ANNEX B

MOUCHEL PARKMAN CASE STUDY: THE M25 SPHERE

(The Annexes from this case study have been removed. If required, please contact gwilliams@trl.co.uk)

TRL Project – Whole Life Cost-Benefit Analysis for Median Safety Barriers

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TRL Project – Whole Life Cost-Benefit Analysis for Median Safety Barriers

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Contents

1.0 Introduction

TRL Ltd have been commissioned by the UK Highways Agency to undertake an investigation into the Whole Life Costs associated with concrete and metal vehicle restraint systems (safety fences and barriers) in the median of UK Motorways and Trunk Roads.

The output from this work is required to support a review of Highways Agency policy on the level of containment provided in the median and the optimum products in terms of safety and cost benefit to provide this.

The output is also required to inform a review of the use of concrete barrier to support a new initiative for `Maintenance Friendly Design`. This will require the review to take particular account of all aspects of maintenance requirements for metal and concrete barriers.

2.0 Client Brief

As a result of this study, and its outlined aims and objectives, Mouchel Parkman are tasked with supplying TRL with any information relating to the following salient points:

- The number and extent of repairs as a result of accidents involving concrete and metal barrier systems;
- Repair costs per annum and for the whole life of concrete and metal barrier systems;
- The time required for the repair and maintenance of concrete and metal barrier systems and associated traffic delay costs;
- Any information relating to the severity injuries observed after impacts with concrete and metal barrier systems.

The following information is requested for the M25 motorway:

(1) The number of accidents involving concrete barriers;
(2) The number of accidents involving metal barriers;
(3) Injury severity indices for the accidents, including the number and type of injuries for accidents involving concrete barriers;
(4) As for (3), but for metal barriers;
(5) The number of repairs as a result of accidents on concrete barriers;
(6) As for (5), but for metal barriers;
(7) Repairs costs per annum for concrete barriers;
(8) As for (7), but for metal barriers;
(9) Extent of repairs for concrete and metal barriers;
(10) Traffic delay and associated costs for accidents/clear up/ repairs involving concrete barriers;
(11) As for (10), but for metal barriers;
(12) The length of concrete safety barrier installed in the median;
(13) As for (12), but for metal barriers;

All data shall be provided electronically, preferably in Word or Excel format.

3.0 The number and extent of repairs as a result of accidents involving concrete and metal barrier systems

This report reviews the number and extent of repairs as a result of accidents involving concrete and metal barrier systems for the period of the 1st January 2002 to the 31st December 2002.

Table 1.1 gives the number of incidents that have been logged by the Network Control Centre (NCC) as incidents resulting in damage to safety barriers for the period January 2002 – December 2002.

All information is recorded on the Pinnacle system (Network information database) the information gathered from site is passed through to the NCC by the emergency services, member of the public, and M25 Sphere staff.

Table 1.1

Location	**Concrete**		**Metal**		**Totals**	
	Incidents	Repairs	Incidents	Repairs	**Incidents**	**Repairs**
Nearside repairs	14	0	873	873	**887**	**873**
Central reserve repairs	36	0	784	784	**820**	**784**
Totals	50	0	1657	1657	**1707**	**1657**

Due to the nature/severity of the incident some damage to the safety barriers are called through and recorded under other symptoms such as Total closures, fatalities, oil spill etc. This has been taken into consideration and accounted for in table 1.2 under 'other' repairs. This is especially pertinent to strikes to the centre reserve and nearside concrete safety barriers. The emergency services often call these incidents through as debris in carriageway due to no noticeable damage to the barrier.

Table 1.2

Location	**Concrete**		**Metal**		**Totals**	
	Incidents	Repairs	Incidents	Repairs	**Incidents**	**Repairs**
Nearside repairs	14	0	873	873	**887**	**873**
Central reserve repairs	36	0	784	784	**820**	**784**
Other**	0	0	**	652	**	**652**
Totals	50	0	1657	2309	**1707**	**2309**

** Other barrier damage has been recorded under total closures, fatalities & other injuries on the database.

All information regarding incidents/defects on the network for the year 2002 is in Appendix A.

4.0 Repair costs per annum and for the whole life of concrete and metal barrier systems

An analysis of the maintenance

2) Repair costs per annum and for the whole life of concrete and metal barrier systems:

Table 1.3

Barrier type	Number of repairs	Costs of repair per annum	Whole Life (years)	Total costs per whole life	Comments
Concrete	0	£00.00	50	?	Whole life taken from HCD, series 400 paragraph 2 Durability
Metal	2309	£2,856,242.00	20	£57,124,842.40	
Metal	0	£93,781.38	20	£1,875,627.60	**Maintenance Lump sum activity CR4.1:** Re-tension all safety fence throughout the network once every two years
				£59,000,470.00	
+Contract price fluctuation @ 6.97%				**£4,113,167.03**	
Total				**£63,113,637**	

The actual costs in table 2.2 does not include for Traffic Management or call out charge as these are paid separately under the Lump Sum activities.

