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Assessment of route and destination displays on PSVs - Part 3: Field trials report

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Part 3:

Field trials

Assessment of route and destination displays on PSVs

PPAD 9/72/5

Part 3
Field trials report

Prepared for:

Department for Transport

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Summary

Following from the research review undertaken within phase one of this project and the laboratory trials in which conditions were controlled such that the type of technology was the main variable under assessment, field trials were conducted. The aim of the field trials was to assess displays in their real world setting and identify factors that influence their readability. The displays were assessed by members of the public, including those who had a visual impairment, under day and night-time conditions.

The findings relating to these trials are summarised below.

PSV identification

Vehicle size and colour are the primary cues indicating that an approaching vehicle is a bus.

Location of display within the vehicle

Deep recessing of displays contributes to poorer angles of readability. It is recommended that the displays are located immediately behind the display window aperture.

Type of information

The front display was significantly more important to both groups of participants than the other displays. The side display was more important to the participants with a visual impairment than the sighted participants.

The route number was significantly more important to both groups of participants than the other elements of destination information.

Amount of information

The addition of one intermediate place name significantly increases reading time over just the route number and final destination. In addition, considering that the route number and final destination were considered to be more important than the intermediate place names, it is recommended that intermediates only be used where they do not detract from the optimum provision of the route number and final destination.

Layout of display

Where preferences were expressed, the majority were for the route number to be to the right-hand side of the display and the final destination to be below the route number.

Technology

When corrected for character height, LED displays could be read at significantly greater distances when viewed statically than the other technologies. (Sighted participants by daytime only).

The printed yellow on black display could be read at significantly wider forward viewing angles than the other technologies (Sighted participants by daytime and night-time) as could the

printed white on black display over the flip-dot display (Night only).

The printed white on black and flip-dot displays were assessed dynamically under day and night conditions. The reading distances were significantly less than for reading the static displays, the exception being the flip-dot display under night-time conditions.

Preferences were expressed for printed displays; the flip-dot and LED displays were considered to be less readable when viewed close-to.

Character height

Based on our sample, it is probably not possible to design a display that can be read by 95% of visually impaired passengers even at the estimated minimum stopping distance of 40m.

Increasing the route number height to 655mm and the final destination height to 670mm will enable 25% of passengers with a visual impairment to achieve reading performance equivalent to 25% of passengers without a visual impairment reading 200mm and 125mm respectively.

The calculations given above differ to those calculated for the laboratory trials. This is considered to be due to a variety of

factors including differing font styles and differing visual conditions of the participants.

Display design

Larger, clearer numbers were stated by the participants as their favoured means to improve display readability.

Contents

Summary ..... **i**

1.0 Aims of the field trials **1**

2.0 Methodology **1**

2.1. Display equipment 1

2.2. Experimental variables 4

2.2.1. Independent variables 4

2.2.2. Dependent variables 4

2.2.3. Confounding variables 4

2.3. Experimental measures 5

2.3.1. Objective measures 5

2.3.2. Subjective measures 5

2.4. Participants 5

2.4.1. Recruitment sources 5

2.4.2. Participant details 6

2.4.3. Description of participants' visual performance 8

2.5. Test site 9

2.6. Experimental procedure 10

2.6.1. Briefing 10

2.6.2. Measures of readability 11

2.6.3. Questionnaire 14

2.6.4. De-brief 14

3.0 Results **15**

3.1. Display technology 15

3.1.1. Reading distance 15

3.1.2. Reading angles 25

3.1.3. Participant comments 28
3.2. Amount of information 30
3.3. PSV use 31
3.3.1. Frequency of use 31
3.3.2. Identification of approaching vehicle as a bus 31
3.4. Display use 32
3.4.1. Importance of displays 32
3.4.2. Ratings of readability 33
3.4.3. Aspects making reading displays difficult 34
3.4.4. Aspects assisting reading displays 35
3.5. Display elements 36
3.5.1. Importance of display elements 36
3.5.2. Layout of display elements 37
3.6. Display design 40
3.6.1. Current good practice 40
3.6.2. Improvements 40
4.0 Summary of findings 42
4.1. Technology 42
4.2. Character height 43
4.3. Type of information 45
4.3.1. Type of display 45
4.3.2. Display element 45
4.4. Amount of information 45
4.5. PSV use 46
4.6. Display use 46

4.7. Display layout 46

4.8. Display design 47

1.0 Aims of the field trials

The laboratory trials investigated the performance of different PSV display technologies in controlled conditions such that the type of technology was the main variable under assessment. In the real world, other variables come into play and the aim of the field trials was to identify these variables and their importance to the readability of the displays.

2.0 Methodology

2.1. Display equipment

Four different types of display technology were selected for assessment in the field trials as shown in Figure 1.

PRINTED – White on black	PRINTED – Yellow on black
Flip-dot	LED

Figure 1: Illustration of the display technologies assessed in the field trials

The characteristics of these displays are described in detail in Table 1 below. Whilst working with a combination of two PSV operators it was possible to assess all four technologies, due to the operating complexities in the real world, it was not possible to sufficiently control the displays to accurately compare 'like-with-like'. For instance the LED was a side, not a front, display; the printed yellow on black display did not have intermediate place names, the age of the displays varied, etc.

		PRINTED WHITE (Front display)	PRINTED YELLOW (Front display)	FLIP-DOT (Front display)	LED (Side display)
GENERAL	OPERATOR	1	2	2	1
DATA	DISPLAY AGE	Six months	4-5years	4-5 years	Six months
	CONTRAST - DAYTIME	0.87	1.50	0.62	2.33
	CONTRAST - NIGHT-TIME	10.00	3.00	2.00	361.50
OVERALL	BOTTOM OF DISPLAY TO GROUND (mm)	2590	2505	2460	2355
DISPLAY	OVERALL DISPLAY HEIGHT (mm)	530	530	275	100
DATA	OVERALL DISPLAY WIDTH (mm)	1470	1600	1460	912
	USED DISPLAY HEIGHT (mm)	360	75	230	80
	USED DISPLAY WIDTH (mm)	1270	880	1100 est	890
NUMBER	NUMBER HEIGHT (mm)	240	100	172	70
INFORMATION	NUMBER WIDTH (mm)	140	95	127	50
	NUMBER THICKNESS (mm)	25	25	37	20
	NUMBER SPACING (mm)	80	15	24	10
FINAL	FD WORD SPACING (mm)	40	70	N/A	N/A
DESTINATION	FD CHARACTER SPACING (mm)	15	10-12	12	12
INFORMATION	FD CHARACTER HEIGHT - CAPITAL / X-HEIGHT (mm)	130 / 95	75 / 58	100 / 70	65 / 40
	FD CHARACTER WIDTH - CAPITAL / X-HEIGHT (mm)	70 / 55	75 / 60	72 / 70	22 / 30
	FD CHARACTER THICKNESS - CAPITAL / X-HEIGHT (mm)	20 / 14	17 / 16	24 / 24	5 / 5
INTERMEDIATE	I WORD SPACING (mm)	40	No intermediates	48	No intermediates
INFORMATION	I CHARACTER SPACING (mm)	7 - 13		12	
	I CHARACTER HEIGHT - CAPITAL / X-HEIGHT (mm)	60 / 45		80 / 57	
	I CHARACTER WIDTH - CAPITAL / X-HEIGHT (mm)	40 / 30		60 / 47	
	I CHARACTER THICKNESS - CAPITAL / X-HEIGHT (mm)	7 / 7		12 / 12	

Table 1: Characteristics of PSV displays assessed in the field trials

2.2. Experimental variables

2.2.1. Independent variables

The independent variables (those which were controlled and varied within the experiment) were:

- Display technology
  - Printed (white on black)
  - Flip-dot
  - Printed (yellow on black)
  - LED
- Ambient lighting – The trials were undertaken under both daytime and night-time conditions. At night-time the site was lit by low-level security lighting and lighting from an adjacent public footpath.
  - Daytime (980 – 7,200 lux)
  - Night-time (0.4 – 150 lux)
- Level of participant vision
  - Visually impaired participants (Refer to 2.4.3)
  - Sighted participants.

2.2.2. Dependent variables

The dependent variable (that aspect of performance which was measured) was display readability. This was measured in terms of reading distance and reading speed.

2.2.3. Confounding variables

The following variables were fixed properties of the display technology as used within the vehicle on the road and so could not be controlled.

- Character size,
- Font style,

- Display age,
- Display layout (this was also a variable of the bus design).

2.3. Experimental measures

2.3.1. Objective measures

Objective measures of display design (those which can be directly quantified by measurement) were:

- Reading distance (metres),
- Viewing angle (degrees).

2.3.2. Subjective measures

Subjective measures of display design (those which cannot be directly measured and are reported by the participant) were:

- Ratings (using a 5-point scale),
- Expressed preferences,
- Open-ended questions.

2.4. Participants

2.4.1. Recruitment sources

The following organisations were approached for assistance with the field trials:

- RNIB Scotland,
- RNIB Scientific Research Unit,
- RNIB equipment and information resource centre,
- RNIB Education Centre: Scotland,

- Royal Blind school,
- Heriot-Watt University,
- Disabled Living Centre: Edinburgh
- Princess Alexandra Eye Pavilion: Edinburgh,
- New Beacon RNIB magazine,
- Newspaper recruitment,
- Local radio.

2.4.2. Participant details

Data was collected from a total sample size of 22 participants, comprising of 13 sighted participants and 9 participants with a visual impairment. The characteristics of the participants are given in Table 2.

