Title slide for use with Transportation work stream

Why research SRS signage?

- Current SRS Signage: WR3 and TR2

SaferRoads Conference 2017

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NZTA T10 specification in 2010:

- ↑ the range of curves
- ↑ min standards for SCRIM investigatory levels for high risk curves

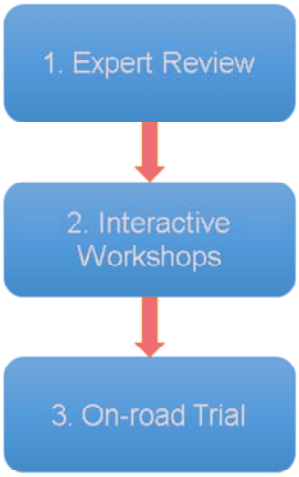
Need a consistent, understandable & cost effective way of warning drivers of the potential for lower skid resistance

BUT the current SRS signage NOT WELL UNDERSTOOD

Addresses by investigating drivers' comprehension and behavioural responses to SRS signage.

Programme Design

- Three Phase Iterative Process



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Expert Review

The Expert Review Involved…

- Examination of current SRS signage,
  - –New Zealand
  - –International
- Identification of ergonomics principles relating to signage comprehension
  - –how these can apply to potential SRS signs
- Impact of signage of SRS signage on driver behaviour

NZ supplementary signage

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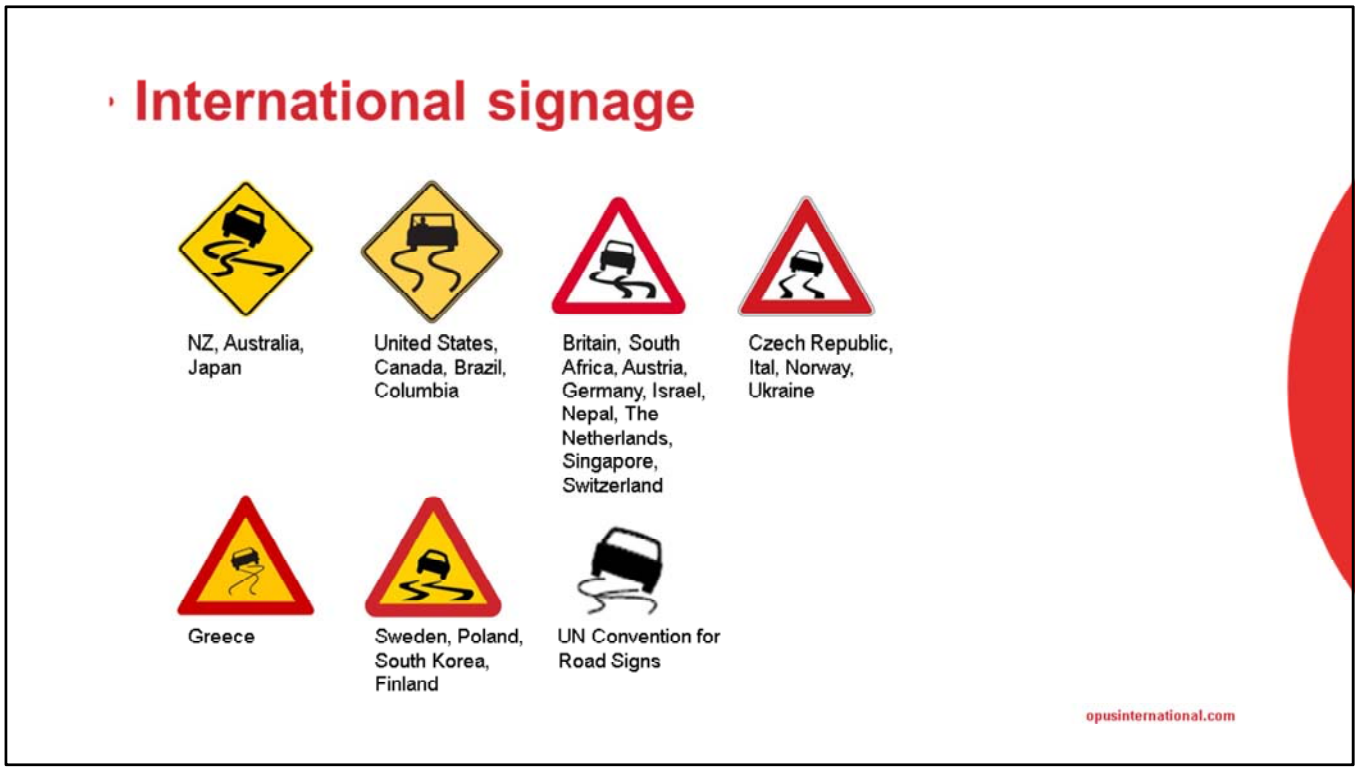

International Signage…

Image of an off balanced vehicle followed by tyre tracks

The main **differences** are:

•**Shape** (mostly diamond, such as in New Zealand, Australia, USA, or triangular, such as in the UK and Europe)

•**Colour** (mostly yellow/black, yellow/red, or red/white combinations for permanent signage)

•Whether the vehicle **tracks** in symbol **cross** or not.

