COMPETITION: Electric vehicle charging for public spaces: real-world demonstrators

PROJECT TITLE

Scaling On-Street Charging Infrastructure (SOSCI) Project No: 34290

Periodic Report

Period: Q8

‘Disabled Driver Investigations User Trial Report’

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1. EXECUTIVE SUMMARY

This report is one of a series prepared under the SOSCI project.

This report covers the on-site investigation in October 2021 using an actual EV charge point and several volunteers with various disabilities which affect their ability to use a standard EVCP.

By way of providing an overview to the challenges of the disabled driver, these photos from the trial are a good indication.

1.1. Key Findings

- The trial was set up in a car park in County Durham where EVCPs had been installed earlier as part of the SOSCI project
    - The trial site had three operational Alfen CPs on the MER network, including two models with different socket height: two single-socket devices and a higher twin-socket unit
    - In addition to the installed charging devices, a mock-up device was set up to test initial theories developed during the Project's Stage 2 in regard to a possible inclusive socket height and protection bollard arrangement.
- On the day we had 16 potential participants and several passers-by who made enquiries around electric vehicles and electric vehicle charging.
    - We achieved 13 full sets of data from the participants who completed all activities.
    - The participants included 6 wheelchair users, 6 ambulant disabled persons and one non-disabled person
    - The large majority of participants, 11 persons (84.6%) were over the age of 45
- The tasks were categorised as follows;

Task 1:	Bay and Cable
Task 2:	940mm socket height charging device
Task 3:	1065mm socket height charging device
Task 4:	850mm socket height (mock-up) charging device, on loan from MER

- Challenges Identified by the participants
    - Managing the cable
    - Protective bollards
    - Initiating charging – card or fob reader or otherwise
    - Sockets and/or flap cover
    - Screen information
    - Parking bay size and markings
- A total of 32 recommendations have been made – see Section 5.1

1.2. Foreword

This project for development of guidance standards for EV charging facilities is supported by funding from OZEV via Innovate UK, and forms part of the Scaling On-Street Charging Infrastructure (SOSCI) project led by Cybermoor Services Ltd.

This report has been prepared by Access Consultancy Support.

1.3. Acknowledgements

The user trial event held 6 October at Sniperley Park and Ride in Durham was largely successful thanks to the involvement of all who willingly and patiently participated in the trial tasks, and the involvement during the event of members of the Access Association Northeast Regional Group and the Durham City Access for All Group. The authors are especially thankful to Joanne Kelley, Durham County Council Equalities Officer, for her pivotal role in communications with local disability groups and also as a trial task monitor throughout the event.

2. INTRODUCTION

The Stage 2 Report, issued 17 September 2021, investigated EV charging device accessibility for people with mobility impairments: the proposed relationship between charging device and bollard protection and proposed chargepoint physical installation requirements. The outputs from that investigation were:

- Guidance for EV Chargepoint Installers
- Templates for Installers application in a variety of site configurations and charging device configuration. The templates are in the form of checklists with companion model layout diagrams for application by installers as appropriate to site.

Additionally, we proposed a user-group trial involving disabled people, including existing and prospective drivers of electric vehicles, to test the proposed relationship between vehicle bay and charging device configuration with bollard protection, using a mock-up charging device with socket centreline located at 850mm above ground.

As outlined in the Stage 2 report, the outcomes of this user-group trial report is expected to further inform the issues considered by the Stage 2 Report and the documented guidance and templates developed for chargepoint installers; as well as informing the issues discussed in the Stage 3 Report that may require further consideration by designers and manufacturers of EV charging equipment and potentially for future electric vehicle design.

The information and conclusions within this report are compiled from data collected during a one-day service user-trial event. The event was specifically arranged and staged to provide data on user needs with respect to the use of public EV charging facilities by persons with impairments affecting their mobility and reach capabilities. The aim of the event was to provide such user information to aid determination of appropriate standards for the provision of EV Charging facilities that can satisfy the widest possible needs of disabled persons who may need to re-charge an electric vehicle.

2.1. Report Structure

The report has the following main sections:

- Report on Findings, including the CP design considerations
- User Trial Results and Data Review including recommendations
- Appendices
    - Summary of Recommendations
    - Analyses of results
    - Report on participant contribution

The following Executive Summary provides an overview of the event and outcomes of the data review. A Summary of Recommendations is provided later in the report along with the collated user trial results.

3. REPORT ON FINDINGS

3.1. Trial Set-up & Structure

On 6 October 2021, a user-trial was conducted at Sniperley 'Park and Ride' in the City of Durham. The choice of location was based upon several positive factors, including: this project's connection with Durham County Council; an earlier online presentation and consultation with Durham City Access for All Group for this project; and the potential availability of other local disability groups. The Sniperley site was also selected due to its location on the outskirts of the city, with good access available from the local major road network, the available city bus services, and on-site accessible facilities.

The trial site had three operational Alfen charging devices on the MER Charging UK network, including two models with different socket height: two single-socket devices and a higher twin-socket unit. The two charging device versions also had dissimilar electronic information screens and protective bollard arrangements in relation to the charging devices. These variations in features combined to augment the testing environment. Importantly for the user-trial, the site layout provided level access to the chargepoints. Finally, in addition to the installed charging devices, a mock-up device was set up to test initial theories developed during the Project's Stage 2 in regard to a possible inclusive socket height and protection bollard arrangement.

Figure 1: User trial participants and observers in event area of site during user trials

Although information was issued well in advance of the event to several local disability groups and other parties, the response was less than anticipated. However, on the day we had 16 potential participants and several passers-by who made enquiries around electric vehicles and electric vehicle charging.

Even though there was not enough time available for all who attended to complete the event activities, we consider the event overall to have been largely successful: during which we achieved 13 full sets of data from the participants who completed all activities. The results collected during the trial include data from tasks completed by 6 wheelchair users, 6 ambulant disabled persons and one non-disabled person.

The outcomes of the event have been very revealing and instrumental in making our subsequent determinations in response to the data, participants' comments, and observation during the event.

Though we are of the opinion that further user-testing is required, we have sufficient confidence to update our earlier Stage 2 proposals for the design of accessible EV charging facilities, that are now supported by this new data from user involvement and testing as well as the existing published data and standards we have previously referenced in the 'BS8300:2018 Code of Practice for the accessible and inclusive design of the built environment'

The large majority of participants, 11 persons (84.6%) were over the age of 45. Although there was only one participant who did not identify themselves as a disabled person, we consider the age range may be fairly representative of the UK age groups most likely to currently have or consider having an electric vehicle as their primary means of personal transport; and as such there appears to be a likelihood of a significant proportion of drivers having impairments that may affect their day-to-day life and thereby affecting their use of EV charging infrastructure and their need for such facilities to be more accessible and inclusive.

Before participants commenced the planned tasks, monitoring information was voluntarily obtained from each, including measurements of their approximate head height and eye level, and their permission for our use of photographic materials in connection with the project, for reporting, and future presentations. A brief questionnaire was also completed with each participant for local authority monitoring on involvement of persons with regards to disability, gender, and age group.

In advance of the user-trial, data collection sheets were prepared for each potential participant relating to their use of the following:

Task 1:	Bay and Cable
Task 2:	940mm socket height charging device
Task 3:	1065mm socket height charging device
Task 4:	850mm socket height (mock-up) charging device, on loan from MER Charging UK

While undertaking the individual tasks, each participant was monitored and were asked a series of questions related to their experience of using a charging cable and the three charging devices: to rate the tasks on a scale of 0 to 5 (with 5 being easy); and to provide comments on screen information display, printed information and any other comments on their use of the cables and charging devices. The collated data from participants' scores for each task, answers to questions and their comments, formed the basis for review and considerations; such considerations have also been informed by observations from monitoring of the participants' activities. The review of the collated information is discussed in the body of the report, from which conclusions have been developed as far as possible on the basis of current knowledge and, where possible, recommendations have been developed to inform current guidance. For ease of recognition within this report, the three chargepoint devices are referred to on the basis of their socket (centre-line) height above ground, as listed above for participant tasks 2, 3 and 4.

3.2. Bay and Cable Data

Individuals were asked to obtain the charging cable from the boot of a vehicle and then connect the cable between the vehicle and charging device. Participants were observed during the task and the space they each required to perform this task in the aisle adjacent to the vehicle. As expected, side aisle width of 1200mm was adequate for the majority of users, other than two powered wheelchair users who required wider turning space when manoeuvring to connect and disconnect the cable at side of vehicle. None of the participants required more than 1500mm aisle width during this task at side of the vehicle. However, based on the existing published Department of Transport research data in BS8300-2:2018[1], we continue to advise a preferred 1600mm-wide side aisle width, and a minimum width of 1500mm where existing space constraints prevent increased provision.

Figure 2: Participant with cable in monitoring space at side of vehicle for task 1

3.3. Charging Cables

It was evident from the data that use of a cable and interaction with a vehicle and charging device is heavily reliant on an individual's ability and capacity. The results may also be influenced to some degree by the disposition of an individual and how they manage their impairment, particularly when faced with new or unfamiliar tasks, as in this trial event. Many participants had some problem with the cable, either to remove the dust cover from the plug end, moving with the cable, or when trying to re-coil the cable after use. Crutch users in particular had problems moving around with the cable.

The overall results for all activities associated with this task was below 80% success, for the participants' experience of using a cable to connect between a vehicle and chargepoint, indicating that charging an electric vehicle with the current equipment available is likely to be problematic for most drivers with impairments: suggesting there is urgent need for improvement in both the design and the technology of Electric Vehicles and EV charging equipment. Such issues are considered further in section 4.5 of this report and in the Stage 3 Report.

Where possible, the weight of a cable should be as light as is absolutely necessary to satisfy the required electrical duty and safety regulations.

[1] BS 8300-2:2018 Design of an accessible and inclusive built environment: Part 2 Buildings – Code of practice, Annex G Space allowances for wheelchair manoeuvring and Tables G.2 and G8 - Dimensions associated with occupied space when stationary and turning 90-degrees.

3.4. Protective Bollards

The two operational charging devices used in the trial had different bollard arrangements while the non-operational mock-up unit provided a third arrangement for testing.

Figure 3: Participant during task 4 at mock-up trial device with 850mm socket-height

The lowest overall rating was returned by the 850mm-socket height shown in the image above for the mock-up chargepoint. Using this arrangement, the lowest scores were given by two wheelchair users who found it problematic to obtain an ideal position to access the chargepoint.

Observations during the trial confirmed that some wheelchair users positioned themselves at an angle to the bollards and chargepoint, which had been the expected method of approach and reach to use the chargepoint preferred by the majority of wheelchair users prior to the trial, and a dominant factor for the bollard arrangement for this mock-up. Whereas most wheelchair users were observed to actually prefer a less angled and more straight-on approach and forward reach; in some cases leaning forward to lift the flap, to make the cable connection, and when removing the cable. This arrangement also scored highly with the majority of ambulant disabled participants, but was a problem for one crutch user who reported the bollards impeded his access. This individual was observed to need to support himself against the chargepoint when interacting with it, which was not adequately facilitated at the mock-up chargepoint with it being a non-structural temporary installation for the trial.

The width between the bollards in combination with the socket height appears to have been one of the positive contributory factors in regards to the 940mm height socket device. The 1065mm-height socket was second preference, however, by comparison with the 940mm-height socket device, the negative contributory factors for this arrangement was the socket height, bollard location and the location of printed information on the side panels of the charging device – the latter of which was problematic to access for wheelchair users due to the bollard arrangement.

In view of the above results, participant comments, and observations of participants during the trial, the location of bollards has been given further consideration. These considerations have informed the recognition of the requirements for unobstructed close approach to chargepoints by individuals with impaired mobility, and the apparent need to locate protection bollards to enable a wide angle of approach to chargepoint to support unobstructed access.

3.4.1. Chargepoint Protection Bollards Location

The following measures are provided in order to prevent or minimise the potential of vehicle impact damage to the charging unit.

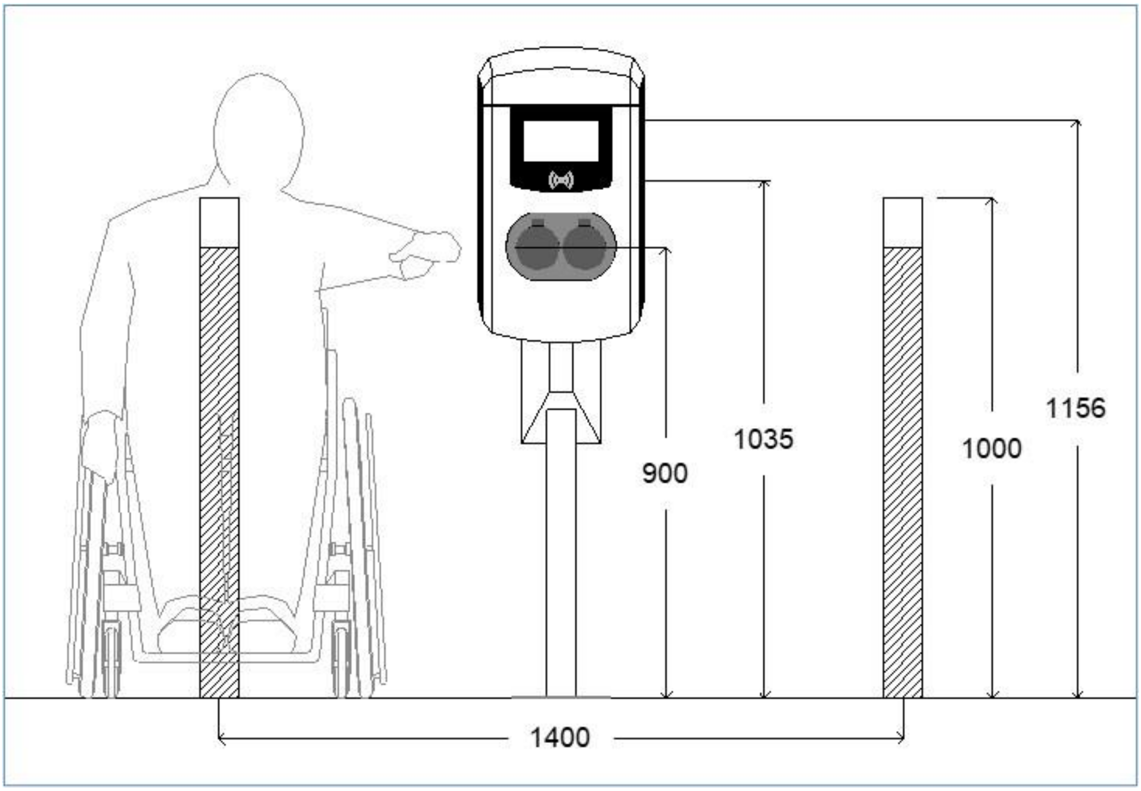

Figure 4: Diagram above demonstrates protection bollards arrangement at chargepoint

Their location as advised is also important to minimise any obstruction to interaction with the socket connections and charging device activation by wheelchair users, persons of short stature, and other persons with impaired mobility:

- Two bollards located at 1400mm between centres and equidistant to the centreline of the Centre Access Aisle (i.e. located with centre of bollards 700mm each side of the centre aisle centreline); and
- For chargepoints located on or behind a kerb or kerb-line, the rear face of the bollards should be positioned at least 50mm forward of the power outlet sockets (or chargepoint if side sockets) and preferably not more than 100mm forward of the kerb when measured along the centre aisle.
- For chargepoints located in front of the kerb, or at head of centre aisle with a level access cross aisle, the rear face of the bollards should be positioned at least 50mm and preferably not more than 100mm forward of the power outlet sockets (or chargepoint if side sockets) when measured along the centre aisle.

