TECHNICAL PAPER

HOW WELL DO NEW ZEALAND DRIVERS UNDERSTAND VARIABLE MESSAGE SIGNS?

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ABSTRACT

In 2004 the Transit New Zealand ITS team produced a strategy that focused on how technology could play a leading role in improving levels of service to all state highway users. Variable Message Signs (VMS) located in strategic and key decision making locations throughout New Zealand were identified as a top priority for implementation.

To obtain the full benefit of VMS it is critical that messages are quickly and easily comprehended. Previous international research suggests that messages that are too long or confusing may cause driver overload, distraction and/or anomalous reactions like drivers slowing down abruptly to read and/or decipher messages.

This project investigated how well drivers in New Zealanders understand abbreviations and phrases that have been used on VMS. Recommendations are made to assist practitioners with developing message sets for VMS use.

INTRODUCTION

A VMS is an electronic sign that can be used on the roadside to provide real-time situation specific information to the road-user public. As the signs are readily updated remotely they can enhance the level of customer service that a road controlling authority has with the general public and can aid in the safety and efficiency of a roading network. Pedic (1999) characterised the use of VMS including (note: not mutually exclusive) to:

- Traffic information;
- Emergency information;
- Route guidance;
- Bad weather warning; and
- Speed control or advice.

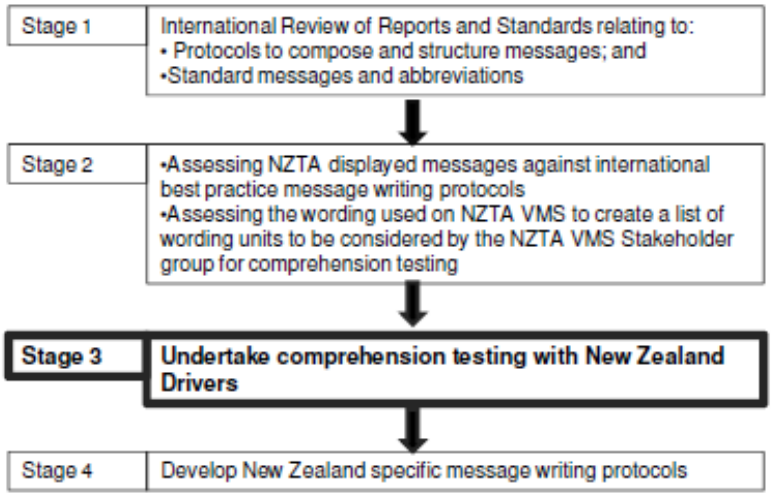
To obtain the full benefit of VMS it is critical that messages are quickly and easily comprehended and consistent. A potential negative effect of messages that are too long or confusing is that drivers will not read messages, slow down to read and/or decipher the message. Montoro, Lucas and Blanch (2004) suggest that messages that have too much information may cause driver overload, distraction and anomalous reactions such as drivers slowing down abruptly. In reviewing literature on "enhancing motorist understanding of variable message signs" Wang, Collyer and Yang (2005) report a study in Washington where a significant reduction in mean speed and an increase in speed deviations occurred when VMS were operating. The study further suggested that drivers compensate for slowing down to read messages by speeding up after the message and that this may lead to safety issues.

Abbreviations are often used to help shorten a message to aid fast comprehension and often fit better within space restrictions on physical VMS. However, previous research by Hustad and Dudek (1999) found regional differences in the understanding of abbreviations. It is reasonable to expect that regional variations impacting understanding of other terminology on VMS signs may exists.

As a result of the ITS strategy the NZ Transport Agency (NZTA) was planning a national roll out of VMS across New Zealand's state highway network. To avoid the comprehension problems raised above, and to build on international experience and research it was important to consider how messages should be worded and constructed to ensure that as many people as possible could understand their meaning.

STUDY OBJECTIVE

The objective of this study was to evaluate the driving public's understanding of abbreviations and message components that appear on VMS within the New Zealand context. The ultimate goal of this work is to provide guidance for the wording on variable message signs (VMS) in New Zealand. Reported here is the third work stage in a multipart project that included:



This stage (and this paper) reports the results of the comprehension testing.

In the review of messages being displayed in New Zealand it was found that a wide range of terms was being used to display similar message meanings. International experience recommends using a limited range of terminology to aid faster comprehension times. The wide range of terms being used was pared down into two lists; those that should not be used and terms that should be tested with the driving public.