SRS literature

Study	Signage	Method	Slippery Road surface (SRS) sign findings
Charlton (2006), Charlton & Baas (2006)	NZ signage	Static and dynamic comprehension using driving simulator	SRS signs performed worst across suite of measures.
Dewar et al. (1997)	US signage	Static comprehension of projected images	Correctly identified by 44.6% (bottom 12 of 86)
Shinar et al. (2003)	Signage common to Israel, Finland, Poland, Canada, Australia (plus some specific to each)	Static comprehension using image cards	Correctly identified by more than 90% of participants
Ben-Bassat & Shinar (2006)	Signage common to Israel, Finland, Poland, Canada, Australia (plus some specific to each)	Static comprehension using computer	Correctly identified by more than 90% of participants
Bazire &Tijus (2009)	French signage	Identify the sign as real or pseudo	Correctly identified by 97% of participants

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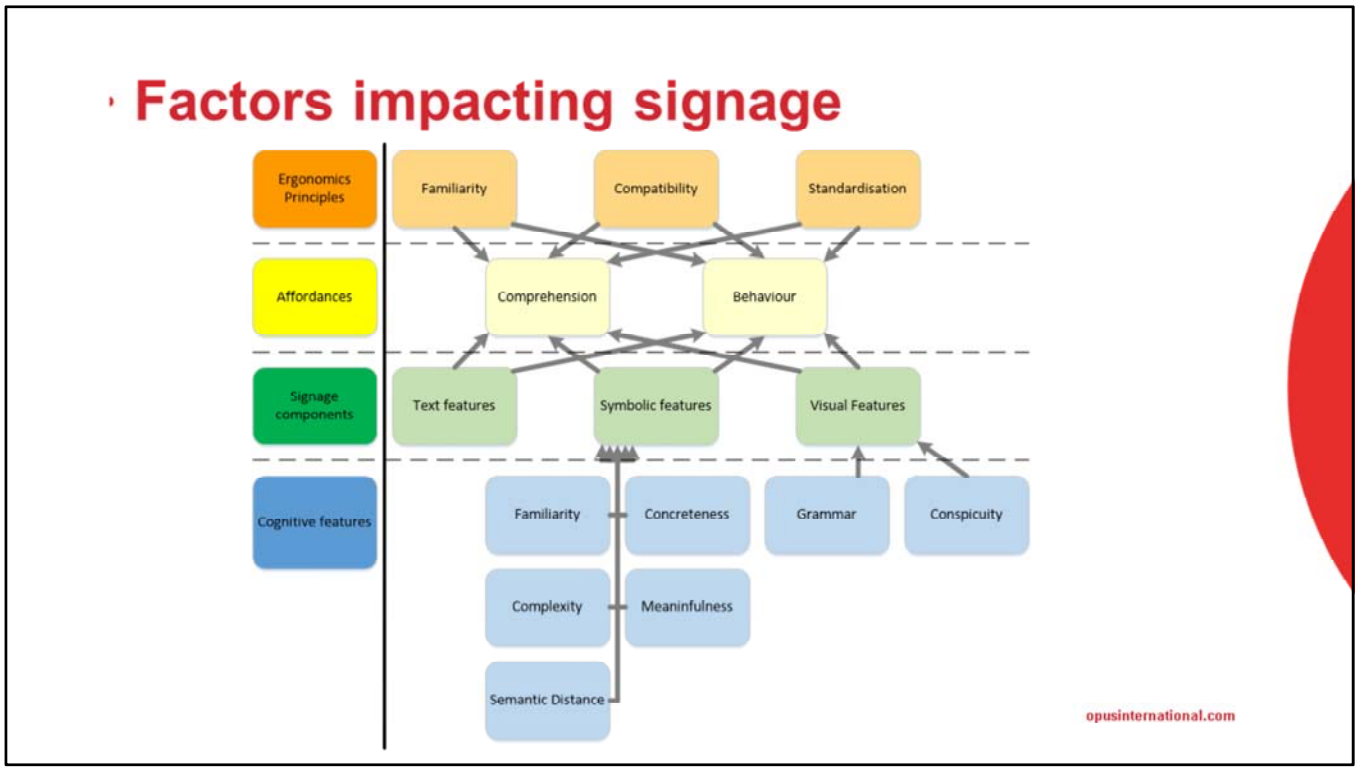
- Small % signage comprehension lit looked specifically at SRS signs.
- Mixed results
  - Poor with NZ sample and using dynamic test, driving simulator
  - Good some static tests



Ergonomic Principles

Three ergonomics principle identified as significantly correlated with the probability of drivers' correctly comprehending traffic warning signs (Ben-Bassat & Shinar 2006):

Familiarity
Compatibility
Standardisation

The specific design features reflected in these ergonomics principles relate to either visual features (e.g. size, shape, and colour) or cognitive features (Ng & Chan 2009).

Familiarity relates to the frequency with which drivers experience a sign;
Compatibility relates to the degree of correspondence between the symbols and text making up a sign and the message it is attempting to convey; and
Standardisation relates to the consistency with which the colour, shape, symbols and other features of the sign are used to represent that particular message.

