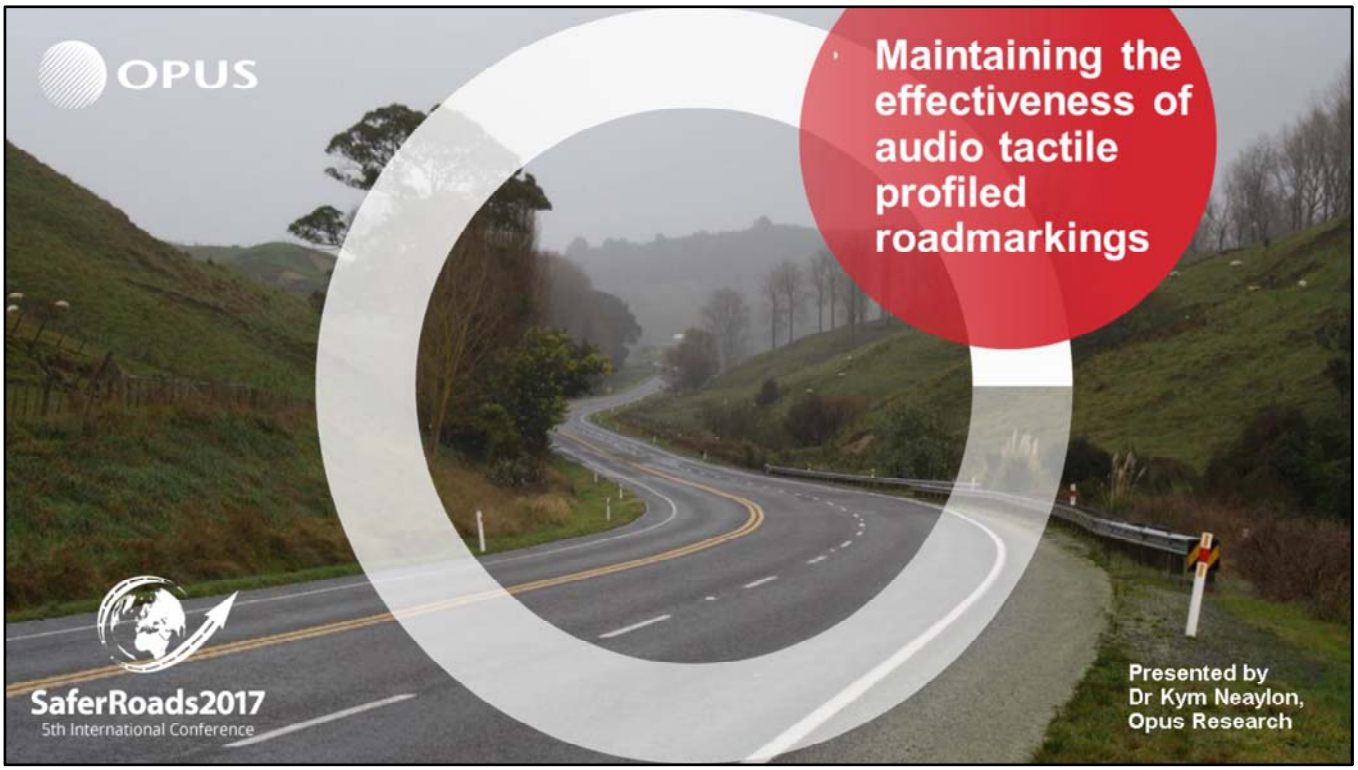
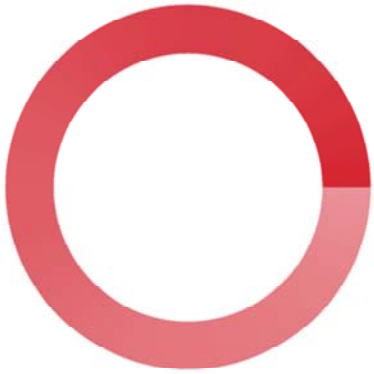

OPUS
Maintaining the effectiveness of audio tactile profiled roadmarkings
SaferRoads2017
5th International Conference
Presented by
Dr Kym Neaylon,
Opus Research

Maintaining the effectiveness of audio tactile profiled roadmarkings



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- Presented by
  - Dr Kym Neaylon

SaferRoads2017
5th International Conference

Intro: Audio tactile profiled road markings

- NZ has adopted the raised rib ATP road marking
- Safety benefits
- Visual effects
- Audio effects
- Tactile effects
- What happens at reseal time?
  - Early practice was to remove ATPs
  - This removed any remaining value.
  - 'In-lane reseal' or 'seal-over'?
- What should happen?

