MS4 off-road research summary report

Prepared for Traffic Systems and Signing Division, Highways Agency

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TRL Report TRL556

First Published 2002
ISSN 0968-4107

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Executive Summary

The Highways Agency (HA) has initiated a programme to develop a new Variable Message Sign (VMS) called a Motorway Signal Mark 4 (MS4) to replace the life expired central reservation signs on inter urban motorways. This development is an integral part of the Highways Agency ten-year plan.

The prototype MS4 sign is based on a fully populated LED panel. The 3840mm × 2560mm panel has a high-resolution, two-colour display, which is capable of showing both text messages and pictograms.

The Highways Agency commissioned TRL to carry out a number of off-road research trials to investigate the legibility and comprehension of traffic messages showing text and pictograms. This involved both trials at motorway driving speed (dynamic) to establish the comprehension of text messages and pictograms and stationary trials at fixed distances from the MS4 (static) to investigate text message and pictogram legibility.

The dynamic testing showed text messages and pictograms on the MS4 sign to trial participants travelling at motorway speeds (70mph). For comparison, identical text messages were also shown on the standard Motorway Signal Mark 3 (MS3) and the Enhanced Message Sign (EMS) variable message signs. These tests established the comparative comprehensibility of text messages using different fonts of various sizes. The comprehensibility of two sizes of pictograms, shown only on the MS4, were also established. The static testing was carried out to measure the performance of the MS4 sign and make comparisons with the MS3 and EMS signs. These tests consisted of legibility measurements of text messages on all three VMS signs and of pictograms on the MS4. The comprehension and reading times of different types of message including pictograms were also tested on the MS4.

The results of the dynamic and static trials were used to establish the size of the MS4 display panel for the on-road trial.

The dynamic testing also highlighted a problem of headlamp reflection from the polycarbonate front screen of the MS4 panel. This provided the opportunity to modify the panel specification for the on-road trial.

The dynamic and static trial (Part 1) showed that the legibility of text messages of a particular font and capital height were lower if the messages contained numerals. To investigate this a preliminary trial was undertaken, with only a small representative sample of participants, to see whether the legibility distances of text messages containing numerals were improved by changing the numeral font and increasing the separation between numeral characters.

The dynamic and static trial (Part 1) also showed that using 440mm height Transport Mixed Case (TM 440) displayed on the MS4 provides broadly the same legibility as the 400mm height Upper case VMS font used on the MS3 VMS. However, using TM 440 only 97% of the HA/Association of Chief Police Officers (ACPO) VMS Code of Practice legends can be displayed on the MS4. The remaining 3% can only be displayed by reducing the character width to 2-pixel stroke-widths. Therefore the preliminary trial also investigated the comparative legibility of Transport Mixed 440mm characters with 2- or 3-pixel stroke-widths.

The results of the small static trial (Part 2) showed that there were benefits in applying treatments to messages containing numerals. These treatments included a wider spacing between numerals and different numeral fonts. It was also shown that there was a difference in legibility distance between messages constructed with 3-pixel and 2-pixel stroke-width characters.

Follow up supplementary research, static trial (Part 3), was commissioned to address and resolve these issues using a robust sample size. The additional research also included an investigation into the improvement of messages containing words that were found difficult to read by participants of the first series of trials (such as debris) and the comprehension/ reading times of combined pictogram, Electronic Motorway Indicator (EMI) and text messages proposed for the on-road trial.

The results of these trials showed that the legibility of some difficult words could be improved by showing them in an alternative format such as upper case letters or, in the case of one difficult word, replacing the word with a pictogram. The legibility of messages containing numerals was increased using a hybrid numeral set and increasing the spacing between numerals. The legibility of messages using Transport Mixed 440mm 3-pixel stroke-width characters was greater than for messages using 2-pixel stroke-width characters. The results of the pictogram comprehension/ reading time trials showed that there should be sufficient time for drivers travelling at motorway speeds to read almost all of the pictogram message formats tested.

Following the successful conclusion of these trials, the results have been fed into the on-road trial, which is planned to take place on the M4 motorway in 2003.

1 Introduction

The Highways Agency has initiated a programme to develop a variable message sign (VMS) to replace the life expired central reservation signs on inter urban motorways. The replacement VMS sign, a Motorway Signal Mark 4 (MS4), is based on a fully populated LED panel. The MS4 panel has a high-resolution display capable of showing both text messages in various fonts and character heights together with pictograms in one of two colours (see Figure 1). Previous VMS signs have only been capable of displaying one font and character height (e.g. VMS 400 for an MS3 VMS).

Figure 1 MS4 sign

The Highways Agency commissioned TRL to carry out a number of off-road research trials to investigate both the legibility and comprehension of text messages and pictograms. This involved trials at motorway driving speeds (dynamic) to establish the comprehension of text messages and pictograms and trials taking observations at fixed distances from the MS4 (static) to investigate text message and pictogram legibility.

The MS4 was installed on the TRL Research Track in June 2000. The panel size of the MS4 used for off-road trial was 3840mm × 2560mm. Additionally, two standard VMS signs: a Motorway Signal Mark 3 (MS3) and an Electronic Motorway Signal (EMS) were installed on the research track at different locations. The purpose of these signs was to provide comparative measurements for both the dynamic and static trials. The results of these trials were used to establish the size of the MS4 display panel for the on-road trial. The off-road testing was carried out as several discrete trials over a period of approximately two years. Table 1 lists the dates of these trials.

Table 1 Summary of dates of off-road testing

Event	*Date*
Dynamic off-road trial	June / July 2000
Static off-road trial (Part 1)	October 2000
Static off-road trial (Part 2)	January 2001
Static off-road trial (Part 3)	December 2001 - May 2002

2 Dynamic off-road trial

2.1 Introduction

Prior to the development of the MS4, an initial trial was carried out looking at various character fonts on a ‘small panel’ installed at TRL. This panel was a high-resolution single colour panel, capable of displaying any bitmap, with an LED pitch of just over 20mm. Results of the small panel trial indicated that a different font might be suitable for display on the MS4 sign other than the ‘standard’ VMS font and also a text size smaller than 400mm may be acceptable.

The first off-road trial consisted of dynamic tests (high speed ‘drive through’) at motorway speeds (70mph). The trial is described in detail in the MS4 Off Road Trial Report (WS Atkins, 2000).

2.2 Trial objectives

The objectives of this trial were to:

- Establish the comparative comprehensibility of text messages using different fonts of various capital heights.
- Establish the comprehensibility of pictograms in two different sizes.
- Establish the required panel size for the on-road trial.
- Compare the performance of MS4 with EMS and MS3.

Comparative comprehension tests were carried out on the MS4 and the EMS / MS3. These comparative tests could only be carried out with text messages as neither the EMS or MS3 are capable of showing pictograms. The EMS and MS3 can also only display text messages in VMS font with capital heights of 320mm and 400mm respectively. Due to its design the MS4 sign is much more flexible, therefore the relative legibility of fonts and pictograms of varying types and sizes were tested on the MS4 to establish the optimum fonts and pictograms to be used in the on-road trial.