METHODOLOGY

A workshop was held with the NZTA stakeholder group to discuss the wording that has been used on VMS and to formulate a forward path for the testing. The NZTA stakeholder group is comprised of NZTA staff with responsibilities for national road signage policy and standards, Intelligent Transport Systems (ITS) specialists, road safety engineers as well as regional staff whose responsibility includes operation of VMS. Following the meeting and after subsequent email communication agreement was obtained as to what needed to be tested. This included:

- Testing a number of existing abbreviations used both in NZ and overseas
- Testing a number of existing phrases used bith in NZ and overseas

It was further agreed that a minimum of 80 participants would be tested, with equal numbers of males and females over and under the age of 30. Half of the participants were to be tested in Christchurch and half in Wellington. The selection criteria was used to get a

representative spread of the population and to account for any differences in use of abbreviations that might be related to age. Previous research by Hustad and Dudek (1999) found regional differences in the understanding of abbreviations so two test locations were chosen (Wellington and Christchurch).

Procedure

Participants were run through the study in groups of up to 14 people. Participants were welcomed to the study and given an answer booklet and pen. The study was explained briefly to them and then they were asked to complete a consent form and answer some demographic questions.

Participants were given two example messages and one trial run. Participants were then asked if they had any questions.

The study began with participants viewing 39 messages one at a time. There was a short pause half way through the messages so that participants could stretch. The messages were a mixture of messages that contained components that were of interest and those containing abbreviations.

The messages were displayed using a timed PowerPoint presentation. The messages were displayed as amber text on a black background to simulate the actual VMS in situ.

Figure1: Message Example

The order of the message was randomised and then counterbalanced across participants with half of the participants seeing the messages in the reverse order. Each message was displayed for 8 seconds (similar to the viewing time that might occur on the open road). The participants then had 1 minute and 10 seconds per question to record answers to three questions about each message in their answer book. The timing was tested in a pilot study and found to be adequate to capture participants answers and to keep the participants attention for the duration of the study.

Participants were required to answer the following three questions:

- What does the message mean?
- What changes would you make to your driving behaviour as a result of the message?
- What could be the consequences be if you didn't change your current driving behaviour?

Participants then filled out a short questionnaire. The questionnaire contained both closed and open ended questions. The purpose of the questionnaire was to assess whether participants knew what a set of abbreviations stood for and to gain more information into the different terminology used.

Participants were then thanked for their participation and invited to comment on the study or VMS. The procedures in Wellington were the same as in Christchurch with the exception that the messages in each location were altered to use local place names.

Study Participants

Participants for the comprehension testing were recruited from the general public in both Christchurch and Wellington. A breakdown of the participants is given below:

Table 1: Christchurch Participants

Number of participants	Age range of participants	Average Age
10 females 29 years old or younger	16 – 28	24
10 females 30 years or older	30 – 52	40
10 males 29 years old or younger	16 – 29	22
10 males 30 years or older	37 – 63	49

Table 2: Wellington Participants

Number of participants	Age range of participants	Average Age
11 females 29 years old or younger	18-25	21
11 females 30 years or older	33-57	46
10 males 29 years old or younger	20-24	22
10 males 30 years or older	35-67	49

All participants had a driver's license, and drove regularly. Six of the participants reported that English was their second language.

RESULTS

The results for Christchurch and Wellington were analysed separately to determine if there were any regional differences. The combined results are shown below as are any regional differences identified. For an abbreviation or message to be acceptable it needed to meet the criterion of being understood by 85% of the population. This criteria is consistent with procedures validated in previous research by Huchingson and Dudek 1983, & Hustad and Dudek (1999).

Abbreviations

The results of the abbreviations are shown in the table below:

Table 3: 85% or higher correct answers

Abbreviation	Meaning	Percent Correct
MON	Monday	100%
WED	Wednesday	100%
THU	Thursday	100%
FRI	Friday	100%
PM	Post meridiem - time between noon and midnight	100%
AM	Ante meridiem - time between midnight and noon	100%
MIN	Minute/s	100%
APPROX	Approximately	100%
ST	Street	100%
RD	Road	100%
SH	State Highway	97.5%
JCT	Junction	94%
JN	Junction	88%
MWAY	Motorway	86%
ALT	Alternative	100%
INFO	Information	100%
FRM	From	99%
MAINT	Maintenance	96.5%

Also of interest was whether JCT or JN should be used for the word junction. As can be seen above both JN and JCT scored higher than 85% comprehension in the testing.

Abbreviations - Fewer than 85% correct answers

Two of the abbreviations were correctly understood by less than 85% of the group, this was CBD for Central Business District and EXPWAY for Expressway. When these results were separated out by region the Christchurch group scored lower than the Wellington group.

