TRIAL AND EVALUATION OF INTELLIGENT ROAD STUDS FOR HAZARD WARNING

Linda O’Connor
Joanne Casey
Faber Maunsell

1 INTRODUCTION

This paper details the impact and effectiveness of Intelligent Road Studs (IRS) installed on the M8 in Scotland to provide delineation for motorists in poor visibility conditions and to flash as a warning when incidents are occurring downstream. This is similar to the COMPANION hazard warning system installed on the A90 but it is considered that IRS may offer a more cost effective solution.

The evaluation therefore sought to ensure technical competence of that the IRS are technically competent and have a similarly positive impact on motorists as the COMPANION system. The results from the evaluation show that the system was available for 96.4% of the trial period, although 3% of the unavailability was due to system maintenance. The evaluation also shows that all the speed activations took place when appropriate and that fog activations show a good correlation with independent meteorological data.

Feedback regarding the system has been positive with the only negative point mentioned being that the studs are too bright at night time. This was addressed by a retrofit dimming facility. Further, the activation of the flashing studs resulted in a decrease in speed, headway and lane change manoeuvres.

It is considered that the system should be transferable to other EU countries, subject to regulations about the use of studs and colours. The Highways Agency is currently investigating IRS applications on their network.
2 BACKGROUND

2.1 The COMPANION Hazard Warning System

The Scottish Executive installed a COMPANION system on the M90 approaching the Forth Road Bridge in 2000. This system proved useful in reducing vehicle speeds and in providing a safer road on which to drive. However, despite the recognised benefits that COMPANION could offer in other applications around the network, the COMPANION system is relatively expensive and requires the installation of obtrusive infrastructure.

Astucia supply a system of Intelligent Road Studs (IRS) which have the potential to provide the same functionality as COMPANION at a reduced price and with less obtrusive infrastructure.

The Scottish Executive therefore decided to trial the IRS and compare their impact on traffic speeds and behaviour with the impact of COMPANION to determine if the IRS would offer a feasible solution to routes where problems are caused due to secondary incidents or due to poor visibility.

2.2 Selection of Trial Site

A site was sought that would allow the IRS trial to offer a genuine benefit to the network as well as providing the opportunity to evaluate the effectiveness of the ITS in improving road safety. For this, a number of criteria were considered with Trunk Roads categorised into those with NADICS power and communications infrastructure, those with non- NADICS power and communications infrastructure and those with no existing power or communications infrastructure.

Based on the costs involved in providing new power and communications infrastructure, it was concluded that any trial must be undertaken on a site with existing infrastructure of adequate quality.

To maximise the benefits derived from implementing IRS, each possible trial site was ‘scored’ in relation to the existing Infrastructure (including street lighting), recurrent congestion, meteorological conditions (fog/ice), road alignment and topography, visibility, historical accident/incident data and above average rate of secondary incidents.

It was also considered desirable to select a site that was under-provisioned in traffic detection and driver information infrastructure. Following this assessment criterion, the site selected was the M8 westbound between Juncions 5 and 6. Figure 2.1 shows the extent and layout of the selected site.

2.3 Issues Addressed

It was anticipated that the provision of IRS would increase the safety and efficiency of the section of road network where installed. These issues would be considered in the context of their ability to provide a feasible and more affordable alternative to the COMPANION system which could be installed at suitable sites in the future.
Figure 2.1 – IRS Installation Site
3 THE INTELLIGENT ROAD STUD SYSTEM

3.1 System Functionality

IRS are a cost effective form of technology which can potentially contribute to providing safer roads, reliable journeys and informed travellers. To do this, IRS can combine detection and warning to give new forms of information and warning in a more targeted manner to drivers (e.g. examples of breaking distances).

All these are made possible as IRS is able to enhance lane markings and separation; detect the number, speed and classification of vehicles; detect incidents and provide warning of hazards ahead; and monitor weather.