This arrangement of bollards has been determined with the assistance of computer aided design diagram layouts to consider the manoeuvring requirements of wheelchair users as well as ambulant impaired persons.

3.5. Summary of Charging Device Design Considerations

3.5.1. Charging Device Operational Status

The operational status of any chargepoint should be evident on arrival before alighting from a vehicle. This could best be achieved through a standardised system for all chargepoints (or at least for public ones) by their use of high-contrast LED lights located prominently on the charging device and visible from a distance on approach to the charging bay location, for example: green where the charging device is operational; blue when the charging device is in use (charging); and red indicating that the charging device is non-operational; as well as possibly flashing blue intermittently when charging is finished.

Figure 5: 1065mm height double-socket chargepoint and bollard arrangement for task 3

This facility would obviate the requirement for such as a wheelchair user to alight from their vehicle, take the time and effort to transfer to their mobility aid only to discover a charging device is not operational. We appreciate this would require users to be familiar with the process, as well as the potential need to standardise the colours used by different charging device manufacturers / suppliers.

Such information on chargepoint status recognition might best be supplied via vehicle dealers / sales outlets and as a companion document to the vehicle handbook, to increase awareness among EV drivers of the different charging devices currently available for public charging in relation to the charging modes suitable for the vehicle, which is likely to represent use of either a fast charger, rapid charger, or both for a specific plug-in vehicle model.

3.5.2. Screen Information

From data collected, it was screen information, which ranked lowest among the charging device features. There are a number of factors, which we believe influenced the results, the principal of which was reflectivity. Both screen sizes presented with problematic legibility for the majority of participants, caused by reflection – either due to light or to portions of their own image being reflected. The reported comments relating to use of charging devices also centred on poor colour contrast and small font size for both screen sizes. The issue of glare and reflection served to exacerbate legibility issues. Printed information also returned low ratings and more on printed Information can be found below.

Where information screens are to remain in use, we suggest these utilise anti-glare properties to reduce or obviate reflection; with high-contrast LED text and iconography where it is appropriate to do so. Font size should be as large as practicable to enable reading from a reasonable distance, and text requires good colour contrast against its background.

Screen text could be limited to:

1. Charge rate: £/kWh (where a charge is included in permanent display of remotely updateable information).
2. Touch card to reader (icon displayed where this is a required function) to start charge (included in permanently displayed information as appropriate).
3. Charging: To end charging and remove plug touch card to reader icon location (this also could be provided in permanently displayed information).

This will require charging devices to be standardised; in order that a cable plug may be inserted without an order preference for cable connection to either vehicle or charging device first.

With the current data, the optimum height(s) for screens for ambulant persons and for wheelchair users and persons of short stature cannot be reliably advised. Instead we advise further consideration by designers and manufacturers of the issues discussed in this report and its recommendation in regards to the design specification and use of display screens.

3.5.3. Charging Device Sockets and Cover Flap

The process of lifting the socket-flap before inserting the plug, presented with issue for some participants including those who are crutch users and some wheelchair users with limitation of manual dexterity who also experienced increased difficulty. The primary cause for this appears to be the inability to engage with the lower element of the flap in order to raise it and insert a plug.

We recommend further consideration should be given to increase the projection of the lower portion of the flap to provide a ‘lip or tab’ which may afford easier engagement with the flap for people with limited manual dexterity.

Generally, inserting the plug at a height of 940mm did not present with much of an issue for all but a few participants, however for some, the effort required to withdraw the plug from the unit was more problematic. Elbow-crutch users found the effort required to extract a plug from the charging device – with a sudden release – may be hazardous, risking their loss of balance and a potential fall, which would be a greater concern when conditions are slippery underfoot.

While we appreciate the necessity to ensure the plug is firmly engaged, further investigation and review of the issue should be considered to reduce the force required for both insertion and extraction of the cable plug.

The limited separation distance between the two sockets on the 1065mm height charging device was a concern commented on by one of the participants: when one of the sockets already had a plug in the outlet, this caused problematic access for the participant when attempting to insert and extract the cable plug at the remaining socket (this refers to the above image of the device).

As discussed in the body of this report, a socket height of approximately 900mm above ground level may provide an optimum position for both wheelchair users and ambulant users. However, with current charging devices this does not address the issue of screen height; where the low results returned for the 940mm socket height unit may be largely attributed to smaller font size and screen size only half that of the 1065mm socket-height charging device.

Figure 6: Participant with elbow crutches at 1065mm height socket device during task 3.

3.5.4. Printed Information

Figure 7: Printed information on side of double socket unit and front of single socket unit.

Printed information located to the side of the twin-socket units went unnoticed by some individuals. This was also difficult to access for some people with impaired mobility who found it difficult to manoeuvre clear of the protective bollards to view the information. Several individuals were required to withdraw from the unit and manoeuvre around to the side to access the information. One commented that although the printed information had a reasonable font size, the instructions were quite verbose.

3.5.4.1 Twin Socket

Printed information located to the side of the twin-socket units went unnoticed by some individuals. This was also difficult to access for some people with impaired mobility who found it difficult to manoeuvre clear of the protective bollards to view the information. Several individuals were required to withdraw from the unit and manoeuvre around to the side to access the information. One commented that although the printed information had a reasonable font size, the instructions were quite verbose.

3.5.4.2 Single Socket

The single socket unit with printed information located on the front face was preferred, however, several negative comments were received, including that the text was too small and one participant commented that there was "too much going on". Generally overall, individuals preferred the printed information to be located on the front of the unit, which obviates any confusion with whereabouts and assists with accessibility. In general, the font size used is problematic for some individuals to read and requires further consideration with regard to increasing font size and reducing the amount of text required.

The necessity to provide lengthy instructions on use for those unfamiliar with the procedure should be avoided whenever possible. The simplest process to be considered is one in which the service user simply inserts the plug into whichever socket is the preferred option, usually this is the vehicle. After inserting the plug into the charging device, any screen should commence with the items/information outlined above in Screen Information.

Figure 8: Observer estimates participant head and eye level at Task 1 location.

3.5.5. Card Readers

Generally, card readers did not represent an issue once an individual was informed about the location of the appropriate icon. Holding the card for extended periods of time may present with difficulty for some individuals with manual dexterity and / or reach issues.

We believe the location of the card reader directly above the relevant charging device socket(s) appears to be a logical location for activation of any charging device without a display screen. However, where a display screen is provided to monitor activation, operation and completion of the charging cycle, and smart card recognition required at start and again at the end of charging for cable release, it may be more appropriate to locate the card reader either: directly below, alongside, or within the display screen panel.

However, alternatives for user communication with the chargepoint network require consideration to facilitate access and control of charging function by persons without the necessary smart card or smart phone technology. This issue is considered further in Stage 3 of this project.

3.6. The User Trial Event Set-Up

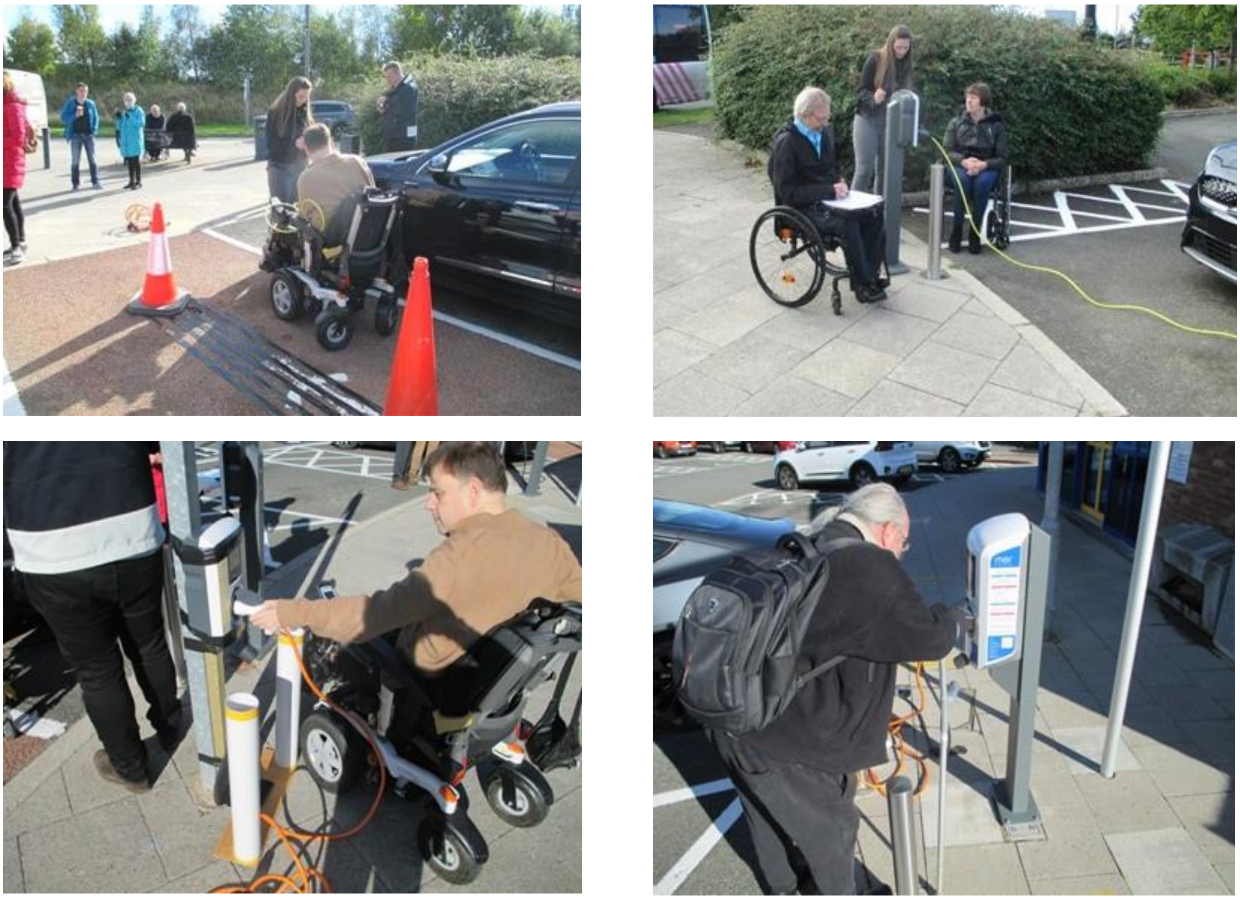

Figure 9: Observers and participants pictured during the four tasks

Three charging devices and a plug-in vehicle were used in user trial activities, which were generally performed in the order as depicted in the above images, clockwise from top left. The following provided the basis of the trial set-up: -

1. Electric Vehicle: Located in a bay adjacent to a charging device where the socket height was located at 940mm above ground level.
2. Bay surface: Side aisle marked in 100mm increments from 1200mm to 1600mm in order to establish spatial requirements at the side of a vehicle.
3. Operational Alfen single-socket unit: Socket height at 940mm above ground level, with two protection bollards 740mm in height, located 750mm between their centres and positioned 40mm in front of the charging device face and power outlet socket.
4. Operational Alfen Twin-Socket Unit: Socket height at 1065mm above ground level, with two protection bollards 740mm in height, located 940mm between their centres, and positioned approx. 400mm in front of the charging device (apparently as a result of being a replacement for a previous installation).
5. Non-Operational Mock-Up: Alfen Single-Socket Unit: This unit was identical to the 940 height unit, but not operational, set up as a mock-up test unit with the socket height intentionally lower at 850mm above ground level. Two mock-up bollards 600mm in height, located 500mm between their centres were positioned 60mm forward of the charging device face.

3.6.1. The Tasks

Before commencing the tasks outlined below a brief questionnaire was completed with each participant for the local authority monitoring purposes, on the basis of the DCC's stated aim 'to involve as many people as possible to make sure everyone has the opportunity to become involved'. These questions were entirely optional for participants and covered how they recognised themselves in regard to gender, disability and age-group. The results of which were as follows, however only one non-disabled person completed the trial:

Participants identifying as:			Age Group			Age Group	
Male	12		Under 18	0		45-54	4
Female	2		18-24	0		55-64	2
Disabled	12		25-34	1		65-74	4
Not disabled	2		35-44	1		75+	2

No one preferred not to answer or disclose the information for monitoring.

