

# PERFORMANCE MANAGEMENT OF NETWORK PAVEMENT MARKING

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*Note: The views expressed in this paper are those of the author, and do not necessarily reflect those of the Department for Transport, Energy and Infrastructure.*

## **ABSTRACT**

The road user expects road authorities to provide a safe, sustainable, integrated and competitive transport system. Pavement marking is an important part of the road network, and is critical to the safe movement of vehicles through clear delineation and guidance. The 1980's and 90's saw a significant shift in the way many organizations operated, with financial specialists infiltrating senior management positions. For many Government transport authorities, this meant a dramatic shift from an engineering focus to one that revolved around financial accountability.

Like most Australian state road authorities, the Department of Transport, Energy and Infrastructure (DTEI) pavement marking program had been entirely time-based. This method of programming, whereby lines are marked yearly or 2-yearly, is the easiest to manage in terms of operations and budgeting, particularly where this service is outsourced. In addition, for the sake of simplicity, the vast majority of marking was paint/ glass bead based.

With increasing pressure on the distribution of Federal and State funds to health, education and welfare, managers have had to battle harder for funds to develop and maintain transport networks. This has increased the focus on needs-based management of roads, replacing the previous time-based maintenance model.

This paper describes a management process and strategies which have yielded significant cost savings, releasing funds to be directed at targeted network improvement.

## **1.0 INTRODUCTION**

The availability of funding for maintenance of the transport network is becoming increasingly limited, and it is therefore important that Government direct funding where it is most needed. Pavement marking is a critical maintenance function for road authorities, consuming a significant percentage of the maintenance budget.

DTEI initiated a project in 2001, which investigated ways in which a safe standard of delineation could be achieved at a lower cost. This project identified a number of strategies which, if implemented, would not only deliver reduced cost, but would allow an improvement in the standard of performance of the network<sup>1</sup>. A number of these strategies have now been implemented, and this paper provides information regarding the specific outcomes.

## **2.0 MILESTONES**

As line marking makes up the greatest percentage of the pavement marking budget, it also provides the greatest opportunity for savings. The initial focus was therefore to make improvements to line marking, based on the strategies identified in the DTEI project, and then to address other pavement marking issues later.

With regard to line marking therefore, a number of milestones were established:

- 1) Identifying and controlling the factors affecting performance of line marking.
- 2) Standardising the procedures and equipment for assessing performance.
- 3) Re-assessing the way in which the network was managed geographically.
- 4) Developing a new contract and procurement format.
- 5) Quantifying savings resulting from changes in strategy.
- 6) Identifying opportunities for improvement of the network, by re-investing savings.

### **3.0 DISCUSSION**

#### **3.1 Factors Affecting Performance**

The factors affecting performance were:

- Materials
- Application rates
- Plant
- Application and curing conditions
- Pavement type and condition
- Traffic volume and type

In terms of materials, DTEI used Australian Paint Approval Scheme (APAS) waterborne paints and beads conforming to AS 2009 as quality criteria.

Based on previous DTEI R & D<sup>2</sup>, the paint application rate was specified as 300µm wet and the glass bead application rate as a minimum retained 275 g/m<sup>2</sup>.

Application equipment has a significant impact on the quality of line marking produced. DTEI uses plant certification to pre-qualify contractor equipment which can demonstrate control of application quality within specified parameters.

In terms of application conditions, data was available which demonstrated that waterborne paint applied in the cool and wet months did not perform as well as those markings applied in good conditions. DTEI contracts now preclude marking in the 3 month winter period in SA. In terms of curing conditions, the main risk is in opening markings to traffic before they have fully cured, which results in a loss of initial retroreflectivity. DTEI contracts specify a retroreflectivity value for fresh markings to cover damage due to inadequate protection during curing.

Extensive retroreflectivity monitoring, carried out over a number of years, has shown that pavement macrotexture has minimal impact on the durability and performance of waterborne paint. Pavements which are in poor condition will however have a negative impact on performance.

There is a direct relationship between traffic volume and the life of markings. For this reason, traffic volume and type is a primary performance parameter and retroreflectivity requirements have been determined for different levels of traffic volume. See Table 1.

#### **3.2 Performance Assessment**

In order to use residual performance of markings as a programming tool, it is important that performance assessments are carried out in a uniform manner, using calibrated equipment where possible. DTEI use daytime visibility and retroreflectivity as the key performance criteria for line marking assessment. Retroreflectivity is assessed in accordance with a DTEI procedure<sup>3</sup>,

with measurements carried out using an MX 30, in accordance with the DTEI night visibility procedure<sup>4</sup>. Standard procedures have also been developed for the assessment of daytime visibility, using visible distance as the assessment criteria<sup>5</sup>.

### **3.3 Network Geography**

The pavement marking schedule previously employed by DTEI was time-based, with roads marked at yearly, two-yearly and three-yearly intervals. The selection of marking interval was based on guidelines which were developed to ensure that maintenance funding was directed at those roads deemed to be most important to the state's economy.

