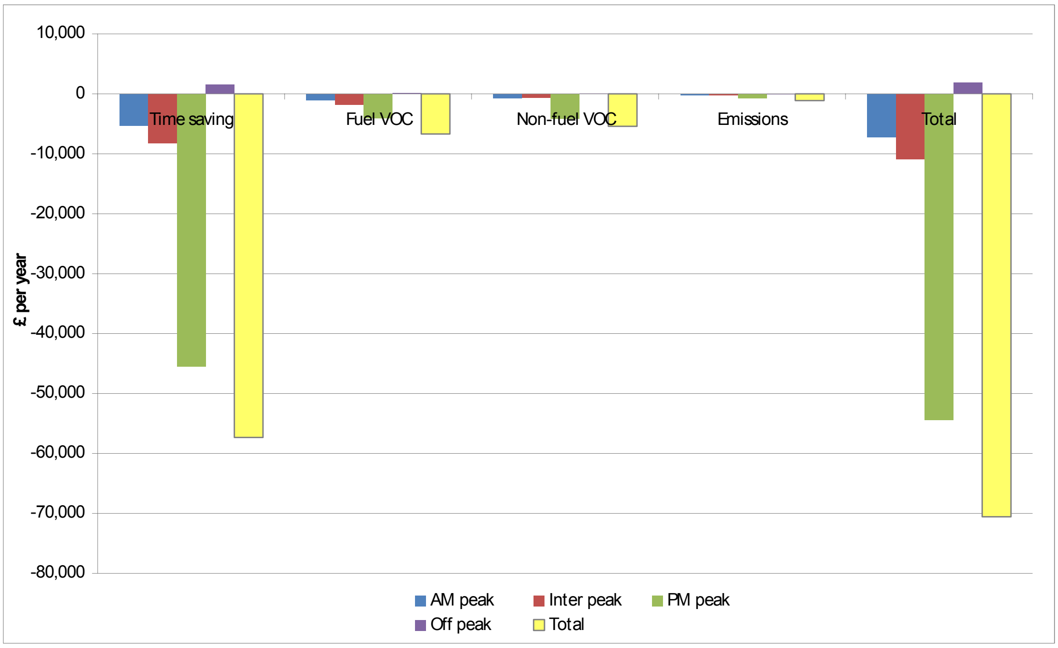
5.3.7 Overall the results show that there are differences between individual junctions. For instance, the junctions at Edgware Road and A13 River Road indicate that there would be a disbenefit from removing traffic signals in the morning and evening peak, but a benefit from doing so during the inter-peak. The East Barnet junction appears to benefit from removal of traffic signals at all times of day. One consistency is that all junctions benefit from the removal of traffic signals during the off-peak, when flows are typically lower.

5.3.8 As tends to be the case in transport economic appraisals, the results are driven by the time savings, while the weighting given to the vehicle operating costs and emissions is comparatively smaller.

5.3.9 The junctions with the largest scale of benefit / disbenefit are Edgware Road and Target Roundabout (Church Road); consequently the results for these junctions have the largest influence when a weighted average[4] is produced, as shown in Figure 5.6.

[4] The five junction types modelled cover approximately 67% of junctions in London, but an adjustment has been made to effectively assume that they cover 100%. In other words, the results in Figure 6 act as a proxy for the average benefit / disbenefit per London junction.