The activities that then followed provided four sets of data in response to the task each participant was asked to attempt and as far as possible perform:

3.6.2. Bay and Cable Use Tasks

The first data set related to the 'Bay and Cable Use' activity, which also involved some event and task-related monitoring questions, which included identifying:

Q1. Whether they identified themselves as having an impairment including any non-visible impairment that may affect their mobility?

They were also asked:

- The relative impairment group for those persons identifying as a disabled person;
- What if any mobility aids they regularly used;

- Approx. head height measurements were taken;
- Approx. eye level measurements were taken;
- As well as their permission for monitoring during the event using photography and video, and the use of such media for demonstration in reports and presentations.

Participants were then asked to perform the 'Bay and Cable Use' tasks and asked questions relevant to each part of the task and to rate their experience between 0 and 5 for ease of use, as follows for Tasks A, B and C:

A. Each participant was asked to remove a coiled charging cable from the boot of the vehicle and connect it to the vehicle inlet port (socket height 860mm above ground). The trial observer monitored the width of aisle required by the participant while carrying out the task.

Q2. The participant was then asked how easy was it to insert and remove the plug at the vehicle

B. Using the charging cable connected to the vehicle, they were then asked to move with the cable to the chargepoint and attempt connection to the charging device (with a socket height at 940mm above ground level).

Participants were then asked: -

Q3. How easy was it to move around with the cable?
Q4. How much did the weight of the cable affect their experience? and
Q5. What width of space do they normally need for getting in and out of a vehicle?
Q6. Observers noted the width of space required to accommodate the tasks at the side of the vehicle

C. Attempt to extract the cable and return it to the vehicle.

Q7. What was their experience of connecting the charging cable to the vehicle?
Q8. What was their experience of connecting the charging cable to the charging device?

Participants were finally asked if they had any other comments.

3.6.3. Chargepoint Use Tasks

Participants were then asked a series of questions solely related to their experience of using the same single-socket charging device with 940mm socket height and to rate the tasks again on a scale of 0 to 5, with 5 being easy, and to provide comments on screen information and any other comments on their use of the charging device.

The questions asked included:

Q1. Reach height capacity?
Q2. How easy was it to lift the flap?
Q3. How easy was it to insert the plug?
Q4. How easy was it to reach the card reader?
Q5. How much did the bollards affect their access?
Q6. How would they rate their ease of reading the screen text?
Q7. They were then asked to comment on whether there was anything they would change about the screen information?
Q8. How would they rate the printed information provided on how to use the charger?

Q9. How easy was it to remove the plug?

Q10. How would they rate the experience of using the charger?

The above tasks and questions were next repeated using another charging cable, but without making connection to a vehicle, for user experience of connecting to and using an operational double-socket charging device with sockets height at 1065mm above ground level: then repeated once again at the non-operational single-socket mock-up unit, with the socket height at 850mm above ground level. This was carried out primarily to establish the ease or otherwise of plug insertion and extraction and to gather opinion on screen height. In all examples, we noted how the relative bollard positions affected or facilitated the various tasks.

Participants were also asked to confirm which type(s) of vehicle they regularly drove or used for personal transport; and finally each were asked if they had any additional comments relating to electric vehicle charging that were not covered in the data sheet questions.

4. USER TRIAL RESULTS AND DATA REVIEW

4.1. Bay and Cable Data

Individuals had been asked to obtain the charging cable from the boot of a vehicle and then connect the cable between the vehicle and charging device. During this procedure they were observed and the space required to perform this task in the aisle adjacent to the vehicle was noted. The resulting data from this series of tasks is outlined below; this is in the form of a summary of the overall average of the results for all user ratings, from their scores of 0 to 5, where 5 equals 'easy':

Task	Rating	Percentage
1. Inserting and removing plug at a vehicle:	3.88	77.69%
2. Moving around with the cable:	3.81	76.15%
3. Weight of cable affecting experience:	3.92	78.46%
4. Experience of connecting cable to vehicle	3.92	78.46%
5. Experience of connecting to chargepoint	3.69	73.85%

In carrying out task 1, only one individual (wheelchair user) with limited manual dexterity could not perform the procedure and returned a rating of 0.

Task 2 was rated highest by ambulant disabled and non-disabled individuals, on average, wheelchair users and crutch rated the task lower; between 2.0 and 4.0.

Figure 10: Participants at side of vehicle to attempt cable connection during Task 1

When asked about the weight of the cable affecting their overall experience, unsurprisingly, it was rated highest by the same group of ambulant disabled and non-disabled individuals, while again, it was rated lower by wheelchair users and crutch users.

When asked about the overall experience of connecting a cable to a charging device, the results returned a rating of 3.69 or 73.85%. Investigation of the statistics revealed that some of the highest ratings were returned across several impairment groups. A maximum score of 5.0 was returned by one ambulant disabled individual; one non-disabled person; two manual wheelchair users and one powered wheelchair user.

The lower ratings 0 to 3, for connecting cable to charging device, were returned from two ambulant crutch users; one other ambulant disabled individual; one powered wheelchair user and a manual wheelchair user. The manual wheelchair user with limited upper body strength and dexterity provided the only score of zero, which was also the score given when they were unable to achieve the task to connect and remove the cable at the vehicle.

Several participants, including wheelchair users and ambulant persons with impairments, either commented or were observed to struggle with the removal of the rubber dust cover on the end of the cable plug, and in some cases required assistance from observers to remove the cap.

Some participants also had problems when trying to re-coil the cable after use, to the extent that assistance was also required by some participants.

It is evident from the above data that use of a cable and interaction with a vehicle and charging device is heavily reliant on an individual's physical ability and capacity. Individuals who can only be ambulant with the aid of crutches, and others with impairments affecting their upper body mobility, strength or dexterity, found such tasks considerably more problematic. The results may also be influenced to some degree by the disposition of an individual and how they manage their impairment, particularly when faced with new or unfamiliar tasks.

However, the overall results for all participants in this task, and for all five elements of the task, remain below 80% success for their experience of using a cable to connect between a vehicle and chargepoint. This overall result remains the same even if the highest scoring individual with 100% and lowest with 24% is discounted from the results. The results also indicate that over 50%, seven of thirteen, participants scored less than an 80% score. Such results appear to give a clear indication that the physical tasks involved in charging an electric vehicle with the current equipment available is likely to be problematic for drivers with impairments; suggesting there is urgent need for improvement in both the design and technology of Electric Vehicles and EV charging equipment. Such issues are considered further in section 4.5 of this report and in the Stage 3 Report.

Recommendation

R1. Where it is possible to do so, the weight of a cable should be as light as is absolutely necessary to satisfy its required electrical duty and safety regulations, and consideration should also be given to other factors, including ease of cable storage, care of cable, and the ease of removing and fitting dust caps.

Discussion of cable use also requires consideration of the end connections, for charging, i.e. plugs and sockets, as these features are inextricably linked; and as such can impact on access to and ease of charging. It is imperative that inserting and extracting a plug is made as easy as is practicable to do so. Improvement to these features would enhance user interaction, accessibility and usability of cables, charging devices and connection to vehicles. Please refer also to the following recommendations in relation to the use of charging cables in association with charging device sockets and cover flaps in section 4.3 below.

4.2. Aisle Width

As outlined above, each individual's space requirements at the side of the vehicle was noted when attaching a cable to the vehicle's inlet socket. The side aisle was surface-marked in 100mm increments between 1200mm and 1600mm width. In all user trials, it was noted that the maximum space requirement was 1450mm, utilised by a powered wheelchair user. Of the remaining participants, one other person who was also a powered wheelchair user required 1300mm; whereas for all other participants, a standard 1200mm side access aisle width was adequate.

From these results, we can conclude it is likely an aisle width at 1500mm will accommodate most users' requirements for manoeuvring space, for ambulant mobility impaired persons as well as wheelchair users. However, based on existing published Department of Transport research data in BS8300-2:2018[2], a 1600mm aisle width is potentially required to accommodate the access and manoeuvring needs for the majority of all manual and powered wheelchair users.

Recommendations

R2. We advise a 1600mm access aisle width is the preferred provision, and where this cannot be accommodated a minimum width of 1500mm should be maintained for access at the side of vehicle charging bays.

This recommendation on access aisle width equally applies where access is provided at charging bay level across the head of the charging bay(s) to facilitate cable connections between the front of a vehicle and the chargepoint, as well as ease of access around the vehicle from each side and thereby minimising the travel distance for persons with impaired mobility and / or with reduced stamina.

It should also be noted that where such level access is not provided across the head of the vehicle bays, this may result in the driver's need to park their vehicle into the bay in reverse, which also has potential issues in regard to whether the charging cable is of adequate length to reach the chargepoint. This is an issue that is also likely to be a problem where chargepoints have tethered cables.

A further recommendation therefore is that:

R3. Provision of a level access cross-aisle at the head of accessible charging bays is generally preferable; as such provision is likely to be essential for drivers with impaired mobility whose vehicles have a front power-inlet charging socket.

4.3. Charging Device Tasks

4.3.1. Lifting the Power Socket Flap

The process of lifting the socket-flap before inserting the plug, presented an issue for some individuals, including some ambulant disabled participants and some wheelchair users at one or more of the

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[2] BS 8300-2:2018 Design of an accessible and inclusive built environment: Part 2 Buildings – Code of practice, Annex G Space allowances for wheelchair manoeuvring and Tables G.2 and G8 - Dimensions associated with occupied space when stationary and turning 90-degrees.

chargepoints. Individual ratings between 0 and 3 also suggest that some persons experienced difficulty with the flap at one of more of the chargepoint locations, whereas others scored consistently between 4 and 5 across the three locations. Both ambulant persons and wheelchair users were included in lower and higher scoring groups; suggesting dexterity issues, which may also be relative to the age range of participants, was potentially one reason for the difference.

Some participants attempted to lift the flap with one hand and insert the cable plug with the other hand, while others who were unable to utilise or reach with two hands, tried to lift the flap with the end of the plug and slide the end into the socket.

The following are the combined data results for all users for each of the three test units:

- Socket Height at 850mm: scored an average of 4.3 out of 5 or 86.92%
- Socket Height at 940mm: scored an average of 4.2 out of 5 or 84.62%
- Socket Height at 1065mm: scored an average of 4.0 out of 5 or 80.00%

From the above we can conclude that a socket height at 850mm yielded the most favourable result for ease of lifting the flap. We can also determine that two lowest-height sockets have little more than 2% difference between the results. However, this procedure should not be viewed in isolation.

If we separately consider the results for all six wheelchair users as a group and all six ambulant disabled persons as a group: we obtain the following results:

Socket Height above ground (mm)	Wheelchair Users Ave. Score	Percentage Score	Ambulant Disabled Ave. Score	Percentage Score
850	4.17	83.3%	4.42	88.3%
940	4.17	83.3%	4.17	83.3%
1065	4.00	80.0%	3.83	76.7%

Figure 11: Participants at 940mm socket-height chargepoint during Task 1

The results appear to confirm that the lower-height sockets were easier in regards to lifting the flap, with the 850mm height socket flap being preferred by most individuals with physical impairments, both wheelchair users and ambulant persons. These results also indicate that the effort of lifting the flap on the 940mm socket height device was scored the same on average by the six wheelchair users as it was for the six ambulant disabled persons.

It should also be noted, in case of any relevance, that both the 850mm height and 940mm height devices were identical single-socket Alfen devices; even though the 1065mm height double-socket version of this Alfen charging device range appeared to have similar sockets and socket-cover flaps to the smaller single-socket devices. The results therefore appear to indicate that it was generally easier to lift the lower height socket flaps and the flap on the 850mm height socket was the easiest for all participants with impairments.

4.3.2. Plug Insertion

The following are the data results for the three test units when factoring in all users:

- Socket Height at 850mm: scored an average of 4.1 out of 5 or 81.54%
- Socket Height at 940mm: scored an average of 4.2 out of 5 or 84.62%
- Socket Height at 1065mm: scored an average of 3.7 out of 5 or 74.62%

From the above we can conclude that a socket height at 940mm yielded the most favourable result overall.

However, if we again consider the separate impairment groups of six wheelchair users and six ambulant disabled users, the results are as shown below. Results based on Impairment groups for cable plug insertion:

Socket Height above ground (mm)	Wheelchair Users Ave. Score	Percentage Score	Ambulant Disabled Ave. Score	Percentage Score
850	4.33	86.7%	3.66	73.3%
940	3.83	76.6%	4.50	90.0%

1065	3.33	66.7%	3.92	78.3%

This result clearly indicates the difference in the preference for wheelchair users being the lowest socket height and ambulant disabled participants preferring the mid-height socket at 940mm height.

4.3.3. Plug Extraction

The following are the data results for the three test units when factoring in all users:

- Socket Height at 850mm: scored an average of 3.9 out of 5 or 78.46%
- Socket Height at 940mm: scored an average of 4.3 out of 5 or 86.15%
- Socket Height at 1065mm: scored an average of 3.4 out of 5 or 67.69%

From the above we can again conclude that a socket height at 940mm yielded the most favourable result. However if we separate the results between groups of the six wheelchair users and six ambulant disabled participants, we can again see a differing result:

Results based on Impairment groups for cable plug extraction:

Socket Height above ground (mm)	Wheelchair Users Ave. Score	Percentage Score	Ambulant Disabled Ave. Score	Percentage Score
850	4.50	90.0%	3.17	63.3%
940	4.17	83.3%	4.33	86.7%
1065	3.33	66.7%	3.17	63.3%

The difference in preference for ease of plug extraction is similar as for plug insertion between the two groups, with wheelchair users favouring the lower height socket and ambulant participants with impairments preferring the mid-height socket.

Combined Results for Lifting Flap plus Plug Insertion and Extraction:

Overall totals for each of the three units:	Rating	Percentage
• Socket Height at 850mm:	12.3	246.92%
• Socket Height at 940mm:	12.8	255.38%
• Socket Height at 1065mm:	11.1	222.31%

Results based on Impairment groups for the flap and socket use:

Socket Height above ground (mm)	Wheelchair Users Ave. Score	Percentage Score	Ambulant Disabled Ave. Score	Percentage Score
850	4.33	86.7%	3.75	75.0%
940	4.06	81.1%	4.33	86.7%
1065	3.56	71.1%	3.64	72.8%

From the above sets of results we can recognise that when all 13 sets of results are included for all participants (including one ambulant non-disabled participant), the results appear to indicate an overall preference for the 940mm centreline height of socket for 'cover-flap and socket use'.

