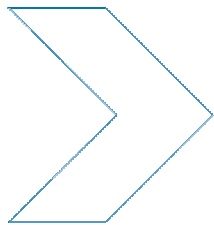


# ➤ Centre for Automotive Safety Research



## Edge delineations

JE Woolley, AJ McLean

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## TITLE

Edge delineations

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## ABSTRACT

In 2001, the Motor Accident Commission (MAC) sponsored a trial of a comparatively inexpensive form of audio tactile raised pavement marker as a fatigue driving countermeasure on the Dukes Highway east of Keith, South Australia. MAC has asked the Centre for Automotive Safety Research (CASR) to comment on the relevance of this treatment including its compliance with road design rules, its cost effectiveness when compared to other treatments and any safety issue with their use.

## KEYWORDS

Human fatigue, Edge marking, Rumble strip

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## Summary

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As a fatigue driving countermeasure, the Motor Accident Commission (MAC) has previously sponsored a trial of audio tactile pavement markers on a section of the Dukes Highway immediately east of Keith, South Australia. The trial involved the use of comparatively inexpensive raised pavement markers (with the proprietary name of Polydots) at regular intervals along the painted edge line in order to keep costs down.

At the time, the treatment was approximately one quarter the cost of equivalent thermoplastic audio tactile line marking (ATLM). However, the treatment had lost favour with DTEI due mainly to the poor in-field performance of the product, which tended to fail within 2 years of its initial application. This unsatisfactory performance, however, may have been caused by the application of the Polydots when the road surface was moist, leading to poor glue joints. The approach has only been trialled elsewhere in Australia in Victoria. It is notable that VicRoads has discontinued its use of Polydots as edge and lane delineators, one reason being that they can pose a hazard and be thrown up by passing vehicles should their glue joint fail.

Since that time and using Department for Transport, Energy and Infrastructure (DTEI) costings valid from the 1st September 2006, ATLM treatments have come down in price and the Polydot treatment (\$984/km) is approximately half the cost of other ATLM treatments (\$1500-\$1800/km) in South Australia. When a further \$318/km per annum is taken into account for the linemarking that thermoplastic ATLM avoids, the Polydot treatment ends up more costly in the long term. An additional reduction in ATLM costs may be possible if contractors were to be based in South Australia but the size of this reduction could not be established.

A review of practices around Australia revealed that thermoplastic ATLM is still the preferred option for fatigue driving edgeline treatment, however application varies depending on road width and the presence of sealed shoulders. For example, most states apply ATLM to high quality roads with sealed shoulders. This tends to limit its application to major highways and motorways. The exception is Queensland which has found benefits from applying ATLM even when there is no sealed shoulder present.

Thermoplastic ATLM has many advantages over the Polydot type treatment:

- Polydots do not have any reflectivity
- The ATLM thermoplastics have glass beads mixed in at the time of application providing good reflectivity for the life of the application (as the ATLM wears, more reflective beads are exposed)
- This reflectivity outperforms conventional line marking and overcomes conspicuity problems when there is surface water
- The larger spacing of the Polydots means that even larger gaps will exist on the edge of the road should glue joints fail (when compared to equivalent failures in ATLM)
- If bonded well, thermoplastics tend to break away in small pieces and do not present the type of hazard that a loose Polydot would present
- Due to the conspicuity of ATLM with mixed in glass beads, it is not necessary for an edgeline to be painted; the same does not apply to Polydots which require the painting of edgelines at a cost of \$318/km per annum

A further issue identified with all types of tactile edge line treatments was ongoing maintenance. Given an assumed field life of four years, no road authority had yet worked out how to best maintain sections that had failed or been removed with regular road works. It was also unclear as to how complete sections would be replaced once their useful field life had expired. Victoria and Tasmania simply reapply the ATLM over sections which have failed.

Table 1 provides a comparison of the treatments for a 50 km stretch of road over a 3 year period. Although ATLM can range in costs from \$1500 to \$1800, the higher value is used to provide a conservative estimate. The majority of Polydots in the original application in the South East and the Riverland were observed to come off within 2 years. Due to suspicions about the quality control at application, a conservative estimate of the life of Polydots of 3 years is used for the comparison. DTEI has yet to come up with a regular maintenance approach to the treatments and this cost is therefore omitted, the preferred option being to re-apply the treatment at the end of its service life. The treatments are applied on both sides of the road resulting in an actual treated distance of 100 km.

**Table 1**  
**Comparison of Polydot and ATLM type treatment costs for**  
**a 50 km section of road over a three year period**

	Unit cost per km	Length	Number of years	Total
<b>Polydot type treatment</b>				
Initial Application (3 year life)	984	100	1	\$98,400
Maintenance costs	984	0	3	\$0
Linemarking costs	318	100	3	\$95,400
<b>Total</b>				<b>\$193,800</b>
<b>ATLM</b>				
Initial Application (4 year life)	1800	100	1	\$180,000
Maintenance costs	1800	0	3	\$0
Linemarking costs	318	0	3	\$0
<b>Total</b>				<b>\$180,000</b>

Notes and assumptions:

- Linemarking costs are for 150 mm wide application including glass beads
- Linemarking is applied annually on national highways
- ATLM includes glass beads
- Polydot treatment consists of four polydots between each raised reflective pavement marker
- At present, no attempt is made to maintain or repair damaged sections of tactile edge treatments so the ongoing maintenance cost is set to zero dollars
- Assumed life for the Polydot type treatment is 3 years
- Assumed life for the ATLM type treatment is 4 years
- Actual cost of ATLM ranges from \$1500 to \$1800
- Treatment is applied on both sides of the road (ie doubling the application distance)
- Prices supplied from DTEI valid as of 1st September 2006

Whilst the Polydots are cheaper to apply initially, the additional annual cost of linemarking makes the Polydots slightly more costly over a full life cycle. A comparison over a 12 year period is shown in Table 2.



