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HIGHWAYS AGENCY

M25 DBFO LUS

Managed Motorways

Stage 3 – Preliminary Design

MM2 Economic Appraisal Report – Section 5

Version: 3.0

Document No: 5084755-S5-DO-TR-209 Rev B

09 August 2012

POSITIVE ABOUT DISABLED PEOPLE

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An Executive Agency of the Department for Transport

M25 DBFO LUS **Managed Motorways - Stage 3 – Preliminary Design**

Product Sign Off Sheet

Product Title	MM2 Economic Appraisal Report – Section 5	
	Document No: 5084755-S5-DO-TR-209 Rev B	Version: 3.0
Produced By (who is the author of the document)	Name	Role
	[redacted]	Senior Transport Planner / Senior Managing Consultant (Atkins Highways & Transportation)
Document Status	Final	

Consulted With

Name	Role	Date Consulted	Signature*

Comments

(Comments from HA)

Approval

As the individual accountable for this product sign off to confirm that:
The product has been produced and is PCF compliant (e.g. in line with the product description)
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This document has 48 pages including the cover.

Document history

Job number: 5084755			**Document ref: 5084755-S2-DO-TR-209 RevB**			
Version	Purpose description	Originated	Checked	Reviewed	Authorised	Date
1.0	Draft for Comment	[redacted]	[redacted]	[redacted]	[redacted]	16/12/11
2.0	Reflecting Change to MM-ALR scheme	[redacted]	[redacted]	[redacted]	[redacted]	20/07/12
3.0	Reflecting new noise disbenefit and HA comments	[redacted]	[redacted]	[redacted]	[redacted]	09/08/12

Client signoff

Client	
Project	
Document title	
Job no.	
Copy no.	
Document reference	

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1. Introduction

1.1 Introduction to the Project

The Skanska - Balfour Beatty Joint Venture has commissioned Atkins to develop traffic forecasts and associated appraisal material for two Managed Motorway Schemes on the M25 between:

- Junctions 5 and 7 to the South of London (M25 Section 2), and;
- Junctions 23 and 27, to the North of London (M25 Section 5).

The proposed Managed Motorway – All Lane Running (MM-ALR) schemes entail permanent use of the hard shoulder and full managed motorway control technology including MIDAS incident detection technology and variable message signs capable of controlling traffic flows through the use of variable mandatory speed limits.

The appraisal reported herein relates solely to **M25 Section 5 (Junctions 23-27)** and has been undertaken at Stage 3 of the Highways Agency (HA) Project Control Framework (PCF).

The forecasting model is a variant of that developed by the Halcrow Hyder Joint Venture (HHJV) and used at PCF Stage 2 for the assessment of the M25 Section 5 Managed Motorway Scheme. The latest variant of that model has been revalidated by Atkins and documented in *B602 M25 Assignment Model Local Model Validation Report*[1]. The assignment model is linked to a demand model – the M25DM – which has been recalibrated by AECOM to reflect changes in the assignment model and updated to use April 2011 economic parameters and growth assumptions. The model development and subsequent use in scheme appraisal has been undertaken to the standards documented in the DfT's WebTAG guidance and HA Standards.

1.2 Purpose of the Economic Appraisal Report

The Economic Appraisal Report is a requirement in the PCF – termed a 'PCF Product'. This report contains the economic appraisal and is used to assess the scheme with regard to meeting the following five sub-objectives:

- to get good value for money in relation to impacts on public accounts;
- to improve transport economic efficiency for business users and transport providers;
- to improve transport economic efficiency for consumer users;
- to improve reliability; and
- to provide beneficial wider economic impacts.

One of the safety sub-objectives – accident reduction - also forms part of the economic appraisal.

All elements of the economic appraisal process are reliant on future year forecasts of highway travel demand and cost from the transport models. The traffic forecasts used are detailed in the M25 Section 5 Traffic Forecasting Report[2].

The calculations of noise and greenhouse gas emissions are documented in the appropriate environmental reports, but their monetisation is recorded in this report as part of chapter 8.

Analyses of the social and distributional impacts (SDI), which include economic impacts, are documented in the SDI Report.

[1] Document Reference 5084755-ALL-DO-TR-164 Rev C of 11/05/2012.
[2] *Traffic Forecasting Report – Section 5*. Document Reference 5084755-S2-DO-TR-204 Rev B of 16/07/12.

1.3 Structure of the Report

This Economic Appraisal Report presents the methodology and assumptions adopted for the economic appraisal, and the consequent appraisal results. Following this introduction, the remainder of the report is structured as follows:

- Chapter 2 : describes the background to the project;
- Chapter 3 : describes the general methodology and assumptions underpinning the economic appraisal;
- Chapter 4 : presents the assessment of transport economic efficiency (using TUBA);
- Chapter 5 : presents accident benefit assessment (using COBA);
- Chapter 6 : presents the impact of delays during construction and future maintenance (using QUADRO);
- Chapter 7 : presents impacts on journey time reliability due to incidents and day to day variability (using INCA);
- Chapter 8 : presents the results of the monetisation of other scheme impacts – namely air quality and noise impacts; and
- Chapter 9 : provides a summary and conclusion.

2. M25 DBFO LUS Project

2.1 Background

The London Orbital Multi-Modal Study (ORBIT MMS) was commissioned by the Government Office for the South East in Spring 2000 to examine the problems of congestion on the strategic road network, seek solutions from all modes of transport and develop a long-term sustainable management strategy for the M25.

On 9th July 2003, the Secretary of State responded to the ORBIT MMS by accepting the recommendation to widen the M25 to four lanes in each direction in a number of places. Following on from the Secretary of State's announcement that further development on M25 widening schemes should be undertaken by the Highways Agency (HA), a scheme to widen the M25 was added to the Targeted Programme of Improvements (TPI) on 13th April 2004. This scheme involved widening 107km of the remaining three-lane sections of the M25 to four lanes. Section 2 (J5 – J7) and Section 5 (J23 – 27) were the last sections to be upgraded and are known as the M25 DBFO Later Upgraded Sections (M25 DBFO LUS).

Sections 2 and 5 have since been subjected to further review following the publication of the Advanced Motorway Signalling and Traffic Management Feasibility Study in March 2008, which concluded that Dynamic Hard Shoulder Running (DHSR) could provide a large proportion of the benefits of widening at significantly lower cost. In essence the dynamic use of the Hard Shoulder under Managed Motorway conditions would permit an increase in capacity on motorways at those times it is needed most, without the large expenditure of adding another lane to the carriageway. This means that when traffic flow exceeds a threshold which is currently 1,500 vehicles per hour per lane or 4,500 vph for a Dual 3 Lane Motorway (D3M) section, provided the hard shoulder is clear of any obstructions it will be opened to general traffic.

The above report resulted in the Department for Transport's command paper 'Roads – Delivering Choice and Reliability' July 2008, following which the Department for Transport initiated a nationwide study into whether the application of DHS schemes could provide a workable and more cost effective solution than motorway widening. Consequently, Sections 2 and 5 were considered for DHSR and, following a Stage 1 study for each Section, in January 2009 the Secretary of State announced a proposal to take forward Sections 2 and 5 as Dynamic Hard Shoulder Running schemes.

Following the Government's Comprehensive Spending Review (CSR) in October 2010, it was announced that both the M25 Section 2 from J5 to J7 and Section 5 from J25 to J27 DHSR schemes would be progressed by the HA, subject to statutory processes.

Subsequently, all new managed motorway schemes have been migrated from the DHSR proposals to a permanent equivalent known as Managed Motorways – All Lane Running (MM-ALR). As the MM-ALR does not involve switching 'on' and 'off' and so does not require as much driver information and operational/safety checks ahead of switches, costs can be saved in terms of both technology installation and motorway operations. M25 Sections 2 and 5 are two such schemes.

The project is currently in 'Stage 3: Preliminary Design' of 'Phase 2: Development' within the PCF. Although current work is being undertaken for Stage 3, it is not envisaged that further changes to the forecasting or appraisal methodologies will be made. The proposals documented herein are therefore intended to remain suitable through to PCF Stage 5.

Alongside the Budget announcement on the 21st March 2012, the Government confirmed that these schemes are included in the roads programme as Managed Motorway schemes with prioritised start of works in financial year 2013/14.

2.2 Scheme Description

An assessment of the improvements needed to deliver safe operation of MM-ALR, including through junction running where justified, will provide the core element of the proposed scheme. MM-ALR makes use of the existing hard shoulder to provide additional lane capacity on a permanent basis. This is achieved by providing gantry mounted signals, variable message signs and Emergency Refuge Areas (ERA).

The scheme involves MM-ALR operation in both directions between the existing D3M section though Junction 23 and the existing D3M section through Junction 25. East of the Holmesdale Tunnel there is a 500m section of D4M widening in both directions, with MM-ALR operation between here and a point 500m west of Bell Common Tunnel in both directions, with the exception of the existing D4M climbing lane arrangements east of Junction 26, to which there is no change. From 500m west of Bell Common Tunnel to 500m east of Bell Common Tunnel D4M widening is proposed in both directions. From there to Junction 27 a short length of MM-ALR operation is proposed in both directions

The following two figures show the existing and the proposed carriageway layouts for Section 5.

Figure 1. Existing Section 5 Carriageway Layout

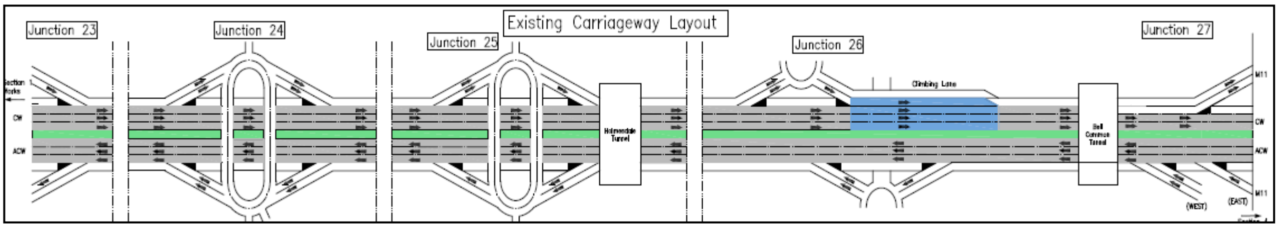
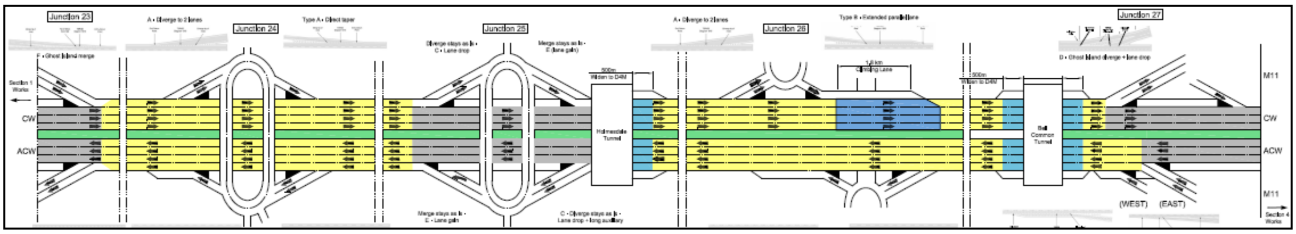


Figure 2. Proposed Section 5 Scheme Layout



3. Approach to Economic Evaluation

3.1 Overview

The appraisal of highway schemes is required to take account of multi-modal aspects, such that all transport projects are evaluated within a consistent framework. This appraisal framework is set out in the Department for Transport's (DfT) Transport Analysis Guidance (TAG) website, WebTAG[3,4]

The WebTAG approach embodies five objectives against which schemes are to be assessed:

- Environment;
- Safety;
- Economy;
- Accessibility; and
- Integration.

This Economic Appraisal Report is primarily concerned with the 'Economy' objective, which again comprises of five sub-objectives:

- to get good value for money in relation to impacts on **public accounts**;
- to improve transport economic efficiency for **business users and transport providers**;
- to improve **transport economic efficiency for consumer users**;
- to improve **reliability**; and
- to provide beneficial **wider economic impacts**.

One of the safety sub-objectives – accident reduction - also forms part of the economic assessment.

3.2 Estimation of Costs and Benefits

Appraising against the Economy objective involves analysis of costs and benefits, where benefits of a scheme are balanced against its costs; and the calculation of the costs includes an assessment of the impacts of a scheme on all types of road users; with a monetary value applied to these impacts.

Any network changes that affect the generalised cost of travel will in consequence also affect the demand for a particular mode. In the past highway improvement schemes were primarily assessed by estimating the benefits on the basis of a fixed level of traffic on the network. This method does not allow the effect of "induced" (or "suppressed") traffic to be analysed in the economic analysis. Since the introduction of WebTAG unit 3.10, all major schemes funded through central government need to consider the effects of variable demand, thereby explicitly considering trip "suppression" and "induced" trips.

To comply with WebTAG, a bespoke variable demand model, the M25 Demand Model (M25DM)[5] was developed to estimate the behavioural response due to the proposed improvement. The purpose of variable demand modelling is to estimate the extent of trip suppression in the 'without scheme' case and 'induced trips' in the 'with scheme' case. The main objectives of the M25 DM are to provide:

- forecasts of changes in traffic over time, as a result of changes in land-use, economic growth, travel costs and committed transport supply changes;
- forecasts of the demand responses of highway traffic and public transport trips to changes to the transport system; and,
- forecasts that are the result of convergence between demand and supply models.