2.3 Messages shown

- Sixteen text messages taken from The Highways Agency and Association of Chief Police Officers (HA/ACPO, 1999) approved list of legends for display on variable message signs were shown to trials participants. Eight of these messages contained numerals.
- Text messages were shown with either 320mm or 400mm capital height characters so that they could be compared with messages on the EMS and MS3 respectively.

- All characters shown on the MS4 had a 2-pixel stroke-width (2) except for 400mm Transport font, which had 3-pixel stroke-width (3) characters.

Messages were displayed on the MS4 in three fonts: Transport Medium (Upper (TU) and Mixed case (TM)) and a General Upper case font (GU) (an amalgamation of VMS and Transport font). The General font gave advantages where a reduction of panel width is required, as its characters are narrower than for the other two fonts. Examples of the different fonts are shown in Figure 2. 'Simple' messages are those that do not contain numerals, whereas 'complex' messages contain numerals.

Messages displayed in VMS font were not shown on the MS4 in this trial as the small panel trial had indicated that the performance of Transport Upper (TU) font was superior to that of VMS, even allowing for differences in message word length.

Figure 3 shows the set of pictograms shown to participants. The 'accident' pictogram was the preferred design from the EU research programme (TROPIC, 1999). For the other pictograms The Traffic Signs Regulations and General Directions (TSRGD, HMSO, 1994) diagram numbers (where appropriate) are shown in brackets. Prior to testing, participants were educated as to the meaning of each of the pictograms.

2.4 Results

2.4.1 Text messages

Table 2 shows the percentage of correct responses, in both daylight and darkness, for complex messages shown in 320mm capital height Transport Upper (TU) and Transport Mixed (TM) case on the MS4 sign and the corresponding results shown for messages shown in VMS font on the EMS sign.

Table 3 shows the percentage of correct responses for the MS4, for simple messages shown in 320mm Transport Mixed case with a 2-pixel stroke-width character spacing, Transport Mixed case with a 1.5-pixel stroke-width character spacing and General Upper case 1.5-pixel stroke-width character spacing. These messages were tested in both daylight and darkness. Table 4 shows the corresponding results shown for simple messages shown in VMS font on the EMS sign.

TM 320 (2) simple message with a 2-pixel stroke–width character spacing

TM 320 (2) simple message with a 1.5-pixel stroke–width character spacing

GU 320 (2) simple message with a 1.5 pixel stroke–width character spacing

TU 400 (3) complex message with a 3-pixel stroke–width character spacing

TM 400 (3) complex message with a 3-pixel stroke–width character spacing

Figure 2 Examples of text messages shown in different fonts

Table 2 Percentage of correct responses for 320mm capital height complex messages

	MS4 complex						*EMS complex*		
	TU 320 (2)			*TM 320 (2)*			*VMS 320*		
Font	*Correct*	*Total*	*%*	*Correct*	*Total*	*%*	*Correct*	*Total*	*%*
Daylight	92	96	96	93	96	97	188	192	98
Darkness	46	48	96	43	44	98	94	96	98

Accident

Cross wind (581)

Danger of ice (544.2)

Queue / congestion (584)

Skid risk (557)

Other hazard (562)

Advisory 50 mph speed limit

Mandatory 50 mph speed limit

1500mm EMI wicket with TM 320 text

1800mm EMI wicket with TM 400 text

Figure 3 Pictograms shown to participants

Table 3 Percentage of correct responses for 320mm capital height simple messages shown on MS4

	MS4 320mm Simple								
	TM (2-pixel s/w spacing)			*TM (1.5-pixel s/w spacing)*			*GU (1.5-pixel s/w spacing)*		
Font	*Correct*	*Total*	*%*	*Correct*	*Total*	*%*	*Correct*	*Total*	*%*
Daylight	102	102	100	90	90	100	96	96	100
Darkness	52	52	100	44	44	100	48	48	100

Table 4 Percentage of correct responses for 320mm capital height simple messages shown on EMS

	EMS 320mm simple		
	VMS		
Font	*Correct*	*Total*	*%*
Daylight	283	286	99
Darkness	141	143	99

Table 5 shows the percentage of correct responses for the MS4, in both daylight and darkness, for complex messages shown in 400mm Transport Upper and Mixed case with a 3-pixel stroke-width character spacing and the corresponding results shown for complex messages shown in VMS font on the MS3 sign.

Summary of results: text messages

- Recall rates for simple messages shown on the MS4 were 100% in both daylight and in darkness.
- Recall rates were slightly lower for complex messages, with a lowest recall rate of 94%.
- The recall rates for all fonts and message types, except for TU 400 complex messages, are at least as good in darkness as in daylight.

These results ignore the effect of sign obscuration due to HGVs that would be expected on live motorways.

During darkness the effect of glare due to the car headlamps made the reading of text messages more difficult.

2.4.2 Pictograms

Tables 6 and 7 show the percentage of correct responses for the MS4, in both daylight and darkness, for 1500mm pictograms with 320mm and 400mm Transport Mixed (TM) supplementary text respectively. Table 8 shows the percentage of correct responses for 1800mm pictograms with 400mm text.

Summary of results: pictograms

- Recall rates varied from 95% (1500mm pictograms with 400mm Transport Mixed text in darkness) to 100% (1800mm pictograms with 400mm text in darkness).
- Of a total of 350 responses for the dynamic testing, 340 were fully correct, 7 recalled the pictogram correctly but not the text and 3 could not recall any of the information.

Table 6 Percentage of correct responses for 1500mm pictograms with 320mm transport mixed text

	1500mm pictograms with TM 320mm text				
	Correct	*Pictogram correct only*	*Incorrect*	*Total*	*% correct*
Daylight	94	3	1	98	96
Darkness	50	2	0	52	96

Table 7 Percentage of correct responses for 1500mm pictograms with 400mm Transport Mixed text

	1500mm pictograms with TM 400mm text				
	Correct	*Pictogram correct only*	*Incorrect*	*Total*	*% correct*
Daylight	41	0	1	42	98
Darkness	19	1	0	20	95

Table 8 Percentage of correct responses for 1800mm pictograms with 400mm transport mixed text

	1800mm pictograms with TM 400mm text				
	Correct	*Pictogram correct only*	*Incorrect*	*Total*	*% correct*
Daylight	92	1	1	94	98
Darkness	44	0	0	44	100

2.4.3 Overall summary of results

- The minimum recall rates for text message and pictogram comprehension was 94%.
- There was no significant difference between the recall rates for various text fonts and sizes.
- When simple messages were displayed on the MS4 a 100% success rate was achieved. This level of success rate was not achieved for messages shown on either the MS3 or EMS signs.
- The recall rates of pictograms varied between 95% and 100%.