**Table 2**  
**Comparison of Polydot and ATLM type treatment costs for**  
**a 50 km section of road over a twelve year period**

	Unit Cost /km	Length	Number of years	Total
<b>Polydot type treatment</b>				
Initial Application (3 year life)	984	100	1	\$98,400
Maintenance costs	984	0	12	\$0
Linemarking costs	318	100	12	\$381,600
Re-application at end of life (after 3 years)	984	100	1	\$98,400
Re-application at end of life (after 6 years)	984	100	1	\$98,400
Re-application at end of life (after 9 years)	984	100	1	\$98,400
<b>Total</b>				<b>\$775,200</b>
<b>ATLM</b>				
Initial Application (4 year life)	1800	100	1	\$180,000
Maintenance costs	1800	0	12	\$0
Linemarking costs	318	0	12	\$0
Reapplication at end of life (after 4 years)	1800	100	1	\$180,000
Reapplication at end of life (after 8 years)	1800	100	1	\$180,000
<b>Total</b>				<b>\$540,000</b>

Notes and assumptions:

- Linemarking costs are for 150 mm wide application including glass beads
- Linemarking is applied annually on national highways
- ATLM includes glass beads
- Polydot treatment consists of four polydots between each raised reflective pavement marker
- At present, no attempt is made to maintain or repair damaged sections of tactile edge treatments so the ongoing maintenance cost is set to zero dollars
- Assumed life for the Polydot type treatment is 3 years
- Assumed life for the ATLM type treatment is 4 years
- Actual cost of ATLM ranges from \$1500 to \$1800
- Treatment is applied on both sides of the road (ie doubling the application distance)
- Prices supplied from DTEI valid as of 1st September 2006

Over the longer term, the Polydot treatment ends up costing considerably more as linemarking and re-application costs begin to dominate. It is evident that given current pricing, the savings that could be made with Polydots in 2001 can no longer be achieved in 2006.

What is also evident in Tables 1 and 2 is that although ATLM is more expensive than linemarking, the cost of linemarking alone is substantial, especially when applied on an annual basis. When considering the long term cost benefits of ATLM over linemarking, it appears that the additional cost of ATLM is relatively minor and likely to be worthwhile.

## CONCLUSIONS AND RECOMMENDATIONS

The literature strongly supports the fact that better delineation leads to improved road safety. Tactile marking is consistently shown to reduce single vehicle run off road crashes and its application in South Australia should be continued.

It is evident that thermoplastic ATLM has superior performance characteristics to Polydots. A National review showed that thermoplastic ATLM was the preferred fatigue edgeline delineation technique amongst road authorities. Although significantly more costly than conventional linemarking, there are numerous benefits with the use of ATLM and application costs have come down over time.

Thermoplastic ATLM has now been applied on many sections of the State's highways. However, much of this has been achieved through special funding schemes rather than regular road maintenance budgets.

On the basis of discussions with engineers from South Australia and Interstate, and given the many advantages of ATLM over Polydots, the following is recommended:

- A. Thermoplastic ATLM should be used as a fatigue driving countermeasure.
- B. The application of ATLM be considered as part of conventional road construction and maintenance practices in South Australia.
- C. A DTEI policy be developed supporting the adoption of ATLM together with guidelines supporting its regular use.
- D. ATLM be applied to further sections of National Highway One with a view to obtaining complete coverage of the Highway.
- E. The results of trials of centreline ATLM in Victoria and NSW should be monitored; it is likely this will become the next major use of ATLM throughout the Australian road network.
- F. Having completed coverage on the major highways, consideration should be given to the application of ATLM on sections of road where there is a high prevalence of run off road crashes regardless of whether a sealed shoulder is present or not.

# Contents

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- 1 Introduction..... 1
  - 1.1 Objectives..... 2
- 2 The MAC sponsored edge delineation treatment ..... 3
- 3 Alternative treatments ..... 6
- 4 Experience and practices in other States ..... 8
  - 4.1 New South Wales..... 8
  - 4.2 Queensland..... 9
  - 4.3 Victoria ..... 9
  - 4.4 Tasmania ..... 10
  - 4.5 Western Australia ..... 11
- 5 South Australian considerations ..... 12
  - 5.1 Extent of current ATLM ..... 13
  - 5.2 Cost..... 13
  - 5.3 Extent of current shoulder sealing..... 17
  - 5.4 Maintenance issues ..... 17
  - 5.5 Other differences between Polydots and ATLM..... 18
- 6 Conclusions and recommendations ..... 19
- Acknowledgements ..... 20
- References ..... 21



# 1 Introduction

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Fatigue during long distance driving has been well established as a major contributor to overall crash numbers in rural areas (Armour, Carter and Cinquegrana, 1990). An engineering solution to the problem of drivers becoming drowsy and veering off the road is to place audio tactile devices along the edges of the road. These devices, such as audio tactile line marking (ATLM), create vibration and noise when in contact with the tyres of a moving vehicle. The rationale for their use is that a driver can be alerted and/or awoken by the device. Having been alerted, the driver would then have time to react and steer the vehicle back onto the carriageway or at least correct the vehicle so that it does not run into roadside objects.

Audio tactile treatments have been proven as an effective countermeasure against single vehicle run off road crashes in Australia and overseas. In the United States, “rumble strips” have been used on major interstate roads and have led to significant reductions in run off road crashes including: New York 72%; California 49%; Pennsylvania 60-65%; Massachusetts 42%; Washington 18%; Kansas 34%; and New Jersey 34% (FHWA, 2001; Charlton, Baas and Towler, 1995). Rumble strips have also been found to be effective in Japan and not pose a problem to cyclists and motorcyclists (Hirasawa, Asano, and Saito 2005).

Charlton *et al* (1995) reported on an extensive literature review on delineation treatments. Three areas were concentrated upon:

1. the effects of centre line and edge delineation
2. the effects of centre line and shoulder rumble strips
3. the durability and effectiveness of marking materials

Although this report is focussed on tactile edgeline treatments, many of the findings across all three areas are of some relevance. The main findings from the review were as follows:

- There is little evidence to suggest that both centre lines and edgelines increase speed unless added to a road with no previous edgelines or centrelines
- Lateral position is influenced by shoulder width, painted line thickness and the contrast between the road surface and the road edge; enhanced delineation of centrelines and edgelines (in combination) tends to produce smaller steering wheel movements and lower lane position variability
- Wider linemarking produces consistent improvements in lane keeping by drivers and especially so for intoxicated drivers, young drivers and elderly drivers
- The application of edgelines commonly leads to considerable reductions in crashes
- Drivers tend to prefer more delineation of roads, especially elderly drivers
- There is no evidence that tactile linemarking increases vehicle speeds over conventional linemarking
- Tactile centre linemarking has been shown to make vehicles travel away from the centre of the road; the effect of tactile edgelineing is less clear due to the differing effects of shoulder width on compared roads
- Tactile centre linemarking has the effect of reducing overtaking attempts
- The literature strongly supports the notion that tactile edgelineing leads to a reduction in crashes, especially run off road crashes. Unlike other safety measures, this effect does not diminish with familiarity or time.
- Tactile centre linemarking has been shown to reduce head on collisions in the United States
- Noise from tactile linemarking has been identified as an issue for roadside residences

- Tactile linemarking can be unpopular with truck drivers who frequently contact the marking when on narrow roads

The review made it clear that increased delineation, including the greater use of audio tactile treatments, will improve road safety. Other recent studies continue to support this point.