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[3] http://www.dft.gov.uk/webtag/

[4] Unless otherwise stated the version used throughout is that published April 2011, which remains the definitive guidance at the time of writing.

[5] The model development is documented in *M25 Demand Model Development and Validation Report – September 2009, AECOM* with further updates relevant to this economic appraisal documented in *Technical Note - M25DM Update July 2010, AECOM* and *Technical Note - M25DM Update July 2011, AECOM*.

The transport economic efficiency (TEE) and public accounts sub-objectives involve a cost-benefit analysis of the M25 MM-ALR scheme based on variable demand modelling.

To estimate the costs and benefits of a transport scheme a number of models are generally used:

- Transport Economic Efficiency (TEE) benefits (savings relating to travel times, vehicle operating costs and user charges) experienced by transport users are estimated using **T**ransport **U**sers **B**enefit **A**ppraisal (TUBA) software taking input from the traffic assignment model, namely the M25AM documented elsewhere[1,2];
- Accident costs and savings associated with Personal Injury Accidents (PIA) are estimated using **Co**st **B**enefit **A**nalysis (COBA) software;
- Costs to users due to the delay experienced during the scheme construction and future maintenance are estimated using **Qu**eues **A**nd **D**elays at **Ro**adworks (QUADRO) software; and
- Reliability benefits associated with reduced congestion and improvement in day to day journey time variability and delay during incidents, are assessed using **In**cident **C**ost-benefit **A**nalysis (INCA) software.

The results from the different elements of the economic assessment are presented in a TEE Table which consists of three parts, to reflect transport efficiency benefits, public accounts, and an overall analysis of monetised costs and benefits. The following key economic statistics are used to demonstrate the economic case for the scheme improvements:

- The Present Value of Benefits (PVB) represents the total monetised benefits from the scheme, discounted to 2002 prices and values. As of April 2011, this includes the impact of the scheme on central government indirect tax revenues;
- The Present Value of Costs (PVC) represents the total scheme investment, maintenance and operating costs, and is also discounted to 2002 prices and values;
- The Net Present Value (NPV) represents the absolute difference between the PVB and PVC; and
- The Benefit-Cost Ratio (BCR) is the ratio of PVB to PVC and represents a measure of the overall value for money of the scheme[6].

The remaining sub-objective of Wider Economic Impact is separately addressed under 'Regeneration Impacts' in Chapter 8, alongside the monetised values of greenhouse gas emissions and noise impacts of the scheme.

This analysis is intended to complete all the information required for direct translation to the Appraisal Summary Table (AST) for the scheme under the Economy objective.

[6] Note that the BCR is now calculated using PVB and PVC as outlined above. Until recently this was referred to as 'BKR' to distinguish it from the previous official definition of BCR, which was calculated by applying indirect tax revenues as a negative cost rather than as a positive benefit.

4. Transport Economic Efficiency Analysis (TUBA)

4.1 TUBA Overview

TUBA software has been used to estimate the Transport Economic Efficiency (TEE) benefits. This includes estimation of benefits relating to travel times, vehicle operating costs, any user charges and private sector revenues, all of which contribute to the Present Value of Benefits (PVB) for the scheme proposals, as presented in the TEE table.

TUBA also calculates the Present Value of Costs (PVC), based on the scheme investment data, and balanced by any indirect tax revenues to central government. These costs are presented in the form of the Public Accounts (PA) table.

The TEE benefits and Public Accounts information are combined along with other monetised costs and benefits to produce an overall value for money assessment, as presented in the Analysis of Monetised Costs and Benefits (AMCB) table. In this particular instance, greenhouse gas emissions have been calculated outside the TUBA appraisal and are reported in chapter 8; hence TUBA greenhouse gas emissions are not shown in the results below.

TUBA is an industry standard software package, recommended by DfT for the appraisal of highway and public transport schemes. It is of particular use where variable demand responses have been included in the transport modelling, as TUBA is based on the 'rule of half[7]', which allows for changes in demand between the 'Do-Minimum' and 'Do-Something' scenarios.

4.2 Traffic Model Input to TUBA

4.2.1 Traffic Model

The M25 Section 5 Traffic Forecasting Report2 describes the traffic forecasts for the M25 Section 5 MM-ALR Scheme prepared for the Do Minimum and Do Something scheme scenarios for all modelled time periods and all model years. These forecasts adopt April 2011 guidance, which remains current at the time of writing. The most recent Road Traffic Forecasts 2011 (RTF11) from the National Transport Model have been used for the background growth of commercial vehicles (unlike the main forecasts for M25 Section 2 which were undertaken marginally earlier and used RTF09 forecasts of background commercial vehicle growth).

It is noted that while the flow validation of the base traffic model was deemed acceptable, journey time validation did not meet all guidance criteria. Instead, the base traffic model representation had M25 speeds that were faster than those observed. However, in the context of economic appraisal this shortcoming should yield conservative estimates of the scheme benefits, as lower levels of congestion will result in the scheme providing lower levels of congestion relief. Consequently the economic appraisal remains robust.

[7] The rule of a half calculates the change in consumer surplus between the cases 'with' and 'without' the scheme. In turn, the consumer surplus is the difference between the costs that travellers are prepared to pay for their journey and what they actually do pay. If the demand can be assumed to vary linearly with cost, between the cases 'with' and 'without' the scheme, then the rule of a half benefits may be calculated as:

$$ROH = \sum_{ij} \frac{(T_{ij}^0 + T_{ij}^1)}{2} * (c_{ij}^0 - c_{ij}^1)$$

Where T_{ij}^0 is the number of trips between origin *i* and destination *j* in the Do-Minimum case, "1" denotes the Do-Something case and *c* represents total perceived costs for the trip (i.e. time and money costs)

The modelled years are as follows:

- Base Model Year 2004;
- Opening Year 2015;
- Design Year 2030; and
- Further forecast year 2040.

The modelled time periods are as follows:

- Weekday Morning or AM Peak Hour (0800 – 0900);
- Weekday Average Inter-peak Hour (average hour between 1000 – 1600); and
- Weekday Evening or PM Peak Hour (1700 – 1800).

Based on the weekday and weekend tidality observed on M25 S5, 0600 – 1500 in the weekend was considered similar to the weekday AM peak period. A weekend-AM appraisal period was therefore defined for these hours, taking forecasts of traffic flow, journey times and distances from the equivalent weekday AM peak hour model. Similarly a weekend-PM peak appraisal period was defined, covering 1500 – 2000, using model outputs from the equivalent weekday PM peak hour model. Note that no weekend models were developed – with weekday peak hour models used to provide appraisal data, duly adjusted to reflect actual flows during the weekend periods as well as vehicle composition and journey purposes. These adjustments are explained in the appropriate sections below.

4.2.2 User Classes

All combinations of scheme and development scenarios have been modelled using trip matrices that are disaggregated into five user classes: Cars on business trips, Cars being used for commuting trips to/from work, Cars being used for other purposes (e.g. leisure trips), Light Goods Vehicles and Heavy Goods Vehicles.

TUBA requires more user classes as different types of vehicle and/or journey purpose have different values of time and vehicle operating costs. Accordingly seven user classes have been used for the economic assessment. The following table shows the relationship between the forecasting and appraisal sets of user classes. The percentage 'splits' for light goods vehicles (LGVs) are taken from WebTAG[8] and the percentage 'splits' for heavy goods vehicles (HGVs) are taken from national statistics for motorway traffic[9].

Table 1. User Classes Used in TUBA Analysis (Weekday Models)

TUBA User Class	Equivalent M25AM User Class	TUBA UC as % of SATURN UC
User Class 1: Car Business	User Class 1: Car Business	100%
User Class 2: Car Commuting	User Class 2: Car Commuting	100%
User Class 3: Car Other	User Class 3: Car Other	100%
User Class 4: LGV Personal	User Class 4: LGV	12%
User Class 5: LGV Freight	User Class 4: LGV	88%
User Class 6: OGV1	User Class 5: HGV	31%
User Class 7: OGV2	User Class 5: HGV	69%

For the aforementioned weekend-AM and weekend-PM appraisal periods the user class proportions were adjusted to reflect observations and national average statistics for motorways at weekends. This involved the weekday demand matrices being globally factored such that they yielded the following weekend traffic mix.

8 WebTAG 3.5.6 – Table 8 – Proportion of Trips Made in Work and Non-work Time.
9 Transport Statistics Great Britain 2010, Table TRA9904.

Table 2. Percentage Split for Weekend Traffic

User Class	Description	% Split
UC1	Car Business	1.2%
UC2	Car Commuting	6.6%
UC3	Car Other	64.6%
UC4	Light Vehicles	7.9%
UC5	Heavy Vehicles	19.7%
Total		100.0%

4.3 Economic Parameters

TUBA provides a complete set of default economic parameters in its 'Standard Economics File'. The default economic parameters have been used as the basis for the assessment. These parameters are based on DfT guidance as set out in Unit 3.5.6 of WebTAG (April 2011), and include data on the following:

- Values of time and value of time growth;
- Fuel costs, rates of fuel consumption and changes in vehicle efficiency over time;
- Vehicle occupancies;
- Journey purpose splits;
- Rates of taxation; and
- Carbon equivalence values for assessing the impact of the scheme on greenhouse gas emissions.

All monetised costs and benefits are presented in terms of **present values**. All current economic assessments are presented for a present value year of 2002, meaning the assessment assumes that all costs are benefits are assessed as if they would occur in 2002; this addresses the problems associated with schemes being implemented in different years and recognises that schemes that are completed sooner are more preferable to those that would be completed at some more distant date.

Discounting is the technique of converting future costs and benefits to a common present value. The DfT's current standard rate of discount has been applied to scheme costs and benefits for this appraisal. The current guidance defines the following discount rates:

- 3.5% for the first thirty years of the appraisal period;
- 3% for years 30-75 of the appraisal period; and
- 2.5% for years 76 - 80.

The standard appraisal period for a scheme of this nature is sixty years, so only the first two discount rates apply for this assessment.

4.4 Scheme Specific Parameters

4.4.1 Parameters

The Scheme parameters are largely determined by the parameters used in the forecasting models. The parameters that have been used for the TUBA analysis are:

- First Year – Scheme opening year (2015);
- Horizon Year – 60-year appraisal period (2074);
- Modelled Years – Scheme opening year (2015), design year (2030) and further forecast year (2040); and
- Current year – Year TUBA run is carried out (2012). Discount rates in between present value year and current year are the same as in the current year.

4.4.2 Time Periods

The time periods used in the TUBA analysis are shown in the following table.

Table 3. Time Periods Used in TUBA

Time Period	Description	Period Coverage
1	AM Peak	0600 - 1000
2	PM Peak	1600 – 2000
3	Inter-peak	1000 – 1600
4	Weekend-AM	0600 - 1500
5	Weekend-PM	1500 – 2000

In the absence of off-peak hour models, TUBA analyses have not been carried out for these time periods. Considering the lower traffic flows during the period 2000 – 0600 hours, it is expected that any scheme benefits during this period will be small.

4.4.3 Annualisation Factors

The benefits from each time period calculated by TUBA are converted into an estimate of annual benefits using annualisation factors. These factors were derived to allow the modelled benefits to be expanded to represent a full year.

A conservative approach was taken in calculating the benefits the MM-ALR scheme will bring. It was assumed that the hours with higher flow, taken as 4500 veh/hr or more for consistency with earlier Managed Motorways analyses, will accrue the benefits of having an additional lane in the form of the hard shoulder. Conversely, no benefits are assumed to accrue at times when the traffic forecasts predict fewer than 4500 veh/hr.

The observed traffic flow for J23 to J27 was collated for the year 2010 using long term observed traffic data, obtained from HA's **TRA**ffic Information **D**ata-ba**S**e (TRADS). The observed weekday daytime profile was then factored using forecasts from the AM peak, inter-peak or PM-peak models (as appropriate) to yield forecast annual average weekday flows for each of the 14 daytime hours for each forecast year. Forecasts for annual average weekday nighttime hours were generated by factoring the observed profile using a 12hr combination[10] of forecasts from the three daytime hours, to calculate weekday nighttime annual average hourly flows for each forecast year.

For weekend flows – 24 annual average Saturday hourly flows and 24 annual average Sunday hourly flows – the observed weekend flow was factored by the 12 hr weekday daytime growth factors calculated above, for each forecast year.

With annual average forecast flows for each weekday and weekend hour, those hours during which average flow is predicted to equal or exceed 4500 veh/hr were identified and counted. While being consistent with the threshold used in earlier DHSR analyses, it is also noted that the appraisal is not particularly sensitive to this assumption; the 'sides' of the diurnal flow profile are so precipitous that within a relatively wide range of potential threshold values the resulting annualisation factors would be little changed. The resulting annualisation factors required to convert hourly appraisal results to full-year benefits are presented below. Note that in order to account for flow variation between the identified appraisal hours and the modelled hour addressed in the traffic models, an additional demand factor was calculated, as described below.

[10] Assuming 3 AM peak hours, 6 interpeak hours and 3 PM peak hours.

