Motor vehicle and pedal cycle conspicuity: part 3 - retroreflective and fluorescent materials: conspicuity of markings.

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Motor Vehicle and Pedal Cycle Conspicuity

Part 3: Retroreflective and Fluorescent Materials - Conspicuity of Markings

Project Number 9/33/13

Undertaken on behalf of

The Department of Environment, Transport and the Regions (DETR)

Prepared by

Sharon Cook

July 1998

Checked by ....................
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Summary

The aim of this assessment was to determine if the application of retro-reflective material to the side and rear faces of heavy and long vehicles and their trailers could improve their conspicuity.

In this study conspicuity was approximated by obtaining measures of visibility and image. Visibility was measured using a visibility meter which recorded, on the three digit scale, the extent of obscuration required for the truck markings to be completely obscured from view. Image was assessed using a 7-point rating scale which measured the extent to which the markings suggested that ‘there was something ahead on the road’.

The Draft Regulation XA marking formats, consisting of a full contour, partial contour, full horizontal line and two horizontal dashed lines, (see Appendix 1) were assessed in the following colours: white, fluorescent yellow, yellow, fluorescent red-orange and red. The ECE70 rectangle and diagonal marking formats were also assessed (see Appendix 2) as was a no marking / lights only condition. The marking formats were viewed under daytime and night-time conditions at 135m.

The results showed that:

- Full and partial contours are more visible and present a stronger image than full and dashed lines formats day and night.
- Red markings are less visible and present a weaker image day and night than other colours.
- Draft Regulation XA markings applied in red should take the form of full or partial contours to be at least as visible as, and present as strong an image as the yellow dashed lines formats specified by the Draft Regulation.
- Full and partial contours are more visible than the ECE70 rectangle and diagonal formats at night; there is no difference by day. The full and dashed lines in red are less visible day and night. In terms of image, nearly all forms and colours of the
Draft Regulation XA markings presented a stronger image than the ECE70 formats at night; by day this was only true of the fluorescent and white variants.

- Fluorescent materials improve daytime visibility and image, but add little to nighttime performance.
1.0 Aim

The aim of the assessment was to determine if the application of retro-reflective material to the side and rear faces of heavy and long vehicles and their trailers could improve their conspicuity. Conspicuity is the ability of an object to draw attention to itself even if a person is not actively searching for it. Since it is difficult to ask a participant to report seeing an item of interest without prompting them to do so, measures of conspicuity are approximated by other means. In this study conspicuity was assessed according to:-

- visibility - measured through the use of a visibility meter (see Appendix 3), and
- image - a rating scale was used to measure the extent to which the markings suggested that ‘there was something ahead on the road’.
2.0 Methodology

2.1 Variables

The study was conducted during the daytime and night-time at a local test site. A rig was built to represent the rear of a truck and was fitted with rear lamps and retro-reflectors.

The retro-reflective materials used took the form of contour markings which are defined in the Draft Regulation XA as ‘a series of rectangular strips intended to be placed in such a way that it shows the contour of the vehicle to the side or rear’. The performance requirements of the contour markings met those defined in the Draft Regulation and are given in Appendix 4. The Draft Regulation XA permits four types of contour marking format. (Refer to Appendix 1). All four variants were assessed in the night-time condition and the assumed best case of a full contour outline and worst case of two horizontal dashed lines to the lower edge of the truck were assessed in the daytime. (These assumptions were based on the likely photometric performance of the marking format due to the amount of material available for exposure).

For comparison the ECE70 rectangle and diagonal marking formats which are currently used on vehicles were also assessed. (Refer to Appendix 2).

A summary of the variants used in this assessment are given in Table 1 below:
Table 1: Main variants of marking format assessed

<table>
<thead>
<tr>
<th>Format</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Draft Regulation XA</td>
<td>White</td>
</tr>
<tr>
<td>Contour Markings</td>
<td>Yellow</td>
</tr>
<tr>
<td>Full contour outline</td>
<td></td>
</tr>
<tr>
<td>Partial contour outline</td>
<td>*</td>
</tr>
<tr>
<td>Red</td>
<td></td>
</tr>
<tr>
<td>Dashed horizontal lines</td>
<td>Fluorescent orange</td>
</tr>
<tr>
<td>*Also assessed in daytime</td>
<td></td>
</tr>
<tr>
<td>Full horizontal line</td>
<td>Fluorescent yellow</td>
</tr>
<tr>
<td>ECE 70</td>
<td>Red &amp; yellow</td>
</tr>
<tr>
<td>Block</td>
<td></td>
</tr>
<tr>
<td>Diagonal</td>
<td></td>
</tr>
</tbody>
</table>

The markings were viewed at a distance of 135m for both the daytime and night-time trials. At night-time they were viewed under dipped beam.

2.2 Subjects / Participants

Two groups assisted in the study and their details are given below in Table 2.

Table 2: Participant details

<table>
<thead>
<tr>
<th></th>
<th>Group 1 - Daytime</th>
<th>Group 2 - Night-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>6 participants 22-74 years old</td>
<td>14 participants 30-69 years old</td>
</tr>
<tr>
<td>Female</td>
<td>10 participants 22-73 years old</td>
<td>6 participants 22-75 years old</td>
</tr>
</tbody>
</table>

2.3 Procedure

The trial was divided into two main tasks; those of assessing visibility and image.

Visibility was assessed using a visibility meter. This necessitated the participant viewing the truck rig through the eyepiece of the visibility meter and turning a dial until the truck became obscured from view. The degree of obscuration required to conceal the truck from view was recorded by a three-digit readout. The higher the
reading, the greater the extent of obscuration needed and therefore the more visible the image being viewed (see Appendix 3).

**Image** was assessed using a 7-point rating scale. Image was defined as ‘the extent to which the markings indicate that there is something ahead on the road’. 1 was defined as markings which could barely be seen, and 7 as markings which clearly indicated that there was something ahead on the road. The different formats of markings were then presented in quick succession with the participants recording their first impression.
3.0 Results

3.1 Visibility

The analysis contained in the following sub-sections is summarised in section 3.1.5, Table 13.

Shaded cells in tables indicate statistically significant differences between variables.