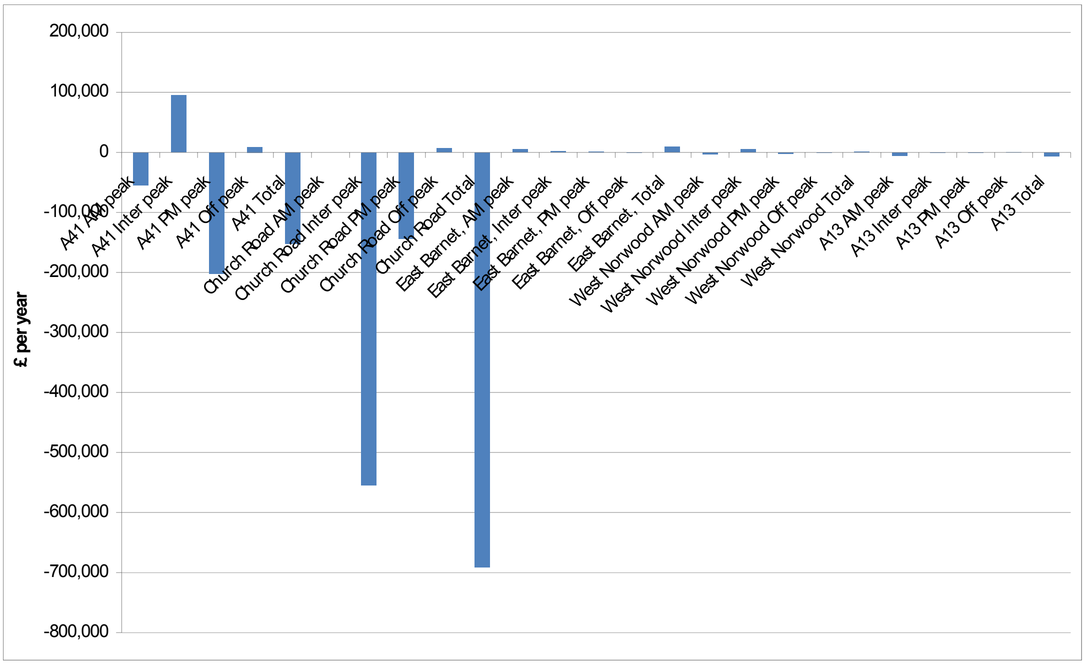
Figure 5.6: Impact of removing traffic signals, weighted average of five modelled junctions



5.3.10 The results in Figure 5.6 indicate that, on average, it would not be beneficial to remove traffic signals from junctions with the exception of the off-peak period.

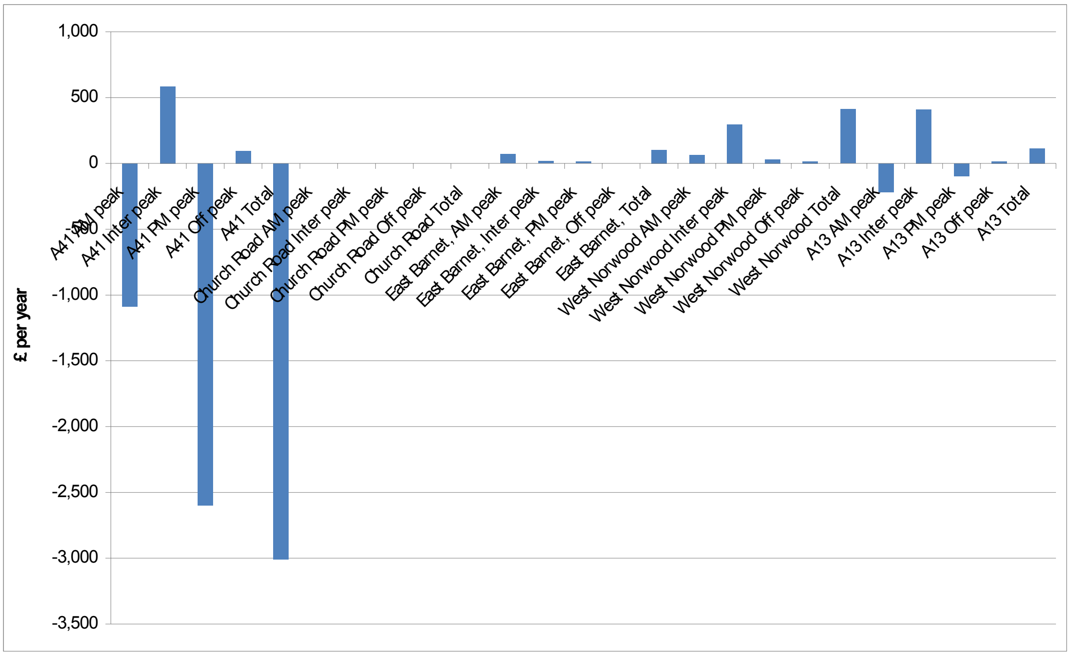
5.3.11 Other splits of results are also possible. Figure 5.7 to Figure 5.11 show results split by mode.