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Unless otherwise stated, in this report 'ATP roadmarking' refers to a roadmarking with regular raised segments which when traversed provide audible and vibratory/tactile feedback to the road user. In New Zealand, for ATP roadmarking centrelines the ribs are placed on the line, and for ATP roadmarking edgelines the ribs may be placed on the line or on the shoulder immediately adjacent to the line. As defined earlier, in New Zealand the ribs may be formed with thermoplastic or a two-part reactive cold-hardening material (referred to in the sector as cold plastic or cold-applied plastic). The line under the raised ribs or adjacent to the raised ribs may be regular-build paint or a higher-build material matching the material of the ribs.

Safety benefits

- ATPs significant breakthrough in driver safety
- Proactive implementation by NZTA
- 3,300 linear km by end 2012
- Review by Steve James (2014) NZTA
- 34% reduction in fatal crashes
- 24% reduction in serious crashes
- BCR ≈ 25

James, S (2014). The safety effectiveness of the audio tactile profiled markings programme. International Safer Roads Conference, 4th. Cheltenham, UK.

International Safer Roads Conference

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James, Steve (2014). The safety effectiveness of the audio tactile profiled markings programme. International Safer Roads Conference, 4th. Cheltenham, UK.

http://saferroadsconference.com/wp-content/uploads/2016/05/Monday-pm-SandC-4-James_Steve_118_V1_2014129-The-Safety-Effectiveness-of-the-Audio-Tactile-Profiled-Markings-Programme.pdf

The problem

- ATPs last 6 to 8+ years
- Roads may require a reseal whilst ATPs have remaining life
- 2 techniques commonly practiced:
  - 'In-lane reseal'
  - 'seal over'
- Which method should be preferred?
- Why?

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The effective life of ATP roadmarkings was estimated to be about 4+ years in the 1990s and now (2016) estimated effective life of ATP roadmarkings is usually taken as 6 to 8+ years.

New Zealand has adopted the raised rib form of audio tactile profiled (ATP) roadmarkings. The ribs are typically formed of thermoplastic or two-part reactive cold-hardening material (referred to in the sector as 'cold plastic') and the ATP roadmarkings are generally used longitudinally as edgelines or centrelines.
The effective life of ATP roadmarkings is estimated as 6 to 8+ years. Theoretically, the effective life of ATP roadmarkings is comparable to the effective life of the road surface on which they are laid. However, to date many ATP roadmarkings have been introduced onto road surfaces that are already midway through their lives. In addition, road surface failures do sometimes occur prematurely. Therefore situations arise where ATP roadmarkings have effective life remaining at a time when the road surface's effective life is expired and reseal of the road surface is scheduled.
This report describes a project commissioned by the NZ Transport Agency in 2013. At that time in New Zealand there was no formal advice on techniques for the retention of ATP roadmarking through reseal cycles; though two techniques were being practised at a local level:

- 'In-lane reseal' where the road surface of the trafficked lane adjacent to ATP roadmarkings is resealed but the non-trafficked shoulder and the ATP roadmarking

itself are left without being resealed.

- ‘Seal over’ the ATP roadmarking, with the intention of allowing its audio/tactile effects to be retained through the reseal layer.

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- ‘In-lane reseal’ where the road surface of the trafficked lane adjacent to ATP roadmarkings is resealed but the non-trafficked shoulder and the ATP roadmarking itself is left without being sealed over.
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Existing knowledge

- Australia has ATPs on chip seals, UK & USA do not
  - 'sealing over' gives reasonable results with smaller chip sizes
- NZ practices, experiences & observations workshop
  - Advantages and disadvantages for both
    - In-lane reseals
    - Sealing over ATPs
- NZ practices very subjective

Example of in-lane reseal in heavy rain

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The literature review found no substantive relevant literature on ATP roadmarking maintenance and/or retention from countries outside New Zealand and Australia.