3.1.1 Mean readings

a) Night-time visibility

Table 3 shows the mean night-time visibility readings for each of the Draft Regulation XA and ECE70 marking formats ranked in order of performance. The mean readings generally show that:

- Full and partial contour markings are generally more visible than the full and dashed lines and the ECE70 markings;
- Fluorescent markings are more visible than non-fluorescent markings;
- All forms of red markings are less visible than other colours.
### Section 3: Conspicuity of Truck Markings

#### Results

**Table 3: Summary of mean visibility readings - night-time**

<table>
<thead>
<tr>
<th>Marking format</th>
<th>Visibility reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amended XA Full contour Flu yellow</td>
<td>958.80</td>
</tr>
<tr>
<td>XA + ECE70 Full contour White Diagonal</td>
<td>956.90</td>
</tr>
<tr>
<td>Amended XA Partial contour Flu yellow</td>
<td>951.40</td>
</tr>
<tr>
<td>XA Full contour Yellow</td>
<td>946.00</td>
</tr>
<tr>
<td>XA Partial contour Yellow</td>
<td>944.80</td>
</tr>
<tr>
<td>Amended XA Full contour Flu red-orange</td>
<td>942.20</td>
</tr>
<tr>
<td>Amended XA Partial contour Flu red-orange</td>
<td>937.00</td>
</tr>
<tr>
<td>XA Full contour White</td>
<td>919.40</td>
</tr>
<tr>
<td>XA Partial contour White</td>
<td>915.35</td>
</tr>
<tr>
<td>XA + ECE70 Full contour White Rectangle</td>
<td>911.30</td>
</tr>
<tr>
<td>Amended XA Full line Flu yellow</td>
<td>908.15</td>
</tr>
<tr>
<td>Amended XA Full contour Red</td>
<td>896.25</td>
</tr>
<tr>
<td>Amended XA Dashed lines Flu yellow</td>
<td>894.35</td>
</tr>
<tr>
<td>XA Dashed lines White</td>
<td>882.85</td>
</tr>
<tr>
<td>XA Full line Yellow</td>
<td>881.25</td>
</tr>
<tr>
<td>Amended XA Full line Flu red-orange</td>
<td>878.80</td>
</tr>
<tr>
<td>Amended XA+ECE70 Dashed lines Red Diagonal</td>
<td>868.50</td>
</tr>
<tr>
<td>Amended XA Partial contour Red</td>
<td>856.65</td>
</tr>
<tr>
<td>XA Full line White</td>
<td>854.80</td>
</tr>
<tr>
<td>Amended XA Dashed lines Flu red-orange</td>
<td>852.30</td>
</tr>
<tr>
<td>Amended XA+ECE70 Dashed lines Red Rectangle</td>
<td>844.70</td>
</tr>
<tr>
<td>XA Dashed lines Yellow</td>
<td>840.80</td>
</tr>
<tr>
<td>Amended XA Dashed lines Red</td>
<td>809.65</td>
</tr>
<tr>
<td>Amended XA Full line Red</td>
<td>801.80</td>
</tr>
</tbody>
</table>
b) Daytime visibility

The mean daytime visibility readings for the various marking formats are given below in Table 4. The mean readings generally show that:-

- Full contour markings are more visible than dashed line and ECE70 markings;
- Fluorescent markings are more visible than non-fluorescent markings;
- Red markings in the Draft Regulation XA format are amongst the poorest in terms of visibility. (In fact they may be considered to add nothing to daytime visibility at all since they achieved lower visibility ratings than the no marking condition).

<table>
<thead>
<tr>
<th>Marking format</th>
<th>Visibility reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amended XA</td>
<td></td>
</tr>
<tr>
<td>Full contour</td>
<td>Flu yellow</td>
</tr>
<tr>
<td></td>
<td>937.13</td>
</tr>
<tr>
<td>XA</td>
<td></td>
</tr>
<tr>
<td>Full contour</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>913.00</td>
</tr>
<tr>
<td>Amended XA</td>
<td></td>
</tr>
<tr>
<td>Dashed lines</td>
<td>Flu yellow</td>
</tr>
<tr>
<td></td>
<td>910.81</td>
</tr>
<tr>
<td>Amended XA</td>
<td></td>
</tr>
<tr>
<td>Full contour</td>
<td>Flu red-orange</td>
</tr>
<tr>
<td></td>
<td>909.31</td>
</tr>
<tr>
<td>ECE70</td>
<td></td>
</tr>
<tr>
<td>Rectangle</td>
<td>Flu red-orange</td>
</tr>
<tr>
<td></td>
<td>903.13</td>
</tr>
<tr>
<td>ECE70</td>
<td></td>
</tr>
<tr>
<td>Diagonal</td>
<td>Flu red-orange</td>
</tr>
<tr>
<td></td>
<td>902.19</td>
</tr>
<tr>
<td>XA</td>
<td></td>
</tr>
<tr>
<td>Full contour</td>
<td>Yellow</td>
</tr>
<tr>
<td></td>
<td>873.63</td>
</tr>
<tr>
<td>ECE70</td>
<td></td>
</tr>
<tr>
<td>Rectangle</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>867.25</td>
</tr>
<tr>
<td>Amended XA</td>
<td></td>
</tr>
<tr>
<td>Dashed lines</td>
<td>Flu red-orange</td>
</tr>
<tr>
<td></td>
<td>860.94</td>
</tr>
<tr>
<td>XA</td>
<td></td>
</tr>
<tr>
<td>Dashed lines</td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>830.31</td>
</tr>
<tr>
<td>None</td>
<td></td>
</tr>
<tr>
<td></td>
<td>812.06</td>
</tr>
<tr>
<td>Amended XA</td>
<td></td>
</tr>
<tr>
<td>Full contour</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>793.81</td>
</tr>
<tr>
<td>ECE70</td>
<td></td>
</tr>
<tr>
<td>Diagonals</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>792.94</td>
</tr>
<tr>
<td>XA</td>
<td></td>
</tr>
<tr>
<td>Dashed lines</td>
<td>Yellow</td>
</tr>
<tr>
<td></td>
<td>791.88</td>
</tr>
<tr>
<td>Amended XA</td>
<td></td>
</tr>
<tr>
<td>Dashed lines</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>648.19</td>
</tr>
</tbody>
</table>
3.1.2 Comparison of Draft Regulation XA formats

a) Night-time visibility

An analysis was undertaken to determine if there was any difference in visibility according to the form of the Draft Regulation XA marking used (full contour, partial contour, full line or dashed lines). These results are given in Table 5 and indicate that:-

- There is a significant difference in the performance of the full and partial contour marking formats compared to the dashed line format. Reference to Table 4 suggests that the full and partial contour formats are more visible than the dashed line formats. However this is not true for white which was generally considered less visible in the contour formats and more visible in the dashed lines format than the other colours;
- There is no significant difference in the visibility of the full and dashed lines formats.
- There is no significant difference in the visibility of the full and partial contour formats.