Figure 5.7: Impact of removing traffic signals, car



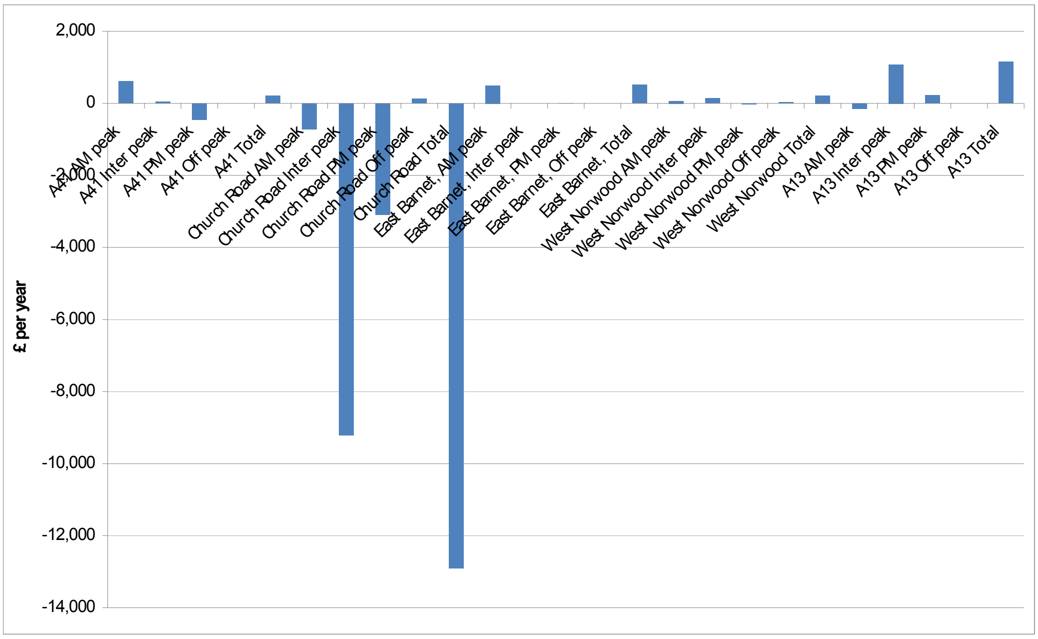
5.3.12 On the whole the disbenefits to cars of removing traffic signals outweigh the benefits. The disbenefits to cars are particularly large for Target Roundabout (Church Road); a disbenefit of approximately £690k a year which is equivalent to over 80% of the total Target Roundabout disbenefit.

Figure 5.8: Impact of removing traffic signals, LGV



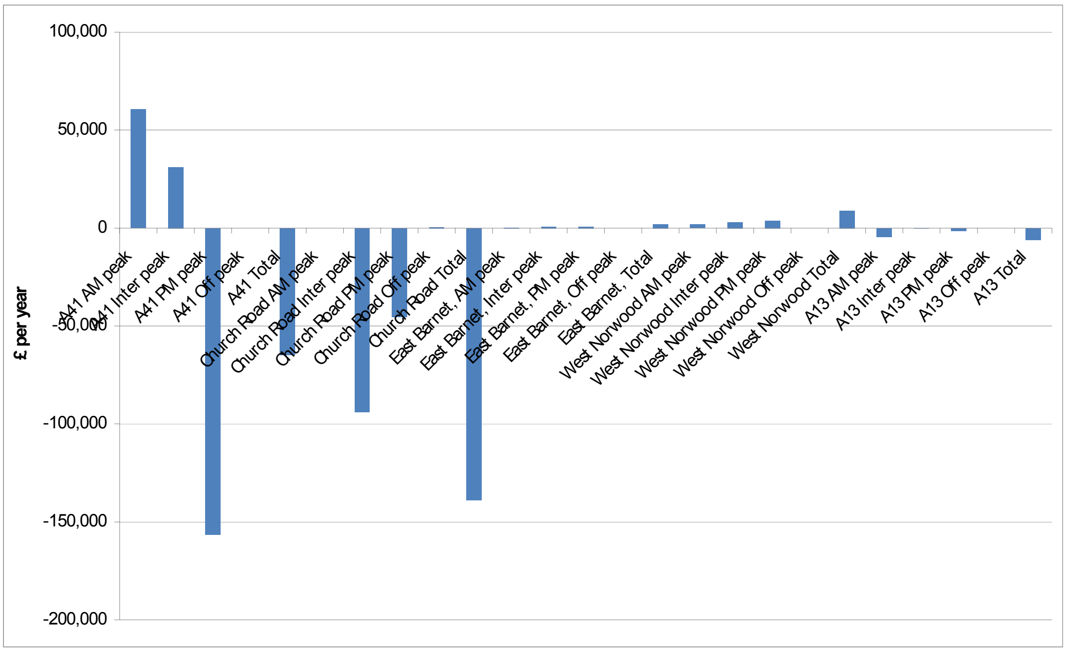
5.3.13 The impact on LGV is relatively small. The biggest impact is at the Edgware Road junction, with disbenefits from removing traffic signals in the morning and evening peak and a benefit in the inter-peak and off-peak. LGVs are not present in the Target Roundabout model.