Table 5 Percentage of correct responses for 400mm capital height complex messages

	MS4 400mm complex						*MS3 400mm complex*		
	TU (3-pixel s/w spacing)			*TM (3-pixel s/w spacing)*			*VMS*		
Font	*Correct*	*Total*	*%*	*Correct*	*Total*	*%*	*Correct*	*Total*	*%*
Daylight	94	96	98	90	96	94	185	191	97
Darkness	45	48	94	46	48	96	94	96	98

- There was no significant difference between recall rates for either size of pictogram displayed (1500mm or 1800mm).
- Most of the incorrect responses were due to errors in recalling the text information.
- The results for both text messages and pictograms ignored the effects of sign obscuration due to HGV's and the reflection observed on the polycarbonate front screen.

3 Static off-road trial (Part 1)

3.1 Introduction

Following the dynamic off-road trial in June and July 2000, additional trials were carried out to investigate more fully the performance of the MS4 sign and make comparisons with the MS3 and EMS signs. An experiment was devised to measure message legibility which gave drivers at a fixed location, a finite length of time (comparable with that available in real road conditions) to view messages. Legibility measurements were made of text messages with and without numerals.

Measurements were also made of the legibility distances of two sizes of pictogram (1500mm and 1800mm). Additionally, the comprehension and reading times of different types of message, including pictograms, were tested.

The trial is described in detail in Project Report PR/T/170/2000: Further off-road legibility measurements of MS4, MS3 and EMS (Cooper, Mitchell and Flint, 2000).

3.2 Trial objectives

- To fully investigate the performance of the MS4 sign and make comparisons with the MS3 and EMS signs.
- To investigate the comprehension and reading time of text messages and pictograms.

3.3 Static legibility trial

3.3.1 Messages shown

Text messages

- Eighteen text messages, nine of which contained numerals, (from the HA/ACPO approved list) were shown to trials participants.
- Messages were displayed in two different fonts: Transport Medium (Upper and Mixed case) and VMS font.
- Text of 320mm, 360mm, 400mm and 440mm capital height were shown on the MS4 sign.
- Transport Upper and Mixed case characters of 320mm and 360mm capital height had a 2-pixel stroke-width. Transport Upper 400mm characters had a 3-pixel stroke-width; Transport Mixed 400mm (TM 400) characters were shown in either a 2- or 3-pixel stroke-width. Transport Mixed 440mm (TM 440) characters had a 3-pixel stroke-width. VMS characters had a 2-pixel stroke-width.

Examples of text messages displayed in different fonts on the MS4 are shown in Figure 4. Simple messages are those that do not contain numerals whilst complex messages contain numerals.

TU 320 (2) simple message

VMS 320 (2) simple message

TU 400 (3) complex message

VMS 400 (2) complex message

Figure 4 Examples of text messages shown on the MS4

Pictograms

- Six pictograms were shown without text (see first six pictograms in Figure 3).

3.3.2 Results

Table 9 shows the legibility distances measured at the 95th percentile confidence level for both simple and complex messages, shown in different fonts and with different capital heights, shown on the MS4 sign.

Table 9 The effect of message complexity on legibility distance (m) (95th percentiles)

MS4	*95th percentile legibility distances (m)*			
	Daylight		*Darkness*	
Font / character height	*Simple messages (m)*	*Complex messages (m)*	*Simple messages (m)*	*Complex messages (m)*
TU 320	225	200	175	150
TM 320	*240*	*215*	*150*	*135*
TU 360	275	255	200	150
TM 360	*240*	*225*	*165*	*145*
TU 400	300	275	230	185
TM 400	*275 (300)*	*250 (235)*	*175 (165)*	*150 (150)*
TU 440	>400*	355	275	185
TM 440	*350*	*300*	*250*	*175*

Figures in brackets refer to a stroke-width of 2-pixels as opposed to 3-pixels.

** All participants were able to read all the simple messages in TU 440mm font at the maximum viewing distance in daylight.*

Sample size: 18 observations per data point.

Table 10 shows the comparison in legibility distances (at the 95th percentile confidence level), in daylight and darkness, for simple and complex messages shown in different fonts and capital heights. These messages were shown on the MS4, MS3 and EMS signs. The MS3 and EMS, due to their technology, are only able to show messages in VMS font.

Table 11 shows the legibility distances (at the 95th percentile confidence level), in daylight and darkness of 1500mm and 1800mm pictograms shown without text on the MS4 sign.

3.3.3 Summary of the static legibility trial results

- As expected, the legibility distance of complex messages on the MS4 is lower than that of simple messages. It is likely that by using more distinguishable numerals, possibly with a wider spacing, the legibility distances of complex messages could be improved.
- The Transport Upper case font generally performed better than the Transport Mixed case font. However, mixed case messages occupy less space and the use of a slightly larger character size (to maintain legibility) might be possible with no overall increase in panel size.

Table 10 The effect of message complexity on legibility distance (m) (95th percentiles)

	Daylight		*Darkness*	
Sign / font / character height	*Simple messages (m)*	*Complex messages (m)*	*Simple messages (m)*	*Complex messages (m)*
MS4 (VMS 400)	255	265	225	185
MS4 (TU 400)	300	275	230	185
MS3 (VMS 400)	*335*	*315*	*195*	*185*
MS4 (VMS 320)	240	235	175	125
MS4 (TU 320)	225	200	175	150
EMS (VMS 320)	*275*	*250*	*165*	*185*
MS4 (TM 400)	275 (300)	250 (235)	175 (165)	150 (150)
MS4 (TU 440)	>400*	355	275	185
MS4 (TM 440)	350	300	250	175

Figures in brackets refer to a stroke-width of 2-pixels as opposed to 3-pixels.

** All participants were able to read all of the simple messages in TU 440 font at the maximum viewing distance in daylight.*

Sample Size: MS4 18 observations per data point, MS3 and EMS 36 observations per data point.

Table 11 95th percentile legibility distances (in metres) of individual 1500mm and 1800mm pictograms

	Daylight		*Darkness*	
Pictogram	*1500mm (m)*	*1800mm (m)*	*1500mm (m)*	*1800mm (m)*
Accident	205	265	185	240
Cross wind	>400*	285	240	265
Danger of ice	320	320	185	265
Queue / Congestion	240	320	230	265
Skid risk	285	320	235	240
Other hazard	>400*	>400*	335	>400*

** All participants could read these pictograms at the maximum viewing distance.*

Sample size: 8-10 observations per data point.

- Messages shown with Transport Mixed 440mm (TM 440) capital height characters had legibility distances (95th percentile) which either were close to or just exceeded those of similar messages shown on the MS3 (VMS 400). It was therefore decided that TM 440 would be the preferred font used for text messages shown on the MS4. Using TM 440 font will allow 97% of HA/ACPO Code of Practice VMS messages to be shown on the MS4. The remaining 3% would be able to be displayed by reducing the character stroke-width from 3- to 2- pixels.
- Generally, pictograms can be read more easily than either simple or complex text messages hence require correspondingly lower legibility distances. However, the addition of supporting text would increase reading times with a corresponding increase in the required legibility distance.

