The accident records of twenty five high-speed traffic signal junctions that had been converted from Speed Assessment (SA) or Speed Discrimination (SDE) control to MOVA with no other changes were assessed. As in an earlier study, the results showed no significant difference in the frequency of personal injury accidents between MOVA and SDE/SA control. However, the quality of the MOVA configuration data was shown to have a bearing on safety. The configured free flow speed (‘cruise speed’) appeared to have the greatest effect on safety. Developments to MOVA are proposed to improve the ease with which the configuration data is specified, including on-line facilities to measure cruise speeds and saturation flows.

INTRODUCTION

In the UK it is a requirement that isolated traffic signals on high speed roads (where the 85th percentile speed exceeds 35 mph) are installed with speed detection equipment (Speed Assessment (SA) or Speed Discrimination (SDE)) or MOVA (Microprocessor Optimised Vehicle Actuation). Speed Assessment and SDE attempt to find a suitable stage change time that avoids drivers having to make a difficult decision of whether to stop or continue in the face of an amber signal, often referred to as the ‘dilemma zone’. Although MOVA was not implicitly designed to do this, the strategy inherently reduces red-running through its stage change decisions and in an earlier study it has been found to be at least as safe as SA or SDE. Also importantly MOVA has proven to significantly reduce vehicular delay and increase junction capacity.

TRL was commissioned by the Department for Transport to further investigate the safety of MOVA traffic signal control at ‘high-speed’ junctions. It should be noted that any views expressed are those of the Authors and they do not necessarily reflect the views of the Department for Transport.

MOVA requires configuration data, some of which needs to be measured on-site by observers prior to its installation and should be validated once MOVA is running. TRL provides a software package called ‘Bundle’ which can be used on a palmtop or a laptop to aid collection of on-site data. Configuration data includes measurements of vehicle speeds (to derive ‘cruise speed’, in MOVA this is the 15th percentile speed of vehicles approaching the signals on green in free flow conditions) and ‘saturation flows’ (average rate of vehicle discharge across the stopline from a continuous queue). These are used by MOVA to model vehicles position approaching the stopline and discharging across the stopline. The thrust of this work was to consider whether the quality of the MOVA configuration data has an influence on safety.
BACKGROUND

MOVA is a traffic signal control strategy designed for isolated (uncoordinated) junctions. It has been installed at about 15% of isolated signal controlled junctions in the UK, and installation rates remain healthy. The main reason for the existence of MOVA and its widespread use is its extremely effective control of traffic at isolated signal controlled junctions.

In uncongested situations MOVA operates in a delay minimising mode; MOVA monitors traffic flows and pedestrian demands on all links, and estimates the costs and benefits of continuing the current stage green once the end of saturation flow has been reached. In congested situations MOVA operates in a junction capacity maximising mode and no longer checks for the end of saturation flow in the normal way; instead, it assesses the efficiency of use of the green and decides whether capacity is likely to be maximised by continuing the green or not (Vincent at al, 1990).

MOVA has proven to be significantly better than standard Vehicle Actuation (VA) traffic signal control in terms of junction capacity and vehicular delay. It is estimated that MOVA reduces delays by over 13% compared to junctions under VA control together with significant increases in capacity (Peirce and Webb, 1990).

For some years now, MOVA has been the standard control strategy for new and refurbished trunk road sites (TD 35/91 All purpose trunk roads MOVA system of traffic control at signals). And the recently published Traffic Advisory Leaflet for Signal-control at junctions on high-speed roads (TAL 2/03) allows MOVA to be installed as an alternative to VA with SA or SDE on high-speed roads.

Early studies showed that MOVA can reduce red-running substantially, and an improvement in safety was also indicated when a study of four high-speed sites gave a 30% reduction in injury accidents compared with traditional methods of control on high speed sites, VA with SA/SDE, although only statistically significant at the 10% level.