Figure 5.9: Impact of removing traffic signals, heavy goods vehicle



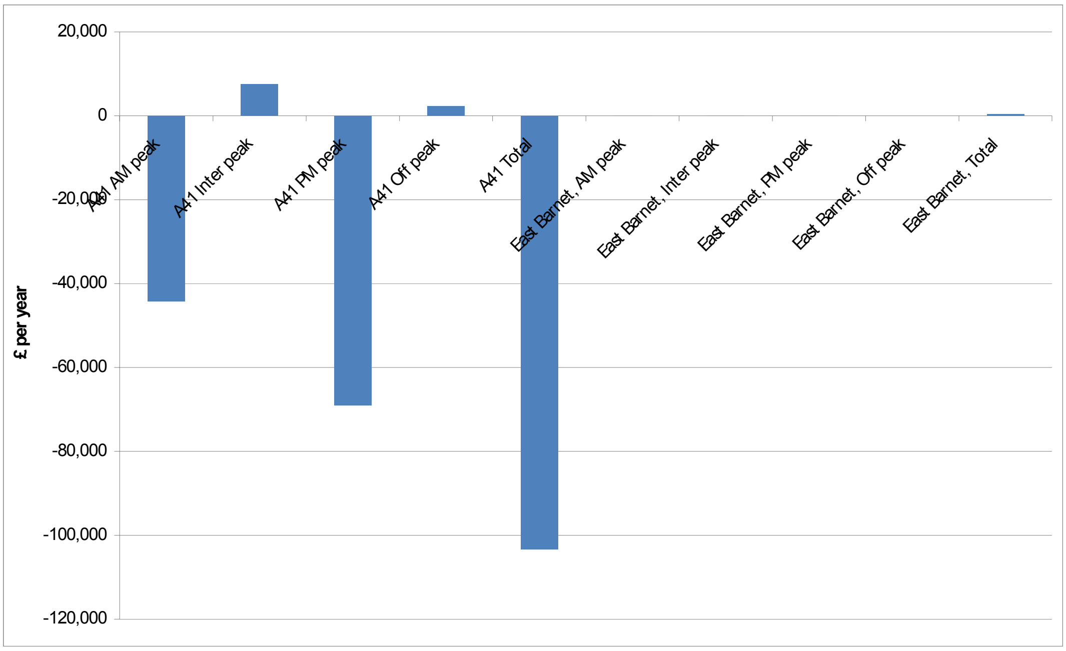
5.3.14 Heavy goods vehicles have a disbenefit from removing traffic signals during the inter-peak and evening peak at the Target Roundabout. The scale of benefits / disbenefits is small at the other junctions.

Figure 5.10: Impact of removing traffic signals, bus



5.3.15 Overall buses experience a significant disbenefit from removing traffic signals at the Edgware Road (A41) and Target Roundabout junctions, largely due to disbenefits in the evening peak.