Participant number	Participant age	Participant gender
1	17	Female
2	19	Male
3	22	Male
4	44	Female
5	31	Female
6	55	Female
7	34	Female
8	26	Female
9	22	Male
10	16	Female
11	63	Male
12	19	Male
13	15	Female
14	16	Female
15	16	Female
16	75	Male
17	16	Female
18	22	Male
19	18	Male
20	20	Male
21	18	Male
22	25	Female
	Min = 15 Mean = 28 Max = 75	Male = 10 Female = 12

Table 2: Characteristics of field trial participants

Due to participant availability, the participants were employed within the trials as given in Table 3.

	Visually impaired participants	Sighted participants	Total
Daytime	9	13	22
Night-time	3	8	10

Table 3: Participant attendance in the field trials

2.4.3. Description of participants' visual performance

As for the laboratory trials, when recruiting the participants with a visual impairment all efforts were made to recruit a sample that reflected a range of low vision casual factors. In addition it was necessary to screen the participants to ensure that only individuals with appropriate levels of visual impairment were selected to participate in the research.

A breakdown of the causes of the low vision conditions experienced visual impairments is given Table 4.

Participant number	Visual impairment	Snellen reading
1	Cortical visual impairment	36
2	Moabius syndrome	9
3	Unknown	36
4	None	6
5	Albinism	36
6	None	7.5
7	None	7.5
8	None	7.5
9	None	12
10	None	7.5
11	Macular degeneration, glaucoma, cataracts	Can't read
12	Unknown	6
13	None	7.5
14	Unknown	Poorer than 60
15	None	4
16	None	7.5
17	None	6
18	None	6
19	Small retina	Poorer than 60
20	None	No data
21	Detached retina (left) Partially detached retina (right)	No data
22	None	7.5

Table 4: Visual performance of field trial participants

2.5. Test site

The test site was at the depot of Operator 1 since this provided sufficient space for all displays to be viewed at distances of 100+m. However due to the width of the viewing strips and the LED display being on the side of one of the vehicles, it was not possible to position the vehicles side by side.

The test environment consisted of a tarmac road with a background of buildings and vehicles. This therefore approached the visually cluttered, road scenes in which PSVs may be expected to be observed when operating. Refer to Figure 2.

Figure 2: The test site for the field trials

2.6. Experimental procedure

The experimental procedure comprised the following main elements.

2.6.1. Briefing

- The participants were greeted on arrival and escorted to site office,
- The participants were briefed as to the format of assessment, time required, safety procedures, etc,
- The participants read/had read to them and then signed the form consenting to their participation in the research,
- Personal details and measures of visual performance were obtained.

2.6.2. Measures of readability

Dynamic reading distances

The aim was to assess the readability of the display, in terms of reading distance, whilst the vehicle was moving. The participants and experimenters stood at one end of a straight stretch of road and a bus was driven towards them from the other end thereby simulating the approach of a bus to a bus stop. Refer to Figure 3. By a given point, marked by a cone, the vehicle reached a speed of 15mph, which was then maintained. Since, at this point, the majority of sighted participants were able to read the route number, the participants were asked to indicate to the experimenter working with them when the final destination became visible to them and when the intermediates became visible to them. When the vehicle reached the cone and the start of its constant speed, it flashed its headlights to signal the experimenters to start their stopwatches. Split times were then taken for each participant for when they confirmed they could see the final destination and intermediates. From this data, viewing distances were then calculated under dynamic conditions. Due to the need to use intermediates, this was only undertaken using the printed, white on black display and the flip-dot display.

Figure 3: Dynamic assessment of display readability

Static reading distances and angles

Starting at distances at which the participants were unable to read any of the display information, each participant-experimenter pair approached the vehicle noting the distance at which the route number, final destination and intermediates could be confidently read; ratings were given at each point.

The participants then stood to the left of the vehicle, level with its front and facing forward. They then walked in an arc, whose radius was centred on the front centreline of the vehicle; until such time that all of the display information could be confidently read. At this point the angle formed by the participant and a tangent to the front of the vehicle was noted and a rating given. Refer to Figure 4.

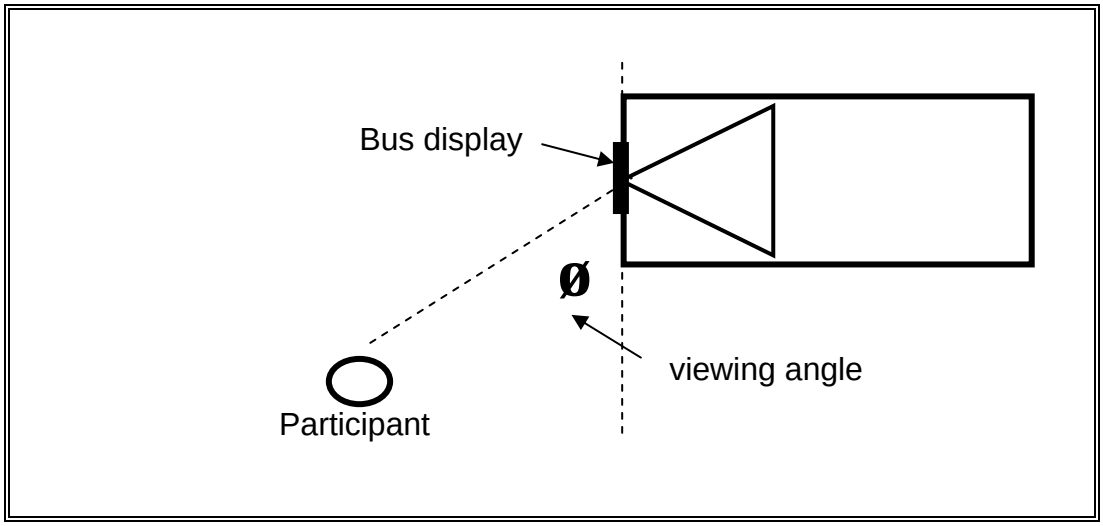


Figure 4: Assessment of reading angularity

This procedure was undertaken for all four display technologies.

Reading times

Timings were taken for the participants to read the following amounts of information:

- Route number and final destination,
- Route number, final destination and one intermediate,
- Route number, final destination and three intermediates.

The aim of this was to determine the extent to which the addition of intermediate information significantly increased reading time above that taken to read just the route number and final destination.

2.6.3. Questionnaire

The participants then returned to the site office to complete a questionnaire which covered various aspects of display design including:

- Layout preferences for relative locations of the route number, final destination and intermediate information,
- The relative importance of the route number, final destination and intermediate information,
- The relative importance of front, side and rear displays
- Factors that make displays more or less readable,
- Suggested improvements.

Refer to Appendix 1 for a copy of the questionnaire.

2.6.4. De-brief

At the end of the assessment any questions that the participants had were addressed, following which the participants were thanked for their assistance and escorted safely from the site.

3.0 Results

Within this section the following abbreviations will be used:

- W/B - Printed White on Black
- Y/B - Printed Yellow on Black
- FD - Flip-dot
- LED

3.1. Display technology

3.1.1. Reading distance

Static reading distance - Measurements

Figure 5 shows the mean reading distances for all participants for each of the front displays assessed.

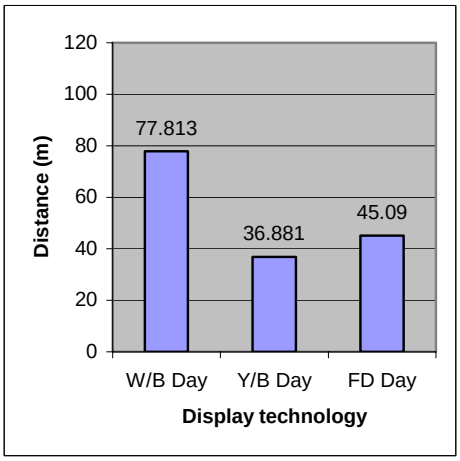
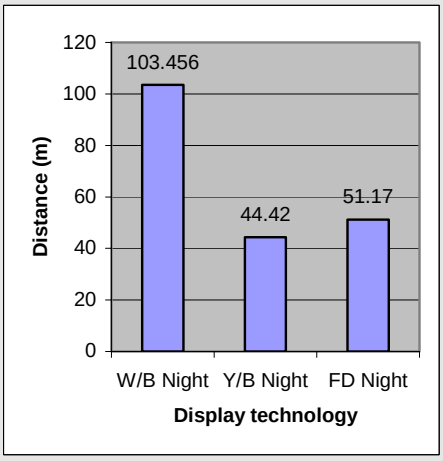
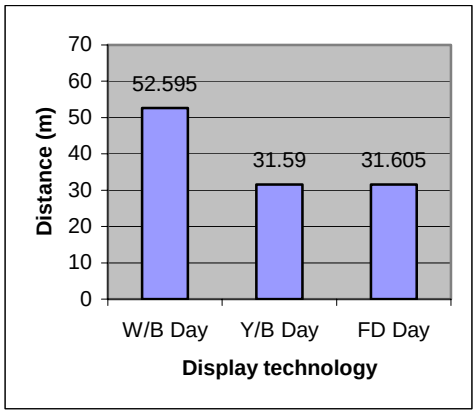
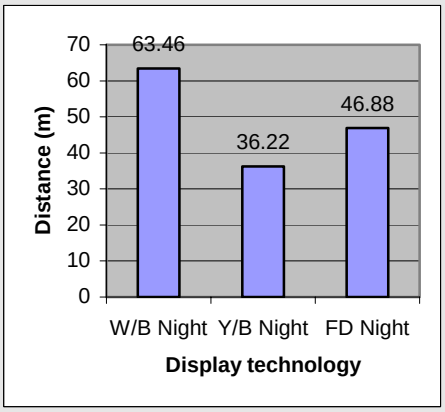
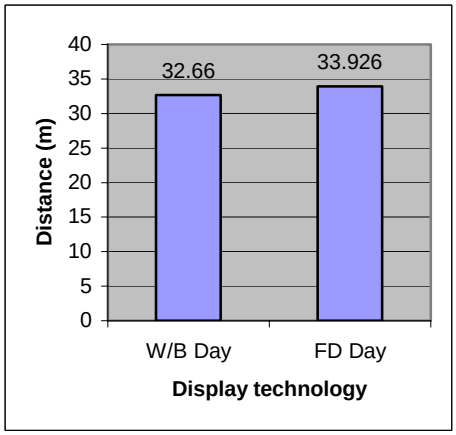
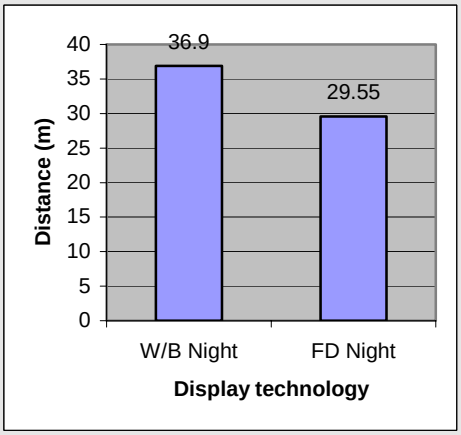
	Daytime	Night-time
a) Route number		
b) Final destination		
c) Intermediates		