3.4 Comprehension / reading time trial

3.4.1 Messages shown

- Four simple and four complex text messages, which used Transport Mixed (TM 400) 3-pixel stroke-width characters were tested.
- Four 1800mm pictograms without text were tested.
- Tests were carried out in both daylight and darkness.
- Viewing distance was 150m from the MS4 sign.

3.4.2 Results

The estimated reading times (95th percentiles) for simple and complex text messages, and pictograms are shown in Table 12.

Table 12 Estimated reading times (s) for different message types

TM400 3-pixel stroke-width characters		
Viewing distance:150m		
	95th percentile reading time (s)	
Message type	*Daylight*	*Darkness*
Simple text	1.8	2.4
Complex text	2.3	3.5
Pictogram (no text)	< 0.5	0.6

3.4.3 Summary of comprehension / reading time results

- Pictograms required shorter reading times than either simple or complex messages.
- Complex messages required the maximum reading time of 3.5 seconds.

4 Initial indications based on dynamic and static trial (Part 1) results

The results of the dynamic and static trial (Part 1) provided the following indications, which were used to derive the MS4 panel size for the on-road trial. However, further on-road and off-road research may indicate that smaller text and pictograms may suffice allowing a smaller MS4 panel to be used for wider network use.

- Text messages: The trial results showed that complex messages are slightly more difficult to comprehend than simple messages. This problem may be overcome by increasing the spacing between numerals in the complex messages. This should not have implications on the width of the panel, as complex messages are normally shorter in length than simple messages.
- Pictograms: To enable drivers to read the pictogram in advance of the text an 1800mm pictogram is preferred. The results of the static trial (Part 1) indicated that where possible, the size of text under a pictogram should be Transport Mixed 440mm capital height (TM 440).
- MS4 on-road trial panel size: The height of panel should allow for 1800mm pictogram plus supporting text to be used (i.e. minimum height 2460mm). The width of panel for the on–road trial should be able to display the longest words / messages in TM 400 font such as ‘carriageway’, ‘obstruction’ and ‘congestion’ (i.e. minimum width 3640mm). The size of the panel for the initial on-road pilot should therefore be 3640mm × 2460mm.
- Messages shown with Transport Mixed 440mm (TM 440) capital height characters had legibility distances (95th percentile) which either were close to or just exceeded those of similar messages shown on the MS3 (VMS 400). It was therefore decided that TM 440 would be an appropriate font used for text messages shown on the MS4 on the on-road trial. Using TM 440 font will allow 97% of HA/ACPO Code of Practice VMS messages to be shown on the MS4. The remaining 3% would be able to be displayed by reducing the character stroke-width from 3- to 2-pixels.
- Generally, pictograms can be read more easily than either simple or complex text messages hence require correspondingly lower legibility distances. However, the addition of supporting text would increase reading times with a corresponding increase in the required legibility distance.

5 Static off-road trial (Part 2)

5.1 Introduction

Results obtained from the dynamic (Atkins, 2000) and static off-road trial (Part 1) (Cooper, Mitchell and Flint, 2000) showed that when numerals were included in a message the legibility distance was considerably reduced.

The static trial (Part 1) included some legibility measurements of text messages shown in Transport Mixed 440mm font (TM 440) with 3-pixel stroke-width characters. The results showed that the legibility distances observed for this font were closest to the MS3 results. As a result, it was recommended that the TM 440 should be used whenever possible on the MS4 sign. However, using TM 440 only 97% of the HA/ACPO VMS Code of Practice legends can be displayed on the MS4. The remaining 3% can only be displayed but reducing the character stroke width from 3- to 2-pixel stroke-widths. If TM 440 font is to be used it is therefore necessary to investigate whether there is a significant difference in legibility distance if 2-pixel stroke-width characters are used.

It was therefore decided to carry out a preliminary investigation, with only a small sample of participants to test the following:

- whether treatments designed to improve legibility could be successfully applied to messages containing numerals;
- to establish any difference in legibility between 2- and 3-pixel stroke-width TM 440 text messages.

5.2 Results summary

Legibility comparisons of 2- and 3-pixel stroke-width simple and complex messages

The results showed that there are differences in the legibility distances between messages shown with 2- and 3-pixel stroke-width characters. It was therefore recommended that the experiment be repeated using a larger representative sample to calculate the differences and assess their impact on the legibility of the sign.

Standard or increased numeral spacing legibility comparisons

The results of the preliminary trial investigating the effect of increasing the spacing between numerals showed that positive increase in legibility distances can be achieved. It was therefore recommended that the experiment be repeated with a larger and more representative sample and to test different numeral fonts to achieve a preferred hybrid numeral set.

6 Static off-road trial (Part 3)

6.1 Introduction

The dynamic and static off-road research trials (Cooper, Mitchell and Flint, 2000, Mitchell and Flint, 2001) identified a number of issues that required further off-road testing. Following recommendations within the reports and the results of the preliminary trials described in section 5, the Highways Agency commissioned TRL to undertake additional off-road research trials to address and resolve these issues using appropriate sample sizes.

Details of these trials can be found in Project Report PR/T/064/2002: Supplementary MS4 off-road Research Report (Mitchell, Cooper and Freeman, 2002).

6.2 Trials objectives

The various areas for further research were incorporated in the final programme, as five main objectives:

- *Objective 1:* To further test the concept that a reduction in the stroke-width of Transport Mixed 440mm characters to 2-pixels may result in little or no loss in legibility.
- *Objective 2:* To raise the legibility of Transport Mixed 440mm complex messages, i.e. those containing numerals.
- *Objective 3:* To raise the legibility of Transport Mixed 440mm messages containing difficult words such as ‘debris’ and ‘queue’.
- *Objective 4:* To investigate the effect of luminance settings on legibility distance and possible limiting factors.
- *Objective 5:*

i To measure the comprehension / reading times of 1800mm pictograms without text at a distance of 210m and compare this to the results of pictogram comprehension / reading times, derived from the initial MS4 Off Road Trial, measured at 150m.

ii To investigate comprehension / reading times for a range of display options, tested at either one viewing distance (150m) for the 1500mm pictograms, or two viewing distances (150m and 210m) for the 1800mm pictograms, which may be used on the MS4 panel:

- 1800mm pictograms with one line of supporting text.
- 1800mm pictograms plus EMI (Lane closure wickets or 50mph advisory speed limit) with one line of supporting text.
- 1500mm pictograms with one or two lines of supporting text.
- 1500mm pictograms plus EMI (Lane closure wickets or 50mph advisory speed limit) with one or two lines of supporting text.
- Lane closure EMI wicket with one line or two lines of supporting text.

iii To carry out additional comprehension / reading time testing on the following:

- Network traffic messages containing 1800mm pictograms with one or two lines of supporting text.
- Lane closure wicket EMI enclosed either in a rectangular box or without a box.

