Evaluating the benefits of MIDAS automatic queue protection

Steve Tucker, *Highways Agency and* ***Ian Summersgill, John Fletcher, David Mustard,*** *TRL*

This paper reports on a study of the operation of MIDAS (Motorway Incident Detection and Automatic Signalling) over a ten year period and covering a route 602 kilometres in length. The study analysed accident injury records in order to arrive at an estimation of safety benefits. In order to estimate congestion relief benefits, a relationship was developed between the delay attributed to non-recurrent congestion and AADT flow. These benefits were costed and compared with the current cost of installing MIDAS and demonstrate that the system continues to provide good value for money delivering safety and congestion benefits of over £60m per year.

INTRODUCTION

MIDAS (Motorway Incident Detection and Automatic Signalling) automatic queue protection is currently in operation on 1015 kilometres of motorway route in England. MIDAS uses induction loops spaced at 500 metre intervals in the road to detect slow moving, queueing or stationary traffic arising from an accident, incident or other cause. The system sets upstream signs automatically to show to drivers 40mph and 60mph advisory speed limits together with supplementary text messages such as 'QUEUE AHEAD' and 'QUEUE CAUTION'. This protects the back of the queue from secondary collisions. The signs are mounted either on cantilevers or take the form of individual lane signs mounted on portal gantries.

This study of 10 years of operations has shown a safety improvement of 13% and significant congestion relief benefits.

SAFETY BENEFITS

Approach

The safety benefits were estimated by analysing injury accident records covering a ten year period from January 1993. They covered 602 kilometres of route. Only those sections of motorway where MIDAS had been operating for at least six months were analysed. The analysis was based on the time series of the numbers of accidents occurring in each quarter of a year on each link (section of motorway between individual junctions).

Accident numbers are influenced by many variables other than MIDAS operation. It is necessary, therefore, to estimate the effects of changes in these variables in order to distinguish them from the effect of introducing MIDAS. The variables that were taken into account in the analysis were:

- Time trend
- Annual average daily traffic flow
- Length of the link
- Season (by quarter)
- Number of motorway lanes
- Road lighting
- Intensity of roadwork activity
- Effect of other operational systems, for example, the Controlled Motorway

The accident records that were used in the analysis were obtained from the Department for Transport (DfT) STATS19 injury accident database and these were allocated to the motorway links using TRL's Microcomputer Accident Analysis Package (MAAP) software. Estimates of annual average daily traffic flows (AADT) for each motorway link were obtained from DfT sources, whilst the link lengths were measured from 1:25,000 scale Ordnance Survey maps.

The accident records also provided information about the existence of road lighting and whether roadworks were present when an accident occurred. The proportion of accidents occurring during roadworks was used as a means of estimating the intensity of roadwork activity.

The number of lanes on each motorway link and any changes that occurred during the study period were obtained mainly from DfT and Highways Agency (HA) sources. Information about the time periods and links on which the following systems were operated were obtained from HA sources: MIDAS operating alone; MIDAS operating in conjunction with the Controlled Motorway; preliminary MIDAS

