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Review of Delineation Research

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1 Introduction

Between 1993 and 2004 Central Laboratories have undertaken a series of approximately fourteen related significant research projects into New Zealand delineation. These projects followed on from a number of operational research projects carried out for Transit NZ and National Roads Board prior to 1993.

A major influence on the research was a move by Transit NZ towards a performance-based approach to the management of the highway network. Research was therefore needed in several areas:

- to identify driver needs of delineation so that appropriate performance requirements could be set;
- to develop test methods by which delineation performance could be reliably quantified, especially in-situ on the highway;
- to understand the behaviour of materials and develop tests that could be used by the roadmarking industry to develop improved products; and
- to benchmark current performance so the extent of any improvement needed to meet driver needs could be identified.

Underlying the move to performance-based standards was recognition that, for roadmarking materials in particular, the systems used in New Zealand were only modest by international standards and improved products were needed. A method-based approach to introduce improved products is cumbersome whereas a performance-based approach allows industry to easily introduce new products as they become available.

New Zealand has a mixed delineation system provided through items such as roadmarkings, raised pavement markers, edge marker posts, chevrons and hazard markers. Most emphasis of the research was placed on the roadmarkings however, as the other products and their uses already better matched best international practice.

The nature of all research is that it is evolving knowledge, and the findings of earlier work are often reviewed and viewed differently as later work is completed.

The purpose of this report is twofold. It is first to collate all of the delineation research work, and second to review the work and from the current position now apply the wisdom of hindsight to the findings as they were set out at that time in the report or associated papers.

Funding of road research in New Zealand is provided by several agencies. Funding for the delineation research projects was therefore sought for these different projects according to spheres of interest. There is however considerable overlap on the type of subject funded.

- Transit New Zealand funds operational research especially around specification development, highway maintenance processes and quantifying of on-road performance.

- Land Transport New Zealand (formerly Transfund Research and formerly Transit Research) fund a wide range of applied research with an emphasis on applying overseas practice to a New Zealand setting. The delineation projects funded by the agency tended to be the development of test methods and trials around introducing new materials and safety systems, and projects measuring the effectiveness of improvements.
- Road Safety Trust (administered by the former LTSA) funds research specifically in road safety including work around driver behaviour. Delineation research funded by the Trust was primarily into researching driver needs and the consequent performance standards required.

The format of this report is to group the projects by the focus of the work, and then to provide an approximately one page commentary on each group, outlining both the main focus of the work and also further comments on how those findings should now be viewed in relation to other work. A final section in the report provides some comment on future research directions.

The work groupings are:

1. Early work,
2. Materials, test methods and field trials,
3. Driver needs,
4. Cyclists and delineation,
5. Benefits of improvements,
6. Specification development, and
7. Intelligent systems.

A listing of all the relevant reports and associated papers is provided at the end of each section.

2 Early work

The early work was undertaken from 1987 to about 1992 and was primarily operational research undertaken for Transit NZ/National Roads Board.

This early work with its emphasis on ways to measure paint film thickness is probably of little current interest but it is useful to recall in its context.

Roadmarking at that time was managed entirely by methods-type contracts. In these contracts a paint type of modest quality, selected by the engineer, was applied under contract by the roadmarker. The main contract measure, apart from correct placement, was paint film thickness, since it was considered that marking durability was directly linked to applied thickness. Additionally, since the contractor was responsible for sourcing and purchasing the material, a below thickness film was one way that a contractor may seek to gain an inappropriate economic advantage.

The method of collecting a sample of paint was to lay a zinc coated steel plate in the way of the line to be painted so that the paint lands on the plate and can be retrieved and, after drying, measured for thickness.

The purpose of the research work was to develop a robust method of paint film measurement for contract improvement. It would identify the variability likely to be encountered in paint measurements taken across the painted area of the plate as well as the uncertainties of measurement arising from equipment calibration, and allowing for the thickness of the zinc plate.

Although the goals of the research programme were achieved, it was futile as a contract enforcement tool. The taking of the paint sample is overt, and so is easily defeated as the contractor could slow and apply thicker paint for the sample, or could disrupt the sampling by, for example, partly missing the plate.