Table 5: Comparison of Draft Regulation XA formats - night-time

<table>
<thead>
<tr>
<th></th>
<th>T-Test Comparison with Dashed Line Format</th>
<th>T-Test comparison with partial contour format</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full contour</td>
<td>Partial contour</td>
</tr>
<tr>
<td>White</td>
<td>0.32</td>
<td>0.24</td>
</tr>
<tr>
<td>Flu yellow</td>
<td>0.02</td>
<td>0.05</td>
</tr>
<tr>
<td>Yellow</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Flu red-orange</td>
<td>0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Red</td>
<td>&lt;0.01</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Investigation was made into determining what level of red Draft Regulation XA format would be needed to achieve the same visibility rating as the yellow dashed
lines format. (This is the minimal performing Draft Regulation XA specified colour and format). Table 6, in consultation with Table 3, suggests that:-

- The red full contour marking is significantly more visible than the yellow dashed lines,
- The red full line is significantly less visible than the yellow dashed lines.

**Table 6: Comparison of Draft Regulation XA formats in red with yellow dashed lines - night-time**

<table>
<thead>
<tr>
<th></th>
<th>Full outline</th>
<th>Partial outline</th>
<th>Full line</th>
<th>Dashed lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>0.01</td>
<td>0.51</td>
<td>0.02</td>
<td>0.18</td>
</tr>
</tbody>
</table>

**b) Daytime visibility**

Paired T-tests were undertaken to determine if there was a significant difference in terms of daytime visibility between the full contour and dashed lines markings formats specified by the Draft Regulation XA. The results, given in Table 7, indicate that there is a significant difference in these formats for all colours except fluorescent yellow. Analysis of the mean readings suggests that the full contour markings are significantly more visible than the dashed lines markings.

**Table 7: Comparison of Draft Regulation XA formats - daytime**

<table>
<thead>
<tr>
<th></th>
<th>T-Test comparison of full contour and dashed line formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>0.02</td>
</tr>
<tr>
<td>Flu yellow</td>
<td>0.08</td>
</tr>
<tr>
<td>Yellow</td>
<td>0.04</td>
</tr>
<tr>
<td>Flu red-orange</td>
<td>0.01</td>
</tr>
<tr>
<td>Red</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Further investigation was made to determine the level of red markings which would be comparable to the yellow dashed lines markings. (The minimum level specified by the Draft Regulation XA). Reference to Table 8 and Table 4 indicates that:-
The red Draft Regulation XA markings applied as either a full contour or the dashed lines format are not significantly more or less visible than the yellow dashed lines.

Table 8: Comparison of Draft Regulation XA formats in red with yellow dashed lines - daytime

<table>
<thead>
<tr>
<th></th>
<th>T-Test comparison with yellow dashed line format</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full outline</td>
</tr>
<tr>
<td>Red</td>
<td>0.94</td>
</tr>
</tbody>
</table>

3.1.3 Comparison of fluorescent materials

a) Night-time visibility

Analysis was undertaken to determine if there was a significant difference in the night-time visibility performance of the fluorescent and non-fluorescent marking formats. The paired T-test results given in Table 9 and the mean scores given in Table a indicate that for all marking formats, except the dashed lines, the fluorescent red-orange material is significantly more visible than the red material. The same superior performance is true for the fluorescent yellow but only for the dashed lines format.
Table 9: Comparison of fluorescent and non-fluorescent marking formats - night-time

<table>
<thead>
<tr>
<th>Marking format</th>
<th>T-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full contour</td>
<td>Flu yellow &amp; yellow 0.40</td>
</tr>
<tr>
<td></td>
<td>Flu red-orange &amp; red 0.01</td>
</tr>
<tr>
<td>Partial contour</td>
<td>Flu yellow &amp; yellow 0.55</td>
</tr>
<tr>
<td></td>
<td>Flu red-orange &amp; red &lt;0.01</td>
</tr>
<tr>
<td>Full line</td>
<td>Flu yellow &amp; yellow 0.17</td>
</tr>
<tr>
<td></td>
<td>Flu red-orange &amp; red 0.03</td>
</tr>
<tr>
<td>Dashed line</td>
<td>Flu yellow &amp; yellow 0.02</td>
</tr>
<tr>
<td></td>
<td>Flu red-orange &amp; red 0.13</td>
</tr>
</tbody>
</table>

b) Daytime visibility

Analysis was undertaken to determine if there was a significant difference in the daytime visibility performance of the fluorescent and non-fluorescent marking formats. The paired T-test results given in Table 10 indicate that there is a significant difference and that it is the fluorescent materials which are significantly more visible (refer to the mean readings of Table 4).

Table 10: Comparison of fluorescent and non-fluorescent marking formats - daytime

<table>
<thead>
<tr>
<th>Marking format</th>
<th>T-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full contour</td>
<td>Flu yellow &amp; yellow 0.01</td>
</tr>
<tr>
<td></td>
<td>Flu red-orange &amp; red &lt;0.01</td>
</tr>
<tr>
<td>Dashed line</td>
<td>Flu yellow &amp; yellow &lt;0.01</td>
</tr>
<tr>
<td></td>
<td>Flu red-orange &amp; red 0.01</td>
</tr>
</tbody>
</table>
3.1.4 Comparison with ECE70 markings

a) Night-time visibility

T-test analyses were undertaken to compare the performance of the Draft Regulation XA markings, in all colours, with the marking formats currently found on the road - ECE70 rectangle and diagonals and also a no markings / lights only condition. The results for this are given in Table 11.

Rectangle and diagonal: In general all the full and partial contour formats are significantly more visible than the ECE rectangle and diagonal. The full and dashed line formats in red are significantly less visible.