Figure 5: Mean static reading distances (Raw Data)

Statistical analysis was undertaken to determine any significant differences in the reading distances. These are given in Table 5.

Participants	Daytime	Night-time
Route number		
All participants	W/B > FD > Y/B	W/B > FD > Y/B
Visually impaired	W/B > Y/B	No data
Sighted	W/B > FD > Y/B	W/B > FD > Y/B
Final destination		
All	W/B > FD > Y/B	W/B & FD > Y/B
Visually impaired	No difference	No data
Sighted	W/B > FD > Y/B	W/B & FD > Y/B
Intermediates (B/W and FD only)		
All	No difference	No difference
Visually impaired	No difference	No data
Sighted	No difference	No difference

Key:
- > = was seen at a significantly greater distance than
- No data = There was an insufficient number of visually impaired participants within the night-time trials for analysis.

Table 5: Significant differences in static reading distances by technology based on raw data

In summary this indicates that:

- **Route number** – Generally the white on black display could be read at a greater distance than the flip-dot display that could in turn be read at a greater distance than the yellow on black display. This was true of all participant groupings both day and night except for the participants with a visual impairment during the daytime where the white displays and Flip dot displays performing better than the yellow display was the only significant difference.
- **Final destination** – By day, for the participants without a visual impairment the findings were the same as for the route number; however for the visually impaired participants there was no difference between the technologies. By night, the white on black and flip-dot displays could be seen at a greater distance than the yellow on black display.
- **Intermediates** - There was no significant difference for either participant group, day or night, between the white on black and flip-dot display.

However since the heights of the text in all the displays differed, further analysis was undertaken to control for this. The revised mean distances are illustrated in Figure 6.

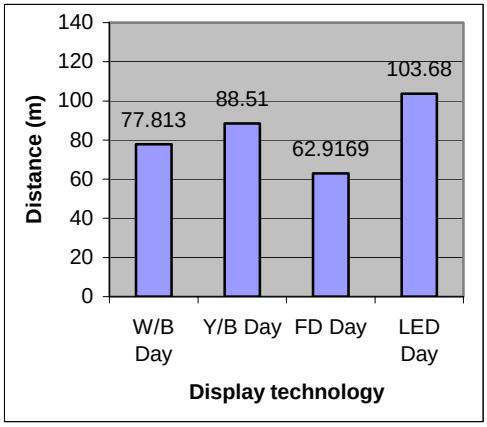
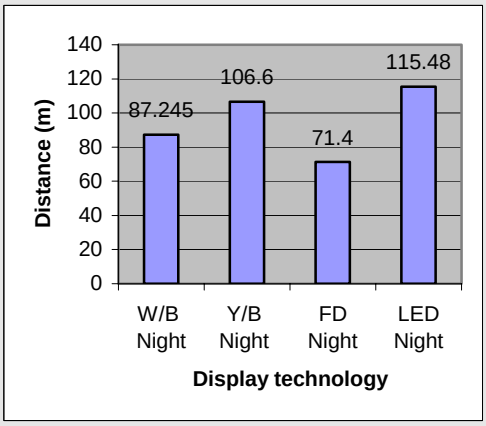
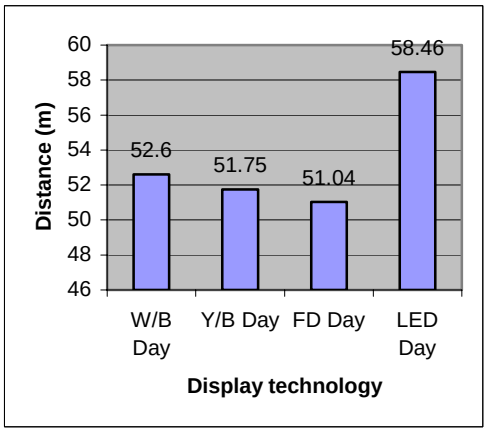
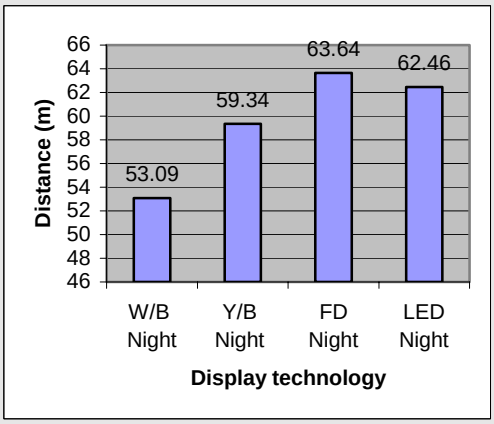
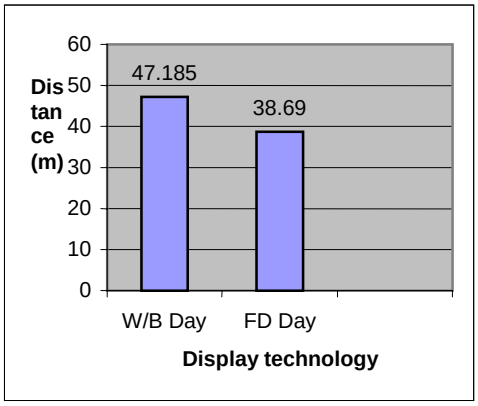
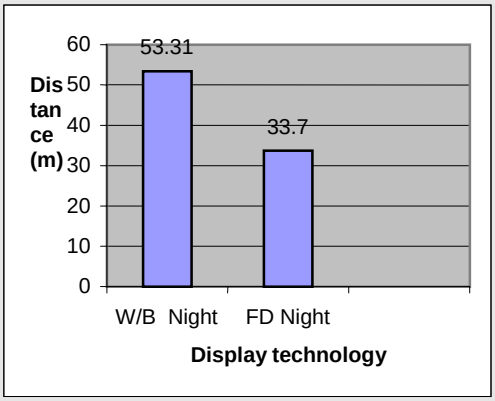
	Daytime	Night-time
a) Route number		
b) Final destination		
c) Intermediate		

Figure 6: Mean static reading distances (Controlled for height)

Statistical analysis was undertaken to determine any significant differences in the reading distances. These are given in Table 6.

Participants	Daytime	Night-time
Route number		
All	LED = Y/B LED > W/B	No difference
Visually impaired	No difference	No data
Sighted	LED = Y/B LED > W/B & FD W/B & Y/B > FD	No difference
Final destination		
All	LED > FD	No difference
Visually impaired	No difference	No data
Sighted	LED > FD	No difference
Intermediates (B/W and FD only)		
All	No difference	No difference
Visually impaired	No difference	No data
Sighted	No difference	No difference

Key:
- > = was seen at a significantly greater distance than
- No data = There was an insufficient number of visually impaired participants within the night-time trials for analysis.

Table 6: Significant differences in static reading distances by technology based on height-controlled data

In summary this indicates that:

- **Night-time** – There were no significant differences between the technologies for either participant group.
- **Daytime** – There were no significant differences between the technologies for the participants with a visual impairment.
- **Intermediates** - There were no significant differences between the technologies for either participant group.

The following results therefore only apply to the sighted participants by daytime:

- **Route number** – The LED display performed as well as the yellow on black display and could be seen at a greater distance than the white on black and flip-dot displays. The printed displays could be read at a greater distance than the flip-dot display.
- **Final destination** – The LED display could be seen at a greater distance than the flip-dot display.

It should be noted that the flip-dot display was the older of the displays and, in addition to its greater recessing within the vehicle; this may have contributed to its poorer performance compared to the other technologies.

Static reading distance - Ratings

The participants were asked to rate the displays using the following scale. Refer to Figure 7.

In terms of reading the information (Number, Final Destination or Intermediates) would you rate the display as:

1	2	3	4	5
Very poor	Poor	OK	Good	Very good

Figure 7: Rating scale

The findings indicate that the different technologies were similarly rated i.e. whilst all the displays were viewed at a confident reading distance, no technology was perceived as being easier to read than any other. Refer to Figure 8.