Kiesel (2007) in Victoria, Australia. The ATP roadmarkings were raised ribs formed of thermoplastic, very similar to typical New Zealand practice. A set of test sites was identified with existing ATP roadmarkings being 'sealed over' with a range of road surface types, including chipseals. The test method involved a station wagon being driven over ATP roadmarkings and the driver subjectively noting in-cabin sound level changes and vibration levels. The driver rated the effect of the ATP roadmarkings as 'reasonable' if having an effect similar to new ATP roadmarkings, 'medium' if having a reduced effect, or 'poor' if having little or no audio and tactile effect.

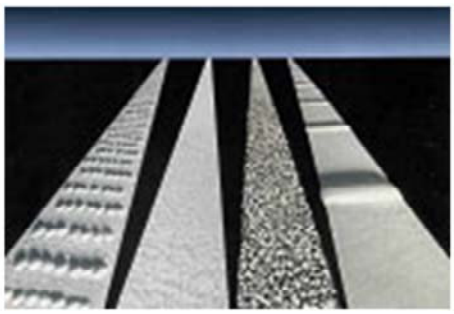
Kiesel (2007) finds where ATP roadmarkings are sealed over with a chipseal road surface, the effect of the existing ATP roadmarking can be retained as reasonable if the reseal uses a small chip size, say 7mm , and retention of the existing ATP roadmarking effect diminishes if the reseal uses larger chip sizes.

The New Zealand Roadmarkers Federation (NZRF 2011) has a Line removal guide with a section on removal of ATP roadmarkings prior to reseal. The purpose of the guide is oriented to practical advice.
NZRF (2011) recommends removal of ATP roadmarkings prior to reseal as sealing over

existing ATP roadmarkings may affect road surface drainage or create extra stresses in the reseal layer related to the now underlying ATP roadmarking. There is also concern if an ATP roadmarking is reinstated over the position of an existing or now underlying ATP roadmarking, there may be a ‘confusion of profiles’ as ‘it is likely to be very difficult to match exactly the marking spacing’.

Visual effects of ATP

- Visibility of road marking is expected
  - Day
  - Night
  - Wet
  - Dry
- Conspicuity (day)
- Retroreflectivity (night)
- ATPs considered to have better reflectivity
  - Raised faces shed water



ATP roadmarkings need to be driven over to provide their special audio/tactile effects but should provide visual effects all the time: during daylight and night conditions, and during dry or wet conditions.
The visibility of roadmarkings needs to be considered for night conditions and during daylight conditions. Visibility during night conditions is provided by different mechanisms or properties compared with visibility during daylight. Visibility performance of roadmarkings at night should not be inferred from visibility performance in daylight, nor vice versa.

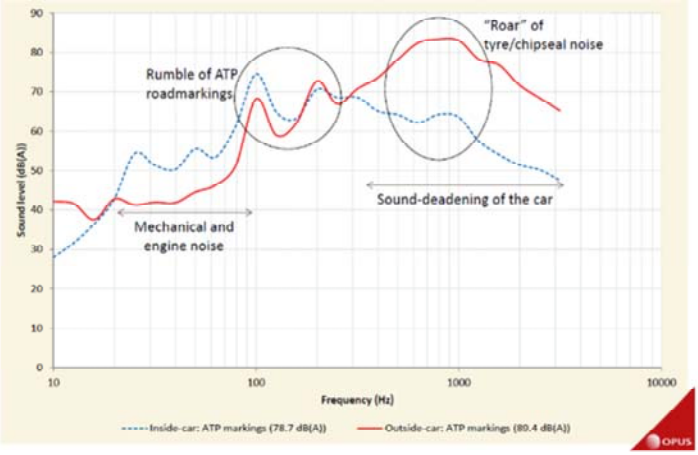
Audio/tactile effects

- Audio/tactile effects depend on spacing and prominence of the raised ribs
- Tactile effects are felt through the steering wheel, seat, pedals, foot-well
- Audio effects are heard at the drivers ear level
- Vehicles are designed for occupant comfort
- Sounds and vibrations entering the cabin are dampened
- Dampening focuses on particular frequencies

Audio tactile effects also depend on the vehicle speed and the vehicle type

Audio effects

- Graph shows noise measured inside and outside a car cabin
- ATP road marking noise is distinctive inside