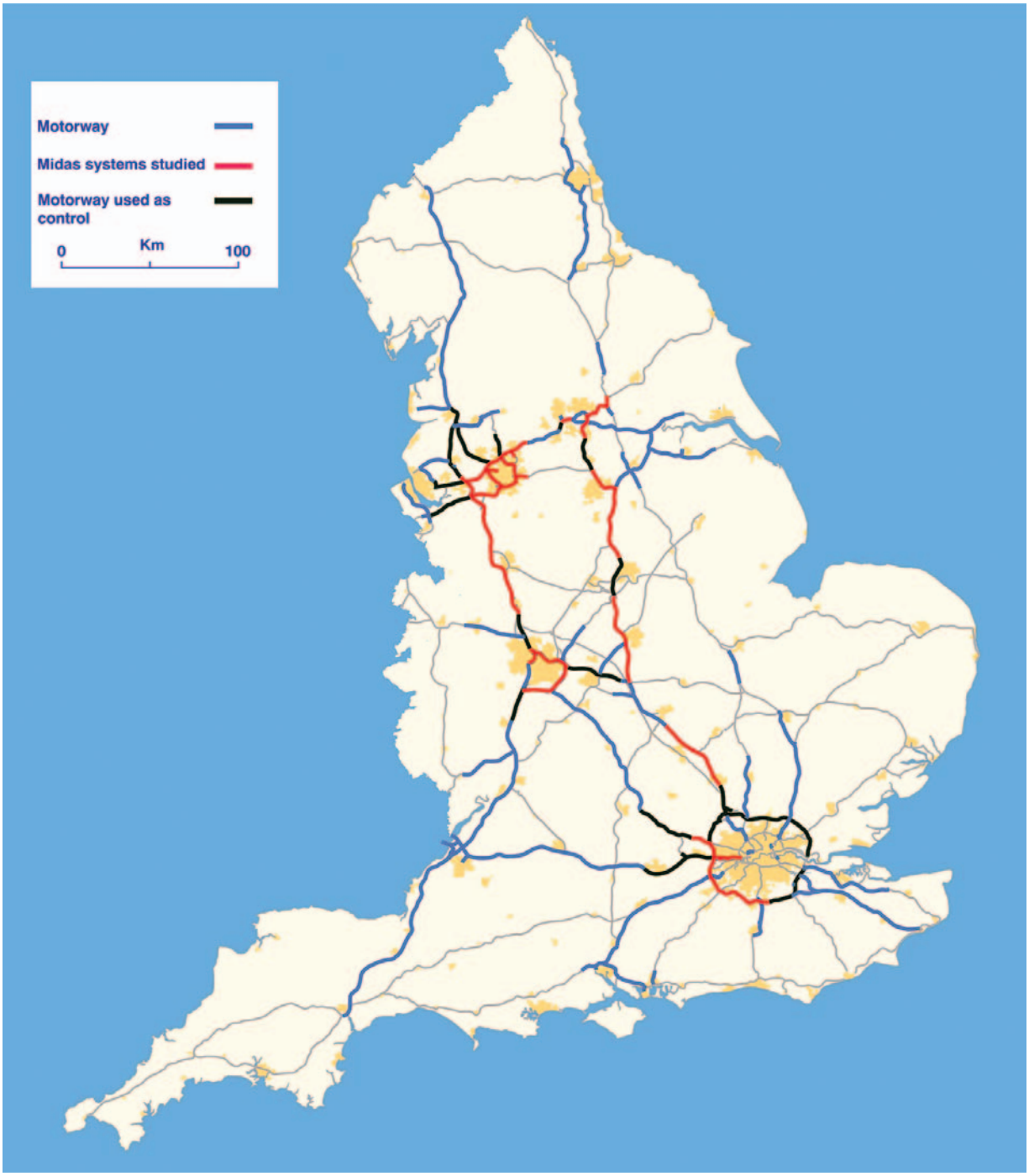

Figure 1: MIDAS systems studied

operation; Controlled Motorway operating alone; and Automatic Incident Detection (an earlier form of MIDAS) operating alone.

Additional links without MIDAS were selected to act as statistical controls and these included 592 kilometres of motorway route. Analysis of the statistical control sections showed that the relationship between accident numbers and traffic flow was substantially different to that for the MIDAS sections and, in addition, the accident severity was somewhat different. Hence the control sections are not included in the analysis presented here.

Figure 1 shows details of the MIDAS schemes that were included in the study together with those sections of motorways used as controls.

Form of analysis

The number of injury accidents that occurred during the periods when MIDAS was operated is known. This must be compared with the number of injury accidents that would have occurred if MIDAS had not been operated. This latter number is not known and can only be estimated. Thus, the benefits of MIDAS in terms of accident reduction are estimates and there is some uncertainty in the estimated values.

The estimates are obtained by assembling all of the available information to develop models which can take into account the effect of the variables (including MIDAS operation) on accident numbers.

Table 1: 'Multiplier' by accident severity for MIDAS operation

Severity	'Multiplier'		
	Lower 95%ile	Central estimate	Upper 95%ile
All injury accidents	0.81	0.87	0.93
Fatal + serious injury accidents	0.76	0.90	1.07
Slight injury accidents	0.80	0.86	0.93

Fatal accidents saved per year	9
Serious injury accidents saved per year	47
Slight injury accidents saved per year	363
Damage only accidents saved per year	3,184
Value of accident savings per km per year	£48,750
Value of accident savings per year on 800km	£39.0 million

Table 2: Estimated annual benefits of MIDAS for 800km of route

The methods of Generalised Linear Modelling (GLM), an advanced form of regression analysis (McCullagh and Nelder, 1989), were used to relate the numbers of injury accidents to the explanatory variables using the GENSTAT statistical package. The methodology is explained in Maher and Summersgill (1996).

Separate relationships have been developed for each of the 21 schemes included in the study. However, in order to eliminate unnecessary detail, only the relationships for all the schemes combined are considered in this paper.

Estimation of safety benefits

Relationships were developed for various groups of injury accidents and schemes (including those for individual schemes) during the course of the study. However, only the more important are discussed here:

- All injury accidents
- Fatal and serious injury accidents
- Slight injury accidents

The model results that are presented include central (best) estimates of the 'multiplier' representing the effect of MIDAS operating alone, together with the upper and lower limits of the 95 per cent confidence interval. The confidence interval is the range within which the true value may confidently be expected to lie. For example, a 'multiplier' of 0.87 means that there are estimated to be only 87 per cent of the accidents with MIDAS as there would have been without it (a 13 per cent reduction in injury accidents).