A later unpublished MOVA safety study, completed in 2001, looked at the accident records of 31 high speed sites that had been converted to MOVA from VA with SA/SDE. MOVA was found to be as safe as VA with SA/SDE, but no more than that. Better was expected, and this new study was commissioned to consider the reasons for the lack of improvement.

STUDY OBJECTIVES

This assessment of MOVA safety on high-speed roads was based on the 31 sites studied in 2001. The previous study primarily looked at accident rates, this study also attempted to assess whether or not the quality of the MOVA configuration data had an influence on safety. The underlying objectives were as follows:

- Assess the quality of the MOVA configuration data at the 31 sites.
- Assess whether there is a link between the quality of the data configured and the accident rates shown.
- Assess whether there are other common factors that explain the accident rates.
- Consider the implications of the findings in regards to the advice currently given about the application of MOVA and whether changes are needed or not.

STUDY METHODOLOGY

Of the 31 sites in the previous study 25 were used in the current study. The others had undergone changes that prevented their inclusion. Up-to-date accident data from before and after the installation of MOVA was analysed. Generalised linear modelling was used to determine the statistical significance of differences between the forms of signal control over the 15 year accident period, taking into account general accident trends over the period and
seasonal factors. The analysis was carried out using the GENSTAT computer program (Alvey et al, 1977).

In order to assess whether or not the quality of the MOVA configuration data had an influence on safety, a sample of the data required to configure MOVA was collected at each site. The sample data was compared with the MOVA data in use and a score was deduced based on the comparison. In addition, further assessments were made of the MOVA data, including the link-lane structure, detector configuration and bonus data (normally used for flared approaches) by TRL experts.

Additional work included an estimation of the consistency of cruise speed measurements by time-of-day and observer, and a questionnaire to the Highway Authorities involved in this study.

RESULTS

Table 1 shows the raw accident data under each form of signal control.

<table>
<thead>
<tr>
<th>Accident group</th>
<th>VA</th>
<th>MOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junction years</td>
<td>124.0</td>
<td>156.25</td>
</tr>
<tr>
<td>All accidents</td>
<td>628</td>
<td>777</td>
</tr>
<tr>
<td>Serious and fatal</td>
<td>97</td>
<td>110</td>
</tr>
<tr>
<td>Slight</td>
<td>531</td>
<td>667</td>
</tr>
<tr>
<td>Severity (% fatal or serious)</td>
<td>15.4%</td>
<td>14.3%</td>
</tr>
<tr>
<td>All accidents per junction per year</td>
<td>5.06</td>
<td>4.97</td>
</tr>
<tr>
<td>Serious and fatal accidents per junction per year</td>
<td>0.78</td>
<td>0.70</td>
</tr>
<tr>
<td>Slight accidents per junction per year</td>
<td>4.28</td>
<td>4.27</td>
</tr>
</tbody>
</table>

Overall, there was no significant difference in the personal injury accident frequency between MOVA and VA with SA/SDE and MOVA at the signal junctions studied i.e. the previous result stands that MOVA is at least as safe as the traditional method of control. Table 2 shows the overall results for the 25 junctions after using generalised linear modelling to take account of general accident trends and seasonal factors; it indicates that MOVA was slightly worse for the ‘all-accident’ group, but better for accidents involving two or more vehicles. However, as stated, none of the results were statistically significant.

<table>
<thead>
<tr>
<th>Accident group</th>
<th>Ratio of effect of MOVA to effect of VA</th>
</tr>
</thead>
<tbody>
<tr>
<td>All accidents within 100m</td>
<td>1.07</td>
</tr>
<tr>
<td>Junction accidents</td>
<td>1.01</td>
</tr>
<tr>
<td>Two vehicle junction accidents</td>
<td>0.93</td>
</tr>
</tbody>
</table>

‘All accidents’ are defined as personal injury accidents occurring within 100m of the junction; ‘Junction accidents’ are those occurring at the junction or within 20m on any of the arms; ‘Two-vehicle junction accidents’ are those occurring at the junction or within 20m on any of the arms and involving two or more vehicles.

