The Determination of Accessible Taxi Requirements

PPAD 9/72/87 (UG539)

Undertaken on behalf of

Mobility and Inclusion Unit,
Department for Transport

Prepared by

John Richardson, ESRI
David Yelding, Ricability

June 2004

Acknowledgements

The researchers would like to express their thanks for the many individuals and organisations that supported this work and in particular:

- The participants who gave generously of their time to provide the data that informed this research
- DPTAC and the many disability organisations who contributed advice and views
- Gowrings Mobility, Rohill Bodies, Elap Ltd and LTI for their support of the technical trials
- Intertek – ITS Laboratories for completing the assessment trials

Executive Summary

This report describes the results of a programme of ergonomic research undertaken to provide a scientific basis for the generation of regulations concerned with the introduction of accessible taxis in the UK. Accessibility was characterised as the ability to accommodate a broad range of non-disabled and mobility impaired passengers in reasonable safety and comfort. Two critical aspects of the brief were that the research should not be constrained by current vehicle design and that a ‘design-for-all’ specification should be assumed as a goal. However, the brief did not task the researchers with proposing specific design solutions.

Following a literature review and a series of consultation exercises assessment trials were conducted with a large sample of mobility impaired participants and a fully adjustable test rig.

The results of these assessments were analysed in detail to provide recommendations on the dimensions and characteristics that would make future taxis accessible to the majority of potential passengers. Further recommendations were proposed on the basis of existing knowledge, best practice and current requirements and guidance.

The research established that the floor height, door height and internal space (floor and head room) of current purpose built taxis represent significant barriers to accessibility.

Contents

1 Introduction 9
1.1 Aims and scope 9
1.2 Summary of phase 1 activities 10
2 Summary of main findings 13
2.1 Doors 13
2.1.1 Introduction 13
2.1.2 Tests 13
2.1.3 Participants 14
2.1.4 Wheelchair users 14
2.1.5 People with other mobility impairments 16
2.1.6 People with visual impairments 17
2.2 Ramps 18
2.2.1 Introduction 18
2.2.2 Acceptable gradients 19
2.2.3 Ramps in taxis 19
2.2.4 Our assessments 20
2.2.5 Tests 21
2.2.6 Results 21
2.2.7 Assisted access 23
2.3 Step height 24
2.3.1 Introduction 24
2.3.2 Tests 24
2.3.3 Participants 24
2.3.4 People with impaired mobility 25
2.3.5 People with visual impairments 26
2.3.6 People with impaired dexterity and reach 27
2.3.7 Suggested improvements 28
2.3.8 Other data on steps 28
2.4 Interior space 29
2.4.1 Introduction 29
2.4.2 Roof height tests 29
2.4.3 Floor plan 33
2.4.4 Swivel seats 42
3 RECOMMENDATIONS 50
4 APPENDICES 71
4.1 APPENDIX 1: Summary of methods employed 71
4.1.1 Desk research 71
4.1.2 Empirical research 71
4.1.3 Assessment rig 72
4.1.4 Data capture 73
4.1.5 Assessment tasks 73

4.1.6 Wheelchair users 73
4.1.7 Ambulant users 74
4.1.8 Additional tasks/feedback 74
4.1.9 Analysis of results 75
4.1.10 Existing requirements 75
4.1.11 Additional data collection 75
4.1.12 Expert advice 75
4.1.13 Consultation 76
4.2 APPENDIX 2: Consultation 77
4.2.1 Findings 80
4.2.2 Taxi design 81
4.2.3 Floor height 81
4.2.4 Swivel seats 82
4.2.5 The position of the rear seat in relation to the door 83
4.2.6 Door opening 83
4.2.7 Wheelchair access 84
4.2.8 Securing wheelchairs 85
4.2.9 Grab handles 87
4.2.10 Design of the rear seat 88
4.2.11 Features 88
4.2.12 Meters 88
4.2.13 Climate control 89
4.2.14 Seatbelts 89
4.2.15 Additional requirements listed in 1997 consultation 90
4.2.16 Service issues 90
4.2.17 Booking 91
4.2.18 Tariffs 91
4.2.19 Steps 91
4.2.20 Code of practice 93
4.3 APPENDIX 3: Ramp gradients and handling efforts 94
4.3.1 Assessment of wheelchair handling efforts 94
4.3.2 Test measurements 96
4.3.3 Conclusions 99
4.4 APPENDIX 4: Door closure, door and grab handles 100
4.4.1 Introduction 100
4.4.2 Door opening and closing forces 100
4.4.3 Sliding door operation 102
4.4.4 Posture 103
4.4.5 Reach 103
4.4.6 Door handle operation 105
4.4.7 External door handles 105
4.4.8 Interior door handles 107
4.4.9 Handle visibility 108

4.4.10 Grab handles 109
4.4.11 Location 110
4.4.12 Size and design 110
4.5 APPENDIX 5: Interior lighting 112
4.5.1 Interior lighting and colour and luminance contrast 112
4.5.2 General guidance & consequent recommendations 112
4.6 APPENDIX 6: The Rohill TaxiRider vehicle 115
4.6.1 Participants 116
4.6.2 Findings 116
4.6.3 Wheelchair users 117
4.6.4 Other groups 118
4.7 APPENDIX 7: Service standards 119
4.7.1 Finding a taxi and booking 119
4.7.2 Hailing a cab 119
4.7.3 Booking by telephone 120
4.7.4 Standards of service 120
4.7.5 Help and assistance 120
4.7.6 Communication 121
4.7.7 Safety 121
4.7.8 Regulation and accreditation 122
4.8 APPENDIX 8: Sample details 123
5 References 130

1 Introduction

The Mobility and Inclusion Unit at the Department for Transport (DfT) commissioned ESRI and Ricability to advise them on ergonomic requirements for the specification of accessible taxis. A programme of work was agreed comprising an initial review of relevant issues followed by a pilot evaluation trial with a limited sample of older and disabled people. The results of the initial trial would inform the design of a more comprehensive set of trials to be undertaken in a second phase of the work. The first phase of the work was reported in November 2003.This report covers the second phase of the project and includes a report on the full assessment trials, the consultation results, additional empirical tests and contextual factors critical to the interpretation and implementation of the test results. Recommendations are made for ergonomic access requirements based on all these inputs.

1.1 Aims and scope

The aim of the work was to advise the DfT on the ergonomic requirements for taxis that would enable disabled people, including wheelchair users, to get into and out of licensed taxis and travel in reasonable safety and comfort. The advice provided would inform the generation of detailed technical regulations on the design of taxis that would be introduced at a future date under the powers given to the Government under the Disability Discrimination Act 1995.

The specific issues on which advice was requested included entry and exit for ambulant and wheelchair users using steps and ramps, the use of handles and handholds and interior space, seating and lighting.

The research did not assume that future DDA compliant taxis would necessarily provide either side or rear access for wheelchair users. There are operational factors (e.g. the presence of pavements and kerbs) that affect the convenience of both forms of entry. The tests and research findings reported here should be understood to be equally applicable to side and rear access unless indicated to the contrary.

The brief did not require advice to be given on engineering solutions or potential vehicle designs that would accommodate the ergonomic requirements. However, these issues were inevitably raised in the discussions held with the relevant stakeholders.

Although the numbers affected have not been accurately estimated in the literature it is nevertheless accepted that taxis are not accessible for a substantial number of people with mobility impairments. It was agreed that the aim of the current work should be to define access requirements that would enable the majority of people who wish to use taxis to be able to do so. This would be achieved by way of empirical tests and population estimates so that the final advice would indicate, where possible, the degree of additional accessibility enabled by the adoption of a specific ergonomic dimension.

1.2 Summary of phase 1 activities

An initial review of the technical and scientific literature relating to the design of taxis with respect to their use by older and disabled people was undertaken. Despite an extensive search of international technical sources relatively few relevant reports were identified and only one was directly relevant to the current work. The UK enjoys an advantageous position in comparison to the majority of other countries with respect to taxi accessibility. All taxis now licensed in London (by the Public Carriage Office) must be able to accommodate wheelchairs and their occupants. This requirement is in excess of that required in most other capital cities and it means that research on accessibility undertaken in other countries often assumes that wheelchair users will transfer from their wheelchairs to vehicle seats.

The most significant previous research comprised a project sponsored by the European Commission entitled ‘Taxis for All’[1]. The project reviewed taxi operation in Sweden and the UK, developed a prototype accessible taxi and completed field trial evaluation studies and laboratory based assessments of user requirements. The final report provided advice on a range of dimensions and user preferences for two types of vehicle; a vehicle in which it was possible to enter at standing height (i.e. walking) and a more conventional vehicle which must be entered with a degree of stoop. Table 1 below provides a summary of their main findings.

Table 1: Final parameters proposed by Oxley and Stahl (2001)

Dimension	Walk in then sit	Enter and sit down
Door width	900mm	900mm
Door height	1650mm acceptable; 1800mm preferred	1400mm
Floor/step height	230mm	230mm
Ramp	As wide as doorway; max slope 9° (1 in 12 or 8%)*	
Seat height	450 – 500mm (above floor)	650mm (above ground)
Grab handles	800-900mm above floor	
Leg room	450 - 500mm	450 - 500mm
Internal space for wheel chair	1300-1500mm in length and 800mm wide (more space may be required for manoeuvring)	

*inconsistency noted

Additional relevant information was obtained from standard ergonomic advice on anthropometric measurements and human capability (Humanscale; Henry Dreyfuss Associates, 1974). This work provides comprehensive data on appropriate physical dimensions and resistant forces for a wide range of environments and situations but is not specific to the taxi context. Useful guidance was also obtained from the growing body of advice and direction produced as a consequence of the implementation of accessibility regulations under the DDA to other transport modes i.e. Rail Vehicle Accessibility Regulations 1998 (as amended) and Public Service Vehicle Accessibility Regulations 2000 (as amended). Further useful input was obtained from 'Inclusive Mobility – a guide to best practice on access to pedestrian and transport infrastructure, DfT, November, 2000. However, in all cases it was necessary to consider the different context provided by taxi accessibility.

A set of pilot trials was devised taking guidance from previous research and the direct input from consultation with disabled taxi users. The pilot trials comprised a set of critical tasks to be attempted by a selection of disabled participants using an adjustable rig. The tasks mapped onto the main barriers to taxi usage identified: vehicle entry, internal manoeuvre and vehicle exit. The samples of disabled participants were drawn using a sampling frame based on a comprehensive set of functional impairments relevant to mobility implemented by the Office of Population Census and Surveys (OPCS). The rig comprised a vehicle passenger compartment with adjustable floor height, seat position and roof height; access was enabled by adjustable steps or ramp. The aim of the pilot trial was to develop, and confirm the suitability of, an assessment methodology (procedure, timing, questionnaires, participant recruitment etc).

The rationale for the pilot trial is described in the Phase 1 report along with a detailed consideration of the methods to be employed. A summary of the methods used in the current research is included as Appendix 1 and a summary of the findings of the consultation activities is included in Appendix 2. The current report presents the measurements made as part of the main Phase 2 work.

2 Summary of main findings

2.1 Doors

2.1.1 Introduction

The size and shape of the door has a direct bearing on how easy it is to use for people with restricted movement. Our tests focused on key dimensions - the overall width and height of the door.

Discussions about the relative merits of sliding and conventionally opening doors were discussed as part of our consultations and trial taxi journeys – see Section 4.2.6.

Issues associated with reaching and using the door handles were also discussed during consultations, and have also been covered by previous work. Information on these topics is given in Section 4.

Data relating to door dimensions and ramp angles apply equally to both rear and side entry vehicles unless we say otherwise in the text. However there are of course other differences between these two modes of entry. Those which arose during our consultations were:

- Lack of space in urban and some other areas for rear entry
- Rear entry vehicles are usually accessed from the road, which means that kerbs often have to be negotiated first
- Side entry vehicles can only usually be entered from one side; it is not always possible to ensure that this is on the pavement side
- Rear entry vehicles usually mean that passengers remain facing forwards, which requires a different form of anchoring system
- Most people prefer facing forwards, and with a rear entry vehicle this eliminates the need to manoeuvre the wheelchair once inside the vehicle

2.1.2 Tests

Three widths (800mm, 850mm and 900mm) and three door heights (1395mm, 1595mm, 1745mm) were tested. The middle sized door was tested first. If this was unacceptable participants went on to try the larger or smaller door, as appropriate. For all doors tested participants rated the ease of getting in and out and were asked if a door of these dimensions would be acceptable. They were asked which of the doors tested they preferred and to provide reasons for any door they considered unacceptable.

More information was provided on the door configuration preferred by each participant. Observers noted any use made of grab handles and any help needed to get both in and out of the taxi rig. Participants rated the width and height of the door separately and described the extent of any effort involved in using the door and the degree of any additional discomfort experienced. They were also asked if they felt safe using the door (for example did they feel in any danger of bumping their heads). Final questions probed for:

- suggestions for any changes that could be made to the door to make it possible to get in and out more easily, comfortably or safely
- ideas for changes that could be made to the taxi to reduce the need for help
- comments on the position of grab handles
- any other comments from participants or observers

2.1.3 Participants

Separate tests were carried out with 20 wheelchair users, 16 people with visual impairments and 24 ambulant disabled people.

2.1.4 Wheelchair users

As might be expected, the tests showed that the key dimension for wheelchair users was width, and that the basic requirement was that the door should be wide enough for the easy passage of the wheelchair. Height did not emerge as a major issue given that most wheelchair users cleared the door easily. However one respondent considered that the door would need to be higher if the ramp was any steeper than the one tested.

The door needed to be wide enough to get through easily without requiring too much precision and without any danger of grazing elbows or the wheelchair. All the wheelchair users in the test were able to get in and out of the narrowest door.

Table 2: Door size and ease of access for wheelchair users

Width of door:	900mm	850mm	800mm
Height of door:	**1745mm**	**1595mm**	**1395mm**
No. participants assessed:	20	20	20
	%	%	%
Could not get in or out	0	0	0
Dimensions acceptable	100	100	85
Dimensions unacceptable	0	0	15

Nearly all of the testers (17 or 85%) found a door 800mm wide acceptable, however two of them thought the door was on the narrow side; one felt there was not much of a margin and the other said that the door would be too narrow if any shopping was being carried. Another person said that the door needed to be clearly outlined so that wheelchair users could judge how easy it would be to negotiate.

Those who considered doors of 800mm unacceptable were people who had wider chairs. They rejected the narrowest door because they needed help to negotiate it and because getting through it was uncomfortable.

All testers considered that a door of 850mm was acceptable, and no one made any qualifying comments about doors of this size.

These findings are compatible with measurements of wheelchairs and their users taken at the 1999 Mobility Roadshow[2].The range of widths found was:

Table 3: Wheelchair measurements

Type of wheelchair	Average width (mm)	Maximum width (mm)
Pushed by someone else	586	674
Electric wheelchairs	631	755
New style manual chair	633	741
Old style manual chair	615	722

This shows that most wheelchairs (being relatively small) would pass easily through an 800mm door. However the largest wheelchairs would require steering with some precision. The Department for Transport reference wheelchair is likely to represent the largest wheelchair transport operators are obliged to carry. It is 700mm wide which leaves a margin of 50mm on each side; theoretically enough if it is assumed that wheelchair users and their helpers have precise control and are able to take the time to negotiate the door carefully.

Compared to other features of the taxi the door width presented few problems. Three wheelchair users used the grab handles when getting in or out. These were typical of what might be found in a side entry vehicle, and only one person thought their placement could be improved by making them lower.

Only two could suggest ways in which door width could be improved, either to make it possible to get in and out more easily or to make it possible to get through the door without help.

2.1.5 People with other mobility impairments

The size of the door had a marked effect on people who did not use a wheelchair but had mobility impairments which affected their movement in different ways.

Table 4: Door size and ease of access for ambulant disabled users

Width of door:	900mm	850mm	800mm
Height of door:	**1745mm**	**1595mm**	**1395mm**
No. participants assessed:	24	24	24
	%	%	%
Could not get in or out	0	0	9
Dimensions acceptable	100	91	33
Dimensions unacceptable	0	8	58
Difficult to get in	0	0	16
Difficult to get out	0	0	29

Everybody in the tests found the largest door acceptable. Reducing the width by 50mm and the height by 150mm made the door unacceptable to 2 of the 24 mobility impaired testers (although all of them were able to use it). The smallest door caused problems for the majority of participants.

Nearly all the participants needed to use the grab handles to help them in and out of the smallest acceptable doorway.

