ITS Radar Helpdesk Query: Dynamic Road Markings/Variable Road Studs

Query no:	15	Query initiator:	Amanda Wilson
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Query topic areas:	Dynamic Road Markings and Variable Road Studs schemes particularly in Holland		

Categories and level of relevance:	Monitoring	Some Relevance
	Pilots	Very Relevant
	Traffic Management Technology	Very Relevant
	Traffic & Travel Information	Some Relevance
	Safety	Very Relevant
	Technology Solutions	Very Relevant
Transferability to Highways Agency:	Meets Policy Objectives	Yes
	Cost/Benefits Information	
	Development status	Schemes Piloted Successfully
	Innovative	Yes
	UK legal issues	Yes

Summary:

Several case studies are explored involving instances of Dynamic Road Markings and Variable Road Studs colloquially known as Intelligent Road Studs (IRS).

From the UK;

- A143
- A4226
- M8
- A38

From the Netherlands;

- N513
- N200
- A50

The technology has been used to serve a number of purposes by way of improving safety standards and more efficiently managing the highways including; greater night time illumination and delineation; hazard detection and warning; guided use of the hard shoulder during periods of heavy congestion; alerting drivers to a pedestrian crossing; and operation of a part-time bus lane.

Unfortunately, published documentation on this innovative area of traffic technology is sparse, with limited statistical evidence of any impacts available. However with the number of examples of IRS and Dynamic Road Marking schemes on the increase a substantive review of the technology will not be long in coming.

Introduction

This document is provided in response to the above query regarding information on studies of dynamic road markings and Variable Road Studs, with particular reference to Holland. A number of case studies have been reviewed and are summarised below.

Variable Road Studs use for Lane Delineation

Variable Road Studs (VRS) have been used in the following examples to provide drivers with information in their natural field of vision about road conditions ahead. In some cases VRS are able to emit as much as 10 times greater visibility over traditional retro-reflective road studs providing clearer more effective guidance to road users.

Netherlands, N513 - Night Delineation and Bicycle Crossing

In response to fears over the safety of cyclists in the remote and environmentally sensitive area around the Province of Noord-Holland (a nature conservation area) where street lighting is banned, Dutch authorities commissioned a number of trials on innovative and alternative technologies in an attempt to allay concern and improve safety at a number of regions in the area. Impressed by the positive performance of Variable Road Studs in this trial, the N513 just outside of Castricum was selected as a key area to install VRS so as to improve visibility of crossing cyclists returning from the beach/nature reserve after dark.

Hardwired Intelligent Road Studs (IRS – see Manufacturers section below) were chosen as an effective solution to the problem. Powered by a single externally mounted solar panel, the studs were installed in 2003 over a distance of approximately 55 metres in the centre of the carriageway on either side of the crossing. Inductive loops set into the road surface on the approaches to the site were linked to the bi-directional LED studs and acted as a light switch whenever a vehicle was detected approaching the area.

The government has reported a 99.2% saving in energy and because the studs are only illuminated for a few seconds each time an approaching vehicle is detected there has been minimal reported effect on wildlife. A post-implementation study carried out by the Dutch authorities found that of all the systems that were tested, the IRS were the most effective and the safest form of guiding at night and in bad atmospheric circumstances[(1)].

Netherlands, N200 – Night Delineation

The twisting dual carriageway between Overveen and Bloemendaal in the Noord-Holland Province of the Netherlands was seen by the Dutch authorities as another area of environmental importance where improved safety standards were desired but preferably without the need for high energy consuming, electric street lights. Hardwired flush mounted Intelligent Road Studs were used in this case to delineate the sharp bends in the roads and are activated as and when vehicles using the stretch of the N200 pass over loops in the road. This method of limiting operation of the IRS to times when they are required has helped to minimize the light pollution as well as reduce energy demands. Providing 900 metres of visibility to the driver as opposed to the standard 90 metres associated with traditional retro-reflective road studs, the hardwired flush mounted intelligent road studs appear to the driver to be permanently illuminated and thus help to improve driver awareness.