While it is not possible in the design process to influence drivers' familiarity with a specific sign, it is possible to include sign features that are familiar to drivers from their use in other forms of signage. If these familiar components are used in a manner consistent with other signs it is possible to achieve a high degree of standardisation leading to higher levels of comprehension.

Visual Features…

•Drivers are influenced by the particular "grammar"
•E.g, diamond shaped signs represent a particular type of information/warning, while round shaped signs represent another
•Disrupting this grammar can have a negative effect on comprehension, therefore it is not advised that the

shape or size of the SRS be altered outside the current specifications.
•Bazire &Tijus 2009 demonstrated that the drivers' main focus when interpreting road signs was on the icon or symbol component of the signs

Symbolic Features...

•McDougall, Curry and de Bruijn (1999) describe five cognitive features that are important to consider when designing comprehensible symbols or icons. These are:

Familiarity: frequency of encounters.
Concreteness: depicting objects in the real world, opposite to abstract.
Complexity: amount of detail.
Meaningfulness: relevance/instructiveness.
Semantic distance: relatedness or closeness of symbol to what it represents.

•Most strongly related to comprehension:

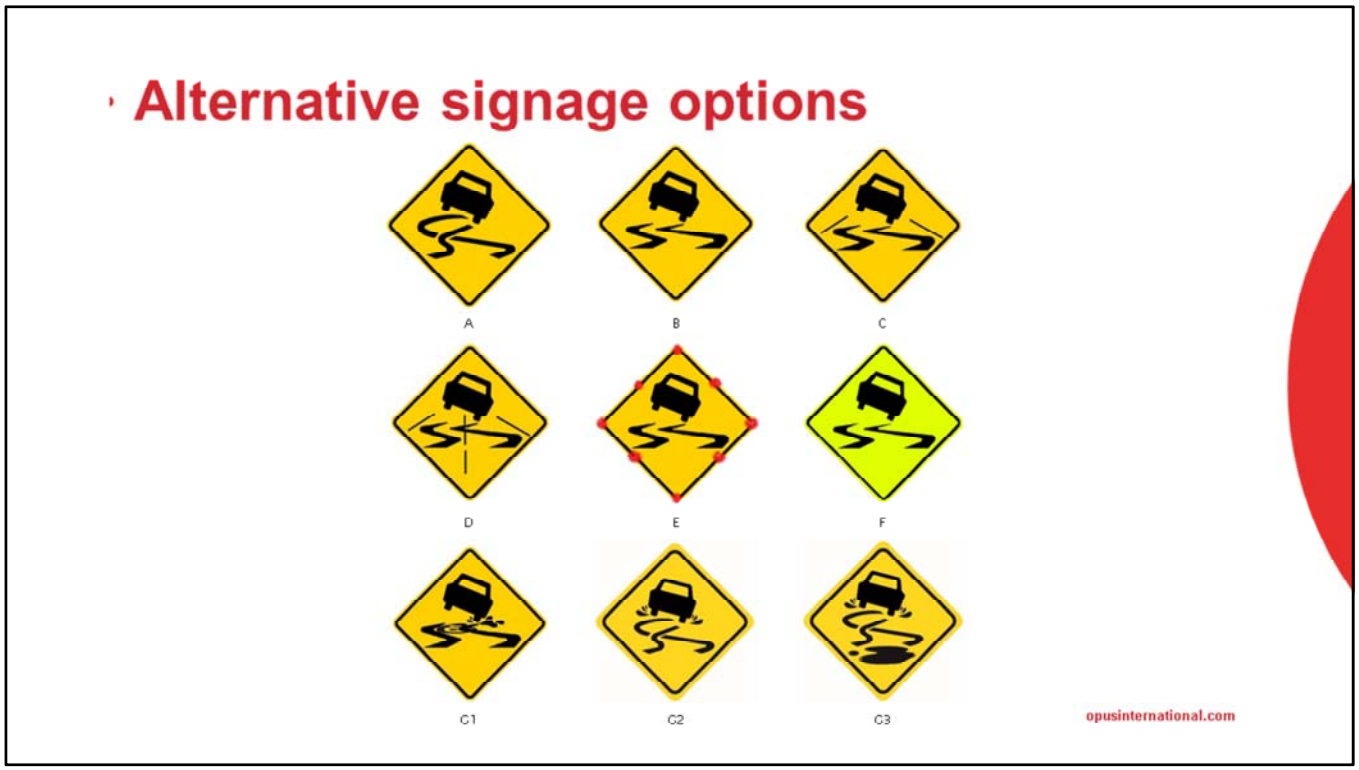
McDougall, Curry, and de Bruijn (2001) semantic distance.
Ng and Chan (2008): familiarity

Text Features...

•Permanent SRS sign always presented with a supplementary plate ('when wet'; 'when frosty; gravel road) .
•Temporary SRS sign does not have a supplementary plate unless it is associated with ice/grit
•Signs that include a combination of text and symbols are more likely to be correctly comprehended and are also comprehended faster than symbols alone (Shinar & Vogelzang 2013).
•Interpretation of "When wet" dependent on interpretation of SRS sign, as this provides drivers with the information about what is to be expected when the conditions are adverse.
•No messages contain, action words that indicate the desired behavioural response they are aimed at inducing. Including such may increase drivers' ability to respond appropriately.