Figure 5.11: Impact of removing traffic signals, taxi

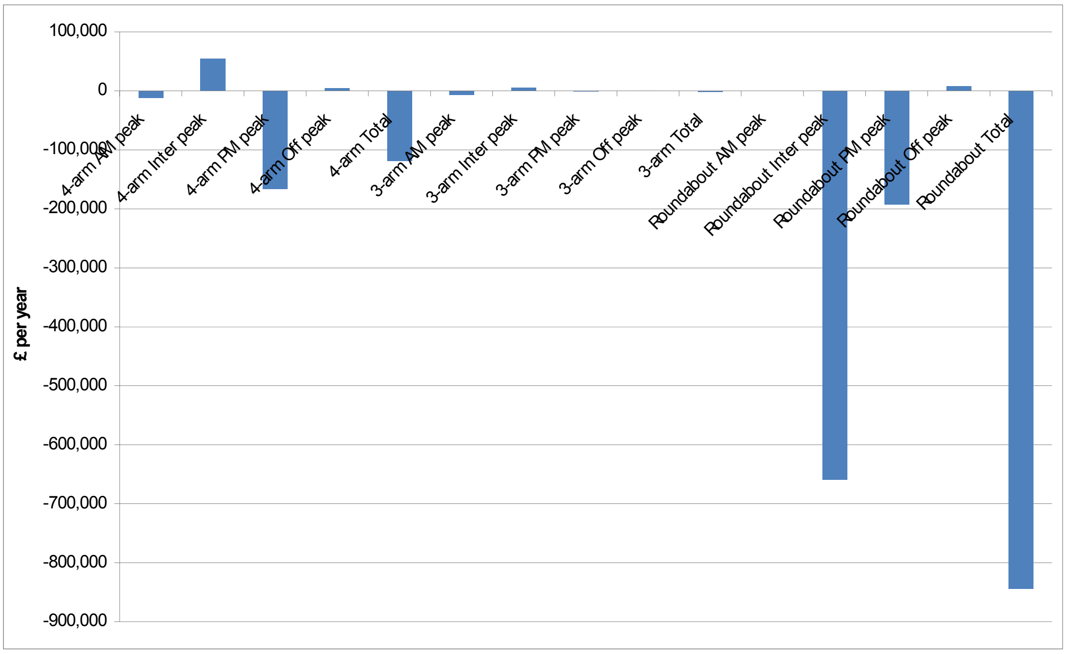


5.3.16 Taxis are only present in the Edgware Road (A41) and East Barnet models. There is a benefit to taxis from removing traffic signals at East Barnet, but this is negligible and does not show up on the chart. There is a relatively large disbenefit to taxis from removing traffic signals at the Edgware Road junction (just over £100k a year). Impacts on motorbikes and bicycles are negligible and are not shown here.

5.3.17 The main observation from the charts for individual modes is that the largest benefits / disbenefits apply to car and bus. This is unsurprising as cars form the majority of vehicle flows and bus has the highest value of time per vehicle due to its level of passenger occupancy.

5.3.18 Another split that can be shown is the benefits by junction type. In this case we have split by 4-arm junction, 3-arm junction and roundabout (a 4-arm junction but treated separately here). The 4-arm junction results are a weighted average of Edgware Road (A41) and East Barnet results; the 3-arm junction results are a weighted average of West Norwood and A13 River Road results. Only one roundabout (Target Roundabout, Church Road) has been modelled.

Figure 5.12: Impact of removing traffic signals, by junction type



5.3.19 The 4-arm and 3-arm junctions both show a disbenefit of removing traffic signals in the peak periods, with a benefit during the inter-peak and off-peak. The scale of impacts is larger for 4-arm junctions, although this may be due to other individual junction characteristics rather than a reflection of a consistent difference between 4-arm and 3-arm junctions. Target Roundabout on the other hand shows a large disbenefit in the inter-peak, as well as a disbenefit in the evening peak.

5.4 Pedestrians

5.4.1 The analysis undertaken does not take into account the benefits and disbenefits to pedestrians. This, as discussed previously, is largely due to a lack of data, but also from the lack of validated methods of forecasting and modelling pedestrian behaviour when traffic signals are not in use.

5.4.2 It is apparent from the analysis that there are disbenefits from removing traffic signals during the morning and evening peaks, and this generally coincides with periods when pedestrian numbers are also high. The inter-peak period is more complex, in parts of London both pedestrian and vehicle numbers are high during this time, but in other locations numbers are much reduced.

5.4.3 Where it has been shown that there are benefits from switching off (introducing flashing amber) traffic signals during certain periods, it is possible that these benefits would significantly reduce if pedestrian actuation of an all-red pedestrian crossing stage was introduced, resulting in additional delay to vehicles. This is more likely to be an issue at inner-London sites and could therefore negate any benefits.

5.5 Road safety

5.5.1 The economic analysis of switching off traffic signals does not account for the possibility of benefits or disbenefits arising from the impact of the proposals on road safety, more specifically personal injury accidents (PIAs).

5.5.2 There are very limited studies of the impact of removing formal control at junctions on road safety, and what data there is seems to provide mixed messages.

5.5.3 A report written for TfL in 2006 (*TRL PPR292 A Review of Simplified Streetscape Schemes)* concluded that the collision data (from a number of European schemes) did not provide a safety case for simplified streetscapes one way or the other. This did not specifically deal with part-time switching off of traffic signal control, but provides a reference to sites with before and after data for the presence of traffic signals.