Doorways which were unacceptable were mainly those which caused discomfort or involved too much effort – their small size meant a certain amount of bending and ducking or other contortions that were difficult for this group of people to accomplish.

Suggestions for improvement included higher doors, padding around the doors and a step that was inside the cab rather than outside.

While wider and higher doors were valued, some participants pointed out that this had implications for the position of the interior door handle if it was to be reachable from the rear seat.

2.1.6 People with visual impairments

Common sense and our observations suggest that the width of the door was not an overriding issue for visually impaired people, providing they could see edges.

However our tests showed that door height did make a marked difference. A large proportion of visually impaired people found a door with a height of 1395mm unacceptable. They were divided evenly between people who were partially sighted and people who had little useful sight. No difficulty was reported for doors which were 200mm higher. Lower doors were criticised because they made participants feel unsafe, particularly when leaving the taxi and because of the physical effort and discomfort involved in ducking under a lower aperture.

A high proportion of visually impaired people used the grab handles when getting in and out. These were used to identify and mark the position of the door as well as provide a gripping point.

Suggestions for improvement included the need for higher doors, contrasting colours and a light which would indicate the height of the door.

Table 5: Door height and ease of access for visually impaired users

Height of door:	1745mm	1595mm	1395mm
No. of participants assessed:	16	16	16
	%	%	%
Could not get in or out	0	0	0
Door size acceptable	100	100	63
Door size unacceptable	0	0	37

The six participants who found the lowest door unacceptable criticised it for just being too low. This was sometimes expressed in terms of having to bend too far (one user actually hit their head). In addition one user pointed out that a clearly visible contrasting colour was needed to mark out the top and sides of the door.

2.2 Ramps

2.2.1 Introduction

Both common sense and research show that wheelchair users by far prefer access to buildings and vehicles to be level. This cannot always be achieved, and a ramp of appropriate gradient is the simplest way of overcoming differences in level.

Powered lifts provide a safe and effective means of access for wheelchair users. However, their size and operational constraints have seen them used more frequently in community transport rather than taxi operation. Their successful use does not generally depend on ergonomic considerations and they were therefore not considered in the current research.

While level access should be the objective of taxi design, the brief for this research recognised the technical and other issues which make this difficult to achieve. Common sense suggests that the steeper the ramp the more difficulty wheelchair users and people with other mobility impairments will have with it. The research reported here provides estimates of the scale of the exclusion associated with ramps of different gradients.

2.2.2 Acceptable gradients

Recommendations for maximum acceptable gradients for ramps exist in regulations and guidelines for a range of access situations. It is not always clear how far these are based on consultation and research among disabled people themselves and how far they have been based on a compromise considered to be acceptable to service providers.

For buildings a maximum gradient of around 4.75 degrees (1 in 12) is typically recommended for comfortable access. However, this assumes that the physical layout of the building can accommodate ramps which may be several metres in length. Regulations and guidelines for transport vehicles have recognised the practical difficulties associated with long ramps. In the UK a maximum gradient of 8 degrees (approx. 1 in 7) is considered acceptable for rail vehicles and PSV’s.

2.2.3 Ramps in taxis

In the UK the floors of wheelchair accessible taxis have typically been more than 350mm above ground level. This would imply a ramp gradient of some 13 degrees when a ramp of 1000mm is used on a kerb 125mm high – substantially steeper than that which is permitted in other modes of public transport. In situations where there is no kerb the ramp angle can reach 20 degrees – far too steep for most powered wheelchairs and requiring substantial effort from those who push manual wheelchairs. (NB some taxis carry ramp extensions for such situations and may achieve shallower gradients.)

During our consultations with wheelchair users and disability organisations, it was claimed that ramps used with current taxis caused difficulty. We found that;

- some people had difficulty with steep ramps. A proportion did not like relying on taxi drivers for assistance

- in many cases taxi drivers chose to ‘tip’ a wheelchair into the passenger compartment of their vehicles without using the ramp. It appears that this is done largely to save time but it may also be perceived to be easier in terms of physical effort.

2.2.4 Our assessments

Three fundamental constraining factors were considered in our assessments:

- the maximum gradient that wheelchair users felt was comfortable and safe when propelling themselves

- the maximum gradient that can be climbed by a powered chair

- the maximum gradient that is consistent with recommended push efforts in the manual handling regulations. While some wheelchair users will always require assistance in accessing a taxi (and drivers are required to provide assistance where required) it would seem unreasonable for those wheelchair users who wish to enter with minimal assistance to be prevented if the gradient can be reduced.

Other issues – such as the restrictions imposed by anti-tipping devices – emerged during the trials. These are discussed below.

2.2.5 Tests

Twenty participants took part in the ramp assessments. They were asked to wheel themselves into the assessment rig and park facing rearwards immediately inside the taxi by the door, with their wheelchairs against the tip-seat (which was in an upright position). They were then asked to come out again. Help was provided for all participants where this was needed or requested, although they were asked to perform the tasks alone if this was their normal way of getting around.

The ceiling height and door opening were set to their maximum setting, and the rear seats were moved to their rearmost position so that they did not influence the ratings given for this task. The ramp was 1030mm long and angles of 4.5°, 8°, 12°, 16° and 20° were tested. The ramp was covered in a non-slip material and had a lip fitted to the bottom to provide a smooth incline for the user to manoeuvre up.

Participants were asked to start from a stationary position at the bottom of the ramp to replicate a scenario where no ‘run-up’ was possible. Participants started by attempting an angle of 8°. If they could not manage this or if this was considered to be unacceptable, they went on to try the 4.5° ramp. After this each user tried the ramps in order of steepness until they reached one they could not manage or which was too steep to be acceptable to them.

2.2.6 Results

The findings, as might be expected, showed that progressively steeper ramps caused progressively more problems.

Table 6: Gradient findings

Gradient	4.5º	8º	12º	16º	20º
No. of participants assessed	20	20	20	20	20
	%	%	%	%	%
Acceptable	100	70	35	20	0
Unacceptable	0	30	65	80	100
Could not get up	0	5	10	20	25
Could not get down	0	5	10	15	20

Table 6 shows headline findings for all gradients. This table has been compiled by using the statistics cumulatively – for example, if a user found that a 12° ramp was unacceptable, it has been assumed that all ramps steeper than this were also unacceptable.

Two main findings emerge. The first is that the acceptability of the gradient is not directly related to being able to negotiate the ramp. Many people who were able to get up or down the ramp considered it to be too steep and would not like to see a ramp of this gradient used in practice. It is interesting to note that in the environment of a comparative test only about a third of participants considered the angles found in current ramps to be acceptable. Once a ramp reaches 12º substantial numbers of people begin to be excluded.

Secondly, further analysis showed that

- those who propelled their own chairs had most difficulty, although the differences were slight

- the reasons given by participants for why ramps were unacceptable did not seem to vary with steepness. Once a ramp angle was judged to be unacceptable it was not regarded as more unacceptable if it was made steeper. The reasons given for regarding a ramp angle as unacceptable were concerned with the physical effort required and perceptions of safety. Generally these comments were applied to attempts to go both up and down the ramp

Table 7: Ramp unacceptability findings

Why do you find this ramp unacceptable?	
No. participants finding a given ramp unacceptable	20
	%
Angle too steep	95
Felt unsafe going up	65
Too much physical effort required going up	40
Needed help to get up	35
Felt unsafe going down	30
Needed help to get down	30
Too much physical effort required going down	25

It is interesting to note that many more people felt unsafe going up the ramp than coming down it.

Each respondent was asked to suggest changes which might be made to the ramp (or other parts of the taxi) to make using it easier.

Few suggestions were made about ramps as concerns about their steepness and dimensions had already been expressed during the tests. Ramps were too short and too steep for some and there were some complaints about drivers being unwilling to deploy them. One person who had used a taxi with a ramp into the rear of the vehicle said that this was more difficult when the road had a strong camber.

2.2.7 Assisted access

Appendix 3 describes the calculations and measurements undertaken to estimate loading efforts for those assisting wheelchair users up ramps of different gradients. In combination they indicate that the safety of male assistants may be compromised with gradients of more than 8° - for less robust assistants (i.e. many women and older carers) an angle of 4.5° is more appropriate.

2.3 Step height

2.3.1 Introduction

The step into a conventional black cab causes difficulty for many people. Conventional wisdom and our consultations suggest that significant numbers of people are excluded from using taxis because stepping into them is too difficult. The most recent survey of disability[3] estimated that 9.6% of the disabled population had a locomotion impairment categorised as 9.5 or above on a severity scale, the definition of which included an inability to manage a single step. This represents 824,000 people in the population.

2.3.2 Tests

Six step heights were tested from 100mm to 225mm in increments of 25mm. Participants began by getting in and out of the taxi using the 125mm step and then tried a higher or lower step as appropriate. The participants continued to test new step heights until they reached a step height that they could not safely or comfortably manage. They were allowed to use any walking aids or receive any help that they would normally expect to have.

Participants rated the steps for ease of getting up and down and identified the step height they preferred.

For the maximum step height each participant considered to be acceptable, observers noted the type of help, if any, that they required and if they used the grab handles. Participants commented on the dimensions of the step, rated the physical effort required to get up and down, and gave details of any additional discomfort experienced. They were asked if they felt safe using this step and for suggestions for any changes which would make getting into or out of the taxi easier or make it possible to do so without help.

2.3.3 Participants

The main target group for this test were people with mobility impairments who were ambulant. Tests were carried out with 24 ambulant disabled people, 21 people with impaired dexterity or reach and 16 people with visual impairments.

2.3.4 People with impaired mobility

This group included people who could not walk far, those who had difficulty with steps, people who could not bend and people who used walking aids such as sticks or frames.

Our tests confirmed the common sense view that steps with the lowest rise were preferred and that the acceptability of a particular step decreased as it became higher. Steps 100mm high were acceptable to everybody; steps of 200mm or more were unacceptable to the majority of people:

Table 8: Acceptability of step heights for people with impaired mobility

	100mm	**125mm**	**150mm**	**175mm**	**200mm**	**225mm**
No. of participants assessed	24	24	24	24	24	24
	%	%	%	%	%	%
Preferred	29	25	29	13	4	0
Acceptable	100	83	71	63	38	13
Unacceptable	0	17	29	38	63	88
Could not get up	0	0	0	0	0	0
Could not get down	0	0	0	0	0	4

Again it should be noted that settings thought to be unacceptable were not confined to those that participants could not manage. All but one person managed all of the steps in the test, albeit with varying degrees of difficulty:

Table 9: Ease of getting up or down the step

	100mm	**125mm**	**150mm**	**175mm**	**200mm**	**225mm**
No. of participants assessed	24	24	24	24	24	24
	%	%	%	%	%	%
Difficult getting up	0	8	33	33	50	58
Difficult getting down	4	17	50	54	63	67

Participants were asked to describe why they found steps of a given height unacceptable. Reasonably enough some people just said that the step was too high. However as the steps in the test became higher (200mm or more) more people tended to express their dislike in terms of discomfort or physical effort. A few people felt unsafe going down the steps and some people thought the steps tested were not deep enough.

Participants were asked to identify their maximum acceptable step height. It is interesting to note that while the lower the step the more it was preferred, there was some leeway – slightly higher steps would be tolerated, providing they could be negotiated without too much difficulty or discomfort:

Table 10: Maximum acceptable height

	100mm	**125mm**	**150mm**	**175mm**	**200mm**	**225mm**
No. of participants assessed	24	24	24	24	24	24
	%	%	%	%	%	%
Proportion citing this height	17	13	8	25	25	13

Numbers were small but there did not appear to be any major differences in opinion between people who used a walking aid, those who could not bend and those could not walk very far or had acknowledged difficulty with steps.

An analysis of the steps identified as being the maximum height acceptable by each participant showed that a very high proportion of participants used the grab handles going up (71%) and going down (58%) when negotiating this step. Four of the 24 testers criticised the position of the grab handles – these were needed on the outside of the vehicle and needed to be lower. The impossibility of using grab handles in conjunction with walking aids was pointed out.

2.3.5 People with visual impairments

Steps of 150mm or less were acceptable to everybody, and very few people had problems with a step height of 175mm. After this acceptability dropped off sharply and it was clear that steps of

200mm or above would be too high for substantial numbers of visually impaired people:

Table 11: Step height acceptability for visually impaired participants

Step height	100mm	125mm	150mm	175mm	200mm	225mm
No. of participants assessed	16	16	16	16	16	16
	%	%	%	%	%	%
Acceptable	100	100	100	94	56	50
Unacceptable	0	0	0	6	44	50

The maximum acceptable step height for this group was:

Table 12: Maximum acceptable height for visually impaired participants

	100mm	125mm	150mm	175mm	200mm	225mm
No. of participants assessed	24	24	24	24	24	24
	%	%	%	%	%	%
Proportion citing this height	0	0	6	38	6	50

As might be expected steps became unacceptable when they were thought to be simply too high. This criticism was made by half of the visually impaired testers, although only two of them also had locomotion impairment. Almost as important to this group was the feeling of safety. They felt less secure on higher steps, particularly when coming down. Clearer markings and tactile clues would go some way to obviating this problem.

2.3.6 People with impaired dexterity and reach

Steps were a real barrier to a high proportion of this group – one person could not negotiate a step of any size; steps of 175mm or more would exclude a high proportion of people.

Table 13: Step height acceptability for people with impaired dexterity

	100mm	125mm	150mm	175mm	200mm	225mm
No. of participants assessed	21	21	21	21	21	21
	%	%	%	%	%	%
Acceptable	95	90	86	57	43	24
Unacceptable	5	10	14	43	57	76

The maximum acceptable step height for this group was:

Table 14: Maximum acceptable height

	100mm	125mm	150mm	175mm	200mm	225mm
No. of participants assessed	21	21	21	21	21	21
	%	%	%	%	%	%
Proportion citing this height[4]	5	5	29	14	19	24

The main problem for this group was the physical effort of getting up and down the steps – a consideration mentioned by over half of the testers. A high proportion of people mentioned the discomfort involved, particularly when going down the steps and nearly as many felt vulnerable and unsafe on them.

2.3.7 Suggested improvements

Suggestions for design improvements which would make steps easier were deeper treads, edges which were marked in contrasting colours or were illuminated, non slip surfaces and tactile clues to show where the left and right edges of the step were.

2.3.8 Other data on steps

Recommendations and specifications for steps exist in other areas. The maximum height for steps recommended or specified in the literature are 178mm (indoor) and 127mm outdoor; 100mm[5]; 200mm[6],[7]. Most of these are higher than the majority of people in our tests considered acceptable. There has been some concern that lower steps constitute a trip hazard, since they may not be noticed and identified as steps. However we do not consider that this is a risk with taxis and would in any case be minimized by the proper use of colour contrasting markings.

The other issues described in the literature are clearer. Steps should have a depth of 280-300mm min; risers should be vertical and solid, noses should be rounded and there should be no overhang, width should be at least 400mm and preferably the same as the entrance.

2.4 Interior space

2.4.1 Introduction

The size of the interior of the cab, its layout and the configuration of its fixtures and fittings are critical factors in its accessibility. Our tests concentrated mainly on the overall height of the taxi and the space needed for manoeuvring the wheelchair inside it.

2.4.2 Roof height tests

Three roof heights were tested – 1425mm, 1625mm and 1825mm.

In the majority of cases, the middle height was tested first. If this was unacceptable then participants went on to try a higher or lower roof height until they reached the point where they had adequate room and no criticisms to make.

For each height tested participants rated the ease of getting to the seat and out of it again or, if they used a wheelchair, to the travelling position. They were asked if each roof height tested would be acceptable and for which of the three they preferred overall. Reasons were provided for each height considered unacceptable.

More information was provided on the roof height preferred by each participant. Observers noted the need for any help when getting to and from the seat or wheelchair parking position. They noted if any participant had particular difficulty or if any pain was involved.

Participants were asked if the preferred height was just right or if it needed any further adjustment up or down. They described the extent of any effort involved in manoeuvring within the taxi with a roof set at this height and if this caused any pain or additional discomfort. They were also asked if they felt safe getting to the seat or wheelchair travelling position, if they used the grab handles (or any other handhold) and if these were in the right position. Final questions probed for:

- suggestions for any changes that could be made to the interior to make it possible to get to, or out of, the seat or wheelchair travelling position more easily, comfortably or safely
- ideas for changes that could be made to the taxi to reduce the need for help
- any other comments from participants or observers

Participants
Separate tests were carried out with 20 wheelchair users, 16 people with visual impairments and 24 ambulant disabled people.