No markings / lights only: This condition was significantly less visible than the fluorescent yellow full contour and significantly more visible than the red full and dashed line formats.
Section 3: Conspicuity of Truck Markings

### Table 11: Comparison of ECE70 marking formats - night-time

<table>
<thead>
<tr>
<th>Draft Regulation XA markings</th>
<th>ECE70 markings</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rectangle</td>
<td>Diagonal</td>
<td>Lights only</td>
</tr>
<tr>
<td>Full contour</td>
<td>White</td>
<td>0.27</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Flu yellow</td>
<td>0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>Yellow</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Flu red-orange</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Red</td>
<td>0.16</td>
<td>0.02</td>
</tr>
<tr>
<td>Partial contour</td>
<td>White</td>
<td>0.19</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>Flu yellow</td>
<td>0.04</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Yellow</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Flu red-orange</td>
<td>0.02</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td></td>
<td>Red</td>
<td>0.72</td>
<td>0.93</td>
</tr>
<tr>
<td>Full line</td>
<td>White</td>
<td>0.45</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>Flu yellow</td>
<td>0.09</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Yellow</td>
<td>0.50</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>Flu red-orange</td>
<td>0.61</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>Red</td>
<td>0.08</td>
<td>0.02</td>
</tr>
<tr>
<td>Dashed lines</td>
<td>White</td>
<td>0.40</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>Flu yellow</td>
<td>0.50</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>Yellow</td>
<td>0.35</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>Flu red-orange</td>
<td>0.57</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td>Red</td>
<td>0.07</td>
<td>0.02</td>
</tr>
</tbody>
</table>

b) **Daytime visibility**

Similar analysis was undertaken for the daytime visibility readings. However, for the daytime condition two types of ECE70 rectangle and diagonal marking formats were used - one incorporating fluorescent red and one incorporating non-fluorescent red. Table 12 shows the results of T-test comparison of the Draft Regulation XA markings against these ECE70 marking variants and also against a no markings condition. In summary these results indicate:-
**Rectangle:** There are some instances in which there is a significant difference between the visibility of Draft Regulation XA and the ECE70 (fluorescent and non-fluorescent) marking formats. General conclusions, with reference to Table 4, are that:

- the fluorescent yellow Draft Regulation XA markings are significantly more visible than both the fluorescent and non-fluorescent forms of the ECE70 marking;
- the red Draft Regulation XA markings are significantly less visible than both the fluorescent and non-fluorescent forms of the ECE70 marking;
- the use of fluorescent red-orange in the rectangle marking improved the visibility of this type of marking.

**Diagonal:** There are several instances in which there is a significant difference between the visibility of Draft Regulation XA and the ECE70 (fluorescent and non-fluorescent) marking formats. However, the only general conclusions which may be drawn are that:

- the fluorescent yellow Draft Regulation XA markings are significantly more visible than both the fluorescent and non-fluorescent forms of the ECE70 marking.
- the use of fluorescent red-orange in the rectangle marking improved the visibility of this type of marking.

**No markings / lights only:** The following Draft Regulation XA formats significantly increase visibility over a no marking condition:

- fluorescent yellow - full contour and dashed lines;
- fluorescent red-orange - full contour and dashed lines;
- white - full contour only;
- yellow - full contour only.
Table 12: Comparison of ECE70 marking formats - daytime

<table>
<thead>
<tr>
<th>XA markings</th>
<th>Draft Regulation</th>
<th>ECE70 markings</th>
<th>T-Test comparison of</th>
<th>No. markings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rectangle</td>
<td>Diagonal</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Red</td>
<td>Flu Red</td>
<td>Red</td>
</tr>
<tr>
<td>Full contour</td>
<td>White</td>
<td>0.07</td>
<td>0.63</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Dashed lines</td>
<td>White</td>
<td>0.10</td>
<td>0.03</td>
<td>0.11</td>
</tr>
<tr>
<td>Full contour</td>
<td>Flu Yellow</td>
<td>0.01</td>
<td>0.04</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Dashed lines</td>
<td>Flu Yellow</td>
<td>0.03</td>
<td>0.71</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Full contour</td>
<td>Yellow</td>
<td>0.85</td>
<td>0.32</td>
<td>0.01</td>
</tr>
<tr>
<td>Dashed lines</td>
<td>Yellow</td>
<td>0.02</td>
<td>0.01</td>
<td>0.95</td>
</tr>
<tr>
<td>Full contour</td>
<td>Red-orange</td>
<td>0.11</td>
<td>0.70</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Dashed lines</td>
<td>Red-orange</td>
<td>0.73</td>
<td>0.05</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Full contour</td>
<td>Red</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>0.96</td>
</tr>
<tr>
<td>Dashed lines</td>
<td>Red</td>
<td>0.04</td>
<td>&lt;0.01</td>
<td>0.37</td>
</tr>
</tbody>
</table>

3.1.5 Summary of visibility results

A summary of the results for visibility discussed so far is given in Table 13.
### Table 13: Summary of visibility results

<table>
<thead>
<tr>
<th></th>
<th>Night-time</th>
<th>Daytime</th>
</tr>
</thead>
</table>
| Mean visibility readings      | • Full and partial contour markings are more visible than the full and dashed lines and the ECE70 rectangle and diagonals.  
                                • Fluorescent markings are more visible than non-fluorescent markings.  
                                • All forms of red markings are less visible than other colours.               | • Full contour markings are more visible than dashed lines or ECE 70 rectangle and diagonals.  
                                • Fluorescent markings are more visible than non-fluorescent markings.  
                                • Red markings add little to daytime visibility.                               |
| Comparison of the different   | • Full and partial contour markings are significantly more visible than the dashed line formats, except for white.  
                                • There is no significant difference in the visibility of the full and dashed lines formats.  
                                • There is no significant difference in the visibility of the full and partial contour formats.  
                                • The red full contour marking is significantly more visible than the yellow dashed lines whilst the red full line is significantly less visible. | • Full contour markings are significantly more visible than the dashed line markings for all colours except fluorescent yellow.  
                                • Red full contours and dashed lines markings are not significantly more or less visible than the yellow dashed lines. |
| types of Draft Regulation XA  |                                                                                           |                                                                                          |
| formats                      |                                                                                           |                                                                                          |

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ICE Ergonomics Ltd
Comparison of fluorescent and non-fluorescent markings (for both Draft Regulation XA and ECE70 formats)

- Fluorescent red-orange is significantly more visible than red for all marking formats except the dashed lines.
- Fluorescent yellow is significantly more visible than yellow for the dashed lines format only.

Comparison of Draft Regulation XA markings with ECE70 markings

- In general the full and partial contour formats are significantly more visible than the ECE rectangle and diagonal.
- The fluorescent yellow full contour marking is significantly more visible than the no markings / lights only condition.
- The full and dashed lines formats in red are significantly less visible than the ECE70 rectangle and diagonals and the no markings / lights only condition.

- Fluorescent markings are significantly more visible than non-fluorescent markings.