5.5.4 As part of the study, accident data across London for periods when traffic signals were not in use due to a fault was examined. LRSU data showed that in three years there were around 180 PIAs (60 PIAs per annum) at sites where signal faults had occurred. For the year up to February 2009, there were over 2,700 faults. The length of time that signals were not in use varied considerably, with a modal average of 2 hours, yet a mean average of 21 hours. This gives 0.0010 PIAs per hour, or 9 PIAs per site per year if signals are always out, compared to an average of 2.4 accidents at signalised junctions in inner-London. It is difficult, however, to draw clear conclusions from the data as when signals are not working no alternative guidance in terms of priority is provided to drivers.

5.5.5 As shown below in Table 5.1, the average value of a personal injury accident on urban roads is around £91k. The potential impact on the economic benefits of considering the effect of the change in PIAs as a result of switch-off could be very significant. With junction benefits at sites during certain periods of the day valued at around £100k or less, it would only take one additional injury accident occurring at the junction per year to negate all benefits. On the other hand, any single accident saving could easily double the benefits of switch-off.

Table 5.1: Collision costs by severity and type of road (£ per accident, June 2007 prices)[5]

Type of collision	Urban roads	Rural roads	Motorways	All roads
Fatal	1,769,900	1,930,740	2,145,280	1,876,830
Serious	207,120	231,110	235,690	215,170
Slight	21,000	24,750	29,490	22,230
All injury collisions	59,240	121,420	91,930	75,610
Damage-only collisions	1,840	2,720	2,620	1,970
Average collision cost per injury collision (including an allowance for damage-only collisions)[6]	91,810	142,640	111,810	104,900

Source: Issue 12 of Levels of Collision Risk in Greater London (Feb 09)

[5] Values taken from 'Road casualties Great Britain 2007' Department for Transport September 2008
[6] Department for Transport figures from the 'in draft' Accidents Sub-objective Unit on the Transport Analysis Guidance web site (www.dft.gov.uk/webtag)

6 Conclusions and Recommendations

6.1 Conclusions

6.1.1 The economic analysis has used VISSIM model outputs to estimate the economic impact of removing traffic signals at five individual junctions in London.

6.1.2 It was assumed that if the traffic signals were to be switched-off (or flashing amber was introduced) for all or part of the day, drivers will be informed about the alternative control regime before being introduced. As such, the study assumes drivers to be informed about the new regulations and expected behaviour through regulating traffic signs, public information campaigns, training and through gradual learning and word of mouth.

6.1.3 The set of junctions selected for this study represents a wide range of junctions from both outer and inner-London. They also represent a good range of traffic and pedestrian demand throughout the day. It should also be noted that different junctions can display very different characteristics. It is fair to say that there is no such thing as an 'average' junction, so the results should be treated with caution.

6.1.4 In particular, some junctions including roundabouts are peculiar examples of signalised junctions where the delay for individual arms and that for overall traffic is highly dependent on the balance of flows and available gaps for major traffic movements. Unbalanced flows, eg in the inter-peak scenarios, can result in higher delay for all traffic but can be easily minimised by introducing demand operated traffic signals.

6.1.5 Each of the modelled junctions was used to analyse two sets of results: the existing or Base (Do Minimum) scenario and a Do Something scenario where the traffic signals were replaced with an alternate measure of control.

6.1.6 The main conclusions are as follows:

- Traffic signals generally provide significant benefits to road users;
- It would, however, be beneficial to switch-off traffic signals at some junctions at particular times of day;
- In particular, there would be a benefit at the junctions studied from switching off during the off-peak, after a full safety assessment.

6.1.7 The results do not include the net economic cost or benefits to pedestrians who are assumed to cross in gaps in the traffic or at stand alone pedestrian crossings. If delays to traffic are imposed by pedestrians calling up a pedestrian crossing stage during the period of flashing amber, this could have a significant impact on any benefits.

6.1.8 The results do not include the net economic cost or benefit due to changes in accident numbers. The studies that were carried out to attempt to value this impact were inconclusive, yet with the average cost of a personal injury accident at over £90k, an increase or decrease in accident levels could have a significant impact on the results.

6.2 Recommendations

6.2.1 This study has identified substantial economic benefits to road users from having traffic signals and this benefit needs to be more widely promulgated.