The research work was extended to examine the use of less overt sampling methods such as by way of a series of small metal discs placed on the line. These sampling methods were however less reliable, therefore negating the intended purpose of a robust method. Additionally, the use of the semi-covert method was opposed by the industry as being disagreeable to a good Principal/Contractor relationship. The work was also futile as it could not be applied to reflectorised lines.

However, the research work is still useful for contractors in the set up of their equipment and trimming their equipment to give the required film thickness. Film thickness is still a highly relevant parameter in achieving a satisfactory performance from roadmarkings and to ensure proper retention of properties, but the relationship of roadmarking performance to film thickness is complex.

A further relevance of this body of work is that it helps to illustrate the attractiveness of performance-based approaches to roadmarking performance. This early work was essentially of little use for retrieving quality delineation because it was trying to measure an intermediate outcome (applied thickness) that is much further removed from the main intended outcome of bright durable markings.

Reports

- Measurement of Paint Film Thickness – Ball, G., Dravitzki, V., and Potter, S. 1991. Central Laboratories Report 91-27328.00
- Thermoplastic Roadmarking Trials – Dravitzki, V., Munster, D., and Potter, S. 1991. Central Laboratories Report 91-27326.00
- Mirolux 12 Reflectometer Performance Assessment on Road Test Sites – Dravitzki, V., and Munster, D. 1991. Central Laboratories Report 91-27329.00

Related Papers

- *Nil*

3 Materials, test methods and field trials

A significant portion of the work undertaken in this area is not directly available in public reports as it was part of work undertaken for industry in establishing compliance with Transit NZ specifications such as TNZ M/7 (paint markings), TNZ M/20 (long-life markings), TNZ M/14 (edge marker posts), TNZ M/12 (raised reflectorised pavement markers) or to AS1906.1 (material for road signs).

Overall more than 170 individual products have been tested and of these about 65 percent have been roadmarking materials.

While the individual test is routine, overviews of materials' behaviour are obtained when these trials are viewed collectively. Some of these overviews are then presented at conferences. Examples are:

- Results of 1998 New Zealand Roadmarking Test Programme – Dravitzki, V. and Potter, S. *Roadmarking Industry Association Conference*, Geelong 1998.
- Performance of Pavement Markings Over Chipseal – Dravitzki, V., Potter, S. and Owen, T. *REAA Conference*, Wellington 1998.
- Materials and tools for better road markings – Dravitzki, V. *Transport Safety Symposium*, Rotorua 1998.

The overviews also help to identify areas where more research is needed. For example, Transfund Research Report No. 177 examines the reliability of field trials and factors that can influence the performance of roadmarkings. The need for this work was identified by observations of inconsistencies in the results obtained in the tests undertaken for industry.

Overall, work in this section on materials has emphasised that New Zealand's main road surface of chipseal has a pronounced effect on roadmarking performance. Both the materials and knowledge from other countries need to be evaluated for applicability in New Zealand conditions.

For markings on chipseal:

- The paint film thickness when applied on chipseal is less than would be expected when applied on other road surfaces, because the surface area of chipseal is large, as well as material flowing off the top of the chip.
- The mode of paint wear is different, being mainly adhesive loss rather than abrasive loss.
- Marking life on chipseal is usually shorter than for markings on flatter asphalt surfaces.
- Much of the applied marking area is not visible to motorists, only the marking that is on top of the chips is visible to motorists.
- The angular and free draining nature of chipseal means that even basic markings have moderate levels of visibility, even at night, and in wet conditions

While the influence of these types of issues should be evident in research from other countries where chipseal is used or where textured surface dressings are applied over asphalt, such findings do not appear to have been reported. This may be due to different approaches to testing markings in New Zealand compared to other countries. In New Zealand the test emphasis has been on demonstrating "suitability of purpose" of a roadmarking material, so markings are applied over our most common surface, which is chipseal. In other countries, a dominant influence in the testing design has been the requirement for a stable test surface for the marking, so asphaltic concrete type surfacings have been used for roadmarking trials, even if chipseal is the prevalent surface, as it is in South Australia for example.