The Netherlands Province of Noord-Holland has been awarded the Dutch Association for Lighting Knowledge's (NSVV) National Light-award 2005 for the innovative way it has applied active marking road studs on the N200. Accident numbers on the stretches of the N200 where the IRS have been installed have fallen to zero and there is also the added cost benefit of surprisingly large, safe distances between the IRS. An acceptable distance apart through bends on roads with a maximum speed of 80 Km/h can be 15 metres, and on straights up to 25 to 30 metres apart.

UK, Norfolk, A143 - Night Delineation

Linking the two English towns of Beccles and Great Yarmouth, the A143 crosses for 2km the Haddiscoe Marshes over a particularly winding and dangerous stretch that has in recent years been an accident hot spot. 22 Accidents were recorded in only a three year period with 40% of these accidents occurring in the dark. In an attempt to reduce the number of accidents happening on this road the Norfolk County Council made the decision to install IRS in conjunction with the road being resurfaced with highly skid resistant material. In 1999 over 200 solar powered white Intelligent Road Studs with rechargeable batteries were installed to delineate the centre line of the road.

In the 2 years and 2 months since the initial scheme was implemented there have been only 5 slight incidents none of which occurred in dark conditions. This represents a reduction in accident frequency of 5 per year, from 7.3 to 2.3; and a reduction in accident severity ratio from 36% to zero.

UK, Vale of Glamorgan, A4226 - Night Delineation

Extremely concerned about the unacceptably high accident record of the A4226 ("The Five Mile Lane"), the Vale of Glamorgan Council has undertaken an extensive programme of safety improvements along the road which include the imposition of a 40mph speed limit, deployment of a mobile speed camera (and more recently a permanent speed camera), additional road markings, increased signage and resurfacing with high skid resistance material. Further to these measures, to improve visibility on the road at night time, 200 solar powered IRS were installed in July 2002, providing delineation from dusk to dawn of the centre line with white studs. On the most severe of bends the carriageway edges are enhanced with red studs. The combined improvements have so far, in the three years following implementation, yielded a reduction in accidents of 72% on the stretch of the A4226 compared with the three years prior to the scheme.

Variable Road Studs use for Fog Detection and Guidance

Variable Road Studs (VRS) have been used in the following example to improve road safety, providing guidance and advance warning to drivers approaching hazardous conditions.

UK, Scotland, M8 - Incident detection, fog detection & guidance, surface water detection and hazard warning

As part of a national road management scheme, VRS have been fitted to a 3km stretch of Scotland's busiest motorway, the M8. This particular stretch of road, approaching junction 6 on the west bound section of the M8 was chosen due to it being both very busy and prone to foggy hazardous conditions.

IRS technology has been trialled as a flexible and cost effective alternative to the inductive loop as means of monitoring traffic conditions. The technology was also chosen due to a desire to link new technology with traffic speed collection, to provide feedback to road users approaching hazards.

Twelve 250 metre long strings of Intelligent Road Studs have been installed at 18m centres between the hard shoulder and the inside lane along the chosen stretch of road. To enhance brightness each IRS is fitted with 14 red Light Emitting Diodes (LEDs), allowing them to be seen from a distance of up to 1 kilometre.

Detector studs, deployed at 500 metre intervals in the centre of the lane collect data on traffic speed, weather incidents etc. These studs are connected to a series of seven cabinets, housing a fog sensor, the controller, communications and power equipment, installed adjacent to the detector studs.

Algorithms determine the type and extent of alert required, before control units automatically relay instructions to the appropriate strings of IRS, which in turn flash a warning to approaching traffic or increase in brightness to aid visibility. Intelligent queue tracking allows only the strings of studs upstream of any slow moving or stationary traffic to be activated.

This system although fully automatic is flexible and allows for remote or on site manual control or monitoring of traffic conditions.

Post evaluation of the system has found the studs to be both robust and low maintenance, since implementation in 2003. It was reported that the system is 'expected to improve safety overall', with tests indicating a small decrease in speed (3%), 13% change in headway and a 65% drop in lane changing[(2)]. Full analysis of accident statistics are yet to be undertaken as there is not yet 3 years of post implementation data available.