A driving simulator study of 40 shift workers in Sweden (Anund, Hjalmdahl, Sehammer, Palmqvist and Thorslund, 2005) found that milled rumble strips had clear alerting effects and consistently induced correct averting action. The study also found that there was little difference between four types of rumble strip design and placement and that there was no risk with using more aggressive designs.

Sun and Tekell (2005) conducted a study into the impact of edge lines on the safety of rural two lane highways in Louisiana. It was found that painted edge lines had a positive effect in confining the travelled path of drivers, especially at night, and had little or no effect on travelling speed.

In Australia, raised ATLM has been used in preference to milled rumble strips due to the nature of the road pavement construction. Queensland, NSW, Victoria and Tasmania have been using ATLM since the 1990s and each has had positive experiences in terms of reducing overall numbers of crashes and single vehicle crashes although most evaluations were based on very short before and after comparisons (QT, 1994; Cairney and Tan, 1996). The use of ATLM is also frequently referred to and recommended in parliamentary enquiries and task forces (eg RSTF 2001).

ATLM is around five to six times more costly to use than conventional line marking. In addition, there are significant issues surrounding serviceability and maintenance and this tends to make road authorities only apply the treatment to high quality roads.

## 1.1 Objectives

The Motor Accident Commission (MAC) has previously sponsored a trial of audio tactile pavement markers on a section of the Dukes Highway immediately east of Keith, South Australia. The trial involved the innovative use of raised pavement markers (with the proprietary name of Polydots) at regular intervals along the painted edge line in order to keep costs down compared with thermoplastic ATLM.

MAC has asked the Centre for Automotive Safety Research (CASR) to comment on the relevance of this treatment including its compliance with road design rules, its cost effectiveness when compared to other treatments and any safety issue with its use.

## 2 The MAC sponsored edge delineation treatment

Around 2001, the Tatiara Community Group rallied strongly for tactile edge delineation treatments to be applied on the Dukes Highway between Keith and Bordertown. At the time, the cost of thermoplastic tactile linemarking was considered prohibitive by Transport SA (now the Department of Transport, Energy and Infrastructure (DTEI)) and a cheaper alternative was developed.

The new treatment used non-reflective dome shaped raised pavement markers (having the proprietary name of Polydots) to line the edge of the traffic lanes at set intervals. This treatment is also used in South Australia to delineate lanes at signalised intersections and along lengths of multi-lane roads including Port Road and the South Eastern Freeway.

On rural roads, DTEI places reflective pavement markers (RPMs) every 24 metres along the roadway. Trials were conducted with four, five and six Polydot markers between every RPM. This related to spacings between markers of 6, 4.8, 4 metres respectively with the shorter spacings requiring more markers and therefore costing more. Five markers every 24 metres was eventually adopted on the Dukes Highway as the best compromise between effectiveness and cost. Figure 2.1 outlines the adopted application at that time. Current standards would now dictate an unbroken edgeline similar to the treatment at the bottom of Figure 2.1.

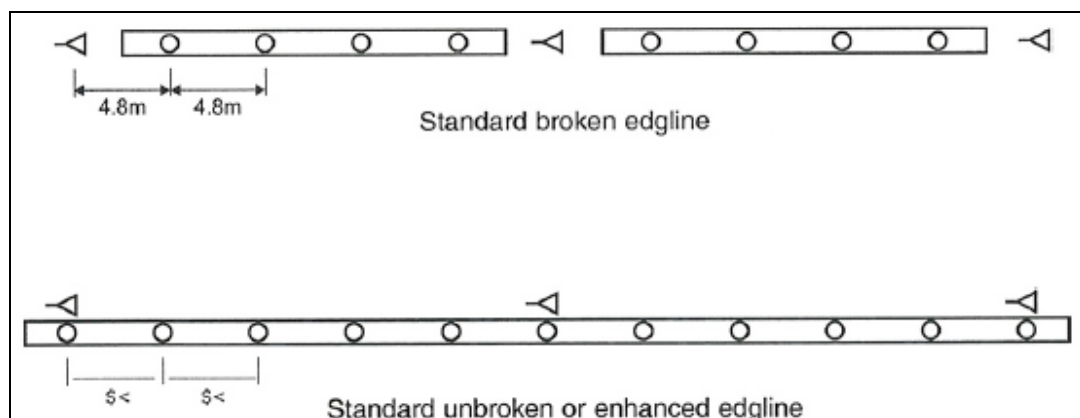


Figure 2.1  
Application of Polydots as a form of profile edge line delineation (source: DTEI)

Figures 2.2 and 2.3 show the Polydot treatment as applied in the field. In the first photo, the red maker in the foreground is a standard reflective RPM and the Polydots are positioned between these at regular intervals. The second photo shows a close up of a Polydot.