Wheelchair users
Research carried out by TRL[8] showed that the average and maximum seated height of wheelchair users was as follows for manual and powered wheelchairs[9]:

Table 15: Seated height of wheelchair users

Wheelchair seated height	Highest found	Average
Manual	1407mm	1237mm
Powered wheelchairs	1451mm	1262mm

These figures suggest that the roof heights tested should not have caused problems for the majority of our participants, since even the lowest height tested should provide adequate headroom for most people.

However two fifths of the testers said that the lowest roof tested (1425mm) was unacceptable, even though they could all get into the taxi and sit upright in it without touching the roof. In other words the roof felt uncomfortably close – roofs were criticised for being too low and for inducing a feeling of claustrophobia by six of the eight people who found the roof height unacceptable. A further three said these low heights made them feel uncomfortable. The next height tested (1625mm) suited nearly everybody:

Table 16: Acceptability of roof heights for wheelchair users

Roof height	1825mm	1625mm	1425mm
No. of participants assessed	20	20	20
	%	%	%
Height of roof acceptable	100	95	60
Height of roof unacceptable	0	5	40

Although base sizes are too small to allow confident generalisation, the tests suggested that people who were pushed (rather than propelled themselves or used a powered chair) were more likely to consider the low roof heights unacceptable. This may be because they felt less in control and thus more likely to bump their heads than those who got in and out of the taxi unaided, and because they were concerned about the effort and clearance of the ‘pusher’.

It should be noted that while participants were able to identify the minimum acceptable roof height, they did not consider that roofs higher than this were unacceptable. Very few people thought any of the roofs tested were too high.

Suggestions for improvement mainly focused on the disposition, size and shape of the grab handles. These are discussed in Section 4.4.10.

People with other mobility impairments

The lowest roof height tested was unacceptable to nearly two thirds of those who participated in our tests. Raising the roof by 200mm increased its acceptability, but even so a quarter of respondents still considered it to be undesirable. The highest height tested was approved by all who tried it.

Table 17: Roof height acceptability for those with other mobility impairments

Roof height	1825mm	1625mm	1425mm
No. of participants assessed	24	24	24
	%	%	%
Height of roof acceptable	100	75	29
Height of roof unacceptable	0	25	63
Unknown			4
Could not get in or out	0	0	4

Only the very lowest roof actually prevented anyone from using the taxi – the overwhelming majority of people were able to get in and out. However in the environment of a test, roofs which caused difficulties were considered to be unacceptable (the acceptability of different heights had a clear relationship to the ease of getting in and out of the taxi):

Table 18: Roof height and ease of access and egress for those with other mobility impairments

	1825mm	1625mm	1425mm
No. of participants assessed	24	24	24
	%	%	%
Difficult to get in	0	17	38
Difficult to get out	0	17	50
Could not get in	0	0	4
Could not get out	0	0	4

Consistent with this, the reasons given for rating a roof height as unacceptable included the levels of physical effort required and discomfort experienced.

Visually impaired people

The views of visually impaired people were similar to those of people with other impairments. Just over two fifths of the visually impaired testers considered that the lowest roof height tested was unacceptable, although everybody managed to get in and out of the cab. All of these people had great difficulty getting to the seat in the cab or could not do this at all.

The next height tested (1625mm: 200mm higher) was acceptable to everyone, and none of the testers reported having any difficulty getting into the taxi with the roof set at this height.

As before, participants complained about the effort and difficulty of bending and moving underneath a low roof. Some people felt uncomfortable or claustrophobic and a few felt unsafe because of the danger of bumping their heads when the height of the roof could not be estimated by sight.

Although numbers were small, people who were partially sighted were less concerned about lower roof height than people who had little or no useful sight presumably because they could see enough of the roof to keep clear of it.

Table 19: Roof height acceptability for those with visual impairments

Roof height	1825mm	1625mm	1425mm
No. of participants assessed	16	16	16
	%	%	%
Height of roof acceptable	100	100	56
Height of roof unacceptable	0	0	44
Could not get in or out	0	0	0

2.4.3 Floor plan

The unobstructed shape and size of the taxi floor is of great importance to wheelchair users. Once inside a side entry taxi, wheelchairs have to be manoeuvred into the safe travelling position and anchored down. After the journey the securing device has to be released and the wheelchair moved into position to descend the ramp. Most people travel forwards into the taxi, but come out facing backwards. These manoeuvres are almost always carried out with help and it is the taxi driver’s responsibility to provide assistance if no other help is available and to ensure that the wheelchair is safely secured for the journey.

Tests were carried out to discover how much floor space was required for these manoeuvres to be carried out.

Tests
The taxi rig (see Section 7.1.3) was used for this test. The floor was raised to 250mm to represent the typical floor height of a purpose-built taxi.

Tests were carried out using the Department for Transport reference wheelchair whose overall dimensions represent the maximum size wheelchair public transport operators are obliged to cater for.

Temporary walls on the rig could be adjusted to delineate the space available. The walls were flush with no protrusions. These were moved progressively until the point was reduced where the participant considered the space was too confined to be acceptable. A number of sweeps were needed to manoeuvre in smaller spaces, the maximum number considered acceptable by the participant was not exceeded.

Six tests were performed. These consisted of getting the wheelchair:

- into a rear facing travelling position with the door in three positions (left edge flush with the partition wall directly behind the driver; left edge 200mm away from the partition; and 400mm away from this wall)

- into a forward facing position, with the door settings as described above. This position was included in the tests because a number of wheelchair users in our consultations expressed a preference for travelling facing forwards, although this has several implications for safety and the design of securing devices[10]

Participants
The ‘pusher’ was a large, tall male and the wheelchair was occupied by his wife. She weighed approximately 63-70kg. The ‘pusher’ was asked not to shunt the wheelchair into position[11].

Results
The position of the door made a noticeable difference to the dynamics of manoeuvering the chair inside the rig.

Door flush with the front partition
This configuration is typical of current purpose-built side entry taxis. Less space was required to place the wheelchair backward facing than forward facing. The minimum space required to get the chair into a backward facing position was when there was a clear space 1300mm wide and 1340mm long. To achieve this, the chair had to make three sweeps. This was considered acceptable by the couple who carried out the test.

Of all the variants tested the smallest acceptable floor space was achieved with the door placed next to the front partition when the wheelchair was parked facing backwards.

This document details the results of these tests, including comments from the participant.

Table 20: Door position flush with the front wall: Wheelchair forward facing

Width (door to door)	Length (front to back)	Comment
1460 mm	1510 mm	Overly generous
1370 mm	1440 mm	The width was too narrow.
1440 mm	1440 mm	Square shape acceptable with door in this position

Table 21: Door position flush with front wall: Wheelchair rearward facing

Width (door to door)	Length (front to back)	Comment
1440 mm	1440 mm	Very easy
1300 mm	1340 mm	Easier to place in rearward position – minimum acceptable

Door 200mm from the front partition

Doors which are nearer the rear seat may make getting in and out of the taxi easier for ambulant people, some of whom find it difficult to get from door to seat in the stooped position imposed by the low roof. However a door in this position would be difficult for wheelchair users unless the unobstructed space measured 1400mm x 1400mm at minimum. This held true for people who travelled in their wheelchairs facing forwards or backwards.

The width of the cab (as long as it is over 1370mm) is not critical for placing the wheelchair in position. The length is critical. With the door in this position and a floor length of 1440mm the wheelchair could be placed in either position with only one turn. The person carrying out the test considered this was the best alternative if the design of the vehicle is to allow wheelchair users to face either backwards or forwards.

Table 22: Door position central (200 mm from front wall) Wheelchair forward facing

Width (door to door)	Length (front to back)	Comment
1400 mm	1400 mm	First setting tried was judged to be acceptable minimum

Table 23: Door position central (200 mm from front wall) Wheelchair rearward facing

Width (door to door)	Length (front to back)	Comment
1300 mm	1340 mm	Impossible
1370 mm	1340 mm	Too tight
1370 mm	1370 mm	Still tight
1400 mm	1400 mm	Minimum acceptable

Door 400mm from the front partition

Rearward facing wheelchairs needed unobstructed floor space which was both longer and wider than when the door was placed next to the front partition. The floor space needed to be longer than would be needed with a central door, but could be slightly narrower. Wheelchairs which faced forwards needed slightly less space than they did for the other two dimensions tested, but the differences were small.

Table 24: Door position 400 mm from front wall, Wheelchair forward facing

Width (door to door)	Length (front to back)	Comment
1400 mm	1400 mm	Generous but length more important than width
1370 mm	1400 mm	Tight for getting into forward facing position
1340 mm	1440 mm	Minimum acceptable

Table 25: Door position right (400mm from front wall) Wheelchair rearward facing

Width (door to door)	Length (front to back)	Comment
1370 mm	1400 mm	Impossible
1370 mm	1420 mm	Very tight
1370 mm	1440 mm	Minimum acceptable

Comments

- It was important to get the wheelchair in the right position from the start. Getting the wheelchair close to the edge of the door reduced the overall footprint by a few useful centimetres.

- However a lone wheelchair user probably could not align the chair with such precision as the momentum necessary to get up the ramp would mean that the wheelchair would stop several centimetres inside the cab. Thus more space would be needed if taxi design were to allow wheelchair users to get in and out without assistance.

- The test involved assessing a smooth sided space and did not take into account the most likely projections – seatbelts, their mountings and other anchorages. The tests also assumed that the taxi floor would be flat without recesses, grooves or slopes which may make movement more difficult.

- Because of the articulated front wheels it was generally easier to get a wheelchair into the rearward facing position – as with any vehicle reversing into a space. It was particularly difficult to get a rear facing wheelchair into position to go down the ramp backwards.

- Recesses (of around 200mm in height x 100mm in depth) in the lower part of the front partition and underneath the seat squab would allow the footplates to pass underneath. The minimum dimensions could be reduced accordingly.

After carrying out these tests the person who carried them out suggested a further variation based on experience. This was to increase the length of the space (front to back) and decrease width (door to door), as this is more important for manoeuvrability. This was tried with only one wheelchair user and helper.

It should be borne in mind that a helper with different technique/experience might get slightly different results.

Table 26: The door position central (200mm) with the wheelchair facing forwards and backwards

Width (door to door)	Length (front to back)	Comment
1440 mm	1560 mm	Generous width
1360 mm	1550 mm	A little awkward
1370 mm	1440 mm	Best arrangement of all – only one turn each way to position

Comments on interior space

A number of comments were made about the interior space available by participants and observers made comments about the strategies adopted by testers when getting onto and out of the seat:

Interior Space and Seat Design

The floor in the test rig was flat; wheelchair users considered this should be the case in real taxis. People who travelled with a fully elevated leg rest pointed out that a much longer taxi was needed to accommodate them. Those who travelled with a bag fastened to the back of their wheelchair also needed additional space.

Some people wanted the rear seat to be higher to make getting out of it easier. A few people disliked the sprung hinge on the rearward facing folding seats because it was too strong or just because it was self shutting. It was suggested that the rear seat should have an elevating squab to help passengers stand up.

The space available within the passenger compartment also has a direct impact on the ease with which ambulant passengers can access the seats. There are two separate considerations here.

The first is based on the idea that the passenger can get into the vehicle easily – the focus then falls on getting to the seat once inside. In this case the vehicle needs to have a high roof (to minimise stooping), low floors and shallow steps as discussed in the report. The configuration of seats within the vehicle would need to allow for:

- Minimum movement once inside, but with enough space to turn round easily – all these dimensions would be less than the manoeuvring space allowed for wheelchairs, so are not the limiting factor.

- Seats which are high enough to allow passengers to get on and off them easily. Measurements (floor to the underside of the knee) taken of people[12] aged 65 and over gave the following dimensions:

Table 27: Lower leg length for older men and women

	Age	Mean (mm)	5th percentile	95th percentile
Men	65+	445	400	490
	65-74	446	403	490
	75+	443	398	487
Women	65+	406	362	450
	65-74	407	365	449
	75+	404	361	446

Equivalent figures for the whole adult population are:

Table 28: Lower leg length for adult population

Men		426	383	469
Women		396	352	439

Taking the view that the height of the squab should be consistent with these distances, suggests seat height should be in the range of 350 - 470mm. Current recommendations for buses and trains are 430 - 460mm and both advise against the use of seat squabs which are excessively sloped.

- Roof height which would minimise stooping.

The average height of men and women is 1755mm and 1620mm respectively. The 95th percentile figures are 1869mm and 1725mm. Older adults are shorter – the 95th percentile of men and women aged 65-74 are 1823mm and 1686mm. A roof height of

1825mm would be required to prevent the majority of passengers from having to stoop.

- Grab rails on at least one side

The second concerns direct access from the pavement. The reason many people prefer saloon cars to purpose built taxis is that they find it easier to lower themselves down on to the seat directly from the kerbside. Research by ICE has shown the optimum ground to seat height for this lies around 500mm[13] If a 125mm kerb is assumed the height of the seat from the pavement would need to be 375mm although the problem for designers would be how to meet the needs of people who get in and out from both kerbside and road. Our recommendation for a mandatory powered swivel seat was based on the understanding that a seat height of these dimensions may not be practicable in a taxi which meets other requirements such as a small turning circle. However if a seat within this range could be incorporated other dimensions would be:

- Leg room (to allow people to swing their legs in).

Here the limiting factor is the width of the door (although a pronounced sill can also be a problem). Anthropometric measurements show that, among older adults, the distance from the buttock to the sole of the foot (leg straight and sitting) is:

Table 29: Leg length for older men and women

	Age	Mean (mm)	95th percentile
Men	65+	1066	1168
	65-74	1074	1176
	75+	1050	1150
Women	65+	1022	1127
	65-74	1040	1142
	75+	999	1099

The 95th percentile have a seated leg length of over a metre; much longer than any standard vehicle door. It would seem unlikely that a hinged door capable of accommodating these dimensions would be practicable.

- Head height.

If passengers get onto the seat directly rather than climb into a taxi the seat squab to top of door measurement needs to be at least 980mm to meet the needs of 95% of adult males. Assuming the seat squab is 430mm from the floor of the vehicle and that there is no sill, the door would have to be 1410mm high.

Visual contrast
Some visually impaired participants wanted a higher level of visual contrast inside the taxi to distinguish different features. In particular, the edges of seats needed to be delineated. Better interior lighting would also have helped.

Support
Many people with mobility impairments needed to haul on a grab handle to get out of the rear seat and some used them as a steadying device. Some visually impaired people used grab handles to orient themselves. This argues for the careful placing of these handles and some consistency between taxis. Some participants found the grab handles used in the test too far away from the seat and some people wanted the taxi to be fitted with more grab handles. Longer grab handles were needed; some participants found those in the test were too high while others thought they were too low. Particular requests were made for a grab handle opposite the seat, and over the step to help with getting out (a vertical handle on the right hand edge of the door was thought to be useful here).

Some people got in or out of seats by leaning on walking sticks and crutches, pushing against the seat or arm rest or holding onto the door. Sometimes these were used in combination.

2.4.4 Swivel seats

People who had difficulty getting into a taxi without an interim step were invited to try the swivel seat. The seat that was used in the tests was identical to the one available as an optional extra on TXII taxis. It had a flat squab and back. It swivelled 90° out of the cab and was power operated. Generally, the seat was tried with the taxi floor set at the highest position acceptable to the participant, although if the seat was too high, the floor was lowered until the seat height was acceptable at the lowest setting.

For purposes of comparison, and because some mobility impaired people find saloon cars easier to get in and out of than purpose built taxis, they were also invited to try a swivel seat fitted to a saloon car. The seat was supplied by Gowrings Mobility and was fitted to a Ford Fiesta. This seat was included in order to be able to provide some information on alternative potential designs of swivel seat, and also to prompt discussion about the advantages and disadvantages of saloon cars and purpose built taxis.

Tests

Participants who were willing to try the swivel seat used it to get both in and out of the taxi. Assistance was offered if they considered they would normally expect to have it. The seat was lowered to the optimum height for each person before the test began.

The Ford Fiesta was chosen as an example of a popular car. The seat was fitted to a four door version The maximum dimensions of the Fiesta's door aperture were 815mm wide by 920mm high. However, the aperture width was considerably less (650mm) at the base of the door and this would have restricted the space available for the participants' legs to swing into the car as the seat was swivelled back into the travelling position.

Participants were asked to rate the speed of its powered operation and the effort needed to swing the seat in and out of the taxi (which is not done by power). They were asked if they considered the seat to be a dignified way to get in and out of a taxi and rate the effort involved in getting on and off it. They were asked if they felt safe using the seat and for suggestions for ways in which it might be improved.