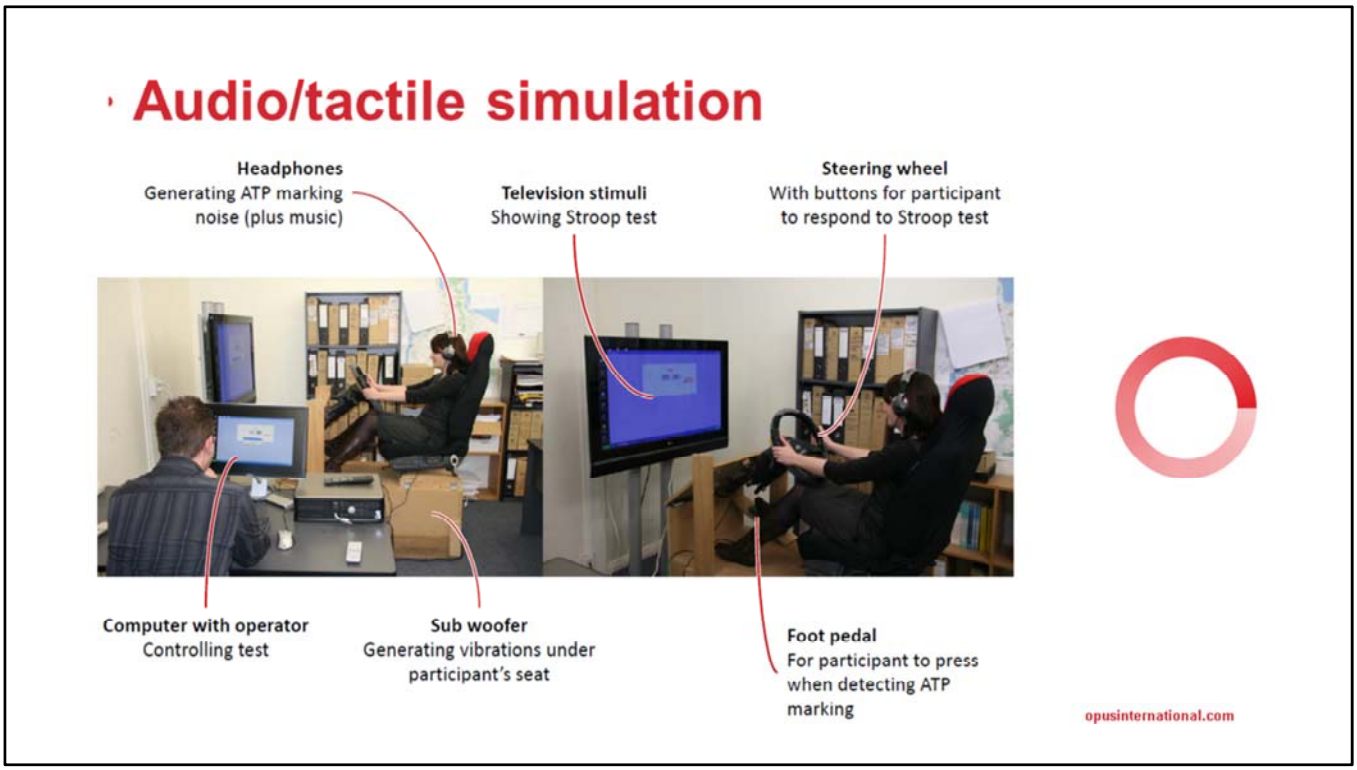
Dravitzki, V 2013, 'Are the audio tactile profiled road markings still effective?'

Audio/tactile effects measured

- In-lane reseal:
  - Audio/tactile effects unchanged
- Seal over:
  - Variable success
  - Initial condition of the raised ribs
  - Chip size of reseal

Audio/tactile effects simulated

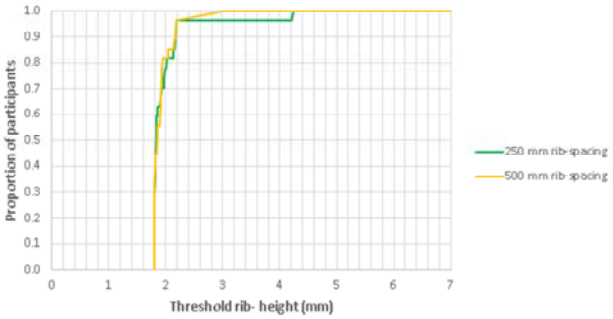
- Real road markings
  - Variations in block profile
  - Variations in cars
- Simulation
  - Block profile constant
  - Different block heights can be compared