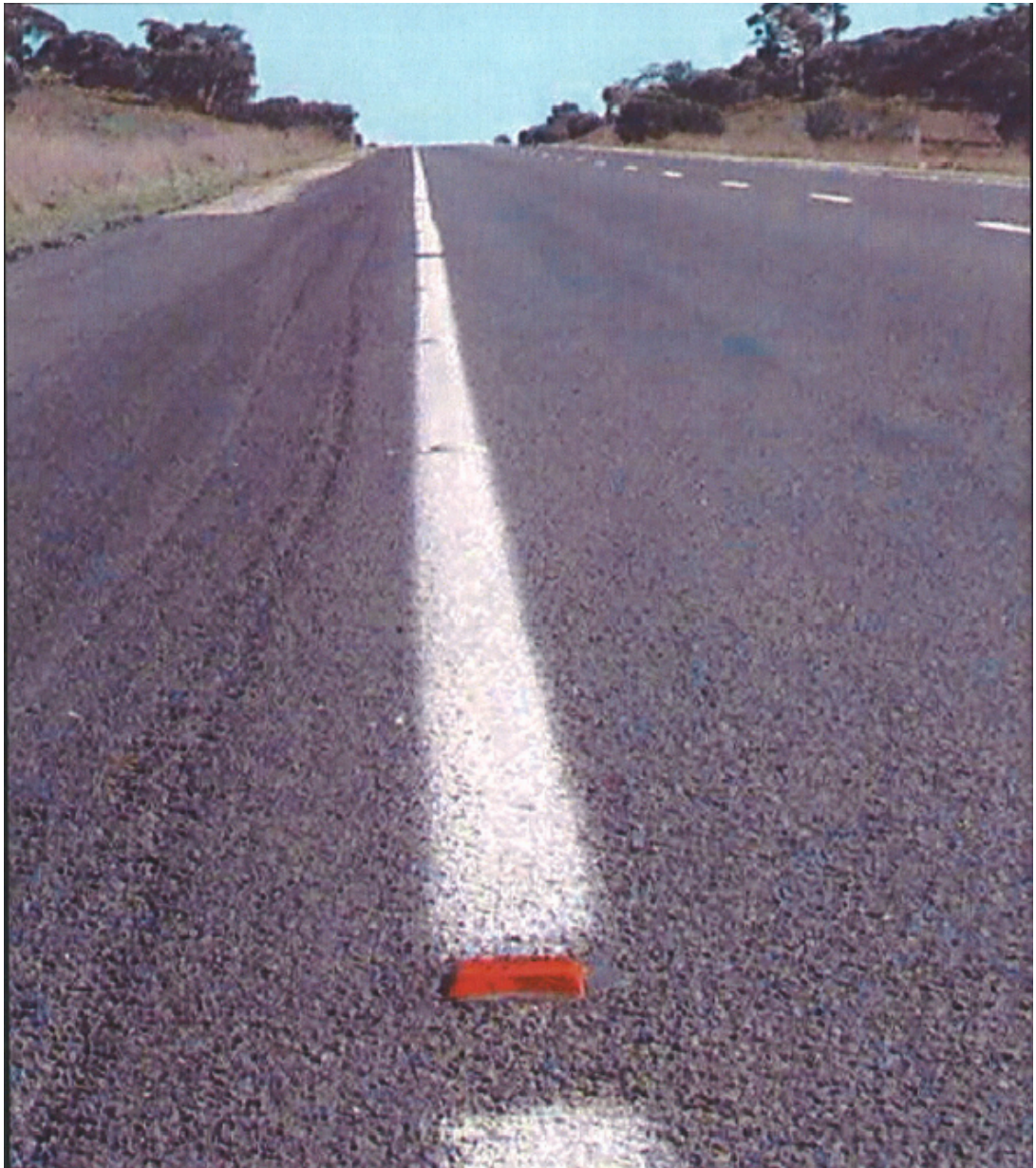


Figure 2.2  
Example of the Polydot profile edge delineation treatment on the Dukes Highway with  
a red reflective pavement marker in the foreground (source: DTEI)





**Figure 2.3**  
Close up of a Polydot on the Dukes Highway near Bordertown (source: J Woolley)

In 2001, the initial application cost of the Polydot treatment was approximately one quarter the cost of the equivalent ATLM treatment in South Australia. This meant that the treatment could cover at least four times more road distance than the equivalent ATLM treatment for the same cost. However an additional cost of the Polydot treatment was the need for annual linemarking to be applied. This is discussed later in the report.

There was no formal assessment conducted of the Polydot treatment and crash numbers were too few to sensibly determine any effect. However, given the enthusiastic support of the community group, the trial had a high degree of community acceptance.

Transport SA also applied the same treatment on the Sturt Highway in the Riverland and on National Highway One near Snowtown (personal communication from Peter Mayger, DTEI, April 2006). In the Riverland, the treatment was much less popular with the local communities and there were many complaints from motorists and expressions of doubt about its effectiveness (personal communication from Steve Clark, DTEI, December 2005). The treatment also generated numerous complaints from within DTEI mainly in relation to maintenance issues. One of the significant problems that arose was the accidental removal of the Polydots by grader blades during roadside maintenance. A quality control issue also arose with the Polydots being laid down during winter presumably when the road surface was moist. This led to failures of most of the glue bonds within 2 years of their application. A further complication was the application of the Polydots on top of pre-existing line marking which also made the glue joint prone to failure. These experiences led DTEI to favour the use of thermoplastic treatments, as is the case for the other Australian States. Around 2001, a draft DTEI guideline for ATLM was being developed but was never completed.

### 3 Alternative treatments

Several alternatives exist for audio-tactile treatments to line the edges of roads. These include:

1. Profile treatments
2. Milled-in depressions in the road
3. Rolled-in depressions in the road
4. Formed-in depressions in the road
5. The provision of contrasting shoulders

Each of the treatments when combined with reflective line marking provide more effective delineation of the road during night time and when it is wet.

Most profile treatments are laid using a special machine which forms plastic moulded ribs (often in combination with the line marking paint) to a minimum thickness of 150 mm. A proposed profile for South Australia is shown in Figure 3.1 and Table 3.1. Polydots also fall into this category but consist of preformed domes that are glued onto the road surface.