As to date MCL have not issued any works orders for repairs to concrete safety barriers.

5.0 The time required for the repair and maintenance of concrete and metal barrier systems and associated traffic delay costs

5.1 The Trunk Road Maintenance Manual

The Trunk Road Maintenance Manual: Volume 2, *1.13 Safety Fences and Barriers* states:

1.13.1 General

Maintenance of safety fences and barriers is generally confined to the repair of damaged sections and ensuring correct assembly and operation. The repair of damaged sections will usually be instigated by safety Inspections or reports from other sources and will require prompt attention in view of the likelihood of danger to road users. Maintenance Requirements are therefore more onerous than for the majority of other items within this part.

1.13.3 Maintenance Requirements

The following Maintenance Requirements are in addition to those stated in 1.1.4.

Tensioning bolts of steel tensioned safety fences shall be checked and reset to the correct torque every 2 years, preferably in conjunction with the Detailed Inspection.

Damaged sections of safety fences and barriers shall be treated as Category 1 defects unless damage is clearly superficial with no loss of integrity of the safety fence/barrier. Permanent repairs shall be carried out as soon as possible and in any case within 7 days.

5.2 Concrete barrier systems

The concrete barrier systems within M25 Sphere have to-date only suffered superficial, cosmetic damage. We cannot comment on time taken to repair this system, as the need has not arisen.

5.3 Cyclic maintenance of metal barrier system

Re-tensioning of metal safety barriers is carried out under static traffic management layouts. Near side work is carried out within either hard shoulder, or lane one closures. The closures are affected purely for this function. Central reservation re-tensioning is carried out within single or double lane closures. Seventy to eighty percent of this work is undertaken within planned closures for other maintenance works, with the balance requiring additional closures. A number of exit/entry slip require total closures with diversion routes to carry out maintenance works.

5.4 Metal safety fence repairs categories

Damage caused by vehicle impact is generally repaired with reference to the following criteria:

i. Damage requiring immediate repairs.

These sites are usually classified as such due to severely compromised fencing leading to the possibility of a crossover incident or structure strike. The geometry of the site and previous RTA history will be used to assess if damage is repaired immediately. Congestion is a major factor, with these works usually covering at least one and sometimes two peak periods.

ii. Damage requiring repair within twenty-four hours.

These sites are similar to the previous category, but where due to the extent of the damage and associated factors the decision is taken down grade the response to carrying out repairs within twenty-four hours. The decision is taken by balancing the probability of a further hit/cross-over incident against the congestion and likely rear end shunts that are likely to occur by treating site as requiring immediate repair. Availability and safety of resources are factors that need to be considered.

iii. Damage requiring repair within a week.

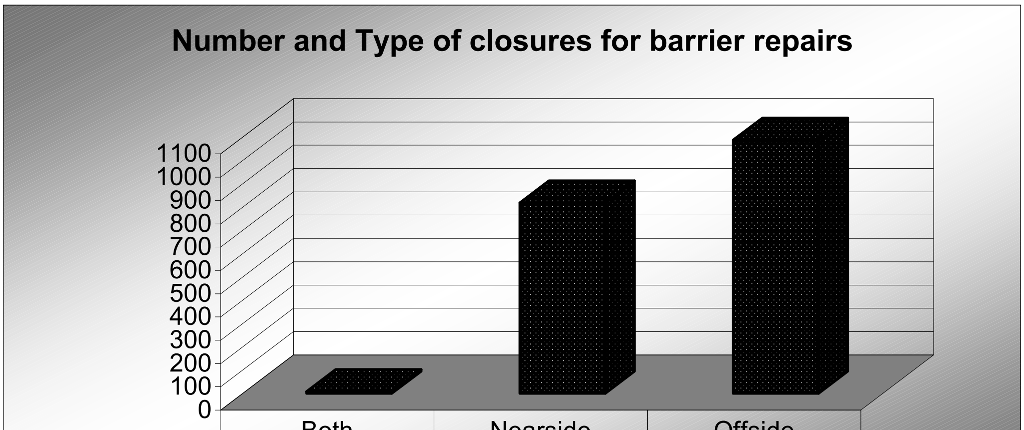
This category form the majority of damage experienced within M25 Sphere, and encompasses damage that is substantially intact and upright. Repairs are programmed as soon as road-space availability and resources allow.

iv. Superficial damage.

Repairs to damage where considered more than cosmetic necessary are programmed where possible to take advantage of traffic management layouts planned for other works or by extending layout for other barrier repairs.

As with metal safety barrier maintenance, a number of exit/entry slip require total closures with diversion routes to carry out repair works.