Participants
28 people (15 with impaired mobility, 13 with impaired dexterity or reach) tried the powered swivel seat on the taxi simulation rig and 19 (11 with impaired mobility and 8 with impaired dexterity or reach) tried the swivel seat fitted in a saloon car.

Eight of the nine people who did not attempt to use this seat did not do so because they were unable (were too tall, did not have enough flexibility, were too large for the small car or did not have enough strength to operate the controls); one person refused because they did not think the seat was a dignified way of getting into the car.

Findings
Interviews at the Mobility Roadshow and discussions with people who undertook trial taxi journeys suggested that powered swivel seats would be of value to the great number of mobility impaired people who might have difficulty stepping into a conventional cab, or who would be unable to get into a cab even when an interim step was fitted. The consensus view of both these groups was that swivel seats were very useful but that few people realised that they existed.

Swivel seats are a recently introduced feature on LTI’s TX taxis. Powered versions have only been available following the introduction of the TXII as an optional feature. The number implemented is low.

While few of the people who took part in the tests were aware of the existence of swivel seats, not all were impressed with the seats used for the test. Some people were unable to swing the seats in or out and some found that it took a degree of physical effort to get out of the seat once the journey was complete. Some people reported that the seat was uncomfortable.

The operation of powered seats requires intervention from the driver and, while it is possible, in practice it would be very unlikely for a passenger to deploy and swivel the seat without driver assistance. Currently taxi drivers swing the seat in by hand so disabled passengers are not required to make any effort themselves. However, some people object to this dependency and some dislike the close proximity that such handling involves.

Powered seat as currently fitted to the TXII

Overall nearly a fifth (18%) of participants said they would prefer to use the swivel seat to get in and out of a taxi rather than step into it. Fourteen per cent had no strong feelings either way. The majority would prefer to step into the taxi in the normal way. Over half (57%) thought that using the swivel seat was a dignified way of getting into a taxi.

However these preferences should be interpreted with some caution for two main reasons:

- all respondents were (with different degrees of difficulty) able to get into the taxi rig when adjusted to meet their requirements and so were not dependent on the swivel seat

- their judgements were affected by criticisms of the swivel seat tested – a high proportion of participants had adverse comments to make about its design (see below)

Table 30: Proportion of people who said the following tasks took a great deal or some effort

Using the powered swivel seat	**28**
	%
swinging the seat when not sitting on it	25
could not do this	14
swinging the seat when sitting on it	25
could not do this	11
getting onto the seat	32
getting out of the seat	36

Four people were unable to use the seat. Two considered that it was undignified or somehow stigmatising. One person had a stiff leg which meant they could not negotiate the doorway. One person felt unsafe trying to swing in on it alone while another did not feel comfortable using it because it did not lock into position.

Respondents were also asked to say if they felt any discomfort when using the seat, and describe how severe this was:

Table 31: Discomfort associated with swivel seat use

Additional discomfort using the swivel seat	28
	%
Discomfort felt getting in	18
Discomfort felt getting out	18

They were also asked if they felt safe using it:

Table 32: Perceptions of safety associated with swivel seat use

Felt unsafe using swivel seat	28
	%
Getting in	21
Getting out	29

Respondents who found that effort was involved in getting in or out of the seat were asked to describe what was involved and they also were asked how the swivel seat could be improved. The number of responses to these questions was high, indicating both that swivel seats were seen as a useful innovation and that the current design needed refinement.

A number of people wanted an armrest or handrail to hold onto while using the seat. Some felt insecure because the seat was small and not shaped to be supportive; others considered that a larger seat would have been better for this reason. One person thought that a footrest would help. Swinging the seat took too much effort for some people (it was considered to be quite heavy). Some people wanted the seat to lock into place, both inside and outside the taxi.

Manual swivel seat as fitted to a saloon car

Overall fewer people were able to use this seat than the one fitted to the taxi rig. Not surprisingly (since it was not powered) it took more effort to use than the other seat tested.

Table 33: Proportion of people who said the following tasks took a great deal or some effort

Using the manual swivel seat	19
	%
swinging the seat when not sitting on it	21
could not do this	47
swinging the seat when sitting on it	32
could not do this	26
getting onto the seat	26
getting out of the seat	26

Comments on the swivel seat were often related to the fact that respondents were using it for the first time. While some thought it easy to use, others thought practice was needed. Criticisms were mainly related to the size of the car and to the size and position of controls.

Respondents who tried both types of swivel seat were asked which they preferred:

Table 34: Preferences for types of swivel seat

Preferences for swivel seat	19
	%
Preferred the taxi rig with a powered seat	42
Preferred saloon car with manual seat	21
No strong preference	5
Did not like either	26
No response	5

Conclusions

As might be expected taxi users prefer to get into a taxi in a ‘conventional’ way rather than having to use any special equipment. While such equipment would be welcomed if the alternative was not travelling by taxi, some people thought it was stigmatising and were aware of the extra time and fuss involved in deploying it. This would suggest that priority should be given to optimising the overall dimensions of the taxi to enable as many people as possible to get in and out without special equipment.

However swivel seats do enable those who cannot manage even a shallow step to get into a taxi. Essential requirements of such seats are:

- they are powered so that they can lift passengers up from whatever height they feel most comfortable getting onto the seat
- they give sufficient support to give the passenger confidence both when being lifted in and out of the taxi and when riding on the seat
- they are fitted with a handrail or armrest to provide support when getting in and out of the seat, and also when moving in it

Our discussions and observations suggest that a powered swivel seat would enable those people who currently can only use saloon cars to use a conventional taxi. However, such seats would need to:

- be able to descend to the height preferred by the passenger
- be designed to provide adequate support
- have arm rests and be within reach of grab handles
- have a foot rest
- have a travelling position which is adjustable in height
- have a folding seat without a strong spring
- be sufficiently robust to inspire confidence

- have a locking mechanism when passengers are getting on and off the seat to provide greater stability

3 RECOMMENDATIONS

Feature	Recommendation	Rationale	Discussion
Ramp gradients	Ramps should be no greater than 7°.	Ideally ramps should be no greater than 5° since slopes steeper than this will represent a barrier for wheelchair users who would wish to access the vehicle unaided. However, the provision of assistance is an established characteristic of wheelchair access in other transport modes that are already subject to DDA regulation; assistance will always be required by some taxi users who have the more restrictive mobility impairments and the driver is already required to provide assistance and safely apply restraint systems in taxis that are currently wheelchair accessible. Slopes of 8° and above may represent a potential manual handling risk for drivers (and helpers) attempting to manoeuvre heavier wheelchair/occupant combinations.	Ramps with a gradient of less than 5° also provide the best means of entry for ambulant disabled passengers and the non-disabled who have luggage or small children that need assistance.

Feature	Recommendation	Rationale	Discussion
Ramp lengths	Arguably, ramps should be no longer than 1000mm.	Ramps longer than 1000mm may not be capable of deployment in situations where pavement width is limited. (Excessively long ramps may also lead to unacceptable height gain).	The ramp length recommendation assumes access from a raised pavement. To achieve the same gradient from the road a taxi may need to 'kneel'.

Feature	Recommendation	Rationale	Discussion
Ramp design	Ramps should: (i) have a side safety lip (upstanding edge) of at least 50mm. (ii) have a width that matches the vehicle entrance width (iii) consist of a single surface (i.e. not comprise channel ramps) (iv) have a non-slip surface continued…	(i) a safety lip is necessary to prevent wheelchair wheels slipping off the ramp. (ii) the ramp width and door width should be equivalent to reduce opportunities for misalignment. (iii) channel ramps preclude some wheelchair designs and are perceived to be less safe by some wheelchair users (iv) a ramp must be capable of use in all weathers (v) it is important that all participants are clearly aware of the edges of the ramp in a wide range of lighting conditions (vi) the passage of wheelchairs onto, off and along ramps should be as smooth as possible.	A critical aspect of ramp design is the ease with which the ramp can be deployed. Easy and quick deployment (e.g. automatic) will greatly facilitate usage. This would be of benefit to both passenger and driver. Sudden changes in surface height can cause a jolt that is painful to some wheelchair users, and makes manoeuvering more difficult.

Feature	Recommendation	Rationale	Discussion
Ramp design cont'd.	(v) have all edges defined by a 50mm wide strip in a strongly contrasting colour (vi) have changes in surface level of less than 6mm.		

Feature	Recommendation	Rationale	Discussion
Door width	Doors need to be at least 850mm, but preferably 900mm wide. These measurements should apply to the majority of the door.	The great majority of wheelchairs would pass through an 800mm door. However some are wider than this and for others the fit is too tight to be comfortable or to facilitate unassisted entry. Door width was not a major issue for people with other mobility impairments.	Consideration also needs to be given to the space available to open wider doors in practice. Larger doors require greater reach when being closed from the inside. Interior catches and handles would need to be designed to overcome this problem

Feature	Recommendation	Rationale	Discussion
Door height	Doors need to be substantially higher than currently found in taxis. The higher the door the better; a door height of 1595mm should be considered as the minimum acceptable; 1745mm was preferred by a small number of participants with particular impairments.	Substantial numbers of ambulant people have difficulty stooping to get under low doors; some found this uncomfortable to do. Visually impaired people perceive low doors to be hazardous, even when delineated by colour contrasting markings. A door height of at least 1410mm is also required to give sufficient head clearance for passengers directly accessing a seat with a squab 430mm above the vehicle floor.	Grab handles of the right dimensions and in the right place make a substantial difference to ease of entry.

Feature	Recommendation	Rationale	Discussion
Step height	Tests confirmed the common sense view that steps became easier as their height was reduced. A step height of 100mm is recommended as the optimum.	While nearly all people in tests managed steps up to 225mm high, higher steps were only negotiated with difficulty and effort. The majority of people considered steps of 200mm or more unacceptable and important minorities said that steps of 150mm or more were too high. The adoption of a lower step height should not result in multiple steps to achieve a higher floor height. Multiple steps represent an access barrier and aggravated trip hazard.	Alternative to steps need to be provided for the large number of people who cannot manage any step. Some people found walking up a ramp easier, as long as it was fitted with a handrail. Powered swivel seats also cater for people who cannot manage steps. However our tests showed that most of those who could manage a low step preferred steps to a swivel seat, so this solution should not be considered as a substitute for lower steps.

Feature	Recommendation	Rationale	Discussion
Roof height	The interim height of 1625mm may present the best compromise between the need to minimise the overall height of the taxi while allowing enough height for tall people who have difficulty stooping. However the optimum interior height would be 1825mm or more.	Roof height was not a physical barrier for most wheelchair users, although many thought a low roof claustrophobic when head clearance was limited. A roof height (cab floor to ceiling) of 1825mm was acceptable to everybody because it obviated the need for stooping. This would have implications for the overall height of the vehicle. A roof height of 1425mm physically prevented a small number of people getting into the taxi.	The height of the roof was an important issue for ambulant people who found manoeuvring in a stooped position difficult or impossible. The tests also suggested that a low roof made some people feel uncomfortable.

Feature	Recommendation	Rationale	Discussion
Floor plan	The smallest unobstructed floor area needed by wheelchair users in a side entry taxi was achieved with a door which abutted the front partition. It measured 1300mm wide x 1340mm long and assumed the wheelchair would be parked facing backwards, as is the current practice. continued…	The position of the door on the side of the taxi made a difference to the ease of manoeuvring the wheelchair inside it.	The unobstructed length of the taxi floor could be reduced if recesses for footplates were built underneath the seat or into the front partition. If wheelchair users are to be able to travel facing forwards (a position many prefer), new wheelchair and passenger restraining systems would have to be developed.

Feature	Recommendation	Rationale	Discussion
Floor plan cont'd.	The length of the unobstructed space would need to be 1440mm long, and the door would need to be at least 200mm from the front partition if the design of the taxi was to allow wheelchair users to choose if they travelled facing forwards or backwards.		

Feature	Recommendation	Rationale	Discussion
Swivel seats	All taxis should be fitted with a powered swivel seat.	A large number of people cannot negotiate a single step. Some of these people would find it difficult to walk up a ramp, and this might be hazardous. A powered swivel seat is a viable alternative for both of these groups.	While most ambulant people would prefer a low step to a swivel seat (because it is quicker, less obvious and in some cases easier), a substantial minority would prefer to use the seat. Seats need to be contoured so that they provide some support, feel stable and be comfortable and rigid enough to ride in without apprehension. A number of passengers transfer from the current design of swivel seat once inside the cab because they feel insecure on it.

Feature	Recommendation	Rationale	Discussion
Seat height	The distance from floor to seat squab should be in the range 430 – 460mm.	Low seats can be difficult or painful for passengers to rise from if they have stiff legs or limited upper body strength.	Seat squabs with a pronounced angle can also present a difficulty. Ideally seats should also be firm and be upholstered with a fabric that allows a degree of sliding.

Feature	Recommendation	Rationale	Discussion
Door closure - effort	The force required to close or open a hinged or sliding door, by pushing or pulling, should be less than 70N. This should include latching operations.	Closure efforts should be kept well within recommended limits to ensure that the majority of passengers can comfortably gain access. Hinged door closure efforts are typically less than this but some passengers may find efforts of 70N painful or difficult. Some passengers will always need assistance with door opening and power assisted operation may provide a safe and secure means of controlling sliding doors.	Heavy doors can present a problem for passengers with painful arthritis or limited upper limb strength. The effort required to move a sliding door is typically greater than that required for a hinged door because the movement is typically across the body rather than towards/away from it.

Feature	Recommendation	Rationale	Discussion
Door closure - reach	The maximum reach distance from the nearest forward facing seat to the nearside door handle should be 450mm.	Excessive reach distances can make door opening and closure difficult. They can force some people to move out of their seats to less secure and stable positions.	Taxis that can accommodate wheelchairs in front of the forward facing seats will tend to increase the distance from side aperture to seat.
Door handle - design	Door handles that enable ‘power grip’ (full wrap around of fingers and thumb) should be implemented rather than ‘hook grips’.	Optimised door handle design can facilitate access for passengers with limited manual dexterity.	There is little difference in effort requirements but Power grip handles enable a wider range of operating strategies to overcome limited dexterity to be used.

Feature	Recommendation	Rationale	Discussion
Door handle - size	Internal and external door handles should be at least 65mm long.	Small door handles were reported as a problem for some passengers during consultation.	A larger door handle allows a passenger to hook more fingers around the handle and exercise greater leverage.
Door release - effort	Maximum door release effort should be less than 5.4N.	Stiff door handles provide an access barrier for those with limited manual dexterity and strength.	Careful consideration needs to be given to sliding door latching where higher efforts have been a common feature in the past. Automatic latching is now a feature on some vehicles and may represent a successful solution for taxis.

Feature	Recommendation	Rationale	Discussion
Grab handle - dimensions	Grab handles should have a circular cross section and have a diameter of between 30 and 50mm (40mm recommended). There should be clearance of at least 45mm from adjacent surfaces.	Handles must be comfortable to grip for those with restricted dexterity. Clearance is required to allow for gloves and to prevent abrasion.	Evidence suggests that handles of these dimensions provide optimum grip and comfort.

Feature	Recommendation	Rationale	Discussion
Grab handle location	Grab handles should be located where they provide maximum support for stability for passengers entering, exiting and manoeuvring within the taxi. Exact location is dependent on taxi design but is likely to include either side of the entrance door, the partition wall between driver and passenger compartment and the inside of the door and/or the interior of the side wall below window height.	Grab handles provide critical stability support for passengers entering and manoeuvring within the vehicle.	The number required depends on the size of the passenger compartment and internal seating arrangements

Feature	Recommendation	Rationale	Discussion
Grab handle positioning	Within the vehicle horizontal grab handles should be located at 900mm from the floor. Grab handles either side of the entrance should be vertical and extend from at least 900mm down to 550mm. Extent above 900mm (to around 1200mm) would be advantageous but to assist access but this dimension is partly determined by door height and the number of external steps etc.	Grab handles provide critical stability support for passengers entering and manoeuvring within the vehicle.	The 900mm recommendation assumes upright gait. A lower level may be required if a stooped posture is necessary.

Feature	Recommendation	Rationale	Discussion
Visibility	The following features should be highlighted to enhance their visibility for passengers with low vision: (i) Exterior and interior door handles (ii) Step and ramp edges (iii) Door edge (iv) Grab handles (v) Front edge of seat squab (vi) Perimeter of driver communication ‘window’.	Hi-lighting critical features in a taxi can assist passengers with low vision and help all passengers when lighting is limited.	