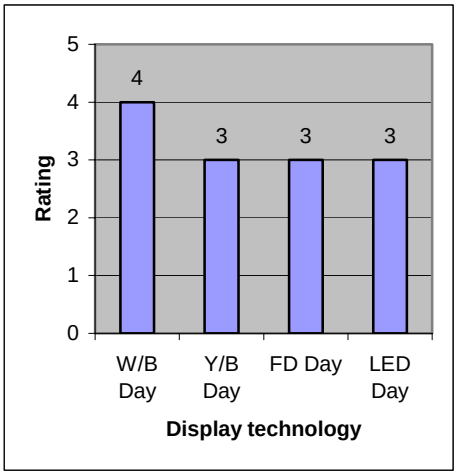
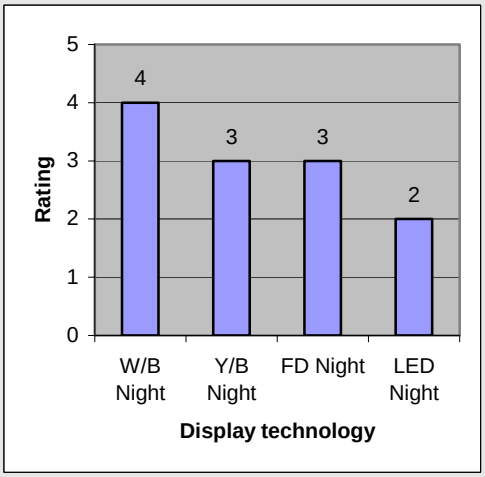
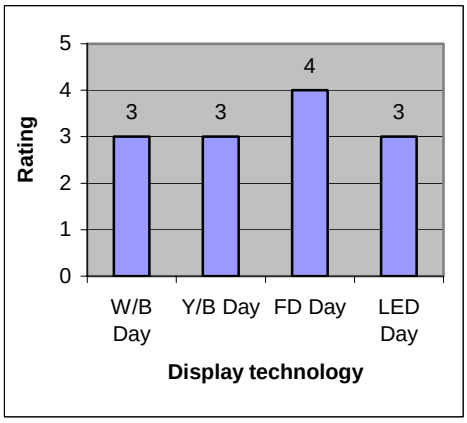
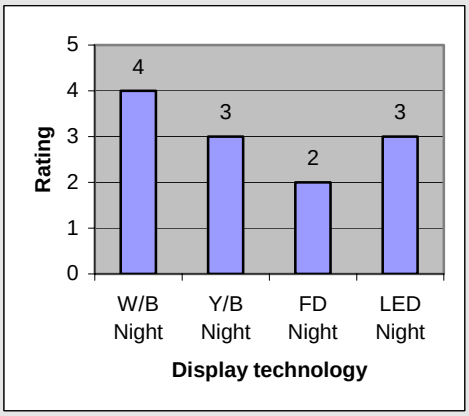
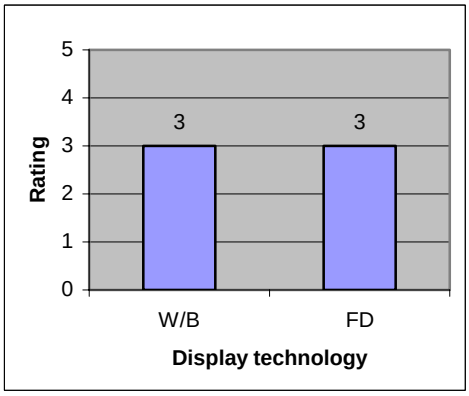
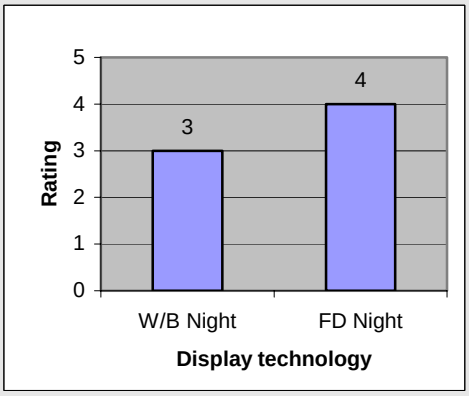
	Daytime	Night-time
a) Route number		
b) Final destination		
c) Intermediates		

Figure 8: Mode ratings for reading distance

Dynamic reading distances – Measurements

Table 7 shows the mean reading distances for both participant groups under static and dynamic viewing conditions. The data indicates that there is a decrease in reading distance for both types of display elements (final destination and intermediates) when viewed dynamically compared to statically. This is statistically significant for all conditions except the flip-dot (final destination and intermediates) when viewed at night.

	Final destination			
	Daytime		**Night-time**	
	W/B	**FD**	**W/B**	**FD**
Static	58.13	42.59	58.04	60.60
Dynamic	31.24	25.91	36.16	28.51
% Reduction	46.26	39.16	37.7	52.95
	Intermediates			
	Daytime		**Night-time**	
	W/B	**FD**	**W/B**	**FD**
Static	42.60	43.74	44.30	30.64
Dynamic	15.85	15.85	23.35	19.78
% Reduction	62.79	63.76	47.29	35.44

Table 7: Differences in static and dynamic reading distances

3.1.2. Reading angles

Reading angles – Measurements

Figure 9 shows the mean horizontal angle at which the participants could confidently read each of the displays. The findings indicate that:

- there was no difference between the technologies for participants with a visual impairment by daytime and night-time,
- the Y/B has a wider forward viewing angle than the other displays by daytime and night-time,
- W/B has a wider forward viewing angle than FD at night-time.

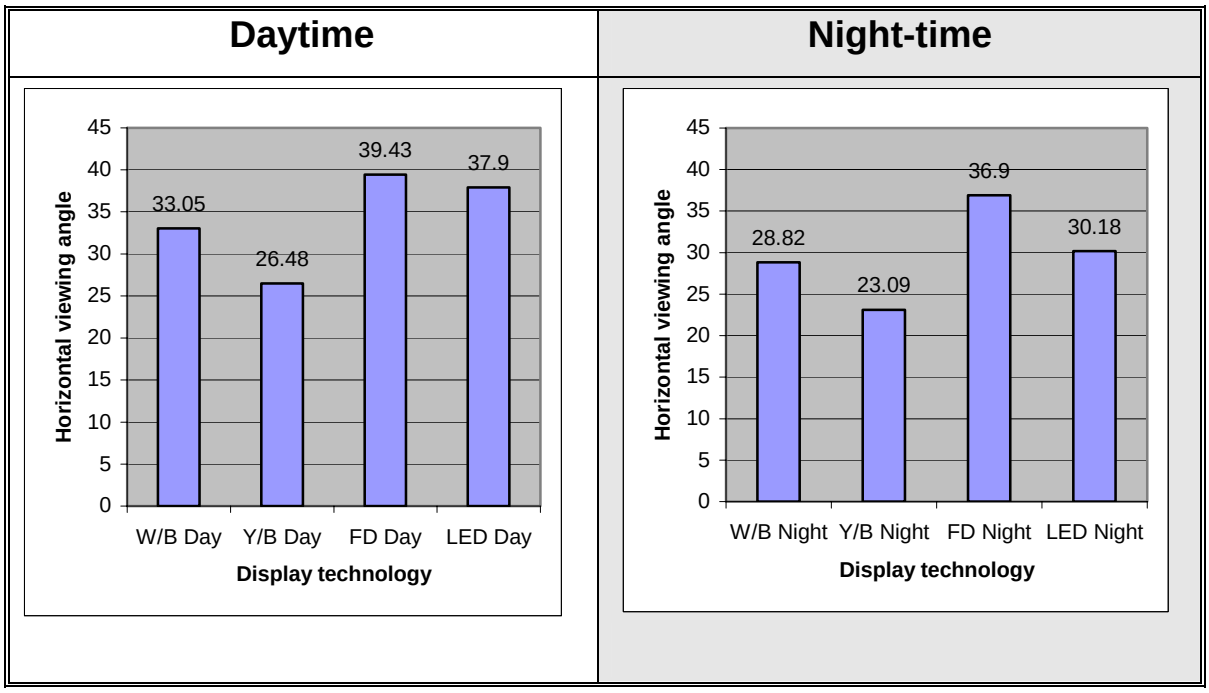


Figure 9: Mean reading angle

<u>It should be noted</u> that the findings above for the participants without a visual impaired for FD might be unfavourably biased

due to the greater recessing of this display within the vehicle compared to the others.

Reading angles – Ratings

The participants were asked to rate the ease of reading the displays at an angle using the scale in Figure 10.

In terms of reading the information (Number, Final Destination or Intermediates) would you rate the display as:

1	2	3	4	5
Very poor	Poor	OK	Good	Very good

Figure 10: Rating scale

The findings, illustrated in Figure 11 show that:

- In daytime conditions there was no difference between the technologies for those participants without a visual impairment and those with a visual impairment.
- In night-time conditions the printed displays were more favourably rated by participants without a visual impairment.