6.3 Legibility trials

These trials covered Objectives 1 to 4 listed in Section 5.2.

6.3.1 Transport mixed 440mm characters stroke-width legibility

Messages shown

A total of eight simple and eight complex messages, the latter containing numerals, were produced in both 2- and 3-pixel stroke-width formats. For the complex messages a set of hybrid numerals used in the previous trial (see Section 5.3) was used. Figures 5 and 6 show examples of a complex message in 2- and 3-pixel stroke-width format.

Results

The measured legibility distances (at the 95 percent confidence level) in daylight and darkness are summarised in Table 13 for messages comprising 2- and 3-pixel stroke-width (s/w) characters.

Summary of results

- All messages with 3-pixel stroke-width characters had a legibility distance greater than or equal to that with 2-pixel stroke-width characters.
- Legibility distances of all messages (simple and complex combined) with 3-pixel stroke-width characters outperformed those with 2-pixel stroke-width characters by 40m in daylight and by 15m in darkness.
- However, it should be noted that the legibility distance for the 2-pixel stroke-width character messages (185m) will still allow enough time for drivers travelling at motorway speeds to read the sign. A message containing

Figure 5 2-pixel stroke–width complex message

Figure 6 3-pixel stroke–width complex message

6.3.2 Numeral treatments legibility testing

Messages shown

In an attempt to increase the legibility distance of messages containing numerals a set of hybrid numerals was developed. Numerals 0, 1 and 7 were based on the Transport font alphabet. Numerals 2, 3, 4, 5 and 8 were based on VMS characters as specified in TSRGD. Numerals 6 and 9 were based on the Albertus Medium font. The hybrid numeral set is shown in Figure 7.

Figure 7 Hybrid numeral set used for the numeral trial

Table 13 95th percentile legibility distances (m) for different message types in daylight and darkness

Font / character height (mm) / s/w (pixels)	*Daylight*			*Darkness*		
	Simple messages (m)	*Complex messages (m)*	*All messages (m)*	*Simple messages (m)*	*Complex messages (m)*	*All messages (m)*
TM 440 (2)	249	225	235	188	175	185
TM 440 (3)	275	275	275	202	175	200

Sample size: Daylight – 56 observations per data point, Darkness – 64 observations per data point.

three units of information (N) would take 3 seconds to read using the equation: reading time = N/3+2 seconds (Moore and Christie 1963). A legibility distance of 185m would still allow a driver travelling at 70mph in the offside lane (the worst case viewing position see Table 20) 3.56 seconds to read the sign.

- There is approximately an 11% reduction in panel width required for messages shown using 2-pixel stroke-width characters compared to those shown using 3-pixel stroke-width characters. It is worth noting that the reduction in word length for messages constructed from 2-pixel stroke-width characters is due to the reduced character spacing and not the character width, which is the same for comparable letters and numbers in each character set.
- Six complex messages in Transport Mixed 440mm 3-pixel stroke-width (TM 440) characters were shown.

All messages were shown in one of two different treatments:

- A ‘standard’ 6-pixel (2-stroke-width) spacing between numerals and between the ‘M’ (motorway) and the ‘J’ (junction) letters and numerals.
- A wider 9-pixel (3-stroke-width) spacing between numerals and between the ‘M’ (motorway) and the ‘J’ (junction) letters and numerals.

A wider spacing of 12-pixel (4-stroke-width) was considered, but observations showed that words became disjointed making them difficult to read.

Results

Legibility distances (median and 95 percent criterion) are summarised in Table 14 for complex messages consisting of a standard (6-pixel) and a wider (9-pixel) numeral spacing.

Summary of results

- When analysing the success rate with respect to the distance to the sign, there was a greater increase in success rate for messages displayed with a wider spacing between numerals and motorway / junction letters in both daylight and darkness.
- Legibility distances of messages (95th percentile) with a wider (9-pixel) numeral spacing outperformed those with the ‘standard’ (6-pixel) numeral spacing by 13m in daylight and by 6m in darkness. For the median values (50th percentiles) the wider (9-pixel) numeral spacing outperformed the ‘standard’ (6-pixel) numeral spacing by 10m in daylight and by 19m in darkness.

Table 14 The effect of message numeral spacing on legibility distance (m)

Font / character height / stroke-width TM 440 (3)				
	Complex messages			
	Daylight		*Darkness*	
Numeral spacing (pixels)	*50th per -centile (median) (m)*	*95th per -centile (m)*	*50th per -centile (median) (m)*	*95th per -centile (m)*
6-pixel	360	253	253	189
9-pixel	370	266	272	195

Sample size: 48 observations per data point.

6.3.3 Difficult word legibility

The words identified from the dynamic and static trials that appeared to be less legible than others were 'toll', 'debris' and 'queue'.

Messages shown

Table 15 shows the messages shown containing the difficult words (in bold).

Table 15 List of messages shown containing difficult words

No.	*Message*	*Line 1*	*Line 2*	*Line 3*
1	Long delays at **toll**	Long	delays	at toll
2	**Debris** in road Slow	Debris	in road	Slow
3	**Queue** SLOW DOWN	Queue	SLOW DOWN (TU 400 2-pixel s/w)	n/a

- All messages shown were composed of Transport Mixed characters (TM 440), except for the message 'Queue SLOW DOWN' where Transport Upper case characters (TU 400) were used for the second line. For this message, 2-pixel stroke-width characters were used to enable the two words 'SLOW DOWN' to fit on one line. This meant that the character spacing was reduced accordingly.
- Two alternative formats for the difficult words were used for the first two messages listed in Table 15:
  1 Displaying the difficult word in Transport Upper case to improve legibility.
  2 Displaying the difficult word with wider letter spacing to reduce the effects of glare, particularly at night.
- A third variant was tested for the 'Queue SLOW DOWN' message by replacing the word 'Queue' with the 1800mm Queue pictogram.

Examples of these alternative formats are shown in Figures 8 to 10.

Results

a Effect of main treatments on the words 'toll' and 'debris'

Legibility distances (50th and 95th percentiles) are summarised in Tables 16 and 17 for each of the messages in standard format, upper case or wider letter spacing.

b Effect of replacing the word 'Queue' by a pictogram

Legibility distances (50th and 95th percentiles) are summarised in Table 18 for the message with the word 'Queue' in standard format, upper case, with wider character spacing or with the word replaced by a pictogram.

