Using a combination of road safety solutions to save lives

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1. Introduction

Traditional measures of alerting motorists to impending dangers ahead, specifically at junctions, are falling victim to ongoing budget cuts and a lack of strategic targets to maintain roads and improve safety records. Increasingly, road operators are being forced to seek more cost-effective options to tackle the challenges posed by dangerous junctions. Fortunately, new technology developments and some creative thinking can offer alternative, sustainable options to support road operators in making journeys safer and better.

2. Why are improvements in junction and highway safety still necessary?

Department for Transport (DfT) statistics released in February 2018, show that there were an estimated 1792 road deaths in 2016, a 4% increase from the previous year, and a total of 24101 Killed & Seriously Injured (KSIs). As identified in a 2012 Transport for London Road Safety Action Plan, most road safety initiatives rightly focus on the human cost and the personal tragedy of death and injury on the roads. In terms of direct costs, a lifetime of care for a single victim can cost more than £20m, putting the NHS, support care systems, emergency services, and highways maintenance organisations under substantial financial stress.

However, collisions also have a significant economic cost as the knock-on effects of congestion adversely impacts on British trade when commuters, emergency services, non-office based mobile workers, and hauliers are held up in traffic jams caused by collisions.

The 2015 EuroRAP report by the Road Safety Foundation estimated that Britain loses around 2% of its GDP in road crashes. The report went on to analyse Britain's most improved roads in consultation with authorities, and concluded that attention to detail - such as improved road markings, junction layouts, speed limits, and pedestrian crossings - enabled authorities to reduce road crashes by as much as 80% on the ten most improved sections.

Following on from this, the 2017 EuroRAP Results report by the Road Safety Foundation entitled 'Cutting the Cost of Dangerous Roads' identified that the largest cause of serious injuries on the British road network are crashes at junctions (33%). The authors highlighted the need to continue to research and implement new ideas to positively influence driver behaviour and provide motorists with better advance information and visual aids.

Investment in road safety, and its consequent reduction in collisions and casualties, can deliver substantial economic benefit and the value of preventing the casualties in the first place is significant, both in economic and social terms.

3. How effective are typical safety measures?

Junction Warning Signs

Traditional warning signs are useful and a familiar sight on our roads, but are typically speed or approach orientated. Since the formal introduction of standardised road signs under the Road Traffic Act of 1930, and further regulations in 1933, their use has been carefully regulated and regimented. This ensures uniformity across regions and local authorities and is now legislated by the Road Traffic Regulation Act 1984 and the Traffic Signs Regulations and General Directions 2002.

Chapter 4 of the Traffic Signs Manual deals with the subject of Warning Signs. This resource states that: *'The Traffic Signs Manual is intended to give advice to traffic authorities and their agents on the correct use of signs and road markings…..but it is for traffic authorities to determine what signing they consider necessary to meet those duties.'*

It is widely acknowledged that appropriate warning signs in the right place can significantly improve road safety, but for them to be most effective, they should be used sparingly. Frequent use to warn of impending junctions, which are readily visible and obvious in other ways, tends to detract from their effectiveness.

Research (by AECOM, 2009) has shown that the greater the number of signs which drivers are presented with simultaneously, the more difficulty they are likely to have in assimilating and understanding the information being presented to them. This information overload, coupled with the fact that the traditional signage is so familiar that they are often very easily overlooked by drivers, leads to a phenomenon known as 'inattentional blindness'. In the context of road safety and driver behaviour, inattentional blindness can easily lead to accidents when focus is unconsciously diverted away from important information that we should be processing.

Signalised Junctions

Some authorities favour signalised junctions as a more forceful intervention to slow drivers down at complex junctions, but opponents argue that traffic lights can also pose potential dangers as drivers attempt to jump an amber light, or speed up and have to brake suddenly when they realise they won't make it through in time.