Driver behaviour...

•Rather than meaning and recall, what is fundamentally important for a sign to be effective is that it induces the desired behaviour change is drivers (Fisher,1992) .
•While SRS signs were the worst performers in the suite of measures including comprehension and conspicuity, in observations they were associated with one of the largest reductions in speed (Charlton & Baas, 2006)
•Necessary to examine whether signage options do promote the desired behavioural response in drivers.
•This study takes this into account by including an on-road testing phase of the signs developed in the following section.



Alternative Designs Developed Based on Cognitive Design Features...

The Expert Review Involved…

- Examination of current SRS signage,
  - –New Zealand
  - –International

- Identification of ergonomics principles relating to signage comprehension
  - –how these can apply to potential SRS signs

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Public Interactive…

Participants

•Ten participants (six males, four females) aged 24-64

•Pre-screened: range of ages, genders, driving experience, education levels, licence types.

Procedure

•2 hours in evening

•Intro to SRS signs and five cognitive design principles

•Participants ranked top three options on each of the design principles, as well as overall most preferred.

•Discussed strengths and weakness of the signage options

Expert Interactive…

Procedure

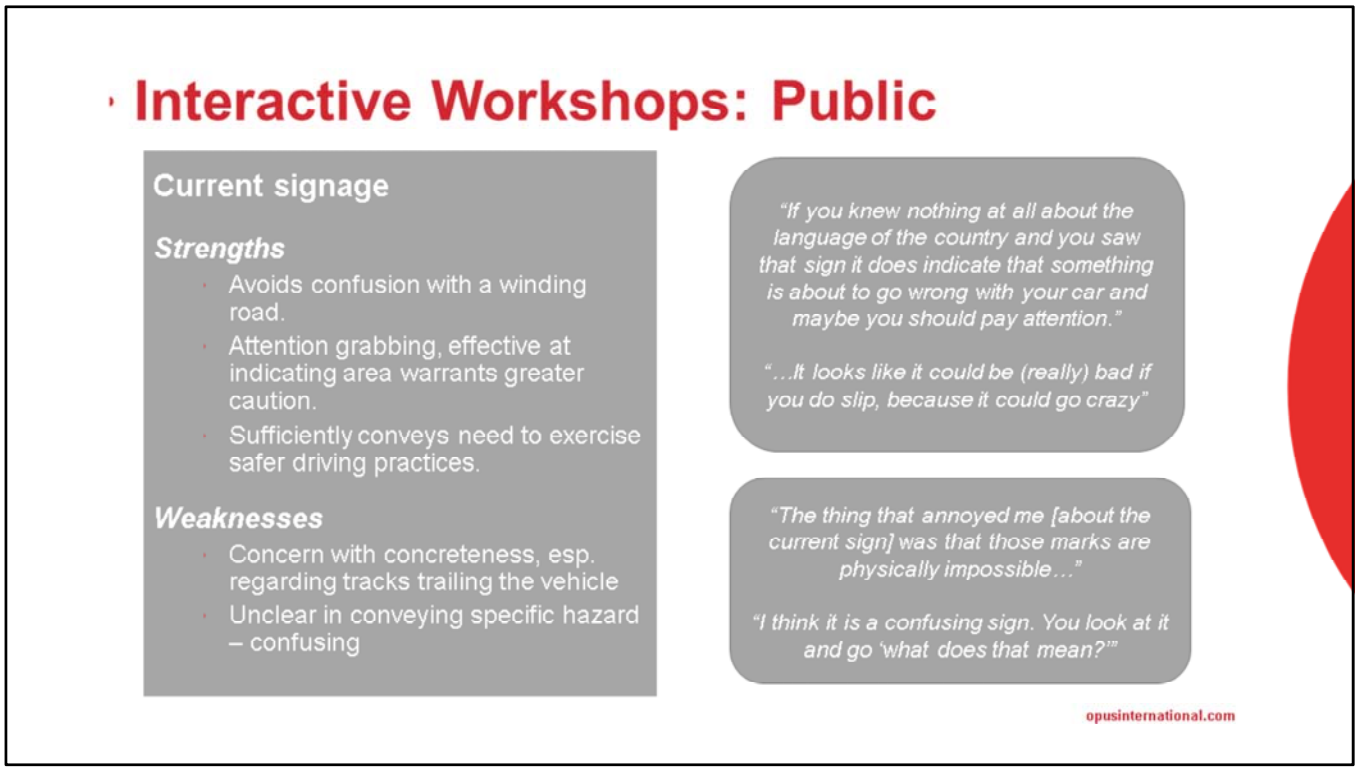
•Project steering group: technical experts NZTA, AA, NZRMF, RSMA, local government reps.

•Same sign ranking exercise, indicating their overall three most

preferred signage options.
•Discussed and integrated preferences in order to shortlist signage options.

Data Analysis…

•Qualitative analysis techniques including thematic analysis.
•Where possible, quantified, analysed using chi-square testing and percentage comparisons.



Strengths

•Avoids confusion with a winding road, due to the crossed tyre tracks following the tipping vehicle.

•Attention grabbing, effective at suggesting to drivers that the area warranted greater caution

"If you knew nothing at all about the language of the country and you saw that sign it does indicate that something is about to go wrong with your car and maybe you should pay attention."