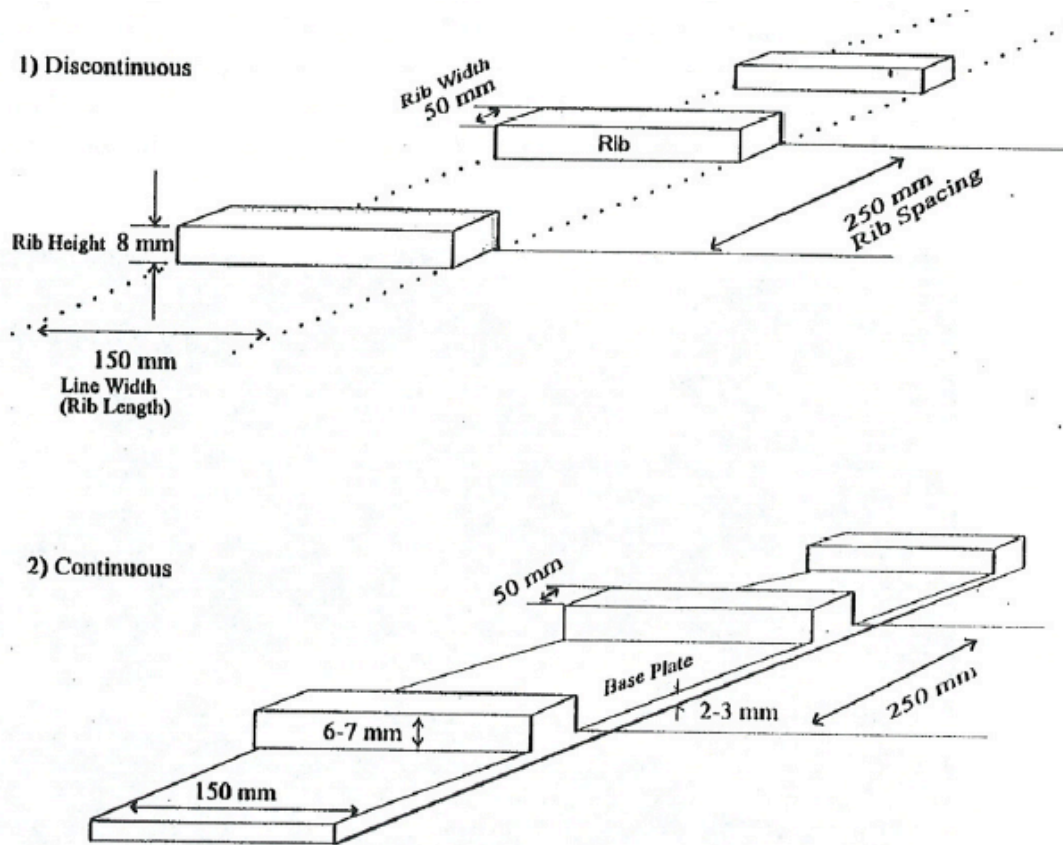


Figure 3.1  
Proposed profile line marking suggested for South Australia (source: DTEI)

**Table 3.1**  
**Proposed thermoplastic ATLM profiles for South Australia (source: DTEI)**

Line width	150 mm extending to 200 mm on curves of radii less than 2,000 m subject to suitable site conditions
Rib width (along the line)	50 mm
Rib height* for a continuous line	8-10 mm for rib (from road surface) and base plate 2-3 mm from road surface
Rib height* for a discontinuous line	8 mm from road surface
* Measured from the plane surface formed by the tops of the aggregate particles	
Rib spacing	200 mm spacings

Milled, rolled and formed slots have been proven to be highly effective in reducing run off road and head on collisions in the United States and Japan (Garder and Alexander, 1995; Griffith, 2000; Chen, 1994; Harwood, 1993; Wood 1994; Spring, 2003; Perrillo, 1998; Hickey, 1997; Khan and Bacchus, 1995; and Hirasawa, Asano, and Saito 2005). Referred to as Rumble Strips or Continuous Shoulder Rumble Strips (CSRS), most studies in the US have found that they have been associated with run off road crash reductions and have very high Benefit-Cost Ratios (BCR) ranging from 30:1 to 182:1 (Charlton *et al*, 2005). These applications have mainly been on interstate divided motorways with generous shoulder widths (by Australian standards) however the Federal Highway Administration is encouraging their use on other road types should their application be warranted (FHWA, 2001). Some states have also used rumble strips on centrelines for roads with a history of head on and side swipe collisions.

Another alternative for rural roads is to form the shoulder from a different coloured material and sometimes this is extended to a larger size of aggregate. Drivers straying onto the shoulder receive an audio warning and vibration for the duration that their wheels are on the width of the shoulder (as opposed to crossing a thin line).

## 4 Experience and practices in other States

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Much of the information relating to ATLM in Australia that is presented here can be sourced from an ARRB report for Queensland Main Roads (Cairney and Tan, 1996).

Most inter-urban roads in Australia are constructed as a spray seal. This means that roads are constructed from compacted gravel that is sealed with a sprayed on layer of bitumen with aggregate poured and rolled on top of it. This results in a thin road surface layer which is unsuitable for the hot forming or milling treatments frequently used in North America. There may be possibilities to form patterns in the road surface prior to the spray sealing operation but such techniques are as yet undeveloped. Another alternative could be to stamp patterns into the road however it is thought that the pooling of water will affect pavement strength and life. This means that for the majority of rural roads, audio tactile treatments are restricted to application on top of the road surface.

There are three proprietary ATLM treatments currently available in Australia:

1. Zaganite
2. Vibraline
3. Stimsonite (and Polydots)

Zaganite consists of small thermoplastic bars which are laid down on the road surface with gaps in between the bars. Vibraline is also a thermoplastic material laid down as a continuous strip with ribbed profiles at set spacings. Stimsonite was trialled by VicRoads in its Western Region and is similar to the treatment that MAC sponsored on the Dukes Highway with Polydots.

Practices in other states in relation to edge delineation vary somewhat. For example, South Australia has been using 100 mm wide edge line marking as opposed to the minimum 80 mm specified in the Australian standards and used in other states. Unlike South Australia, Queensland uses ATLM irrespective of whether a sealed shoulder is present. It should be noted that the current ATLM treatments exceed the 80 mm minimum line marking width (thermoplastic ATLM is typically 150 mm wide) and this in itself can increase costs for the road authorities if they were to match the width with line marking.

The impact of these ATLM treatments on heavy vehicles is not clear and while some literature implies that it is effective for heavy vehicles (in terms of noise from running over the ATLM), others do not. However, the treatments do provide better visibility and delineation for heavy vehicles even if their drivers do not receive an audible warning.

### 4.1 New South Wales

The NSW Roads and Traffic Authority (RTA) has conducted many trials and has generally concluded that Vibraline was the best performing product. Their experience indicated that:

- The product provided better wet weather and night time conspicuity
- Achieved a strong bond with spray seal surfaces
- Had poor wearing characteristics when subjected to high turning movements and heavy braking
- Ongoing maintenance was an unresolved issue

The RTA concluded that ATLM application on roads with at least 6,500 vehicles per day would result in crash cost savings sufficient to make the treatment cost effective. Initial evaluation of crash data has shown positive results.

## 4.2 Queensland

Queensland conducted trials with both Vibraline and Zaganite on roads with and without sealed shoulders. ATLM was trialled on the Bruce Highway as part of a coordinated approach to fatigue management in the region (Lee and Spencer, 1996). Issues have arisen as to the ongoing serviceability of the treatments on roads without sealed shoulders due mainly to road maintenance practices and the edges of the roads deteriorating. However, even those sections of road with the degraded ATLM had higher conspicuity than conventional line marking.