Summary of results

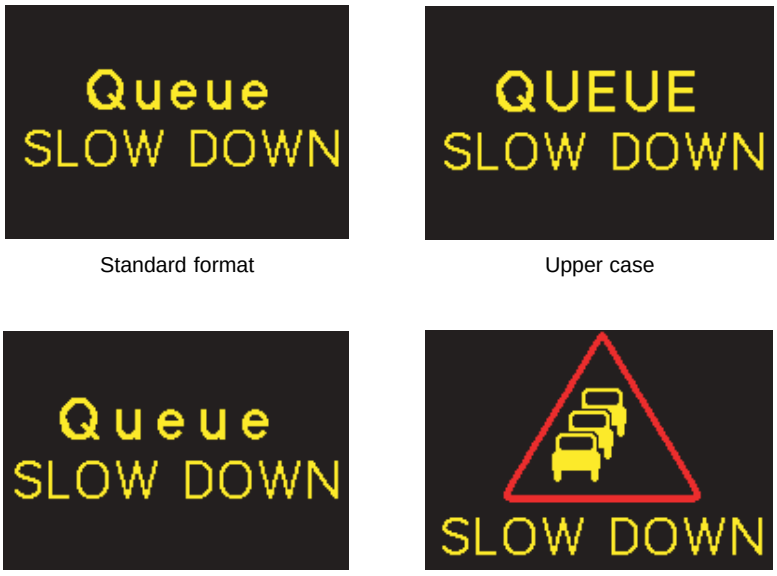
- Difficult word: 'toll': The message containing 'toll' in 'standard' (mixed case format), when shown in darkness, gave a much lower legibility value at the 95th percent confidence level compared to the expected value for TM 440 simple 3-pixel stroke-width messages (see Table 13). However, there was a considerable improvement in legibility of the message shown in darkness when the word 'toll' was shown in uppercase letters or with wider letter spacing, the values obtained were increased to their expected levels.
- Difficult word: 'debris': All treatments tested for the word 'debris' failed to increase the legibility of the sign. Feedback from participants at the trial suggested that failure to recall the word correctly was due to a lack of familiarisation and recognition.
- Difficult word: 'queue': When an 1800mm queue pictogram replaced the word 'Queue', the legibility of the message (at the 95th percent confidence level) was increased by 67m in daylight and by 20m in darkness. Showing the word in uppercase format increased the legibility by 28m in daylight and 20m in darkness. Displaying the word with wider letter spacing reduced the legibility distance.

Standard format | Upper case | Wider letter spacing

Figure 8 Message: 'Long delays at toll' shown in different formats

Standard format | Upper case | Wider letter spacing

Figure 9 Message: 'Debris in road Slow' shown in different formats



Standard format | Upper case

Wider letter spacing | Word 'Queue' replaced by a pictogram

Figure 10 Message: 'Queue SLOW DOWN' shown in different formats

Table 16 The effect of difficult word treatment on legibility distance (m) for the message 'Long delays at toll'

Font / character height / stroke-width TM 440 (3)

	Message: Long delays at toll			
	Daylight		*Darkness*	
Difficult word treatment	*50th per -centile (median) (m)*	*95th per -centile (m)*	*50th per -centile (median) (m)*	*95th per -centile (m)*
Standard	>400	249	301	121
Upper case	>400	321	368	199
Wider spacing	373	268	333	199

Sample size: 16 observations per data point.

Table 17 The effect of difficult word treatment on legibility distance (m) for the message 'Debris in road Slow'

Font / character height / stroke-width TM 440 (3)

	Message: Debris in road Slow			
	Daylight		*Darkness*	
Difficult word treatment	*50th per -centile (median) (m)*	*95th per -centile (m)*	*50th per -centile (median) (m)*	*95th per -centile (m)*
Standard	374	292	300	198
Upper case	392	292	315	120
Wider spacing	>400	268	356	171

Sample size: 16 observations per data point.

Table 18 The effect of difficult word treatment on legibility distance (m) for the message 'Queue SLOW DOWN'

Font / character height / stroke-width TM 440 (3)				
	Message: Queue SLOW DOWN			
	Daylight		*Darkness*	
Difficult word treatment	*50th per -centile (median) (m)*	*95th per -centile (m)*	*50th per -centile (median) (m)*	*95th per -centile (m)*
Standard	>400	292	360	200
Upper case	>400	320	365	220
Wider spacing	>400	270	343	170
Pictogram	>400	359	370	220

Sample size: 16 observations per data point.

6.3.4 Reduced luminance legibility

Messages shown

- Twelve messages, in Transport Mixed 440mm 3-pixel stroke-width characters, were shown in darkness at either full or half luminance to participants. Six of these messages were simple messages without numerals and six were complex messages containing numerals.
- The complex messages used numerals from a set of hybrid numerals, which were used in the numeral legibility trial (see Section 6.3.2). A 9-pixel (3 stroke-width) numeral spacing was used for these messages, which was the optimum spacing for maximum legibility.

Results

Legibility distances (at the 95 percent confidence level) are summarised in Table 19 for simple, complex and all messages (simple and complex combined) shown at either full or half luminance.

Table 19 The effect of message luminance on 95th percentile legibility distance (m)

Font / character height / stroke-width TM 440 (3)		
	Luminance level	
Message type	*Full (m)*	*Half (m)*
Simple	216	190
Complex	170	174
All messages	202	188

Sample size: 36 observations per data point.

Summary of results

- Overall, there was a decrease in legibility distance for all messages shown at half luminance.
- The legibility distances, at the 95th percent confidence level, of simple messages were reduced by 26m when shown at half luminance.
- There was a small increase of 4m, at the 95th percent confidence level, in legibility distance when complex messages were shown at half luminance.

6.4 Pictogram comprehension and reading time trials

These trials covered objective 5 in Section 6.2.

For the MS4 roll-out programme, the use of a second line of text below a pictogram is being considered.

Before the trials were carried out a subjective assessment was made of pictograms that had a reduced width of red triangle border, which resulted in improved pictogram comprehension. The trials were therefore conducted using a reduced width red triangle border. For some of the pictograms shown, where the pictogram was offset to one side of the display panel, it was necessary to show them with a white triangle rather than a red one. This was because the prototype MS4 sign used in the off-road research trials did not have the capability of showing a full range of colours across the width of the display panel.

6.4.1 1800mm pictograms

Messages shown

- 1800mm pictograms without text.
- 1800mm pictograms with one line of reinforcing or supplementary text.
- 1800mm pictograms plus EMI (Lane closure wickets or 50mph advisory speed limit) with one line of reinforcing or supplementary text.

Reinforcing text describes the meaning of a pictogram; e.g. appropriate reinforcing text alongside the 'Queue' pictogram is 'queue' or 'congestion'. Supplementary text is that which gives drivers additional information, such as 'SLOW DOWN'.

Examples of both types of pictograms with one line of reinforcing text are shown in Figures 11 and 12.

6.4.2 1500mm pictograms

Messages shown

- 1500mm pictograms with one line of reinforcing or supplementary text.
- 1500mm pictograms plus EMI (Lane closure wickets or 50mph advisory speed limit) with one line of reinforcing or supplementary text.
- 1500mm pictograms with two lines of reinforcing and supplementary text.
- 1500mm pictograms plus EMI (Lane closure wickets or 50mph advisory speed limit) with two lines of reinforcing and supplementary text.

Examples of 1500mm pictograms with two lines of text are shown in Figures 13 and 14.