There are also economic arguments cited against the use of traffic lights, with a report by the Institute for Economic Affairs ('Seeing Red: Traffic Controls and the Economy', IEA, 2016) estimating that if traffic management measures, such as traffic lights, cause a two-minute delay to every car trip, the cost to the economy is around £16 billion per year. Other opponents of signalised junctions highlight the environmental concerns, stating that vehicles are more efficient when moving at a steady speed, rather than stopping and starting, so traffic lights add to fuel consumption, increasing emissions and noise pollution.

Variable Messaging Signs and Vehicle Activated Signs

High contrast or bright lights are important sensory factors in affecting how noticeable something is. For this reason, electronic LED based Variable Message Signs (VMS) and Vehicle Activated Signs (VAS) are becoming more common on our road network. They are also known as dynamic or matrix signage.

VMS tends to be used to display a brief message such as 'Slow Down', time to next junction, speed limits, traffic conditions ahead, or available parking spaces in nearby car parks, whereas VAS can be

linked to in-road or above ground sensors that are used to provide vehicle presence, size and speed detection. This enables specific warning signs to be triggered by vehicles exceeding a pre-determined safe speed on the approach to a junction or bend, or even by detecting a vehicle waiting to join a main route, cross over a busy road, or turn right across a dual carriageway.

Research on behalf of the DfT ('Vehicle-activated signs – a large scale evaluation', DfT, 2002) on dynamic vehicle-activated signs reported that drivers can be influenced to reduce speed with specifically targeted messaging, whilst fixed signs used in isolation are less likely to produce this positive effect. The researchers found that: *'Vehicle-activated signs appear to be very effective in reducing speeds; in particular, they are capable of reducing the number of drivers who exceed the speed limit and who contribute disproportionately to the accident risk, without the need for enforcement such as safety cameras.'*

Other benefits of VAS which were highlighted by the DfT report were:

- Vehicle-activated signs can be operated at thresholds well below normal police enforcement levels;
- No evidence that drivers become less responsive to the signs, even over three years;
- Operating costs are low; and
- In this study, a substantial accident reduction has been demonstrated.

Although the Traffic Signs Manual states that VMS and VAS should be used only to supplement fixed signing, and not as a substitute for it, it is clear that different volumes of traffic and usage patterns, varying topography, and individual junction design all combine to present a variety of unique challenges and scenarios in any location.

The distinct advantage of dynamic signage is in the ability to update and adapt the information provided based on the peculiarities of any specific junction. Additionally, VAS and VMS provide a strong, concise visual guide without distracting the driver. Retaining the balance between providing a clear warning of dangers ahead, whilst avoiding over-loading the driver with information, is vital.

4. Integrating technologies to create bespoke solutions

In recent years, there has been significant progress in how junction safety schemes are planned, designed and implemented. Better partnership and collaboration between all stakeholders has enabled an increased pace of development and the innovative use of existing and new technologies to create integrated, intelligent solutions to complex road safety challenges.

The potential benefits of dynamic signage are proven and such innovative solutions are becoming more common with the recognition that new technology can be harnessed in increasingly unique ways to inform oncoming traffic of potential dangers ahead, as well as influencing and reducing the speed of approaching traffic.

From VMS and VAS based solutions through to clever use of solar powered road studs, a combined and intelligent use of existing technology can substantially enhance road user awareness of the potential dangers around junctions and have a distinctly positive impact on driver behaviour. The key challenge for local authorities, road operators, and intelligent solution providers is to take these different

technologies and integrate them so that they successfully work together for very different junctions to resolve some very different issues.

Clearview Intelligence has significant experience in designing and delivering a variety of junction safety schemes in a wide range of scenarios. In this section, we examine some of those projects, the challenges faced, the end solution, and the success factors evidenced.

Case Study 1 – Active Delineation on the A1, Scotland

The A1 is 410 miles (660 km) in length and connects the capitals of London and Edinburgh. The A1 Action Group is made up of elected members from Scottish Borders and East Lothian Council, transportation groups and community councils and is campaigning for single carriageway sections to be dualled. They also seek other ways to improve the safety performance on the road.