"…It looks like it could be (really) bad if you do slip, because it could go crazy"

•Sufficiently conveys need to exercise safer driving practices, e.g. reducing speed."

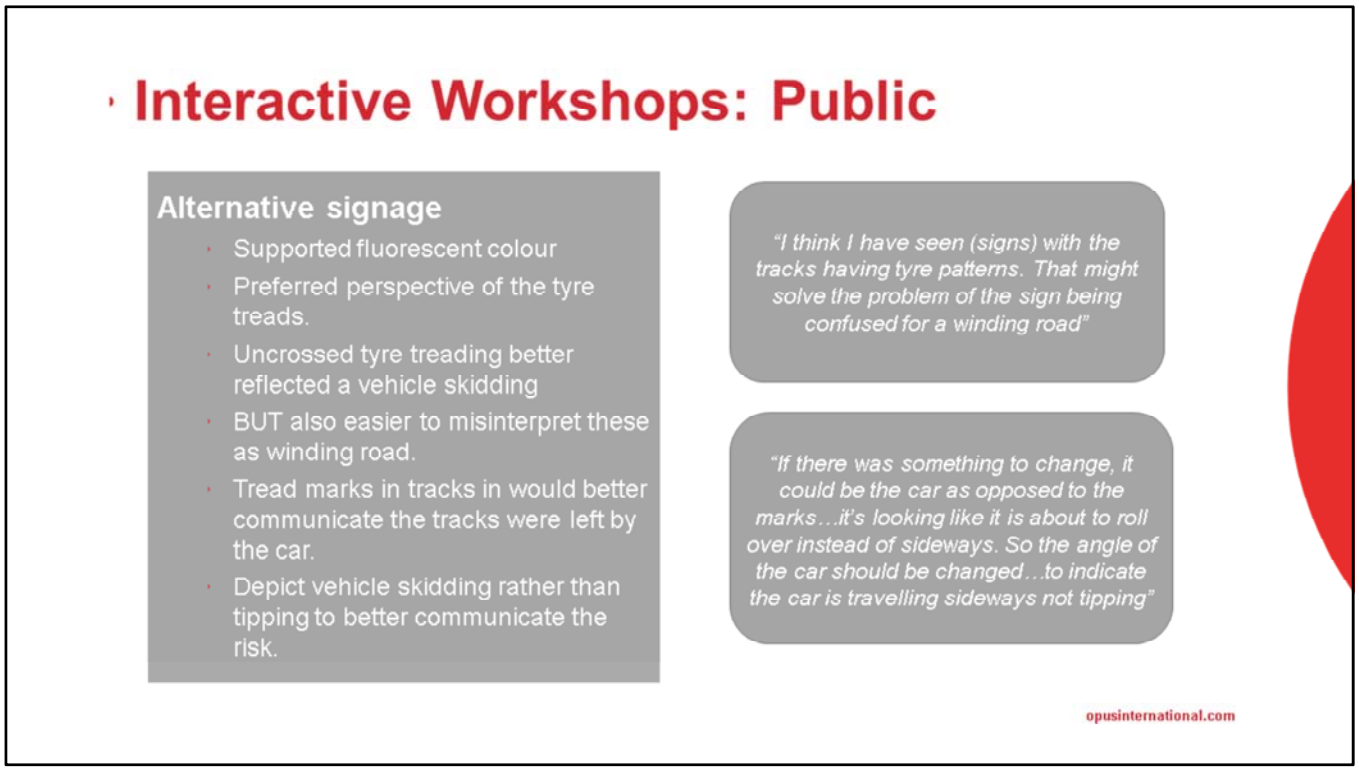
Weaknesses

•Concern with concreteness, esp. regarding tracks trailing the vehicle

“The thing that annoyed me [about the current sign] was that those marks are physically impossible…”

•Unclear in conveying specific hazard – confusing

”I think [the current sign] suggests wheels may disconnect at random”
“I think it is a confusing sign. You look at it and go ‘what does that mean?’”



•Supported fluorescent colour, standing out from other road signage would encourage better driving behaviour.
•Preferred perspective of the tyre treads. improved their interpretation, understanding that the hazard lay ahead.
•Uncrossed tyre treading better reflected a vehicle skidding BUT also easier to misinterpret these as winding road.
•Add tread marks to the tracks in current sign to better communicate the tracks were left by the car.

"I think I have seen (signs) with the tracks having tyre patterns. That might solve the problem of the sign being confused for a winding road"

•Depict vehicle skidding rather than tipping to better communicate the risk.

"If there was something to change, it could be the car as opposed to the marks…it's looking like it is about to roll over instead of sideways. So the angle of the car should be changed…to indicate the car is travelling sideways not tipping"

Preferred Text…

•Supplementary plates seen as effective means of enhancing driver understanding and compliance.
•Recommending travel speed within the supplementary plates would encourage appropriate driving behaviours from road users (including naïve drivers and visitors travelling on New Zealand roads)

"They might not understand the actual sign but they can always understand the speed."

•If recommended speed included, it would need to communicate:
how long the recommended speed was in place for
under what conditions it was applicable.
•Phrases containing a command or instruction more likely to elicit greater behaviour change, while avoiding the misinterpretation that could result from the inclusion of a recommended speed.