The sites were then split into two groups according to the scores allocated for quality of MOVA dataset and layout configurations, without prior reference to the accident frequency. The group with the highest scores had a lower accident frequency under MOVA than under
VA with SDE/SA. Table 3 shows the results. The difference was statistically significant at the 5% level for junction accidents and for two vehicle accidents. The differences were 19% for all accidents within 100m of the junction, 26% for junction accidents and 29% for two-vehicle junction accidents.

Table 3. Estimated effect of MOVA compared with VA for 8 higher scoring sites

<table>
<thead>
<tr>
<th>Accident group</th>
<th>Ratio of effect of MOVA to effect of VA</th>
</tr>
</thead>
<tbody>
<tr>
<td>All accidents</td>
<td>0.81</td>
</tr>
<tr>
<td>Junction accidents</td>
<td>(0.74^*)</td>
</tr>
<tr>
<td>Two vehicle junction accidents</td>
<td>(0.71^*)</td>
</tr>
</tbody>
</table>

* Significant at the 5% level

The modelling results for the remaining group of lower scoring sites showed an increase in accident frequency with MOVA compared with VA, of 20% for all accidents within 100m of the junction, 15% for junction accidents and 3% for two-vehicle accidents at the junction. The increase for ‘All accidents’ was statistically significant at the 5% level.

Table 4. Estimated effect of MOVA compared with VA for 17 low-scoring sites

<table>
<thead>
<tr>
<th>Accident group</th>
<th>Ratio of effect of MOVA to effect of VA</th>
</tr>
</thead>
<tbody>
<tr>
<td>All accidents</td>
<td>(1.20^*)</td>
</tr>
<tr>
<td>Junction accidents</td>
<td>1.15</td>
</tr>
<tr>
<td>Two vehicle junction accidents</td>
<td>1.03</td>
</tr>
</tbody>
</table>

* Significant at the 5% level

Further investigation was undertaken to try to identify the elements of the site configuration that had most effect on accident frequency. The ‘stop penalty’ (weighting for the cost of delay based upon cruise speed and proportion of large vehicles) and the link/lane structure showed little correlation with high scoring sites. Sites with good estimates of saturation flows tended to have high scores, but the correlation was only about 27%.

Cruise speeds showed the highest correlation with a value of about 70%. However, they did not offer any better discriminatory power than the overall score for the configuration. It did not prove possible to say whether under or overestimating the cruise speed was better, since only 3 of the sites included in the accident analysis had speeds underestimated compared with the measured data.

Other variables tested were:

- The number of stages (2 or 3 stages, more than 3 stages)
- Whether or not the junction was on a trunk road
- Whether the junction was on a single or dual carriageway
- Whether or not the junction was in Greater London
- Whether the junction was in urban or rural (speed limit \(\leq 40\) miles/h; \(> 40\) miles/h)

The analysis was undertaken for each variable separately by grouping the data into two mutually exclusive subsets of junctions with and without the feature. Accident frequency differed between subsets, but no statistically significant difference in accident frequency was found between MOVA and VA control for any of these subsets.

Five of the sites were re-visited by MOVA experts, three that had a poorer safety record under MOVA and two with a better record, to see if factors affecting the safety that were relevant to
MOVA could be seen. Issues concerning MOVA were observed, but nothing that could be related to safety in any direct sense.

A review of accidents was also undertaken for the original 4 high speed sites that had led to the earlier tentative conclusion that MOVA was safer than VA. Overall a slight upward trend in accidents was found. However, it seems reasonable to suggest (if not conclude) that the original good showing (30% reduction in personal injury accidents) has been largely maintained.

CRUISE SPEED MEASUREMENT CONSISTENCY

MOVA uses the cruise speed measurement to model the approximate position of each vehicle on each approach that is currently green. This information, together with knowledge of vehicles waiting on red, is used in deciding exactly when to change the signals. If the cruise speed is significantly in error, MOVA may decide that the signals can change ‘now’ possibly asking a driver to make an awkward decision about whether to stop or continue. It should be noted that the MOVA logic allows quite a large degree of tolerance in this process and there should not normally be a problem.