The work on road signs was in two parts. The first examined the degradation of the sign sheeting material and was the dominant work. The second part examined sign effectiveness using a visibility model developed by ARRB. This second stage was inconclusive in that the model indicated that a number of near new signs were not effective. Whether this was a problem with the signs' placement or a defect of the visibility model could not be resolved at that time as ARRB had discontinued the development of that model.

The modelling approach developed by ARRB offered the ability to test the adequacy of a sign to be conspicuous and legible to a driver in sufficient time for the required driver action and so offered a robust rationale for selecting sign materials, sign size, and position. It is noted that there is an increasing trend to very bright signs and such a visibility model would allow the actual improvements of bigger and brighter signs to be evaluated. There would be benefit in revisiting this area of work if the ARRB visibility model was improved or if a visibility model from another source became available.

Reports

- Literature Review of Road Signs or Delineation - Dravitzki, V.1993. Transit New Zealand Research Project PR3-0123 (unpublished)
- Roadmarking Paint Film Thickness, Paint Type and Retroreflectivity Retention – Dravitzki, V. 1995. Transit New Zealand Research Project PR3-0131 (unpublished)
- Quantifying and Improving the Performance of Road Markings – Dravitzki, V., Loader, M., Potter, S., and Walton, D. 2001. Transfund Research Report No. 177
- Use of Rumble Strips as Warning Devices on New Zealand Roads – Dravitzki, V., Logan, N., and Munster, D. 1998. Transfund Research Report No. 103
- Photometric Properties of New Zealand Road Signs – Dravitzki, V., Munster, D., Potter, S., and Wood, C. 1996. Central Laboratories Report 96-527412 *Prepared for the Road Safety Trust*
- Photometric Properties of New Zealand Road Signs - Part 2: Deterioration of Reflective Material with Age – Dravitzki, V., Munster, D., and Potter S. 1998. Central Laboratories Report 98-527516 *Prepared for the Road Safety Trust*
- Review of the Best Practice for the Use of Rumble Strips in New Zealand – Dravitzki, V., and Munster, D. 1998. Central Laboratories Report 98-527449
- High Speed Mobile Collection of Street Lighting Illumination Data – Harte, D., and Kean, R. 2005. Central Laboratories Report 05-527685 *Prepared for the Road Safety Trust*

- Visibility of Road Markings When Wet – Dravitzki, V., and Munster, D. 2000. Central Laboratories Report 00-527552.00 *Prepared for the Road Safety Trust*

Related Papers

- Roadmarking Paint Film Thickness Paint Type and Retroreflectivity Retention – Dravitzki, V. *RIAA Conference*, Surfers Paradise 1996.
- Results of 1998 New Zealand Roadmarking Test Programme – Dravitzki, V., and Potter, S. *Roadmarking Industry Association Conference*, Geelong 1998.
- Materials and tools for better road markings – Dravitzki, V. *Transport Safety Symposium*, Rotorua 1998.
- Performance of Pavement Markings Over Chipseal – Dravitzki, V., Owen, T., and Potter, S. *REAA Conference*, Wellington 1998.
- Safety Benefits of Using Rumble Strips - Dravitzki, V., Munster, D. and Wong-Toi, D. *Road Safety Conference*, Wellington 1998.
- Rumble Strips – Development of Guidelines for their use in New Zealand – Munster, D., Wong-Toi, D., Owen, M. and Dravitzki, V. *19th ARRB Transport Research Conference: Investing in Transport*. Sydney 1998.
- Field Trials of Roadmarking Materials – Dravitzki, V., Potter, S. and Walton, D. *New Zealand Roadmarkers Federation Conference*, Rotorua 2001.
- When Do Signs Become Inadequate for Night Time Driving – Dravitzki, V. and Munster, D. *Road Safety Conference*, Wellington 1998.