Attempts were made to obtain relationships between the effect of MIDAS on accidents (the 'multiplier') and AADT flow, both for all injury accidents and separately for fatal and serious injury accidents. However, the relationships varied with the form of model used to determine them and therefore they cannot be regarded as reliable. In the remainder of this article it is assumed that the MIDAS 'multiplier' does not vary with AADT flow.

Table 1 (previous page) shows the 'multiplier' by accident severity for MIDAS operated alone. For all injury accidents combined, the 'multiplier' has a central (best) estimate of 0.87 with a 95 per cent confidence interval ranging from 0.81 to 0.93. For fatal and serious injury accidents combined, the 'multiplier' has a central (best) estimate of 0.90 with a 95 per cent confidence interval ranging from 0.76 to 1.07. For slight injury accidents, the 'multiplier' has a central (best) estimate of 0.86 with a 95 per cent confidence interval ranging from 0.80 to 0.93. It can be seen that the 95 per cent confidence interval for the fatal and serious injury accidents combined is larger than for either slight injury accidents or all injury, since there are relatively few of the former (about 11 per cent of all injury accidents).

AADT flow (veh per day)	Number of injury accidents per km per year	
	No system	MIDAS
80,000	3.11	2.71
100,000	3.75	3.26
120,000	4.36	3.79
140,000	4.95	4.31
160,000	5.54	4.82
180,000	6.11	5.32

Table 3: Number of injury accidents per kilometre per year

The proportional reductions ('multipliers') in accident numbers attributable to MIDAS operation have been described. However, in order to estimate the reductions in the absolute numbers of accidents it is necessary to estimate the numbers of accidents to which the proportions apply.

The method that has been adopted is that of estimating the average number of injury accidents per kilometre per year on the schemes in 2003.

The value was 3.50 injury accidents per km. It can therefore be estimated that the number of injury accidents per km would have been expected to have been 1/0.87 times as great if MIDAS had not been operational. This gives a value of 4.02 injury accidents per km.

It would also be possible to obtain similar estimates separately for fatal and serious injury accidents and for slight injury accidents. However, there are relatively few of the former and hence the national (GB) accident statistics for motorways in 2003 (Department for Transport, 2004a) were used to estimate the proportions of fatal, serious and slight injury accidents per km per year. These were: fatal (2.10 per cent), serious (11.23 per cent) and slight (86.67 per cent). On motorways there are estimated to be 7.6 damage only accidents for each injury accident (Design Manual for Roads and Bridges, 2004).

The average economic values (Department for Transport, 2004a) for the prevention of motorway accidents at 2003 values and prices were: fatal accident (£1,630,430); serious injury accident (£195,150); slight injury accident (£23,500); and damage only accident (£2,080).

Table 2 presents the estimated overall annual benefits of MIDAS operation for the 800 kilometres of route on which it operated at the time of the study.

There are two important questions that need to be assessed to which the study has provided answers:

- Which sections of motorway have provided the greatest accident reductions?
- Which sections would be likely to provide the greatest benefits from future MIDAS provision?

In order to answer these questions, it is first necessary to determine the relationship between the number of injury accidents and AADT traffic flow. The relationships are presented in Table 3.

The monetary value of accident reductions according to the AADT flow can be estimated based on the assumptions set out previously. These are presented in Table 4.

Table 4 shows that the value of accident savings attributable to MIDAS varied from about £38,000 per km per year for a section of motorway carrying an AADT flow of 80,000 vehicles per day to about £74,000 per km per year for a section of motorway carrying an AADT flow of 180,000 per day.

CONGESTION RELIEF BENEFITS

Approach

An estimate has been made of the congestion relief benefits of MIDAS automatic queue protection. The approach used has been to develop a relationship between the delay attributable to non-recurrent congestion and AADT flow. Non-recurrent congestion is defined to be that which is not due to the volume of traffic, but to incidents and roadworks.

The non-recurrent delays were calculated using journey times derived from MIDAS loops. Journey times from this

source are available for 2003 and 2004 separately for each carriageway of each link. On average, non-recurrent delay made up 25 per cent of all delay. Relationships between non-recurrent delay and AADT flow were derived from this data using regression analysis.

The proportion of non-recurrent delay that is attributable to accidents is estimated to be 60 per cent based on the results of other unpublished studies. Delays caused by accidents are therefore estimated to form 15 per cent of all delays on motorways.

It has been assumed that the secondary accidents that MIDAS automatic queue protection prevents would generate the same delay per accident as primary accidents produce.