Whilst this process may have been appropriate for road maintenance, pavement marking is specifically a road safety issue and the need for re-marking should be based on the performance of the marking and its residual life. The performance will essentially depend upon the quality of application and traffic volume, which is discussed in greater detail in the following paragraphs. The marking program is now 90% needs-based with few roads linked to perceived importance.

### **3.4 Contracting and Procurement**

Like most road authorities, DTEI's pavement marking program had been entirely time-based. This method of programming, whereby lines are marked yearly or 2-yearly, is the easiest to manage in terms of operations and budgeting, particularly where this service is outsourced. In addition, the vast majority of marking was paint/ glass bead based for the sake of simplicity.

With increasing pressure on the distribution of Federal and State funds to health, education and welfare, managers have had to battle harder for funds to develop and maintain transport networks. This has increased the focus on needs-based management of roads.

Pavement marking is a critical maintenance function for road authorities, consuming a significant percentage of the maintenance budget. The development of a contracting and procurement form which would compliment the needs-based marking approach was required, and is discussed in further detail in Clause 4.

### **3.5 Quantifying Savings**

South Australian roads are divided up into marking zones, with each zone having 2 or 3 significant arterial roads and a number of local roads. Time-based marking meant that whole zones were marked in the same time frame, which allowed for accurate costing. The shift to the needs-based program meant that not all roads within a zone were marked, and it was therefore simple arithmetic to determine the cost reduction using selective marking. This is discussed further in Clause 4.

### **3.6 Identifying Opportunities**

Most of the changes to the pavement marking program have been in rural zones, as this is where the bulk of the line marking is. However, it was obvious that the use of the same materials for the treatment of urban zones required more frequent marking, and this was seen as the first opportunity to re-invest savings from the rural program.

As a key objective of this project was to improve the performance of the network for the road user, it was important that increased durability of markings was not the only focus. The metropolitan area of SA's capital, Adelaide, was targeted for improvements to wet night visibility, whilst maintaining high levels of skid resistance. The use of long-life markings was therefore proposed, with approximately 25% of the Adelaide metropolitan intersections subsequently marked using polymethyl methacrylate (PMMA) material with aggregate and

Type D glass bead. It is envisaged that the remainder of the metropolitan area will be marked with long-life material over forthcoming seasons.

In addition, a number of rural centres will be targeted for long-life materials, with the additional improvements to wet night visibility.

The next area of focus will be the use of high performance materials for high risk areas on twisty local and arterial roads in hills areas, where visibility in low light, foggy or wet conditions are an issue for road users.

#### **4.0 THE NEW CONTRACT FORM**

##### **4.1 Performance-Based Contracts**

There are a number of variations on the contract and procurement form with regard to performance-based contracts:

- Long term (5 to 10 years) maintenance of pavement marking as a small part of a total roads management contract. In this form, contractors are required to monitor performance and carry out maintenance when a defined parameter reaches intervention level. Choice of materials used is free. Decision-making may be at the principal contractor level.
- Long term (3 to 5 years) maintenance of pavement marking as a management contract for pavement markings only. In this form, contractors are required to monitor performance and carry out maintenance when a defined parameter reaches intervention level. Choice of materials used is free.
- Short-term (1 to 3 years) maintenance of pavement marking, whereby contractors are required to monitor performance and carry out maintenance when a defined parameter reaches intervention level. Materials and application rates are usually specified, tend to be paint and bead based.
- Short-term (1 to 3 years) maintenance of pavement marking, whereby contractors are required to carry out maintenance, at locations and times determined by the principal, who determines when a defined parameter has reached intervention level. Materials and application rates are usually specified.

This latter form is the one adopted by DTEI.

##### **4.2 Contractor Performance Parameters**

The parameters used to measure the Contractor's performance are:

- 1) Accuracy of spotting for new work.
- 2) Accuracy of placement of markings over spotting or existing markings, including alignment.
- 3) Marking dimensions, including width of line marking.
- 4) Control and consistency of application rates of materials.
- 5) Material quality.
- 6) Performance of markings audited.
- 7) Working to a schedule, timeliness.
- 8) Personnel management.
- 9) Document control.
- 10) Environmental management.

These elements define a Contractor's performance standard and are used in the weighting process at the time of tendering. Competent performance in a previous contract therefore counts toward likely success in subsequent tender processes.

### 4.3 Programming

In this new contract form, the Contractor does not need to make decisions about what needs to be done or when it needs to be done, this process being managed by the Principal. For this process to be successful, a number of things need to be established:

- 1) Pavement marking monitoring services need to be routinely available.
- 2) Standard procedures and calibrated equipment must be used to ensure consistency.
- 3) Close liaison between the monitoring group and the programming group must be established and maintained.
- 4) A commitment from management to re-invest savings is essential if road users are to benefit.

Retroreflectivity has been shown to be the prime performance indicator for line marking. DTEI has systematically measured the retroreflectivity of line marking over a period of more than 5 years, and this data has been used to develop a line marking strategy. The materials used over this period have been waterborne paint and drop-on Type B glass beads, such that deterioration curves developed from the monitoring process can be used for prediction modelling and program development.