6.2.2 The study has also demonstrated that for certain junctions at certain periods of the day there would, based on the assumptions made regarding traffic and pedestrian behaviour, be some benefit to switching off traffic signals (or introducing flashing amber). It is evident, however, that this is site-sensitive and can only be used as a broad guide to the type of sites that might deliver such a benefit.

6.2.3 It is recommended that consideration is given to a pilot of switching off traffic signals at junctions at times when the level of traffic does not justify such controls subject to a safety audit. There is present DfT guidance as to the level of daily traffic that justifies particular types of traffic control. Based on this guidance it is possible to determine the hourly level of traffic below which formal control is not necessarily appropriate and therefore junctions which could be piloted. (The actual traffic numbers depend on the flows on each arm of the junction so is not a single number.)

6.2.4 In the UK legislation does not allow for the use of switching all signals at a junction to flashing amber at less busy times, a measure which is commonplace in a number of European countries. We recommend discussions should take place with the appropriate European traffic authorities to obtain evidence and ascertain their views on the impact that such traffic control methods have on safety, vehicle and pedestrian movement.

6.2.5 The study assumes that when traffic signal control is disabled, traffic behaviour would revert to some form of conventional priority control, which might even be stipulated through analysis of traffic demand and turning patterns and the use of advance signing. It is possible, however, that junctions could operate without any imposition of regulated traffic controls, with the expectation that road users would behave appropriately. This form of behaviour cannot, at present, be modelled – yet it is recommended that scope for this form of uncontrolled arrangement is also investigated. This can only be achieved through live trials at a variety of sites. The results would have the potential of determining precisely how traffic would behave at ‘shared space’ type environments and could provide unparalleled knowledge in this field. Such work would also need to monitor the behaviour of pedestrians.

Appendix – Assumptions used for economic analysis

Journey purpose splits

Car (source: WebTAG)

	IWT	Commute	Leisure
Morning peak	18.1%	46.0%	35.9%
Inter-peak	19.9%	11.4%	68.7%
Evening peak	13.0%	40.8%	46.2%
Off-peak	12.3%	36.2%	51.5%

LGV (source: WebTAG – does not distinguish by time period – and only splits between IWT and ‘other’, so assume the 12% other is allocated evenly to commute and leisure)

	IWT	Commute	Leisure
Morning peak	88.0%	6.0%	6.0%
Inter-peak	88.0%	6.0%	6.0%
Evening peak	88.0%	6.0%	6.0%
Off-peak	88.0%	6.0%	6.0%

HGV (source: WebTAG – assumes 100% work for all time period)

	IWT	Commute	Leisure
Morning peak	100.0%	0.0%	0.0%
Inter-peak	100.0%	0.0%	0.0%
Evening peak	100.0%	0.0%	0.0%
Off-peak	100.0%	0.0%	0.0%

Bus (source: LATS)

	IWT	Commute	Leisure
Morning peak	4.1%	31.5%	64.4%
Inter-peak	2.7%	7.7%	89.6%
Evening peak	4.4%	33.6%	62.0%
Off-peak	4.8%	36.6%	58.6%

Taxi (source: LATS)

	IWT	Commute	Leisure
Morning peak	16.9%	24.2%	58.9%
Inter-peak	15.7%	9.7%	74.6%
Evening peak	9.7%	16.7%	73.5%
Off-peak	4.5%	12.7%	82.8%

Motorcycle (source: LATS)

	IWT	Commute	Leisure
Morning peak	15.11%	70.14%	14.75%
Inter-peak	19.44%	33.33%	47.22%
Evening peak	10.83%	66.79%	22.38%
Off-peak	13.08%	51.48%	35.44%

Bicycle (source: LATS)

	IWT	Commute	Leisure
Morning peak	11.37%	57.42%	31.21%
Inter-peak	8.17%	19.52%	72.30%
Evening peak	7.09%	39.71%	53.21%
Off-peak	8.32%	39.87%	51.81%