4 Driver needs

The findings of the first of these reports, Transfund Research Report No. 65, should be treated with some caution. Subsequent to the completion of this work, discussion with Dr Peter Cairney of ARRB Research identified that the methodology used probably biased the finding. This methodology presented about six safety experts with images of roadmarkings at six different levels of brightness and asked them to identify an adequate level. Dr Cairney commented that a typical bias was that the panel probably realised that the poorer ones represented brightness levels already regarded as inadequate and the brightest represented the best achievable. As a consequence they tended to accept the middle value as the "compromise". In this study, the middle value was selected.

The two other reports on performance requirements approached driver needs with a much more robust methodology, where human perceptions of marking visibility had been encapsulated into visibility models. These models were then used to identify the reflective properties needed from New Zealand markings given their size and location of the road with other inputs being driver age, speed, degree of street lighting, vehicle type and lighting, road geometry.

There are limitations on the modelling in that the models used could consider only roadmarkings when most New Zealand roads have also RRPMs and edge marker posts. While roadmarkings are regarded as important for shore range visibility and edge marker posts for long range these functions are not exclusive.

This work could be revisited if more sophisticated models become available that can accommodate several of the delineation types.

In the meantime the present models provide a rational base for setting delineation reflectivity levels. They also allow a more justifiable basis for having lower levels of marking performance on lower volume roads, rather than arguments based on affordability, typically lower volume roads have both less roadmarkings and also markings of lower level of reflectivity than busy roads. This variation is argued as justified based on affordability. However the visibility models show that a similar variability can be justified on the basis that the visibility level, expressed as preview time, is reasonably constant.

A user of Central Laboratories Report 99-527450 on The Extent and Need for Reflectorised Markings noted an error in the data used. The analysis was intended to be based on crash number however it appears that it is number of injuries that has been used.

Reports

- Retroreflectivity: A Recommended Minimum Value – Dravitzki, V. and Potter, S. 1997. Transfund Research Report No. 65
- Minimum Performance Requirements for Delineation Dravitzki, V., Laing, J. and Potter, S. 2002. Central Laboratories Report 02-527450 *Prepared for the Road Safety Trust*
- Guidelines for Performance of New Zealand Markings – Dravitzki, V., Wood, C., Laing, J. and Potter, S. 2003. Central Laboratories Report 03-527605 *Prepared for the Road Safety Trust*
- Extent and Need for Reflectorised Markings – Dravitzki, V. and Potter, S. 1999. Transit NZ project 99-527450

Related papers

- Should Preview Time be the Measure of Level of Service for Delineation – Dravitzki, V. *ARB Transport Conference*, Melbourne 2000.
- Retroreflectivity Levels Required of Markings – Dravitzki, V. and Munster, D. *New Zealand Roadmarkers Federation Conference*, Queenstown 1999.
- How Bright Should Markings be and how do Current New Zealand Markings Compare – Dravitzki, V., Laing, J. and Potter, S. *New Zealand Roadmarkers Federation Conference*, Auckland 2003.

5 Cyclists and delineation

Most of this work is directed at the hazard that may occur for cyclists from delineation provided mainly for motorists.

This phase of the work arose from complaints from cyclists that new thermoplastic lines used on the roads was causing instability when these lines were crossed over at shallow angles such as when moving from the road shoulder into the trafficked lane, and also for the reverse manoeuvre. Several cyclists reported falling from their cycles, and in one instance it is believed that the thermoplastic line helped to initiate a cyclist's fall into the traffic lane, resulting in death for the cyclist.

These complaints appeared to be mainly confined to the Wellington area and mainly with regard to state highways. Few similar complaints have been recorded with thermoplastic lines on Wellington streets where they had been for about three years prior to the cyclist fatality. Whether this is due to the absence of incident, or reflects instead a lack of reporting, is unknown.

The unique aspect of the thermoplastic line was its thickness, which was 2 to 4mm thick, compared to paint of 0.15 to 0.30mm thick. It appears that lines associated with instability may have been applied far too thick, being in the vicinity of 5 to 10mm thick.

The first two reports (Stage 1 and 2) give much of the context of the work and of New Zealand practice in relation to international practice.

The third report undertook stability testing on lines of a range of thicknesses so as to be able to set upper limits to line thickness in specifications. The findings of Stage 3 should be treated with some caution, as subsequent to its publication comment has been received (*D. K. Walton, personal communication*) that the methodology was loose and participants should have been set an additional task while traversing the lines.