“reduce speed (now)”

“slow down”, with participants showing a preference for the latter

•Include reference to conditions under which the warning would be relevant, e.g. wet, frost, or gravel conditions,

•Preferred text = “Slow down when wet”

Preferred Signage Discussion…

•Despite reservations, the steering group's first preference was for the current sign,
•They felt that it could still be effective at eliciting the desired behavioural response (e.g. reduced speed).

"The fundamental design and familiarity and everything else of the sign and the semantic (disposition) of it (the sign), the symbol is doing everything it reasonably can in simple terms and it is used internationally with slight variations and I think the one we've got is as good as any and probably better than some."

•Fluorescent yellow-green has been reserved to represent vulnerable road uses. Felt it should remain specific to these.
•The second most preferred sign (Figure 10) insufficient for communicating risk for slippery conditions other than those related to the wet.

“We use this basic sign when it is wet, icy, gravel, any slippery condition. It is not necessarily for when wet.”

•Queried how much improvement to the symbol is necessary given majority of drivers executed the appropriate behavioural response in reaction to the sign.

“…But as I’ve said the research indicates that people still do what we want them to do, so are we really concerned if they don’t understand why they’re doing it?

Preferred Text Discussion…

•Following discussion, supported testing an alternative supplementary plate.
•The current signage seen as lacking info on behavioural response expected from drivers.
•Addition of appropriate action thought to be valuable
•The Steering group suggested that the word “down” in “Slow down when wet” was superfluous and suggested “slow when wet” would convey the same message.
•The steering group also suggested the addition of the word “slippery” could aid in driver understanding and comprehension:
•Discussed recommended speed to elicit the desired driving behaviour regardless of whether or not the warning was correctly understood.

“… an advisory speed with the appropriate supplementary, when wet or something like that, which might elicit another degree of understanding that one here is a warning sign so I have to do, what am I supposed to do and the idea is a number to give you some guidance.”

Expert Decision…

•Following the discussions, the steering group decided that the various selected signage options did not differ significantly enough from the current signage to warrant testing alternative designs.
•The steering group decided to focus on alternative supplementary plate options.

“I think from the discussion today most people seem satisfied that that is reasonable. The other thing from the research is that adding a supplementary plate with a text message to help expand on the meaning, the desired instruction and all those sorts of things is the way to make the sign work better. I think that what we’ve chosen there as supplementary plates will give us a reasonable indication if that is going to add something or not.”

•The group identified two alternative supplementary plate options for testing in the on-road trial component of work to be tested along with the current signage.

On-Road Trial: Method

- Signage on-road

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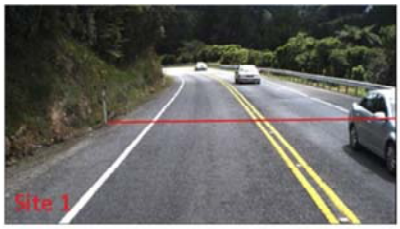
Signage on-road…

•All signs were tested using the Temporary signage colour (reflectorised fluorescent orange) and dimensions.
•All road signs tested were constructed following the design specifications set out in the TCD including specifications for sign dimensions, font size and type, materials and luminance.

•All road signs tested were constructed following the design specifications set out in the Transport Agency's Traffic Control Devices (TCD) Manual (NZTA, 2016) including specifications for sign dimensions, font size and type, materials and luminance. All sign designs, including alternative and locations were reviewed by the Transport Agency's TCD committee and given permission for on road use for the trial period. A Gazette notice authorising the trial, which set out the specification for the supplementary plates used, was published following the TCD committee meeting as NZ Gazette 9 July 2015, No. 74, au3962. (https://gazette.govt.nz/assets/pdf-cache/2015/2015-au3962.pdf?2015-07-09%2010:01:07).

On-Road Trial: Method

- Signage locations



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Signage Locations…

•Three locations, representing three different curve radii:
•The locations were identified through liaison with the Transport Agency, and were coordinated in conjunction NOC holder in the Greater Wellington region.

•**Site 1:** Radius 270m; curve length 160m; left had curve; approach speed limit 100 km/h

•**Site 2**: Radius 184m; curve length 300m; right hand curve, approach speed limit 100 km/h

•**Site 3:** Radius 88m; curve length 90m; left hand curve; approach speed limit 80 km/h

•All three locations were on State Highway 58.

Signage Performance…

•Key measure = free vehicle speed
•Comparing before the addition of any signs (baseline) and after the addition of each sign.
•Speed data collected for final two weeks of the five-week rotations at each location using Metrocount tube counters
•Metrocounters placed following the signage, immediately prior to start of the curve.