Table 4: Abbreviations - Breakdown of responses by location

Abbreviation	Christchurch % Correct	Wellington % Correct	Total % Correct
CBD	75%	95%	83%
EXPWAY	82.5%	86%	85%

While the abbreviation for Expressway (EXPWAY) passed as a whole it is of concern that it scored lower than 85% in Christchurch.

Messages

Each message had one or more aspects that were of interest. Each of the aspects of interest is further discussed below.

Messages - Drive with Care, Drive with Caution, Take Extra Care and Fog Forecast

It was of interest to assess if drivers interpreted the terms: “drive with care”, “drive with caution” and “take extra care” any differently and if the word “forecast” was added to a message, how it changed the meaning of the message. The intent of adding the word forecast was to indicate that while it was not certain that fog or snow would be present there was a likelihood that it would be

The messages were contained within the message set that participants viewed on the screen for eight seconds.

Ninety % of the participants from Christchurch (36 people out of 40) did not differentiate between: drive with caution, take extra care and drive with care. 37 people (91%) used a term like “is expected” or “could be” for the fog forecast sign and all 40 people (100%) used a term like “could be” or “expected” for snow forecast.

36 people out of 41 participants in Wellington did not differentiate between: drive with caution, take extra care and drive with care. This is 88% of participants. 39 people (93%) used a term like is “expected” or “could be” for the fog forecast sign and 40 participants (95%) used a term like “could be” or “expected” for snow forecast.

These results showed very little difference in interpretation between locations.

Messages - Use of the terms: Opening, Closed, Closures and Location Identifiers

To test if the word “opening” could be used to indicate that the road would be opening soon and how well terms such as; “from”, “after”, “use”, “closed” and “closure” are understood the messages below were created. These messages were included in the set of messages that participants saw for eight seconds. The results for each message are given adjacent to them.

Table 5: Responses to terms opening, closures and location identifiers

Message	Response
OPENING IN APPROX 15 MIN	91% of people interpreted this message correctly. However, there were 5 don't knows in Wellington and 2 in Christchurch (who didn't know what was opening) as well as a small number who commented that they assumed it was the road that was opening, but were not sure. This may have been a result of the lack of context that the sign appeared in – however, it is interesting to note that this was not a comment made where closed was used below.
CLOSED FROM SMITH RD	98% of people interpreted this message correctly.
CLOSED AFTER SMITH RD	92% of people interpreted this message correctly. 2 people in Christchurch and 3 people in Wellington thought that this message meant do not use Smith Rd.
USE SH1 FOR CHRISTCHURCH	100% of responding participants interpreted this message correctly. Note that 1 participant did not answer this question.
MWAY CLOSED 2KM AHEAD	96% of participants interpreted this message correctly. The participants who did not answer it correctly did not understand the abbreviation for MWAY.
CLOSED FIND OTHER ROUTE	100% of participants interpreted this message correctly.
CLOSED FIND ALT ROUTE	100% of responding participants interpreted this message correctly. Note that 1 participant did not answer this question.
SH3 CLOSURES MON 9AM – THU 2PM	90% of people interpreted the word closures in this message the same as if the word was identical to closed i.e. that the highway would be closed This left 10% of people who made comments indicating that the message meant "may be" or periodically. Note that 4 participants did not answer this question.
SH3 CLOSED MON 9AM – THU 2PM	100% of responding participants interpreted this message as meaning that the highway would be closed for the periods advised. Note that 3 participants did not answer this question.
Note: although not measured in this study there were a number of comments that these two messages (closed and closure) were too long and many people either did not note the dates and times or if they did got them wrong. There was also confusion on whether the road was closed from 9am – 2pm on each of the days or if it was closed from 9am on the Mon until Thur 2pm.	

Messages - Delay Differences

Participants were asked to indicate the length of time that they might expect to wait if faced with the signs in the left column of the table below. This question was asked as an open ended question as we did not want to anchor the participants by providing ranges to select. The length of time that participants responded with was then grouped as follows :15 minute segments up to two hours, two to four hours, then everything over four hours.

For each message an average score was given then calculated for Christchurch and Wellington. This score was then converted back into minutes which are given below.