A further limitation of the Stage 1 to 3 reports arises from their scope. Each was funded as a small investigation project in response to an emerging problem, rather than as a larger research programme to take a wider view of the issue.

The fourth report, "Balancing the needs of cyclists and motorists" continued this work, but with a much more robust methodology, which this time included randomised tasks, and examined the effect of a much wider range of marking types. It identified the relative effects on stability of a number of delineation devices/line types and showed that cyclist stability on markings was determined by more than simple relationships of line thickness or the skid resistance of a line material. However more research would be needed to fully identify these relationships.

A second strand of the work was the positive help that delineation may provide cyclists. "Balancing the needs of cyclists and motorists" also examined the role of the road edge line in cycling. It showed that the edge line and the width of cycle-able, obstruction-free shoulder inside the edge line was a powerful predictor of the cyclists' path on the road.

Reports

- Investigation into Thermoplastic Performance: Part 1, Review of Current Practice – Munster, D. and Dravitzki, V. 1999. Central Laboratories Report 00-527550
- Performance of Thermoplastic Markings and Cyclists' Safety: Stage 2, Line Thickness and Skid Resistance Studies – Munster, D., Dravitzki, V., and Mitchell, J. 1999. Central Laboratories Report 00-527550.02

- Performance of Thermoplastic Markings and Cyclists' Safety: Stage 3, Further Line Thickness Studies – Munster, D., Dravitzki, V., and Mitchell, J. 2000. Central Laboratories Report 00-527559.00
- Balancing the Needs of Cyclists and Motorists: Walton D.K. Dravitzki V.K., Cleland B. and Thomas J. Transfund Research Project

Related papers

- Thermoplastic Road Marking Research – Donbavand, J., and Munster, D. *Engineering for Road Safety Symposium* Rotorua October 2000
- The Relative Effect of Line Markings on Cycle Stability – Cleland, B., Thomas, J., and Walton, D. *Safety Science,* 43(2) pp 75-89
- The Effects of Line Markings for Wet/Night Visibility on Cycle Safety – Cleland, B., Dravitzki, V., and Walton, D. *26th Australasian Transport Research Forum* Wellington October 2003
- Balancing the Needs of Motorists and Cyclists: Nine Myths about Cyclists and the Road Shoulder – Dravitzki, V., Thomas, J., and Walton, D. *Australasian Road Markers' Society Conference* Brisbane September 2004
- Does Providing Wet/Night Visibility for Motorists Compromise Cyclist Safety? Dravitzki, V., and Walton, D. *New Zealand Roadmarkers Federation Conference* Auckland September 2003

6 Benefits of improvements

The first two projects, "Effectiveness of Road Edge Marker Posts" and "Safety Benefits of Brighter Roadmarkings" sought to establish the safety benefits of improved delineation. In both instances the improvement comprised a change whereby the delineation device was made more visible, usually be making it more retroreflective, but in the case of the edge marker posts, the spacing of the posts was decreased. Both projects sought to identify the benefits of specific elements. They are therefore different from assuming the effectiveness of treatment at road "black spots". These assessments calculate the total effect of all the treatments at the black spots.

Neither study was conclusive as to there being any effect. These are studies that will typically use a "before" and "after" period of two to five years, and it appears that other changes, such as changes in reporting rates may have helped mask any trend. Another difficulty in the analysis is the degradation of the delineation over time and the linkage of maintenance programmes to this deterioration. Within a maintenance cycle the delineation will change from clearly visible to medium to low visibility, yet this is seldom accounted for in there before and after studies and often the information on delineation condition is not available.

A further difficulty in New Zealand, and even in a number of countries, is that a mixed delineation system is used. Roadmarkings, RRPMs and edge marker posts are often used together and while some are definitely associated with long range guidance of the route, and some with short range placement of the vehicle within the lane, none have an exclusive function, nor is the cross-over from short range to long range visibility clearly demarcated.