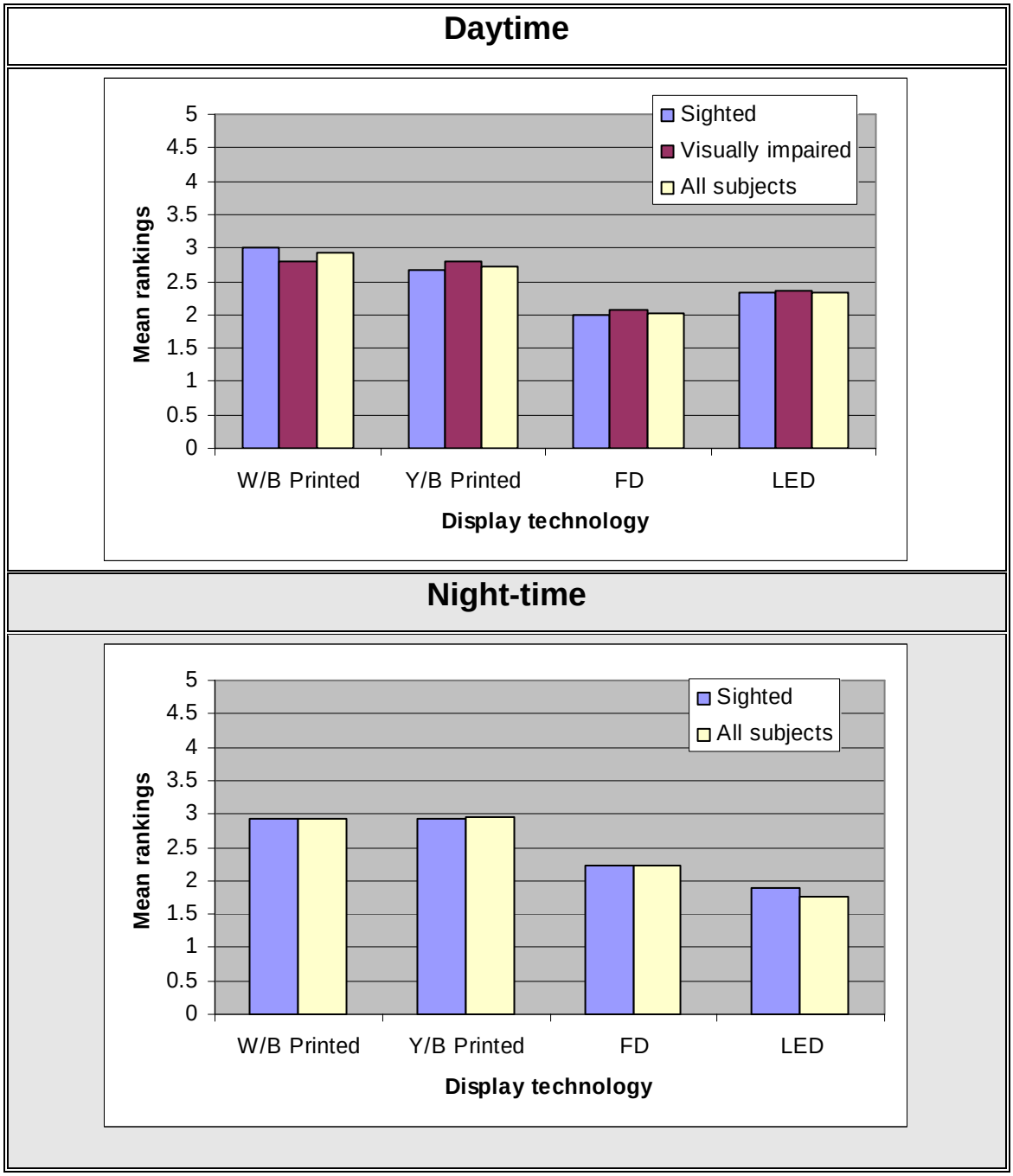


Figure 11: Mean ratings for reading angles

3.1.3. Participant comments

When the participants were asked which technology they preferred, the printed displays were significantly more preferred than the flip-dot and LED displays. It should be remembered that these opinions were based on technologies for which all aspects could not be controlled, therefore it is possible that:

- The printed, white on black, display had a favourable bias due to its larger text size,
- The flip-dot display had an unfavourable bias due to its age and greater recessing in the vehicle,

The participants were then invited to elaborate on their opinions of the different display technologies and these are summarised in Table 8 below.

Printed displays			
Positive comments		**Negative comments**	
Bold	4	Cluttered text	2
Clear	3	Thin, small text	1
Better to read	1		
Good at night	1		
Size	1		
Uncluttered	1		
Flip-dot displays			
Positive comments		**Negative comments**	
Clear at distance	3	Unclear (when close)	4
Well defined	1	Difficult to read/decipher	3
		Cluttered	1
		Needs to be brighter	1
LED displays			
Positive comments		**Negative comments**	
Bright at night	1	Angularity problems	3
Clear at distance	1	Unclear (when close)	2
		Hurt eyes	1
		Difficult to read	1

Table 8: Participants' comments regarding display technologies

The comments suggest that:

- Printed displays – bold and clear but text somewhat cluttered,
- Flip-dot – clear at a distance but difficult to read especially when close to,

- LED – Bright at night and clear at distance but problems with clarity close to as well as angularity.

3.2. Amount of information

Figure 12 shows the mean reading time for different amounts of information presented on the front of the vehicle. The findings indicate that:

- the route number and final destination could be read significantly quicker without the addition of one or more intermediates,
- the route number, final destination and one intermediate could be read significantly quicker than the route number, final destination and three intermediates,
- this was true for both participant groups.

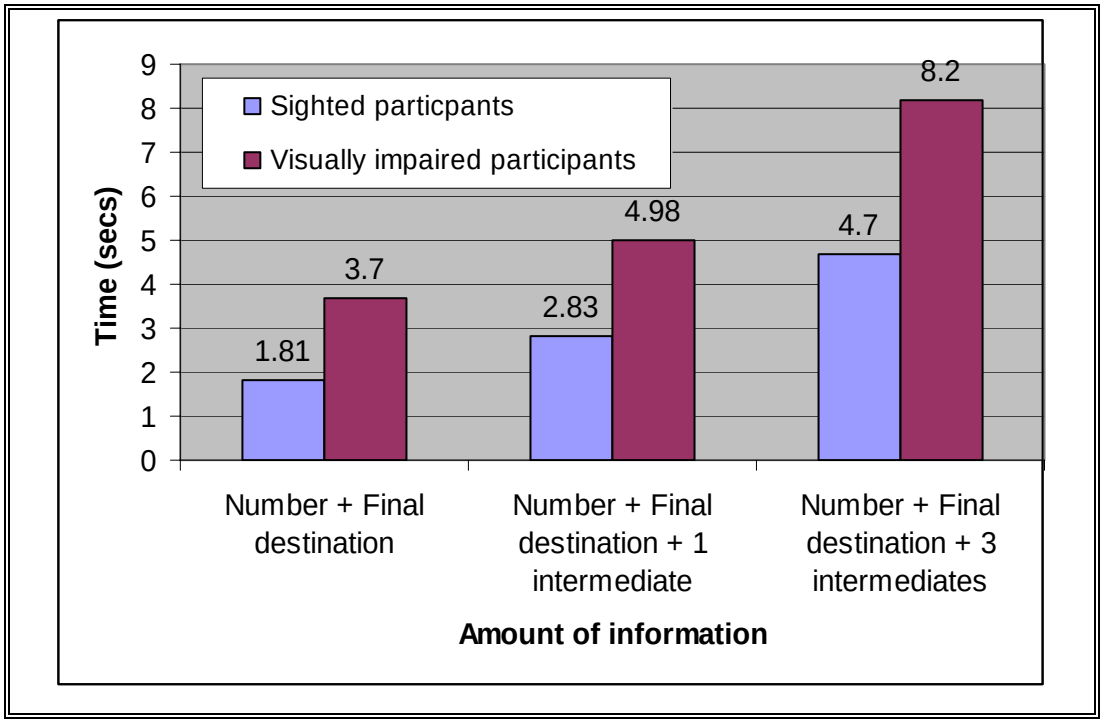


Figure 12: Mean reading time and amount of information

3.3. PSV use

3.3.1. Frequency of use

Table 9 shows the frequency of bus use, accompanied and unaccompanied, by the field trial participants.

	Accompanied use	Unaccompanied use
Daily	4	12
Weekly	6	5
Monthly	4	0
Quarterly	2	2
Annually	0	1
Never	5	2
Not applicable	1	0

Table 9: Table to show frequency of bus use

3.3.2. Identification of approaching vehicle as a bus

For all participants the size and colour of the vehicle, and then the presence of a number on it, were the most used means for identifying it as a bus. Shape and sound were the least used factors. Refer to Figure 13.

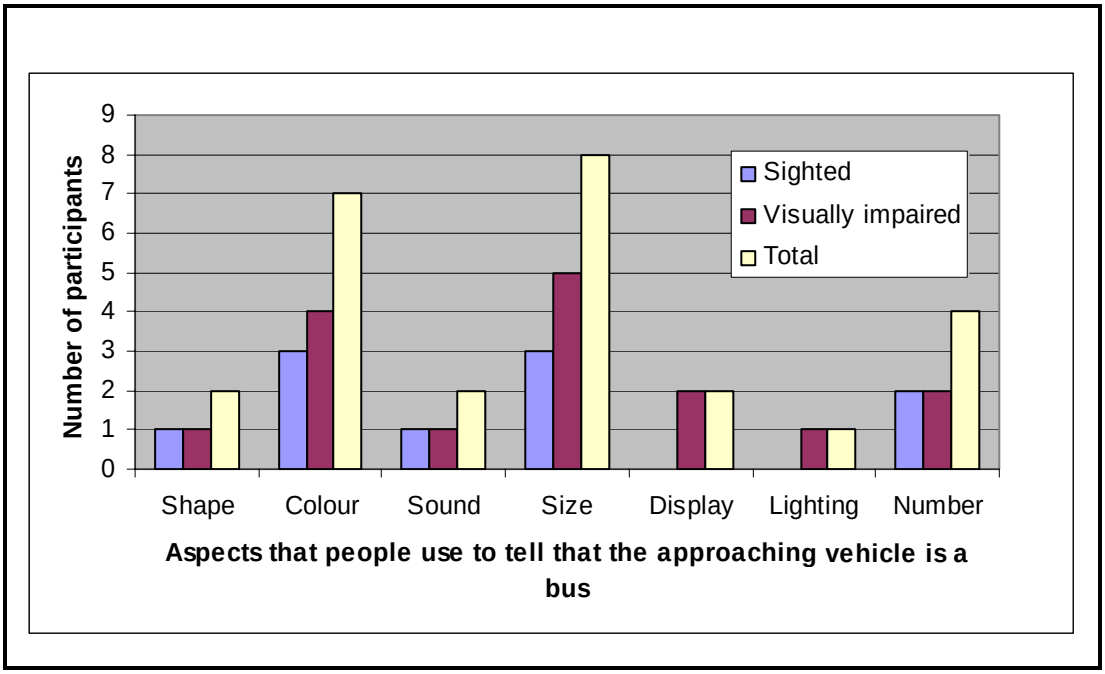


Figure 13: Aspects used to identify approaching vehicle as a bus

3.4. Display use

3.4.1. Importance of displays

When the participants were asked if they considered that they could manage to use the bus without the front, side or rear displays, there was agreement between both sets of participants that they would have most difficulty in using a bus without its front display; the reverse being true for the rear display. With respect to the side displays, these were of more importance to the participants with a visual impairment than to those without a visual impairment. Of those participants with a visual impairment who expressed a preference, there was an equal split as to whether they were able to use the bus without the side display. Refer to Table 10. This suggests that the front display is considered to be the most important display on the

vehicle and statistical analysis confirms this superiority over the side and rear displays.