Table 4. Annualisation Factors Used in TUBA

Time Period	Actual Hours	Annualisation Factors		
		2015	2030	2040
AM Peak Period (0600-1000)	(4x261[11] =) 1,044	1,044	1,044	1,044
Inter-peak Period (1000 – 1600)	(6x261 =) 1,566	1,566	1,566	1,566
PM Peak Period (1600 – 2000)	(4x261 =) 1,044	783	1,044	1,044
Weekend AM Peak (0600 - 1500)	(9x104[12] =) 936	572	624	624
Weekend PM Peak (1500 - 2000)	(5x104 =) 520	468	572	572

4.4.4 Demand Factors

It is noted that during the appraisal hours when the MM-ALR scheme has been assumed to yield benefits, the traffic flows in all parts of the network will differ from those forecast by the hourly traffic models. For instance where a peak hour model is used to appraise a three hour peak period, without any adjustment the appraisal is likely to overestimate benefits as the flows in the peak period are not simply three times those in the peak hour. In this particular case this is a significant issue in the appraisal of the weekday PM peak period.

To account for this, additional demand factors have been applied within TUBA which, using the weekday AM peak as an example, have been calculated as the ratio of:

- Forecast annual average hourly flow during the appraisal hours based on the weekday AM peak model, to;
- Forecast annual average hourly flow during the modelled weekday AM peak hour (08:00-09:00).

Similar factors have been calculated for each appraisal period and each forecast year and these are shown in the following table.

Table 5. Demand Factors for Section 5 TUBA Appraisal

Time Period	2015	2030[13]	2040
AM Peak	0.99791	0.99791	0.99791
Inter-peak	1.00000	1.00000	1.00000
PM Peak	0.97535	0.90959	0.90959
Weekend AM Peak[13]	0.89432	0.90360	0.90825
Weekend PM Peak	0.83836	0.81441	0.81388

The interpeak factors have been set to 1.00 as the interpeak model is already representative of the *average* weekday interpeak hour and all such hours are included in the appraisal. The other factors are lower than 1.00 reflecting the fact that the flow during the average appraisal hour is lower than that in the modelled peak hour, as expected.

[11] Weekdays calculated by 365 – (2 x 52) = 261.
[12] Weekend days calculated by 52 x 2 = 104.
[13] Weekend factors were applied to the respective weekday peak hour matrices, alongside the aforementioned adjustments for weekend vehicle composition and journey purposes.

4.4.5 Scheme Cost

Economic appraisal requires realistic and accurate scheme costs to be produced. The costs of transport schemes are an integral component of the scheme appraisal process, particularly where they are subsequently used to inform decisions on scheme funding.

There are three main elements of a scheme cost estimate:

- The **base cost**, which is the basic costs of a scheme before allowing for risks, but including realistic assumptions of changes in inflation over time (i.e. cost increases above the growth in 'economy-wide' inflation);
- Adjustment for risk, which should cover all the risks that can be identified, the majority of which then need to be assessed and quantified through a Quantified Risk Assessment (QRA) – the outcome of this is the **risk-adjusted cost estimate**; and
- Adjustment for optimism bias, to reflect the well-established and continuing systematic bias for estimated scheme costs and delivery times to be too low and too short respectively, and results in the **risk and optimism bias-adjusted cost estimate.**

These costs are usually supplied by the design team and HA, profiled over the various years of expenditure, and input to the TUBA assessment. The costs are supplied by HA in a standard format which reflects risk and optimism bias[14] in 2002 prices and includes real construction price inflation. The cost estimate profile sheet which has been used is that dated 18th March 2011 and reflects a DHSR scheme rather than the current MM-ALR scheme. However, the total values provided in April 2011 have been revised downward to reflect the reduced costs of the proposed MM-ALR scheme and to exclude the costs of replacement of the steel safety barrier, which is a Do-Minimum scheme.

The following table presents the formal offer made by SBBJV on 5th August 2011 to execute the works as they were defined in IAN 111 in 2002 Factor prices[15], with the spending profile carried over from the MM-DHSR cost profile provided in March 2011.

Table 6. Scheme Cost and Spending Profile

Item	Total Cost	Spending Profile (%)						
		2012	2013	2014	2015	2016	2017	Total
Preparation	£4,444,173	29.2%	50.6%	18.9%	1.2%	0.0%	0.0%	100.0%
Supervision	£2,613,682	0.0%	2.2%	36.7%	47.4%	13.2%	0.5%	100.0%
Construction	£130,561,989	0.0%	2.2%	36.7%	47.4%	13.2%	0.5%	100.0%
Land	£910,423	0.0%	75.5%	24.5%	0.0%	0.0%	0.0%	100.0%
Total	**£138,530,268**	**0.9%**	**4.2%**	**36.0%**	**45.7%**	**12.6%**	**0.5%**	**100.0%**

The expenditure profiles are based upon MM-DHSR cost estimates for each financial year prepared in 2006 Q2 prices and then inflated to outturn costs using projected construction related inflation. These costs have then been converted to calendar year profiles and deflated to 2002 average prices by stripping out general inflation only using the All Items Retail Price Index up to 2009 and the HA's Inflation Forecast from 2010. The costs exclude all VAT, both recoverable and non recoverable. All costs prior to the date of the cost estimate have been removed - previous years and an approximation of this year's spend that occurs prior to the cost estimate.

[14] Note that optimism bias is not explicitly included, but instead is implicitly included through the HA's alternative treatment of risks, using a methodology approved by HM Treasury in 2007.
[15] This assumes that the construction cost of £197.127m provided by email on 3rd July 2012 is in 2011 prices, is undiscounted, includes VAT such that it is a market price and does not include any land, preparation or supervision costs. (The equivalent March 2011 HA Range Estimate cost for MM-DHSR was £327.151m.)

Note that costs of renewals, operations and maintenance and enforcement from the HA's Managed Motorway Operating Cost Model have not been included in the TUBA appraisal. These are presented in chapter 8 and summarised alongside all other costs and benefits in the final chapter of this report.

4.4.6 Input Matrices

Traffic data is input into the TUBA for each user class, time period, scenario and forecast year.

Three data types are input into TUBA from outputs of the traffic models developed for the DM and DS scenarios, namely:

- Skimmed matrices of modelled journey times;
- Skimmed matrices of modelled distances; and
- Travel demand matrices.

The term 'Skimmed matrices' is applied to all matrices that are derived from the traffic model outputs; in the case of TUBA the 'Skimmed matrices' are the times and distances that the traffic models calculate between each and every zone pair.

The number of matrices used in the TUBA assessment for the **weekday** models (AM, Inter-peak and PM) is

= No. of Scenarios (2) x no. of modelled years (3) x no. of time periods (3) x no. of input data type (3) x no. of user classes (7)

= 378

The number of matrices used in the TUBA assessment for the **weekend** models (AM and PM) is

= No. of Scenarios (2) x no. of modelled years (3) x no. of time periods (2) x no. of input data type (3) x no. of user classes (7)

= 252

4.5 Transport Economic Efficiency Benefits

4.5.1 Travel Time Savings

Travel time savings are calculated using the rule of half applied to time skims from the SATURN highway model. Travel times in the traffic model are represented in seconds. These are converted to vehicle hours and annualised for each modelled period, so that annual AM, PM, Inter Peak, Weekend-AM and Weekend-PM period travel time savings can be calculated. The same annualisation factors are applied to all TUBA costs and benefits: namely, time savings and vehicle operating cost savings plus indirect tax impacts, greenhouse gas impacts and any monetary costs, where relevant.

Annual time savings are calculated for each modelled year. Benefits for non-modelled years are calculated via linear interpolation between modelled years, with flat-line extrapolation beyond the final modelled year. However, the impact of discounting on estimated benefits means that the present value of annual benefits declines toward the end of the 60 year appraisal period.

Default economic assumptions have been applied, as contained in the TUBA software and based on guidance contained in the DfT's WebTAG Unit 3.5.6. The latest version of the TUBA software (version 1.8) and economics file was used for this assessment.

4.5.2 Vehicle Operating Cost Savings

Vehicle operating costs are calculated for both fuel and non-fuel elements of the journey, based on formulae set out in the DfT's WebTAG Unit 3.5.6. The rule of half formula is applied as for travel times for perceived vehicle operating costs, with vehicle operating costs being based on distance travelled (vehicle-kilometres) and average vehicle speeds.

All assumptions relating to fuel costs, duty and vehicle efficiency are those contained in the default TUBA economics file.

4.5.3 Monetary Charges

The only charges modelled in the M25AM are the tolls to cross the River Thames. These have been modelled as time penalties rather than as monetary charges. Such charges are transfer costs rather than resource costs and do not change between forecast scenarios. However, their omission from the modelling and appraisal process could impact upon the TUBA assessment.

In this context a comprehensive check has been undertaken, using modelled Dartford Crossing flow differences and annualisation factors taken from the initial DHSR TUBA work[16] for M25 Section 5[17]. Assuming proposed 2012 charges increase with inflation and the net impact of any discounts remain constant, the 60 year assessment calculated the revenue impact of the scheme to be £2.3million in 2002 prices and values. This represents approximately 1% of the TUBA PVB and will affect the NPV only minimally, as the net revenues are balanced by increased user charges; the impact of Dartford tolls on the economic assessment is therefore small and the additional complexity of their inclusion in the TUBA processing is not justified.

Consequently, no monetary charges are considered in the Stage 3 TUBA appraisal.

4.5.4 Greenhouse Gas Benefits

The procedure for the greenhouse gas assessment is given in WebTAG unit 3.3.5.

The TUBA programme provides a calculation for estimating changes in fuel consumption that automatically produces an estimate of the greenhouse gas emissions and the net present value of the associated damages, as described in WebTAG. WebTAG Unit 3.3.5 stipulates that if TUBA is used to estimate the change in greenhouse gas emissions it is essential that all 8760 hours of the year are represented in the analysis.

In addition DMRB guidance urges caution when using TUBA to calculate emissions as it uses trip average speeds rather than link average speeds. For the greenhouse gas assessment therefore, the alternative methodology offered in WebTAG Unit 3.3.5 was adopted - whereby greenhouse gas emissions are estimated by a team of air quality specialists using the DMRB Screening Method v1.03c and the costs calculated using the TAG global emissions Excel spreadsheet, as provided by DfT.

The new values of carbon, which became guidance in April 2011 have been taken into account for this assessment. The results are shown in chapter 8.

4.6 Masking of TUBA Results

Any large model has a number of journeys distant from the scheme which would not be expected to be affected by the scheme. An example of such a journey may be from Manchester to Devon, which would be routed via the M6 to Birmingham and then onto the M5. This journey would not be directly affected by the MM-ALR scheme on the M25 between Junctions 23 and 27. Any calculated benefits for such trips are anomalies due to traffic model noise and should be excluded.

To achieve this exclusion the UK has been divided into 61 sectors and these sectors were then categorised into 4 super sectors - North, South West England and South Wales, East Anglia and South East England. Benefits for journeys going through South East England (i.e. likely to be affected by the MM-ALR scheme) were separated out in a ‘masking process’ and retained for economic analysis. All other user benefits were excluded.

[16] Using NTEM 5.4 growth (duly adjusted to reflect observed growth to 2010, for 2015) and pre-April 2011 WebTAG parameters as documented in *Technical Note 14: Stage 3 Section 5 TUBA Economic Assessment* (5084755-ALL-DO-TR-126Rev2.pdf).

[17] Section 5 was used as the forecast Dartford Crossing flow differences were much greater for the Section 5 scheme than for Section 2 (661 versus 181 vehicles per annual average day using AADT flows provided to the environmental teams).

The following table (origin - destination) shows the movements for which user benefits were either retained or excluded.

Table 7. Super Sectors (Retained and Excluded Movements)

Super Sector	North	South West	South East	East Anglia
North	Excluded	Excluded	Retained	Excluded
South West	Excluded	Excluded	Retained	Retained
South East	Retained	Retained	Retained	Retained
East Anglia	Excluded	Retained	Retained	Excluded

4.7 TUBA Economic Assessment Results

This section presents the Transport Economic Efficiency (TEE), Public Accounts (PA) and Analysis of Monetised Costs and Benefits (AMCB) tables to demonstrate the economic impact of the MM-ALR scheme for M25 Section 5.

Monetary values reported in these tables are in units of £1,000. All the tables show the masked TUBA results, thereby excluding the effects of 'traffic model noise'.

The TEE table shows the user benefits expected as a result of MM-ALR compared to the present combination of D3M and D4M carriageway. The total of the items shown in this table constitute the Present Value of Benefits (PVB) of the scheme.

Public sector costs and revenues, split between local and central government, are presented in the Public Accounts table. The total of the items shown in this table constitute the Present Value of Cost (PVC).

The TEE and Public Accounts tables are brought together in the Analysis of Monetised Costs and Benefits (AMCB) table (Table 10). This table usually includes the results of the TUBA calculations of Net Present Value (NPV) and Benefit-Cost Ratio (BCR) for the scheme. However, to avoid confusion with the final NPV and BCR figures presented in chapter 9, the values calculated by TUBA are not included here.

4.7.1 Transport Economic Efficiency Table

The table below presents the TUBA TEE table for the M25 Section 5 appraisal. The values shown in the table are masked results.