However, when results for the non-disabled participant are discounted, and only the cumulative results considered for the two impairment groups of six wheelchair users and six ambulant participants with impairments, the difference in preference for ease of use for the three associated tasks of lifting the flap, plug insertion, and plug extraction, appears to confirm a definitive split between the two groups based on the socket heights of 850mm and 940mm.

It may also be worth mentioning that the non-disabled ambulant participant scored the maximum 5 points for each of the three tasks for all three heights of chargepoint, which clearly indicated the height difference was not an issue for them.

Combining the data for all three activities, it is clear that a socket height at 940mm produced the most favourable results (86.7%) for the ambulant impaired group of participants, while the 850mm socket height produced the equivalent percentage (86.7%) being most favoured by the wheelchair users group.

It is also clear that the higher 1065mm socket height device yielded poorer overall scores for the three activities associated with this primary function of the charging devices, i.e. to facilitate a cable connection to deliver power to recharge an electric vehicle.

Although the above analysis of results, considering the impact of socket height on these principal impairment groups, does not reveal an optimum height for a chargepoint socket, it does potentially provide confirmation that socket heights above 940mm height are less likely to provide an appropriate solution for persons with impairments affecting their mobility, strength, or dexterity; some of which are recognised impairments experienced by many people with ageing.

A height-adjustable charging device was not available for this trial, which could have otherwise facilitated the identification of an optimal socket height for the majority of participants, as well as providing additional data on screen height suitability. However, we can conclude that if an optimum chargepoint socket height exists, for all potential chargepoint users including those who are ambulant or in wheelchairs with impairments; it is likely that the height would be between 850mm and 940mm above the ground or floor level from where the chargepoint was accessed: suggesting that a height of around 900mm may be more appropriate and an inclusive height for charging sockets.

Generally, inserting the plug at a height of 940mm did not present with much of an issue for all but a few participants, however, for some the effort required to withdraw the plug from the unit was more problematic. Elbow-crutch users found the effort required to extract a plug from the charging device – with a sudden release – could be hazardous, risking their loss of balance and a potential fall, which would be a greater concern when conditions are slippery underfoot.

While we appreciate the necessity to ensure the plug is firmly engaged, further investigation and review of the issue should be considered to reduce the force required for both insertion and extraction of the cable plug. One additional comment was received concerning the limited separation distance between the two sockets on the 1065mm height socket device, where a crutch user struggled to insert the cable plug with a two-handed grip when the adjacent sockets already had a plug in the outlet, which caused problematic access for this participant. A powered wheelchair user with impaired dexterity and reach also had this problem and was unable to insert the plug, even after they were assisted to lift the flap. After he had been given assistance to insert the plug, he was also unable to remove the plug due to not being able to adequately grip the plug with the adjacent socket in use.

It is important to understand that the ease of insertion and removal of the plug from the socket is also affected by the socket's height above ground level. We have outlined the data above for these two processes. Also as discussed above, the process of lifting the socket-flap before inserting the plug, presented an issue for some participants, including a crutch user, some other ambulant persons, and wheelchair users with reach and / or manual dexterity limitations. The primary cause appeared to be as inability to engage with the lower element of the flap, to raise it and insert a plug.

Recommendations

R4. We recommend further consideration should be given to increase the projection of the lower portion of the flap to provide a 'lip or tab' which may afford easier engagement with the flap for people with limited manual dexterity.

R5. An optimum chargepoint socket height is proposed at 900mm above the surface from where the chargepoint is accessed, so as to be accessible by the majority of users.

R6. Further research and investigation is advised by charging socket designers to identify solutions to aid the ease of physical insertion and removal of the cable plug connection at chargepoints, which may also be an issue requiring consideration for electric vehicle development generally. Note: Although this report is based on charging devices with type 2 Mennekes socket connections, it should be recognised that similar issues may or may not be experienced with different charging socket types or devices.

R7. Appropriate separation distance is required between adjacent sockets on double-socket charging devices, so that there is adequate clearance for a two-handed grip around the cable plug when inserting and removing the cable connection. This may also benefit users with upper body prosthetics, as well as others with impaired dexterity and strength limitations, and potential benefit to many older persons.

4.3.4. Smart Card Readers

Figure 12: Close-up view of charging devices showing card reader symbol below screen

The following are the data results for accessing the smart card use height for the three test units when factoring in all users:

- Socket Height at 850mm: scored an average of 4.7 out of 5 or 93.85%
- Socket Height at 940mm: scored an average of 4.7 out of 5 or 93.85%
- Socket Height at 1065mm: scored an average of 4.5 out of 5 or 90.77%

From the above we can generally conclude that use of the card readers did not present with an issue once an individual was informed about the location of the appropriate icon. However, one wheelchair user found the reach more difficult on the 940mm and 1065mm devices and commented that holding the card for extended periods of time against a sensor would be a concern; which is likely to apply to individuals with manual dexterity and / or reach issues.

However, we can again conclude that if an optimum location height exists, for all potential chargepoint users, including those who are ambulant or in wheelchairs with impairments, the results appear to indicate, it is likely that the height would be between approx.950mm and 1050mm above the ground or floor level from where the chargepoint was accessed, based on the easier reach for the lower height devices; although it was evident the highest device card reader at approx. 1200mm was potentially accessible to all participants.

4.3.5. User Communication with Chargepoint Network

The MER chargepoint network currently supports user access and control of the chargepoint function either by means of a smartphone app or smartcard use with the charging device sensor, identified by symbol as pictured above. However, alternatives for user communication with the chargepoint network require consideration to facilitate access and control of the charging function by persons without the necessary smart card or smart phone technology. This issue is considered further below.

The user trial did not include participant experience of the MER App for smart devices, as this was not possible within the time constraints for the one-day trial event; and there was no certainty that all participants would either have possession of, or be familiar with the use of, smartphones or such device applications.

The MER chargepoints currently offer a ‘Pay As You Go’ (PAYG) service, and 24-hour helpline with a 020 telephone number provided for assistance. However, unless the person wishing to use the chargepoint either has an account with this network or access to the smartphone App they will be unable to use the chargepoint and the technical support line cannot provide any assistance. The printed information on the chargepoints currently indicates that a QR Code option for accessing the use of the charging device is coming soon. Above this it also states ‘download the app to use the QR code’ which appears to suggest that a PAYG user would still need to have the Network’s App downloaded on a Smartphone and registered with the network before they can also make use of the QR Code access.

Such requirements for chargepoint access are likely to be a barrier to people who are not computer literate, unable to use the internet to setup an account, or do not have a smartphone to download an App; which is likely to include many older people as well as some with language or literacy issues. It is also likely to be off-putting to some people who do not wish to install another App or setup an account for a network they may seldom if ever use again; such as persons who are travelling through or are temporary visitors.

Currently, anyone travelling away from their local area or region in the UK is likely to find they need to access several different EV chargepoint networks. Some networks will accept a PAYG user phoning the network with a Debit Card or Credit Card to access their chargepoint, and some at supermarkets may even be free to use. However, the further one travels there is increased likelihood of needing several mobile apps and accounts to be able to complete a journey. This needs to be recognised as one of the issues that are currently dissuading drivers from changing to an electric vehicle.

As confirmed during the trial event, several participants did not have the ability to easily read the printed information on how to access the chargepoint network and use the charging devices, due to not having the right spectacles with them. Some were naturally concerned that there was so much that needed to be read before they knew what was required. Access to chargepoint networks and individual chargepoints requires simplification.

Consider simplifying the charging process such as: -

The simplest process to be considered for the existing devices is one in which the service user simply inserts the plug into whichever socket is the preferred option, usually this is the vehicle. After inserting the plug into the charging device, any screen should commence with:

- Charge rate £kWh
- Touch card to reader to start charge (icon here)
- Charging - To end charging and remove cable- touch card to reader (card reader icon)

However, alternatives for user communication with the chargepoint network require consideration to facilitate access and control of the charging function by persons without the necessary smart card or smart phone technology. This issue is considered further in the Stage 3 of this project.

Issues regarding operating the charging device and the printed information are discussed further at sections 4.4.3 and 4.4.4 in this report.

Recommendations

R8. Access to the chargepoint network should be simplified to enable access without the need for internet or Wi-Fi access, such that a PAYG service is available to anyone with a recognised Debit or Credit Card.

R9. An optimum chargepoint Card Reader sensor height is proposed directly above the charging socket and clear of any socket flap when open, so as to be accessible by all potential users.

R10. Card reader sensing location should be readily recognisable by use of a standard icon that is preferably internationally recognised.

4.4. Protective Bollards

The two operational charging devices used in the trial had different bollard arrangements, while the non-operational mock-up unit provided a third arrangement for trial purposes.

Figure 13: Task 4 location with participant accessing mock-up device at angle to bollards

The mock-up chargepoint protection bollard arrangement was based on the initial guidance produced during the Project Stage 2 from consideration of user ergonomics and existing published data[3] on forward and sideways reach abilities of ambulant disabled persons and wheelchair users.

The 850mm socket-height mock-up unit shown above had bollards 600mm in height and spaced apart at 500mm between centres, located equidistant from the centreline of the charger unit and positioned 60mm in front of the charging device face and the charging socket.

Figure 14: Task 2 location with 940mm height socket device and bollards arrangement

[3] BS 8300-2:2018 Design of an accessible and inclusive built environment: Part 2 Buildings – Code of practice, Annex E and Table E.2 - Dimensions associated with comfortable and extended reach ranges.

The 940mm-height socket device (above) had bollards 740mm height and 750mm between their centres, set 40mm in front of the charging device face as shown above. However, note that the position of the bollards was not equidistant of the charging device. The right-hand bollard was offset by approx. 235mm; reportedly as a result of the current chargepoints replacing earlier chargepoint installations.

The 1065mm-height socket device (shown below) had bollards at 740mm in height with 940mm between centres and positioned approx.400mm in front of the unit. Note that the right-hand bollard was also offset: this may have been a result of positioning the bollards equidistant from the centre of the access aisle; however the current chargepoint also appears to be a replacement for an earlier chargepoint installation.

The overall results summary, rating impact of bollards on access to the chargepoint was as follows:

	Rating	Percentage
Socket Height at 850mm	4.2	84.62
Socket Height at 940mm	4.8	95.38
Socket Height at 1065mm	4.5	90.77

Figure 15: Task 3 location with 1065mm height socket device and bollards arrangement.

From the above data we can see that the lowest rating was returned by the 850mm-socket height in which the bollards were 600mm in height and positioned with 500mm between their centres and 60mm in front of the unit. A low score of 2 was given for the bollard arrangement by a manual wheelchair user who found it problematic to obtain an ideal position to access to chargepoint. However, we note that the other five wheelchair users also rated the bollards at this unit an average score of 4.6 with three of them scoring a maximum of 5.0. This maximum score was also given by five of the ambulant disabled persons.

Observations during the trial confirmed that some wheelchair users positioned themselves at an angle to the bollards and chargepoint: this was the method of approach and reach to use the chargepoint that was expected to suit most wheelchair users prior to the trial, and had been a dominant factor for the bollard arrangement for the mock-up arrangement. Whereas, most wheelchair users were actually observed to prefer a more straight-on approach and forward reach, in some cases leaning forward to lift the flap, to make the cable connection, and when removing the cable.

One manual wheelchair user was asked by the trial observer, why he preferred to reach forward in his wheelchair to use the chargepoint: he replied that he was less likely to fall forward as he was able to use the bollards and the charging device for support. This was also observed to be a similar issue for one of the crutch users, who used the chargepoints as a leaning post while attempting the tasks, but as the mock-up chargepoint and bollards were not structurally fixed in position, they did not provide adequate support to lean on when trying to access the device.

The highest overall rating was given for the 940mm-height socket arrangement where the bollards were 740mm in height and positioned with 750mm between their centres and located 40mm in front of the charging device; with the bollards arrangement at the 1065mm-height socket device being the second preference based on the overall scores for this feature of the chargepoint.

However, the lowest individual scores for any of the bollard arrangements were a score of zero for the 850mm-height socket device by a crutches user, who commented that the bollards prevented his close approach; and a score of only '1' given by a powered wheelchair user who commented that the bollards restricted his close approach to the 1065mm-height chargepoint, and also his inability to access the printed information on the side on the chargepoint.

Results based on Impairment groups for bollards arrangement:

Socket Height above ground (mm)	Wheelchair Users Ave. Score	Percentage Score	Ambulant Disabled Ave. Score	Percentage Score
850	4.17	83.3%	4.17	83.3%
940	4.50	90.0%	5.00	100%
1065	4.33	86.7%	4.67	93.3%

The width between the bollards in combination with the socket height appears to have been one of the positive contributory factors in regards to the 940mm height socket device. Note that the 1065mm-height socket was second preference, however, by comparison with the 940mm-height socket device, the negative contributory factors for this arrangement was the socket height, bollard location and the location of printed information on the side panels of the charging device – the latter of which was problematic to access for wheelchair users due to the bollard arrangement.

In view of the above results, participant comments, and observations of participants during the trial, the location of bollards has been given further consideration. These considerations have informed the recognition of the requirements for unobstructed close approach to chargepoints by individuals with impaired mobility, and the apparent need to locate protection bollards to enable a wide angle of access to chargepoint by the following provisions: -

- adequate unobstructed space directly in front for approach and reach by all mobility impaired users; and
- adequate space to facilitate manoeuvring with large powered wheelchairs at both oblique and acute angles directly in front of chargepoint;

- location of bollards to avoid obstruction to approach and manoeuvring in front of chargepoint and at side of vehicle; and
- bollards location to avoid obstruction and approach to power-inlet socket on side or front of vehicle as far as possible.