Participants	Do you consider that you would be able to use a bus without the . . .					
	Front display		Side display		Rear display	
	Yes	No	Yes	No	Yes	No
All	2	15	16	3	20	1
Visually impaired	2	7	4	3	6	1
Sighted	2	11	12	1	11	1

Table 10: Importance of bus displays

3.4.2. Ratings of readability

For the participants with a visual impairment, approximately two-thirds rated the readability of the front, side and rear displays unfavourably. For participants with no visual impairment, nearly all gave favourable ratings for the front and rear displays falling to about a half for the side displays. Refer to Table 11.

Participants	Very poor	Poor	OK	Good	Very good	Not used
Front display						
All	3	2	10	5	2	0
Visually impaired	3	2	2	2	0	0
Sighted	0	0	8	3	2	0
Side display						
All	2	7	6	2	1	4
Visually impaired	2	3	2	0	1	1
Sighted	0	4	4	2	0	3
Rear display						
All	2	3	8	3	0	6
Visually impaired	2	2	1	1	0	3
Sighted	0	1	7	2	0	3

Table 11: Ratings of display readability

3.4.3. Aspects making reading displays difficult

The number being too small was a major factor in making the display difficult to use for all participants, followed by glare and reflection. Additionally the sighted participants stated that the presence of the sun and information misalignment also made displays difficult to use. Refer to Figure 14.

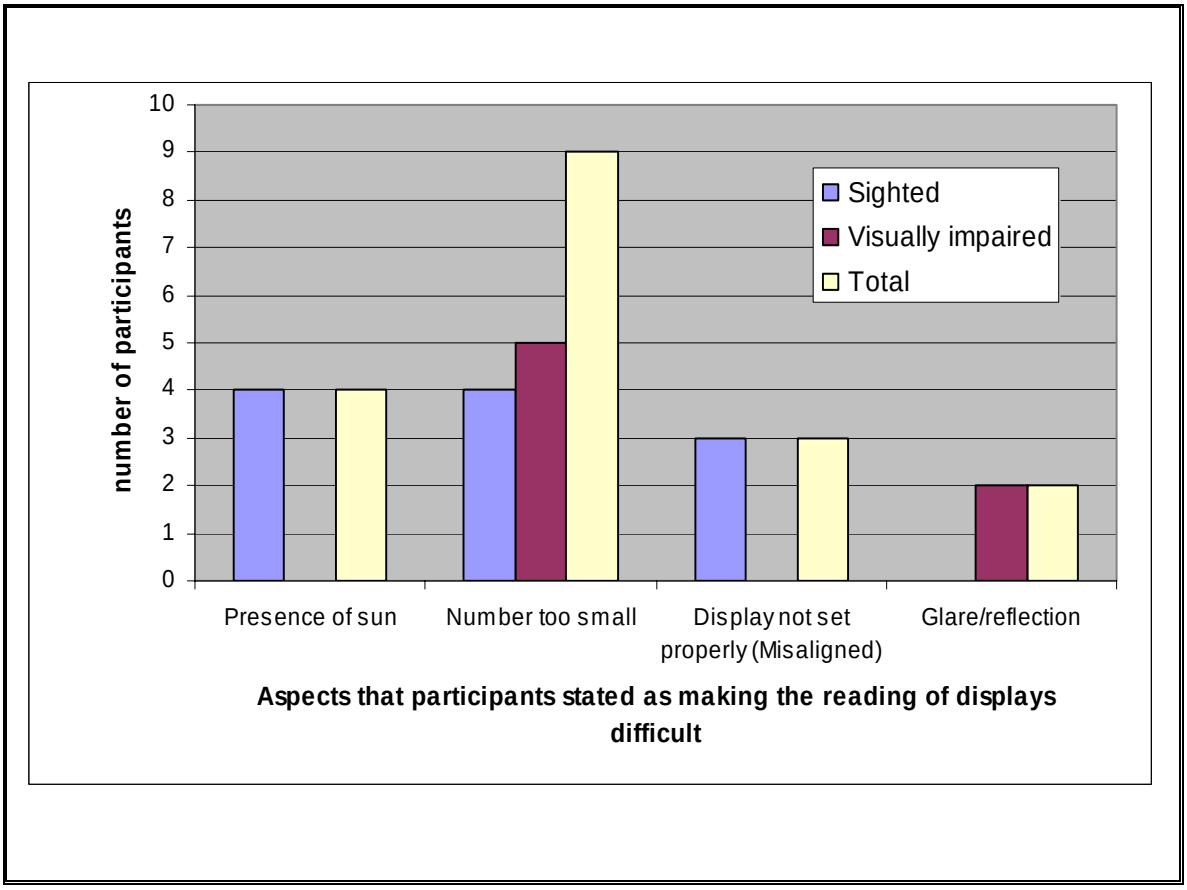


Figure 14: Aspects that make the reading of displays difficult

3.4.4. Aspects assisting reading displays

Large print was the main factor for both participant groups, which made reading the display easy. The display being white on black and being lit up were also cited as favourable aspects (Refer to Figure 15). It should be noted that the experimenters observed a favourable bias towards the printed white on black display in comparison to the other technologies; whilst this may have been a true effect further causal factors for this may have included: the larger characters in the displays, the newness of the displays and buses, the exposure of the participants to these buses in the locality, etc.

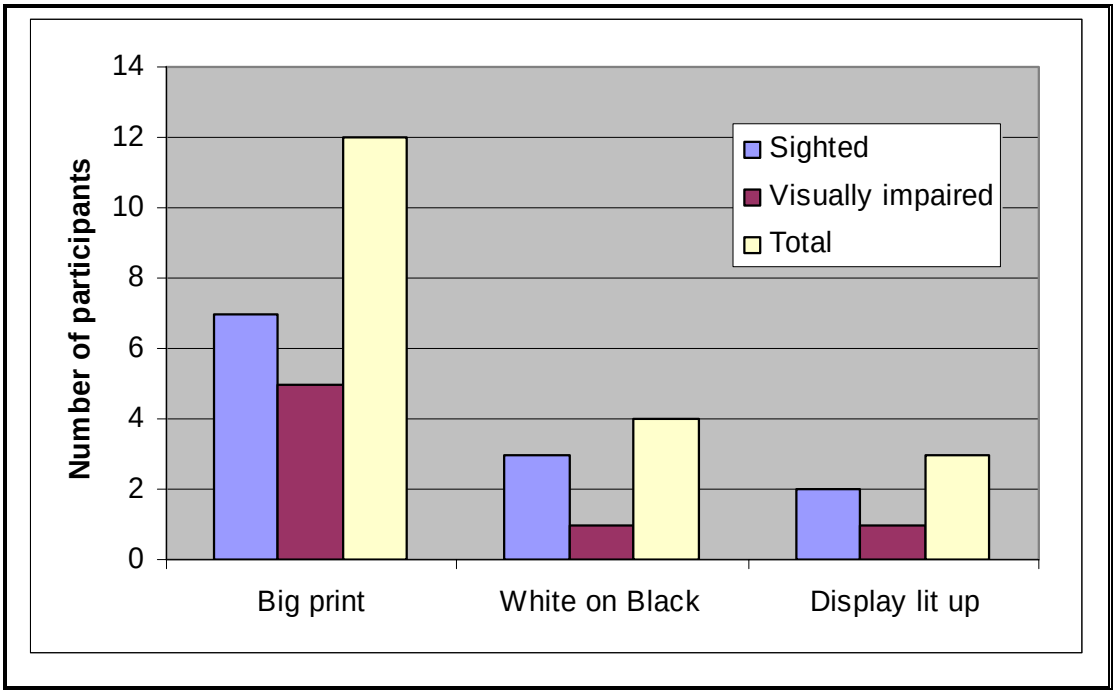


Figure 15: Aspects that make the reading of displays easy

3.5. Display elements

3.5.1. Importance of display elements

When the participants were asked if they could manage to use the bus without the route number, final destination and intermediate display elements there was agreement between both groups of participants that the element they could least do without was the route number followed by the final destination and then the intermediates. Refer to Table 12. This implies that the route number is the most important element within the display and statistical analysis confirms its superiority over the final destination and the intermediate elements.

Participants	Route number		Final destination		Intermediates	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**
All	3	17	11	4	16	2
Visually impaired	1	7	6	1	7	1
Sighted	2	10	5	3	9	1

Table 12: Importance of display elements

3.5.2. Layout of display elements

Visualisations of different layouts of front displays were developed and each participant was asked to indicate which they preferred.