4.7.1.1 Travel Time Benefits

Travel time benefits total £629 million PVB, of which £475 million is due to Business users – with benefits accruing 71% to car/LGVs and 29% to freight. These benefits arise because the proposed MM-ALR scheme is expected to reduce travel time for the majority of the users by enabling them to travel at a higher average speed than in the Do Minimum. This is because the MM-ALR scheme relieves congestion compared to the existing road by increasing the road capacity, thus reducing the time spent in queues of slow-moving traffic.

Table 8. TEE Benefits Table

		TOTAL	Car & LGV	Freight
Consumer - Commuting user benefits				
Travel Time		£30,762	£30,762	
Vehicle Operating Costs		-£30,578	-£30,578	
User Charges		£0	£0	
During Construction & Maintenance		£0	£0	
NET CONSUMER - COMMUTING BENEFITS	(1)	£184	£184	
Consumer - Other user benefits				
Travel Time		£122,669	£122,669	
Vehicle Operating Costs		-£117,862	-£117,862	
User Charges		£0	£0	
During Construction & Maintenance		£0	£0	
NET CONSUMER - OTHER BENEFITS	(2)	£4,807	£4,807	
Business User Benefits				
Travel Time		£475,218	£290,333	£184,886
Vehicle Operating Costs		-£38,493	-£9,072	-£29,421
User Charges		£0	£0	£0
During Construction & Maintenance		£0	£0	£0
Subtotal	(3)	£436,726	£281,261	£155,465
Private Sector Provider Impact				
Revenue		£0		
Operating Costs		£0		
Investment Costs		£0		
Grant/subsidy		£0		
Subtotal	(4)	£0		
Other Business Impact				
Developer Contribution	(5)	£0		
NET BUSINESS IMPACT	(6) = (3)+(4)+(5)	£436,726		
Present Value of Transport Economic Efficiency Benefits (TEE)	(7) = (1)+(2)+(6)	£441,717		

Note: Benefits appear as positive numbers, while costs appear as negative numbers. All costs and benefits are in £'000 at 2002 present values and prices, expressed in market prices.

4.7.1.2 Vehicle Operating Cost Benefits

The Vehicle Operating Costs (VOC) generated by the proposed hard shoulder running however, offset some of the travel time benefits by approximately £187 million.

The change in vehicle operating costs is largely due to diversion of ‘consumer’ traffic from local roads onto the motorway, which has more capacity due to the hard shoulder operation. This results in drivers travelling further to reach their destinations, but doing so in less time. As a result they use more fuel (and non-fuel resources), thus increasing the operating costs of car consumer trips £148 million.

However ‘business’ traffic generally uses strategic roads with higher speeds than local roads anyway (due to their high value of time). For this reason their travel distance has seen a more modest increase with the MM-ALR scheme. The impact on vehicle operating costs for business users is an increase of £38m.

Overall it is the business users who benefit, owing to their higher value of time. While consumer users *do* enjoy modest time savings, these are offset by higher vehicle operating costs due to their travelling further as a consequence of the scheme.

Government derives additional tax revenue due to the overall increase in fuel consumption, from fuel duty and Value Added Tax (VAT). So the increase in vehicle operating costs in the TEE Benefits table is countered elsewhere in the appraisal.

4.7.2 Public Accounts Table

The table below presents the Public Accounts table for the M25 Section 5 appraisal. The values shown in the table are 'masked' results.

Table 9. Public Accounts Table

		TOTAL
Local Government Funding		
Revenue		£0
Operating Costs		£0
Investment Costs		£0
Developer Contributions		£0
Grant/Subsidy Payments		£0
NET IMPACT	(8)	£0
Central Government Funding - Transport		
Revenue		£0
Operating Costs		£0
Investment Costs		£108,379
Developer Contributions		£0
Grant/Subsidy Payments		£0
NET IMPACT	(9)	£108,379
Central Government Funding - Non Transport		
Indirect Tax Revenue	(10)	-£172,927
TOTALS		
Broad Transport Budget	(11) = (8)+(9)	£108,379
Wider Public Finances	(12) = (10)	-£172,927

Note: Costs appear as positive numbers, while revenues and developer contributions appear as negative numbers. All costs and benefits are in £'000 at 2002 present values and prices, expressed in market prices.

4.7.2.1 Indirect Tax Revenues

The indirect tax revenues received by the Government in the Do Something scheme scenario are greater than the revenues received in the Do Minimum scheme scenario. This is principally a result of an increase in overall fuel consumption, and hence increased fuel duty and VAT received by the Government. The PA table shows that the present value of income from indirect taxation will be about £173 million, over the 60-year appraisal period.

4.7.3 Analysis of Monetary Cost and Benefit Table

Table 10 below presents the AMCB table from the TUBA appraisal. The values shown in the table are 'masked' results.

The Greenhouse Gas valuation has been undertaken outside TUBA and is reported in chapter 8. The value is therefore removed from the table below.

Table 10. AMCB Table from TUBA Assessment

		TOTAL
Greenhouse Gases	(13)	
Economic Efficiency: Consumer Users (Commuting)	(14) = (1)	£184
Economic Efficiency: Consumer Users (Other)	(15) = (2)	£4,807
Economic Efficiency: Business Users and Providers	(16) = (6)	£436,726
Wider Public Finances (Indirect Taxation Revenues)	(17) = (12)	£172,927
Present Value of Benefits (PVB)	(18) = (13)+(14)+(15)+(16)+(17)	£614,644
Broad Transport Budget	(19) = (11)	£108,379
Present Value of Costs (PVC)	(20) = (19)	£108,379

Note: All costs and benefits are in £'000 at 2002 present values and prices, expressed in market prices.

4.7.4 TUBA Masked versus Unmasked Results

From the tables above showing results with traffic model noise masked out, the MM-ALR scheme for Section 5 produces a PVB of £615million over a 60 year appraisal. This excludes the valuation of greenhouse gas emissions and other appraisal results introduced in this report, all of which are drawn together in chapter 9.

For comparison, the equivalent 'unmasked' results are very similar, with a PVB of £633m.

4.8 Sensitivity Tests

Two sensitivity tests were undertaken using the forecasting models, as documented in the Traffic Forecasting Report[2]. These were subsequently taken through a full TUBA appraisal, as reported below.

4.8.1 High Growth Scenario

A high growth sensitivity test was carried out using the high growth factor of +2.5%*SQRT(forecasting year-base year) in line with WebTAG guidance. The high growth forecast models were prepared using all three model years (2015, 2030 and 2040) and a full TUBA economic appraisal was carried out.

Table 11 below presents the AMCB table from the high growth TUBA appraisal. The values shown in the table are 'masked' results.

Table 11. AMCB Table from High Growth TUBA Assessment

		TOTAL
Greenhouse Gases		
Economic Efficiency: Consumer Users (Commuting)		£5,865
Economic Efficiency: Consumer Users (Other)		£28,633
Economic Efficiency: Business Users and Providers		£489,852
Wider Public Finances (Indirect Taxation Revenues)		£164,910
Present Value of Benefits (PVB)		£689,260
Broad Transport Budget		£108,379
Present Value of Costs (PVC)		£108,379

Note: All costs and benefits are in £'000 at 2002 present values and prices, expressed in market prices.

For comparison, the equivalent 'unmasked' results are very similar with a PVB of £702m.

The high growth scenario brings significantly higher user benefit than the core scenario as expected, since there is more congestion in the Do-Minimum scenario and hence more congestion relief in the Do-Something scenario. The high growth scenario brings £83m more user benefit than the core scenario (£524m against £442m).

4.8.2 Low Growth Scenario

A low growth sensitivity test was carried out using the low growth factor of -2.5%*SQRT(forecasting year-base year) in line with WebTAG guidance. The low growth forecast models were prepared for the same three model years as the high growth scenario (2015, 2030 and 2040) and a full TUBA economic appraisal was carried out.

The table below presents the AMCB results from the low growth TUBA appraisal. The values shown in the table are 'masked' results.

Table 12. AMCB Table from Low Growth TUBA Assessment

		TOTAL
Greenhouse Gases		
Economic Efficiency: Consumer Users (Commuting)		£5,111
Economic Efficiency: Consumer Users (Other)		-£11,713
Economic Efficiency: Business Users and Providers		£346,666
Wider Public Finances (Indirect Taxation Revenues)		£154,156
Present Value of Benefits (PVB)		£494,220
Broad Transport Budget		£108,379
Present Value of Costs (PVC)		£108,379

Note: All costs and benefits are in £'000 at 2002 present values and prices, expressed in market prices.

For comparison, the equivalent 'unmasked' results are very similar, with a PVB of £504m.

The low growth scenario brings smaller user benefit than the core scenario as expected, since there is less congestion in the Do-Minimum scenario and hence less congestion relief in the Do-Something scenario. The low growth scenario brings £102m less user benefit than the core scenario (£340m against £442m).

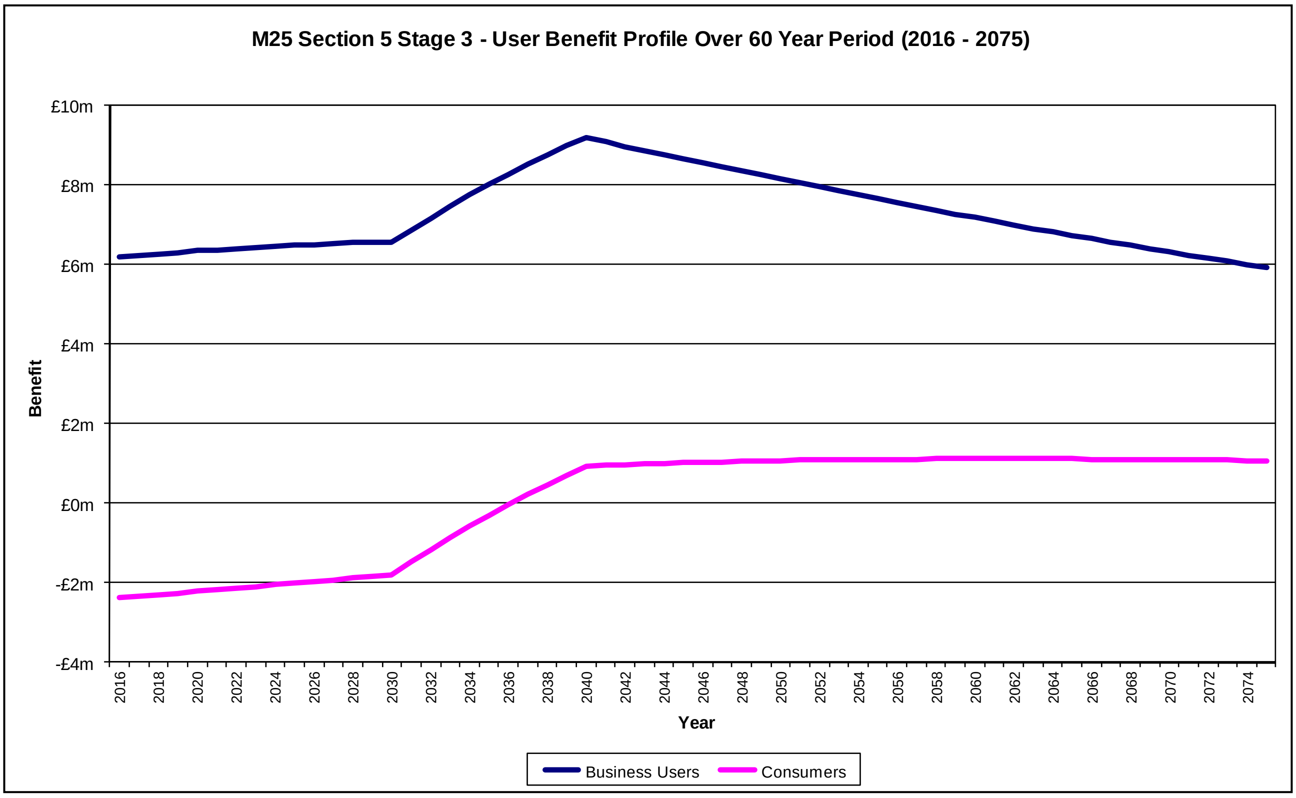
4.9 Analysis of Scheme Benefits

The following sections show the distribution of benefits over the 60 year appraisal period and the contribution of different modelled time periods to the overall benefits calculation. In both cases the results shown are 'masked' to remove geographically spurious results from the traffic model.

4.9.1 User Benefits Profile over 60 years

The following figure shows how the contribution to total PVB varies year by year. The values shown are in 2002 market prices discounted to 2002.

