Reinforcement markings on road maintenance vehicles with UK Battenburg patterns
Evaluation of the speed reducing effect

Johan Granlund, Stefan Hedlöf and Tommy Nilsson

SWEDISH/ENGLISH TRANSLATION

This study shows that enhanced marking on road maintenance vehicles led to the increased attention of road users, resulting in slower speeds. SRA orange/blue Battenburg patterns reduced their speed by 3 km / h in the medium, and the percentage of vehicles that were more than 15 km/h over the speed limit fell by 90%. *Attentive driving prevents the "foolish accident."*

Lower speed also means shorter reaction distance, less kinetic energy and shorter braking distance. This follows the reinforcement of markings on road maintenance vehicles to reduce traffic accident risk for road works. This result supports the idea that enhanced marking should be made compulsory for "temporary road maintenance vehicles". The front area of road maintenance vehicles should get more attention, e.g. a sense of presence in the rear view mirror and out over the bonnet, when compared to the current layout. This work is performed by SRA Consultancy on behalf of the SRA Production, under the Safer Road work sites. The project is funded by the SRA.

Title:
Enhanced marking of road maintenance vehicles with so-called Battenburg patterns.

Published by SRA Consulting.

Contact: Johan Granlund.

Photo: Johan Granlund, Mats Landsberg, Tommy Nilsson, and Kjell Jansson

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Road work is risky - Our vehicles have to be seen!
Road traffic accidents are high on the top of action lists as the "big killers" in Sweden, as well as in other industrialized countries. International comparisons show that approximately 1-2% of all traffic accidents occur at road work sites, which consequently have (relatively) more accidents than the roads without street maintenance. Nine out of ten fatalities in road accidents on road work sites are road users, while "only" one in ten are road workers. Despite the higher number of fatalities, road users have a significantly lower risk than road workers. The simple reason is that road users numbers are many times more. Nine out of ten road workers are concerned about working on the road because of the passing traffic. Traffic accident risk is thus a very serious health and safety problem for the road work community.

Vägverksanställd svårt skadad. Olyckan inträffade på riksväg 80 utanför Falun på torsdagseftermiddagen. Vägverkets fordon blev påkört och en person som satt i bilen skadades svårt. Foto: KJELL JANSSON

Figure 1 - Road maintenance vehicle hit by a car in connection with the rebuilding of freeway 2 +1 road

Much of the risk of accidents at road works is associated with poor driving and high speeds. *Project Safer* road work sites have demonstrated that an effective set of measures reduces the risk of accidents, by increasing attention and reducing speed. A good example is radar-guided "Your speed" - signs. It is often difficult to effectively reduce the traffic accident risk at mobile / intermittent work, without significantly increasing road maintenance and road user charges.

Many accidents manifest on the road by not paying enough attention to road maintenance vehicles. Figure 1 shows an example of a violent rear-end collision. Road workers hit in the vehicle died later in hospital. It is obvious that road maintenance vehicles must be [effectively] marked out and more visible!

Testing enhanced marking

The 1995 edition of the *Handbook of Work On Road* provided the opportunity to fit a road maintenance vehicle with a rear label; so-called observation markings in a yellow-green guild set chevron pattern. To reduce costs this option was used on only a few vehicles. Staff have been monitoring markings on their vehicles, such as the Profilograf P16 road surface measuring vehicle shown in Figure 2 (photo taken in 2002); experienced marked improvement in security since the behaviour of other road users showed increased attention

Figure 2 - Older chevron marking in yellow + green colour is no longer allowed for road maintenance vehicles.

In order to distinguish between police, medical and rescue services at accident scenes, each service type with blue lights on vehicles is marked with the EU-standard colour combinations. Ambulance cars are marked with yellow-green. When this standard was introduced, SRA decided to cease with yellow/green marker chevrons on the rear of the roadway testing vehicles.

The group of road workers who received the new yellow/green marking on their vehicles did not remove them, but got them replaced with an equivalent marking. Other road workers then called for enhanced marking of their vehicles. In June 2005, the SRA conducted a full-scale test of alternative warnings in cooperation with 3M and the Factury brands. A handful of patterns using orange/blue box patterns were tested, see Figure 3. The material is intensely reflective in the dark and luminous (fluorescent) in daylight.

Figure 3. Test of alternative markings on Profilograf P16 at Factury Fire

Decisions on a voluntary enhanced marking

On 13 March 2006 the Road authorities generally approved the Battenburg pattern of enhanced marking of temporary road maintenance vehicles. The decision means that it is permissible, but not mandatory to enhance the markings on road maintenance vehicles.