Feature	Recommendation	Rationale	Discussion
Lighting	Ambient lighting within the passenger cab should be 150lux.	Adequate lighting is required for safe and comfortable use of a taxi by all passengers.	Ambient lighting should not be so bright that it causes distraction for the driver or causes an adaptation problem for a passenger exiting the taxi into an unlit street at night.

Feature	Recommendation	Rationale	Discussion
Additional Lighting	Enhanced lighting (>200lux) of the following features should be achieved: (i) Steps (at step height and from the side) (ii) Meter display and safety signage (iii) The communication window	Enhanced lighting facilitates the use of taxis by passengers with low vision and assists all passengers.	The highlighting of steps is an important safety enhancement. Specific interior lighting can help passengers to read displays and make payments.

4 APPENDICES

4.1 APPENDIX 1: Summary of methods employed

Although the brief for this work indicated that ergonomic guidance should be generated on the basis of original data collection, an approach using a range of complementary methods was judged to have the greatest chance of achieving a robust and comprehensive answer in a resource efficient manner. The following approaches were adopted:

4.1.1 Desk research

Technical literature searches were undertaken by ESRI's information scientist to identify relevant documents describing accessibility assessments in a variety of roles. Searches were also undertaken to identify existing standards, recommendations and guidance.

4.1.2 Empirical research

This activity corresponded to the main assessment trials completed with an adjustable rig.

The aim of this work was to provide reliable guidance on the key ergonomic parameters that determine taxi accessibility. The user trial therefore tested ramp angles and step heights (and associated floor heights), door openings (width and height), interior ceiling height and rear seat position. A full rationale for this work is given in the Phase 1 report.

In order to ensure that an appropriate range of disabilities was considered in the assessments, a total of 60 participants aged from 26 to 86 years were recruited with the following broad impairment groups. These groups are based on the categories of functional impairment as defined by the OPCS severity scales however only those categories with relevance to taxi usage were included:

- Users of manual wheelchairs
- Users of powered wheelchairs

- People who cannot walk very far and who have difficulty with steps
- People who use walking aids, including a single stick, single crutch, double sticks and walking frames
- People with restricted dexterity
- People with restricted strength
- Visually impaired people

4.1.3 Assessment rig

A fully adjustable assessment rig was developed specifically for the trial (See Figure1). The adjustments for floor and ceiling height were electrically controlled, while the door opening and seat position were adjusted manually. An electrically controlled swivel seat was also installed and tested by those participants who felt it might be helpful to them. The participants were also able to assess the suitability of a manual swivel seat fitted to a standard saloon car.

The rig was not intended to represent any particular manufacturer's vehicle but the general layout was consistent with a wheelchair accessible taxi with side door access.

Figure 1: Taxi rig

4.1.4 Data capture

Feedback for all the assessments was obtained via a structured questionnaire that was completed by a user trial supervisor in the form of an informal interview. All areas were explored in detail in order to capture as much information as possible. A full set of the questionnaires used is included as Appendix 6

The participants were asked to complete a series of tasks and then to give subjective assessments and ratings on the ease of completion. The supervisors also made notes on the way that the tasks were completed (apparent effort, use of grab handles etc.). The participants' ratings were given using a 5-point scale, where:

1 = Very Poor/Very Difficult, 2 = Poor/Difficult, 3 = Acceptable, 4 = Good/Easy and 5 = Very Good/Very Easy

4.1.5 Assessment tasks

Several tests were conducted. The participants were asked to try one of the settings (not the one considered most easy) and to identify whether or not it was acceptable to them in terms of comfort, ability and safety.

The settings were altered (made more difficult) until the participant found that the setting was unacceptable to them, i.e. that it compromised their comfort and/or ability. Participants were not invited to attempt a setting that they considered too difficult. The reasons why the setting was unacceptable were captured and a more detailed questionnaire was completed on the settings that they considered acceptable.

The following tasks were performed and the settings assessed:

4.1.6 Wheelchair users

1st Assessment - Ramp angles of 4.5°, 8°, 12°, 16° and 20°

2nd Assessment -Door openings of width 900/height 1745mm, width 850/height 1595mm and width 800/height 1395mm

3rd Assessment -Ceiling heights of 1825, 1625 and 1425mm

4th Assessment -Combined assessment of all preferred settings.

4.1.7 Ambulant users

1st Assessment -Step and floor heights as follows: step 100/floor 205mm, step 125/floor 255mm, step 150/floor 305mm, step 175/floor 355mm, step 200/floor 405mm, step 225/floor 455mm.

2nd Assessment -Door openings of width 900/height 1745mm, width 850/height 1595mm and width 800/height 1395mm

3rd Assessment -Ceiling heights of 1825, 1625 and 1425mm

4th Assessment -Back seat in forward most position (NB. All other assessments were undertaken with the seat in its rear most position)

5th Assessment -Swivel seat use (optional)

6th Assessment -Overall setting of all preferred settings

Following each group of assessment, the participants' optimum or acceptable settings were then used to perform the next group of assessments in order to minimise the possibility of a sub-optimal setting on one dimension affecting the assessment of a second variable. More detail of the assessments can be found within Section 2 - Results.

4.1.8 Additional tasks/feedback

During the trial period, a Swedish designed vehicle offering high levels of accessibility (Rohill Taxi-Rider) was available for participants to try it and comment on. This was used by several participants, but as it was situated outdoors, usage was dependant on the weather.

In addition to the participants, if any helpers were present e.g. to manoeuvre wheelchairs, or to provide support while entering the taxi, these people completed a separate questionnaire. On several occasions, a user trial supervisor provided the help.

4.1.9 Analysis of results

The subjective findings on the specified settings were recorded and statistically analysed in three broad groups: Wheelchair Users, Ambulant Users and Visually Impaired Users.

4.1.10 Existing requirements

Physical accessibility is a major requirement in many public, commercial, and domestic contexts. A body of guidance already exists that relates to the design of trains, PSV's and transport infrastructure in order to maximise accessibility. This information was collated and assessed for its suitability for application in a taxi context. Some guidance was judged capable of direct application without further consideration (e.g. grab handle dimensions), some data was considered relevant but required confirmation (door entrance width) and some guidance was considered unreliable given the special taxi context. An example of the latter category was ramp angle. This parameter has been covered in many guidance documents but much of the guidance assumes a ramp length of several metres or more (i.e. building access ramps) while a taxi access ramp is likely to be considerably shorter. Furthermore, there are issues associated with self propulsion, assisted access and manual handling to take into proper account.

4.1.11 Additional data collection

Although the rig enabled new measurements to be made on a range of fundamental parameters it was felt that some additional data collection was required to verify specific questions. Consequently, separate empirical assessments were made with respect to wheelchair manoeuvre space, manual handling efforts and the typical forces required to achieve door closure.

4.1.12 Expert advice

There has been a considerable amount of previous research on accessibility and relevant knowledge and expertise exists in a broad range of contexts. While not all of this understanding is based on clear empirical research there is sufficient consensus for some finding to be accepted without undertaking further empirical assessments. Such assessments were judged unlikely to generate new findings but would simply repeat earlier work.

Where appropriate, mobility and impairment experts were consulted in order that in depth knowledge and experience could be brought to the project. Thus Motability consultants were asked to advise on the issue of wheelchair travelling position within the vehicle and the RNIB were asked for advice on the requirements of low-vision taxi passengers.

4.1.13 Consultation

There are a wide range of stakeholders with an interest in the design, deployment, administration and use of taxis. All these parties were approached to provide their views on the priority issues for enhancing accessibility. Maximum emphasis was placed on the views of disabled and elderly taxi users but it was judged that all stakeholders could make a valuable contribution to an issue that addresses inclusive design.

4.2 APPENDIX 2: Consultation

As part of the research, the team consulted;

- organisations of and for disabled people

- individual disabled people

- taxi manufacturers and vehicle converters

  Allied Vehicles Ltd
  Brotherwood
  Cabmobility
  Carmobility
  Constables
  Davis Accessible Transport
  Euromotive (Kent) Ltd
  Gleneagles Conversions Ltd
  GM Coachwork Ltd
  Gowrings Mobility
  Interbility limited
  Jubilee Automotive
  KC Mobility
  Lewis Reed (wheelchair accessible)
  LTI
  McElmeel Mobility Services Ltd
  Metrocab UK plc
  Rohill Bodies ltd
  Steering Developments Limited
  Voyager MPV
  Widness Car Centre

- Taxi Associations

  National Taxi Association
  NATPHLEO
  The Scottish Taxi Federation
  The Licensed Private Hire Association
  The London Taxi Board
  Licensed Taxi Drivers' Association

Sixty organisations were approached by letter and phone for their views on the design of taxis, and the appropriateness of the taxi service for older and disabled people. 46 (76%) responded although not all of them had anything of substance to say. The charities who responded were:

Action for Blind People
Age Concern
Alzheimer's Society
Back Care (National Back Pain Association)
BLESMA
British Council of Disabled People
British Deaf Association
CAE
Communication Matters
Contact a Family
Cystic Fibrosis Trust
Deafblind UK
DIAL UK
Disability Alliance
Disabled Parents Network
Disabled Drivers Association
Disability Rights Commission
DLF
Epilepsy Action
GLAD
Guide Dogs for the Blind Association
Hearing Dogs for deaf People
Help the Aged
Henshaw Society for Blind People
Mencap
Motor Neurone Disease Association
MS Society
Muscular Dystrophy Group of GB and NI
Mind
National Association of deafened People
National Information Forum
National Osteoporosis Society
National Rheumatoid Arthritis Society
National Society for Epilepsy
Partially Sighted Society
People First
RADAR
RNIB
RNID

SENSE
Scope
Speakability
Spinal Injuries Association
Stroke Association
Tripscope

In the course of the research, submissions were also received from the following local organisations:

Coventry Wheelchair User Group
College of Occupational Therapists
Disability Gateshead
Disability Information Bureau Macclesfield
Leicester Blind Society
Leonard Cheshire Foundation
Manchester Disabled People's Access Group
York People First

Organisations of disabled people contacted were the major national organisations and those with a specialist interest in transport as recorded in directories and our own databases.

Individuals consulted consisted of:

- 128 disabled people approached at random at the 2003 Mobility Road Show, who tried out and commented on two taxis on our specially created stand

- twenty trial journeys conducted with people who had a range of disabilities for a more textured analysis of existing problems with taxi accessibility. The focus was on interviewing people with more unusual or under-represented disabilities whose views might not have been covered in the Mobility Roadshow interviews. These comprised:

    - walking difficulties caused by stroke or paralysis (nine participants)

    - repetitive strain injury (two participants)

- o aphasia or communication impairments (three participants)
- o severe back pain (two participants)
- o visual impairment (two participants)
- o severe forms of arthritis (two participants)

Eleven participants were identified through national disability organisations, which circulated details of the trials to their members via newsletters, magazines and message boards. The remainder were recruited through a day centre for disabled people. Participants included people who frequently used taxis as well as those who rarely used them, for reasons of cost and service as well as accessibility. The trials comprised a taxi journey, using a combination of participant observation and semi-structured depth interviews, typically lasting half an hour. Trials were often combined with a journey the participant needed to make to add degree of realism. All journeys took place in purpose built taxis.

A total of 43 people who responded to appeals for information put out by disability organisations and those we have approached during the course of the project.

The views presented in the following sections are based on comments made by all those who participated in the consultation process.

4.2.1 Findings

The information provided by all these sources was extremely cohesive, and there was a strong level of agreement about the issues which were of main concern to disabled taxi users. Our findings also were in accord with previous investigations as reported in the literature (see Section 4).

The summary below is divided into three parts. The first deals with considerations that could be addressed by the design of taxi vehicles and falls directly within the remit of the aims of this study.

The second describes additional features which could make taxis easier for disabled people to use but which lay outside our test programme. Finally we summarise views expressed about the nature and standard of service provided by taxi firms. Although these considerations were not part of the original brief it is clear that they are as essential to an accessible taxi service as the design of the vehicle itself.

At the outset the importance of the taxi service to disabled people needs to be emphasised. Unique among modes of public transport taxis provide a door to door service which, at least in theory, is easily available at most times when people need to travel. It was seen as being flexible and using taxis did not have the stigma that was sometimes associated with a dial a ride or ambulance. For some people an accessible taxi was the only viable form of public transport available to them.

4.2.2 Taxi design

As might be expected, opinions of what was needed from taxi design varied. In particular the somewhat contrary needs of wheelchair users and other mobility impaired people had not been reconciled in any current taxi design. Although there were some areas in which both groups of people wanted the same features (lower floors, for example), there were other areas in which they were sharply divided. This led to many non wheelchair users expressing a preference for saloon cars.

Many of the responses from disability charities focused on the service offered to disabled people rather than the taxi design. Where the actual design was mentioned, organisations frequently stated that the newer purpose built taxis were preferable to older models due to the larger door size, lower floor height and better colour contrast inside the cab.

4.2.3 Floor height

The floors of many purpose built taxis are too high for some people. This point was made throughout our consultation. Almost all of those who took part in the trial journeys found the step too high. This problem was compounded when the taxi was not parked right next to the curb. The attachable step available on the LTI TXII was appreciated, although some suggested there should be two steps not one. Some of those with restricted leg movement or who had limited strength on one side of their body preferred walking up a ramp, but would have preferred to have a handrail for extra support while doing so.

4.2.4 Swivel seats

Some purpose built taxis are fitted with a swivel seat. As an optional extra this can be powered and can move up and down outside the taxi. First principles suggest that this innovation would make taxis accessible to a larger number of people. Our interviews showed however that very few people were aware of these seats. Only 9 people out of the 128 we interviewed had ever tried one and a sizeable proportion claimed never to have heard of them. At the 2003 Mobility Roadshow a demonstration of this seat (as fitted in an LTI TXII taxi) suggested that it would be highly valued by a great number of people, and that most people thought it was easy to use. Criticisms of it were few but included the fact that it felt flimsy and that that it was not shaped to give the right level of support. A very small number felt it was unsafe because the passenger was not secured during the access/egress operation or because they just did not like travelling backwards.

All those who undertook trial journeys tried the swivel seat where this was fitted. All found it a useful aid to getting in and out of the cab. However almost all preferred to transfer to the backseat once they were inside. Several reasons were given for this, including the greater comfort offered by the back seat, a feeling that travelling on the swivel seat was not safe and a desire to face the direction of travel.

The 1997 consultation revealed some unidentified concerns about the use of swivel seats. There were also a few comments about the need for arm rests or a modified seat back and some people wanted the seats to be the subject of a standard or accredited test procedure. Some people thought the distance between the seat and the top of the door was insufficient.

4.2.5 The position of the rear seat in relation to the door

For a number of people a shortcoming of purpose built taxi design was the position of the back seat, a difficulty compounded by the high floor and low roof height. Climbing in, stooping and then turning round to sit down was difficult for some. Getting out again was equally difficult.

"… a simple 90 degree transfer is not easy or is impossible … the seat almost needs to slide to be near the door and then moved to a locked position."

4.2.6 Door opening

In most cases the design of the handle was not seen as a critical issue since the driver usually opened and closed the door where a passenger had an obvious disability. However this did not apply where disabilities were less apparent, and was not acceptable to those who did not wish to rely on the help of the driver. The problems for this group were more to do with opening the door from inside than from outside. The main criticisms were that some catches were too small, some were too stiff and they were hard to see. The other main problem was one of reach – particularly because the back seat was so far back in the cab. The door handle on the inside needs to be marked in contrasting colours and:

"The inside handles should be illuminated or lit around the area…"

The trial journeys showed that most participants had little difficulty opening the door and found the existing handle on the TX range of taxis light enough to operate. Closing the door created some difficulties, largely because participants found it awkward to get into position where they could reach the door handle and pull it shut. This could not be managed from the back seat. An added complication for participants with back problems was that closing the door had to be done when the back was in a curved, uncomfortable position.

Some people had experience of MPV type vehicles with sliding doors. There were advantages and disadvantages to each type. Some preferred traditional doors because they were easier to open and to some extent could be lent on for support. Others said that a sliding door allowed the driver to park closer to the kerb or where there would not be room for a conventional door to open fully. Concern has been expressed by some that sliding doors on the offside of a vehicle could be dangerous because it would not be obvious to passing motorists that the door was open, and that people were about to get out. A number of trial participants said that the sliding doors they had experienced had handles that were too hard to grip, were too cumbersome and heavy to open easily. Closing the door was said to be particularly difficult because of the angle from which it had to be pushed. Wheelchair users and those who were holding crutches had more difficulty than others.