Treatment Conditions…

•Dry versus adverse
•Rainfall data from the Metservice website from the Pinehaven Stream weather gauge
•Speed for each signage option measured during both conditions
•Baseline (no sign) measures also taken in both conditions
•Establish impact of conditions on speed, then then any additional impact of the signage options

On-Road Trial: Results

Sign type	km/h (Standard Deviation)								
	Site One			Site Two			Site Three		
	n	Mean	85th Percentile	n	Mean	85th Percentile	n	Mean	85th Percentile
No sign	72	79.9 (10.3)	91.2 (10.3)	64	87.3 (8.9)	98.5 (8.9)	92	57.6 (5.3)	65.9 (5.3)
No supplementary plate	68	78.5 (10.1)	88.9 (10.1)	331	83 (7.4)	90.3 (7.4)	269	52.8 (5.0)	57.6 (5.0)
Slippery when wet	278	74.6 (8.4)	82.9 (8.4)	404	80.7 (6.8)	87.4 (6.8)	322	54.2 (5.8)	59.0 (5.8)
Slow when wet	409	75.6 (8.6)	84.8 (8.6)	239	80.1 (8.3)	88.1 (8.3)	458	54.1 (4.7)	58.7 (4.7)

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Data Analysis…

•Free following vehicle speeds, e.g., vehicles with at least 4 seconds of headway.
•For wet weather speeds, only vehicles travelling in rainfall between 1.4 mm and 2.9 mm/h analysed to control for any effect caused by large variations in rainfall
•One-way ANOVA conducted by site with planned comparisons for all four conditions (no sign, sign with no supplementary plate, sign with ‘slippery when wet’ and sign with ‘slow when wet’ supplementary plates).

Measurements…

•Baseline (no sign) speed measurements all three sites) = 23 September 2015 – 2 October 2015.
•Rain fall = 0.2 mm/h - 1.4 mm/h.
•Signs erected = 16 November 2015 - 28 March 2016.

•Three rotations within this period, each rotation having a sign at one of the three different sites.

For Site One, the results revealed there was a **significant effect of signage** on free vehicle speeds compared to baseline (no sign), $F(3, 823) = 9.14$, $p < 0.01$, $r = 0.18$. Planned contrasts revealed that the presence of any sign significantly reduced vehicle speed compared to no sign at all, $t(823) = -3.30$, $p < 0.01$ (one tailed), $r = 0.11$. Furthermore, the sign correlated with the greatest level of speed reduction compared to no sign at all was the sign with the supplementary plate that said "**Slippery when wet**", which contributed to a 5.3 km/h speed reduction from 79.9 km/h to 74.6 km/h, $t(823) = 4.554$, $p < 0.01$ (one tailed), $r = 0.15$.

Similarly, for Site Two there was also a **significant effect of signage** on free vehicle speeds compared to baseline (no sign), $F(3, 256.38) = 17.75$, $p < 0.01$, $r = 0.24$. Site Two planned contrasts revealed that, as with Site One, any sign significantly reduced vehicle speed compared to no sign at all, $t(69.57) = -5.348$, $p < 0.01$ (one tailed), $r = 0.54$. Unlike Site One, the sign correlated with the greatest level of speed reduction compared to no sign at all had the supplementary plate "**Slow when wet**", which contributed to a 7.2 km/h speed reduction from 87.3 km/h to 80.1 km/h, $t(94.38) = 5.89$, $p < 0.01$ (one tailed), $r = 0.52$.
Finally at Site Three there was again a **significant effect of signage** on free vehicle speeds compared to baseline (no sign), $F(3, 1140) = 20.24$, $p < 0.01$, $r = 0.23$. As with Sites One and Two, the planned contrasts revealed that any sign significantly reduced vehicle speed compared to no sign at all, $t(1137) = -7.017$, $p < 0.01$ (one tailed), $r = 0.20$. Different again to Site One or Two the sign that correlated with the greatest reduction in vehicle speed compared to no sign at all was the **sign with no supplementary plate** affixed, which contributed to a 4.8 km/h speed reduction from 57.6 km/h to 52.8 km/h, $t(1137) = 7.781$, $p < 0.01$ (one tailed), $r = 0.23$. The average speed for each sign type by site can be seen in Table 4.

A preliminary analysis was also conducted in dry weather conditions and while the results indicated there were significant differences between the four conditions this was an artefact of the large sample size and amounted to actual speed changes of approximately 1 km/h. So, while this is a statistically significant finding, it has no practical significance compared to the 7 km/h speed change seen in wet conditions as exhibited at Site Two.

The 85th percentile speeds followed a similar pattern to the mean speeds. The only difference being at Site One, the sign alone did not correlate with a significantly lower speed than in the baseline (no sign) condition; and at Sites Two and Three, the signs with the supplementary plates did correlate with a significantly lower speed compared to baseline (no sign), but did not differ significantly from each other.

On-Road Trial: Results

Findings summary:

- Signage made practical significant different to speed in wet conditions (but not dry)
- Most effective sign differed for curve:
  - Site 1: Slippery when wet
  - Site 2: Slow when wet
  - Site 3: Main plate only
- Results for mean speed and 85th percentile speed very similar but no differences between two supplementary plates
- Slow when wet = largest overall speed reduction from baseline – 7 km/h

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- Practical difference in wet but not dry – observable indicator of conscious processing and comprehension and a positive behavioural response.

- The sign with no supplementary plate sig. different to no sign – even current SRS signage promotes the desired behavioural response in drivers. Highlights importance of the Transport Agency continuing to signpost at risk areas.