Table 5.41 shows the number and type of closures effected to carry out metal safety barrier repairs.



	Both	Nearside	Offside
Number	8	819	1088

Table 5.41

5.5 Associated traffic delay costs

Scope of Evaluation

A request was made to ascertain costs to road users associated with repairs to central reserve safety barriers.
There are several different types of central reserve safety barriers in use in the UK, the most common options being: vertical concrete barriers (VCB), tensioned corrugated beams (TCB), open box beams (OBB) and wire rope barriers. There are short sections of wire rope barriers in Area 5.
The VCBs require minimal maintenance and generally only require inspection after being struck by vehicles. Road user costs for these barriers may be considered to be negligible.
The TCB and OBB barriers require inspection and usually repairs after vehicle impact. Repairs take place within a few days of the damage being incurred and take place during weekday nights (generally between 2200 and 0430) and involve temporary traffic management (TTM) being applied to both carriageways using cones. Two lanes are closed in the primary direction (the side on which damage occurred) and one lane in the secondary direction. Speed restrictions of 50mph are signed and the coning normally extends over 1.8 km. In certain instances the damaged incurred or the location may represent a particular hazard and repairs need to be undertaken at other times of day.
The evaluation looked at several sample cases around the M25 motorway, involving both D3M and D4M sections of road. Road user costs were determined using the standard QUADRO program.

Description of Cases Evaluated

The selected cases are as follows:

Reference	Location	Type of Barrier	Road Standard	Period of Repair	Traffic Flow clockwise (AADT)	Traffic Flow anticlockwise (AADT)
1	J17 - J18 clockwise	OBB	D3M	Night	61,798	72,294
2	J24 - J25 clockwise	OBB	D3M	Night	65,030	64,102
3	J15 - J16 clockwise	TCB	D4M	Night	90,948	87,832
4	J24 - J25 clockwise	OBB	D3M	AM Peak	65,030	64,102
5	J15 - J16 clockwise	TCB	D4M	AM Peak	90,948	87,832

The QUADRO calculations were undertaken as follows:

- QUADRO4 program version
- Present value year 1998
- Discount rate set to 3.5% p.a.
- Road user costs are expressed in market prices (including private sector provider impacts and indirect tax revenues) and equal total impacts less public sector provider impacts
- Year of maintenance – 2004

- Period of TTM – 2200-0400 (6 hours) or 0700-0900 (2 hours) on a weekday
- Works area in centre of junction to junction link
- Works cost set to a nominal £1,000 in 1998 prices (£1,082 in 2002-04 prices) so actual cost may be factored to output PVC
- Road link specified as standard motorway with national accident rates and vehicle classification
- Works defined with standard lanes, accident/incident rates and site capacities
- No diversion route specified (maximum queuing delay of 30 minutes defined)

Results of Tests

The results of the QUADRO analyses were as follows:

Reference	Location	Road Standard	Period of Repair	Works Duration	PVC (£)	Road User Costs (£)
1	J17 - J18 clockwise	D3M	Night	6 hours	984	**317**
2	J24 - J25 clockwise	D3M	Night	6 hours	984	**660**
3	J15 - J16 clockwise	D4M	Night	6 hours	984	**442**
4	J24 - J25 clockwise	D3M	AM Peak	2 hours	984	**63,443**
5	J15 - J16 clockwise	D4M	AM Peak	2 hours	984	**70,187**

Summary

Road user costs have been evaluated for sample central reserve barrier maintenance cases using the standard QUADRO program. The current standard maintenance approach in which works take place at night during low traffic flows is seen to result in very low road user costs, principally because the available capacity is less than traffic demand.