Dynamic Road Markings

Dynamic Road Marking technologies can enable highway engineers to manage road networks according to constantly changing real-time demands of traffic situations. Roads can be manipulated to manage the use, priority and even direction of travel. Several pilots have taken place in Germany and the Netherlands since 1999. Initial schemes in Holland (A15 and A44) encountered problems relating to the durability of the equipment and the heavy traffic demands. The German pilot study on a motorway crossing near Frankfurt involved Dynamic Road Markings to mange off ramp situations, and whilst successful behavioural effects were observed this pilot also suffered technical setbacks. One scheme showing more promising signs is the A50 in Holland, which is in effect the follow-on from the earlier tests undertaken on the A15 and A44 motorways.

Netherlands, A50

The cities of Arnhem and Zwolle in the Dutch Province of Gelderland are linked by the busy A50 motorway, along which 200,000 vehicles pass a day causing problematic congestion during the rush hour periods. Especially high congestion was known to build on the northbound carriageway at the Schaarsbergen junction on-ramp where people struggle to join the already busy carriageway.

In response to this issue the decision was made to install hardwired IRS at one meter intervals along the on ramp and hard shoulder of the A50 to guide drivers onto the hard shoulder during periods of bad congestion. The amber IRS illuminate the on ramp (whilst the hard shoulder/hazard lane is delineated with white IRS) and has the effect of moving the merge point further along the carriageway providing drivers with more time to find a more suitable point at which to merge into the traffic. All individually controlled by a can-bus system the IRS can be organised to create any repetitive pattern by switching combinations of the studs on or off. In normal conditions the IRS are used to guide drivers onto the main carriageway when the hard shoulder is not in use as a third active lane.

The system has been in use since November 2004 and is routinely in operational every Friday and is frequently used at any other periods where traffic circumstances demand it. However, to date no thorough review of the performance of this system has been conducted to our knowledge.

Other schemes

Other schemes to have been piloted in this emerging field of road technology have included;

- A Dynamic Road Marking zebra crossing near a kindergarten in the community of Wattens, Austria[3]. SWARCO were commissioned to install bands of VRS, mounted cross sectionally to the zebra crossing, which are activated by radar when a pedestrian wants to cross the street. The studs flash yellow when in operation to alert drivers more actively to the crossing. A 6 month review has been conducted by the KfV Innsbruck
- A Dynamic Road Marking scheme in Holland, involving a non-permanent bus lane in The Hague. LEDs set into the route displaying the word "BUS" are illuminated during periods of congestion to reserve the lane for bus use only. When the LEDs are off the lane is available to all traffic.
- On the A37 in Hanover, Germany, Variable Road Studs have been used for a Tidal Flow system on the approach to cross over points to guide the traffic onto the opposite carriageway. Proposed benefits include; increased safety; increased capacity; and increased driver comfort. Problems with the scheme have included; excessive cost to clean the studs; reported 'phantom light' problems (bright sunlight causing the studs to appear lit when they are switched off).[4]
- The three-lane single-bore Saltash Tunnel, on the A38 in Cornwall, operates a tidal flow system. During one peak period, two lanes are allocated to westbound traffic and one lane to eastbound traffic and for the other peak period the system is reversed. Active Cats Eyes[4] were fitted on the outside of the westbound nearside-lane to be illuminated so as to delineate the appropriate lane markings during the different peak phases. No figures are available but the general opinion is that the risk of accidents occurring in the tunnel has been reduced and so the Active Cats Eyes have been a success. In fact despite the high installation cost, Cornwall County Council were so pleased with the performance of the scheme they wish they had installed more of them across Cornwall.