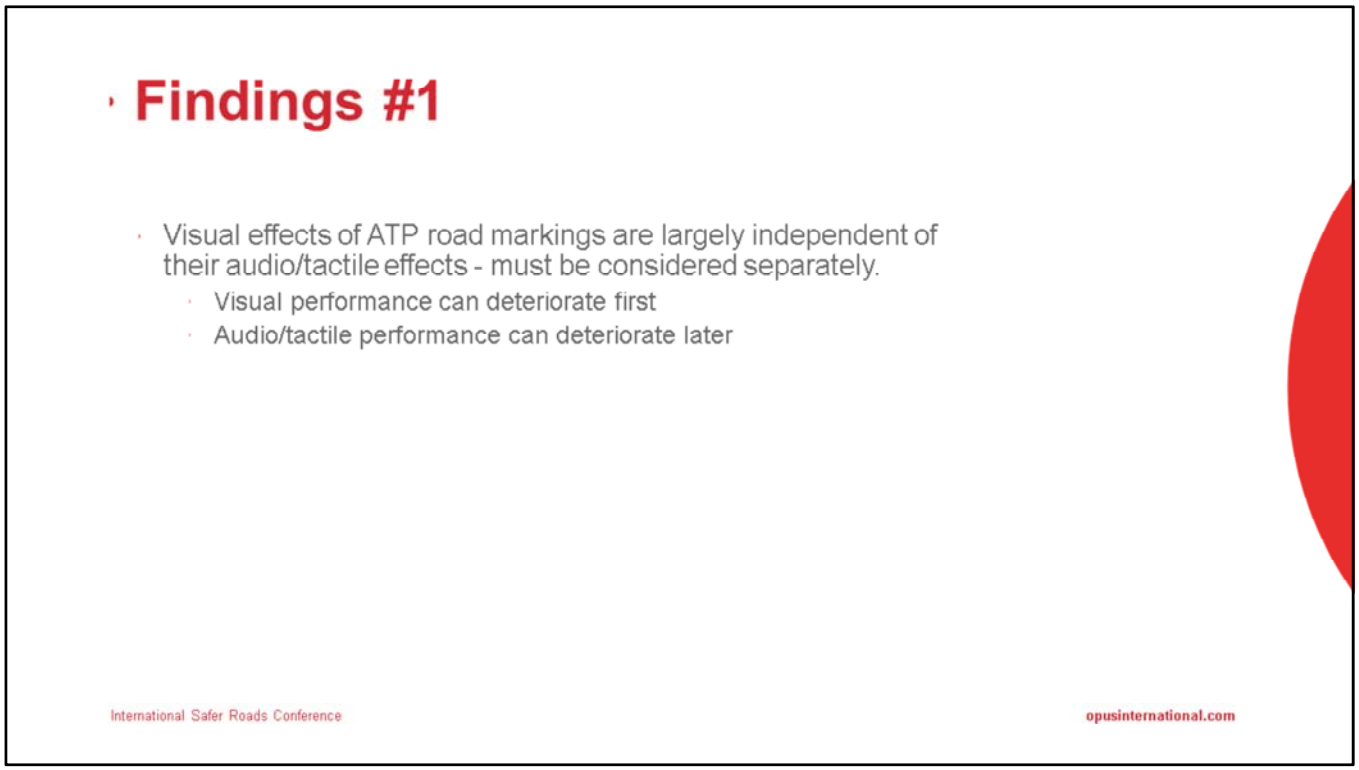
The Stroop test: a cognitive test, visual and complex, comparable to the driving task

Simulation results

- The tonal components are very relevant
- ATPs work via a threshold effect
- 4 mm is the minimum height to be noticed
- There may be age-of-occupant effects
- 5 mm should be the minimum working height



Dravitzki & Thomas 2011, Measuring the effect of audio tactile profiled road markings



Visual effects of ATP roadmarkings are largely independent of their audio/tactile effects, so they must be considered separately.