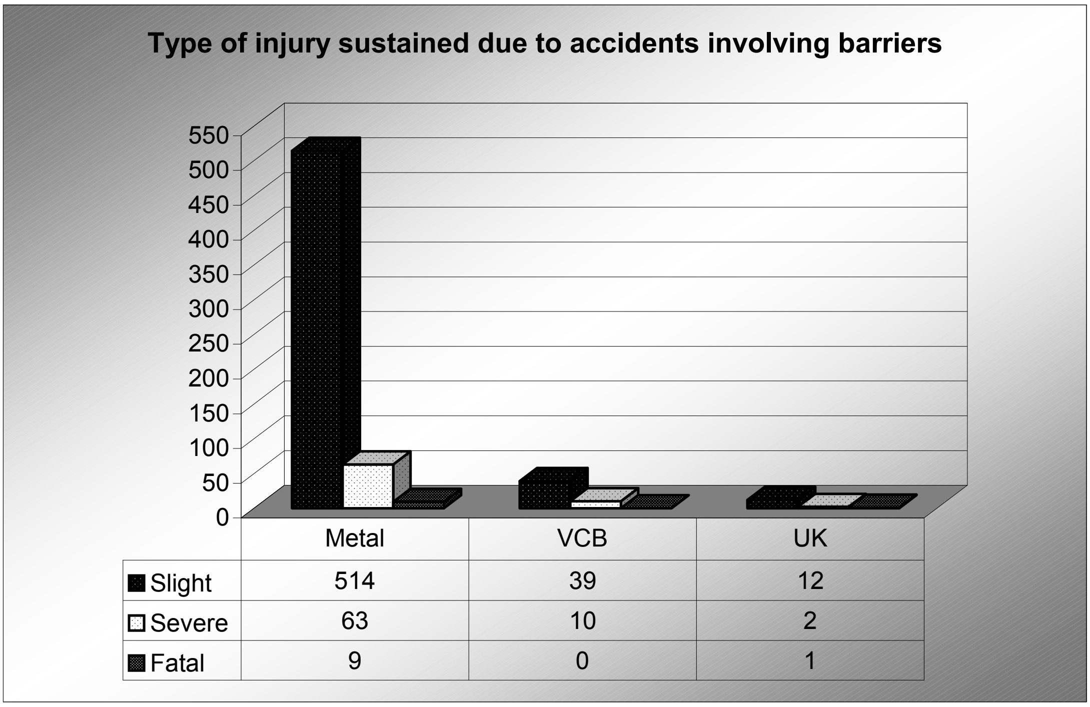
However, when some maintenance does take place at times of higher traffic flow, appreciable delays are incurred by motorists resulting in high road user costs, calculated to be at least **£60,000** for the 2-hour period evaluated, whether on D3M or D4M sections of motorway. This is primarily because demand flow exceeds available capacity through the works.

6.0 Information relating to the severity injuries observed after impacts with concrete and metal barrier systems

The police are required to record information on all reported injury accidents occurring on public roads. The details are then stored on the Stats 19 national database, with separate records for each vehicle and for each casualty involved in the accident. The severity is given separately for each casualty with the overall severity of the accident taken as that of the most serious injury.

For this study, data were required for objects hit off the carriageway. This information is held by *vehicle*. The numbers of vehicles hitting objects is greater than the number of accidents in which an object is hit. In multi vehicle accidents, safety barriers are frequently struck by more than one of the vehicles involved and therefore the number of *vehicles* hitting safety barriers exceeds the number of *accidents*. The number of vehicles hitting, for example a sign, is only slightly higher than the number of accidents in which a sign is hit. For single vehicle accidents, the numbers coincide.

A graphical representation of injuries received for various types of safety barrier used on the M25 Sphere is shown below in Table 6.1.



	Metal	VCB	UK
Slight	514	39	12
Severe	63	10	2
Fatal	9	0	1

Table 6.1

The table provides casualty data for accidents occurring on the M25 sphere for the 12-month period January 2002 to December 2002.

It is clearly obvious from the information that of the 650 total number of casualties, only 7% of these involved hitting a concrete barrier. One cannot conclude from this data that concrete barriers are safer than the metal deformable barriers, as there is a far greater length of the deformable barrier that can be hit on this network. These figures are what one could expect when considering that 95%of this network has deformable safety barriers with the remaining 5% being attributed to concrete.

Indeed, if one was to look at a simplistic factoring of the accidents, based upon lengths of barrier, then concrete barriers being hit could have comparable numbers of accidents as the deformable systems.. Obviously this is purely simplistic, and further research would need to be carried out to check the probability of the number of accidents occurring when hitting concrete barriers.

Table 6.2 below shows the number of accidents hitting various barriers nearside or in the central reserve, and also gives the length of the barriers for the network.

Barrier Type	Length (metres)	Nearside accidents	Central Reserve accidents
VCB	51050	5	24
Deformable (metal)	958736	70	341
WRSF	585	4	7

Table 6.2

There has been much debate regarding the deformable and rigid systems of safety barrier in use on UK roads, and good arguments can be made for both.

A debate was published in Transportation Professional August 2003, where the value in terms of maintenance and safety was compared between the rigid and deformable systems.

Concrete barriers would reduce the number of crossover accidents, however large vehicles can still overturn on impact. Crossover incidents are rare, but when they occur, the consequences are normally catastrophic.

Maintenance costs for rigid systems are low compared with deformable, however, the rebound is not a controlled one compared with the deformable systems.

Concrete appears to be a better solution when considering carriageway widening within existing highway boundary constraints, as they do not require the same amount of central reserve width to operate efficiently.

Appendix A – M25 Sphere Network Control Centre Log

Appendix B – M25 Sphere Safety Barrier Repair Costs

Appendix C – M25 Sphere Barrier Types By Location

Appendix D – VCB sites M25 Sphere

Appendix E – M25 Sphere Safety Barrier Closure Log

Appendix F – M25 Sphere Stats 19 Accident Data

Appendix G – QUADRO Data