Figure 3. Net User Benefit Profile Over 60 Years

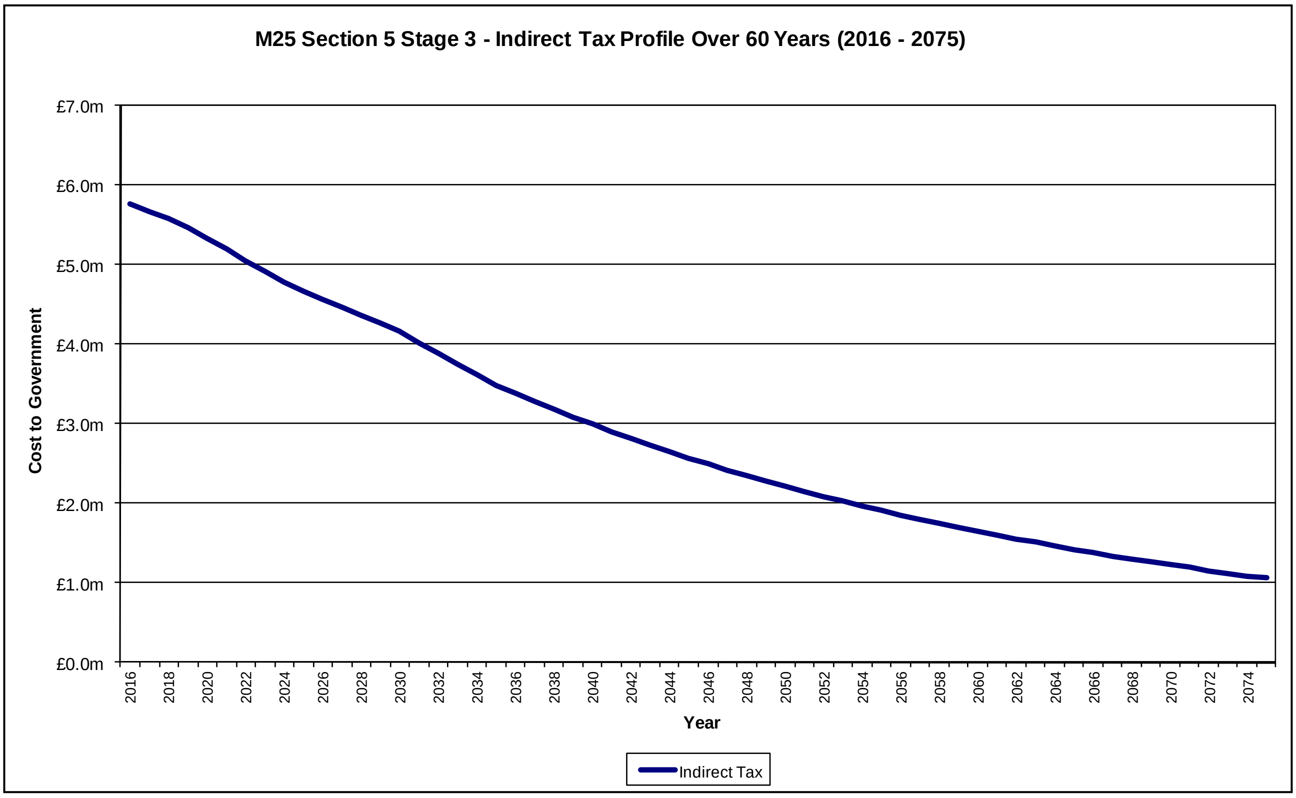


This shows that both the business and consumer user benefits increase from scheme opening until the 2030 design year. Beyond 2030 the benefits increase significantly until 2040 due to increased congestion on the road in the Do Minimum scenario and hence more congestion relief in the Do Something scenario. Then business user benefits drop steadily over time but the consumer user benefits stay relatively constant, albeit at a relatively low value. The overall drop is due to the discounting effect which means the benefit value gets smaller with more distant years. The relatively better performance of consumer benefits in later years is because the value of time growth for business users falls in later years in comparison to that for consumer users.

4.9.2 Indirect Taxation Over 60 Years

The following figure shows the changes to indirect taxation over the 60 year period. The values shown are in 2002 market prices discounted to 2002.

Figure 4. Net Indirect Taxation Change Profile Over 60 Years



The profile shows that the scheme's impact on indirect taxation reduces over time. Discounting is one reason but also vehicle fuel efficiency is assumed to increase over time and consequently fuel consumption decreases as does the indirect tax benefit to Government.

4.9.3 User Benefits by Time Period

The table below shows how masked benefits are spread between different times of the day and between weekdays and weekends.

Table 13. User Benefits by Time Period

		AM Peak	Inter-peak	PM Peak	Weekend	Total
Business	Travel Time	£134,658	£234,916	£69,705	£28,659	£467,939
	VOCs	-£4,670	-£11,057	-£10,204	-£4,897	-£30,828
Consumer	Travel Time	£38,715	£55,814	£12,506	£53,674	£160,710
	VOCs	-£31,529	-£34,686	-£32,021	-£57,869	-£156,104
Total		£137,174	£244,988	£39,987	£19,568	£441,717
Percentages		*31.1%*	*55.5%*	*9.1%*	*4.4%*	*100.0%*

Note: All costs and benefits are in £'000 at 2002 present values and prices, expressed in market prices.

Travel time benefits are dominated by the weekday time periods, particularly the AM and interpeak periods. This is due to the higher proportion of business travellers, coupled with the greater number of appraisal hours during the interpeak period. The weekend benefits are small, as the number of business users (with a high value of time) is very small at the weekend. Another reason is there are fewer appraisal hours in the weekend period than the weekday periods.

The VOC benefit is consistently more highly negative for consumers than business users as the scheme causes them to travel further than they would otherwise have done, as discussed previously.

5. Accident Assessment (COBA)

5.1 General

5.1.1 Overview

The benefits that accrue from a reduction in the number and severity of accidents constitute an important element in the appraisal of highway schemes. A monetised value is placed on accident savings so that they are given an appropriate valuation relative to that given to construction costs and to time and vehicle operating cost savings.

For the proposed scheme, accident benefits have been assessed using the DfT Cost Benefit Analysis (COBA) program (Version 11 R12) which includes economic parameters that have been updated with current values issued in April 2011. This uses a network derived from the SATURN traffic model network, together with further data on the network characteristics, traffic flow and accident rates in order to forecast the number of accidents in the Do Minimum (DM) case and the Do Something (DS) case. The accident benefit of the scheme is the difference between the DM and DS cases. This evaluation is undertaken for a 60-year appraisal period.

5.1.2 Accident Rates

The accident assessment uses accident rates which express the total number of accidents relative to the total distance travelled expressed in accidents per million vehicle kilometres. There is a direct relationship between the total distance travelled and the number of accidents; however, where traffic uses an improved road with a lower accident rate then the total number of accidents may reduce.

5.1.3 Accidents During Construction and Future Maintenance

Accidents during construction and future maintenance are not assessed within the COBA program and hence are not reported in this section. Instead they are assessed using the QUADRO program and are reported in chapter 6 of this document. The assessment of the scheme safety benefits and the accident impact of the scheme during construction and future maintenance are combined and included in the overall economic assessment reported in chapter 9 of this document.

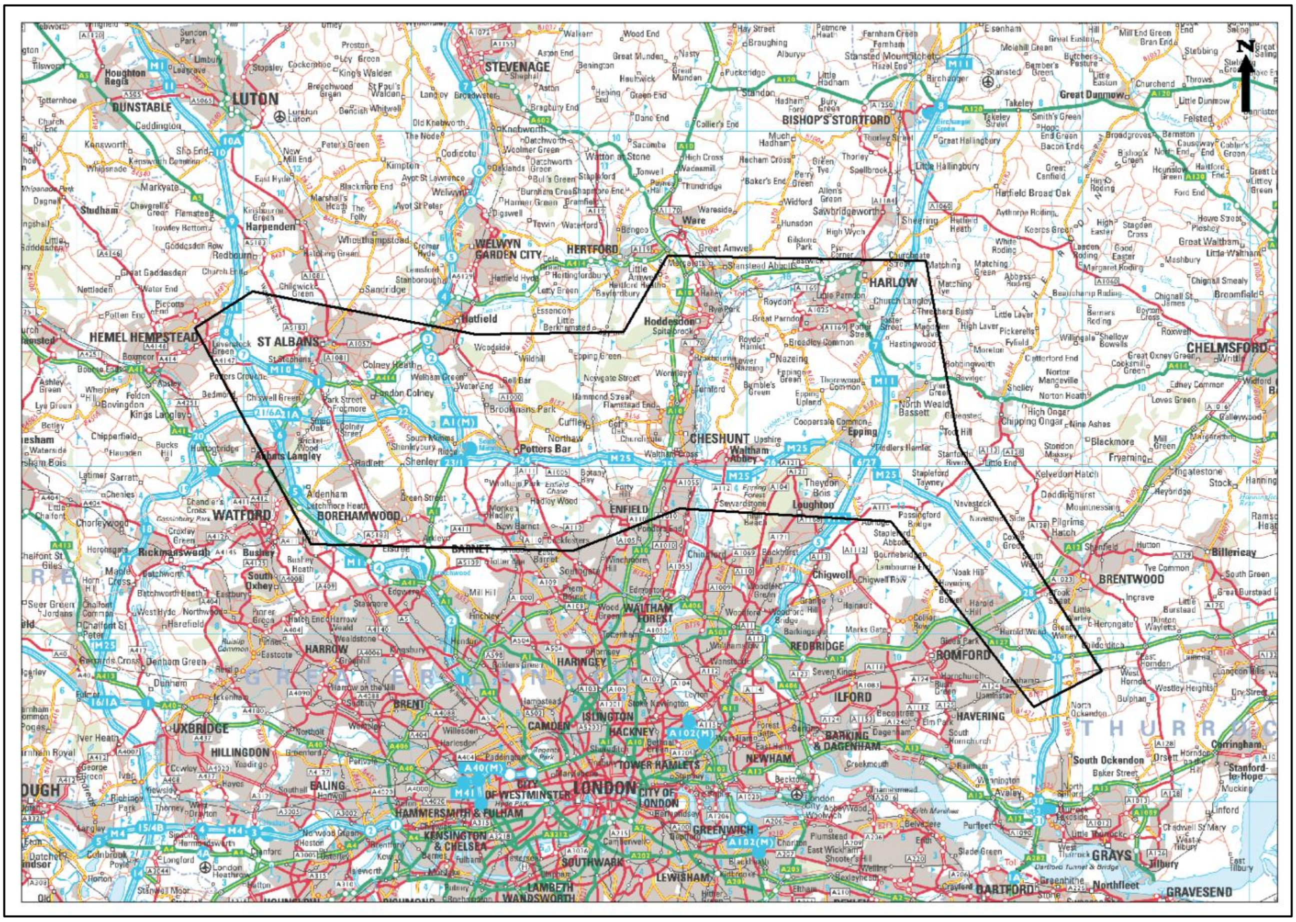
5.2 COBA Model

5.2.1 Extent of COBA Model

The extent of the network for COBA accident analysis was defined as part of the work undertaken by HHJV in 2009 during PCF Stage 2. The COBA network is that part of the model network that is most affected by the scheme[18], in terms of Annual Average Daily Traffic flow. This was determined by comparing differences between the flows in the Do Minimum and Do Something scenarios, with links included in the COBA network where the forecast AADT flows vary by more than ±5% and ±50pcu. The resulting network includes the M25 between Junctions 21 and 29, A1(M), A10, M11 and some links on the local road network. Figure 5 presents the extent of the M25 Section 5 COBA network.

[18] At PCF Stage 2 a full D4M widening scheme was being considered rather than the MM-ALR scheme currently being taken forward. The flow impacts of each scheme (and therefore the COBA network defined using the above criteria) would be expected to be very similar.

Figure 5. Extent of M25 Section 5 COBA Network



5.2.2 Network Data and Traffic Flows

The network data for the COBA network was taken from the SATURN model. This comprised information on carriageway standard, link length and speed limit.

Traffic flows were derived from the DM and DS SATURN traffic model forecasts. COBA uses the Annual Average Daily Traffic forecast calculated from the individual one-hour modelled values.

In total the COBA network has 1.74% more traffic in the Do Something compared to the Do Minimum network due to both the impact of variable demand and traffic assignment. Both of these reflect the impact of the improved M25 network in terms of highway vehicle demand and the assignment of traffic away from relatively more congested sections of the network towards the improved sections of the M25.

5.2.3 Accident Rates

COBA models use accidents rates that calculate accidents for the network links and junctions combined. The accident rates used are derived from two sources:

- **Default Accident Rates:** These are based on national accident statistics for a given road type and speed limit as presented in the Design Manual for Roads and Bridges Volume 13. For the assessment undertaken for the M25 Section 5, all roads that are not part of the M25 use default accident rates.

- **Observed Accident Rates:** Observed accident rates are calculated from (a) at least three years of accident data on a section of road and (b) the total traffic flow on that road. Observed accident rates have been calculated for all sections of the M25 within the COBA assessment area.

5.2.3.1 M25 Observed Accident Rates

Accident data for the period 2003 to 2007 was obtained for the M25 as part of the Stage 2 assessment. This data has been used together with the observed traffic flow data to calculate the observed accident rates as presented in Table 14.

Table 14. Observed Accident Rates (2003 to 2007) and Default Accident Rates

M25 Location	Principal Carriageway Standard	Personal Injury Accidents (PIA's)	Million Veh-Km Travelled	Accident Rate (PIA's per mvkm)	COBA Default Accident Rate (PIA's per mvkm)
Section 1 (J16 to J23)	D3M	2002	9,362 mvkm	0.214	0.098
Section 4 (J27 to J30)	D3M	812	5,749 mvkm	0.141	0.098
Section 5 (J23 to J27)	D3M	1005	5,314 mvkm	0.189	0.098

Notes: 1. All accident rates are for link and junction combined. 2. Default accident rates are for a 2000 base from DMRB Volume 13. 3. Mvkm travelled is an average of 2003 to 2007.