To be robust the condition of the delineation and the condition of the other delineation devices need to be known and accounted for in the analysis, first because the visibility level is variable and second, the total visibility depends on all devices.

Many international studies claim distinct and often high safety benefits of delineation improvements. Given that these studies usually do not appear to include the condition (visibility level) of the delineation or the effect of other devices present, there should be some caution in accepting their findings.

Further complications in before and after studies arise from the complexity with which delineation is used. It provides route guidance along with many other signals, many which are used at the pre-attentive level. The contribution that delineation makes to safer driving and the particular properties of delineation that allow this contribution are still not known. Therefore the analysis can suffer from the absence of critical parameters of the delineation's contribution to safety.

It may be that studies of delineation improvements should focus on intermediate outcomes such as speed, road position, driver comfort, and driver safety.

The level of maintenance may be important for another reason. It is known that most journeys on fully marked roads are completed in safety. Similar, most journeys on roads with no signs or markings are completed in safety. For both to occur there must be a process of adaptation. Drivers would put little trust in poorly maintained delineation, and high trust is very well maintained delineation. There must therefore be some cross-over point between little trust and high trust and this raises the possibility that undue trust is given and that it is defects in otherwise reasonable delineation rather than the presence or absence of delineation which reduces safety.

The third study was much more of the classic before and after study without confounding factors. Vehicle number plates had been changed from non-reflectorised to reflectorised, thereby increasing the visibility of vehicle parked on the roadside. The study found a significant reduction in "hit parked vehicle" crashes for those with reflectorised plates.

Reports

- Effectiveness of Road Edge Marker Posts – Dravitzki, V.K. and Harte, D. 1995. Transit New Zealand Research Project PR3-0021 (unpublished)
- Safety Benefits of Brighter Roadmarkings: Dravitzki V.K., Wilkie S.M., Lester T.J., Transfund Research Project.

Related papers

- Effect of Reflectorised Number Plates on “Hit Parked Vehicles” in Night Time – Dravitzki, V., Tate, F., Koorey, G. and Davies, R. *Road Safety Conference*, Wellington November 1998
- Effectiveness of Reflectorised Number Plates in Reducing "Hit Parked Vehicles" in New Zealand – Davies, R., Dravitzki, V., and Tate, F. *Vision 2000 Conference,* Brisbane October 1999

7 Specification development

Many of the findings of the delineation research have been incorporated into specification. Transit NZ has a set of specifications relating to delineation which are de facto standards for other roading authorities. These specifications include material specifications (such as TNZ M/7, TNZ M/20, TNZ M/12, and TNZ M/14) into which the test methods developed in the delineation research have been included. Performance specifications have also been developed (TNZ P/19 - RRPMs, TNZ P/20 - roadmarkings, and TNZ P/21 – edge marker posts). These performance based specifications incorporate the test methods and performance requirements developed by this research. Section 1 noted that a strong motivation for this body of research was to underpin these performance based specifications.

However the performance based specifications have had only mixed success. Though performance criteria have been specified, it appears that delineation is often less than these specified minima. Their lack of success appears to stem from the need for all in the industry to make a significant cultural shift from a reactive mode, that being one of taking corrective action once a system has dropped below standard, to a managed system of:

- Identifying expected performance
- Testing that the expected behaviour is occurring
- Scheduling corrective interventions to ensure that the system always remains above specified levels.

Central to this concept of a "managed system that remains above specified performance levels" are the concepts of measuring performance, and recording the condition of the asset in a systematic way so that timely planned interventions can occur.

It appears from the performance based contracts to date and as a general impression from those involved that many in the industry are still well within the reactive mode, that is:

- Testing is often only partly carried out, if at all
- Testing is undertaken to confirm observed underperformance, rather than to map asset conditions.

The need for this cultural shift extends across all sectors of contractors, consultants and road authorities.