Difficulties with conventional doors were experienced when the handles were stiff or the door was heavy. Some people had difficulty opening it to the point where it stayed open; sometimes walking aids were used to help. Closing the door and opening it when sitting inside the taxi was a problem for some. Doors could be difficult to reach from a wheelchair.

4.2.7 Wheelchair access

Purpose built taxis (e.g. current Metrocab and LTI's models) were recognised as being the most accessible vehicles so far available. The fact that their design catered for wheelchair users and other disabilities at all inhibited some people from levelling any criticism at them. However:

- Some tall people who could not bend their necks had difficulty getting into the vehicle

- Ramps (particularly when there was no pavement) were too steep for some people to use. A few respondents said that they did not like having to rely on the taxi driver to be pushed up the ramp. A few of those who used powered chairs could get up the ramp without help but described how difficult it was to control the chair at the top of the ramp. Problems were compounded because some taxi drivers do not know how to operate the ramps. Channel ramps were disliked because of the need to be able to steer accurately on them. The use of a pair of channel ramps excluded three wheeled vehicles from travelling by taxi. Some ramps were criticised for the lack of any lip to stop wheels dropping over the edge. Some people wanted lifts rather than ramps. The 1997 consultation provoked several criticisms including the need for a shallower ramp (or a winch). Some device was needed to ensure the vehicle could not move off with the ramp deployed.

- Some people steadied themselves while travelling sideways by holding on to grab handles or some other fitting in the cab.

- Wheelchair securing straps were described as being awkward and some people said that it was not always obvious how these should be attached.

The 1997 proposed specifications envisaged a door width of 780mm. The ensuing consultation criticised this as being too narrow.

In some areas (rural areas with narrow lanes, areas with no pavements) a vehicle in which wheelchair users enter from the rear was preferred. This has implications for safety during loading operations, the arrangement and design of other seats and much else. The practicalities of rear access were also questioned by those who responded to the 1997 consultation. Some wanted more headroom than had been proposed (1400mm headroom above the designated wheelchair space) and some wanted the size of the manoeuvring area to be specified.

4.2.8 Securing wheelchairs

Respondents to our survey carried out at the 2003 Mobility Road Show were asked which way they usually faced when travelling in a taxi. Excluding those who had used a private hire vehicle, 83% had used a purpose built taxi in the last year, 17% had been carried in an MPV type taxi and 5% had been carried by a firm which used a converted van. The majority of the comments below therefore refer to purpose built taxis.

Comparatively few people travelled facing backwards – only a fifth of the people interviewed claimed to do so. The majority travelled facing sideways or, in the rear entry vehicles which allowed it, facing forwards. Several reasons were given: on the LTI TX vehicles the need to lift up the back seat to make room for the chair, the fact that the floor underneath sloped upwards and could interfere with footrests made this a cumbersome manoeuvre. Taxi drivers rarely insisted that wheelchair using passengers were properly situated and anchored and some people claimed that taxi drivers were unwilling to spend the extra time that this involved. A few people reported that travelling facing backwards made them feel travel sick. Others complained that it made it impossible to give directions to the driver. Some people just did not like not being able to see where they were going and one person did not feel safe going backwards because he could not anticipate bumps or corners and so could not brace himself for them.

"The safety of the client tends to depend on the ability of the driver to use all the wheelchair safety straps properly ….do the drivers of these vehicles have any training in safe use of the systems? ….I have had several journeys where the driver has put himself at risk by not offering to use the ramp for access into the taxi and have had instances where the client could have been injured if travelling alone because straps used did not hold them securely. The drivers are not often clear how to secure the wheelchair and how to secure the client within the wheelchair."

The 1997 consultation showed that securing devices needed to be easy to use by the driver (and passenger in an emergency) and that guidance on how to use them needed to be provided (particularly for unusual wheelchairs). Despite this over a third of the people interviewed for this project either claimed that securing devices were difficult to fit or that they did not bother to try. In the Government review some people expressed the opinion that the backrest (against which the wheelchair should be placed) might block the driver's view when reversing. Some people thought it would not fit all wheelchairs.

4.2.9 Grab handles

Grab handles were essential to very many people. They were needed by people who needed to steady themselves as they got in and out; they were used as orientation aids by people with visual impairments. They made it possible for others to haul themselves up into the taxi and to manoeuvre themselves onto the seat. Some of these movements were complex. The disposition of the grab handles on the TXII seemed to suit most people although many wanted an additional handle in the centre of the partition which separated the driver from the cab. The Government's earlier consultation also showed that passengers wanted a grab handle they could hold while the vehicle was moving.

All those who carried out trial journeys used the grab handles for support when entering and exiting the taxi. The consensus was that they were well placed and easy to see. A participant with no movement in one leg would have liked a handle attached in the middle of the taxi ceiling, as a support to manoeuvring himself onto the back seat. Another suggested there should be grab handles on the outside of the cab around the door frame. Grab handles were praised for their high visibility. Criticisms were made of the inside door handle, which was too small and hard to see.

The position of the grab rails attracted some criticism once participants were in the taxi. It was suggested that there should be a horizontal one attached to the partition by the driver's window when the swivel seat is used. Participants whose grip was affected by RSI or arthritis suggested the grab handles should be thicker with better cushioning. One participant said they felt cold to the touch. Participants who had used both types of taxi said that grab handles on the TX taxi were much more comfortable than those on the Fairway.

Those who took part in the empirical tests also described the importance of properly placed grab handles. These were used for every manoeuvre – getting in and out of the taxi, getting to the seat or parking position and getting out of the seat at the end of the journey. They were held onto for stability when opening the door from inside and many people would hold on to them during a journey. Visually impaired people found them a useful orientation aid.

4.2.10 Design of the rear seat

Although almost all of those who carried out trial journeys reported that the backseat in TX taxis were comfortable, some found them hard to get up from because the seat was too deep.

The distance between the door and the backseat was criticised by all participants with limited ability to walk or bend. They generally had to use the grab handles to swing themselves towards the door, then onto the flip down seat and then out.

Some participants considered that the seats needed some lumbar support; one participant remarked that the driver's seat looked especially comfortable and that a similar design should be used on the backseats. This was of particular concern for participants with back pain. One had to keep her back straight whenever possible and found the only way she could travel in a taxi was to lie down on the backseat – which was undignified and meant that she could not use the seatbelt.

4.2.11 Features

A number of people made suggestions for additional features or equipment that would make travelling by taxi easier for disabled people. They are described below.

4.2.12 Meters

These needed display characters with a large font and strong contrast so that they were readable by a greater number of visually impaired people. Both visually impaired participants in the trial journey tests criticised the liquid crystal fare display for being small and having poor contrast. Although both participants generally trusted drivers to charge the right amount, they suggested that the meter should be able to ‘speak’ its price. This view was endorsed by the disability organisations consulted.

“The glass protector between compartments needs a clear indication of where money can be passed through.”

“Amplified communication between passenger and the driver is required. The driver to communicate on the journey and the passenger can then check his or her route.”

“Ideally there should be an illuminated tray to put the money on.”

Respondents to the 1997 consultation wanted the meter to be visible at all times, with a display in the passenger salon. Some organisations advocated a talking meter.

One of the people who carried out a trial taxi journey suggested there should be a small tray by the driver’s partition window for counting out fare money. Another would have liked a meter to be close to the back seat, on the passenger’s side of the partition.

4.2.13 Climate control

The climate control in the taxi was also valued by those who took trial journeys who had conditions that could be triggered by the cold, such as arthritis or RSI. While they felt the controls were effective, the labelling on the fan and heater switches were criticised for not being clear. One participant suggested the arm rests should have heating – or at least heavier cushioning – to help keep his arms warm.

4.2.14 Seatbelts

A common problem reported by trial journey participants was the position of the seatbelt behind the shoulder. This was particularly difficult for those with limited movement in one side who could not reach over their shoulder for the belt. Some of these respondents felt they would have been able to manage a seatbelt that crossed the waist although this type of belt is not permitted by current regulations. The seatbelt buckle also caused some difficulties and was seen as fiddly and hard to hold while fastening.

4.2.15 Additional requirements listed in the 1997 consultation

Additional features requested by respondents to the 1997 consultation included:

- More facilities for people with hearing impairments (including an induction loop)
- Pen and paper to be carried to aid communication
- Clear glass partition to allow lip reading
- Taxi operators to accept bookings through type-talk or text-phone
- Evidence of licensing readable by visually impaired passengers
- Tactile signs
- Door opening space to be marked in contrasting colours
- Contrast between seats and their surroundings
- Means of signalling the driver when facing backwards
- Accessible taxis to be clearly marked
- Better suspension
- Vehicles to be fitted with a kneeling mechanism

4.2.16 Service issues

If was clear that the physical design of the taxi was only one component of an accessible taxi service. By far the most frequently expressed view was the need for taxi firms and drivers to have disability awareness training, possibly backed up by a Code of Practice and, if possible, some kind of inspection and accreditation process. Most of the responses received from disability organisations focused on the need for disability awareness training for drivers. The majority of disabled people interviewed said that they sometimes travelled by taxi alone, so it is particularly important that the service is geared to people travelling independently.

4.2.17 Booking

Many people booked taxis because of the difficulty of hailing them in the street or because they found getting into a taxi at a taxi rank difficult. One organisation for deaf people criticised taxi firms for not having facilities to book by fax or text.

4.2.18 Tariffs

There were a number of instances in which the way charges were levied meant that disabled people paid more for their journey than those without disabilities would. Some drivers levied an extra charge for the carriage of a wheelchair. Some taxi drivers switched on the meter so that it included the time to set up a ramp or provide any extra help to the passenger. This was resented. An organisation representing visually impaired people described other unscrupulous practices by drivers:

“Our experience is that drivers are usually very courteous and helpful. However we are aware of drivers deliberately taking people on longer routes and refusing to help people out of the cab.”

4.2.19 Steps

The most widespread criticism of taxi design was the height of the floor from the pavement or ground. An interim step was vital for some people but some respondents claimed that taxi drivers were sometimes unwilling to deploy it (on some taxis it is part of the ramp assembly and can be difficult and time consuming to fit). Some people did not feel very secure on this step.

Responses to the 1997 consultation showed some concern about steps although it was not possible to separate the comments of disabled people from those of the industry. There was some concern that the (then) proposal permitted the possibility of too many steps. Some thought the first step (250mm from the ground) was too high. Some people wanted the step to be marked in contrasting colours. Ground clearance was thought to be a problem by some.

While those who undertook trial journeys were generally pleased with the standardised and accessible features on the TX, they often chose to travel in private hire cars in practice. One reason for this was cost but they also said that private hire firms were more dependable, and provided a better service to regular customers who they got to know. Taxi firms were much more variable and everybody had had experience of drivers who had been impatient, intolerant and inconsiderate as well as drivers who were polite, thoughtful and accommodating.

Consequently some considered that taxi drivers should have disability awareness or equality training as part of the licensing procedure. The consultation with disability organisations suggested training should include:

- how to use the ramps and swivel seats properly
- how to secure wheelchairs safely
- allowing all assistance dogs into a taxi, not just guide dogs
- not metering for the extra time disabled people may need to get in and out of the cab
- offering to walk the passenger to their door:

  "at the very least drivers should watch to make sure they get safely to their destination"

- help with opening the door and fastening the seatbelt
- basic BSL was suggested by a charity for people with a hearing impairment

A final suggestion was that signs in taxis should highlight its accessible features, give advice for wheelchair users on how their chair should be safely secured, and explain the complaints procedure. Organisations for people with learning difficulties and dementia stressed that these should be accessible to all and make use of diagrams and symbols.

4.2.20 Code of practice

There was a widespread call for a Code of Practice which would set out standards of service for taxi drivers and taxi firms. There was some disagreement about how this might be enforced, although some people suggested that it be tied in with the licensing process and be the responsibility of licensing authorities.

Appendix 7 lists some of the areas such a Code might cover.

4.3 APPENDIX 3: Ramp gradients and handling efforts

4.3.1 Assessment of wheelchair handling efforts

This assessment was undertaken to provide an estimate of the maximum gradient that is consistent with health and safety advice regarding manual handling efforts. The assessment was limited to one type of wheelchair – a lightweight manual wheelchair. It was considered inappropriate to assess electric wheelchairs since (i) they are not intended for manual manoeuvre and (ii) their weight is typically high enough to preclude the majority of assistants from being able to push them up any slope. It was decided that a popular, current wheelchair design should be used and a Worldwide Mobility Economy Plus Wheelchair was obtained specifically for the trials.

The UK manual handling regulations[14] were introduced in response to the European directive 90/269/EEC on the manual handling of loads and place responsibilities on both employers and employees. The guidance document gives recommended maximum safe forces for a variety of tasks involving lifting and pushing. These include the maximum recommended starting effort and sustained effort for men and women when pushing a wheeled trolley or cart. A starting effort is that effort required to accelerate a wheelchair from stationary to a desired travel speed. The maintenance effort is the effort required to keep a trolley in motion once it has been accelerated from stationary. Starting efforts are typically higher than maintenance efforts. Table 25 gives the maximum recommended push efforts (in Newtons) for men and women for the two tasks.

Table 35: Maximum push efforts recommended by Manual Handling Regulations

Maximum safe efforts	Male	Female
Starting effort (N)	250	160
Maintenance effort (N)	100	70

These figures are given for guidance and it is assumed that the requirements of a particular task will be taken into account in their application. This is necessary given the number of factors which can influence the difficulty of a pushing task. These include surface characteristics, wheel diameter and perimeter composition, handle position in relation to trolley dimensions, the orientation of wheels (particularly swivel wheels) when a push commences and the frequency and duration of the effort.

In the case of taxi ramps it is quite feasible to make simple calculations based on geometry, dimensions and representative weights to calculate theoretical estimates.

These were completed with the following assumptions:

- The weight of a wheelchair and occupant would be taken as 125Kg. This corresponds to the 95th percentile value from a recent survey of actual values recorded in the UK[15].
- Friction and wheel orientation would be excluded from the calculation. Friction was deemed to be negligible given the materials used in the typical construction of taxi ramps. Front wheel orientation is an important factor but is dependent on the specific chair design.
- For starting effort an estimate of acceleration involved was required. A value 0.5m/s/s was assumed since this equates to the attainment of a slow walking speed after a push lasting two seconds.

The calculations involve the mass of the wheelchair and occupant, the angle of the ramp, a constant for gravity and the acceleration applied:

Maintenance effort = weight x gravity x SIN (slope angle)

Starting effort = weight x acceleration + (weight x gravity x SIN (slope angle))

For the ramp gradients involved in the trials the following values (in Newtons) were obtained:

Table 36: Calculated forces for 125Kg load and various ramp angles

Slope (degrees)	Start Force (N)	Maintenance Force (N)
4.5	158	96
8	233	170
12	317	255
16	401	338
20	481	419

When compared with the recommended maximum push efforts in table 25 these estimates suggest that when a heavier wheelchair and occupant are concerned a slope of 12° may present a possible hazard for men while for women even a slope of 4.5° is outside the recommended value for sustained push effort.

However, the particular characteristics of the task of assisting a wheelchair user up a taxi ramp may not be consistent with the assumptions behind the manual handling guidance. The push is relatively brief with a sudden effort from a stationary start, minimal maintenance effort and then deceleration as the wheelchair enters the door way. In many trolley push efforts there is steady and sustained effort lasting several seconds (e.g. pushing a hospital bed along a corridor and up internal ramp ways). It was therefore decided that test measurements should be undertaken to provide task specific data.

4.3.2 Test measurements

A series of test measurements were made using a popular, lightweight wheelchair and the test rig. A range of weights were added to the wheelchair to represent the weight of an adult occupant using an H-Point manikin.

An H-Point manikin is a gauging tool used in the design, measurement and adjustment of vehicle seating. It comprises a hinged shell intended to represent the back and thighs of a seat occupant. Articulated legs and weights can be added to the shell to provide a range of realistic weights. The weight distribution approximates that of an adult occupant.

Figure 2: Wheelchair and manikin used in test measurements

The weights employed in the tests were based on data collected in the TRL survey of combined manual wheelchair and occupant weights (see previous reference). Five test values were adopted (50, 70, 90, 110 and 130Kg). The survey data found that for a 'New Style' manual chair the mean combined weight was 90Kg with a 5th percentile value of 54Kg and a 95th percentile value of 123Kg.