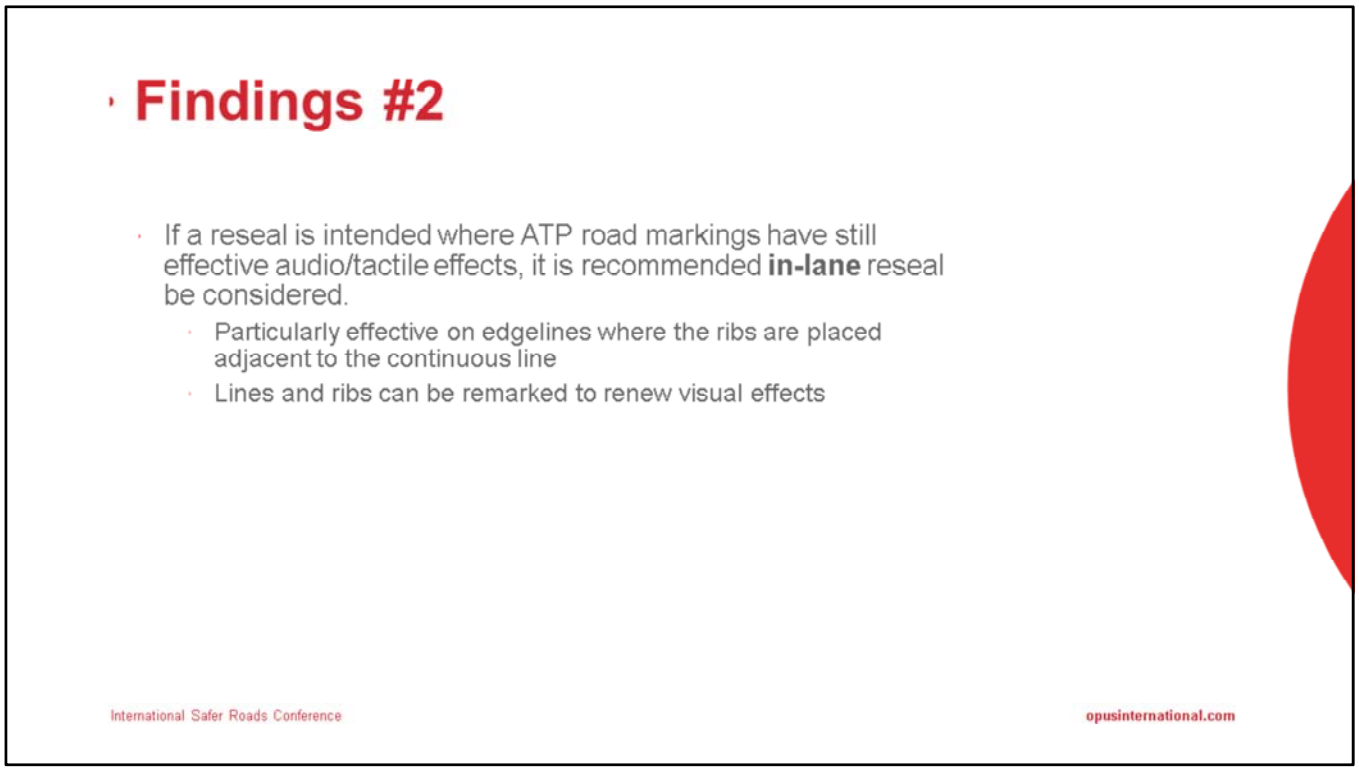
It appears the visual performance can deteriorate well before the audio/tactile performance. Techniques for refreshing ATP roadmarking visibility may be cleaning of the existing ATP roadmarking or recoating the ATP roadmarking with an application of paint (or other regular-build roadmarking material) including beads or other optics, though full measurements have not been undertaken. Increased measurement of ATP roadmarking visual effects including after re-marking and further investigation for better understanding of visual effects in wet conditions is recommended.

In terms of acceptable dimensions for rib height and rib width, the raised ribs of ATP roadmarkings are demonstrating lives of 6 to 8+ years. Within this period, the road itself may need resealing. Taking a precautionary approach, early practice was to remove any ATP roadmarkings prior to resealing. However, this disposes of any remaining value of the ATP roadmarkings and removal in itself is another cost. More recently, practices for resealing without removal of ATP roadmarkings have emerged and this project investigated these.

One main practice is to reseal the full carriageway including over any existing ATP roadmarkings. ATP roadmarkings can be sealed over and some of the pre-reseal audio/tactile effects successfully retained. However, the success is variable and may be difficult to predict, depending on both the pre-reseal condition of the raised ribs and the size of chips used in the resealing.