Table 6: Responses to delay terms

Message	Christchurch	Wellington
ACCIDENT MAJOR DELAY	91-105 mins	91-105 mins
ACCIDENT LONG DELAY	61-75 mins	61-75 mins
INCIDENT MAJOR DELAY	76-90 mins	91-105 mins
INCIDENT LONG DELAY	46-60 mins	61-75 mins
CRASH MAJOR DELAY	76-90 mins	91-105 mins
CRASH LONG DELAY	61-75 mins	61-75 mins
EXPECT DELAY	16-30 mins	16-30 mins

As can be seen in the table above the results of the Christchurch group were similar to that of the Wellington group, except that in some places the Wellington participants selected a longer wait duration. This would appear consistent with traffic in Wellington experiencing longer delays than in Christchurch.

Messages - Flooded, Surface Flooding, Flooding and Surface Water

Participants were asked what they thought the difference between the above terms was. This question was asked as an open ended question as we did not want to limit the participants by providing categories to select. The drawback of using open-ended questions is that the participants' answers do not always fall into a small number of categories. Participants' answers for these were categorised into four groups: not passable or possibly not passable, passable with a large amount of water, passable with a small amount of water and an "other" group.

Included in the "other" group were answers that related to aspects of the water such as:

- Whether the water is flowing
- Location of the flooding being in the general area
- Whether the area was prone to flooding
- How far along the flooding was

As can be seen in the tables below the "other" categories are quite high, this means that the results for this section should be interpreted cautiously.

Table 7: Responses to the term flooded

Category	Christchurch	Wellington
Not passable or possibly not passable	11	15
Passable with a large amount of water	5	0
Passable with a small amount of water	0	1
Other	23	31

Table 8: Responses to the term Surface Flooding

Category	Christchurch	Wellington
Not passable or possibly not passable	0	3
Passable with a large amount of water	5	6
Passable with a small amount of water	27	11
Other	7	30

Table 9: Responses to the term flooding

Category	Christchurch	Wellington
Not passable or possibly not passable	4	3
Passable with a large amount of water	5	1
Passable with a small amount of water	2	6
Other	28	37

Table 10: Responses to the term Surface Water

Category	Christchurch	Wellington
Not passable or possibly not passable	0	0
Passable with a large amount of water	8	1
Passable with a small amount of water	26	17
Other	6	28

Messages - Towing, Trailers

Participants were asked what they thought the difference is between the following terms:

- NO TOWING
- CLOSED TO TOWING
- NO TRAILERS

It was very difficult to gauge participants' understanding of these terms as people tended to copy down either the towing or the trailers. For example, a common answer to this question was:

NO TOWING – No towing anything

CLOSED TO TOWING – Closed to anyone towing

NO TRAILERS – No Trailers only

From the above answers it is difficult to determine if the participant made any differentiation between the terms. However, discussion with the participants indicated that they were not sure if "trailers" covered boats, caravans etc and some participants related towing just to towing cars. Given the difficulties mentioned above it is recommended that this category requires further investigation.

Messages - Chains

From the three messages tested it appears that the percent of people who understand what snow chains are (i.e., state that they should be fitted to the wheels of the car) is quite high.

The discrepancy in understanding of the messages is when the snow chains need to be put on the vehicle. A follow-up question was designed to elicit what action the drivers thought that the following messages was informing them/asking them to do.

Table 11: Responses to the term: Chains Essential

	Wellington Results	**Christchurch Results**
Meaning	**% thought this meaning correct**	
I must have chains in the car	19% (7 people)	8% (3 people)
I must have chains in the car and will be asked to put them on soon	13.5% (5 people)	37% (14 people)
I must put chains on now	59% (22 people)	55% (21 people)
I must carry a chain in case I need towing out	8% (3 people)	0 %

Table 11: Responses to the term: Chains Required

	Wellington Results	**Christchurch Results**
Meaning	**% thought this meaning correct**	
I must have chains in the car	8% (3 people)	33% (13 people)
I must have chains in the car and will be asked to put them on soon	38% (14 people)	33% (13 people)
I must put chains on now	54% (20 people)	31% (12 people)
I must carry a chain in case I need towing out	0% (0 people)	3% (1 person)

Table 12: Responses to the term: Must Carry Chains

Must Carry Chains	Wellington Results	Christchurch Results
Meaning	% thought this meaning correct	
I must have chains in the car	85% (33 people)	77% (30 people)
I must have chains in the car and will be asked to put them on soon	8% (3 people)	18% (7 people)
I must put chains on now	0%	0%
I must carry a chain in case I need towing out	5% (2 people)	5% (2 people)

Given the wide spread of answers for the two messages "Chains Essential" and "Chains Required" it is not recommended that either of these messages be used.

However, for the message "must carry chains" if we collapse the answers "I must have chains in the car" and "I must have chains in the car and will be asked to put them on soon" together this message would be understood by the criterion of more than 85% of participants.