- No consistent trend except that:
  - the fluorescent yellow markings are significantly more visible than both the fluorescent and non-fluorescent ECE70 rectangle and diagonals.
  - the red Draft Regulation XA markings are significantly less visible than the ECE70 rectangle and diagonals.
  - The lights only condition is significantly less visible than:
    - all contour markings (except red)
    - the fluorescent yellow and fluorescent red-orange dashed lines.
3.2 Image

3.2.1 Mean ratings

a) Night-time image

Table 14 shows the ranked mean image ratings for each of the Draft Regulation XA and ECE70 marking formats. The mean readings generally show that:-

• Full and partial contour markings signify a greater presence on the road than the full and dashed line and ECE70 markings;

• Fluorescent markings signify a greater presence on the road than non-fluorescent markings;

• Full and partial red contour markings convey less on-the-road presence than all other colours. However, in their full and dashed lines formats the red markings signify a greater on-the-road presence than yellow and white (the colours recommended by the Draft Regulation XA).

• All Draft Regulation XA markings achieved greater on-the-road presence ratings than the conventional ECE70 marking formats and lights only condition.
### Table 14: Summary of mean image ratings - night-time

<table>
<thead>
<tr>
<th>Marking format</th>
<th>Image rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amended XA</td>
<td>6.52</td>
</tr>
<tr>
<td>Partial contour</td>
<td>Flu yellow</td>
</tr>
<tr>
<td>XA</td>
<td>6.46</td>
</tr>
<tr>
<td>Full contour</td>
<td>Yellow</td>
</tr>
<tr>
<td>XA + ECE70</td>
<td>6.46</td>
</tr>
<tr>
<td>Full contour</td>
<td>White</td>
</tr>
<tr>
<td>Amended XA</td>
<td>6.46</td>
</tr>
<tr>
<td>Full contour</td>
<td>Flu yellow</td>
</tr>
<tr>
<td>XA</td>
<td>6.34</td>
</tr>
<tr>
<td>Partial contour</td>
<td>White</td>
</tr>
<tr>
<td>XA</td>
<td>6.33</td>
</tr>
<tr>
<td>Partial contour</td>
<td>Yellow</td>
</tr>
<tr>
<td>Amended XA</td>
<td>6.33</td>
</tr>
<tr>
<td>Partial contour</td>
<td>Flu red-orange</td>
</tr>
<tr>
<td>Amended XA</td>
<td>6.26</td>
</tr>
<tr>
<td>Full contour</td>
<td>Flu red-orange</td>
</tr>
<tr>
<td>XA</td>
<td>6.19</td>
</tr>
<tr>
<td>Full contour</td>
<td>White</td>
</tr>
<tr>
<td>XA + ECE70</td>
<td>6.14</td>
</tr>
<tr>
<td>Full contour</td>
<td>White</td>
</tr>
<tr>
<td>Amended XA</td>
<td>6.13</td>
</tr>
<tr>
<td>Full contour</td>
<td>Red</td>
</tr>
<tr>
<td>Amended XA</td>
<td>5.67</td>
</tr>
<tr>
<td>Partial contour</td>
<td>Red</td>
</tr>
<tr>
<td>Amended XA</td>
<td>4.94</td>
</tr>
<tr>
<td>Dashed lines</td>
<td>Flu red-orange</td>
</tr>
<tr>
<td>Amended XA</td>
<td>4.68</td>
</tr>
<tr>
<td>Full line</td>
<td>Flu red-orange</td>
</tr>
<tr>
<td>Amended XA</td>
<td>4.61</td>
</tr>
<tr>
<td>Dashed lines</td>
<td>Flu yellow</td>
</tr>
<tr>
<td>Amended XA</td>
<td>4.48</td>
</tr>
<tr>
<td>Full line</td>
<td>Flu yellow</td>
</tr>
<tr>
<td>Amended XA</td>
<td>4.48</td>
</tr>
<tr>
<td>Dashed lines</td>
<td>Red</td>
</tr>
<tr>
<td>Amended XA</td>
<td>4.35</td>
</tr>
<tr>
<td>Full line</td>
<td>Red</td>
</tr>
<tr>
<td>XA</td>
<td>4.29</td>
</tr>
<tr>
<td>Full line</td>
<td>White</td>
</tr>
<tr>
<td>Amended XA+ECE70</td>
<td>Diagonal</td>
</tr>
<tr>
<td>Dashed lines</td>
<td>Red</td>
</tr>
<tr>
<td>XA</td>
<td>4.29</td>
</tr>
<tr>
<td>Full line</td>
<td>Yellow</td>
</tr>
<tr>
<td>XA</td>
<td>4.21</td>
</tr>
<tr>
<td>Dashed lines</td>
<td>White</td>
</tr>
<tr>
<td>Amended XA+ECE70</td>
<td>Rectangle</td>
</tr>
<tr>
<td>Dashed lines</td>
<td>Red</td>
</tr>
<tr>
<td>XA</td>
<td>3.82</td>
</tr>
<tr>
<td>Dashed lines</td>
<td>Yellow</td>
</tr>
<tr>
<td>ECE70</td>
<td>3.81</td>
</tr>
<tr>
<td>Lights only</td>
<td></td>
</tr>
<tr>
<td>ECE70</td>
<td>3.69</td>
</tr>
<tr>
<td>Rectangle</td>
<td></td>
</tr>
<tr>
<td>ECE70</td>
<td>3.43</td>
</tr>
<tr>
<td>Diagonal</td>
<td></td>
</tr>
</tbody>
</table>

b) **Daytime image**
A similar analysis was undertaken for the daytime, as for the night-time, image ratings. In general the mean image ratings given in Table 15 indicate that:-

- Full contour markings achieve a greater rating of on-the-road presence than the dashed lines markings;

- Fluorescent markings achieve greater presence ratings than their non-fluorescent counterparts;

- Red contour and dashed lines markings achieve poorer ratings than any other colour;

- The fluorescent red-orange ECE70 rectangle and diagonal markings out perform the red, yellow and white dashed lines of the Draft Regulation XA markings (and also the red full contour marking);

- The red ECE70 rectangle and diagonal markings outperform the red, yellow and white dashed lines of the Draft Regulation XA markings;

- All marking formats achieved higher on-the-road presence ratings than the no marking condition.
Table 15: Summary of mean image ratings -daytime