3.2 Project Timescale

The system has been installed and successfully underwent the SAT (Site Acceptance Test) in January 2005. It is now operating automatically on the network and performs two main functions. Firstly it detects poor visibility due to fog and heavy rain and will provide delineation when these conditions are detected. The system also detects traffic speeds and when traffic slows down to 25mph or less, it flashes in a similar manner to the COMPANION system. It is anticipated that this will result in drivers slowing down and act as a warning that something may be happening downstream.

The system also has light sensors in order that the brightness of the studs can be altered allowing brighter levels of illumination during daylight so that the studs can be clearly seen and dimmer brightness levels at night time so that the studs are not too dazzling. This was a retrofit functionality for the system.
4 EVALUATION

4.1 Introduction to the Evaluation

The system has been in place and automated since early 2005. The evaluation however has been held back until August 2005 as initially the system received poor publicity (further discussed in section 3.8 under “User Acceptance”) which suggested that it was to be used for speed enforcement. It was considered prudent therefore to allow a settling in period for the system to allow drivers’ behaviour to return to normal (as it was assumed that initially drivers would be slowing down due to their perception of the system’s application following the press coverage). Also, following the initial operation of the system it was considered that the studs were too bright at night time and could be distracting to drivers. Therefore a dimming facility was ordered as a retrofit application and it was agreed to postpone the evaluation until this had been added to the system.

The primary objectives of the evaluation were to allow comparison with the COMPANION system in terms of the system’s impact on driver behaviour including driver speeds, and to determine public opinion of the system.

The COMPANION system proved to be successful in reducing traffic speeds and hence creating a safer driving environment on the approach to the Forth Road Bridge. The IRS system potentially offered the same benefits in a manner that would be more practical for many locations around the network due to the less obtrusive infrastructure. There is the potential that the IRS could be integrated in the Design Manual for Roads and Bridges (DMRB) and MCDHW allowing them to be installed as standard infrastructure.

The IRS were installed on the M8 westbound between junctions 6 and 5 as shown in Figure 1. Information leaflets were therefore distributed in the shopping centres at Braehead and The Fort, at the Bellshill Service Station, the Harthill Service Station and the Harthill truck stop.

It was anticipated that the IRS would have the same impact on traffic as the COMPANION system. In other words it is assumed that when the IRS are flashing they will result in drivers slowing down, fewer lane change manoeuvres, accident statistics will improve and the public will like or at least, not dislike, the system.

4.2 Methodology for Evaluation

To evaluate the performance of the system it was determined that the technical performance, the user acceptance and the impact of traffic speeds and behaviour should be the main parameters. Accident figures would also be considered but there has not been a long enough period following installation of the system to assess this.

In order to evaluate the technical performance, information was provided by Astucia about the system availability providing reasons for system downtime. Information received from Astucia allowed the recorded system data and the activation decisions to be verified. This information showed vehicle speeds and the related incident activations, and visibility readings and the related fog activations. This latter element was also verified using meteorological data.
Future market research undertaken by NADICS will include questions regarding the public acceptability towards the IRS and will therefore help in determining the user acceptance of the system. However as the most recent market research was undertaken in 2004 it will be a couple of years before this exercise is repeated. It was therefore agreed to pursue a relatively low key, qualitative market research exercise in order to determine general feedback and response to the system. For this leaflets were prepared that invited people to comment on the scheme and provided an email address on which to do so and a free phone telephone number. Further information was also placed on the NADICS website.

Leaflets were left in public locations, namely the shopping centres Braehead and The Fort, at the Bellshill Service Station, the Harthill Service Station and the Harthill truck stop. Additionally, taxi drivers and other people were questioned while sitting at a rank in Glasgow City Centre about their views on the scheme.

The final part of the evaluation concentrated on assessing any changes in driver behaviour in terms of driver speeds, lane change manoeuvres and headway due to the impact of the studs. When the studs detect an incident and are activated to flash, it would be expected that traffic will slow down due to the incident. It will therefore not be possible to determine from these events the isolated impact of the studs on driver behaviour.