DISCUSSION/CONCLUSION

This study was designed to gain insight into the driving public's understanding of abbreviations and phrases that are used on variable message signs in New Zealand. In a previous stage of this work which looked at international best practice for developing VMS messages it was concluded that terminology consistency was a key element in enhancing signs' effectiveness. The results from this stage of work provide a starting point for determining both acceptable abbreviations and other message components that should be well understood by the driving public that should be used in a consistent way.

Seventeen of the 19 abbreviations that were tested were found to be acceptable. Furthermore, the results for the days of the week abbreviation (where the first three letters of the day were used) of 100% accuracy could be extrapolated to suggest that this method of abbreviating could be used for the other days of the week (Tue, Sat and Sun).

The abbreviation results also suggest that there are regional variations in the understanding of two terms: CBD and EXPWAY. This finding is consistent with these terms being less used (and hence less well understood) in Christchurch than in Wellington. Regional variations in terminology used are consistent with findings from Hustad and Dudek (1999).

The following terms were found to be correctly interpreted by 85% or more of participants:

- OPENING
- CLOSED FROM
- CLOSED AFTER
- USE XXXX FOR
- XXXX CLOSED 2 KM AHEAD
- CLOSED FIND OTHER ROUTE
- CLOSED FIND ALT ROUTE

From the above list we recommend that where two messages have been found equally acceptable that the message using the least letters be used. This would apply to the messages: CLOSED FIND OTHER ROUTE and CLOSED FIND ALT ROUTE which both had 100% recognition rates.

For the terms: DRIVE WITH CARE, DRIVE WITH CAUTION and TAKE EXTRA CARE no difference in meaning was found. It is therefore recommended that either: DRIVE WITH CARE or TAKE EXTRA CARE be used as these have less letters. We recommend that the stakeholder group choose one of these messages.

Adding FORECAST to FOG or SNOW messages does suggest to drivers less certainty that fog or snow will occur.

It is not recommended that the word closures be used as this was interpreted the same as closed and its use would require more letters on the VMS to be used.

Messages for snow chains currently have a low comprehension by users, these messages would be enhanced by a clearer message as to what action drivers should be taking.

For the areas where we were trying to determine differences in understanding between different messages, care should be taken in interpreting the results as in most cases the results come from asking an open ended question and then fitting the range of responses into categories. The drawback of this methodology is that participants' responses do not always fit easily into a small number of categories so the ability to generalise from this result is decreased. However, the advantage of this type of questions at an exploratory stage is that it provides the complete range of what participants think without anchoring their responses by asking them to select from a range.

The results below all come from open-ended questions.

When providing VMS messages for delays advice should be given using the following time frames:

- ACCIDENT MAJOR DELAY 91-105 mins
- ACCIDENT LONG DELAY 61-75 mins
- INCIDENT MAJOR DELAY 91-105 mins
- INCIDENT LONG DELAY 61-75 mins
- CRASH MAJOR DELAY 91-105 mins
- CRASH LONG DELAY 61-75 mins
- EXPECT DELAY 16-30 mins

Of particular interest in these findings that the terms major, long and expect appear to make more difference in the length of time expected than when the terms accident, incident or crash are used. These findings also showed some regional variation with Wellington drivers typically expecting longer delays than the Christchurch group.

- For messages regarding flooding, two levels of flooding were differentiated:
    - Not passable or possibly not passable
    - Passable with surface water

While a large number of the participants responses did not fall into these categories for the data that did we make the following recommendations:

- Flooded – not passable or possibly not passable
- Surface Flooding or Surface Water – passable with water
- Flooding should not be used. This should not be used as participants associated it's use with meanings such as: whether the water was flowing and whether the area was prone to flooding

These terms could be further tested by providing participants with options to select.

- For the terms: TOWING, CLOSED TO TOWING and NO TRAILERS it is recommended that these be further tested with a question similar to the chains question that provides participants with options as to what each term includes.

In conclusion, the results from this study provide a starting point for determining both acceptable abbreviations and other message components that should be consistently used and that should be easy and quick to understand. The results of this work in conjunction with earlier stages were used to create VMS message guidelines. The guidelines include:

1. Guidelines for constructing messages
2. Acceptable terminology, and
3. Terminology not to be used

In answer to the title of this paper: "How well do New Zealand Drivers Understand Variable Message Signs?", we conclude that some previous message elements have created some confusion, but that application of the work undertaken in this project should increase the level of understanding. Generalising from the results of this study it is clear that any new signage (VMS or otherwise) should be regularly tested with the general public to ensure that the intended message meaning is being conveyed.

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