<table>
<thead>
<tr>
<th>Marking format</th>
<th>Image rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amended XA Full contour Flu Yellow</td>
<td>6.25</td>
</tr>
<tr>
<td>Amended XA Full contour Red-orange</td>
<td>6.00</td>
</tr>
<tr>
<td>XA Full contour White</td>
<td>5.25</td>
</tr>
<tr>
<td>XA Full contour Yellow</td>
<td>4.38</td>
</tr>
<tr>
<td>Amended XA Dashed lines Flu Yellow</td>
<td>4.25</td>
</tr>
<tr>
<td>ECE70 Diagonal Red-orange</td>
<td>4.19</td>
</tr>
<tr>
<td>Amended XA Dashed lines Red-orange</td>
<td>4.00</td>
</tr>
<tr>
<td>ECE70 Rectangle Red-orange</td>
<td>3.94</td>
</tr>
<tr>
<td>Amended XA Full contour Red</td>
<td>3.44</td>
</tr>
<tr>
<td>ECE70 Rectangle Red</td>
<td>3.25</td>
</tr>
<tr>
<td>ECE70 Diagonals Red</td>
<td>3.13</td>
</tr>
<tr>
<td>XA Dashed lines Yellow</td>
<td>2.94</td>
</tr>
<tr>
<td>XA Dashed lines White</td>
<td>2.69</td>
</tr>
<tr>
<td>Amended XA Dashed lines Red</td>
<td>1.94</td>
</tr>
<tr>
<td>None</td>
<td>1.81</td>
</tr>
</tbody>
</table>

3.2.2 Comparison of Draft Regulation XA formats

a) Night-time image

An analysis was undertaken to determine if there was any difference in the image ratings according to the form of Draft Regulation XA marking used (full contour, partial contour, full line or dashed line. These results are given in Table 16 and indicate that:-

- There is a significant difference in the performance of the full and partial contour markings formats compared with the dashed line format. Reference to Table 14 suggests that the full and partial contour formats were considered to have a significantly greater on-the-road presence than the dashed lines format;

- There is no significant difference in the performance of the dashed lines and full line formats;
- There is no significant difference in the performance of the full and partial contour formats except for red where the full contour presents a significantly stronger image than the partial contour.

**Table 16: Comparison of Draft Regulation XA formats - night-time**

<table>
<thead>
<tr>
<th></th>
<th>T-Test comparison with dashed line format</th>
<th>T-Test comparison with partial contour format</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full contour</td>
<td>Full contour</td>
</tr>
<tr>
<td>White</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Flu yellow</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Yellow</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Flu red-orange</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Red</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Investigation was made into determining what level of red Draft Regulation XA format would be needed to achieve the same on-the-road presence rating as yellow dashed lines format (this is the minimal performing Draft Regulation XA specified colour and format). Table 17 suggests that there is no significant difference between the image ratings given to the red and yellow dashed lines markings. Also, with reference to Table 14, the red full contour, partial contour and full line markings achieve significantly higher image ratings than the dashed yellow lines markings.

**Table 17: Comparison of Draft Regulation XA formats in red with yellow dashed lines - night-time**

<table>
<thead>
<tr>
<th></th>
<th>T-Test comparison with yellow dashed line format</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full outline</td>
</tr>
<tr>
<td>Red</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

b) Daytime image
The various recommended Draft Regulation XA formats were compared under daytime conditions. The T-test results given in Table 18, and reference to the mean ratings in Table 14, indicate that the full contour markings have significantly greater on-the-road presence ratings than the dashed lines markings.

**Table 18: Comparison of Draft Regulation XA formats - daytime**

<table>
<thead>
<tr>
<th></th>
<th>T-Test comparison of full contour and dashed line formats</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Flu yellow</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Yellow</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Flu red-orange</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Red</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Further investigation was made to determine the level of red markings which would be comparable to the yellow dashed lines markings (the minimum level specified by the Draft Regulation XA). Reference to Table 19 and Table 15 indicates that:

- There is no significant difference in the image ratings of the red full contour and yellow dashed lines markings;
- The red dashed lines achieve significantly poorer image ratings than the yellow dashed lines markings.

**Table 19: Comparison of Draft Regulation XA formats in red with yellow dashed lines - daytime**

<table>
<thead>
<tr>
<th></th>
<th>T-Test comparison with yellow dashed line format</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full outline</td>
</tr>
<tr>
<td>Red</td>
<td>0.24</td>
</tr>
</tbody>
</table>
3.2.3 Comparison of fluorescent materials

a) Night-time image

Analysis was undertaken to determine if there was a significant difference in the night-time image performance of the fluorescent and non-fluorescent marking formats. The paired T-test results given in Table 20 indicate that, aside from two conditions, there is generally there is no significant difference in image rating due to material type. Where there is a difference the fluorescent formats present a stronger image.

Table 20: Comparison of fluorescent and non-fluorescent marking formats - night-time

<table>
<thead>
<tr>
<th>Marking format</th>
<th>T-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full contour</td>
<td></td>
</tr>
<tr>
<td>Flu yellow &amp; yellow</td>
<td>0.67</td>
</tr>
<tr>
<td>Flu red-orange &amp; red</td>
<td>1.00</td>
</tr>
<tr>
<td>Partial contour</td>
<td></td>
</tr>
<tr>
<td>Flu yellow &amp; yellow</td>
<td>0.82</td>
</tr>
<tr>
<td>Flu red-orange &amp; red</td>
<td>0.04</td>
</tr>
<tr>
<td>Full line</td>
<td></td>
</tr>
<tr>
<td>Flu yellow &amp; yellow</td>
<td>0.22</td>
</tr>
<tr>
<td>Flu red-orange &amp; red</td>
<td>0.14</td>
</tr>
<tr>
<td>Dashed line</td>
<td></td>
</tr>
<tr>
<td>Flu yellow &amp; yellow</td>
<td>0.02</td>
</tr>
<tr>
<td>Flu red-orange &amp; red</td>
<td>0.17</td>
</tr>
</tbody>
</table>

b) Daytime image

A similar analysis was undertaken to investigate the relative performance of fluorescent and non-fluorescent materials in daytime conditions. The paired T-test results given in Table 21, and the mean ratings given in Table 15, indicate that for all the variants assessed the fluorescent variants presented a significantly stronger image than the non-fluorescents.
Table 21: Comparison of fluorescent and non-fluorescent marking formats - daytime

<table>
<thead>
<tr>
<th>Marking format</th>
<th>T-Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full contour</td>
<td>Flu yellow &amp; yellow</td>
</tr>
<tr>
<td></td>
<td>Flu red-orange &amp; red</td>
</tr>
<tr>
<td>Dashed line</td>
<td>Flu yellow &amp; yellow</td>
</tr>
<tr>
<td></td>
<td>Flu red-orange &amp; red</td>
</tr>
</tbody>
</table>

3.2.4 Comparison with ECE70 markings

a) Night-time image

Analysis was undertaken to compare the performance of the Draft Regulation XA markings, in all colours, with the marking formats currently found on the road - ECE70 rectangle and diagonal formats and also a no markings/lights only condition. The T-Test results of this comparison are given in Table 22 and discussed below.