Another main practice is in-lane reseal where the reseal is laid over the traffic lane but stopped adjacent to the raised ribs of the ATP roadmarking. With ‘good practice’, the audio/tactile effects of the ATP roadmarking are unaffected by the in-lane reseal.

Of the two practices, in-lane reseal appears more practicable because there is more certainty the residual audio/tactile life will be unimpaired.

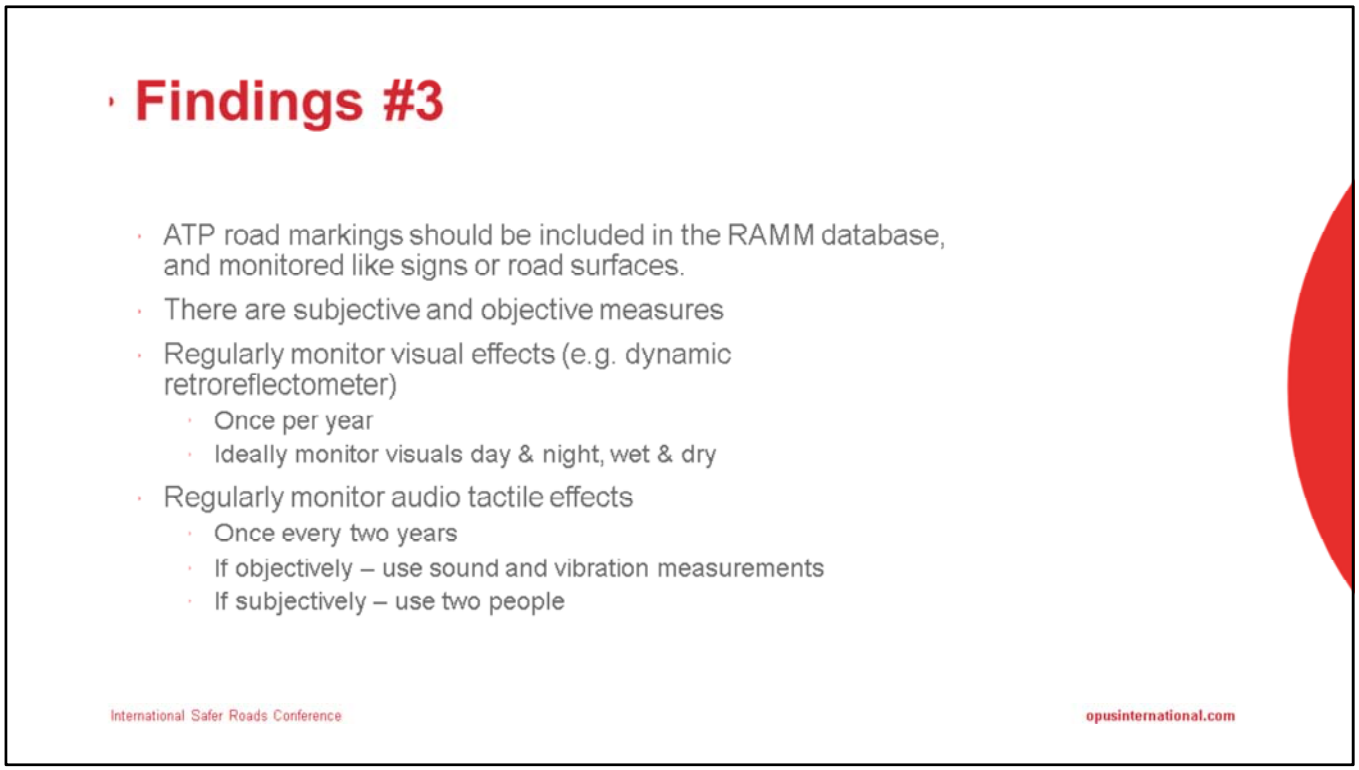


If road surface reseal is intended where ATP roadmarkings have effective audio/tactile effects, it is recommended in-lane reseal be considered.

The in-lane reseal should be checked as acceptable with contractual arrangements and executed in accordance with good practice.

In-lane reseal is particularly compatible with ATP roadmarking edgelines where the raised ribs are placed on the shoulder immediately adjacent to a continuous line. The edge of the in-lane reseal can be placed within the width of the continuous line, parallel but not contacting the raised ribs. Post-reseal, the continuous line is re-marked, with the option of also re-marking the raised ribs which could renew visual effects particular to their vertical profile and provide the benefits of a wider edgeline.