One of the reasons that the need for the cultural change is not always apparent is that some specifications, such as TNZ P/20, have resulted in noticeable improvements. This is because each one of this specification contains an implicit raising of standards compared to the methods based specification. This arises because the specifications contain requirements not previously addressed. For example, a requirement for visibility of markings at night time has been set to the minimum international standard of 100 $mcd.m^{-2}.Lux^{-1}$ and markings are to be managed above that level. Previously when there was no requirement non-reflectorised markings started at this level when new but this was only by chance and deteriorated to about 40-50$mcd.m^{-2}.Lux^{-1}$ before replacement. Markings to P/20 standard therefore appear much better for most of their life but observations are that a number will be below standard at replacement.

Reports

- *Various reports prepared for Transit NZ Specifications, as identified earlier.*

Related Papers

- Development of Performance Based Specification for Roadmarking – Chelliah, T., and Dravitzki, V. *Roads 96 Conference,* Christchurch 1996

8 Intelligent systems

Only a small amount of work has been done on intelligent systems associated with signs and delineation. Report 92 primarily reviews Road Weather Information Systems and comments on their applicability to New Zealand.

A number of intelligent traffic management systems exist in New Zealand. However it is believed most of these have proceeded from site-specific evaluations rather than from general research.

Reports

- Road weather information Systems Dravitzki V., and Varoy C. Transfund Research Report No. 92

9 Recommended further research

The research work to date has had a broad focus of developing and understanding drivers' needs of delineation, tests to quantify delineation performance and research to assist industry to improve its products so that these needs could be met. A strong component of the work was to assess the applicability of international knowledge to a New Zealand setting. New Zealand practices are now equal to international good practice but not necessarily equal to "best practice". A useful next phase of the research is to go beyond matching international good practice and to develop ways of using the various delineation devices in ways that are most appropriate for our circumstances, but which are posited on sound science. This approach would require a significantly greater input from experimental psychology than the previous body of research.

The research should aim to identify how to use signs and delineation to best effect, that is, with respect to road user safety, user satisfaction and the efficient use of what can now be expensive materials.

Road users need an easily read coherent message of the route ahead and the hazards that may exist. We now have the materials available, can measure their material properties, and have some knowledge of how these properties may individually meet drivers' needs. What we do not yet know, is how best to bring these components of signs and delineation collectively to give this easily understood message.

9.1 Issues to be researched

The research should address:

- Understanding how to achieve "visual balance" with delineation and how it can improve the driving task. "Visual balance" refers to how bright should road-edge delineation and warnings should be, relative to on-road markings, so that they warn and guide but do not distract or confuse the driver. On-road visual balance will consider how bright the individual elements are relative to each other so as to provide clear messages of the route, and avoid dominance by one element.
- Identifying the relationship between completeness of delineation and safety. It is important to identify this relationship because of its impact on maintenance standards. It is thought that this relationship is non-linear and that "holes" in an otherwise well delineated road may deceive drivers more than a poorly marked road in which they place little trust.
- Identifying the optimum brightness of signs and warnings especially in wet conditions so they can be seen by drivers, but not too bright so as to avoid glare and distraction and reduce the use of very expensive materials.
- Identifying whether edgelines can be safely used on narrow roads, being roads that are too narrow for a centre line. At present road markings are not advised for these roads because of unsubstantiated concern that edgelines may cause opposing traffic to travel too close to the centre. However such markings may be of considerable benefit for rural drivers
- Identify techniques to effectively mark road furniture close to the road edge. The recently completed study identified the need for such marking, and the need for a new type of marking that provided both a warning, and strengthened the delineation near such furniture
- Identifying advantages of continuous roadmarkings over bright point source delineation (RRPMs). The heavy arrays of RRPMs as currently used often confuse rather than clarify the route ahead. Less bright but continuous markings better used, may provide a more coherent delineation of the route.
- Identify the satisfaction benefits of improved delineation. Driver satisfaction is a tangible benefit of delineation systems that are easily seen and understood (in addition to safety benefits). This satisfaction benefit is thought to be substantial. The advantage of quantifying satisfaction benefits is that they can be quantified more easily and quickly than safety benefits. Safety improvements, as identified by robust laboratory trials, that will also have a high satisfaction benefit could therefore be justified for implementation much more quickly.
- Night time work zones present a massive array of delineation and warning devices based on "more and brighter is better". Alternate devices with a much simpler and a clearer message should be evaluated.