A series of meetings, attended by Transport Scotland, discussed local measures that could be adopted to ensure the continuous improvement of the road safety record of the route. Representations were made from local communities along the route which mainly focused on the junctions of the A1.

Transport Scotland, together with their operating company for the route, Amey, worked with the local communities to take on board the issues highlighted and design measures which would help reduce concerns. To get an appreciation of the concerns, this included a drive through of each of the junctions during the day and hours of darkness. Entering or exiting the A1 during the hours of darkness was highlighted as a major area of concern.

The proposals for improvements targeted three main concerns:

- General visibility to and from the junctions;
- Lack of consistency of signing and road markings; and
- The lack of definition at and around the junctions.

Transport Scotland and Amey proposed the installation of an innovative solution with the use of solar powered LED road studs at nine junctions on the route. This gave a visual consistency to the route by ensuring all major junctions were treated similarly. The studs allow the junctions to be defined to approaching drivers and to operate in darkness without the need for external power. Clearview Intelligence's solution included using white and red SolarLite Flush Road Studs as road edge and centre delineation; and using amber and green studs to highlight junctions and other egress areas.

In total, over 4,100 studs were installed along various sections and junctions covering 14 miles of the A1 from the Scottish border to the Granthouse Junction. The works were completed in early 2016 including a full refreshment of road marking. The effectiveness of the measures will continue to be assessed as part of the annual review of accidents on the trunk road network.

Through winter 2017, Richard Llewellyn BEng MSc(Eng) CEng MICE MCIHT FHEA, Lecturer in Transportation Engineering and Member of Edinburgh Napier's Transport Research Institute, has engaged with the local communities along the A1 route to collate and analyse road user feedback from local residents. This work has centred around a postal questionnaire and an online survey of the qualitative impacts of the SolarLite stud scheme.

The final results will be published as a paper in the summer of 2018 but initial results based around a 5% return of the online questionnaire provides a very positive picture overall. 80% of the respondents

were aware of the installation of SolarLite studs along the route and 93% felt the clarity of the junction layout had improved or strongly improved.

Unsurprisingly, the initial results show that confidence levels of users of the road drop between daytime to night-time driving. There is a 19.5% shift in confidence from 'moderate and above' confidence during the day to 'slightly or not confident' at night.

When comparing the importance of street lighting versus the use of road studs on a junction section of the road, 73% felt lighting was important or very important, whilst there was a 93% corresponding figure for road studs.

However, the difference in the importance of stud use is more than doubled when used on curved road sections. 41% felt lighting was important or very important versus 89% for the use of studs. Specifically, 95% felt that clarity along curved sections had been improved.

91% felt that the use of SolarLite studs should be more widely used and, critically, 78% of the respondents also felt their confidence in driving along the route at night had improved or strongly improved, which was one of the key aims of the road improvement scheme.

Survey Quotes:

"I have found these to be most useful when turning onto or across the A1 from side roads at junctions without lights, e.g. at Ayton and Houndwood (B6347). Normal cats' eyes are no good as my headlights are at 90 degrees to them, but visibility of the LED cats eyes gives confidence I can see the road and that it is clear".

"They have made a HUGE difference to my confidence in driving on the A1 at night - I can see the road ahead and know that I am approaching a bend or a junction which was impossible before. FANTASTIC improvement. More road studs as soon as possible please".

Case Study 2 - Variable speed awareness warning system on the A75 Stranraer to Gretna Green in Scotland

The A75 Stranraer to Gretna Green road is the main route from northern England to the ferry port servicing Northern Ireland. Consequently, traffic tends to come in waves and can be very heavy when a ferry has just been unloaded. The route is estimated to carry up to 10,000 vehicles per day.

The A75 forms part of the Euro-route 18, which runs for 1,890 km (1,170 miles) from Craigavon in Northern Ireland, and on through Scotland, England, Norway, Sweden, Finland and Russia. As such, it is an important strategic route for economic connectivity. Although it is a vital trunk route and has been subject to several upgrades over the years, it remains mostly single-carriageway. There are three sections of dual-carriageway and several long overtaking lanes.