Table 14 shows that the M25 sections of interest have accident rates that are in the range of 0.141 PIA/mvkm to 0.214 PIA/mvkm. These rates are higher than the default national accident rate for motorways of 0.098 PIA/mvkm.

5.2.3.2 Accident Rates for the Proposed MM-ALR Scheme

The proposed scheme is forecast to result in lower accident rates on those sections of the M25 where MM-ALR would be implemented, compared to the Do Minimum. The lower accident rates are due to the MIDAS (Motorway Incident Detection System) loops in the carriageway together with associated VMS signs and communications included as part of the scheme. This would provide a queue protection system which would provide additional safety benefits when traffic is slow moving or stationary. Evidence from similar schemes has shown that this would provide a 13 per cent accident saving.

This benefit would only be attributable to those sections that do not currently have MIDAS loops at a sufficient density coupled with the required VMS signs and communication system.

Table 15 provides a summary of the accident rates used to assess the proposed MM-ALR scheme between junctions 23 and 27.

Table 15. Accident Rates Used in COBA Appraisal

Section	Observed Accident Rate (PIA's per mvkm)	MIDAS Loops	Existing Triple Package Provision	Accident Rate With MM-ALR
J23 to J24	0.189	None	No	0.164
J24 to J25	0.189	4	No	0.164
J25 to J26	0.189	9	No	0.164
J26 to J27	0.189	29	Yes	0.189

5.2.4 Results

The results of the assessment are presented in Table 16.

Table 16. Section 5 COBA Accident Assessment

Scenario	Accidents	Casualties			Cost
		Fatal	Serious	Slight	
Do Minimum	93,837	1,531	10,460	139,522	£3,851.574m
Do Something	92,903	1,514	10,311	138,410	£3,805.224m
Change (DS-DM)	-934	-17	-150	-1,113	-£45.350m
% Change	-1.00%	-1.12%	-1.43%	-0.80%	-1.18%

Notes: 1. All costs and benefits are in £000s in 2002 market prices and present values over a 60-year evaluation period. 2. A negative change represents a benefit (i.e. the Do Something costs are lower than the Do Minimum).

Table 16 shows that the scheme is forecast to result in a saving of 934 accidents over 60-years. The reduction in casualties from the accident saving would be 17 fatal casualties, 150 serious casualties and 1,113 slight casualties. The accident saving provides a monetised benefit of £45.350m, which represents a 1.18% saving compared to the Do Minimum. This saving is despite the higher level of traffic in the Do Something COBA network which would act to reduce the overall level of benefit.

On the mainline scheme links themselves, the analysis shows an increase of 160 accidents as a result of the scheme, over the 60 year appraisal period. This masks a net reduction in accidents on the scheme links between junctions 23 and 26. On junction 26-27 the additional traffic increases the forecast number of accidents and there is no assumed reduction in accident rate to counter this. A ‘Hazard Log’ approach to operational management will be implemented, and mitigation measures put in place to ensure that the absolute number of accidents on scheme links will not increase. Overall therefore, the accident benefits calculated are a conservative estimate of the expected benefits. New guidance on the assessment of accident benefits for Managed Motorway schemes is expected later in 2012.

6. Traffic Delay Assessment (QUADRO)

6.1 General

6.1.1 Overview

This chapter describes the assessment of the costs incurred by road users during construction and future maintenance works on the proposed M25 Section 5. The DfT program QUes And Delays at ROadworks (QUADRO) has been used to assess both the delays to traffic during construction and the delays for subsequent maintenance.

QUADRO assesses:

- The impact on users in terms of time and vehicle operating costs of traffic management;
- The impact on users in terms of safety due to traffic management.
- It can include the capital cost associated with the future carriageway maintenance in the Do Minimum and Do Something scenarios.

The assessment is undertaken separately for construction and for future maintenance:

- The assessment of delays during construction measures the costs to users during the construction of the scheme. This cost is subtracted from the scheme benefits.
- The assessment of delays during future maintenance assesses the difference between the user costs incurred in the Do Minimum compared to the Do Something. In addition the difference in the capital costs of maintaining the carriageway may also be assessed.

6.1.2 QUADRO Version

The DfT computer program QUADRO (Version 4 Release 10.1) was used to assess user delay costs during construction and maintenance. It is noted that the current version of QUADRO is Version 4 Release 10 (released in June 2011) however this version contains software errors which affect the calculation of accidents. Atkins had contacted the developer, Transport Research Laboratory (TRL) in December 2011 to rectify this problem and a revision titled Release 10.1 was made available to Atkins in January 2012.

6.2 QUADRO Assessment

6.2.1 Construction Phases

The construction period for the proposed scheme would run for a period of 104 weeks from October 2013 to September 2015. The construction is divided into four phases as shown in the following table.

Table 17. Construction Phases

Phase	Chainage	Site Length (km)	Speed Limit (mph)	Work Start	Work End	Work Duration (weeks)
Phase 1 – Central Reserve	37,400 – 50,400	13.00	50	Oct-13	Dec-13	13
Phase 2 – Central Reserve	50,400 – 63,100	12.70	50	Jan-14	Mar-14	13
Phase 3 – Both Verges	37,400 – 50,400	13.00	50	Apr-14	Dec-14	39
Phase 4 – Both Verges	50,400 – 63,100	12.70	50	Jan-15	Sep-15	39

Construction work will be carried out under a 24hr operation with 3 lanes available for traffic with narrow width (3.25 + 3.25 + 2.75 = 9.3m). There will be a 50mph speed limit in place. There will be no requirement for contra-flow or cross over during any of the work phases. All of the phases will be done in sequence, so there will not be two work sites at any single point in time.

The installation, testing and commissioning of technology (gantries, loops, cameras etc) will be carried out at later part of each phase. The ‘rolling block’ technique will be used to manage traffic during the installation of each gantry and this work will be carried out at night time when traffic levels are low. According to Connect Plus it would take no more than 20mins to lift a superspan gantry onto its foundations. The length of the works is based on one lift per night. As QUADRO does not have the ability to model the rolling block technique, in order to assess this delay an overnight carriageway closure of one hour has been assumed for every three gantries, in order to capture the additional costs to the road users.

The diagrams of traffic management layouts are provided in Appendix A.

6.2.2 Diversion Routes during Construction

Single diversion routes, one relevant to each of the construction phases, have been defined which are included in the QUADRO assessment. The following information, in Table 18, has been extracted from the SATURN model and input into the QUADRO analysis.

Table 18. Construction Diversion Route Information

Route	Description	Length (km)	Average Free Flow Speed (kph)	Average Speed at Capacity (kph)	Average Capacity(veh/hr)	Minimum Capacity (veh/hr)
23-25 CW	CW – via A1081, A110 and A10. AC – Reversed.	20.0	64	36	1800	1210
25-23 AC		20.0	64	36	1800	1210
25-27 CW	CW – via A10, A110, A1069, A121, A1168; and also A121, Parklands Rd and B1393. AC – Reversed.	19.0	64	36	1800	1210
27-25 AC		19.0	64	36	1800	1210

The average free flow speed, average speed at capacity and average capacity are taken from the link type which characterises the majority of the diversion route. The minimum capacity is the lowest capacity of any link on the diversion route.

For all diversion routes, as the majority of roads traversed are single carriageway A-roads, accident type 4 has been assumed – Modern wide single.

6.2.3 Do-Minimum Maintenance Program

The maintenance will be carried out with a ‘little and often’ strategy in a cyclic round of regular one, two or three lane closures. All of the work will be carried out overnight (2200 – 0500). The closure routine would comprise one night closure every month on each 4km for the nearside lane(s) and one night closure on each 4km every 3 months for the offside lane(s). No contra-flow or narrow lanes will be required for the work and lane availability has been assumed to be three lanes for 70% of the regular maintenance works, two lanes for 20% of the maintenance time and one lane for 10% of the maintenance time.

The resurfacing of the carriageway, sweeping, repair and cleaning of signs, street lights etc will be carried out as part of the regular maintenance cycle mentioned above.

The steel safety barrier will be replaced with a concrete safety barrier with no further requirement for maintenance or replacement within the 60 year appraisal period. This work will require no contra-flow and three narrow lanes will be available for traffic. The work will be carried out both in day and night time and is required for the full scheme length except for within the Holmesdale and Bell Common tunnels. A site length of 1.4km will be used and the works will require 7 weeks for each section.

It has been assumed that all of the 34 bridges and structures will need to be maintained once in the 60 year appraisal period. A site length of 1.8km will be used for the works. It will require contra flow and two narrow lanes will be available for traffic. The work will be carried out both in day and night time and the works will require 4 weeks per structure. For the purposes of this assessment each tunnel has been assumed to constitute one structure.

For drainage and geotechnical issues it has been assumed there will be one significant closure in the 60 year appraisal period which will lead to one closure for every 10km long section. The work will require contra flow with two narrow lanes available for traffic. The work will be carried out both in day and night time over a period of 4 weeks per section.

6.2.4 Do-Something Maintenance Program

The assets (highway and structures) that will need maintaining are essentially the same in both Do-Minimum and Do-Something scenarios. The technologies associated with managed motorways (gantries, loops, cameras etc.) will be maintained as part of the regular maintenance, so will not require more closure in the Do-Something scenario. The only change will be the maintenance of the safety barrier. As part of the proposed scheme, the steel safety barrier will be replaced with concrete barrier during construction so will not require the one off closure assumed in the Do-Minimum scenario.

A single diversion route between each of the M25 junctions have been defined which are included in the QUADRO assessment. The following information, in Table 19, has been extracted from the SATURN model and input into the QUADRO analysis.

Table 19. Maintenance Diversion Route Information

Route	Description	Length (km)	Average Free Flow Speed (kph)	Average Speed at Capacity (kph)	Average Capacity(pcu)	Minimum Capacity (pcu)
23-24 CW	CW – via the A1081 SB, and then A1000 NB to Potters Bar. AC - Reversed	10.1	64	36	1800	1210
24-23 AC		9.2	64	36	1800	1210
24-25 CW	CW – via the A1005 towards Enfield taking the A10 NB. AC - Reversed	11.5	64	36	1800	1210
25-24 AC		13.7	64	36	1800	1210
25-26CW	CW – via A10 NB, A1055 EB, A1010 NB, A121 EB. AC - Reversed	16.6	64	36	1800	1210
26-25 AC		15.7	64	36	1800	1210
26-27 CW	CW – via A121 SB, A406 EB, M11 NB. AC - Reversed	28.1	64	36	1800	1210
27-26 AC		27.0	64	36	1800	1210

The average free flow speed, average speed at capacity and average capacity are taken from the link type which characterises the majority of the diversion route. The minimum capacity is the lowest capacity of any link on the diversion route.

For all diversion routes, as the majority of roads traversed are single carriageway A-roads, accident type 4 has been assumed – Modern wide single.

6.3 QUADRO Construction and Maintenance Results

6.3.1 Safety

The results of the assessment are presented in the following table.

Table 20. QUADRO Accident Assessment

Scenario		Do Minimum	Do Something			Cost (D-A)
Element		Maintenance (A)	Maintenance (B)	Construction (C)	Total (D=B+C)	
Accidents		449	567	79	646	**197**
Casualties	Fatal	3	4	1	5	**2**
	Serious	47	59	7	66	**19**
	Slight	557	709	119	828	**271**
Cost		£19,106	£24,011	£4,618	£28,629	**£9,523**

Notes: 1. All costs and benefits are in £000s in 2002 market prices and present values over a 60-year evaluation period. 2. A positive value in the change column represents a dis-benefit (i.e. the Do Something is greater than Do Minimum). 3. All accidents and casualties have been rounded to nearest integer.

It shows that the future maintenance for the proposed scheme is forecast to result in 567 accidents compared to 449 accidents in the Do Minimum case, an increase of 118 accidents. This is a consequence of (a) the forecast higher level of traffic flow on the M25 between junction 23 to 27 for the Do Something compared to the Do Minimum and (b) due to the greater diversion to alternative routes, for which the accident rates are higher, associated with the higher level of traffic on the M25.

The construction of the scheme would result in an additional 79 accidents. When combined with the safety impact of the future maintenance the net result is that there would be an increase of 197 accidents associated with construction and future maintenance compared to the Do Minimum. In terms of casualties this would represent an increase of 2 fatal casualties, 19 serious casualty and 271 slight casualties. The monetised dis-benefit is £9.523m.

6.3.2 User Transport Economic Efficiency

The following table presents the impact on user transport economic efficiency of construction and future maintenance.

Table 21. QUADRO Transport Economic Efficiency (TEE) Assessment

Scenario	Do Minimum	Do Something			Cost (D-A)
Element	Maintenance (A)	Maintenance (B)	Construction (C)	Total (D=B+C)	
Net Consumer Impact	£202,803	£168,622	£113,491	£282,113	**£79,310**
Net Business Impact	£303,441	£228,332	£179,303	£407,635	**£104,194**
TOTAL Present Value of Non-Exchequer impacts	**£506,244**	**£396,954**	**£292,794**	**£689,748**	**£183,504**

Notes: 1. All costs and benefits are in 2002 market prices and present values over a 60-year evaluation period expressed as £000s. 2. A negative value in the Benefit column represents a dis-benefit (i.e. the Do Something cost is greater than the Do Minimum).