Alternative options for bollard location within the centre-aisle aisle have been subjected to desktop trial and review with the use of CAD scaled layout plans and elevations, and scaled images representing ambulant persons and wheelchair users. This has included persons using large powered wheelchairs, based on the range of data for physical size and manoeuvring space identified in the existing Department of Transport published data, as referenced in the British Standards Institute guidance4.

The desktop studies have led to amended proposals for the arrangement of chargepoint protection bollards, where provision is deemed to be required for protection against vehicle impact with the charging device.

4.4.1. Chargepoint and Vehicle Bay Overrun Protection

As a general rule bollard heights should be located out of the access route. However, when this cannot be adequately achieved, they should be installed at a height of at least 1000 mm above ground level and should contrast visually with the background against which they are seen, preferably with base and top highlighted with high contrast strips; to be visible to people with sight-loss.

Recommendations

R11. All bollard heights above ground level should be at least 1000 mm and should contrast visually with the background against which they are seen, with: a 150mm deep contrasting strip at the top; a surface finish that is not highly reflective; and is contrasted to the ground; to be visible to people with sight-loss, who may be passengers and assisting their driver with impaired mobility to connect to a chargepoint.

4.4.2. Protection of Chargepoints Location

All three chargepoint used in this one-day trial were front-facing charging devices, i.e. intended to have sockets facing the vehicle bays or centre aisle between the bays. It was not possible to test the earlier Stage 2 Report proposals for side-facing sockets arrangements during the user trial. However, based on the considerations of charging bay layout options in the Stage 2 Report and the outcomes and observations from the user trial, we have determined the following proposed bollard arrangements for a double-socket chargepoint located relative to the centre aisle between two adjacent vehicle charging bays:

For chargepoints located on or behind a kerb or kerb-line (such as in a border with no kerb, this would be the edge of the vehicle bay and access aisle): Applies to Stage 2 Templates for charging bay Companion Drawings and Checklists 2B2a, 2B3b, 2B4a, and 2B4b: -

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[4] BS 8300-2:2018 Design of an accessible and inclusive built environment: Part 2 Buildings Code of practice, Annex G Space allowances for wheelchair manoeuvring and Tables G.2 and G8: Dimensions associated with occupied space when stationary and turning 90-degrees.

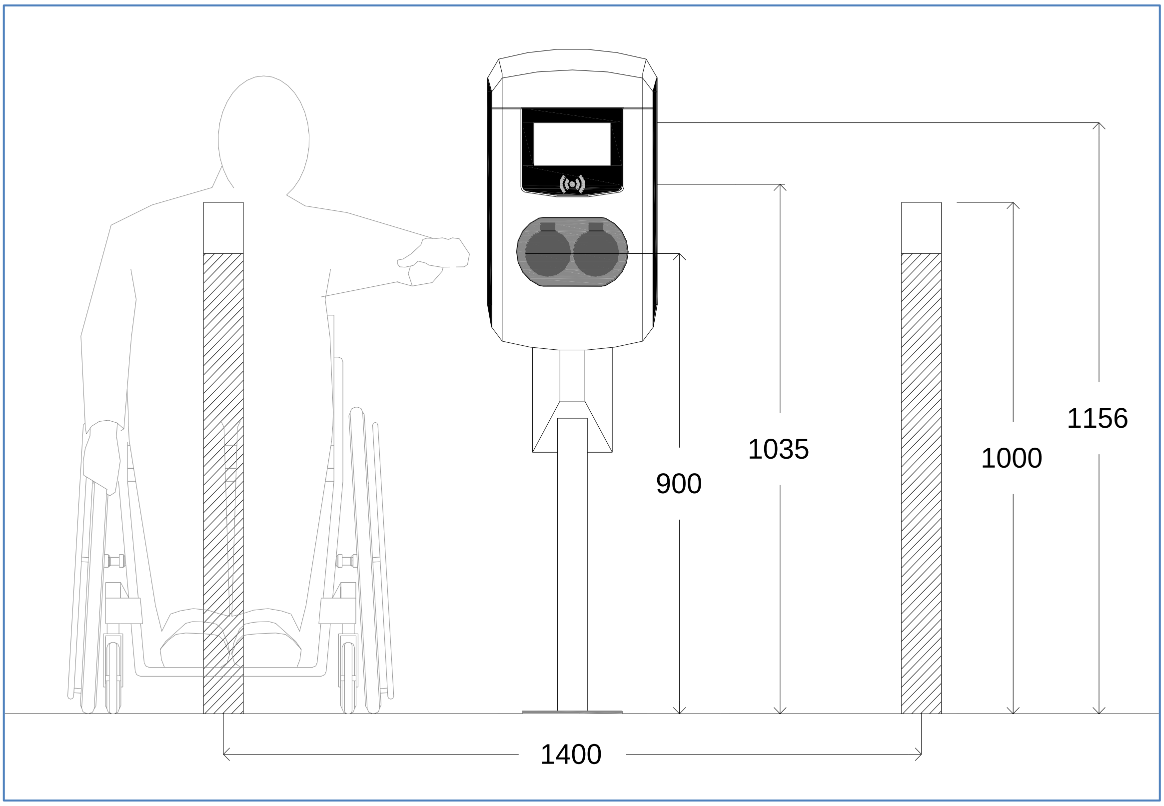

Figure 16: Image demonstrates protection bollards arrangement at front-facing chargepoint

Provision of two chargepoint protection bollards located with their centres 700mm each side of the centre aisle centreline and forward of the charging device, such that the rear of the bollards are at least 50mm forward of the power outlet sockets (or chargepoint if side sockets) and preferably not more than 100mm forward of the kerb when measured along the centre aisle.

For chargepoints located in the centre aisle in front of the kerb, or at head of centre aisle with level access cross aisle (i.e. no kerb): Applies to Stage 2 Templates for charging bay Companion Drawings and Checklists 2B1a, 2B1b, 2B2b, and 2B3a: -

Provision of two chargepoint protection bollards located with their centres 700mm each side of the centre aisle centreline and forward of the charging device, such that the rear of the bollards are at least 50mm and preferably not more than 100mm forward of the power outlet sockets (or chargepoint if side sockets) measured along the centre aisle.

Recommendations

R12. Two bollards located at 1400mm between centres and equidistant to the centreline of the Centre Access Aisle (i.e. located with centre of bollards 700mm each side of the centre aisle centreline); and

R13. For chargepoints located on or behind a kerb or kerb-line, the rear face of the bollards should be positioned at least 50mm forward of the power outlet sockets (or chargepoint if side sockets) and preferably not more than 100mm forward of the kerb when measured along the centre aisle.

R14. For chargepoints located in front of the kerb, or at head of centre aisle with a level access cross aisle, the rear face of the bollards should be positioned at least 50mm and preferably not more than 100mm forward of the power outlet sockets (or chargepoint if side sockets) when measured along the centre aisle.

4.4.3. Information Screens

From data collected, it was screen information, which ranked lowest among the charging device features.

The following are the data results for the three test units when factoring in all users. However, we note that the 850mm height socket was not operational and individuals were asked to rate the screen height as there was no display provided:

- Socket Height at 850mm: scored an average of 3.5 out of 5 or 70.00%
- Socket Height at 940mm: scored an average of 2.9 out of 5 or 58.46%
- Socket Height at 1065mm: scored an average of 2.7 out of 5 or 53.85%

Across the entire impairment range of the individuals who took part in the trial, almost all experienced problems with legibility; irrespective of eye level.

If we omit the mock-up unit, on which the screen was not in operation, we can conclude that the screens for the remaining two charging devices returned quite low scores.

The 940mm socket height charging device received one rating of zero, while the 1065mm socket height charging device received three zero ratings. Incidentally, the mock-up unit received one rating of zero, from a crutches user who had difficulty bending, and who scored 2 for the screen on the 940mm height unit and 4 on the 1065mm height unit.

- Screen height (to top) for the 850mm charging device was 1030mm.
- Screen height (to top) for the 940mm charging device was 1120mm.
- Screen height (to top) for the 1065mm charging device was 1315mm.

This is a difference in height of 195mm between screen heights above ground of the two operational units. However, to illustrate further, the ALFEN single-socket (940mm height socket) charging device has a screen size of 87.5mm (TFT colour display, 320 x 240 pixels) while the ALFEN twin-socket unit (1065mm height socket) has a screen which is twice the size at 175mm (with full-colour LED display). Out of a possible rating of 65, the smaller screen rated a total of 38 (58%), while curiously, the larger screen rated 35 (54%).

The screen on the 940mm socket height device was scored 5 by three participants, including two manual wheelchair users and one non-disabled person; while the larger screen on the 1065mm socket height device was also scored 5, but only by two of the same participants, with one of the same wheelchair users scoring the larger screen zero, commenting that the black border on the screen obscured the lower section of the display.

Socket Height	Screen Top Height	Wheelchair Users Score out of 30	Ambulant Disabled Score out of 30
850	1030	28.5	13
940	1120	22	11
1065	1315	14	12

If we consider all six wheelchair users responses and all six ambulant disabled users' responses for the screens, we obtain the results in the table above.

Perhaps not surprisingly the wheelchair users preferred the lowest screen height, although this was not operational and could therefore not be judged on ease of reading the display. However, if only the results for the two operational units are considered, it is clear that the lower height display was preferred by the wheelchair users; even though it had a smaller size display. Also by comparison, although there is little variation (by only one or two points) between the overall scores for the three unit heights by the ambulant impaired participants, their scores were considerably lower overall than those for wheelchair users: this appears to indicate that the height of each of the devices with operational displays were too low for their ease of reading as well as being difficult to read.

4.4.4. Screen Display - Contrast and Font Size

Both screen sizes presented with problematic legibility for the majority of users. Omitting the three top ratings of 5 for the smaller screen, the resultant potential rating is a maximum of 50. The smaller screen rated by the 10 remaining participants was 23 out of 50 or 46%. For the larger screen, we omitted two participants who rated the screen as 5, with a resultant potential rating at 55. The larger screen rated by the 11 remaining participants was 21 out of 55 or 38%.

In brief, the reported comments relating to use of charging devices overwhelmingly centred on poor background to text, icon contrast, and small font size for both screen sizes. The issue of glare and reflection served to exacerbate legibility issues. In addition to the above, two comments were received from ambulant disabled individuals outlining that they had to ‘bend down’ to read the information, which was also an issue that was observed to affect the two crutch users who needed to stoop to view the screens.

Figure 17: Task 3 Chargepoint with 1065mm socket-height with visible screen reflections

There are a number of factors, which we believe influenced the results, of which the screen reflectivity and poor contrast between display and the screen background were recurring issues in participants’ comments. From our data and observations on the day, we can reason that from 11am until 3pm in the afternoon; the time of day and position of the sun in the sky was not largely an influencing factor during the trials. Most participants experienced problematic legibility caused by reflection and/or screen display contrast.

Reflections were likely a result of angle of viewing as well as the ambient light level, which was generally high throughout the event, and to portions of participants own image being reflected.

Unit orientation may also have affected legibility to some degree. Difficulty was experienced by some participants accessing the smaller screen on the 940mm socket height device when the low autumnal sun was almost directly behind the unit, whereas the charging device with the larger screen size was partially shielded by a building located immediately behind.

Although the results for screen height and size may not be conclusive, if we also take account of participants' comments, it becomes more evident that the height and size of screen was a lesser issue than the screen legibility

4.4.5. Discussion on Display Screen Information

The disparity in the data between the results for wheelchair users and ambulant disabled persons, as indicated in the table above, suggests that it is unlikely that a single display screen height will best accommodate the needs of all users.

Small display screens similar to those on the devices in this trial, when located at a height suitable for ambulant persons are unlikely to be suitable for wheelchair users and persons of short or large stature. Where screens are a requirement they should either be so large that they can be easily read from a distance by all potential users, and in all lighting conditions, by persons when standing and seated; or provided at two heights and located so as to allow close approach by ambulant persons and wheelchair users who require knee clearance to facilitate such an approach.

However, it may be possible to satisfy such disparate user needs by limiting the information and making the display as easy to read as possible.

After accessing a chargepoint location the information that a user may require from current public installations is likely to include:

A. How to use the charging device
B. The cost per kWh
C. How long it will take to charge their vehicle to say half or fully charged.

However, display screens as we know, as with many mobile phones also, are not easy to read in the external environment and therefore should not be an essential to the EV charging process. Neither should there be a reliance on smart phone Apps, as some users may not possess or be familiar with either smart phones or the use of Apps. Provision of a telephone contact number can be an alternative and potentially very helpful means of access to a charging network and information on use, providing the network operates such a support service. However even this option can fail where there is not network reception for the user's phone service, or when the phone battery is depleted; or when a PAYG service requires the user to be registered beforehand as in the case of some network providers.

Recommendations

Where screens are to remain in service the following should be considered:

R15. Minimising the fixed and dynamic variables in the display of information required can simplify the display to such as:

Fixed Display	Variable Information
Cost per kWh (£)	(Digital value)
Estimated full-charge time (Hrs and Mins)	(Digital values)
Cost of charge(£)	(Digital value)

R16. Minimising the amount of information in the display makes it easier and less time consuming for users to obtain the information they are likely to readily need.

R17. On this basis the display functions as a meter. Although the data indicates that one height does not necessarily satisfy all user needs, minimising the display information and providing high contrast easily legible displays, may be adequate for most users. Referring to BS8300:2018[5]: meters should be mounted between 1200 mm and 1400mm from the floor (or ground) so that the readings can be viewed by a person standing or sitting.

R18. Best practice guidance for sign design should be applied to the screen display design as well as any permanent printed information associated with the chargepoint and charging facility location; i.e. including:

- Minimum size of text for viewing display from short distance, should be as large as the screen display will allow and be equivalent to an x-height (lower case 'x' character height) of between 15mm and 25mm;
- Use any sans serif typeface (commonly used include Helvetica, Arial, Futura, Avant Garde);
- Where space permits, symbol should be at least 100mm in overall height;
- Letters, symbols and pictograms should contrast visually with the display background;
- Light coloured text and symbols or pictograms on a dark background are preferred.
- A difference in LRV (Light Reflectance Value) of 70 points between the letters, symbols or pictograms and the display background, can ensure good visual contrast.