With over 1,500,000 vehicles using the A75 each year (200,000 plus are Heavy Goods Vehicles), the route had a Killed or Seriously Injured (KSI) rate 1.5 times higher than the average on South West Scotland's trunk roads and HGV collisions were six times the national average for this type of road.

The main objective for Transport Scotland is to address road safety concerns that have been highlighted by various stakeholders. There is a strong interest in any A75 initiatives from local residents and road safety pressure groups, as well as environmental campaigners, the port operators, hauliers, and the local police force.

Stakeholders at the Dumfries and Galloway Transport Summit Report on Ports, Freight and Roads in Sept 2016 raised various concerns regarding the A75, including the problem of drivers not adhering to the speed limit through the villages of Springholm and Crocketford, whether the speed limit for HGVs should be increased from 40mph to 50mph (in line with the current trial underway on the A9), and demands to make the entire route dual carriageway.

Planning for new road infrastructure can be a lengthy and costly process, so shorter-term speed warning solutions were being investigated and implemented, where suitable, to address the immediate safety concerns of regular users of the A75, and residents of villages/towns along the way.

In November 2016, Transport Scotland commissioned Clearview Intelligence to conduct speed surveys at twelve locations along the A75 from Stranraer to Gretna Green. The surveys highlighted a recurring problem along the length of the A75 with the 85th percentile speed being unacceptably high, most notably with HGV's. The 85th percentile speed is a widely-used metric, being the speed that 85 percent of vehicles do not exceed in a given location - most drivers behave in a safe and reasonable manner, do not drive at excessive speeds and do not want to get into crashes.

A contributing factor to the issue of speeding, which has been put forward by road safety campaigners, is that varying speed limits can be dangerous on a major trunk road when there are few overtaking opportunities as drivers get confused as to what speed they should be doing on a particular stretch. Scotland TranServ, as the road operator, wished to put in place a solution that would encourage speed compliance, lower the 85th percentile speed overall, and change driver behaviour to improve safety for all road users along the route, especially in built-up areas.

Scotland TranServ engaged Clearview Intelligence to help define an operational solution that could be replicated across the length of the A75 to encourage a reduction in overall traffic speed. Clearview designed a solar powered vehicle count and classify solution - by combining vehicle classification with identification of vehicles travelling above the speed limit, the scheme allows vehicle activated signs to show the appropriate speed limit warning according to vehicle type.

Following extensive site surveys to validate the solution proposed, it was installed in six sites along the A75 and has been designed to improve safety along the route, working effectively within the confines of the existing infrastructure, the variable speed limits, and the differing speed limits for different vehicle types.

As the road has differing speed limits according to vehicle classification, the solution is designed to recognise instances of speeding per vehicle type. This has been achieved through the use of the M680 Traffic Count/Classifier, which classifies vehicles in to nine different vehicle classes whilst measuring the speed of the traffic. The M680 then communicates that data to Vehicle Activated Signs (VMS) as per the programmed requirements. Each of the six sites consists of two VMS - one sign facing each direction of travel. These signs display 'SLOW DOWN' messages and an illuminated Speed Display, depending on the vehicle class detected and if the speed detected is above the threshold for that vehicle class.

Due to the length and rural location of the A75, the road infrastructure only allows for permanent power supply in places where it passes through towns and villages, or at major intersections. The speeding vehicle problem is not confined to these built-up sections, so the M680s used on the A75 are powered by harvesting solar power from external solar panels, ideal for permanent locations where it is impractical or not possible to tap into mains power.

This type of vehicle activated, dynamic speed warning system serves as a highly visible and immediate reminder to drivers to monitor and manage their speeds appropriate to their vehicles classification legal limits and is a first of its kind in the UK. It adopts a softer approach to speed compliance than traditional enforcement and penalty measures, but changing driver behaviour for better is a more effective long-term safety measure.

Analysis of data gathered in May 2017 from a site on the straight stretch of road coming to/from Gretna found that the sign has some impact on slowing down speeding HGV's with up to 5% reducing their speed once the sign was triggered. It is also assumed that there will be positive knock-on impacts with vehicles following the first vehicle also slowing down once the warning sign is activated.