Route number

With respect to where the route number should be located within the front display, participants with a visual impairment expressed a preference for the route number to be located to the right-hand side of the display whilst the sighted participants were equally divided as to its location to the right or left. Refer to Table 13.

Participants	Right-hand side	Left- hand side	No preference
All participants	12	8	2
Visually impaired	6	2	1
Sighted	6	6	1

Table 13: Preference for the location of the route number within the front display

The majority of both groups of participants stated that they had a strong to very strong preference for the location of the route number that they had expressed. Refer to Table 14.

Participants	1	2	3	4	5
All	2	2	1	4	11
Visually impaired	1	1	0	0	6
Sighted	1	1	1	4	5

1 = Slight preference

5 = Very strong preference

Table 14: Strength of preference for preferred location for route number

Final destination

With respect to where the final destination should be located in relation to the route number, the majority of participants in both participant groups expressed a preference for the final destination to be located below the route number. Refer to Table 15.

Participants	Above	Adjacent	Below	No preference
All	5	3	13	1
Visually impaired	1	2	6	0
Sighted	4	1	7	1

Table 15: Preference for the location of the final destination within the front display

Whilst the majority of both groups of participants stated that they had a moderate to very strong preference for the final destination location that they had expressed above, the preferences were less extreme than those expressed for the route number. Refer to Table 16.

Participants	1	2	3	4	5
All	1	2	7	3	7
Visually impaired	0	1	2	2	3
Sighted	1	1	5	1	4

1 = Slight preference

5 = Very strong preference

Table 16: Strength of preference for preferred location for the final destination

3.6. Display design

3.6.1. Current good practice

When the participants were asked what they considered constituted a good display, for both groups clear numbers was the most frequently cited response. Large destinations were also favoured, although for the sighted participants colour (yellow on black) was considered to be important. Refer to Figure 16.

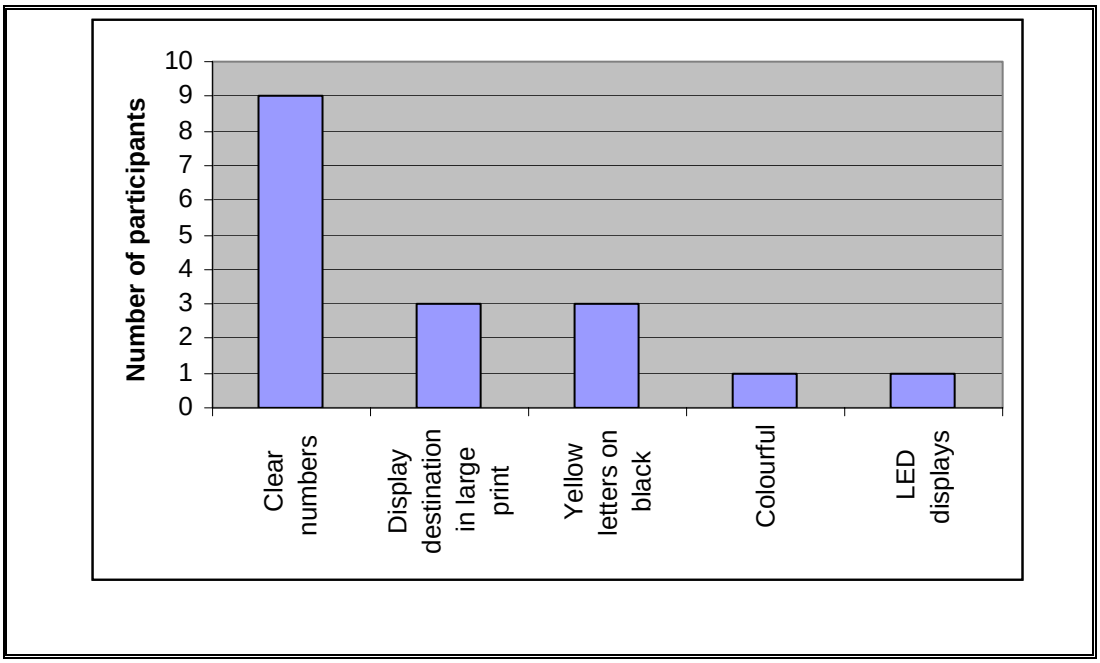


Figure 16: Good aspects to current information design

3.6.2. Improvements

When the participants were asked how they considered that displays could be improved, larger numbers was the most frequently cited response. Bigger displays and elements within them were important to the participants with a visual impairment

whilst standardised signs and timetable information were important to the sighted. Refer to Figure 17.

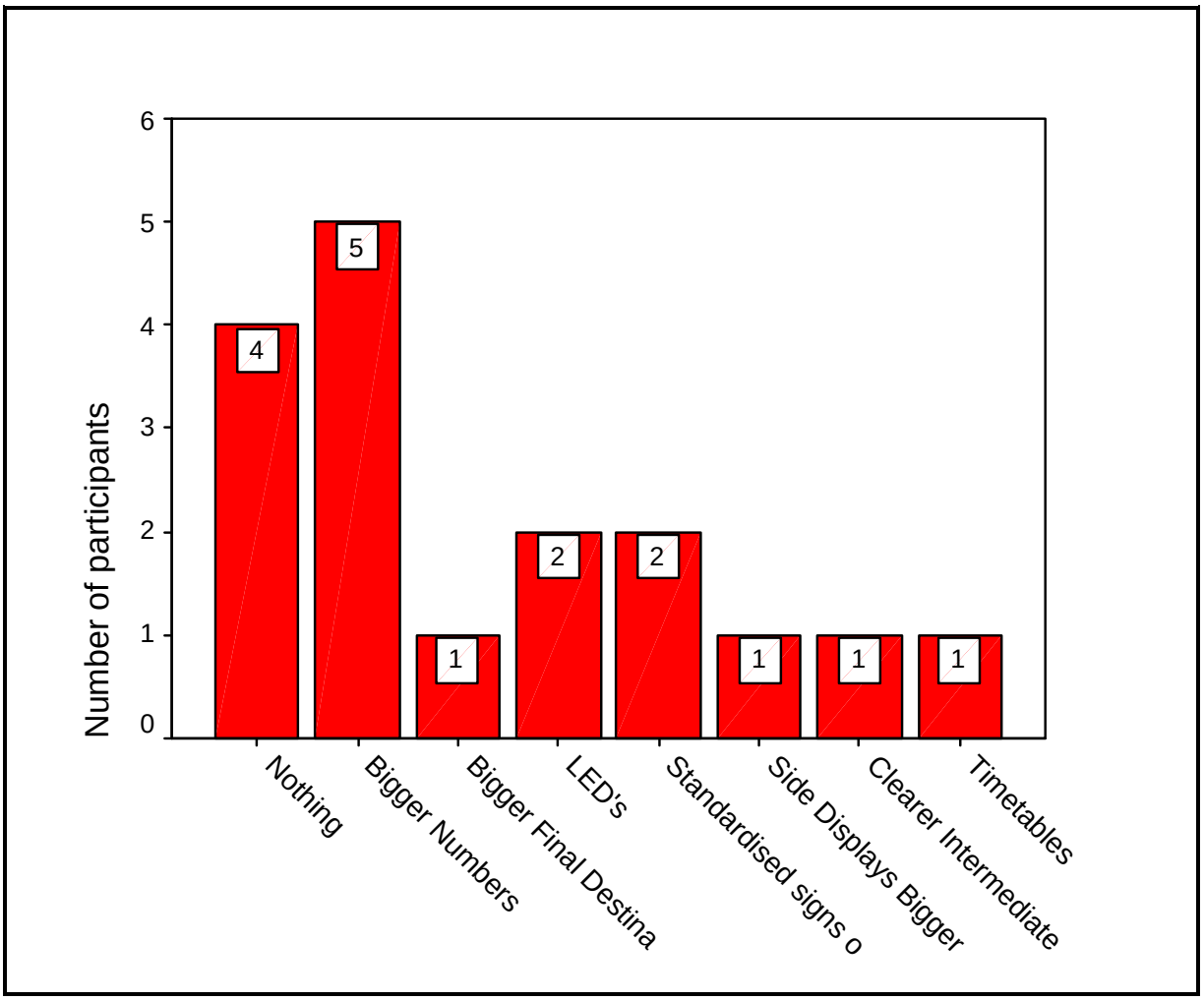


Figure 17: Improvements to display design

4.0 Summary of findings

4.1. Technology

When corrected for character height, the different display technologies performed on a par as measured by reading distance. Significant differences were however found for the sighted participants under daytime conditions in which the LED display outperformed the printed white on black and flip-dot displays.

When assessed dynamically it was found that reading distances were significantly reduced for the printed white on black (day and night) and flip-dot displays (day only).

In terms of the width of the forward reading angle, there was no difference between the technologies for the participants with a visual impairment by daytime or night-time. For the sighted participants the printed yellow on black display was significantly better than the other technologies both day and night as was the printed white on black display over the flip-dot display by night.

Subjectively the printed displays had more favourable comments. Whilst the LED display was commented on as being bright at night, it was, like the flip-dot display considered to be difficult to read close up. Additionally the LED suffered from problems with angularity.

4.2. Character height

Table 17 indicates that 95% of the passengers without a visual impairment can read the display at 66m, therefore displays would need to increase to nearly three times their current size for this 95% to read the displays at 180m (ideal stopping distances). For the visually impaired passengers to achieve the same level of readability, the size would have to increase further and such a level is beyond the bounds of the design of displays in their current forms.