A trial with thermoplastic profile lines on the Bruce Highway near Rockhampton in Queensland found that the ATLM was conservatively estimated to be responsible for a reduction of 12 crashes over a nine month evaluation period (QT, 1994). This amounted to considerable savings to the community as those crashes avoided tended to be the most severe. Based on a 4 year ATLM life expectancy the first year rate of return was estimated to be 10:1.

## 4.3 Victoria

VicRoads has used Zaganite and Vibraline extensively throughout the State. The VicRoads Traffic Engineering Manual (2001) specifies that profiled edge marking should be used:

- When traffic flow is 2000 vehicles per day or greater
- When the run off the road casualty accident rate per 10 km per year is greater than 0.3
- When the road is in a rural area
- If there is a significant fog problem

The minimum width for a two lane carriageway should be 7 metres plus a minimum width of sealed shoulder of 0.5 metres. It is desirable that where shoulders are added these should be 1 metre wide (ie a carriageway width of 9 metres).

Stimsonite was trialled by VicRoads but it appears that the Zaganite and Vibraline treatments remain the preferred options. It is notable that VicRoads has abandoned the use of Stimsonite altogether even as lane delineators on freeways due to adhesion problems. One particular problem is that when the markers break away from the road they become a hazard themselves by being thrown up on to windscreens (personal communication from Cassandra Simpson, Geopave Pavement Technology Services, April 2006).

Trials are currently underway in the VicRoads Western Region using ATLM on the centrelines of roads (see Figure 4.1) and initial results seem promising (personal communication from Steve Clark, December 2005).





Figure 4.1

Example of the use of edge line and centre line ATLM on trial in Western Victoria (source:J Woolley)

## 4.4 Tasmania

Tasmania has used ATLM on its National and State Highways and has not encountered any of the service issues identified in other states. The roads which have been treated tend to be high quality with lane widths of 3 metres or more and sealed shoulders of 1.8 to 2 metres (Figure 4.2). An evaluation by Cairney (1996) found a significant reduction in crashes due to the installation of the ATLM and a benefit-cost ratio higher than 9:1 (the ATLM in Tasmania looks like comfortably exceeding its estimated 4 year service life ).



Figure 4.2  
Example of ATLM treatment on National Highway One in central Tasmania (source: J Woolley)

## 4.5 Western Australia

The Department of Main Roads in Western Australia is using thermoplastic ATLM and in some locations uses contrasting shoulder colours as shown in Figure 4.3.



Figure 4.3  
Example of contrasting shoulder colours on the Freeway to Mandurah south of Perth (source: J Woolley)

## 5 South Australian considerations

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The application of ATLM for edge delineation is not as straightforward as one might expect.

Firstly, current practice within DTEI does not allow for ATLM on the edge of the road unless a sealed shoulder is present. This limits its application to major Highways and Motorways in South Australia where sealed shoulders exist or are being constructed. It should be noted that trials in Queensland have shown a benefit from using ATLM even where a sealed shoulder is absent.

Secondly, the width of the road determines if edge lines should be used at all in accordance with the relevant Australian Standard (AS 1742.2):

- For undivided rural roads less than 5.5 m wide, centrelines are not normally used (except for a single unbroken no overtaking line) and edge lines should not be used.
- For undivided rural roads between 5.5 and 6.8 m wide, a centreline should be used but edgeline is not normally used.
- For undivided rural roads with widths of 6.8 m or more, centrelines should be used and edgelines should be considered.
- When an undivided rural road has a sealed shoulder, edgelines should be provided where there is little or no shoulder contrast.

There are many exceptions in the Standard which would permit the use of edge lines on most road widths (AS1742.2-1994):

*Edge lines are not normally used except where one or more of the following conditions apply:*

- i) Alignment is poor*
- ii) Frequent fogs occur*
- iii) Accident analysis indicates the need for edge lines*
- iv) Contrast between the pavement and shoulder is insufficient, eg sealed shoulders; or*
- v) Roadside hazards occur close to the pavement edge, eg trees*

*Edge lines shall not be used unless a separation line (ie a centreline) is also used.*

The Standard also stipulates that where edge lining is used, a separation line (ie the centreline) must also be used. It is noted that road authorities in Sweden and The Netherlands use edge lines without centre lines (personal communication from Hans Laurell, Swedish Road Authority, December 2005). One study showed that this practice had an added benefit of slowing down vehicles (Davidse, van Driel and Goldenbeld, 2003). The Australian Standard prevents this practice from occurring under all circumstances.

South Australia also has a unique complication as a result of its shoulder sealing program. The program was approved on the basis of a BCR of 2:1. It involved the addition of a 0.5 metre shoulder on the State's major highways. In most cases, the edge of the road was graded and a light construction made with spray seal to complete the shoulder. This technique meant that four times more length of road could be treated than would be the case fully constructing the shoulders. The implications of this are that the shoulders do not constitute structural pavement and therefore cannot support heavy use by trucks. This has resulted in the scenario where despite the addition of shoulders, the traffic lanes could not be widened to the desired 3.5 m width. Where ATLM has been used on the narrower roads (ie 3.2 m width traffic lane or less) there have been numerous complaints from truck drivers whose vehicles constantly run along the ATLM.

Environmental noise is another consideration that must be taken into account and it is DTEI practice that the treatment must not be placed within a 500 m radius from a residence as shown in Figure 5.1 although recent experience suggests that 300 m is acceptable in some cases.