R19. Use anti-glare screens to reduce or remove reflections.

R20. Provide high-contrast screens using good colour contrast for text and any symbol when viewed against the background.

R21. Where screens are a requirement at the chargepoint they should either be: -

A. Large enough to be easily read from a distance by all potential users, and in all lighting conditions, by persons when standing and seated; or

B. Provided at two heights and located so as to allow close approach by ambulant persons and by wheelchair users who require knee clearance to facilitate such close approach.

R22. Where screens are a requirement:

[5] BS 8300-2:2018 Design of an accessible and inclusive built environment: Part 2 Buildings – Code of practice, 15.7.2

a. Any such screen should utilise high contrast LEDs to be readable in all lighting conditions in external uncovered environments as well as internal or covered environments.
b. Where display screens are to be provided / required, improvements should give consideration to the display screen specification parameters including size of screen, quality of display including brightness and contrast between screen characters and background, text format and height, and use of non-reflective display and outer cover screens.

R23. Where display screens are necessitated on any chargepoint device, we advise further research is required to identify the optimum solution for the size and height of display screens to accommodate the viewing needs of wheelchair users and ambulant users, including persons of short or large stature.

R24. Where a display screen is recessed from the face of the device, it is important to ensure the viewing angle and therefore the visibility of the display is not diminished for persons standing or seated.

4.4.6. Printed Information on User Trial Devices

Figure 18: Task 3 participant reviewing printed information at 1065mm height

Figure 19: Example of printed information on side of double socket device

4.4.7. Twin Socket Device

Printed information located to the side of the 1065mm twin-socket device went unnoticed by some individuals, and additionally presented problematic access for some people with mobility impairment who found it difficult to manoeuvre clear of the protective bollards to view the information.

Several individuals were required to withdraw from the unit and manoeuvre around to the side in order to access the information. One comment was received which outlined that although the printed information had a reasonable font size, the instructions were quite verbose.

4.4.8. Single Socket Device

Figure 20: Printed information on front of single socket device

The single socket unit with printed information located on the front face was preferred, however, several negative comments were received, including one which said there was “too much going on”. In general, individuals preferred the printed information to be located on the front of the unit, which obviates any confusion with its location and assists with accessibility.

The font size used was also problematic for some individuals to read and requires further consideration with regard to increasing font size and reducing the amount of text used.

4.4.9. Complementary and Audible Information

Consideration should be given to the use of charging facilities by persons who have limited reading skills, or for whom English may not be a first language: this may need to be in the form of printed information in other language(s) appropriate to the local demographics, or possibly via recorded audio information or a dedicated telephone contact.

Also for persons with impaired hearing, a number of different wireless devices are available for transmitting information to be received via a hearing-aid wearer. Because these systems reduce the number of audible announcements produced, noise nuisance is reduced. Invasive audible announcements can be stressful for hearing aid users who rely on additional visual support such as lip reading to understand a message.

Recommendations

R25. The necessity to provide lengthy instructions on use of charging devices for those unfamiliar with the procedure should be avoided whenever possible.

R26. Best practice guidance for sign design (as referred to in recommendations above) should be applied to any permanent printed information associated with the chargepoint and charging facility location.

R27. Consider simplifying the charging process as outlined under recommendations above, to enable a reduced requirement for printed instruction on chargepoint use.

R28. Consideration should be given to the use of charging facilities by persons who have limited reading skills, or for who English may not be a first language, including information in easy-read format.

R29. Consider provision of recorded information, to be available to persons with impaired hearing who can receive speech via hearing aids equipped with a T-coil.

4.5. Further Considerations - Age and Impairment Implications

Although specific invitations were circulated to the principal contacts of local disability groups, as well as to persons with impairments who were known to the organisers, this user trial event was promoted as a public event that anyone who was interested could attend. Some ambulant individuals who attended also had unseen impairments.

The number of individuals recorded in attendance for the project event was 14 of which 13 took part in the full event, with one person unable to take part within the time available. The chart below identifies the age range of the participants.

Participants identifying as:			Age Group			Age Group	
Male	12		Under 18	0		45-54	4
Female	2		18-24	0		55-64	2
Disabled	12		25-34	1		65-74	4
Not disabled	2		35-44	1		75+	2

The large majority of participants, 11 persons (84.6%) were over the age of 45 and identified themselves as disabled. Only one participant who completed the trial identified themselves as a non-disabled person (i.e. not a person having a long-standing illness, disability or infirmity which has a substantial effect on their day-to-day life, where longstanding means it has lasted, or is likely to last, for over a year).

Assuming the age range of participants to be fairly representative of the UK age groups most likely to either already have an EV, or are considering having an electric vehicle as their primary means of personal transport, then it is also important to consider the implications of age and impairment on the results and implications for future EVs and Chargepoint development.

4.6. Impairment Groups and Implications for Chargepoint Use

Though not attending as a group, the six disabled individuals who were ambulant persons during the tasks have been considered as a group only for the purpose of results comparison, with the six individual wheelchair users who completed the tasks also considered as a group to compare with.

From the six ambulant persons taking part, two were crutch users, who not unusually also have a wheelchair as an additional mobility aid. One visually impaired participant with a white cane arrived with a driver who would normally be his wife: he indicated it would likely be his task to recharge their vehicle if they had an EV, as he usually refuels their existing car for his wife due to her health issues. Three other ambulant participants identified themselves as disabled due to common issues experienced with ageing effects on strength, mobility, and dexterity; as well as another common issue associated with ageing, which is reduced eyesight perception; although they would not be classed as visually impaired..

Two of the wheelchair users used battery powered wheelchairs with small wheels. One of the four manual wheelchair users had a powered assistance device attached to the rear of his wheelchair, to aid his mobility and to compensate for his limitations on upper body strength and dexterity.

Issues observed during the trial event included the difficulty experienced by ambulant persons with impaired mobility trying to maintain their standing position and stability whilst attempting to interact with the charging device, including inserting and removing the cable connection. Those who were possibly most at risk of falling during such procedures were the two crutch users, one of whom was observed to physically lean against the chargepoints either to steady himself or to briefly rest before moving on; which was possibly a further issue for him in regard to his use of the lower height chargepoints being more problematic to view and to use, and his lower scoring of the two lower height units.

In a similar fashion, some wheelchair users were observed to utilise either an adjacent bollard or the chargepoint as a leaning post to steady them when reaching to interact with the two operational chargepoints.

Many participants also had some problem with the cable, either to remove the dust cover from the plug end, moving with the cable, or when trying to
re-coil the cable after use. Crutch users in particular had problems moving around with the cable.

In response to the above issues we initially advised in the earlier Stage 2 Report that provision of a cable rest to enable chargepoint users to lay the cable down at or adjacent to the chargepoint would help with their management of the cable, whilst positioning themselves appropriately to interact with the chargepoint, as well as aiding them to maintain the cable clear from being an obstruction. However, following the user trial it is clear that provision of a cable rest should be incorporated within the charging device design or its mounting.

Consideration should also be given to the needs of individuals who, when standing or seated, need to be able to steady themselves while interacting with the charging device.

4.7. Implications of Ageing

It is well recognised that an individual’s cognition potential can reduce with age by varying degrees, making it more difficult to understand and take on new knowledge and skills. Therefore, ageing is likely to be an inevitable factor that may influence an individual’s ability and experience of new or less familiar tasks.

Several participants including ambulant persons and wheelchair users were observed to wear spectacles or stated they had spectacles for reading. One person said they could not read chargepoint screen displays because they did not have their reading glasses. Another participant commented they found it difficult to read the display wearing their bifocal lenses. So it is clear that several participants would be reliant on having the appropriate spectacle lenses in order to use such chargepoints.

Applying the above assumption of the participant group as a whole being fairly representative of those persons in the UK, who would most likely either already have an EV or be considering having an EV, the above issues of ageing and impairment have considerable importance for EV designers and infrastructure providers.

As with a population tendency to live longer, there is an increasing likelihood of a significant proportion of drivers having some form of impairment that may affect their day-to-day life, and thereby their use of private and public transport; with implications for their use of EVs and the charging infrastructure.

However, given the current limitations of such consumers having adequate accessibility to EVs that are suitably designed to satisfy their needs and expectations, and an infrastructure that also lacks accessibility, there appears to be some very realistic negative implications for the UK's proposed transition from combustion engines vehicles.

Recommendations

R30. EV charging equipment designers and manufacturers should give consideration to provision of a cable rest at the chargepoint either as part of the charging device or its mounting post to improve cable management, minimise obstruction to charging device by any trailing cable, and to enable chargepoint users to safely lay the cable down whilst they interact with the chargepoint; located at a height between 750mm and 1000mm to be accessible to all potential users.

R31. EV charging equipment designers and manufacturers should give consideration to enabling the chargepoint to be used as a hand-hold and rest-post for persons to steady themselves when interacting with the chargepoint, including while inserting and extracting a cable connection.

R32. EV and charging infrastructure designers and manufacturers should give high priority to improving on the current and future design and technology of their products and services, on the basis of inclusive design, which inherently requires consideration for and inclusion of:

C. An ageing population who have an expectation and need to remain mobile whilst experiencing the impacts of age related impairments;
D. People with impairments who are disabled by inadequate environmental design, provision, and services;
E. People with children and infants who may require increased and flexible provision in regards to how equipment and facilities can be used, as well as the potential need of increased space for their access;
F. Suitability of vehicles for ease of adaptation to accommodate the needs of persons with impairments affecting their upper and / or lower body and limbs, who can have the ability to control a vehicle providing the vehicle can accept the required modifications to the physical infrastructure and the electronic infrastructure that controls the vehicle; which also requires the designers and manufacturers consideration of what interfaces can be provided, possibly as standard, to facilitate such adaptation and minimise any need for modifications or conversion.

5. APPENDICES

These appendices contain a summary of all of the recommendations from Section 4, together with the data sets collected from the participants.

5.1. Summary of Recommendations

This section contains a summary of all of the recommendations from the outcomes of the User Trial, informed also in some instances by consultation during the project with other interested groups and the development work during Stages 1 to 3 of this project.

Some issues are also discussed in the Stage 3 Report, which may provide guidance for designers and manufacturers of EV charging equipment and potentially inform future thinking around the design development of electric vehicles and public charging facilities.

Note: Headings and sub-headings are repeated here to aid recognition of where the related issues are discussed in this report.

5.1.1. Bay and Cable Tasks

R1. Where it is possible to do so, the weight of a cable should be as light as is absolutely necessary to satisfy its required electrical duty and safety regulations, and consideration should also be given to other factors, including cable storage, care of cable, and the ease of removing and fitting dust caps.

R2. We advise a 1600mm access aisle width is the preferred provision, and where this cannot be accommodated a minimum width of 1500mm should be maintained for access at the side of vehicle charging bays.

R3. Provision of a level access cross-aisle at the head of accessible charging bays is generally preferable; as such provision is likely to be essential for drivers with impaired mobility whose vehicles have a front power-inlet charging socket.

5.1.2. Charging Device Tasks

R4. We recommend further consideration should be given to increase the projection of the lower portion of the flap to provide a 'lip or tab' which may afford easier engagement with the flap for people with limited manual dexterity.

R5. An optimum chargepoint socket height is proposed at 900mm above the surface from where the chargepoint is accessed, so as to be accessible by the majority of users. However, further research is advised to identify the optimum height socket solution to accommodate the needs of wheelchair users and ambulant users, including persons of short or large stature, and persons with limited strength and dexterity.

R6. Further research, investigation and consideration is advised in regards to the effort required for both insertion and extraction of the cable plug at chargepoints, which may also be an issue requiring consideration for electric vehicle development generally. Note: Although this report is based on charging devices with type 2 Mennekes socket connections, it should be recognised that similar issues may or may not be experienced with different charging socket types or devices

R7. Appropriate separation distance is required between adjacent sockets on double-socket charging devices, so that there is adequate clearance for a two-handed grip around the cable plug when inserting and removing the cable connection. This may also benefit users with upper body prosthetics, as well as others with impaired dexterity and strength limitations, and potential benefit to many older persons.

5.1.3. Smart Card Readers

R8. Access to the chargepoint network should be simplified to enable access without the need for internet or Wi-Fi access, such that a PAYG service is available to anyone with a recognised Debit or Credit Card.

R9. An optimum chargepoint Card Reader sensor height is proposed directly above the charging socket and clear of any socket flap when open, so as to be accessible by all potential users. However where this is not possible, the location of the sensor should be within a height of 750mm to 1200mm above the surface from where it is accessed, i.e. the vehicle bay level, to be accessible to all potential users.

R10. Card reader sensing location should be readily recognisable by use of a standard icon that is preferably internationally recognised.

5.1.4. Protective Bollards and Posts

R11. All bollard and post heights above ground level should be at least 1000 mm and should contrast visually with the background against which they are seen, with: a 150mm deep contrasting strip at the top; a surface finish that is not highly reflective; and is contrasted to the ground; to be visible to people with sight-loss, who may be passengers and assisting their driver with impaired mobility to connect to a chargepoint.

R12. Two bollards located at 1400mm between centres and equidistant to the centreline of the Centre Access Aisle (i.e. located with centre of bollards 700mm each side of the centre aisle centreline); and

R13. For chargepoints located on or behind a kerb or kerb-line, the rear face of the bollards should be positioned at least 50mm forward of the power outlet sockets (or chargepoint if side sockets) and preferably not more than 100mm forward of the kerb when measured along the centre aisle.

R14. For chargepoints located in front of the kerb, or at head of centre aisle with a level access cross aisle, the rear face of the bollards should be positioned at least 50mm and preferably not more than 100mm forward of the power outlet sockets (or chargepoint if side sockets) when measured along the centre aisle.