However, the results of this survey raises the question of how easy cruise speed is to measure and how consistent the results might be. To gain some idea of the consistency of recorded cruise speed measurements, several surveys were taken at a single location as follows:

i. Single person measuring six separate sets of data over a period of about two hours
ii. Three observers taking measurements at the same time, over the same distance, but free to decide for themselves which vehicles to measure
iii. As for ii but all three observers measuring the same vehicles

The results showed little variability between observers, however there was some variability between the time of day measurements (the lowest value being 12.9 ms\(^{-1}\) and the highest 15.1 ms\(^{-1}\)). The time difference in a stage change decision made by MOVA due to a 2 ms\(^{-1}\) difference at about 14 ms\(^{-1}\) would be about 1 second. This is judged to be acceptable, any greater than that probably would not be.

It is clear from the datasets assessed in this study that there might be a problem in measuring cruise speed. However, all the sites investigated were commissioned relatively early on in MOVA’s life and, at the time, cruise speeds did tend to be overestimated. Experience from the early days, and the observed effects of having cruise speeds too high, has resulted, it is thought, in more realistic speeds being used since then.

HIGHWAY AUTHORITY QUESTIONNAIRE

Each of the five highway authorities having responsibility for the sites in this study was sent a questionnaire and four responded. The purpose of this exercise was to find out how the sites were set up originally and how they are set up now.

It was found that in-house staff, mainly at senior level, were nearly always used for the sites in question. Some local authorities used junior staff now. All those involved had received training of some kind. MOVA was not installed for any direct safety benefits (although some junctions were signalised or changed for that reason).

When asked how cruise speeds and saturation flows were measured, a variety of answers were given. Cruise speeds were often measured upstream, with speed guns or with observers being highly visible (and likely to affect speeds). Very occasionally, speeds were determined by ‘educated guesswork’. Saturation flows were usually estimated using RR67 (Kimber et al, 1986).
CONCLUSIONS

This work considered whether the quality of the MOVA configuration data has an influence on safety. The accident records of twenty five high-speed sites that had been converted from SA or SDE to MOVA with no other changes were assessed. As in an earlier study, the results showed no overall significant difference in personal injury accident frequency when running MOVA compared to SDE/SA.

However, the quality of MOVA data appears to have a bearing on the safety of the junction. Junctions with better quality configuration data had lower accident rates under MOVA compared to SA/SDE, while those with ‘poor’ configurations had higher rates. There was an indication that cruise speed data has the greatest effect on safety, but it was not possible to distinguish between overestimating and underestimating speeds in that respect.

The sites considered in this study represent the earlier MOVA installations. Current practice in configuring and setting up MOVA sites could well be such that there are fewer ‘poor’ installations now. It is especially noticeable that the industry has adopted the view that cruise speeds need to be realistic, but to err on the low side. Therefore, it could be the case that the majority of MOVA sites have a reasonable standard of configuration data. However, it is acknowledged that there is scope for improving the ease with which the configuration data is specified.

RECOMMENDATIONS

Steps should be taken to reduce the incidence of poor MOVA configuration data. For TRL this includes:

- Dissemination of the results;
- Development of the online measuring facilities for saturation flow and cruise speed;
- Improvements to ‘MOVA Setup’ (the MOVA configuration data creation program);
- And a review of TRL’s MOVA guidance.

Much of this work is being undertaken as part of the MOVA Development Group and as part of ongoing MOVA maintenance and upgrades.

ACKNOWLEDGEMENTS

TRL are grateful for the assistance of the Local Highway Authorities involved and Transport for London, and also to the Department for Transport for funding this project.

REFERENCES


TD 35/91. All purpose trunk roads MOVA system of traffic control at signals. Department for Transport, August 1991.