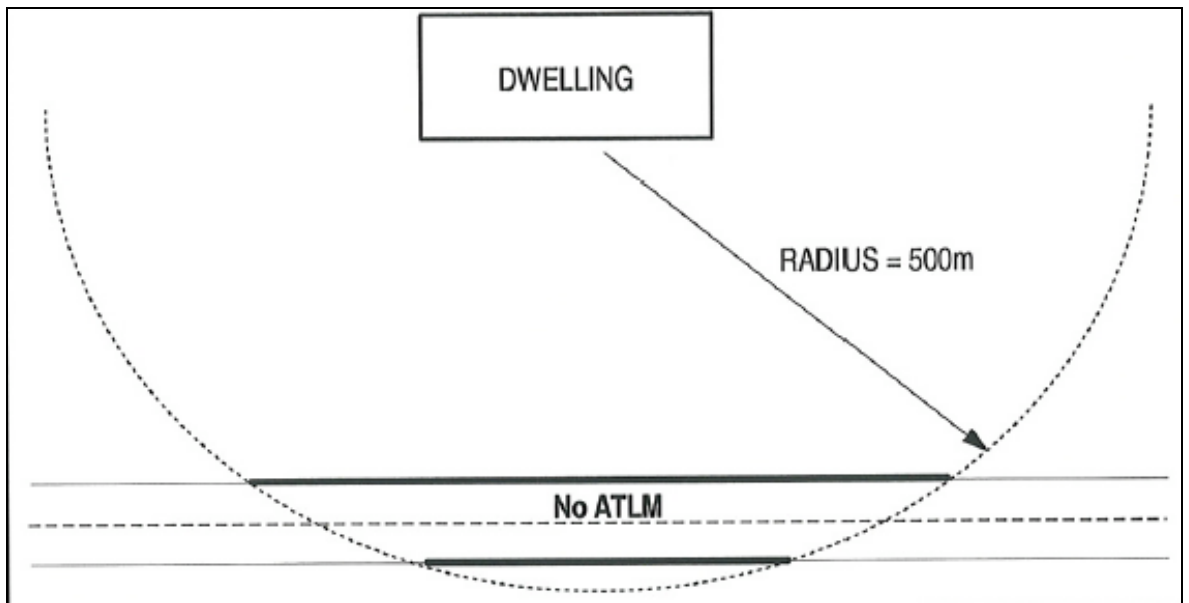


Figure 5.1  
Example of a 500 metre buffer zone to minimise residential annoyance from ATLM noise (source: DTEI)

## 5.1 Extent of current ATLM

In the time since the MAC funded trial in 2001, thermoplastic ATLM has been added to the following roads throughout the State (personal communication from Peter Mayger, DTEI, April 2006):

- Dukes Highway – entire length from Tailem Bend to the Victorian border (with the exception of a 30 km stretch to the north west of Bordertown)
- Sturt Highway – a 30 km section to the west of Blanchetown and the section between Blanchetown and Waikerie
- The new section of the Sturt Highway through Monash
- A 30 km section on the Burra to Morgan Road
- Sections on the Port Wakefield Road between Redhill and Crystal Brook, and north of Port Pirie to Port Augusta

These treatments were made possible with funding from special road safety programs. However, without this special funding, it is unlikely that ATLM would have been applied by DTEI as it is not part of their regular maintenance or construction practice to include the treatment.

## 5.2 Cost

Costs for thermoplastic ATLM have decreased considerably over the last decade. In NSW during the early 1990s, the RTA applied Vibraline to roads in the Parkes Region at a cost of \$5.40 per metre (ie \$5400/km) using a 150 mm edge line. Current prices from VicRoads for the different edge delineation products are \$1000/km for Zaganite and \$3000/km for Vibraline (based on a 150 mm wide line application). This compares to conventional reflective line marking which costs \$335/km for water based paint mixed with large beads which are added to make the lines reflective.

Currently in South Australia, assuming large projects, thermoplastic marking costs approximately \$1500 to \$1800/km to install compared to \$938/km for Polydots (on the basis of one reflective raised pavement marker and four Polydots). However, due to the limited

amount of application of ATLM, no contractor has been willing to base specialised equipment in the State. Therefore, small jobs are likely to be uneconomic or only performed when larger projects are also being undertaken. This makes it difficult for maintenance work to be conducted and short sections of road to be treated. It is possible that if ATLM contractors were to be based locally, costs could reduce further. However, the likely magnitude of this reduction could not be established.

ATLM has actually lead to a reduction in maintenance costs associated with painting edge lines (Personal communication, Peter Mayger, April 2006). As the profiled ATLM provides adequate day and night delineation in its own right, a painted edge line does not need to be applied to a treated section of road. Also, ATLM has superior reflective properties that are maintained well beyond the life of normal reflective linemarking. This saving in paint equates to \$318/km each year for the life of the ATLM (often assumed as being four years). This does not appear to have been a consideration with early comparisons of the Polydot and thermoplastic ATLM type treatments.

Given DTEI costs valid from 1st September 2006 (Personal Communication from Peter Mayger, DTEI, June 2006), Table 5.1 compares the Polydot and ATLM treatments over a life cycle (estimated as being 3 years for Polydots). The majority of Polydots in the original application in the South East and the Riverland were observed to come off within 2 years. Due to suspicions about the quality control at application, a conservative estimate of the life of Polydots of 3 years is used for the comparison. Although ATLM can range in costs from \$1500 to \$1800, the higher value is used to provide a conservative estimate. DTEI has yet to come up with a regular maintenance approach to the treatments and this cost is therefore omitted, the preferred option being to re-apply the treatment at the end of its service life.

**Table 5.1**  
**Comparison of Polydot and ATLM type treatment costs for**  
**a 50 km section of road over a three year period**

	Unit cost per km	Length	Number of years	Total
<b>Polydot type treatment</b>				
Initial Application (3 year life)	984	100	1	\$98,400
Maintenance costs	984	0	3	\$0
Linemarking costs	318	100	3	\$95,400
<b>Total</b>				<b>\$193,800</b>
<b>ATLM</b>				
Initial Application (4 year life)	1800	100	1	\$180,000
Maintenance costs	1800	0	3	\$0
Linemarking costs	318	0	3	\$0
<b>Total</b>				<b>\$180,000</b>

Notes and assumptions:

- Linemarking costs are for 150 mm wide application including glass beads
- Linemarking is applied annually on national highways
- ATLM includes glass beads
- Polydot treatment consists of four polydots between each raised reflective pavement marker
- At present, no attempt is made to maintain or repair damaged sections of tactile edge treatments so the ongoing maintenance cost is set to zero dollars
- Assumed life for the Polydot type treatment is 3 years
- Assumed life for the ATLM type treatment is 4 years
- Actual cost of ATLM ranges from \$1500 to \$1800
- Treatment is applied on both sides of the road (ie doubling the application distance)
- Prices supplied from DTEI valid as of 1st September 2006

Whilst the Polydots are cheaper to apply initially, the additional annual cost of linemarking makes the Polydots slightly more costly over a full life cycle. A comparison over a 12 year period is shown in Table 5.2.