5.1.5. Information Screens

Where screens are to remain in service the following should be considered:

R15. Minimising the fixed and dynamic variables in the display of information required can simplify the display to such as:

Fixed Display	Variable Information
Cost per kWh (£)	(Digital value)
Estimated full-charge time (Hrs and Mins)	(Digital values)
Cost of charge(£)	(Digital value)

R16. Minimising the amount of information in the display makes it easier and less time consuming for users to obtain the information they are likely to readily need.

R17. On this basis the display functions as a meter. Although the data indicates that one height does not necessarily satisfy all user needs, minimising the display information and providing high contrast easily legible displays, may be adequate for most users. Referring to BS8300:2018[6]: meters should be mounted between 1200 mm and 1400mm from the floor (or ground) so that the readings can be viewed by a person standing or sitting.

R18. Best practice guidance for sign design should be applied to the screen display design as well as any permanent printed information associated with the chargepoint and charging facility location; i.e. including:

- Minimum size of text for viewing display from short distance, should be as large as the screen / display will allow and be equivalent to an x-height (lower case 'x' character height) of between 15mm and 25mm;
- Use any sans serif typeface (commonly used include Helvetica, Arial, Futura, Avant Garde);
- Where space permits, symbol should be at least 100mm in overall height;
- Letters, symbols and pictograms should contrast visually with the display background;
- Light coloured text and symbols or pictograms on a dark background are preferred.
- A difference in LRV (Light Reflectance Value) of 70 points between the letters, symbols or pictograms and the display background, can ensure good visual contrast.

R19. Anti-glare screen should be used to reduce or remove reflections: this applies to the display screen and any outer cover protecting the display.

R20. Use of high-contrast screens using good colour contrast for text and any symbol when viewed against the background.

R21. Where screens are a requirement at the chargepoint they should either be: -

a. Large enough to be easily read from a distance by all potential users, and in all lighting conditions, by persons when standing and seated; or

b. Provided at two heights and located so as to allow close approach by ambulant persons and by wheelchair users who require knee clearance to facilitate such close approach.

R22. Where screens are a requirement:

c. Any such screen should utilise high contrast LEDs to be readable in all lighting conditions in external uncovered environments as well as internal or covered environments.

d. Where display screens are to be provided / required, improvements should give consideration to the display screen specification parameters including size of screen, quality of display including brightness and contrast between screen characters and background, text format and height, and use of non-reflective display and outer cover screens.

R23. Where display screens are necessitated on any chargepoint device, we advise further research is required to identify the optimum solution for the size and height of display screens to accommodate the viewing needs of wheelchair users and ambulant users, including persons of short or large stature.

R24. Where a display screen is recessed from the face of the device, it is important to ensure the viewing angle and therefore the visibility of the display is not diminished for persons standing or seated.

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[6] BS 8300-2:2018 Design of an accessible and inclusive built environment: Part 2 Buildings – Code of practice, 15.7.2

5.1.6. Printed Information on or at Charging Devices

R25. The necessity to provide lengthy instructions on use of charging devices for those unfamiliar with the procedure should be avoided whenever possible.

R26. Best practice guidance for sign design (as referred to in recommendations) should be applied to any permanent printed information associated with the chargepoint and charging facility location.

R27. Consider simplifying the charging process as outlined under recommendations, to enable a reduced requirement for printed instruction on chargepoint use.

5.1.7. Complementary and audible information

R28. Consideration should be given to the use of charging facilities by persons who have limited reading skills, or for who English may not be a first language, including information in easy-read format.

R29. Consider provision of recorded information, to be available to persons with impaired hearing who can receive speech via hearing aids equipped with a T-coil.

5.1.8. Participants Age and Impairment Groups

R30. EV charging equipment designers and manufacturers should give consideration to provision of a cable rest at the chargepoint either as part of the charging device or its mounting post to improve cable management, minimise obstruction to charging device by any trailing cable and to enable chargepoint users to safely lay the cable down on the ground whilst they interact with the chargepoint.

R31. EV charging equipment designers and manufacturers should give consideration to enabling the chargepoint to be used as a hand-hold and rest-post for persons to steady themselves when interacting with the chargepoint, including while inserting and extracting a cable connection.

R32. Designers and manufacturers of Electric Vehicles and EV Charging Infrastructure should give high priority to improving on the current and future design and technology of their products and services, on the basis of inclusive design, which inherently requires consideration for and inclusion of:

e. An ageing population who have an expectation and need to remain mobile whilst experiencing the impacts of age related impairments.
f. People with impairments who are disabled by inadequate environmental design, provision, and services.
g. People with children and infants who may require increased and flexible provision in regards to how equipment and facilities can be used, as well as the potential need of increased space for their access.
h. Suitability of vehicles for ease of adaptation to accommodate the needs of persons with impairments affecting their upper and / or lower body and limbs, who can have the ability to control a vehicle providing the vehicle can accept the required modifications to the physical infrastructure and the electronic infrastructure that controls the vehicle; which also requires the designers and manufacturers consideration of what interfaces can be provided, possibly as standard, to facilitate such adaptation and minimise any need for modifications or conversion.

5.2. Summary of Participants' Comments

This table provide an overview of the comments made by the 13 participants, each of whom had a disability which affected their use of an EVCP.

	Bay and Cable Use Ratings by Participant	1	2	3	4	5	6	7	8	9	10	11	12	13		Overall	
Question No.	A = Ambulant, AD=Ambulant Disabled, AC=Crutch User, AV=Ambulant Vision Impaired, W= Manual Wheelchair, WE=Powered Wheelchair, N=Non-disabled	Rating AD	Rating W	Rating AC	Rating AD	Rating W	Rating W	Rating WE	Rating AD	Rating N	Rating WE	Rating W	Rating AC	Rating AV	Totals	Average for All	Overall
	Charging Bay and Cable Use (Chargepoint Socket Height at 940mm)																
1	Do you have an impairment that may affect your mobility or use of a vehicle or a device?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**No**	Yes	Yes	Yes	Yes			
2	On a scale of 0 to 5 how easy was it to insert and remove the plug at the vehicle?	5.0	4.0	4.0	4.0	5.0	**0.0**	5.0	3.0	4.5	2.0	5.0	4.0	5.0	50.5	3.9	77.69%
3	On a scale of 0 to 5 how easy was it to move around with the cable?	5.0	3.5	3.0	5.0	4.0	3.0	4.0	4.0	5.0	2.0	4.0	3.0	4.0	49.5	3.8	76.15%
4	On a scale of 0 to 5 how much did the weight of the cable affect your experience?	5.0	4.0	3.0	5.0	4.0	3.0	5.0	2.0	5.0	2.0	5.0	3.0	5.0	51.0	3.9	78.46%
7	On a scale of 0 to 5 how would you rate your experience of connecting Charging Cable to the Vehicle?	5.0	4.0	3.0	5.0	5.0	**0.0**	5.0	4.0	5.0	2.0	5.0	4.0	4.0	51.0	3.9	78.46%
8	On a scale of 0 to 5 how would you rate your experience of connecting Charging Cable to Charging Device?	5.0	4.0	3.0	4.0	5.0	**0.0**	5.0	3.0	5.0	2.0	5.0	3.0	4.0	48.0	3.7	73.85%
		25.0	19.5	16.0	23.0	23.0	6.0	24.0	16.0	24.5	10.0	24.0	17.0	22.0	250.0	3.8	76.92%
	Number of Zeros (= not able to do task)						3								**3**		
	Individual Particpant Percentage Success	100%	78%	64%	92%	92%	24%	96%	64%	98%	40%	96%	68%	88%		77%	
	Particpants experiencing less than 95% Success	0	1	1	1	1	1	0	1	0	1	0	1	1	69.23%		
	Particpants experiencing less than 90% Success	0	1	1	1	0	1	0	1	0	1	0	1	1	61.54%		
	Particpants experiencing less than 85% Success	0	1	1	1	0	1	0	1	0	1	0	1	0	53.85%		
	Particpants experiencing less than 80% Success	0	1	1	1	0	1	0	1	0	1	0	1	0	53.85%		
	Particpants experiencing less than 75% Success	0	0	1	1	0	1	0	1	0	1	0	1	0	46.15%		
	Particpants experiencing less than 70% Success	0	0	1	0	0	1	0	1	0	1	0	1	0	38.46%		
	Particpants experiencing less than 65% Success	0	0	1	0	0	1	0	1	0	1	0	0	0	30.77%		
	Particpants experiencing less than 50% Success	0	0	0	0	0	1	0	0	0	1	0	0	0	15.38%		
5	What width of space at side of vehicle do you normally need for getting in and out of a vehicle? (Approximately) in Metres { RAW=Rear Access Wheelchair Accessible Vehicle }	0.55	1.20	0.90	<1.2	RAW	RAW	RAW	0.50	<1.2	RAW	1.20	1.20	<1.2			
6	What width (colour) at side of vehicle was required to accommodate the task of connecting cable to vehicle? in Metres	<1.2	1.20	1.20	<1.2	<1.2	<1.2	1.30	<1.2	<1.2	1.45	1.20	1.20	<1.2			
	Types of Vehicles Regularly Used: D = Diesel; P = Petrol; H = Hybrid; W=WAV	D	H	H	P + D	DW	DW	W	P	D	DW	P + DWAV	Petrol	NA			
	Participant	1	2	3	4	5	6	7	8	9	10	11	12	13			

	EV Chargepoint Use Ratings by Participant	1	2	3	4	5	6	7	8	9	10	11	12	13	
Question No.	A= Ambulant, AD=Ambulant Disabled, AC=Crutch User, AV=Ambulant Vision Impaired, W= Manual Wheelchair, WE=Powered Wheelchair, N=Non-disabled	AD	W	AC	AD	W	W	WE	AD	N	WE	W	AC	AV	
		Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	**Average**
	Participants Eye Level Height (m)	1.77	1.26	1.70	1.63	1.10	1.19	1.17	1.47	1.75	1.31	1.25	1.66	1.58	
	Mock-up Socket Height at 850mm														
1	Reach height capacity (It was not possible to consistently collect this data)														
2	On a scale of 0 to 5 how easy was it to lift the flap?	5.0	5.0	5.0	3.0	5.0	2.0	5.0	4.0	5.0	3.0	5.0	5.0	4.5	4.3
3	On a scale of 0 to 5 how easy was it to insert the plug?	5.0	5.0	5.0	4.0	5.0	2.0	5.0	3.0	5.0	4.0	5.0	**0.0**	5.0	4.1
4	On a scale of 0 to 5 how easy was it to reach the card reader?	5.0	5.0	5.0	5.0	5.0	4.0	5.0	4.0	5.0	5.0	5.0	4.0	4.0	4.7
5	On a scale of 0 to 5 how much did the bollards affect your access?	5.0	5.0	5.0	5.0	5.0	4.0	5.0	5.0	5.0	4.0	2.0	**0.0**	5.0	4.2
6	On a scale of 0 to 5 how would you rate your ease of reading the screen height?	2.0	5.0	2.0	3.0	5.0	4.5	5.0	3.0	4.0	4.0	5.0	**0.0**	3.0	3.5
7	On a scale of 0 to 5 how easy was it to remove the plug?	5.0	5.0	5.0	3.0	5.0	5.0	5.0	3.0	5.0	2.0	5.0	**0.0**	3.0	3.9
8	On a scale of 0 to 5 how would you rate the experience?	4.0	5.0	4.0	3.5	5.0	5.0	5.0	3.0	5.0	3.0	4.0	1.0	4.0	4.0
		31.0	35.0	31.0	26.5	35.0	26.5	35.0	25.0	34.0	25.0	31.0	10.0	28.5	4.1
	Number of Zeros (= not able to do task)												4		
	Percentage success	88.6%	100.0%	88.6%	75.7%	100.0%	75.7%	100.0%	71.4%	97.1%	71.4%	88.6%	28.6%	81.4%	**82.09%**
	Operational Socket Height at 940mm	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	**Average**
1	Reach height capacity (It was not possible to consiently collect this data)														
2	On a scale of 0 to 5 how easy was it to lift the flap?	5.0	5.0	5.0	5.0	5.0	3.0	5.0	2.0	5.0	3.0	4.0	4.0	4.0	4.2
3	On a scale of 0 to 5 how easy was it to insert the plug?	5.0	5.0	5.0	4.0	5.0	**0.0**	5.0	4.0	5.0	3.0	5.0	4.0	5.0	4.2
4	On a scale of 0 to 5 how easy was it to reach the card reader?	5.0	5.0	5.0	5.0	5.0	2.0	5.0	5.0	5.0	5.0	5.0	4.0	5.0	4.7
5	On a scale of 0 to 5 how much did the bollards affect your access?	5.0	5.0	5.0	5.0	4.0	4.0	5.0	5.0	5.0	4.0	5.0	5.0	5.0	4.8
6	On a scale of 0 to 5 how would you rate your ease of reading the screen text?	3.0	4.0	2.0	1.0	**0.0**	5.0	4.0	2.0	5.0	4.0	5.0	2.0	1.0	2.9
7	Refer to Comments Report														
8	On a scale of 0 to 5 how would you rate the printed information provided on how to use the charger?	2.0	5.0	5.0	4.0	**0.0**	5.0	5.0	2.0	5.0	4.0	5.0	1.0	1.0	3.4
9	On a scale of 0 to 5 how easy was it to remove the plug?	5.0	5.0	4.0	4.0	5.0	2.0	5.0	5.0	5.0	3.0	5.0	3.0	5.0	4.3
10	On a scale of 0 to 5 how would you rate the experience?	4.5	4.0	4.0	4.0	5.0	3.0	5.0	4.0	5.0	3.0	5.0	3.0	4.0	4.1
		34.5	38.0	35.0	32.0	29.0	24.0	39.0	29.0	40.0	29.0	39.0	26.0	30.0	4.1
	Number of Zeros (= not able to do task)					2	1								
	Percentage success	86.3%	95.0%	87.5%	80.0%	72.5%	60.0%	97.5%	72.5%	100.0%	72.5%	97.5%	65.0%	75.0%	**81.63%**
	Operational Socket Height at 1065mm	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	Rating	**Average**
1	Reach height capacity (It was not possible to consiently collect this data)														
2	On a scale of 0 to 5 how easy was it to lift the flap?	5.0	5.0	5.0	2.0	5.0	5.0	4.0	3.0	5.0	**0.0**	5.0	4.0	4.0	4.0
3	On a scale of 0 to 5 how easy was it to insert the plug?	5.0	5.0	4.0	4.0	5.0	**0.0**	5.0	4.0	5.0	**0.0**	5.0	3.0	3.5	3.7
4	On a scale of 0 to 5 how easy was it to reach the card reader?	5.0	5.0	5.0	5.0	4.0	2.0	5.0	4.0	5.0	5.0	5.0	4.0	5.0	4.5
5	On a scale of 0 to 5 how much did the bollards affect your access?	5.0	5.0	5.0	5.0	5.0	5.0	5.0	3.0	5.0	1.0	5.0	5.0	5.0	4.5
6	On a scale of 0 to 5 how would you rate your ease of reading the screen text?	3.0	1.0	4.0	3.0	**0.0**	**0.0**	4.0	2.0	5.0	4.0	5.0	4.0	4.0	3.0
7	Refer to Comments Report														
8	On a scale of 0 to 5 how would you rate the printed information provided on how to use the charger?	3.0	5.0	3.0	3.0	2.0	5.0	3.0	3.0	5.0	3.0	3.0	4.0	3.0	3.5
9	On a scale of 0 to 5 how easy was it to remove the plug?	5.0	5.0	5.0	3.0	5.0	**0.0**	5.0	1.0	5.0	**0.0**	5.0	2.0	3.0	3.4
10	On a scale of 0 to 5 how would you rate the experience?	5.0	4.0	4.0	3.0	4.0	2.0	4.0	3.5	5.0	1.0	5.0	3.0	4.0	3.7
		36.0	35.0	35.0	28.0	30.0	19.0	35.0	23.5	40.0	14.0	38.0	29.0	31.5	3.8
	Number of Zeros (= not able to do task)					1	3				3				
	Percentage success	90.0%	87.5%	87.5%	70.0%	75.0%	47.5%	87.5%	58.8%	100.0%	35.0%	95.0%	72.5%	78.8%	**75.77%**