The ramp angles tested comprised the gradients offered by the test rig and used in the trials involving volunteer participants (4.5°, 8°, 12°, 16° and 20°). These values span a realistic range of ramp angles ranging from target values rarely achieved to gradients which might be encountered in extreme conditions.

The measurements were obtained by way of a steady thrust applied through a force dynamometer applied to a metal plate fixed between the wheelchair handles. The force was thus applied at the same height as a two handled push although achieving a uniform push through single point proved a challenge (see Figure 3). Attempts to take measurements with the steepest ramp angle and heaviest load were abandoned because it proved impossible to achieve a consistent and controlled push effort. Each measurement was repeated ten times and a mean value calculated to reduce error caused by variation in push efforts.

Figure 3: Measurement of push effort

The procedure employed for each measurement involved:

1. Adjusting the ramp angle and weight loading
2. Placing the wheelchair at the bottom of the ramp with front wheels on the ramp and rear wheels on the level surface.
3. Aligning the front wheels with the direction of travel
4. Engaging the force gauge with the wheelchair and exerting a controlled push up the ramp and into the rig
5. Noting the peak force measured by the force gauge.

Some 200 measurements were obtained and the following results were calculated:

Table 37: Mean push forces for different wheelchair weights and ramp angles

	Combined weight (Kg)				
Slope	**50**	**70**	**90**	**110**	**130**
4.5°	65.2	78.2	95.9	130.5	147
8°	121.5	157.5	172.4	190.7	209.2
12°	137.2	161.2	214.2	**274.1**	**302.9**
16°	169.6	211.2	245	**303.9**	**376.8**

These figures are slightly more conservative than those produced by mathematical calculation and presumably reflect the influence of a range of factors not taken into account. It is also possible that the assumed acceleration used in the calculation was optimistic.

However, there is a clear increase in effort associated with both increasing weight and slope. Figure 4 shows the data plotted and the general trend along with variation in progression is evident.

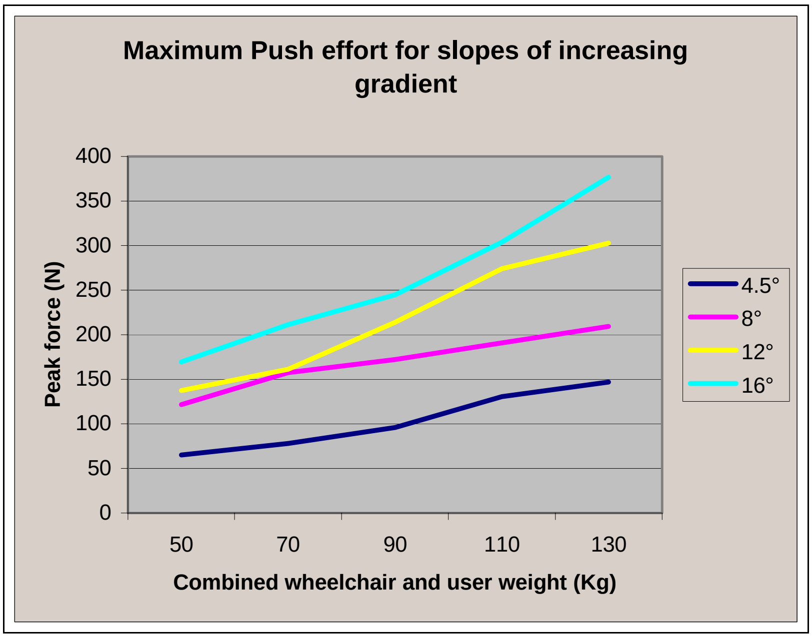

Figure 4: Mean push forces for a range of combined wheelchair weights and ramp angles

The variation in the trend data indicates uncontrolled variation in the test procedure – variation that could be reduced with a more sophisticated methodology. However, the underlying trend is clear – increasing slope and weight requires a substantially stronger push effort from the assistant.

4.3.3 Conclusions

In combination the calculations and test measurements indicate that male taxi drivers, other passengers or carers could be at risk if they attempt to push a wheelchair and occupant up a slope of more than 8°. For women the maximum advisable gradient would be 4.5°. This is not to suggest that any individual push will result in injury to the individual but that the risk of injury increases with repeated efforts at this gradient.

4.4 APPENDIX 4: Door closure, door and grab handles

4.4.1 Introduction

The data from the consultation exercises indicated that, in most cases, the design of the exterior handle did not present a problem for many passengers. However, problems opening the door from inside were reported. The main criticisms were that some catches were too small, some were stiff and that they were hard to see. Another main problem was one of reaching handles while opening and closing the doors whilst inside the cab. The issues of opening and closing doors were primarily raised as a concern by ambulant disabled passengers. While assistance in opening and closing doors may be routinely provided by taxi drivers for passengers with overt mobility impairments this is not necessarily the case with passengers whose impairment is less obvious (e.g. hands affected by arthritis). For such passengers unlatching and then opening a door may present a painful or difficult challenge.

4.4.2 Door opening and closing forces

To gain an indication of the forces required to open and close current taxi doors measures of push and pull forces were taken with a sample of LTI taxis. A force dynamometer was used to measure peak force values. For each action 5 repeat measures were taken by pulling on the external handle or the centre of the horizontal grab handle located on the inside of the door as appropriate. Table 38 presents the mean values for 3 representative tasks.

Table 38: Push and pull efforts required in door operation

Unlatch from outside (N=10)		**Pull door open when unlatched (N=5)**		**Pull door shut and latch from inside (N=5)**	
Range	Mean	Range	Mean	Range	Mean
16.3-88.2	36.5	26.1- 50N	39.5N	27.3-76.5N	49.3N

No appropriate published data regarding the pulling and pushing strengths of disabled people were found. Strength data for older people has therefore been applied as a guide for comparative purposes.

Imrhan (2001) states that *"On average, older people can be expected to pull toward the body with one hand with a force of about 71N with the fingers in a hook grip on a handle. When using the power grip (fingers wrapped around the handles) the increase in strength is insignificant."* Imrhan also states that forces often required for daily activities such as opening refrigerator doors (32.5N) and opening an oven door (36.9N) may be difficult for some older people, especially when performed frequently.

Older Adultdata (DTI 2000) provides values for the static pushing and pulling strengths for 75-79 year old females. At least 95 percent of this population are able to apply pushing and pull forces to a horizontal bar at elbow height while standing in a free posture of at least 113N and 112N respectively.

The forces measured as part of this study are substantially less than these values and it seems likely that opening and closing unlatched doors is not a particular problem for the majority of people with mobility impairments. Although the measurements were not exhaustive they included three critical and frequent tasks: Unlatching the door handle from the outside, opening the door fully and closing the door fully from the inside. The last measure included the effort required to compress rubber door seals and fully latch the door. However additional factors will determine the actual effort required to open vehicle doors and these may result in forces increasing beyond some individuals' capabilities. These factors are listed below. It is therefore recommended that opening forces are kept low and that doors are well maintained to ensure mechanisms do not become stiff.

- Environmental factors. If the car is parked on a hill or is used in windy weather the effort required to open the door may be substantially higher.

- Location in which the force is applied. The closer the hand grip is towards the hinged edge of the door the greater the force required to pull the door open or to bring it to a close. People with restricted movement and who may be unable to reach further out to the door are therefore likely to need to apply greater forces than those measured as part of this study.

- Direction in which the force is applied. Imrhan (2001) states that variation in strength is dependant on posture, for example one handed pull strength when standing was found to be 37% greater than pull strength whilst sitting. Similarly pulling towards the body is 10% stronger that pulling across the body.

- Poor / awkward or unstable postures. (See following section)

4.4.3 Sliding door operation

A number of current accessible taxi designs which are the result of vehicle conversion have sliding doors. As indicated above, the physical manoeuvre required to open or close a sliding door is inherently more awkward for passengers because the movement is across the body and not towards it. This suggests that sliding doors should have lower operating efforts than comparable hinged doors to offer an equivalent level of accessibility.

To assess the challenge provided by one popular design (Fiat Scudo Eurocab) a series of 10 repeat measurements were taken for unlatching and door opening.

Table 39: Efforts required in sliding door operation

Effort required to unlatch door		**Effort required to pull door open whilst outside vehicle**	
Range	Mean	Range	Mean
37.7– 67.3 N	53.2N	41.6 – 59.4N	47.2N

The results suggest that these specific operations should be within the capability of many passengers including older passengers and passengers with mobility impairments. However, the difficulties that some passengers with more severe limitations may face and the more general problem of ensuring that sliding doors are fully latched before departure may indicate that powered operation is a more successful solution.

4.4.4 Posture

Once a particular grip has been adopted on a given handle the amount of force which can be applied to that object will be influenced by the posture adopted. The postures associated with the greatest strength are those which allow the body to capitalise on leverages about the various joints. Further advantage can be obtained by using body weight for enhancing push/pull efforts and to maintain stability. However, disabled or older people may be restricted in their range of motion and stability and therefore may not be able to adopt the most effective postures. To reduce the effort required to open or close a door it is therefore important to keep operating forces to a minimum, to locate handles within easy reach and also ensure that aids for support in maintaining stability are close at hand.

4.4.5 Reach

To maintain a clear access into wheelchair accessible taxis with side door the rear seat is typically located aft of the door opening. In the case of LTI TX and Metrocab taxis the front edge of the seat squab is approximately 350mm from the rear door post. When the door is open and the passenger is seated the reaching distance to the middle grab handles exceeds the recommended maximum seated reach distance of 450mm (HSE) therefore bending of the trunk and extension of the arms is required. To close the door a large proportion of the adult population would need to perch on the edge of their seat and lean out of the doorway to reach the grab handles.

Working at such extreme postures leads to postural instability and increases the effort and forces required to reach and close the door.

Several studies concerned with vehicle access by disabled people have reported that the most general door problem was reaching for the pull to close it while seated in the vehicle (Department of Transport 1985, Institute of Consumer Ergonomics 1985, and Ricability 2002). During the trials by the Institute of Consumer Ergonomics several participants stated that they normally used a hooked stick or other device to reach and close doors in their own vehicles.

Other devices which may aid this task are listed below.

- A sliding seat that enables people to be seated and slide forward to reach the door handles would reduce risk of falling. However reaching out to the side will still occur. Care needs to be taken that the sliding force is within limits and that the seat locks firmly back into place.

- Flexible extensions which connect from the grab handle to the inside of the cab could be used to pull the door to a close but there may be a risk of entrapment. Further investigation into such a mechanism is recommended.

- Depending on seat positioning, a sliding door might also be associated with reach problems. Furthermore strength data suggests that the operating force should be minimal, as pulling and pushing across the body requires more effort than pushing and pulling in towards the body (as used when pulling pushing a standard hinged door). However, vehicles are now being produced with powered sliding doors and such designs could overcome many access problems.

- Grab handles are usually used for support whilst entering the cab. There is a tendency for people to keep hold of the grab handle while they close or open the door. The horizontal grab handle mounted on purpose-built taxi doors may therefore benefit from an increase in length so that as the door is closed or opened the passenger's hand can slide along the handle in accordance with changes in door angle and reach distance.

4.4.6 Door handle operation

4.4.7 External door handles

People with poor or weak grip or missing digits can find some door handles difficult to grasp and operate. This can cause problems in terms of getting into a vehicle without assistance.

Although a wide range of handle designs are potentially available three different types of external door handles are currently commonly found on vehicles; these are depicted in figures 1, 2 and 3. Of these three different designs two different types of grip may be used to grasp the handles;

1. The 'power' grip where the fingers and thumb wrap around the handle.

2. The 'hook' grip in which one or several fingers are hooked onto a ridge or around a handle, unlike the power grip no counter-action is required from the thumb.

All three types of handle can be operated using the hook grip. However only handle A can be used with both types of grip.

Figure 5: Handle A

Figure 6: Handle B

Figure 7: Handle C

The hook grip is the simplest kind of grip for pulling an object. Findings from studies show that there is no significant difference in maximal pulling forces gained when using a power grip or hook grip (Pheasant, 1992 and Imrhan, 2001). However it should be noted that handle A enables a greater variety of grips. This greater flexibility in terms of operation may be beneficial in accommodating a greater range of users.

For example, handles B and C only permit one type of grip (hook grip) and this must occur with the forearm rotated such that the palm is facing upwards. Conversely, handle A can be gripped with the forearm rotated in either rotational direction, with the palm either facing up or downwards. This choice may be beneficial for people with a weakness or restricted range of motion in one rotational direction. In addition, handle A enables a greater area of the hand and fingers to be in contact with the handle thereby creating a more secure grip. Hook grips applied to handles B and C are limited to contact with the finger tips and this may be more prone to slippage.

Type A handles are also better at accommodating the use of assistive equipment. Figure 8 depicts a device used to assist in opening a car door handle of type B; while effective the device is purpose designed. The shape of handle A facilitates use of more general devices i.e. walking stick or prosthetic hand or hook.

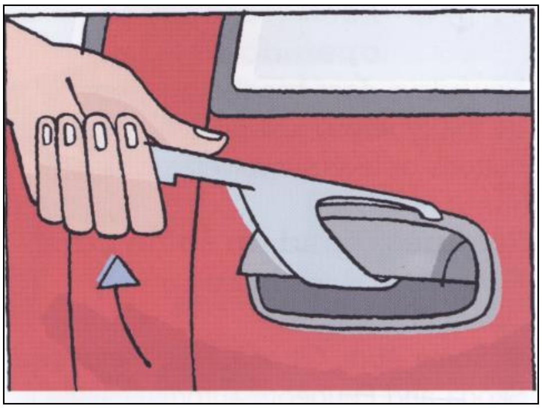

Figure 8: Door opener

4.4.8 Interior door handles

The latch handle depicted in Figure 9 is a design employed in LTI's TX vehicles but handles of this design are commonly used in a wide range of contemporary vehicles. The handle is located flush against the side of the door and must be grasped using a pinch grip or a one or two finger hook grip. To pull the lever of the catch outwards to unlock / unlatch the door, the forearm is drawn inwards towards the body's centre line. This action enables a strong leverage from the arm and does not require excessive wrist extension or excess forearm rotation.

Figure 9

Figure 10

To gain an indication of the force required to pull the lever measurements were taken from 6 different TX vehicles. The forces were low, with a mean value of 4.3N. There is limited published guidance on maximum acceptable lever forces; the Rail Vehicle Accessibility Regulations guidance suggests a maximum value of 15N for operating train door handles and BS 4467; 1991 suggests a force of 5.4 Newtons for operating a door handle by elderly people.

However the size of the lever is small and this aspect was reported as causing problems in data collected for the Phase 1 report. A longer lever would enable more fingers to hook around the handle and therefore increase and further distribute the force that can be applied. Standard anthropometric data (Peoplesize, 2000) indicates that for the largest users (95th percentile males), a lever length of approximately 65mm - 75mm is required.

4.4.9 Handle visibility

Passengers with restricted vision reported that both exterior and interior handles were not always easy to find. Figures 11 and 12 demonstrate that both types of handles would benefit from being made more conspicuous. Better colour contrast of the handles with their background would make them more conspicuous and therefore easier for the partially sighted to locate. In addition, tactile feedback may also aid a range of users in locating the interior handle. A tactile border around the interior latch is recommended, this will assist in its differentiation from other devices commonly found on the door panel such as cigarette ash trays and window winders / switches. ‘Courtesy’ lighting could also be used to hi-light the location of the door handles and to differentiate them from adjacent objects. The taxi in figure 11 has a small light below the handle which draws attention its location.

A contrast colour outlining the opening edge of the door may also be beneficial in terms of indicating the direction of door opening.

Figure 11

Figure 12

4.4.10 Grab handles

On boarding a vehicle and manoeuvring within it disabled passengers require additional support. Handrails should be provided on both sides to enable an ambulant passenger to use their strongest arm or to allow for them to carry a walking aid or luggage in their strongest arm. Wheelchair users may find handholds helpful in manoeuvring through taxi doorways, manoeuvring within the passenger compartment and as a form of additional postural support while travelling.

Figure 13

Figure 14

4.4.11 Location

The consultation findings suggest that the number and location of grab handles in current purpose built taxis is considered largely appropriate with the following exceptions:

- There is limited access to grab handles on the taxi body when boarding. The horizontal handle on the interior of the door is valuable but the vertical handle is difficult to access from outside the vehicle without an awkward wrist action. Future vehicle designs would benefit from a handle that was accessible in the entrance. However, the design of the handle would need to ensure that door width was not compromised.