On other sections of the route there is a more pronounced reduction in HGV speed when the signs are triggered, such as near the village of Castle Douglas. On the west-bound approach to the village there was an 18% reduction in the speed of HGVs that triggered the sign, although this location is the approach to the village entrance and so some natural reduction in speed should be anticipated. A similar reduction (16%) in the speed of HGVs that had triggered the sign was observed on the approach to Mouswald.

In summary, the key benefits of this solution are:

- traffic speed, especially HGV's, is reduced at key sections of the A75;
- speed messages are appropriate to the class of vehicle;
- the system provides a highly visible reminder to drivers to monitor and manage their speeds; and,
- the provision of historic and ongoing records of road usage statistics can inform future decisions on maintenance.

Testimonial – Vincent Tait, Road Safety Manager, Scotland TranServ

"Clearview Intelligence and Scotland TranServ have a strong track record of partnership working to improve road safety, so when we were looking to tackle the issue of encouraging speed compliance on the A75, we were confident that Clearview could help us to deliver an effective and robust solution. The final design is replicable and can be deployed in a variety of locations, even in the absence of mains power in remote areas.

Changing driver behaviour by making speed limits clearer for different vehicle types is a less punitive approach than traditional measures, and will encourage drivers to adjust their speed accordingly to ensure the safety of other road users and local communities along the route".

5. Other examples of bespoke junction safety schemes

Improving lane discipline on the A720 Sheriffhall Roundabout, Edinburgh

A completely different scenario formed the basis of a Clearview junction safety scheme on a busy roundabout in Scotland where positively influencing driver behaviour to improve lane discipline was the key objective.

The Sheriffhall Roundabout is a busy six-arm roundabout which connects several important routes, including the A7 and the A720, and handles upwards of 42,000 vehicles a day. It is the only at-grade junction on the Edinburgh City Bypass and the high traffic volumes mean it has the potential to become very congested at peak times.

Despite various traditional mitigation measures, the junction remained highly prone to collisions and a Stage 4 Road Safety Audit cited poor lane discipline as the primary cause of accidents. An innovative phased lane delineation scheme using Clearview's IRS2 intelligent road stud was proposed to guide traffic through the roundabout. To avoid confusing drivers from the minor routes, the studs are switched on and off in coordination with the traffic signals on the roundabout. In this way, drivers get an illuminated green phase to guide them all the way around and off the roundabout, with clear visual definition of the lanes to heighten lane discipline and reduce preventable collisions.

Independent researchers from the Transport Research Institute at Edinburgh Napier University conducted a full 'before and after' study on driver behaviour at the roundabout analysing over 55,000 individual vehicle movements.

The research team reported that the scheme reduced lane transgression activity across nearly all vehicle types and manoeuvres and has had a significant positive impact on collision risk at the roundabout. They found a reduction in lane transgression activity across nearly all vehicle types and manoeuvres, even during daylight hours, with a significant reduction in transgression rate (>50%) for medium-sized vehicles.

Overall, the study has concluded that the intelligent road stud scheme has significant positive impact on collision risk at the roundabout through reduced lane transgressions, meaning less congestion and fewer accidents.

This project was the first of its type in the UK, but is now being replicated on other complex, circulatory junctions across the UK. The success of this junction safety scheme has been recognised throughout the ITS and road safety industry with six major national award wins for innovation and road safety in 2016/17.

Reducing vehicle speeds on the A41 Chetwynd, Shropshire

One of our very first junction safety schemes was the award-winning Chetwynd project sited on the A41 north of Telford in Shropshire. This was a notoriously dangerous stretch of road with a staggered junction and minimal road markings, delineation or signage. Vehicles frequently exceeded the 60mph speed limit and the area was prone to fog and poor visibility, especially in the hours of darkness.