Figure 4. Approved markings - Battenburg rectangular boxes in 1:3 format

Should be enhanced marking compulsory?

Staff who drive vehicles with enhanced marking report that they feel a very marked increase in the attention and slower speeds of other road users. The marking of the vehicles may increase the safety and security, but it costs a thousand Krona per vehicle for the outsourcing and consulting firm. These costs taken one way or another are paid for by the SRA. The labelling is then paid by the taxpayer, which could otherwise be used to repair the broken and dangerous roads, new safety railings etc. Therefore, the SRA have not yet adopted a general mandatory requirement for marking vehicles with Battenburg Design.

Certain operating contracts now require that vehicles must have individual characteristics. If it appears that the enhanced markings are very good and cost-effective, their use should then increase rapidly.

So there is reason to ask the following questions regarding enhanced markings:

- How much do they slow speed?
- How much do they reinforce the attention other road users?
- How much do they reduce the risk of accidents and severity of accident outcomes?
- Are the enhanced markings cost-effective so that they can quickly be made compulsory?

These questions are not easy to answer. Maybe it will take an unreasonably long time to obtain sufficient and objective facts for a perfectly informed decision? In this case, any mandatory decision if taken fairly quickly should be based on sensitivity. The purpose of this evaluation is so that an objective measurement gives a reliable indication of the effectiveness of the speed reducing effect of enhanced markings fitted to road maintenance vehicles.

Assessment of the Battenburg pattern

The evaluation was done using a Profilograf laser on two measuring cars, P43 and P45, see Figure 5. The measuring cars are built on identical VW Caravelle minibuses and fitted with a 2.5m wide metal support beam on the front which is fitted with lasers to scan the condition of the road surface.

On one car - P43 - the tests were undertaken with the usual (but reflective) corporate decals on the front and sides with rear lighting. The other car - P45 – was fitted with Battenburg fluorescent and highly reflective orange / blue markings affixed all around the vehicle.

The cars had identical flashing lightbars on the roof which were illuminated for all measurements during the tests. Both cars are painted white, which is statistically the colour at lowest risk of collision.

Figure 5. Trial Vehicles with and without Battenburg Markings

The speed of oncoming vehicles respectively *running* was measured with Sierzega SR3 radar units mounted inside the *graphic profiler*. The forward-looking radar was set on the dashboard at a 33-degree angle towards the traffic, see Figure 6. The rearward facing radar was mounted at a 19-degree angle. In all cases the radars sat at 1.4 m above the road. Radar accuracy is less than 1 km/h, ie the measurement is better than the typical original vehicle-mounted speedometer.

Figure 6 The radar unit mounted forward in the Profilograf measuring vehicle

The test stretch consisted of 52 km of road, the route 793/215 Linkoping to Finspång. The tests were carried out in daylight and in darkness. The testing was repeated at the same time on following days in order to eliminate any timing variations in traffic composition. The crossover means that the tests were done with Profilograf P43 in the afternoon on day 1 and repeated with the P45 over two days. Two roadwork operations were tested. The first trial was a classic test called the *Inspection stop*. The measuring car was simply parked on the roadside, see Figure 7 and Figure 8.

Figure 7. *Inspection stop* on the hard shoulder (the flashing lights were turned on, but they are not visible in the photo)