- New supplementary plate sig diff to main plate alone led on 2/3 curves – Fits with research indicating that text+symbols is more effective than symbols alone

- Indicates that the addition of a supplementary plate of the nature tested here to TR2 could have a significant influence of driver speed in wet conditions across similar curves on the network.

- The “Slow when wet” message is particularly advantageous as it includes

direct reference to the desired behavioural response and ties in with the text currently used on VMS SRS signs in New Zealand (“Slow down”) as well as leading to the greatest overall speed reduction.

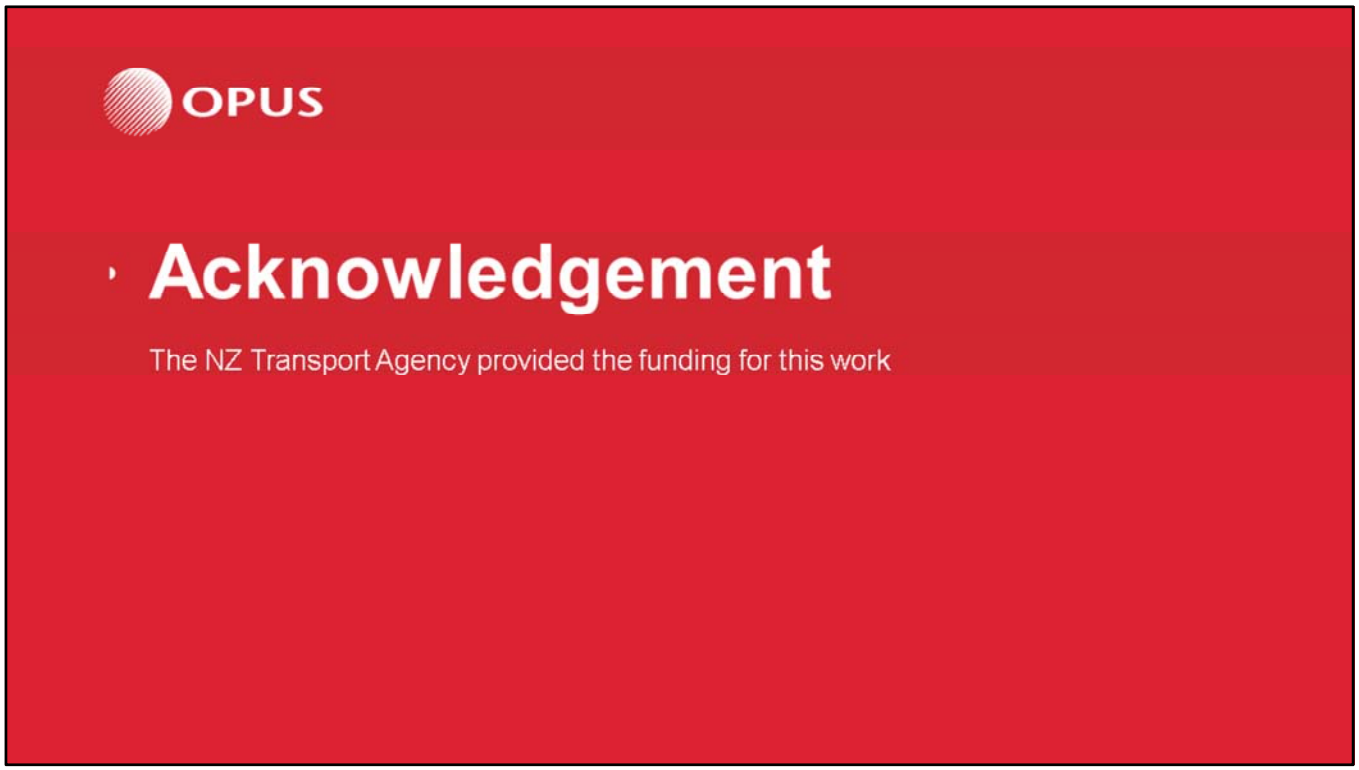
- The finding that even the main plate alone is effective at producing a speed reduction means that a full scale replacement of all permanent supplementary plates and the addition of the supplementary plate to all temporary signage is not required immediately but could be done in conjunction with scheduled maintenance

Recommendations

- We recommend that SRS signs maintain the diamond shape with black on yellow (permanent) or orange (temporary).
- It is recommended that crossed tracks be maintained in any future icon development.
- It is recommended that the Transport Agency continue to signpost all areas where reduced surface friction is likely to impact on driver safety.
- It is recommended that one of the supplementary plates tested in this study by added to the main plate in order to signpost temporary areas of reduced surface friction.
- It is recommended that the SRS main plate be accompanied with the "Slow when wet" supplementary plate in both temporary and permanent situations.

Recommendations

- We recommend that the same message format shown to be effective in this study be adopted for these conditions too. For example, "Slow when frosty" or "Slow: ice/grit".
- It is recommended that these changes be carried out in conjunction with scheduled maintenance and as new signs are erected, potentially targeting higher risk locations earlier.
- Although they were not the focus of this study, based on the findings in the literature review it is recommended that the VMS warning sign including the text "Slow down" continue to be used at particularly high risk sites, and their effectiveness be examined in future research projects.
- In terms of future-proofing, the message, syntax, and icon could be made available to be included in specific software updates for any in-vehicle message systems that include weather detection.



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