As a result, it was necessary to invoke an incident status in the system when nothing was in fact happening on the road and monitor the impact of the studs on traffic behaviour. To maintain driver confidence in the system, a VMS at the end of the site was used to notify drivers that the system had been under test. The VMS was not visible to drivers at the point from which they were monitored and so it would not have affected their behaviour.

Traffic was video taped for thirty minutes before the studs were activated and during the thirty minute activation period. The two periods were then compared to see what effect the studs had on driver behaviour in terms of lane changing and on driver speeds. The trial was undertaken for one hour between 11:00 hours and 12:00 hours on the 9th of August 2005. Figure 1.1 shows the arrangements of the trial including the area where the studs were activated.
VMS used to notify drivers that the IRS had been under test after they have driven through the site to ensure that driver confidence is not lost in the systems.
5 RESULTS

The evaluation of the performance of IRS was divided between the technical performance of the system, the user acceptance and the behavioural change of drivers. This chapter summarises the results of the evaluation.

5.1 Technical Performance

The technical performance of the system is first determined by the period for which the system was fully operational. It is estimated that from the 01st of February 2005 until 07th of September 2005 the system was unavailable for 8 days, equivalent to 3.6% unavailability. One week of this was due to system maintenance and therefore only 0.45% unavailability can be considered to be due to uncontrollable circumstances (namely power cuts). Due to the presence of gaps in the data that do not correspond to loss of system availability the figures presented here represent robust and conservative estimates.

The data was received from Astucia and downloaded from the system for the purpose of this evaluation. This data provided the system readings and responses and thus allowed a check that the “incident” activations correlated with drops in speed and the “fog” activations correlated with poor visibility or heavy rain.

The data received from the system covered a period of 90 days. This data covered dates in February, March, May, June, July and August hence spanning a wide range of weather and driving conditions. During this period there were 141 activations of the system which occurred over 45 days. Figure 2.1 provides a breakdown of this.

Fog activations occur when the system determines that visibility drops below an acceptable threshold. To validate these activations, data was requested from the Meteorological Office showing weather records for particular dates when the system generated a fog response. An existing weather station is located at Salsburgh very close to the IRS site however the station is not manned and therefore does not record visibility. The nearest weather station that does provide information about visibility is located at Gogarbank approximately 22 miles away. Due to this distance there is a relative change in topography between the IRS site and the weather station area.
Data was requested from both weather stations but the data from the Gogarbank station was more useful. We have compared a number of days fog activations with weather data and determined that generally the system correlates with periods of poor visibility (see figure 5.2).
Further analysis was undertaken to show what happened to traffic speeds when the studs were activated due to fog readings with the results shown in Figure 5.3.
Incident activations occur when speeds are detected to drop below 40 Km per hour (approximately 25 mph). It would be expected that speeds would drop during the activation due to the incident rather than purely due to the IRS. The IRS are intended to warn motorists that something is happening downstream allowing them to slow down, drive more carefully and hence avoid secondary incidents. Therefore all incident activations corresponded to drops in the measured vehicle speeds below the threshold of 40 Km per hour.

5.2 User Acceptance

Feedback has been received from 13 people about the IRS to date. In general the respondents feel that the IRS have improved visibility and they are better than the previous studs. One driver commented that they were very bright at night time and slightly distracting. This comment was received before the dimming facility was installed which should address this concern.

One driver commented that the studs were bumpy to drive over and another would like to see more user education to support their installation. Information was put on the NADICS (now Traffic Scotland) web site about the trial site. Table 5.1 shows the number of times the information was viewed on the web site.