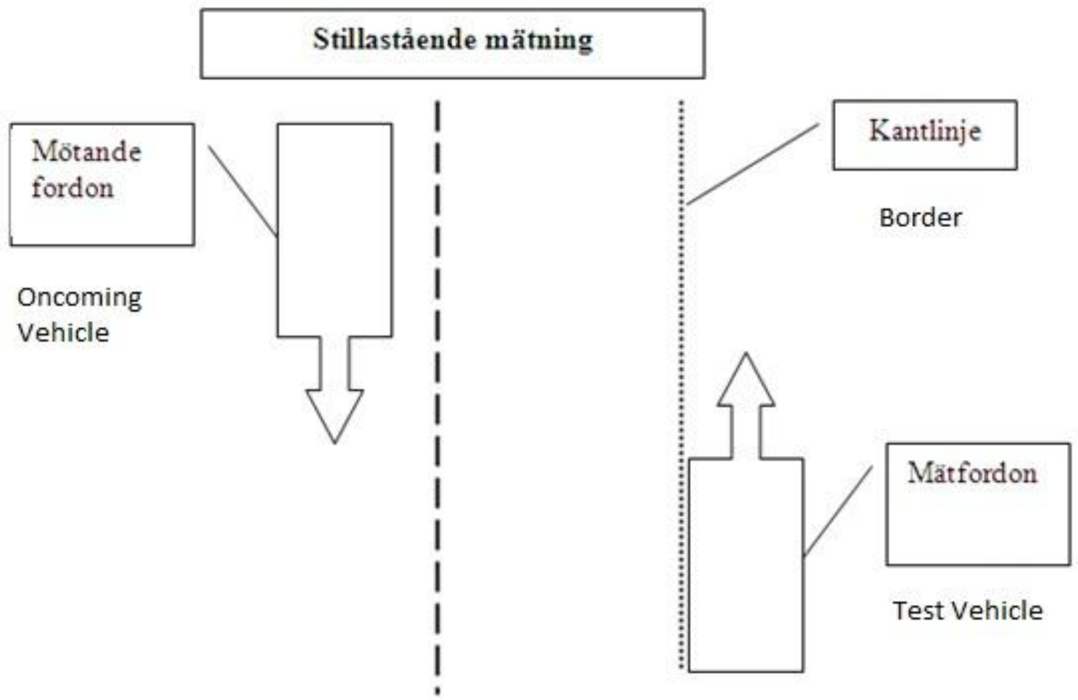


Figure 8 Vehicle location at *inspection stop* (stationary measuring car/radar)

The second test was a moving trial where the measuring cars simulated the testing of the lane centre measurement for asphalting work, see Figure 9 and Figure 10. The measuring cars ran along the centre of the lane in the normal traffic pattern. Therefore, the vehicle moved the radar with the measuring car at speed. Profilograf systems are an extremely sensitive odometer logging the measured car speed, so the radar readings can be calibrated for accurate measurements of road speed.

Figure 9. Centre of lane measurement of normal traffic patterns

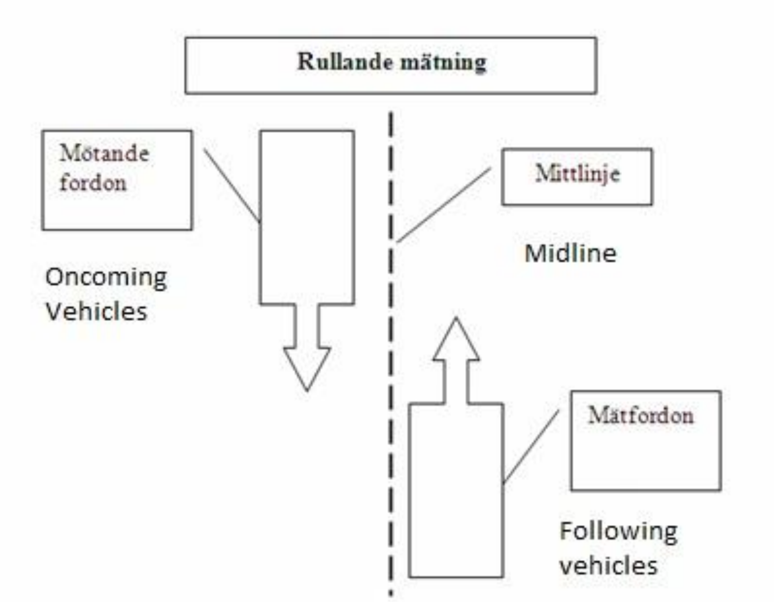
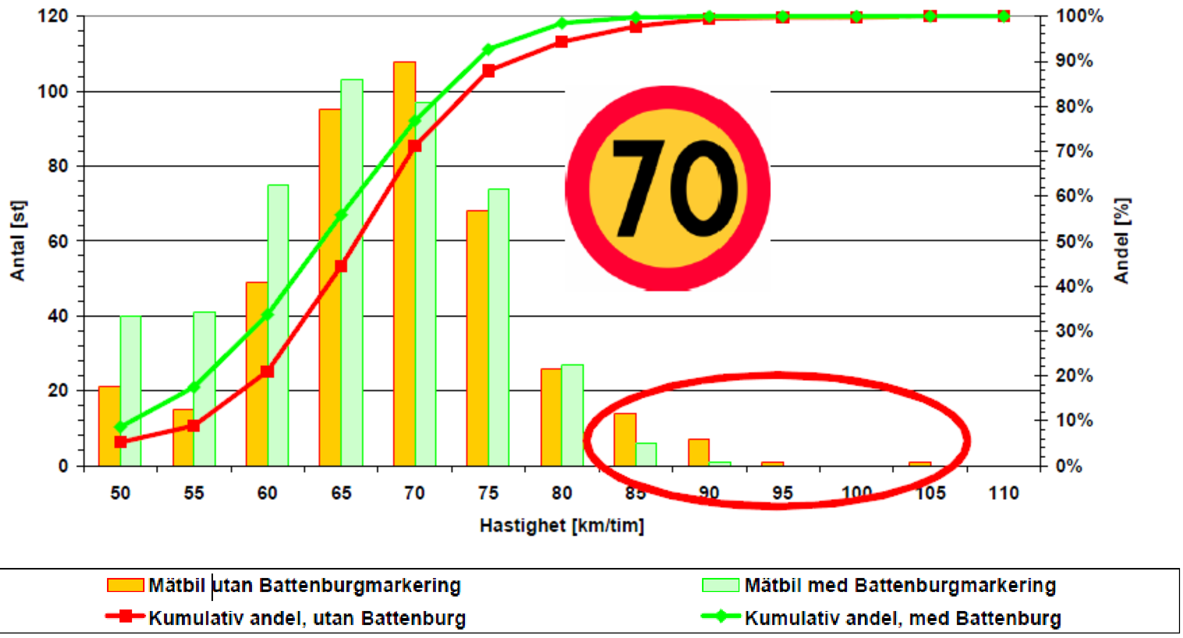