5.3. Participant Comments

This section contains the individual comments of the participants, it is worth noting that although there are many similarities in the comments there are also differences created by the disability of the induvial.

Each participant was asked to respond to the same questions relating to the general access to the EVCP and their ability to use the CP.

Item	Q #	Topic	Comment
Participant # 1 – Male – AD Head Ht – 1.95m – Eye Ht = 1.77m			
Bay and Cable Use	5	What width of space at side of vehicle do you normally need for getting in and out of a vehicle? (Approx. metres)	0.55
	6	What width at side of vehicle was required to accommodate the task of connecting cable to vehicle? (Approx. metres)	<1.2
		Any other comments?	• No comments
940 Height Socket	7	Is there anything you would change about the screen information?	• Difficult to read • Poor contrast • Okay when lit • Have to bend to read
	11	Any other comments?	• Some printed information is too small • Have to bend to read and get in closer
1065 Height Socket	7	Is there anything you would change about the screen information?	• Bend to read it • Reflections are problematic • Screen text is small • Poor contrast of information

Item	Q #	Topic	Comment
			• Wears bifocals which makes reading the screen information difficult
	11	Any other comments?	• Have to bend to read printed information
850 Height Socket	9	Any other comments?	• Screen too low
Participant # 2 – Male – W Head Ht – 1.37m – Eye Ht = 1.26m			
Bay and Cable Use	5	What width of space at side of vehicle do you normally need for getting in and out of a vehicle? (Approx. metres)	1.2
	6	What width at side of vehicle was required to accommodate the task of connecting cable to vehicle? (Approx. metres)	1.2
		Any other comments?	• No comments
940 Height Socket	7	Is there anything you would change about the screen information?	• Provide a bigger screen • Provide larger print • Reflections can affect reading
	11	Any other comments?	• Level area around parking made it easier
1065 Height Socket	7	Is there anything you would change about the screen information?	• Reflection made it very difficult to read
	11	Any other comments?	• Information should not be on the side but on the front
850 Height Socket	9	Any other comments?	• No comments
Participant # 3 – Male – AC Head Ht – 1.37m – Eye Ht = 1.26m			

Item	Q #	Topic	Comment
Bay and Cable Use	5	What width of space at side of vehicle do you normally need for getting in and out of a vehicle? (Approx. metres)	0.9
	6	What width at side of vehicle was required to accommodate the task of connecting cable to vehicle? (Approx. metres)	1.2
		Any other comments?	• No comments
940 Height Socket	7	Is there anything you would change about the screen information?	• Screen positioned at an angle would be better
	11	Any other comments?	• Double crutch user - have to bend to read screen - can cause instability and fall
1065 Height Socket	7	Is there anything you would change about the screen information?	• No comments
	11	Any other comments?	• Information should be on the front
850 Height Socket	9	Any other comments?	• Would be easier as you get used to it • Screen would always be an issue
Participant # 4 – Male – AD Head Ht – 1.74m – Eye Ht = 1.64m			
Bay and Cable Use	5	What width of space at side of vehicle do you normally need for getting in and out of a vehicle? (Approx. metres)	<1.2
	6	What width at side of vehicle was required to accommodate the task of connecting cable to vehicle? (Approx. metres)	<1.2
		Any other comments?	• No comments

Item	Q #	Topic	Comment
940 Height Socket	7	Is there anything you would change about the screen information?	• Difficult to see in daylight • Green symbol not very clear Had to bend and crouch down and get close to read display (did not have his reading glasses) Larger text needed • Better contrast to text and to tick and background
	11	Any other comments?	• Text size of printed information is poor
1065 Height Socket	7	Is there anything you would change about the screen information?	• Too low but easier to read than 940 unit • Highly reflective • Poor contrast
	11	Any other comments?	• Contrast to bollards important • Larger printed text on unit
850 Height Socket	9	Any other comments?	• Better flap lifting capacity
Participant # 5 – Female – W Head Ht – 1.20m – Eye Ht = 1.10m			
Bay and Cable Use	5	What width of space at side of vehicle do you normally need for getting in and out of a vehicle? (Approx. metres)	WAV rear access vehicle
	6	What width at side of vehicle was required to accommodate the task of connecting cable to vehicle? (Approx. metres)	<1.2
		Any other comments?	• No comments
940 Height Socket	7	Is there anything you would change about the screen information?	• **Needs reading glasses • Reflective screen is problematic

Item	Q #	Topic	Comment
	11	Any other comments?	• Left bollard too close to chargepoint • **Needs reading glasses
1065 Height Socket	7	Is there anything you would change about the screen information?	• **Needs reading glasses • Larger screen better Not reflective here
	11	Any other comments?	• No comments
850 Height Socket	9	Any other comments?	• Screen height better than 940 and certainly better than 1065 - this is the best
Participant # 6 – Male – W Head Ht – 1.26m – Eye Ht = 1.19m			
Bay and Cable Use	5	What width of space at side of vehicle do you normally need for getting in and out of a vehicle? (Approx. metres)	• WAV rear access vehicle
	6	What width at side of vehicle was required to accommodate the task of connecting cable to vehicle? (Approx. metres)	<1.2
		Any other comments?	• Cable not as heavy as anticipated
940 Height Socket	7	Is there anything you would change about the screen information?	• No comments
	11	Any other comments?	• Might be easier if flap could be held open while inserting plug
1065 Height Socket	7	Is there anything you would change about the screen information?	• Poor - limited by black border at bottom of screen • No reflection

Item	Q #	Topic	Comment
	11	Any other comments?	• Mechanism which kept flap open would help Using card reader would be worse if have to hold card in place for any length of time A phone App and screen option is better
850 Height Socket	9	Any other comments?	• An automatic sensor to activate flap would help • Bollard position okay but at lower height
Participant # 7 – Male – WE Head Ht – 1.30m – Eye Ht = 1.17m			
Bay and Cable Use	5	What width of space at side of vehicle do you normally need for getting in and out of a vehicle? (Approx. metres)	WAV rear access vehicle
	6	What width at side of vehicle was required to accommodate the task of connecting cable to vehicle? (Approx. metres)	1.3
		Any other comments?	• No comments
940 Height Socket	7	Is there anything you would change about the screen information?	• No comments
	11	Any other comments?	• Screen display may be difficult to read in sunny conditions • Putting printed information on front of unit is easier
1065 Height Socket	7	Is there anything you would change about the screen information?	• Bright sunlight makes it worse
	11	Any other comments?	• Printed information on side is difficult to access

Item	Q #	Topic	Comment
			• The vehicle connector height should be used for unit plug heights
850 Height Socket	9	Any other comments?	• Can manage highest unit plug in
Participant # 8 – Female – AD Head Ht – 1.57m – Eye Ht = 1.47m			
Bay and Cable Use	5	What width of space at side of vehicle do you normally need for getting in and out of a vehicle? (Approx. metres)	0.5
	6	What width at side of vehicle was required to accommodate the task of connecting cable to vehicle? (Approx. metres)	<1.2
		Any other comments?	• No comments
940 Height Socket	7	Is there anything you would change about the screen information?	• The colours used
	11	Any other comments?	• Lifting flap was an issue • Black text on grey screen is difficult • Printed information is wrong typeface • Background colour reflects
1065 Height Socket	7	Is there anything you would change about the screen information?	• Grey background with text is problematic • Change the colours
	11	Any other comments?	• Bollards highlighted • Bollards could have information situated on top
850 Height Socket	9	Any other comments?	• Screen too low

Item	Q #	Topic	Comment
Participant # 9 – Male – N Head Ht – 1.85m – Eye Ht = 1.75m			
Bay and Cable Use	5	What width of space at side of vehicle do you normally need for getting in and out of a vehicle? (Approx. metres)	<1.2
	6	What width at side of vehicle was required to accommodate the task of connecting cable to vehicle? (Approx. metres)	<1.2
		Any other comments?	• Good positive cable connection • Possible trip issues • Use high visibility cables
940 Height Socket	7	Is there anything you would change about the screen information?	• Good positive cable connection
	11	Any other comments?	• None
1065 Height Socket	7	Is there anything you would change about the screen information?	• No comments
	11	Any other comments?	• No comments
850 Height Socket	9	Any other comments?	• No comments
Participant # 10 – Male – WE Head Ht – 1.40m – Eye Ht = 1.31m			
Bay and Cable Use	5	What width of space at side of vehicle do you normally need for getting in and out of a vehicle? (Approx. metres)	WAV rear access vehicle
	6	What width at side of vehicle was required to accommodate the task of connecting cable to vehicle? (Approx. metres)	1.4

Item	Q #	Topic	Comment
		Any other comments?	• No comments
940 Height Socket	7	Is there anything you would change about the screen information?	• Font bigger • Bigger screen
	11	Any other comments?	• Printed information confusing • Too much going on
1065 Height Socket	7	Is there anything you would change about the screen information?	• Reflections are bad • Colours are okay
	11	Any other comments?	• Manual dexterity issues are a problem Bollards prevented close approach to get plug inserted A second plug in the unit made it worse • Too much printed information - use more icons • Easyread information?
850 Height Socket	9	Any other comments?	• Had to waggle cable to remove plug Lifting flap is problematic and hinders plug insertion This allows best approach
Participant # 11 – Male – W Head Ht – 1.36m – Eye Ht = 1.25m			
Bay and Cable Use	5	What width of space at side of vehicle do you normally need for getting in and out of a vehicle? (Approx. metres)	1.2
	6	What width at side of vehicle was required to accommodate the task of connecting cable to vehicle? (Approx. metres)	1.2

Item	Q #	Topic	Comment
		Any other comments?	• No comments
940 Height Socket	7	Is there anything you would change about the screen information?	• Indication of charging so you know it's connected
	11	Any other comments?	• Flap should open down • One-handed operation with more prominent lip on flap
1065 Height Socket	7	Is there anything you would change about the screen information?	• No comments
	11	Any other comments?	• Printed information not easy to read when having to lean
850 Height Socket	9	Any other comments?	• Bollards too narrow - can't get close enough
Participant # 12 – Male – AC Head Ht – 1.78m – Eye Ht = 1.66m			
Bay and Cable Use	5	What width of space at side of vehicle do you normally need for getting in and out of a vehicle? (Approx. metres)	1.2
	6	What width at side of vehicle was required to accommodate the task of connecting cable to vehicle? (Approx. metres)	1.2
		Any other comments?	• Weight of cable is a problem when using crutches - too heavy Would be a lot more difficult when it's icy
940 Height Socket	7	Is there anything you would change about the screen information?	• Text in grey box is difficult to read

Item	Q #	Topic	Comment
	11	Any other comments?	• Printed information is too small
1065 Height Socket	7	Is there anything you would change about the screen information?	• Bigger text required • Less reflective
	11	Any other comments?	• Printed information is better • Icy weather would be an issue when removing plug
850 Height Socket	9	Any other comments?	• Flap no problem • Can't insert plug • Easier without bollards
Participant # 13 – Male – AV Head Ht – 1.70m – Eye Ht = 1.58m			
Bay and Cable Use	5	What width of space at side of vehicle do you normally need for getting in and out of a vehicle? (Approx. metres)	Full width of vehicle door
	6	What width at side of vehicle was required to accommodate the task of connecting cable to vehicle? (Approx. metres)	<1.2
		Any other comments?	• No comments
940 Height Socket	7	Is there anything you would change about the screen information?	• Needs a different display - illuminated from back is difficult - quite feint
	11	Any other comments?	• Printed information is small - should be at eye height
1065 Height Socket	7	Is there anything you would change about the screen information?	• High contrast would be better • Less reflection

Item	Q #	Topic	Comment
	11	Any other comments?	• Better text size for unit number ID • Arrow used to indicate location of printed information • Wife would struggle to get information with her eye height
850 Height Socket	9	Any other comments?	• Flap seems to project more • A dual-height screen?