Table 5.1 – Number of “hits” received on IRS leaflet on the NADICS Web site

<table>
<thead>
<tr>
<th>Month</th>
<th>Number of hits</th>
</tr>
</thead>
<tbody>
<tr>
<td>March</td>
<td>48</td>
</tr>
<tr>
<td>April</td>
<td>270</td>
</tr>
<tr>
<td>May</td>
<td>285</td>
</tr>
<tr>
<td>June</td>
<td>257</td>
</tr>
<tr>
<td>July</td>
<td>271</td>
</tr>
<tr>
<td>August</td>
<td>271</td>
</tr>
<tr>
<td>Total</td>
<td>1,401</td>
</tr>
</tbody>
</table>

5.3 Impact on Traffic

The video footage of the trial period was analysed to examine driver behaviour at the trial site. The results in Table 5.2 show that there was a small decrease in speed (3%), 13% change in headway and a 65% drop in lane changing – including an 81% drop in dangerous lane change manoeuvres.

It should be noted that the studs were tested in the worst-case environmental conditions i.e. dry sunny weather. During these conditions, the studs are at their hardest to see and it is anticipated that the results would be even more conclusive if the test had been undertaken in the hours of darkness.
### Table 5.2 – Trial Day Observations

<table>
<thead>
<tr>
<th></th>
<th>Before activation</th>
<th>During activation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average speed</strong></td>
<td>Average : 98.9 Km/hr</td>
<td>Average : 95.6Km/hr</td>
</tr>
<tr>
<td></td>
<td>(Standard Deviation: 4.97 Km/hr)</td>
<td>(Standard Deviation: 5.62 Km/hr)</td>
</tr>
<tr>
<td><strong>Headway</strong></td>
<td>Average : 4.46 m</td>
<td>Average: 5.02 m</td>
</tr>
<tr>
<td></td>
<td>(Standard Deviation: 2.88m)</td>
<td>(Standard Deviation: 3.26m)</td>
</tr>
<tr>
<td><strong>Manoeuvres from inside to outside lane</strong></td>
<td>187</td>
<td>71</td>
</tr>
<tr>
<td><strong>Manoeuvres from outside to inside lane</strong></td>
<td>61</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total lane change manoeuvres</strong></td>
<td>248</td>
<td>87</td>
</tr>
<tr>
<td><strong>Dangerous manoeuvres</strong></td>
<td>52</td>
<td>10</td>
</tr>
<tr>
<td><strong>Traffic flow</strong></td>
<td>855</td>
<td>782</td>
</tr>
</tbody>
</table>

2 Subjective assessments based on the gap into which the car changing lane manoeuvred into

### 5.4 Conclusion

The system has performed well when compared with COMPANION receiving good feedback from the public and demonstrating a positive impact on driver behaviour when flashing.

Also the overall assessment of the system is considered to be very positive in terms of safety, efficiency and user acceptance. However the evaluation did not prove large scale financial benefits or positive effects on the environment.

Most importantly the system is considered to improve safety overall. Full analysis of accident statistics has not been undertaken as there is not 3 years of post implementation data. However, the trial showed that when flashing the studs do result in a reduction in speeds, increase in headway and reduced lane change manoeuvres. Speed during fog does not consistently reduce and it may be that in some cases, the studs when constantly illuminated result in slightly higher speeds due to the fact that drivers feel safer being able to see the road clearer. This will have to be monitored over time looking at accident statistics.

It is also believed that by reducing the likelihood of secondary incidents the IRS will have a positive impact on network efficiency whilst the IRS has been received
positively by the public. Further market research through the NADICS market research exercise will further consider the user acceptance.

Finally the evaluation shows that the system will have a limited impact on the environment although by reducing the likelihood of secondary incidents and congestion, the IRS may have a positive impact on the environment. IRS have a potential financial benefit over COMPANION due to cheaper installation costs. This would be enhanced if they were included into the DMRB as standard infrastructure. At present however the impact of the studs financially is considered to be neutral.

NOTES

1 This figure has been assumed as the information is not currently available due to a web site fault. The IRS document was available throughout July and for the purpose of this report, the average of May, June and August was used.

2 Subjective assessments based on the gap into which the car changing lane manoeuvred into