Manufacturers

- Astucia - developed the Intelligent Road Stud (IRS) range of products which represents the most prolific of all the Variable Road Stud manufacturers [5].
- Lane Lights (UK) Ltd - developed the Active Cats Eye which is a road stud that emits a bright red light to the driver. The low DC voltage Active Cats Eyes are hardwired and are powered from a road-side unit connected to the lane markers by a cable loom slot cut in the road surface. Used for the A38 Saltash Tunnel (see above) although a web search for the brand "Lane Lights" failed to yield any up to date information suggesting the company has either changed name or has ceased activities.
- BERATEC - manufacturer of LED road studs. Used on the A37 Tidal Flow system (Hanover) [4].
- HOLOPHANE - Their product is described as, a combination of proven solar powered LED studs, with wireless communication between each other, roadside beacons, traffic detectors and the traffic control centre. Relaying information about poor weather and traffic conditions [6].
- Hiltech-LEDline - Manually activated LED lighting strip, a safety tool to enhance visibility for road users [4].
- Harding Traffic Systems-SMARTSTUD - Developed by Harding Systems of New Zealand in partnership with Auckland University, Vega Industries and Hella. SMARTSTUDS do not require physical (hardwired) contact with the power supply. Modulation of the power supply is used to change the colour or intensity of the stud. Each stud is fitted with ten high-intensity Hewlett Packard ALLNGaP LEDs [7].
- Light Guard Systems – Crosswalk Warning System – automatic pedestrian crossing system developed by Santa Rosa California in partnership with Hewlett Packard (LEDs) [8]

- Dalmark Technologies – Active Road Markings System for traffic safety (ARMS) – Israeli based manufacturer of IRS products similar to Astucia [9]

Conclusions

A number of case studies have been reviewed detailing schemes involving Variable Road Studs and Dynamic Road Markings. Pilot schemes in the UK (A143, A4226, M8) and The Netherlands (N513, N200, A50) have been described and some technical specification of the products has been mentioned. This area of highway management is still a relatively new and developing field of the transport industry and as such limited follow-reports and performance reviews have been produced. Often the perceived improvement in safety (in some situations against a history of little or no active road management on the road in question) is taken as justifying the scheme without statistical evidence to corroborate the claim of improved standards. Obviously the extent of post implementation monitoring depends to a large degree upon the scale of the scheme in question, for example a lengthy and detailed assessment of the zebra crossing scheme in Wattens would hardly be realistic or practical.

For the schemes in operation in Britain some follow up work has been produced with positive indications of safety improvement. In the Netherlands the schemes up until now have really paved the way for the development of the current systems in operation on the N513, N200 and particularly the A50 but unfortunately no clear analyses of these systems are available to date. In scenarios where a “+1” scheme (use of the hard shoulder/hazard lane during heavy congestion) is implemented it is certainly worth investigating whether the system is in operation over a sufficient number of junctions to help dispel queues or whether in fact the scheme simply moves traffic jams down stream of the problematic slip road. With the high probability that the IRS technology is likely to be exploited to a far greater geographical extent in the near future, assessments of IRS performance are perhaps more likely to arrive in the next 5 years or so.

References

1. "'n Nieuwe richting voor wegverlichting (A new direction for road lighting)". A copy of this report can be obtained by going to: http://www.nsvv.nl/index.cfm?pageid=5B5226DA-DA1B-CA30-531087B8F75F5EE1&siteid=16B60F38-9096-1C42-1413FC9030A04433&contentid=47C0F7DD-F89A-62C1-5A15B80F13FB62B0
2. Faber Maunsell Intelligent Road Studs Evaluation report 26th September 2005 http://tempo.austriatech.org/fileadmin/library/59/EEG_ST14_IRS_Evaluation.pdf
3. SWARCO IRS Zebra crossing in Wattens, Austria http://www.swarco.com/english/news_sub.asp?MeldungID=85
4. M42 Active Traffic Management Managing Consultancy - Applications for Variable Road Markings (2002) Highways Agency, Mouchel.
5. For a guide to Astucia products and systems, one of the leading IRS Manufacturers, visit: http://www.astucia.co.uk
6. Holophane Tele Traffic System http://www.holophane.com
7. Harding Traffic Systems http://www.smartstud.com
8. Light Guard Systems http://www.lightguardsystems.com
9. Dalmark Technologies http://www.dalmark.com