Rectangle and Diagonal: For all but two of the Draft Regulation marking formats (yellow full line and dashed line) there was a significant difference in the image presented. Reference to Table 14 suggests that the Draft Regulation markings presented a stronger image of presence on the road.

No markings / lights only: The addition of nearly all forms of the Draft Regulation XA requirements significantly improved the notion of on-the-road presence compared to the no markings / lights only condition. The exceptions to this, where there was no significant difference, were full line - white and yellow and dashed line yellow.
Table 22: Comparison of ECE70 marking formats - night-time

<table>
<thead>
<tr>
<th>Draft Regulation XA markings</th>
<th>ECE70 markings</th>
<th>Lights only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rectangle</td>
<td>Diagonal</td>
</tr>
<tr>
<td>Full contour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Flu yellow</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Yellow</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Flu red-orange</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Red</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Partial contour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Flu yellow</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Yellow</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Flu red-orange</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Red</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Full line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>Flu yellow</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Yellow</td>
<td>0.13</td>
<td>0.11</td>
</tr>
<tr>
<td>Flu red-orange</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Red</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
<td>Dashed lines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Flu yellow</td>
<td>0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Yellow</td>
<td>0.85</td>
<td>0.41</td>
</tr>
<tr>
<td>Flu red-orange</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Red</td>
<td>&lt;0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

b) Daytime image

A comparison of the Draft Regulation XA formats and those formats currently found on the road was also made under daytime conditions. Refer to Table 23.
**Rectangle and diagonal:** The general conclusions to draw from Table 23 are that:

- The fluorescent yellow, fluorescent red-orange and white Draft Regulation formats present a significantly better image than the rectangle and diagonals.
- The dashed red lines present a significantly worse image than the rectangle and diagonals.
- The use of fluorescent red-orange in the rectangle and diagonal marking improved their image.

**No markings / lights only:**

- All of the Draft Regulation formats, except the dashed red lines, present a significantly stronger image of presence on the road than the lights only condition.

### Table 23: Comparison of ECE70 marking formats - daytime

<table>
<thead>
<tr>
<th>Draft Regulation XA markings</th>
<th>ECE70 markings</th>
<th>T-Test comparison of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rectangle</td>
<td>Diagonal</td>
</tr>
<tr>
<td></td>
<td>Red T-Test</td>
<td>Flu Red T-Test</td>
</tr>
<tr>
<td>Full outline White</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Dashed lines White</td>
<td>0.08</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Full outline Flu Yellow</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Dashed lines Flu Yellow</td>
<td>&lt;0.01</td>
<td>0.33</td>
</tr>
<tr>
<td>Full outline Yellow</td>
<td>0.01</td>
<td>0.20</td>
</tr>
<tr>
<td>Dashed lines Yellow</td>
<td>0.31</td>
<td>0.02</td>
</tr>
<tr>
<td>Full outline Red-orange</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Dashed lines Red-orange</td>
<td>0.02</td>
<td>0.86</td>
</tr>
<tr>
<td>Full outline Red</td>
<td>0.63</td>
<td>0.27</td>
</tr>
<tr>
<td>Dashed lines Red</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
### 3.2.5 Summary of image ratings

A summary of the results for image ratings discussed so far is given in Table 24.

**Table 24: Summary of image rating results**

<table>
<thead>
<tr>
<th></th>
<th>Night-time</th>
<th>Daytime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean visibility</td>
<td>• Full and partial contours have a stronger image than full and dashed lines and the ECE70 markings.</td>
<td>• Full contours have a stronger image than dashed lines and the ECE70 markings.</td>
</tr>
<tr>
<td>readings</td>
<td>• All Draft Regulation XA markings have a stronger image than the ECE70 markings.</td>
<td>• All Draft Regulation XA markings have a stronger image than the ECE70 markings except for the red, yellow and white dashed lines format.</td>
</tr>
<tr>
<td></td>
<td>• Full and partial contour markings are least effective in red; however for full and dashed lines red is more effective than white and yellow (the colours recommended by the Draft Regulation XA).</td>
<td>• Full contour and dashed lines markings are least effective in red.</td>
</tr>
<tr>
<td></td>
<td>• Fluorescent markings have a stronger image than non-fluorescent markings.</td>
<td>• Fluorescent markings have a stronger image than non-fluorescent markings.</td>
</tr>
<tr>
<td>Comparison of</td>
<td>• The full and partial contour markings have a significantly stronger image than the dashed lines format; there is no difference between the full and</td>
<td>• The full contour markings have a significantly stronger image than the dashed lines format.</td>
</tr>
<tr>
<td>different types</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draft Regulation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>XA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Comparison of Fluorescent and Non-Fluorescent Markings

<table>
<thead>
<tr>
<th>Formats</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dashed lines formats.</td>
<td>Red markings and the dashed yellow lines; however the dashed red lines have a significantly weaker image than the dashed yellow lines.</td>
</tr>
<tr>
<td><strong>Red full contours present a significantly stronger image than red partial contours.</strong> For other colours, there is no significant difference.</td>
<td></td>
</tr>
<tr>
<td><strong>There is no difference in the image portrayed by the dashed red and dashed yellow lines but other forms of the red markings outperform the yellow dashed lines.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>In general there is no significant difference in the image portrayed by fluorescent and non-fluorescent markings for the Draft Regulation XA formats.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>For full contour and dashed lines Draft Regulation XA formats the fluorescent markings present a stronger image than their non-fluorescent counterparts.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>The use of fluorescent red-orange in the ECE70 markings improved their image ratings.</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Note: Draft Regulation XA and ECE70 formats*
Comparison of Draft Regulation XA markings with ECE70 markings

- The Draft Regulation XA markings present a significantly strong image than the ECE70 formats except for the yellow variants.
- Most forms of the Draft Regulation XA formats assessed significantly increased the image ratings over the no markings / lights only condition.
- The full contour Draft Regulation XA formats present a significantly stronger image than the ECE70 formats.
- The dashed red line variants of the Draft Regulation XA formats present a significantly worse image than the ECE70 markings.
- All of the Draft Regulation formats, except the dashed redlines, present a significantly stronger than the no markings / lights only condition.
4.0 Conclusions

4.1 Optimum form of Draft Regulation XA marking format to apply
- Full and partial contours are generally more visible and have a stronger presence on the road than the full line and dashed lines format for both night-time and daytime.