**Table 5.2**  
**Comparison of Polydot and ATLM type treatment costs for**  
**a 50 km section of road over a twelve year period**

	Unit Cost /km	Length	Number of years	Total
<b>Polydot type treatment</b>				
Initial Application (3 year life)	984	100	1	\$98,400
Maintenance costs	984	0	12	\$0
Linemarking costs	318	100	12	\$381,600
Re-application at end of life (after 3 years)	984	100	1	\$98,400
Re-application at end of life (after 6 years)	984	100	1	\$98,400
Re-application at end of life (after 9 years)	984	100	1	\$98,400
<b>Total</b>				<b>\$775,200</b>
<b>ATLM</b>				
Initial Application (4 year life)	1800	100	1	\$180,000
Maintenance costs	1800	0	12	\$0
Linemarking costs	318	0	12	\$0
Reapplication at end of life (after 4 years)	1800	100	1	\$180,000
Reapplication at end of life (after 8 years)	1800	100	1	\$180,000
<b>Total</b>				<b>\$540,000</b>

Notes and assumptions:

- Linemarking costs are for 150 mm wide application including glass beads
- Linemarking is applied annually on national highways
- ATLM includes glass beads
- Polydot treatment consists of four polydots between each raised reflective pavement marker
- At present, no attempt is made to maintain or repair damaged sections of tactile edge treatments so the ongoing maintenance cost is set to zero dollars
- Assumed life for the Polydot type treatment is 3 years
- Assumed life for the ATLM type treatment is 4 years
- Actual cost of ATLM ranges from \$1500 to \$1800
- Treatment is applied on both sides of the road (ie doubling the application distance)
- Prices supplied from DTEI valid as of 1st September 2006

Over the longer term, the Polydot treatment ends up costing more as linemarking and re-application costs begin to dominate. It is evident that given current pricing, the savings that could be made with Polydots in 2001 can no longer be achieved in 2006.

Given the assumptions made in Tables 5.1 and 5.2, it is evident that although ATLM is more expensive than linemarking, the cost of linemarking alone is substantial, especially when applied on an annual basis. When considering the long term cost benefits of ATLM over linemarking, it appears that the additional cost of ATLM is relatively minor and likely to be worthwhile.

### 5.3 Extent of current shoulder sealing

At present, shoulder sealing programs are underway or have been completed on the Dukes Highway (Figure 5.2), the Sturt Highway and National Highway One north of Port Wakefield. This was part of a special program based on the expected safety benefit along long sections of road with an estimated BCR of 2:1. DTEI considers that apart from run off road crashes, sealed shoulders also have other advantages such as permitting easier overtaking when vehicles move further over to the side of the road.

Even with the policy of only applying ATLM to roads with sealed shoulders, there is still scope to increase coverage along sections of National Highway One in South Australia. At the time of writing, it was understood that full coverage was being considered by DTEI.



Figure 5.2  
Example of thermoplastic ATLM application on the Dukes Highway (J Woolley)

### 5.4 Maintenance issues

Several issues have arisen regarding the ongoing maintenance of ATLM applications. These include:

- How to repair sections which have poor adhesion and are breaking away
- How to repair short sections which have been removed for pavement maintenance
- How to reapply the treatment once it has reached the end of its service life

It is noted that in Victoria and Tasmania, ATLM is simply reapplied over older deteriorating sections. VicRoads has also found that current ATLM can have one surface seal coating placed over it and still maintain some of its audio tactile characteristics.

It appears that the majority of failures of ATLM and Polydot treatments in the field can be directly attributed to a lack of care during application (VicRoads, 2005). Much of this has to do with the undesirable presence of moisture on the road surface when the markers are applied to the road surface. This could be one explanation for the poor field performance of Polydots in the Riverland. Thermoplastic ATLM is also sensitive to reheating (in the plant equipment) and the temperature at which it is laid down. It is therefore important that DTEI pay particular attention to quality control when tactile markers are being laid.

## 5.5 Other differences between Polydots and ATLM

There are several reasons why thermoplastic ATLM treatments are preferable to the Polydot treatment:

- Polydots do not have any reflectivity
- The ATLM thermoplastics have glass beads mixed in at the time of application providing good reflectivity for the life of the application (as the ATLM wears, more reflective beads are exposed)
- This reflectivity outperforms conventional line marking and overcomes conspicuity problems when there is surface water
- The larger spacing of the Polydots means that even larger gaps will exist on the edge of the road should glue joints fail (when compared to equivalent failures in ATLM)
- If bonded well, thermoplastics tend to break away in small pieces and do not present the type of hazard that a loose Polydot would present
- Due to the conspicuity of ATLM with mixed in glass beads, it is not necessary for an edgeline to be painted; the same does not apply to Polydots which require the painting of edgelines at a cost of \$318/km per annum

## 6 Conclusions and recommendations

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Given the extra cost of the treatment over conventional line marking, the use of ATLM is more the exception than the norm and additional funds for their installation are not made available outside of special safety budget lines. At present, the use of ATLM is under internal review by DTEI in South Australia and a line marking guideline being developed will include a section on ATLM. Once completed, this may assist with integrating ATLM treatments into regular maintenance and construction activities.

Current national practice is to use thermoplastic ATLM and it is noted that Vicroads has discontinued its use of Polydots as lane and edge delineators. It is possible that if contractors were to be based locally, ATLM costs may reduce but the extent of this reduction could not be established. Comparisons of costings for the Polydot and ATLM type treatments over 3 years and 12 years shows that the Polydot treatment can no longer provide the savings achieved in 2001 when linemarking costs are taken into consideration.

On the basis of discussions with engineers from South Australia and other States, and given the many advantages of ATLM over Polydots, the following is recommended:

- A. Thermoplastic ATLM should be used as a fatigue driving countermeasure.
- B. The application of ATLM be considered as part of conventional road construction and maintenance practices in South Australia.
- C. A DTEI policy be developed supporting the adoption of ATLM together with guidelines supporting its regular use.
- D. ATLM be applied to further sections of National Highway One with a view to obtaining complete coverage of the Highway.
- E. The results of trials of centreline ATLM in Victoria and NSW should be monitored; it is likely this will become the next major use of ATLM throughout the Australian road network.
- F. Having completed coverage on the major highways, consideration should be given to the application of ATLM on sections of road where there is a high prevalence of run off road crashes regardless of whether a sealed shoulder is present or not.

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