Deterioration curves have been translated into contractual requirements, with an allowance for the uncertainty of measurement, and these are shown in Table 1. The table shows minimum requirements for various exposure periods, for roads with 4 different levels of traffic volume.

| Roads with >10000 vehicles/ day             |     |     |     |     |      |      |      |     |     |     |     |
|---|-----|-----|-----|-----|------|------|------|-----|-----|-----|-----|
| Days of Wear                                | 0   | 20  | 60  | 100 | 140  | 180  | 220  | 260 | 300 |     |     |
| Retroreflectivity, mcd/m <sup>2</sup> /lx   | 275 | 240 | 205 | 185 | 175  | 165  | 145  | 125 | 120 |     |     |
| Roads with 4000 to 10000 vehicles/ day      |     |     |     |     |      |      |      |     |     |     |     |
| Days of Wear                                | 0   | 20  | 60  | 100 | 140  | 180  | 220  | 260 | 300 | 340 | 380 |
| Retroreflectivity, mcd/m <sup>2</sup> /lx   | 275 | 240 | 205 | 195 | 185  | 175  | 165  | 155 | 145 | 135 | 120 |
| Roads with 1000 to 4000 vehicles/ day       |     |     |     |     |      |      |      |     |     |     |     |
| Days of Wear                                | 0   | 20  | 60  | 100 | 140  | 180  | 220  | 260 | 300 | 340 | 380 |
| Retroreflectivity, mcd/m <sup>2</sup> /lx   | 275 | 240 | 225 | 225 | 220  | 220  | 215  | 215 | 200 | 195 | 190 |
| Days of Wear                                | 420 | 460 | 500 | 540 | 580  | 620  | 660  | 700 | 740 |     |     |
| Retroreflectivity, mcd/ m <sup>2</sup> / lx | 185 | 180 | 175 | 170 | 165  | 155  | 145  | 135 | 125 |     |     |
| Roads with <1000 vehicles per day           |     |     |     |     |      |      |      |     |     |     |     |
| Days of Wear                                | 0   | 20  | 60  | 100 | 140  | 180  | 220  | 260 | 300 | 340 | 380 |
| Retroreflectivity, mcd/m <sup>2</sup> / lx  | 275 | 265 | 255 | 240 | 240  | 235  | 235  | 230 | 230 | 225 | 225 |
| Days of Wear                                | 420 | 460 | 500 | 540 | 580  | 620  | 660  | 700 | 740 | 780 | 820 |
| Retroreflectivity, mcd/m <sup>2</sup> / lx  | 220 | 220 | 215 | 215 | 210  | 210  | 200  | 200 | 190 | 190 | 170 |
| Days of Wear                                | 860 | 900 | 940 | 980 | 1020 | 1060 | 1100 |     |     |     |     |
| Retroreflectivity, mcd/m <sup>2</sup> / lx  | 170 | 150 | 150 | 145 | 140  | 130  | 120  |     |     |     |     |

Table 1 – Retroreflectivity versus Exposure Time

Using the above chart, the residual life of a specific marking can be predicted using a single measurement session and knowing the age of the marking. This process was implemented early in 2003 and has been an essential part of the programming process since that time. It should be noted that where a road section is targeted for maintenance, on the basis of residual retroreflectivity, all lines are marked. It is possible that a process of marking individual lines within road sections may be investigated in future maintenance programs.

## **5.0 URBAN MARKING**

Urban marking is subject to much greater wear than that in rural areas, because of the higher traffic volumes and the number of vehicles actually traversing the markings. The research project showed that poor application quality was also an issue in the urban areas, not only in terms of poor control of paint film build or glass bead application rates, but also from a lack of protection of waterborne paint work during the curing period.

Urban areas provide greater opportunity for the use of materials other than paint, and long life materials will have greater cost effectiveness in these areas by extending marking cycles to greater than 4 times the current schedule. As detailed in Clause 4.6, PMMA materials have been introduced as intersection markings, but line marking in metropolitan areas would also benefit from the introduction of high performance materials.

## **6.0 CONCLUSIONS**

DTEI has implemented a number of strategies over recent years, aimed at maximising the value of the investment in pavement marking across the whole of the state road network. The conclusions which can be drawn from these experiences are:

- Development of a network monitoring program will allow residual performance of markings to be used as a maintenance tool.
- A focus on a needs-based marking program will reduce the cost of line marking across a network, by a minimum of 10%.
- Savings from line marking programs can be channelled back into other areas of need to improve the performance of the network for the road user.
- The use of high performance markings in areas of special need will reduce maintenance costs and result in greater levels of safety for road users.

## **7.0 References**

1. Performance Based Management of Pavement Marking, MTRD 144, Adelaide South Australia, D. M. Richards
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3. Audit, Line Marking Product, March 2005, DTEI Procedure MAT-TP950
4. Measurement of Night Visibility, March 2005, DTEI Procedure MAT-TP907
5. Assessment of Daytime Visibility, March 2005, DTEI Procedure MAT-TP945