4.2 Minimum level of the Draft Regulation XA marking format to apply in red
- Generally the red markings are less visible and have less presence on the road than the other colours assessed.
- If the Draft Regulation XA markings are applied in red they should take the form of the full or partial contour in order to be at least as visible and ‘present’, by night and day, as the yellow dashed line format. (Due to colour and the amount of material available for viewing this is likely to be the least effective of the Draft Regulation XA specified formats and so has been used as a minimum level of performance to achieve).

4.3 Comparison of the Draft Regulation XA formats with ECE70 formats
- Full and partial contours are generally more visible than the ECE70 rectangle and diagonal formats at night; there is no difference in visibility by day. The red full and dashed lines formats are less visible than the ECE70 formats day and night.
- Nearly all forms and colours of the Draft Regulation XA markings were considered to have more ‘presence’ than the ECE70 formats at night. By day this was only true of the fluorescent variants and the white full contour.

4.4 Contribution of fluorescent materials
- Fluorescent Draft Regulation XA markings are generally more visible than their non-fluorescent counterparts by day, but at night this is only true for the fluorescent red-orange.
- The fluorescent version of the Draft Regulation XA formats and ECE70 Rectangle and diagonal formats have more ‘presence’ on the road by day, but there is no difference at night.
5.0 **Recommendations**

To maximise conspicuity apply the Draft Regulation XA markings as partial or full contours. (These formats are generally more visible and present a stronger image than the full and dashed lines Draft Regulation XA formats and the ECE70 rectangle and diagonal marking formats).

If red is to be used to apply the Draft Regulation XA marking formats it should be applied a full or partial contours. (Red is the poorest performing colour, by day and night, and needs to be applied in these forms so it at least equates to the minimum performing Draft Regulation XA marking format of the yellow dashed lines).

To maximise daytime conspicuity in terms of visibility and image, use fluorescent variants of all the Draft Regulation XA and ECE70 marking formats. The use of fluorescent materials will not detract from night-time conspicuity.
6.0 Future work

The next phase of the test programme will:-

• assess the relative performance of the different marking formats in terms of their effect on stopping distances;

• investigate further the relative performance of the Draft Regulation XA markings when applied in red.

The next phase of the work will assess the critical formats shaded in Table 25 below. A guide to the likely performance of the other formats listed may be inferred from their rankings.
Table 25: Ranking of Draft Regulation XA and ECE70 formats according to visibility and image when viewed under dipped beam headlights

<table>
<thead>
<tr>
<th>Marking format</th>
<th>Visibility rank</th>
<th>Image rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full contour Flu yellow</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Full contour White</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Partial contour Flu yellow</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Full contour Yellow</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Partial contour Yellow</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Full contour Flu red-orange</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Partial contour Flu red-orange</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Full contour White</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Partial contour White</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Full contour White Rectangle</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Full line Flu yellow</td>
<td>11</td>
<td>16</td>
</tr>
<tr>
<td>Full contour Red</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>Dashed lines Flu yellow</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Dashed lines White</td>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td>Full line Yellow</td>
<td>16</td>
<td>21</td>
</tr>
<tr>
<td>Full line Flu red-orange</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>Full line Rectangle</td>
<td>18</td>
<td>26</td>
</tr>
<tr>
<td>Dashed lines Red Diagonal</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>Partial contour Red</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>Full line White</td>
<td>21</td>
<td>19</td>
</tr>
<tr>
<td>Full line Diagonal</td>
<td>22</td>
<td>27</td>
</tr>
<tr>
<td>Dashed lines Flu red-orange</td>
<td>23</td>
<td>13</td>
</tr>
<tr>
<td>Dashed lines Red Rectangle</td>
<td>24</td>
<td>23</td>
</tr>
<tr>
<td>Dashed lines Yellow</td>
<td>25</td>
<td>24</td>
</tr>
<tr>
<td>Dashed lines Red</td>
<td>26</td>
<td>17</td>
</tr>
<tr>
<td>Full line Red</td>
<td>27</td>
<td>18</td>
</tr>
</tbody>
</table>
Appendix 1

Marking formats defined by Draft Regulation XA

Dashed line

Full line

Partial contour

Full contour
Appendix 2

ECE70 marking formats

CLASS 1
← Fluorescent red
← Retroreflective yellow

CLASS 2
← Fluorescent red
← Retroreflective yellow

CLASS 3
← Retroreflective red
← Retroreflective yellow

CLASS 4
← Retro-reflective red
← Retroreflective yellow
Appendix 3

Description of the Visibility Meter

The basic principle of the visibility meter is to reduce a visual task to threshold by some means and use the amount of reduction as a measure of the visibility of the task. A task of high visibility will require a greater reduction than a task of low visibility. It is generally agreed that the most sensitive and preferred method of reducing a task to threshold is to reduce the contrast by superimposing a veiling luminance (Eastman 1969). This is the approach adopted by the CIE (1972) to specify visibility and “represents the most complete and systematic approach to measuring the combined effects of task, lighting and people variables on task performance” (Boyce 1981)

In the meter the task being measured is reduced to threshold by a combination of luminance reduction and the addition of a veiling luminance. The veiling luminance is provided by either the task background or a standard reflecting surface placed beside the task rather than by an internal light source. The observer views the task directly through a variable beam splitter (see below).

A variable veiling luminance is provided by reflecting a portion of the task background, or the standard surface, from the beam splitter and focusing it at the eye with a single lens. The effect is as though the whole area of the focusing lens were the source of the veiling luminance. The task is reduced to threshold by increasing the density of the variable beam splitter which simultaneously increases the veiling luminance. The overall luminance would not change with changes in the position of an ideal beam splitter since the transmittance plus the reflectance would remain constant throughout its length. While the beam splitter is not perfect, the luminance variability is not great enough to be noticed by the observer so that the adaptation of the eye is not changed significantly.
Figure 1.
Appendix 4

Photometric specifications for Contour Markings defined by Draft Regulation XA

1.1 Minimum values for the coefficient of Retroreflection

Photometric specifications for retro-reflective markings of Class C:

<table>
<thead>
<tr>
<th>Observation angle $\alpha$ ($^\circ$)</th>
<th>Entrance angle $\beta$ ($^\circ$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha = 0.33^\circ$ (20')</td>
<td>$\beta$1 0 0 0 0</td>
</tr>
<tr>
<td></td>
<td>$\beta$2 5 30 40 60</td>
</tr>
<tr>
<td>Colour</td>
<td></td>
</tr>
<tr>
<td>yellow</td>
<td>300 130 75 10</td>
</tr>
<tr>
<td>white</td>
<td>450 200 90 16</td>
</tr>
</tbody>
</table>