Figure 10. Vehicle Location at the center line of measurement (rolling survey vehicles /radar)

Good speed damping stopped on road
Measurement results for the high-rise cable harness category "running vehicle" shows the enhanced marking gave good speed damping. The proportion of the course continued running issue (> 15 km / h) decreased by 90%. The average speed moderated by 3 km/hr. The number of observations was N = 870 vehicles

För two way passing at speed in the dark past the stationary vehicle
on the hard shoulder of the road



- Measuring car without Battenburg markings
- Cumulative proportion without Battenburg
- Measuring car with Battenburg
- Cumulative proportion with Battenburg

Figure 11 Enhanced marking resulted in good speed damping when stopped at the roadside

No apparent speed damping at the midline measurement
When moving, each individual measured reading with the calibrated radar measured the car's own velocity as the other vehicle approached. The accurate calibration for "vehicle-to-vehicle" turned out to be more time consuming than expected, and was not included in the project budget. Therefore, the registered readings are only roughly analysed from the calibration with the measuring car moving at medium speed.

The Battenburg marking has a large surface area on the rear of the vehicle; see the photos in Figure 5 and Figure 7. In front, only the low-set measuring beam carried enhanced markings. Thus it is reasonable to expect greater speed dampening effect on the following vehicles, rather than the oncoming vehicles. By driving the measuring car in normal traffic patterns there will be very few numbers of overtaking or on running vehicles. In addition, overtaking or on-running vehicles found their driving affected by other random factors largely unrelated to this evaluation. For example, a "speed fool" who tends to drive very fast will be delayed by the oncoming traffic and ends up in the queue behind the measuring car. These factors meant that the number of on-running vehicles registering in the test was very low and their speed so driven by random factors, that analysis of overtaking or on-running traffic cannot give results with a reasonable statistical certainty. Therefore, this type of data was rejected. The analysis therefore focused on the speed of the oncoming vehicles; however results from this analysis showed no apparent reduction in the approach speed with Battenburg markings displayed.

The loss of speed dampening effect on the oncoming traffic may indeed have masked the perhaps too simple overall calibration. Another reason may be that the frontal surface of Battenburg marking on the metal beam is very small and associated with a lower level, see Figure 12. These point to a need for road maintenance vehicles to be highlighted more on the front. In the specific case of the road surface measuring cars, the staff are keen that the measuring beams are not extended and therefore it is important that the protruding parts are already highlighted. Extensions of any markings should be placed on the bumper, bonnet and rear-view mirror housing. It is important that any markings on the hood do not instigate any unwanted reflections towards the operators. However, this is probably a very low risk.

Figure 12. Hood, bumpers and mirrors can be used to increase the frontal area highlighted at the eye height

Relatively small errors / uncertainties

The number of observations underlying the graph in Figure 11 was N=870. This is considered sufficient for provide a reasonably safe estimate of the speed of attenuation. More observations are, as in most testing and measurement, indeed desirable.

Radar resolution is 0.1 km /h and the accuracy is about 1 km/hr. The uncertainties of the measurement set is, compared to the speed damping effects measured, small enough to not affect the conclusions. The blue company marker at the rear and sides of the reference vehicle P43 (see Figure 5) was reflective and therefore was something more spectacular than many regular "temporary road maintenance vehicles." Furthermore, the P43 has three large blue lights. P43 can possibly have given some road users the impression of being an (older) police vehicle and thus have had some speed damping effect. This means that enhanced markings in the Battenburg pattern can provide even greater speed damping when mounted on vehicles with a history of the less-conspicuous company marking. Extra lights are affective nevertheless notwithstanding the important results of speed reduction at the inspection stops, as they relate to the following vehicles but not oncoming vehicles. In any event, this study can hardly be overestimated due to the assumed Battenburg speed damping effect.