These various components were combined to estimate the relationship between the congestion relief benefits of MIDAS and AADT flow.

Estimation of congestion relief benefits

It has been estimated that MIDAS automatic queue protection reduces accidents by 13 per cent. If it is assumed that each accident prevented by MIDAS (secondary accident) would on average have contributed the same amount of delay as a primary accident, then the estimated congestion relief benefit of MIDAS is 13 per cent of 60 per cent of non-recurrent delay (7.8 per cent). Similarly, the estimated congestion relief benefit of MIDAS is 13 per cent of 15 per cent of total delay (2.0 per cent).

The average cost of a vehicle-hour of delay was obtained from the DfT (Department for Transport, 2004b) and was £11.28 at 2002 market prices. This was used to convert the reductions in delays to monetary values.

Table 5 shows the estimated overall annual congestion relief benefits of MIDAS, for the 800km of route on which it operated at the time of the study. The estimate of the congestion relief benefit per km per year (veh-hr) was obtained using the relationships between congestion relief benefit and AADT flow. This was converted to a monetary value using the figure of £11.28 per veh-hr. The estimates for 800km of route were obtained by multiplying the benefits per km by 800.

Table 6 summarises the estimated congestion relief benefits per year per kilometre of motorway in relation to AADT flow.

CURRENT POSITION

The study has estimated that, on average, the safety benefit of MIDAS automatic queue protection had a value of £49,000 per km per year of motorway route. The associated congestion relief benefit had a value of £11,000 per km per year at the time when the study was conducted. The corresponding value of accident savings on the 800 km on which MIDAS was then operated was £39 million per year and the associated delay savings were £9 million per year.

The benefits were dependent on the traffic flow, so that on a busy motorway carrying 180,000 vehicles per day, the safety benefits were estimated to be £74,000 per km per year together with congestion relief benefits of £30,000 per km per year.

MIDAS studied here was provided as part of a package of improvements, such as the provision of new message signs and new fibre cables, over a number of years. As these works have varied between schemes it is not possible to give a precise cost for just MIDAS. However recent installations indicate that MIDAS costs are in the order of £210,000 per km, which demonstrates that MIDAS continues to provide good value for money. MIDAS is currently operated on over 1000km of motorway route delivering safety and congestion benefits of over £60m per year.

Two-way AADT (vehicles per day)	Value of accident savings (£ per year per km of route)
80,000	£38,000
100,000	£45,000
120,000	£53,000
140,000	£60,000
160,000	£67,000
180,000	£74,000

Table 4: Value of accident savings of MIDAS per km per year by daily traffic flow

REFERENCES

MCCULLAGH P AND NELDER J A (1989). Generalised Linear Models. Chapman and Hall, London.

MAHER M J AND SUMMERSGILL I (1996). A comprehensive methodology for the fitting of predictive accident models. Accident Analysis and Prevention, Vol 28, No 3, pp281-296. Pergamon Press, London.

DEPARTMENT FOR TRANSPORT (2004a). Road Casualties Great Britain 2003. Annual Report. The Stationery Office, London.

DESIGN MANUAL FOR ROADS AND BRIDGES (2004). ECONOMIC ASSESSMENT OF ROAD SCHEMES: THE COBA MANUAL. Vol 13, Section 1. The Stationery Office, London.

DEPARTMENT FOR TRANSPORT (2004b). Values of Time and Operating Costs: TAG Unit 3.5.6. Transport Analysis Guidance (TAG). Available from: www.webtag.org.uk.

This paper has been produced by the authors and is based on work carried out by TRL Limited under contract for the Highways Agency. Any views expressed in it are not necessarily those of the aforementioned organisations.

The authors

The correspondent author,Steve Tucker, Highways Agency, can be contacted on +44 (0) 117 372 8225 or by email. Ian Summersgill, John Fletcher and David Mustard are all with TRL .

Table 5: (below) Estimated annual congestion relief benefits of MIDAS for 800km of route

Congestion relief benefit per km per year	1000 veh-hr
Congestion relief benefit per year on 800km	800,000 veh-hr
Value of congestion relief benefit per km per year	£11,300
Value of congestion relief benefit per year on 800km	£9 million

Table 6: (bottom) Estimated congestion relief benefits of MIDAS per km per year by daily traffic flow

Two-way AADT (vehicles per day)	Congestion relief benefits	
	(veh-hr per year per km of route)	(£per year per km of route)
60,000	390 veh-hr	£4,400
80,000	590 veh-hr	£6,700
100,000	850 veh-hr	£9,600
120,000	1,170 veh-hr	£13,200
140,000	1,550 veh-hr	£17,500
160,000	2,020 veh-hr	£22,800
180,000	2,600 veh-hr	£29,300