The table above shows that the future maintenance for the proposed scheme is forecast to provide a user benefit of £109.290m (£506.244m minus £396.954m) compared to the Do Minimum case. This is a consequence of the lower number of future maintenance interventions as the construction of the concrete safety barrier removes the need for replacement of the steel safety barrier for the Do Something compared to the Do Minimum.

The construction would, however, result in additional user delay of £292.794m. When combined with the maintenance impact the overall impact is a user dis-benefit of £183.504m.

6.3.3 Public Accounts

The following table presents the impact on public accounts of construction and future major maintenance.

Table 22. QUADRO Public Accounts (PA) Assessment

Scenario	Do Minimum	Do Something			Cost (D-A)
Element	Maintenance (A)	Maintenance (B)	Construction (C)	Total (D=B+C)	
Investment Costs	£0	£0	£0	£0	**£0**
Indirect Tax Revenues	-£5,995	-£5,004	-£236	-£5,240	**£755**
Totals					
Broad Transport Budget					**£0**
Public Finances					**£755**

Notes: 1. All costs and benefits are in 2002 market prices and present values over a 60-year evaluation period expressed as £000s. 2. A negative value in the cost column represents a benefit to Government (i.e. the Do Something tax revenues are greater than the Do Minimum).

The capital cost for regular maintenance in the Do-minimum and Do-Something scenarios is very similar and will cancel each other. The additional cost associated with Do-Something technology maintenance is included in the HA Managed Motorway Operating Cost Model. The cost of construction is included in the TUBA models. For this reason the investment cost in QUADRO is taken as zero.

The table also shows that the proposed scheme reduces indirect taxation revenue by £0.755m. This would reflect a marginal reduction in the volume of fuel consumed by users during construction and maintenance.

6.3.4 Greenhouse Gases

The table below presents the monetised impact of the scheme's construction and maintenance in terms of Greenhouse Gas emissions.

Table 23. QUADRO Greenhouse Gases (AMCB Table)

Scenario	Do Minimum	Do Something			Benefit (A-D)
Element	Maintenance (A)	Maintenance (B)	Construction (C)	Total (D=B+C)	
Greenhouse Gases	£5,645	£5,204	£41	£5,245	**£400**

Notes: 1. All costs and benefits are in 2002 market prices and present values over a 60-year evaluation period expressed as £000s. 2. A negative value in the Benefit column represents a dis-benefit.

It shows that the monetised greenhouse gas emissions during future maintenance are marginally lower with the proposed scheme (£5.204m) compared to the Do Minimum (£5.645m). In addition there is a greenhouse gas cost during construction (£0.0.41m). Overall there is a marginal monetised benefit of £0.400m.

6.3.5 Total QUADRO Impact

The table below presents the total monetised impact of the scheme's construction and maintenance in terms of all the above measures, as determined using QUADRO.

Table 24. QUADRO Total Impact (AMCB Table)

Scenario	Do Minimum	Do Something			Cost (D-A)
Element	Maintenance (A)	Maintenance (B)	Construction (C)	Total (D=B+C)	
Overall Impact	£525,000	£421,165	£297,217	£718,382	**£193,382**

Notes: 1. All costs and benefits are in 2002 market prices and present values over a 60-year evaluation period expressed as £000s. 2. A negative value in the Benefit column represents a dis-benefit.

The above table shows that the overall cost during future maintenance is lower with the proposed scheme (£421.165m) compared to the Do Minimum (£525.000m). This is a consequence of the lower number of future maintenance interventions as the construction of the concrete safety barrier removes the need for replacement of the steel safety barrier in the Do Something scenario. In addition there is a cost during construction (which excludes the scheme investment costs which are taken from TUBA) of £297.217m. There is a total dis-benefit of £193.382m with the proposed scheme, including both construction and future maintenance impacts.

6.3.6 Overall Assessment

The overall assessment of the construction and maintenance impacts of the scheme is summarised alongside the other monetised appraisal impacts in Chapter 9 of this report.

7. Incident Assessment (INCA)

7.1 General

7.1.1 Overview

The appraisal of transport schemes aims to assess ‘average travel time’ savings with some other elements such as vehicle operating cost savings, accident reduction and environmental benefits. The average travel time analysis is based on traffic models which take account of the ‘predictable’ journey time variation relating to varying levels of demand by time of the day, day of week, seasonal effects and long term road works. The predictable variation in journey time is part of the transport benefit assessment process by means of TUBA, COBA and QUADRO.

More recently, it has been recognised that substantial benefits can arise from variations in travel time which drivers are unable to predict – such as incident related delay and travel time variability, more commonly termed as ‘reliability’.

For this scheme the reliability benefits have been assessed using the Incident Cost-benefit Assessment (INCA) software, an Excel based spreadsheet application developed by the Department for Transport. The current INCA version 4.1 was used for this assessment incorporating the latest guidance[19] for Managed Motorway - All Lane Running (MM-ALR) from the Traffic Appraisal, Modelling and Economics (TAME) division of HA.

INCA calculates two types of reliability benefit – (i) Incident Delay and (ii) Travel Time Variability Delay. It excludes the effect of predictable journey time variability of which travellers are assumed to be aware.

7.1.2 Incident Delay

Incident delays are calculated from a database of twelve categories of road incidents (e.g. accident, breakdown, debris, fire, load shedding, spillage, animal etc), the duration of the incident, the number of lanes affected by it and the proportion of traffic diverting. It is assumed that diverted traffic experiences the same delay as the traffic that remains. It is also assumed that the incidents have no effect beyond the end of the link and there is no spill-over mechanism to pass on the effect to the next flow group or time period.

7.1.3 Travel Time Variability

Travel Time Variability (TTV) is calculated from the sum of incident-related variability and day-to-day variability (DTDV). DTDV is the variability not caused by any incident but by fluctuations in demand, weather conditions etc.

7.2 INCA Model

7.2.1 Network Representation

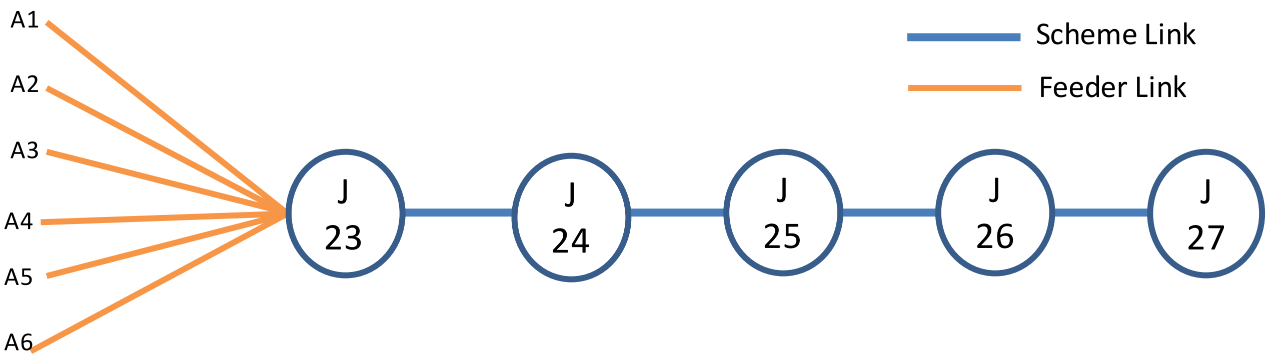
The benefits to a journey passing through a link directly associated with improvement works also depend on the amount of variability on the non-scheme links – as shorter trips tend to get more benefit than longer trips. INCA models use two types of road links to represent the whole trip length.

1. Scheme Links – Links undergoing road improvement works; and
2. Feeder Links – Links that represent the other part of the journey.

The current version of INCA has a limitation on the number of links and possible movements of a maximum of 63. For this study the INCA network was developed with the 4 scheme links and 6 feeder links resulting in 60 possible movements. The following figure shows a simplified network representation.

[19] *MM-ALR Reliability Assessment Methodology_April 2012.doc*. Developed by TAME, HA and provided by Michael Jones via email (03/04/2012).

Figure 6. M25 Section 5 INCA Network



The feeder links represent numerous model links within a given total trip length range. Finer dis-aggregation has been used for shorter trip lengths, where the sensitivity to journey time variance is highest.

The feeder link lengths are determined using the following process:

- For the trip matrices (discussed in the later sections), the corresponding trip lengths have been obtained from the Do-Minimum model;
- The scheme link lengths have been deducted from the total trip lengths, as these are included within the INCA network structure for scheme links; and
- The average trip lengths for trips within distance bands have been obtained. Each feeder link represents trips within a particular distance band.

The distance bands were chosen so as to split the overall demand into equal segments, with roughly a sixth of the trips in the shortest distance band represented by feeder link A1, another sixth in feeder link A2, etc. The following table shows the scheme and feeder links used for the M25 Section 5 INCA models.

Table 25. M25 Section 5 INCA Links

Link Name	Link Type	Distance Band (km) 2015	Distance Band (km) 2030	Link Length (km) 2015	Link Length (km) 2030
J23 – J24	Scheme Link	-	-	4.3	4.3
J24- J25	Scheme Link			8.8	8.8
J25 – J26	Scheme Link	-	-	5.9	5.9
J26 – J27	Scheme Link	-	-	7.3	7.3
A1	Feeder Link	0 - 25	0 - 25	15.7	15.6
A2	Feeder Link	25 – 45	25 – 45	34.3	34.4
A3	Feeder Link	45 - 65	45 - 75	54.4	58.5
A4	Feeder Link	65 – 115	75 – 115	87.7	93.2
A5	Feeder Link	115 – 215	115 – 225	156.7	160.0
A6	Feeder Link	>215	>225	348.2	353.8

7.2.2 Trip Matrix Development

The trip matrices have been obtained for the Do-Minimum scenario using a large number of select link analyses on the M25 Assignment Model (M25AM) for all the movements given in the following table. Traffic flows were obtained for 2015 and 2030 and for all three time periods (AM, IP and PM).

Table 26. Trip Matrices Obtained by Select Link Analysis

Direction	Origin	Destinations			
Clockwise	J23	J24	J25	J26	J27
	J24		J25	J26	J27
	J25			J26	J27
	J26				J27
Anti-clockwise	J27	J26	J25	J24	J23
	J26		J25	J24	J23
	J25			J24	J23
	J24				J23

Thus, for example, there are three select link matrices for trips moving clockwise from Junction 24: one for trips leaving the motorway at Junction 25, another for trips leaving the motorway at Junction 26 and a third for those continuing to the end of Section 5, to Junction 27 or beyond.

Trip numbers in vehicles, taken from forecasts of 'actual' flow, have been obtained by user class to enable HGV proportions to be derived. These trip numbers have been converted to AADTs for input into INCA. The AADT conversion process is consistent with other parallel analysis carried out for Section 5 (such as the environmental assessment).

7.2.3 Flow Group Definition

INCA assumes that demand flow is constant for the whole of the queue build up and decline period. As the traffic flow is input into INCA as AADT, to limit the effect of the assumption a flow group definition is used. INCA uses four flow groups which correspond to the COBA flow groups[20].

Table 27. Flow Group Definition

Flow Group	Time Period	2015		2030	
		Annualisation Factor (hrs)	Factor Hr/AADT	Annualisation Factor (hrs)	Factor Hr/AADT
1	Off Peak	5,367	0.0278	5,106	0.0270
2	Inter-peak	1,566	0.0617	1,566	0.0626
3	-	-	-	-	-
4	AM & PM Peak	1,827	0.0651	2,088	0.0618
Total		**8760**	**-**	**8760**	**-**

Table 27 presents the flow group definition used for this study. The 'Factor Hr/AADT' is applied to the AADT to calculate the hourly flow in the relevant flow group. The values of 'Factor Hr/AADT' have been derived using hourly flows from the traffic models, with those for flow group 4 duly adjusted by the observed ratio of

[20] Design Manual for Roads and Bridges – Volume 13, Part 4, Chapter 7. The INCA definitions were founded on the four flow groups of COBA10, in which AM *and* PM peaks are considered to be flow group 4. The AM and PM peak calculations continue to be grouped together here so that the proportion of HGVs in peak periods can correctly be applied to both peak periods. (Flow group 3 has not been used to separate AM peak from PM peak, as the HGV proportion for flow groups 1, 2 and 3 has to be entered as an average across all three periods, which results in a serious overestimation of the effects of delays in the AM peak in 2030)

peak-period hourly flow to peak-hour hourly flow. The factor for the un-modelled Off-Peak has been calculated to ensure that the sum of the appraised flows equal the 365 times the AADT, over the year.

The choice of flow group definition has necessitated a change to the default proportions of cars in working time. This proportion has been calculated as an average across the scheme links, using a weighted average of the AM and PM forecast model flows for flow group 4, and the interpeak model flows for flow group 2. In the absence of a model for the off-peak, it has been assumed that no cars are travelling for business purposes in the off peak period. (Although this is a conservative assumption with respect to working *cars*, it is important to note that INCA will correctly appraise the scheme impacts on *HGVs* at such off peak times – and HGVs form the majority of off-peak working traffic).