Route number (Character height 200mm)						
Participants able to read display	95%		50%		25%	
Participant group	NVI	VI	NVI	VI	NVI	VI
Reading distance – Field (m)	66	4	113	17	131	40
Final destination (Character height 125mm)						
Participants able to read display	95%		50%		25%	
Participant group	NVI	VI	NVI	VI	NVI	VI
Reading distance – Field (m)	54	2	73	8	91	17

Table 17: Dynamic reading distances

(The viewing distances given in the table above differ to those calculated for the laboratory trials. This is considered to be due to a variety of factors including differing font styles and differing visual conditions of the participants).

Since it is not possible to achieve suitable reading distances, an alternative approach is to try to equate the reading distance of the participants with a visual impairment with the levels currently experienced by the participants without a visual impairment.

Route number

From the table above, it can be calculated that:

- For 95% of the passengers with a visual impairment to achieve the reading distance of the sighted, character height would need to be increased by a factor of 16.5 (66/4) to 3,300mm,
- For 50%, the character height would need to be increased by a factor of 6.65 (113/17) to 1,329mm,
- for 25%, the character height would need to be increased by a factor of 3.28 (131/40) to 655mm.

Final destination

Using the worst case figures in the above table, it can be calculated that:

- For 95% of the passengers with a visual impairment to achieve the reading distance of the passengers without a visual impairment, character height would need to be increased by a factor of 27 (54/2) to 3,375mm,
- For 50%, the character height would need to be increased by a factor of 9.13 (73/8) to 1,141mm,
- For 25%, the character height would need to be increased by a factor of 5.35 (91/17) to 669mm.

In addition, height increases described above would need to be further increased to compensate for reduced dynamic reading distances compared to static reading distances. Refer to section 4.1.

4.3. Type of information

4.3.1. Type of display

The front display was found to be significantly more important to the use of the bus by both groups of participants and the side display was found to be more important to visually impaired participants than the sighted participants.

In general the majority of the sighted participants rated the display readability favourably, the reverse being true for the visually impaired participants indicating the difficulty of the latter group in reading bus displays generally.

4.3.2. Display element

The route number was found to be significantly more important to the use of the bus by both groups of participants.

4.4. Amount of information

The findings indicate that for both participant groups the addition of even one intermediate stop significantly increases

the reading time of the display information above that of just the route number and final destination.

4.5. PSV use

Both groups of participants primarily use vehicle size and colour as a cue to whether or not the approaching vehicle is a bus followed by the presence of a route number on it.

4.6. Display use

Features, cited by both participant groups, which made the displays difficult to read were the number being too small, followed by glare and reflection. Additionally the participants with a visual impairment stated presence of the sun and information misalignment.

Features that assisted display reading were large print followed by the display being well lit. (The use of white on black was also cited but this may have been an artefact of character height, favourable bus age and /or greater exposure).

4.7. Display layout

Images of simulated bus displays in which only the location of the information changed were used as a means for minimising the influence of local practices in display layout. On viewing these images, the majority of the visually impaired participants expressed a preference for the route number to be to the right

of the display whilst for the sighted participants there was no consensus. For the majority of participants in both groups the preferences given were rated as strong to very strong, although this was more pronounced for the visually impaired participants.

The majority of the participants in both groups also stated a preference for the final destination to be displayed below the route number and the preferences given were rated as moderate to very strong.

4.8. Display design

Both participant groups stated clear numbers constituted a good design of display. Large destinations were also favoured, although for the sighted the colour (yellow on black) was considered to be important.

For both participants, larger numbers was the most frequently cited method of improving bus displays in the future. Bigger displays and elements within them were important to the visually impaired participants whilst standardised signs and timetable information was also important to the sighted.

Appendix 1: Field trials questionnaire

PERSONAL DETAILS

1. Identity number: .....

2. Subject group: Non visually impaired (1) Visually impaired (2) .....

3. Name: .....

4. Age: .....

5. Address incl postcode: .....

.....

.....

6. Telephone number:

VISUAL CONDITION

7. What is the medical term for your impairment?

Don't know (0) Macular degeneration (1) Glaucoma (2)

Retinitis Pigmentosa (3) Diabetic Retinopathy (4) Hemianopia (5)

Cataracts (6) Albinism (7) Other (please state)

8. Could you please describe the type of material that you are able to read?

Don't Know (0) Newspapers (1) Standard books (2)

Large print books (3) Other, please state:

9. At what age did you become visually impaired?

0-10 (1) 41 –50 (5) 81 plus (9)

11 –20 (2) 51 – 60 (6)

21 –30 (3) 61 – 70 (7)

31 – 40 (4) 71 – 80 (8)

MOBILITY

10. Do you use a mobility aid when outside?

Yes No Sometimes

a) If yes or sometimes, please could you describe what type of aid this is:

Long cane Symbol cane Guide cane

Guide dog Monocular

Other (please state)

11. Do you have any other disabilities or health problems which affect your ability to walk or use public transport?

Yes No (2)

a) If **yes**, please could you describe this

Long cane (3) Symbol cane (4) Guide cane (5)

Guide dog (6) Monocular (7) Other, please state

BUS USE (Not minibus)

12. How frequently do you travel by bus **accompanied**?

Daily (1) Weekly (2) Fortnightly (3)

Monthly (4) Quarterly (5) Annually (6)

Never (0)

13. How frequently do you travel by bus **Unaccompanied**?

Daily (1) Weekly (2) Fortnightly (3)

Monthly (4) Quarterly (5) Annually (6)

Never (0)

14. How do you identify an approaching vehicle as a bus?

15. How do you know if you are getting on the right bus?

16. What are the most difficult aspects for you when using a bus?

1)	5)
2)	6)
3)	7)
4)	8)

17. What information do you first look for on the front of an approaching bus?

18. Could you manage to use the bus service without:

a) the Route Number	Yes (1)	No (2)	Possibly (3)	Don't know (0)
b) the Final Destination	Yes (1)	No (2)	Possibly (3)	Don't know (0)
c) the Intermediate stop names	Yes (1)	No (2)	Possibly (3)	Don't know (0)

EASE OF READING

19. What things make reading the route and destination information displayed on the front of the bus **difficult** for you? (Prompt re:low sun)

20. What things make reading the route and destination information displayed on the front of the bus **easy** for you?

FRONT, SIDE AND REAR DISPLAYS

21. Could you manage to use the bus service without:

a) the Front display	Yes (1)	No (2)	Possibly (3)	Don't know (4)
b) the Side display	Yes (1)	No (2)	Possibly (3)	Don't know (4)
c) the Rear display	Yes (1)	No (2)	Possibly (3)	Don't know (4)

GENERAL QUESTIONS

22. What do you think is good about the current design of bus destination information?

23. What would you like to see improved?

24. Do you have any further comments, which you would like to make concerning the route and destination information displayed on buses?

25. Could you please describe your level of difficulty concerning your vision i.e. how it affects your daily life

VISUAL ABILITY

26 Snellen reading

a) Right: ..... b) Left: ..... c) Both: .....

27. N-print .....

28. Are you colour blind?

Yes (1) ..... No (2) ..... Don't know (3) .....

DESTINATION INFORMATION

29. How would you rate the reading of destination information on the **front** of buses?

0	1	2	3	4	5
Not used	**Very poor**	**Poor**	**O.K**	**Good**	**Very good**

30. How would you rate the reading of destination information on the **side** of buses?

0	**1**	**2**	**3**	**4**	**5**
Not used	**Very poor**	**Poor**	**O.K**	**Good**	**Very good**

31. How would you rate the reading of destination information on the **rear** of buses?

0	**1**	**2**	**3**	**4**	**5**
Not used	**Very poor**	**Poor**	**O.K**	**Good**	**Very good**

32. In terms of helping you to use bus services, please could you mark on the scale below the relative importance to you of the route number, the final destination and the intermediate stop names.

Not at all important — **Very important**

INFORMATION LAYOUT

33. When looking at the front of the bus should the route number be to the RHS or LHS of the information display. (Show pictures)

Picture A	Picture B	Picture C
RHS (1)	LHS (2)	No preference (3)

a) If you expressed a preference as to where the number is displayed, please could you indicate how strongly you feel about this using a scale of 1-5, where 1 is slight preference and 5 is a very definite preference.

1 2 3 4 5

Slight preference — **Very strong preference**

34. When looking at the front of the bus should the final destination name be above, adjacent or below the route number. (Show pictures)

Picture D	Picture E and F	Picture G	
Above (1)	Adjacent (2)	Below (3)	No preference (0)

a) If you expressed a preference as to where the number is displayed, please could you indicate how strongly you feel about this using a scale of 1-5, where 1 is slight preference and 5 is a very strong preference.

1 2 3 4 5

Slight preference **Very strong preference**

35. Do you have any further comments concerning the layout of the information displayed on the front of the bus?

FRONT, SIDE AND REAR DISPLAYS

36. Displays can be found to the front, side and rear of buses, please could you mark on the scale below the relative importance of these to you

Not at all important **Very important**

37. Could you manage to use the bus service without:

a) the Front display	Yes (1)	No (2)	Possibly (3)	Don't know (0)
b) the Side display	Yes (1)	No (2)	Possibly (3)	Don't know (0)
c) the Rear display	Yes (1)	No (2)	Possibly (3)	Don't know (0)

TECHNOLOGIES

38 Insert participant opinions concerning their likes/dislikes of the relative technologies

	PRINTED	FLIP-DOT	LED
Likes			
Dislikes			

39. Of the different types of displays which you have seen while working with us, please could you indicate on the scale below your relative preference

Least preferred — **Most preferred**

LETTER CASE

40. Do you have any preference for how the places names are displayed?

Capitals (1) Mix (lower case with capital at start) (2) No preference (3)

Other, please state

GENERAL QUESTIONS

41. What do you think is good about the current design of bus destination information?

42. What would you like to see improved?

43. Do you have any further comments, which you would like to make concerning the route and destination information displayed on buses?

Thank the participant for their time