The inception of this project demonstrates that ATP roadmarkings are recognised as assets; however, ATP roadmarkings are generally not managed to the extent that other assets are.



For 'best practice', ATP roadmarkings should be included in the Road Asset and Maintenance Management database, and given documentation and condition monitoring just as other assets such as signs or road surfaces are given.

For ATP roadmarkings, 'best practice' monitoring could include regular measurement of visual effects, possibly using a dynamic retroreflectometer, and regular measurement of audio/tactile effects, possibly with a sound level meter mounted in-vehicle. Alternatively, the report has discussed a subjective rating system and this could be developed to complement objective measurements or applied to the current situation where there is not yet a fully developed method for objective measurements.

Future research should develop criteria and methods for objective measurements as well as a method for subjective rating. Either approach, objective or subjective, needs to account for audio, tactile and visual effects of ATP roadmarkings.

Recommendations from this research are:

- Audio/tactile effects should be assessed relative to the adjacent road

surface.

- Visual effects should be assessed in daylight and night conditions, in dry and wet conditions, and in continual wetting conditions if practicable.
- Assessments should be made periodically, repeating the same method each time and should be well documented. Indicative recommendations are monitoring of visual effects at least once a year and monitoring of audio/tactile effects at least once every two years, with additional monitoring if a reseal is proposed.

For objective assessments, sound level measurements (and vibration measurements) should record the total level and the spectral analysis.

For subjective assessments, at least two people should be used, with their age and any vision or hearing impairments/aids noted.

Dynamic retroreflectometers. These are externally mounted on vehicles, typically 100 mm to 150 mm above the road surface, so can easily accommodate the profile of ATP roadmarkings. Dynamic retroreflectometers can take measurements at a set sampling rate with the vehicle travelling at up to open road speeds, so can readily take multiple measurements to represent the longitudinal effect of ATP roadmarkings as they present to drivers.

For measuring retroreflectivity in dry conditions, dynamic retroreflectometers appear to offer advantages over static retroreflectometers, notwithstanding the availability of the equipment.

Considering visibility in wet conditions is also important. Typically retroreflectivity of a roadmarking in dry conditions is degraded in wet conditions. There are two primary reasons.

1 Accumulation of water can form a continuous layer on top of the glass beads or other optics in the roadmarking material so much of the incident light that would ordinarily be retroreflected is instead reflected off the water surface.

2 The beads or other optics in the roadmarking material have a particular refractive index or retroreflectivity efficiency in air. When wet, the refractive index of the beads in combination with the refractive index of water alters the angles at which light is reflected for a different retroreflectivity efficiency. (Diamandouros 2013).

Whether considering audio, tactile or visual effects, to be considered 'effective' the assessors should agree effects are *easily discerned and recognisable*, or otherwise considered not effective.

To assist consistency between assessments and also national uniformity of assessment, a video could be developed to provide training on how the subjective assessments should be performed and clear judgements made.

The research project tested noticeability of ATP roadmarking audio/tactile effects with 250 mm rib spacing compared with 500 mm rib spacing. This work combined objective and subjective approaches. It highlighted that interpretation of the subjective implications of total sound levels and spectral analyses of those total sound levels are complex. There is further complexity added when considering how the engineering and damping of different vehicles affects the in-vehicle experience of ATP roadmarking effects. There is scope for further investigation of the experimental method and operating mechanisms. However, for the experimental conditions used in this project, it was found that at the rib heights required by current New Zealand ATP roadmarking specifications (between 4 mm and 9 mm) there was no significant difference in noticing audio/tactile effects at 250 mm rib spacing compared with 500 mm rib

spacing.

Further information

- NZ Transport Agency research report 615 in publication:
  - 'Maintaining the effectiveness of Audio tactile profiled road markings for their full life cycle'
- Dravitzki, V, Thomas, J and Mora, K (2012), Improved effectiveness and innovation for audio tactile profiled roadmarkings, Research Report 478, NZ Transport Agency,
- Dravitzki, VK and Thomas, J (2011). Audio tactile profiled roadmarkings: Understanding how they work and when they are effective. NZRF/RIAA Roadmarking Conference. NZ Roadmarkers Federation. Rotorura.