7.2.4 Incident Rates and Duration

The incident rates and duration for INCA models are based on a database of observations on existing motorways, which records the incidents, types, build up, duration and number of lanes affected. The incident rates for this study were supplied by TAME[19]. The following table presents the incident rates and durations used for this study.

Table 28. INCA Incident Rates and Durations

Incident Category	Incident Rates (incidents per million veh-km)		Duration (mins)
	D3M / D4M	MM - ALR	All
Single lane accident	0.1173	0.1640	24.6
Multi-lane accident	0.0267	0.0439	86.4
Non-HGV breakdown	0.1047	2.0350	16.8
HGV breakdown*	0.0304	0.5907	51.6
Minor Debris	0.1928	0.1972	19.6
Non-HGV Fire	0.0084	0.0450	39.4
HGV fire*	0.0014	0.0074	138.8
Load shedding	0.0025	0.0025	17.6
SL emergency Roadworks	0.0410	0.0427	241.9
ML emergency Roadworks	0.0118	0.0123	29.5
Spillage	0.0022	0.0022	46.5
Animal	0.0032	0.0052	27.0

The rates for “HGV Breakdown” and “HGV Fire” are required to be adjusted if the proportion of HGVs on the scheme link is significantly different from the COBA motorway default (12.6%). For J23 to J27 the percentage of HGVs was found to be reasonably close to 12.6%, so the two values were not adjusted.

7.3 INCA Benefit Summary

The INCA model results for opening (2015) and design year (2030) were combined by using the “Master” spreadsheet supplied by DfT. The changes in incident delays and travel time variability were monetised and discounted over a 60 year appraisal period. The following table presents the reliability benefit values discounted to 2002 and in 2002 market prices.

Table 29. INCA Summary Results for Core Scenario

Benefits	2015	2030	60 Year Appraisal Total
Delay Benefit	-£734	-£5,890	-£236,436
TTV Benefit	£9,478	£5,294	£276,788
Total	£8,743	-£596	£40,352

Notes: 1. All costs and benefits are in 2002 market prices and present values over a 60-year evaluation period expressed as £000s. 2. A negative value in the Appraisal Total column represents a dis-benefit.

The table shows that with higher incident rates and flows with the MM-ALR scheme, the delay associated with incidents rises. But it also shows considerable benefits due to the reduction in variability in journey time. This is a direct result of the reduction in congestion resulting from the additional running lane.

8. Other Scheme Impacts

This chapter considers the monetisation of other scheme impacts required for the appraisal, specifically Air Quality and Noise impacts and the outputs from the HA's Managed Motorways Operating Cost Model. It also considers Regeneration Impacts.

8.1 Air Quality Assessment

The greenhouse gases assessment has been undertaken following the procedure given in TAG Unit 3.3.5 The Greenhouse Gases Sub-Objective, April 2011 as follows:

- The assessment used traffic model output based on growth from the National Trip End Model (NTEM) version 6.2 and RTF11 forecasts of background traffic growth;
- The traffic network included in the greenhouse gases assessment has been limited to the Traffic Model Reliability Area;
- The valuation of greenhouse gas emissions used the Department for Energy and Climate Change (DECC) 'Valuation of Energy Usage and Green House Gas Emissions for Appraisal and Evaluation' published in June 2010. These are 2009 prices which have been converted to a 2002 base price and £ per tonne in carbon rather than CO2 for the greenhouse gases assessment; and
- Values are discounted over the 60 year appraisal period to 2002 values (discounted by 3.5% for years 0-30 and 3% for years 31-60).

A summary of the results and the comparison between the Low, Core and High traffic growth scenarios are presented in the following table.

Table 30. Greenhouse Gases Assessment Summary 2015-2074

GHG Assessment Parameter	Low	Core	High
NPV	-£146,897,242	-£159,203,917	-£177,041,125
Change in C emissions in Opening Year, tonnes	+14,574	+17,757	+21,113
Change in C emissions over 60 year appraisal period, tonnes	+1,377,382	+1,491,987	+1,658,080
Upper estimate of NPV	-£224,286,116	-£243,066,876	-£270,302,018
Lower estimate of NPV	-£69,508,336	-£75,340,912	-£83,780,175
Change in million Annual Vehicle kilometres over 60 year appraisal period	+23,084,081,702	+24,177,901,069	+26,809,270,286
Change in Carbon Dioxide in Opening Year, $MtCO_2e$	*+0.05*	*+0.07*	*+0.08*
Change in Carbon Dioxide in 2013-2017 (*actually 2015-2017*), $MtCO_2e$	*+0.17*	*+0.20*	*+0.23*
Change in Carbon Dioxide in 2018-2022, $MtCO_2e$	*+0.32*	*+0.36*	*+0.41*
Change in Carbon Dioxide in 2023-2027, $MtCO_2e$	*+0.37*	*+0.40*	*+0.44*
Change in Carbon Dioxide over 60 year appraisal period, $MtCO_2e$	*+5.05*	*+5.47*	*+6.08*

Money values are in £'000s and in 2002 prices, discounted to 2002.

The carbon values are now much higher than assumed at PCF Stage 2, which explains the increase in the NPV of the Greenhouse Gas emission impacts. The calculations are based on traffic forecasts for 2015, 2030 and 2040, in common with the TUBA economics. The NPV for the Core scenario is -£159m.

8.2 Noise Assessment

A noise assessment has been undertaken to estimate the noise impacts of the scheme and its mitigation measures. The method follows WebTAG guidance and the monetisation uses the same appraisal period, price base, discounting and present value year as all the other components of the economic appraisal. The results of the assessment may be summarised as:

- No. of households enjoying reduced noise in the Opening Year – 44
- No. of households suffering increased noise in the Opening Year – 596
- No. of households enjoying reduced noise in the Design Year – 510
- No. of households suffering increased noise in the Design Year – 0
- No. of people ‘annoyed’ in the Design Year (Do Minimum) - 3115
- No. of people ‘annoyed’ in the Design Year (Do Something) – 3128
- Net Present Value of Noise – -£1.259m (i.e. a dis-benefit).

8.3 Managed Motorway Operating Cost Model

The Operating Cost Model has been populated with scheme data assumptions in line with Interim Advice Note 164/12 – *The economic assessment of Managed Motorways – All lanes running*. The following three operating cost elements were extracted from the model in 2002 market prices and values[21] and reflect 60 years of operation:

- Enforcement Costs - £2.548m
- Operations and Maintenance - £13.900m
- Renewals - £6.348m
- **Total - £22.796m**

These are the incremental costs associated with operating the scheme and primarily comprise the maintenance and renewal of technology components. The enforcement costs are identified in the Cost Model as “payments to police”.

8.4 Regeneration Impacts

At PCF Stage 2 it was concluded that a Regeneration Impacts Report would not be required for this scheme. This decision was reviewed and confirmed at Stage 3, as documented in Technical Note 21[22]. Since then revised guidance has been issued[23]. This states that the need to address Regeneration Impacts remains “in line with standard procedures under WebTAG”. Consequently no additional analysis has been undertaken.

[21] Note though that the outputs were factored by 1.035 to reflect the fact that the Operating Cost Model erroneously discounts all costs by one more year than it should.
[22] *TN21: Section 5 Regeneration Impacts*. Document Reference 5084755-S5-DO-TR-185 Rev A of September 2011
[23] CHE Memorandum 276/11 - Managed Motorway Requirements of 06/12/11. See page 5 of Annex C.

9. Summary and Conclusion

9.1 Analysis of Monetised Costs and Benefits Table

The table below provides the Analysis of Monetised Costs and Benefits (AMCB) table disaggregated so that the source of each item within the AMCB can be identified. In all cases the values are those presented in the preceding chapters.

Table 31. AMCB Table Disaggregated by Source

	TUBA	COBA	QUADRO	Other	Total
Noise	-	-	-	-£1.259m	-£1.259m
Local Air Quality	-	-	-	-	-
Greenhouse Gases	-	-	£0.400m	-£159.204m	-£158.804m
Journey Ambience	-	-	-	-	-
Accidents	-	£45.350m	-£9.523m	-	£35.827m
Economic Efficiency: Consumer Users (Commuting)	£0.184m	-	Na	-	Na
Economic Efficiency: Consumer Users (Other)	£4.807m	-	Na	-	Na
Economic Efficiency: Consumer Users (All)	**£4.991m**	**-**	**-£79.310m**	**-**	**-£74.319m**
Economic Efficiency: Business Users and Providers	£436.726m	-	-£104.194m	-	£332.532m
Wider Public Finances (Indirect Taxation Revenues)	£172.927m	-	-£0.755m	-	£172.172m
Option Values	-	-	-	-	-
Present Value of Benefits (PVB)	**£614.644m**	**£45.350m**	**-£193.382m**	**-£160.463m**	**£306.149m**
Investment Costs	£108,379m	-	£0.000m	-	£108,379m
Operating Costs	-	-	-	£22.796m	£22.796m
Present Value of Costs (PVC)	**£108.379m**	**-**	**£0.000m**	**£22.796m**	**£131.175m**
OVERALL IMPACTS					
Net Present Value (NPV)					**£174.974m**
Benefit to Cost Ratio (BCR)					**2.334**

Notes: 1. All costs and benefits are in 2002 market prices and present values over a 60-year evaluation period expressed as £m.

As required by guidance, this table excludes the monetisation of the scheme's impact on journey time reliability, which is reported in chapter 7.

9.2 Conclusion

The MM-ALR scheme on M25 Section 5 can be seen to offer significant net economic benefits. The BCR is currently 2.3, which, in the absence of formal costs from the HA Range Cost Estimate, is based on the contractor's MM-DHSR based cost estimate issued in August 2011.

Appendices

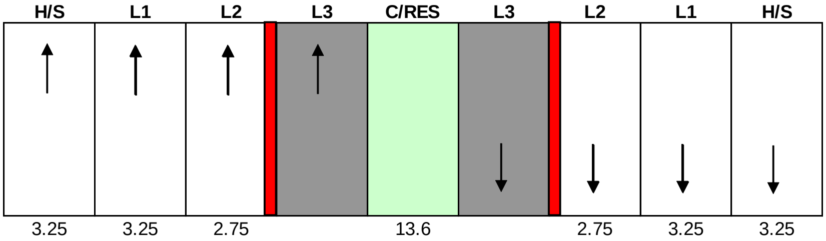
Appendix A.

QUADRO Construction Phases

M25 Section 5 - MM2 (All Lane Running) Construction Phases

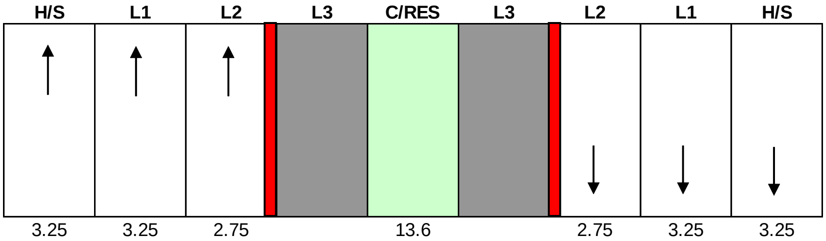
<u>Phase 1</u> (Ch 37400 - 50400) Duration 13 weeks

<u>Central Reserve</u> - <u>(24hr)</u> 13000 m



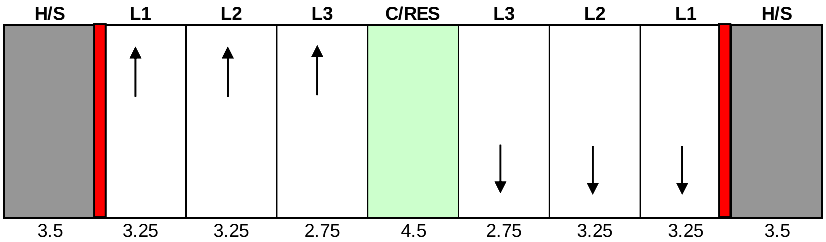
<u>Phase 2</u> (Ch 50400 - 63100) Duration 13 weeks

<u>Central Reserve</u> - <u>(24hr)</u> 12700 m



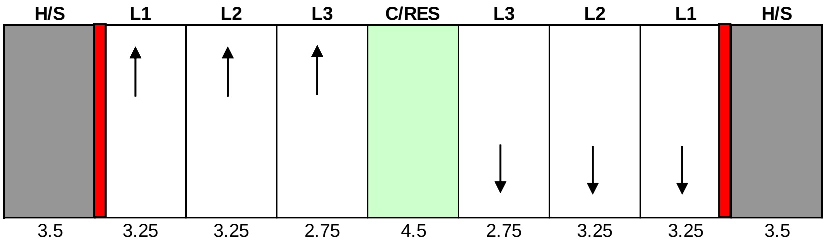
<u>Phase 3</u> (Ch 37400 - 50400) Duration 39 weeks

<u>Both Verges</u> - <u>(24hr)</u> 13000 m



<u>Phase 4</u> (Ch 50400 - 63100) Duration 39 weeks

<u>Both Verges</u> - <u>(24hr)</u> 12700 m



Notes
1. Traffic speed to be 50 mph for all phases except during the rolling block routine.
2. No requirement for cross overs or contra-flow
3. All the phases will be done in sequence, so there will be no two phases at one point of time.
4. Gantries will be erected via rolling block method, 20 mins for each, one lift per night.

[redacted]
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[redacted]