Figure 11 1800mm pictogram with one line of reinforcing text

Figure 12 1800mm pictogram plus EMI with one line of reinforcing text

Figure 13 1500mm pictogram with one line of reinforcing text and one line of supplementary text

Figure 14 1500mm pictogram plus EMI with two lines of supplementary text

6.4.3 EMI wickets

Messages shown

- Lane closure EMI wicket with one line of supplementary text.
- Lane closure EMI wicket with two lines of reinforcing and supplementary text.

Examples of EMI wickets shown to participants are shown in Figures 15 and 16.

Figure 15 EMI wickets with supplementary text

Figure 16 EMI wickets with reinforcing and supplementary text

6.4.4 Strategic network pictograms

Strategic messages using pictograms relating to the wider network are under consideration for the roll-out programme. Since network messages provide information on the surrounding network to drivers, red triangles will not be used. It was proposed that the strategic network pictograms were shown either as a symbol or enclosed in a box.

Messages shown

- 1800mm pictograms with symbol inside box with one or two lines of supporting text.
- 1800mm pictograms with symbol only with one or two lines of supporting text.

Examples of these message formats are shown in Figures 17 and 18.

6.4.5 Lane closure wicket EMI enclosed either in a rectangular box or without a box.

Messages shown

Examples of these message formats are shown in Figures 19 and 20.

Figure 17 1800mm 'queue' pictogram - symbol inside box with supplementary text

Figure 18 1800mm 'queue' pictogram - symbol only with reinforcing and supplementary text

Figure 19 EMI wicket inside box with supplementary text

Figure 20 EMI wicket without box with supplementary text

6.4.6 Results

Relating off-road results of the reading times of messages to the on-road situation

The cut off position for viewing the sign (i.e. the distance from the sign where drivers must finish reading the message) is different for each particular lane of the carriageway. Table 20 shows the sign cut off distance, i.e. the distance from the sign where drivers must finish reading the message and the corresponding maximum available viewing time for each lane. This assumes that vehicles are travelling at 70mph and no obscuration of the sign has occurred. In the trial, participants read the sign at one of two fixed positions, either 150m or 210m.

Table 20 Maximum available viewing times for a three-lane motorway

		Maximum viewing time (s)	
		Viewing distance	
Lane	*Sign cut off distance (m)*	*150m*	*210m*
1	43.7	3.4	5.3
2	57.4	3.0	4.9
3	74.2	2.4	4.4

Viewing distances and exposure times

- 1800mm pictograms, with the exception of the strategic network pictograms, were viewed from two static positions: 150m and 210m from the MS4 sign.
- 1500mm pictograms, EMI wickets and the strategic network pictograms were viewed from one static position (150m).
- All pictograms were seen for fixed exposure times between 0.5 seconds and 4.0 seconds (the lower and upper limits being dependent on the complexity of the information displayed).

The observed 95th percentile comprehension / reading times at the 150m and 210m viewing positions, where applicable, are summarised in Table 21.

A comparison in reading times can be made between text only messages and those messages containing pictograms. Table 22 shows the 95th percentile reading times of simple and complex text messages that were tested in the static off-road (Part 1) trial (see Section 3.4).

When comparing the results shown in Table 22 for the 95th percentile reading times of text messages with the corresponding values for messages containing both pictograms and text (see Table 21), it can be seen that a 1500mm pictogram with one line of reinforcing or supplementary text has a much shorter reading time.

The results in Table 22 show that the reading times of simple text messages are 1.8 seconds in daylight and 2.4 seconds in darkness. The reading times of complex messages are 2.3 seconds in daylight and 3.5 seconds in darkness.

Table 21 shows that a 1500mm pictogram with one line of reinforcing or supplementary text has a 95th percentile reading time of less than 0.5 second in daylight and 0.9 seconds in darkness. A 1500mm pictogram plus EMI with

Table 21 Comprehension / reading times (95th percentiles) for pictograms viewed at 150m and 210m

		Reading times (s)			
		Daylight		*Darkness*	
Pictogram size (mm)	*Format*	*150m*	*210m*	*150m*	*210m*
1800	Pictogram without text.	<0.5	<0.5	<0.5	1.1
1800	Pictogram with one line of supplementary or reinforcing text.	<0.5	<0.5	<0.5	<0.5
1500	Pictogram with one line of supplementary or reinforcing text.	<0.5		0.9	
1800	Pictogram + EMI with one line of supplementary or reinforcing text.	1.3	1.7	2.0	3.3
1500	Pictogram + EMI with one line of supplementary or reinforcing text.	1.5		2.8	
1500	Pictogram with two lines of supplementary and reinforcing text.	1.0		>3.5	
1500	Pictogram + EMI with two lines of supplementary and reinforcing text.	2.9		>4.0	
1800	Pictogram (triangle replaced by box) with one line of supplementary text.	1.9		2.9	
1800	Pictogram (symbol only) with one line of supplementary text.	1.7		2.8	
1800	Pictogram (triangle replaced by box) with two lines of supplementary and reinforcing text.	2.9		>3.0	
1800	Pictogram (symbol only) with two lines of supplementary and reinforcing text.	2.9		>3.0	

Key:
- The 95th percentile reading time for the message is within the maximum viewing time for the viewing position.
- The 95th percentile reading time is greater than the maximum viewing time for the viewing position in lane 3. However, a driver will be able to read the sign travelling at 70mph providing part of the message is read before the tested viewing position.
- The 95th percentile reading time might be too large for a driver to read the message comfortably when travelling at 70mph.

one line of reinforcing or supplementary text has a 95th percentile reading time of 1.5 seconds in daylight and 2.8 seconds in darkness. Both of these message formats contained some complex messages, i.e. with numerals.

Table 22 Estimated reading times (s) for different message types

TM400 3-pixel stroke width characters		
Viewing distance:150m		
	95th percentile reading time (s)	
Message type	*Daylight*	*Darkness*
Simple text	1.8	2.4
Complex text	2.3	3.5
Pictogram (no text)	< 0.5	0.6

Summary of results

- The 95th percentile reading time of all messages containing 1800mm pictograms tested at the longer viewing distance, 210m were calculated to be less than the maximum viewing time available (4.4s) for that distance.
- Some of the pictogram message formats had reading times equal or greater to the maximum viewing time available for lane 3 (i.e. 2.4 seconds) for the 150m viewing position (highlighted in yellow or pink). After studying the legibility distances of individual elements of these particular messages it was decided that for all messages in the table marked yellow, drivers should have sufficient time to read each message travelling at normal motorway speeds (70mph), providing they read part of the message before reaching the 150m position. However, for the message highlighted in pink, it is thought that in darkness drivers might not be able to read the text part of the message completely before reaching the sign cut-off distance.
- When comparing the reading times, shown in Table 21, of pictograms combined with an EMI with one line of supporting text, viewed from 150m in both daylight and darkness, there is a reduction in reading time if an 1800mm pictogram is shown instead of a 1500mm pictogram. It can be concluded that there are benefits in using 1800mm pictograms in combination with an EMI.