Vehicle occupancies

Mode	Occupancy	Source
Car	Morning peak: IWT: 1.23 Commute: 1.16 Leisure: 1.71 Inter-peak: IWT: 1.19 Commute: 1.15 Leisure: 1.78 Evening peak: IWT: 1.17 Commute: 1.13 Leisure: 1.82 Off-peak: IWT: 1.18 Commute: 1.13 Leisure: 1.77	WebTAG
LGV	IWT: 1.20 Commute: 1.46 Leisure: 1.46	WebTAG. Weekday average value is used – a split by time period is not available
HGV	IWT: 1.00 Commute: 1.00 Leisure: 1.00	WebTAG. Value of 1.00 at all times is assumed.
Bus	Morning peak: IWT: 25.1 Commute: 25.1 Leisure: 25.1 Inter-peak: IWT: 11.9 Commute: 11.9 Leisure: 11.9 Evening peak: IWT: 25.1 Commute: 25.1 Leisure: 25.1 Off-peak: IWT: 8.0 Commute: 8.0 Leisure: 8.0	TfL's 'Travel in London – key trends and developments: Report number 1' indicates that the all-day average occupancy (not split by journey purpose) is currently 15.9 passengers per bus. A manual adjustment is then made, assuming that the inter-peak and off-peak occupancies are 25% and 50% lower than the average respectively. It then turns out that, to ensure that our all-day average matches the 15.9 above, the morning and evening peak occupancy is just under 60% higher than average.
Taxi	IWT: 1.625 Commute: 1.625 Leisure: 1.625	LATS – overall average, could split by time period & purpose
Motorbike / Bicycle	1 at all times	

N.B. All Values Include The Vehicle Driver

Annualisation factors

Derived by taking hourly flows at each site and scaling up the model results accordingly (eg to derive the annualisation factor for the morning peak hour, take the ratio between the total flow for 7:00 – 10:00 and the flow for the peak hour (8:00 – 9:00) and multiply by 253 (the number of weekdays in a year).

	Morning peak hour (8:00 – 9:00) to morning peak period (7:00 – 10:00)	Inter-peak hour (12:00 – 13:00) to inter-peak period (10:00 – 16:00)	Evening peak hour (17:00 – 18:00) to evening peak period (16:00 – 19:00)	3 modelled off-peak hours (22:00 – 1:00) to full off-peak period (19:00 – 7:00
A41	814	1,600	716	910
New Barnet	676	1,543	733	1,162
West Norwood	763	1,559	750	1,347
A13	678	1,520	735	850
Church Road	731	1,585	754	800

Value of time

2002 values of time per person all taken from WebTAG, with the WebTAG growth rate applied to obtain 2009 values. The journey purpose splits and vehicle occupancy rates above are then applied to obtain the values of time per vehicle as shown in the table below:

	Morning peak	Inter-peak	Evening peak	Off-peak
Car	12.69	13.89	11.38	11.22
LGV	13.70	13.70	13.70	13.70
HGV	12.07	12.07	12.07	12.07
Bus	165.22	79.60	166.90	61.81
Taxi	19.93	19.53	17.76	16.17
Motorbike	9.09	9.85	8.07	8.49
Bicycle	7.20	6.47	6.44	6.63

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Greek

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Turkish

Bu belgenin kendi dilinizde hazırlanmış bir nüshasını edinmek için, lütfen aşağıdaki telefon numarasını arayınız veya adrese başvurunuz.

Punjabi

ਜੇ ਤੁਹਾਨੂੰ ਇਸ ਦਸਤਾਵੇਜ਼ ਦੀ ਕਾਪੀ ਤੁਹਾਡੀ ਆਪਣੀ ਭਾਸ਼ਾ ਵਿਚ ਚਾਹੀਦੀ ਹੈ, ਤਾਂ ਹੇਠ ਲਿਖੇ ਨੰਬਰ 'ਤੇ ਫ਼ੋਨ ਕਰੋ ਜਾਂ ਹੇਠ ਲਿਖੇ ਪਤੇ 'ਤੇ ਰਾਬਤਾ ਕਰੋ:

Hindi

यदि आप इस दस्तावेज की प्रति अपनी भाषा में चाहते हैं, तो कृपया निम्नलिखित नंबर पर फोन करें अथवा नीचे दिये गये पते पर संपर्क करें

Bengali

আপনি যদি আপনার ভাষায় এই দলিলের প্রতিলিপি (কপি) চান, তা হলে নীচের ফোন্ নম্বরে বা ঠিকানায় অনুগ্রহ করে যোগাযোগ করুন।

Urdu

اگر آپ اِس دستاویز کی نقل اپنی زبان میں چاهتے هیں، تو براہ کرم نیچے دئے گئے نمبر پر فون کریں یا دیئے گئے پتے پر رابطه کریں

Arabic

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