Clearview installed SolarLite Flush Road Studs in the centre of the road to define the lanes, and hardwired intelligent road studs (IRS2) along the edges of the lanes. Two radar controlled VAS were installed at either side of the connecting roads to flash a 'Slow Down' message to any vehicles exceeding the predetermined trigger speed. This also triggered the IRS2 studs to brighten on their approach to heighten awareness of the junction layout ahead.

Encouraging speed compliance in Fairlie (A78)

In February 2013 an HGV crashed into a property close to the existing signalised junction on the A78 in the village of Fairlie tragically killing the resident and causing major damage and disruption. With concerns raised by the local community, Scotland Transerv carried out speed surveys which identified that vehicles were regularly travelling through the village exceeding the speed limit of 30 mph.

Scotland Transerv tried a number of traditional traffic calming measures to reduce the speed of vehicles, but unfortunately these did not have the desired effect. In collaboration with Clearview Intelligence, a bespoke speed compliance system was designed.

The system combines wireless vehicle detection for speed assessment, vehicle activated signs for visual impact and the use of existing traffic signals to stop offending drivers and penalise them for exceeding the predefined speed threshold and it is a ‘first of its kind’ in the UK.

Approaching vehicle speeds are calculated using wireless vehicle sensors, omitting the requirement for costly trenching and ducting. The vehicle speed is wirelessly relayed to the traffic signals and if speeds are detected as being above the 30mph threshold then the signals are programmed to turn to red, thus safely stopping the speeding traffic and increasing their overall journey time through the village.

The scheme is aimed at positively influencing driver behaviour and is more of a 'carrot' for speed compliance than many common speed enforcement measures. A report by Transport Scotland to the Fairlie Community Council in January 2017 concluded that overall the scheme has had a positive impact on vehicle speeds with a negligible increase in red light running at the traffic signals. There have been no accidents at the junction since the scheme was introduced.

Improving road layout visibility on the A701 Beattock, Dumfries and Galloway

On the A701 in Beattock, our junction warning system utilises both fixed and vehicle activated messages to warn drivers of the upcoming junction on a bend in the road and to encourage them to reduce their speed. If a vehicle approaches as another one is detected waiting to join the main road, the sign displays a ‘vehicle turning’ message.

The solution has also been designed to detect any traffic that exceeds a set speed threshold, which triggers a ‘slow down’ warning message on the same sign.

Long vehicle detection on the A590 Foulshaw Lane, Cumbria

In Cumbria, the A590 is the main trunk road in and out of the southern area of the Lake District. Traffic turning right onto the A590 at the Foulshaw Lane junction typically has to stop in the central reservation area to wait for a break in traffic. When long HGVs turn right across the carriageways they put oncoming traffic at risk of side-on collisions and over the past five years there have been several fatal and serious incidents at this location.

Clearview and partners, Kier and Carnell, designed a bespoke long-vehicle detection system. This operates across the junction with a VAS warning sign further up the road activated when a large HGV is detected leaving Foulshaw Lane, or when making a right turn through the central reservation into Foulshaw Lane. The programming also accommodated scenarios when multiple long vehicles are detected and the VAS is required to remain on for longer.

6. Summary

This paper has examined the extent to which traditional forms of junction warning signage have their limitations, how dynamic signage and better guidance can contribute to improving road safety conditions at complex junctions, and examples of successful junction safety schemes already in operation which can be readily adapted to suit a variety of scenarios and locations.

Road safety is an area which can always be improved upon and transport professionals and the general public must constantly strive to reduce casualties of all degrees of seriousness. It’s clear that strong visual guidance, placed in the direct line of sight, can help to supplement traditional junction signage to improve driver behaviour and provide advance warning of potential risks and dangers ahead.

Clearview's junction safety schemes positively improve driver behaviour and enhance the journey experience through increasing visibility of the road layout ahead and providing advanced awareness of upcoming junctions, allowing drivers more time to react accordingly and adjust their driving to suit the scenario and conditions.

Such solutions represent solid value for money when compared to the astronomical costs – human, environmental, and economic – of avoidable deaths and serious injuries caused by collisions between road users of all types at junctions.

7. Acknowledgements

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