7 Summary and conclusions

Summary of main results

All legibility distances and reading times are based on the 95th percentiles.

7.1 Dynamic off-road trial

- Recall rates of all text messages shown on MS4 were greater than 93%.
- Recall rates of pictograms with text shown on MS4 were greater than 94%.
- Ambient lighting conditions (daylight/ darkness) had little effect on recall rates.

7.2 Static off-road trial (Part 1) - legibility and comprehension / reading times tests

- Messages containing numerals, shown on the MS4, had lower legibility distances compared to messages without numerals.
- The Transport Upper case font generally performed better than the Transport Mixed case font for messages shown with characters of the same capital height.
- Messages shown on the MS4 in Transport Mixed 440mm (TM 440) font had legibility distances that were comparable to those of similar messages shown in VMS 400mm font on the MS3. TM 440 was the preferred font to be used for text messages shown on the MS4 during the on-road trial.
- Pictograms can generally be read more easily than text messages, hence require lower legibility distances.
- Pictograms required shorter reading times than either simple or complex messages. Complex messages required the longest reading times.

7.3 Static off-road trial (Part 3) - static legibility tests and comprehension / reading times tests

The following trials were conducted on based on recommendations of the dynamic and static trials and results from preliminary research. The testing also included evaluating the reading times of various complex pictogram messages intended for the on-road trial and an investigation into the effects of displaying messages and half luminance:

a Transport Mixed TM 440: 2-pixel v 3-pixel stroke-width character legibility comparison:

– Generally, messages, with and without numerals, had a greater legibility distance, in both daylight and darkness, with 3-pixel stroke-width characters compared to those with 2-pixel stroke-width characters. The results at the 95th percent confidence level are summarised in Table 23.

Table 23 Transport Mixed 440mm (TM 440) 2- v 3-pixel stroke-width legibility distance comparison

Transport Mixed 440mm (TM 440)				
	Daylight		*Darkness*	
Stroke-width	*Simple messages*	*Complex messages*	*Simple messages*	*Complex messages*
2-pixel	249	225	188	175
3-pixel	275	275	202	175

Key:
- Higher comparative legibility distance (m) of messages shown with either 2- or 3-pixel stroke-width characters.
- Lower comparative legibility distance (m) of messages shown with either 2- or 3-pixel stroke-width characters.
- No difference in comparative legibility distance (m) between messages shown with either 2- or 3-pixel stroke-width characters.

b Transport Mixed TM 440: numeral spacing legibility comparison:

– There was a greater legibility distance for messages, shown in both daylight and darkness, with a wider spacing between numerals and motorway / junction letters. The results at the 50th and 95th percent confidence level are summarised in Table 24.

Table 24 Legibility distance comparison for Transport Mixed 440mm (TM 440) standard numeral spacing v increased numeral spacing

Transport mixed 440mm (TM 440) 3-pixel stroke-width characters				
	Complex messages			
	Daylight		*Darkness*	
Numeral spacing (pixels)	*50th per -centile (median) (m)*	*95th per -centile (m)*	*50th per -centile (median) (m)*	*95th per -centile (m)*
6-pixel	360	253	253	189
9-pixel	370	266	272	195

Key:
- Higher comparative legibility distance (m) of messages shown with either a 6- or 9-pixel numeral spacing.
- Lower comparative legibility distance (m) of messages shown with either a 6- or 9-pixel numeral spacing.

c Difficult word legibility:

– The comparison in legibility distances for each of the difficult words, in standard mixed case format or in one of the alternative formats, are summarised in Table 25.

(d) Reduced luminance legibility comparisons:

– Overall, there was a decrease in legibility distance for all messages shown at half luminance.

– The legibility distances of simple messages were reduced when shown at half luminance. There was a small increase in the legibility distance of complex messages shown at half luminance.

(e) Combined message formats containing pictograms:

– Drivers, travelling at motorway speeds, should generally have sufficient time to read the pictogram message formats tested, with the possible exception of a 1500mm pictogram plus an EMI with two lines of supporting text seen in darkness. Under this lighting condition drivers may have insufficient time to read all of the text information.

– If a pictogram is shown in combination with an EMI there are benefits, in terms of a reduction in reading time in both daylight and darkness, of showing an 1800mm pictogram instead of a 1500mm pictogram. However, the results show that a 1500mm pictogram should be sufficient.

– Pictograms, with reinforcing or supplementary text have shorter reading times compared with text only messages. This is also the case if the pictogram is combined with an EMI plus one line of supporting text.

Table 25 Legibility distance comparison of difficult words: standard format v alternative formats

Difficult word	*Difficult word format*		
	Upper case	*Wider letter spacing*	*Word replaced by a pictogram*
Daylight			
Toll	+72m	+19m	n/a
Debris*	0m	-24m	n/a
Queue	+28m	-22m	+67m
Darkness			
Toll	+78m	+78m	n/a
Debris*	-78m	-27m	n/a
Queue	+20m	-30m	+20m

Key:
- Legibility distance (m) of messages shown with difficult word in alternative format higher than messages shown with difficult word in standard format.
- Legibility distance (m) of messages shown with difficult word in alternative format the same as messages shown with difficult word in standard format.
- Legibility distance (m) of messages shown with difficult word in alternative format lower than messages shown with difficult word in standard format.

** All treatments tested for the word 'debris' failed to increase the legibility of the message. Failure to recall the word correctly was probably due to a lack of familiarisation and recognition.*

Conclusion

The off-road research programme has provided a full evaluation of the prototype MS4 VMS. It has tested numerous fonts, numeral sets, character spacing and pictogram combinations. The study has optimised the performance of the sign by maximising the legibility of messages shown which will enable drivers' travelling at motorway speeds to recall the information displayed. The results of this research will be fed into the on-road trial, which is planned to take place on the M4 motorway in 2003.

Further off-road testing might be carried out using a Type Approval display panel to reinforce the on-road testing. This may identify further improvements in performance compared with the off-road prototype panel.

8 References

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Abstract

This report summarises the off-road research trials on display parameters for the proposed Motorway Signal Mark 4 (MS4), carried out by TRL on behalf of the Highways Agency. The trials investigated both the legibility and comprehension of text messages and of pictograms. Dynamic trials established the comprehension of text messages and pictograms seen by drivers travelling at motorway speeds. Static trials investigated the legibility of text messages and pictograms. The results of these trials were used to establish the size of the MS4 display panel for the on-road trial.

The results and recommendations of the dynamic and static trials led to further supplementary off-road research trials, which investigated legibility and developed an improved numeral set.

The programme of work started in June 2000 and was completed in May 2002.

Related publications

TRL526 *Safety and effectiveness of the wider use of VMS – Final report* by B R Cooper and J Mitchell, 2002 (price £40, code HX)

CT64.2 Variable message signs update (1999-2001) *Current Topics in Transport: selected abstracts from TRL Library's database* (price £20)

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