Recommendations / further work

SRA should consider introducing a requirement for mandatory Battenburg markings, or otherwise accelerate the pace of voluntary use. SRA's definitions of Battenburg markings can also be redrafted to be more certain and more effective. The primary risk is a rear-end collision followed by the risk of a frontal collision. Many marked vehicles have a relatively small frontal area of Battenburg displayed. Therefore, these vehicles will demand more markings on the front.

Contour markings are included as a requirement of Battenburg markings. Contour markings are perceived by many road workers as fairly bland and an unnecessary tape cost, because the risk of collision is relatively low in many types of road works. Therefore, contour markings have been made optional. Instead the expensive tape markings should be used on the hood and on the back!

The orange/blue Battenburg boxes should be in the size formats defined as 1:3. At the same time, they must be adapted to some extent to fit the body lines on any current vehicle. There has been some discussion concerning unacceptably high deviations from the 1:3 format. For the sake of clarity, it would be helpful to introduce new guidelines outlining the maximum acceptable deviation from 1:3. SRA also requires that the corporate logo will be displayed within the field. This means that the logo must have the same 1:3 format, which entails extra work for the many signage contractors and consultants marking programs. The beats are not competitively neutral and may hardly be cost effective. Thus, SRA should consider adjusting requirement logo formats. One possibility is that the logo should be in a 1:3 "Battenburg Square", whereas the device itself may have different height / width ratio.

If you want to read more

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Internet (free): http://www.vti.se/templates/Report____2796.aspx?reportid=9014
D'Elia, A. & Newstead, S. (2007). An Investigation Into the Relationship Between Vehicle color and crash risk. Monash University Accident Research Centre, Report 263rd
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Friberg, F. (2007). Calmer work on the road. SRA, publ 2007:26.
Internet (free): http://publikationswebbutik.vv.se/shopping/itemlist____277.aspx

Friberg, F., Granlund, J., Johansson, A. & Persson, M. (2006, 2007). Project Safer roadwork sites, interim 2004-2005 and 2006 respectively.
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SRA website Work on the Road. Internet: www.vv.se / APV

Reinforced marking of road maintenance vehicles with SK Battenburg patterns
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Civil Engineer Johan Granlund is the IPMA Certified Senior Project Manager and has worked with the SRA vägbanereparationer since 1991. John is the inventor of two patented road engineering methods, has implemented the EU-project ROADEX *Health Issues Raised by Poorly Maintained Road Networks*. He is secretary of the Nordic Road Engineering League committee "Vehicles and Transport", Chairman of Skandinaviska Vibration Association's committee "vibration effects on humans", member of the Swedish Standards Institute committees Vibration and Shock and road surface characteristics. John has acted as teacher Asphalt in school, is a sought-after lecturer and has written articles in several international scientific journals in vehicle and road engineering.

Tommy Nilsson has extensive experience of working on the road, largely in connection with road marking and measuring term length.

Stefan Hedlöf now works on the bridge project with the road surface, depending on the season.

SRA Consulting
Road and Transport Business
Red road 1
781 1995 BORLÄNGE
Tel: 0243-943 88, 070-337 53 88
Fax: 0243-832 28
E-mail: @ johan.granlund vv.se
Internet: www.vagverketkonsult.se

ADDENDUM – January 2011
PLEASE NOTE that SRA does not exist anymore.
After a decision in parliament, SRA has become the Swedish Transport Administration (www.Trafikverket.se). All material at the old SRA website www.vv.se will in due time be moved into www.trafikverket.se

SRA Production has in a similar way become the state-owned company Svevia (www.svevia.se)

The state-owned company Vectura (www.vectura.se) was formed by a merger between SRA Consulting Services and the Swedish RAILway Consulting Services.

An update of contact info on page 16:

Old/current version reads
SRA Consulting Road and Transport Business
Red road 1
781 1995 BORLÄNGE
Tel: 0243-943 88, 070-337 53 88 Fax: 0243-832 28
E-mail: @ johan.granlund vv.se
Internet: www.vagverketkonsult.se

Updated version:
Vectura Consulting AB
Forskargatan 3
781 28 BORLÄNGE
Sweden
Tel: +46 771 159 159, +46 70 337 53 88
E-mail: johan.granlund@vectura.se
Internet: www.vectura.se