- The vertical position of this handle is important. Current locations are typically higher than the recommended height for hand rails (900mm) and they are not suitable for younger children or passengers with limited growth. A mobility impaired passenger travelling with small children would find vehicle access easier if they did not need to provide support for children. The provision of a second lower handrail (or a single longer handrail) would assist accessibility.

- There is limited support provided on the partition wall separating the driver from the passenger compartment. An additional grab handle mounted horizontally on the partition would provide further support for ambulant passengers when boarding or alighting.

4.4.12 Size and design

Specifications for handrails and grab handles exist in a number of transport relevant guidance documents (Rail Vehicle Accessibility Regulations (RVAR) 1998; Public Service Vehicle Accessibility Regulations 2000 and the Department for Transport Guidance on Inclusive Mobility). The recommendations are broadly consistent.

A handrail or grab handles should have:

- a height of 900mm above the floor if to be used by standing passengers (550-650mm if children are to be assisted)
- a circular cross section as this enables a comfortable grip for most people
- a diameter of 30-50mm (40 mm recommended) as passengers with arthritic hands may find it painful to open or close their hands beyond this range
- at least 45mm of clearance between the handle and adjacent surfaces to allow easy access and avoid finger traps. A minimum figure of 45mm is stated in the RVAR
- a slip resistant surface (powder, ceramic or nylon coated – slip resistant, matt finish and warm to touch)
- a strong colour contrast with surrounding background in a matt non-reflective colour. The colour should be used consistently throughout the vehicle.

4.5 APPENDIX 5: Interior lighting

4.5.1 Interior lighting and colour and luminance contrast

People with visual impairments can vary greatly in terms of how the impairment affects their vision. Even people with the same diagnosis can differ considerably in their residual visual abilities. Visual impairment can mean a loss in some of the visual field, foveal acuity or contrast sensitivity, or a problem adjusting to a sudden change in light levels.

Since light is a fundamental requirement for colour vision and contrast sensitivity, the provision of an adequate artificial lighting scheme has the potential to assist a large number of visually impaired persons, (Cook et al 1996). However, a short review conducted as part of this project indicated that there is little specific guidance regarding illumination levels that should be provided for people with visual impairments either within buildings or vehicles. However, it is recommended by the RNIB that general guidance regarding illumination is followed. The technical literature suggests that the most effective way to enhance residual vision is through the application of magnification, luminance and contrast.

4.5.2 General guidance and consequent recommendations for taxis

The ability of older people to see in low light levels is typically reduced. Greater illuminance relieves eye strain by reducing the pupil opening and thereby increasing the depth of focus and minimising constant eye adjustment. However large amounts of light on surfaces will cause contrast to reduce and glare to increase. High luminance can also cause problems for people with cataracts.

The level of illumination at which taxi interior should be illuminated has not been specifically investigated. However guidance has been provided for a number of relevant transport contexts (PSV, Rail and Pedestrian and Transport Infrastructure).

- Highly reflective surfaces should be avoided as they can be confusing for people with visual impairments. Furnishings and surfaces within the interior should have matt or mid sheen finishes. Anti glare screens should be used within the partition between driver and passenger.

- Light should be constant and of an even level throughout the interior to reduce the formation of shadows which may reduce the definition of objects and features.

- Design guidance for the built environment generated to assist those with visual impairments suggests that colour differentiation can be helpful for distinguishing walls from floors and ceilings. This helps assist the accurate perception of the size of a space. It could be argued that colour and tone should be used to indicate interior shape rather than used for aesthetic reasons.

- Door handles and door edges (primarily floor and ceiling outline edges) should have strongly contrasting colours to differentiate them from the surrounding areas.

- The external, vertical door edge should be strongly contrasted to the remainder of the door and vehicle body so that a strong indication of the location and direction of the opening is provided.

- Visual clutter should be avoided. Figure 15 illustrates presentation of information and advertising in a taxi. The presentation of information and /or advertising may lead to confusion for visually impaired people.

- The opening providing access through to the driver in the passenger compartment partition should be clearly marked and outlined in a contrasting colour.

- The levels of illuminance suggested in Table 40 suggest that internal ambient lighting within a taxi should be at least 150 lux. However, critical areas (steps, the area adjacent to the meter display and the payment ‘window’ should have 200-250 lux. It is recommended by the RNIB that this guidance is followed but that adaptability of the illumination levels is possible to enable visually impaired people to adjust lighting to their personal preferences, to improve comfort and performance. Whether adjustable lighting would be practical and useful in taxis requires further investigation.

Figure 15: Visual clutter in a taxi

Table 40: Recommended levels of illuminance for different environments[16]

Transport Environment	Recommended Illuminance
Entrances to building	150 lux
Passages and walkways	150 lux
Steps and stairs, at tread level	200 lux
Ramps, at top and bottom	200 lux
Maps and displays, text panels	200 lux
Counter tops	250 lux
Lifts, internal (minimum, uniformly distributed)	100 lux

4.6 APPENDIX 6: The Rohill TaxiRider vehicle

The taxi rig used in the tests was not meant to mimic or replicate the design of any particular taxi. However most people are familiar with the various forms of purpose built taxi in use in London and elsewhere. The aim of the research was to inform the design of future taxis and it was considered important that the participants' expectations should not be bounded by existing design constraints. For purposes of comparison a radical, Swedish-designed vehicle was borrowed for the duration of the tests. See Figure 16 This vehicle had a number of features not found in the current purpose built taxis. These included:

- Kneeling mechanism to give very low floor height
- Sliding door
- High door and roof
- Flexible seating arrangement

Participants were invited to inspect and try getting in and out this vehicle, and report on how easy it was to use. They were also asked if they preferred it over the more familiar purpose built taxis.

Figure 16: Rohill TaxiRider

4.6.1 Participants

35 participants tried this vehicle including 15 wheelchair users, 10 visually impaired people and 10 people with other mobility or dexterity impairments.

4.6.2 Findings

The general dimensions of the Rohill taxi were very much approved. 32 of the 35 people who tried it scored it either 4 or 5 on a 5 point rating scale.

The wide door (1200mm) was rated as being ‘just right’ by all but four participants. Three of these considered it to be too wide and one wheelchair user considered it to be too narrow. The height of the door (1695mm) and roof (1800mm) met with almost universal approval. Just one person thought the door was slightly too high. Everybody else said its height was just right. Similarly all but three people considered the roof to be at an ideal height. Those that did criticise it thought it was slightly too high.

Only one of the 35 participants thought that there was not enough interior space, and this was because of the arrangement of seats found in the vehicle supplied for the test (they were reconfigurable to allow variable numbers of wheelchairs and seated passengers).

Participants did not report any discomfort associated with getting in and out of this taxi. One person said that a great deal of effort was involved in getting into it and two said this was true of getting out of it. Slightly more (3 and 5 respectively) reported that getting to and from the parking position or seat required some effort, but this appeared to be due to the arrangement of the seats in the particular vehicle tested rather than any fixed aspect of its design.

Respondents were asked if they would prefer a Rohill type taxi or one built to match their optimum specifications (for that respondent) as revealed in our trials with the rig. Opinion was divided between wheelchair users and others:

Table 41: Taxi design preference

	Wheelchair users	Others
No. of participants	15	20
Preference	%	%
Rohill taxi	27	60
Rig with preferred settings	60	25
No strong preference	13	15

There was a preference for the dimension of the Rohill taxi among ambulant people. However, despite their approval of most of its features, the majority of wheelchair users opted for a taxi built to their preferred specifications.

4.6.3 Wheelchair users

Although the majority preferred conventional taxis, their comments on the Rohill vehicle showed that their reservations were based on the features of the model borrowed for the test. These consisted of criticisms of the:

- ramp (made by 11 of the 15 wheelchair users). Features disliked were its lack of friction, the lip at the top which impeded access and the fact that because it flexed it appeared to be weak. Some people would have liked the ramp to have lips at the side and some thought it was too steep

- interior layout (made by 10 wheelchair users). The majority of these comments were focused on the arrangement of seats in the taxi which (in the configuration found in the borrowed vehicle) was not ideal for manoeuvring a wheelchair. Some people found that they caught their feet on the seats. Two wheelchair users thought that there was too much space inside the vehicle

- disposition of the grab handles (made by 5 wheelchair users)

4.6.4 Other groups

Ambulant people had fewer criticisms of this vehicle and these were mainly about the grab handles. 13 criticised the lack of colour contrast, position or number of the grab handles.

4.7 APPENDIX 7: Service standards

This report focuses on the physical characteristics of an accessible taxi. However, individual disabled people and the organisations that represented them pointed out that consistent standards of service were also required if taxis were to be easily accessible to a greater number of people. Most people reported that the majority of taxi drivers exhibited a high level of disability awareness and were extremely helpful. This was borne out by a survey carried out by DPTAC in 1999 which found that 63% of disabled people were satisfied with the service and that only 6% considered taxi drivers and firms to be unhelpful[17]. However most people we consulted also had experience of journeys in which the service was unacceptably poor. A number of them suggested that taxi drivers should have disability awareness training backed up by a system of inspection and accreditation.

In this section we outline some of the issues for consideration.

4.7.1 Finding a taxi and booking

4.7.2 Hailing a cab

In London taxis are not permitted to refuse to carry a passenger on the grounds of disability[18]. The DDA will eventually make discrimination on these grounds illegal throughout the country. However even in London disabled people have reported that some taxis do not stop (or switch off the For Hire sign) when they see someone in a wheelchair, with a guide dog or with some other disability. This is not in itself illegal – drivers are not obliged to stop for anybody when moving, even when the For Hire light is on. However refusing to carry a disabled person on the grounds of disability is illegal in London[19] if the taxi has actually stopped or is waiting for passengers at a taxi rank. Some people have been refused at the point the driver realises that the prospective passenger needs to use a ramp or a step or will need help getting in and out of the vehicle.

Recommendation: Although taxi drivers are not obliged to stop when hailed it is a matter of common experience that some do ignore people with obvious disabilities. The obligations of taxis travelling with the For Hire light on need to be reviewed. Disabled passengers and their companions need to be encouraged to be more assiduous in reporting such instances. Licensing and other authorities need to consider what penalties would be appropriate for such transgressions[20].

4.7.3 Booking by telephone

All those who take bookings for taxi journeys need to have disability equality training. This needs to include:

- communication, particularly with people who have speech and hearing or intellectual impairments
- how to elicit information about any assistance required, equipment or other practical matters
- awareness of any particular risks that affect people with different disabilities. – e.g. people who cannot stand for long; problems associated with extended waits etc.

4.7.4 Standards of service

A number of issues emerged from the research and appear as a summary of the results of our consultation, see Section 7.2. Some of the main contentions that emerged from our discussions and which need to be incorporated into driver training and embedded in an industry wide code of practice are described below[21].

4.7.5 Help and assistance

Many people need assistance getting in and out of a taxi. Some may need help getting into their destination, with the mechanics of paying the fare or with information. Other people prefer to travel with as little assistance as possible and may be offended by a presumption that help is necessary.

Drivers’ disability awareness training needs to include

- non patronising ways of offering assistance
- techniques for handling different types of wheelchair
- techniques for assisting visually impaired people
- techniques for assisting mobility impaired but ambulant people

4.7.6 Communication

Drivers’ disability awareness training needs to include

- techniques for communicating with people who have hearing or visual impairments; who are deaf/blind or who have learning disabilities
- practical and helpful strategies, such as telling people visually impaired people where the door in their destination is
- Some system is needed (perhaps by dialling a number on a mobile phone) of telling you where you are

All critical information (taxi number, fare) should be readily accessible. A talking meter (providing the sound could be muted) would be an advantage.

4.7.7 Safety

Drivers’ disability awareness training needs to include

- training in securing seat belts and ensuring passengers are safe
- dropping off passengers in appropriate places, according to the nature of their impairment. This would include by textured pavements for visually impaired people, parking as close as possible to the kerb and stopping in places that would minimise a passenger’s difficulty in completing the next stage of their journey.

4.7.8 Regulation and accreditation

Consideration needs to be given to the way in which such training might be provided and enforced.

Under Part 5 of the Disability Discrimination Act 1995, the government can make taxi accessibility requirements for England and Wales. These powers are devolved to the respective legislatures in Scotland and Northern Ireland[22]. The precise scope of these regulations is under development and may be introduced in phases as proposed by the DfT in October 2003. However it is likely that they will cover the aspects of taxi design described in this report including wheelchair access, swivel seats, basic dimensions and fittings.

Until these regulations come into force licensing authorities are encouraged to make their own accessibility policies. According to a survey carried out by the DfT[23] very few (53 out of 343) had a mandatory policy which specified dimensions and accessibility to their whole fleet. This may be because it is known that wheelchair accessible taxis currently exclude some people[24].

In London, taxis[25] and their drivers are licensed by Transport for London, through the Public Carriage Office. Elsewhere licensing is carried out by local authorities. Taxi drivers and vehicles are licensed separately. Various regulations allow licensing authorities to limit the number of taxis available in a particular area and lay down requirements for the safety of vehicles, the character and conduct of drivers and the quality of service offered.

Recommendation: it would be consistent with the system of regulation that local authorities be obliged to ensure that licensed taxi drivers receive appropriate training, geared towards meeting minimum standards. These standards could be developed jointly by the industry and organisations of disabled people. Once agreed training could be provided by a number of organisations.

4.8 APPENDIX 8: Sample details

It is impractical to carry out user tests on sample sizes which equate with those used by survey researchers. For example the 1988 Studies of disability[26] involved detailed interviews with some 14,000 people and a screening process which involved contact with a representative population sample of 100,000. The latest version of this survey was based on interviews with respondents to the Family Resources Survey[27], which had a sample size of some 5,500 people after screening a sample of over 33,000 people.

For user tests much smaller sample sizes are used. These can provide reliable results because participants are chosen because they have certain, known characteristics, because the tests are carried out in controlled conditions and generate sufficient data for checks to be carried out for consistency.

For this project, and in order to cover the highly variable nature of the disabled population, the OPCS study mentioned above was used to identify 15 types of impairment that could affect the ease of using a taxi. People with these impairments were recruited from Ricability's inclusive design panel28. The impairments and levels of severity chosen are those which might reasonably affect the use of taxis and are from the higher end of the OPCS severity scales. It was assumed that meeting these needs would also meet the needs of people with less severe impairments.

These small groups were then combined into broader groups for the purposes of analysis, to provide conclusions for broad impairment groups. Details of the sample are summarised in table 42 below:

Table 42: Impairment characteristics of trial participants sample

RICA Taxi Trial Specification		Estimated OCPS Severity Score
Dexterity Impairments		
Cannot pick up and hold a mug of coffee with either hand	3	10.5
Cannot turn a tap or control knobs on with either hand	4	9.5
Cannot pick up & carry a pint of milk or squeeze a sponge with either hand	4	8
Cannot do any of the above with one hand but can with the other	8	0.5 - 2
	19	
Reaching & Stretching		
Cannot hold either arm out in front of them to shake hands with someone	4	9.5
Has difficulty holding either arm in front to shake hands with someone	8	6.5
Cannot hold one arm out in front or up to their head but can with the other	9	2.5
	21	
Locomotion impairments		
Manual wheelchair user, assistant usually pushes	6	9.5 - 11.5
Manual wheelchair user, self-propelled	6	9.5 - 11.5
Powered wheelchair user	8	9.5 - 11.5
Uses a walking aid e.g. crutches, sticks, walking frame	8	5.5 - 7
Cannot bend to touch their knees and straighten up again	8	4.5
Cannot walk very far and has difficulty with steps	8	4.5 - 6.5
	44	
Visual impairments		
People who use an assistance dog	8	5 - 12
Others: Cannot see by the shape where the furniture is or light is coming from: People who cannot read large print; People who cannot read a newspaper headline	8	5 - 12
	16	
TOTAL	100	

As a guide, the 1999 survey (see endnote 27), gives estimates of the number of disabled people in the population according to the prevalence of disability by severity as:

Table 43: Estimates of severity distribution in population

Severity category	Number ('000)	Prevalence per 1000
10	77	2
9-10	445	10
8-10	1049	24
7-10	1836	42
6-10	2687	62
5-10	3662	85
4-10	4682	108
3-10	5669	131
2-10	6806	157
1-10	8582	198

These estimates are based on severity scores which are cumulative where people have more than one disability. The published report does not give information of the prevalence of disability for each level of severity for each type of impairment.

We have carried out a separate analysis of the raw data of the 1999 survey to show how many people in the sample fell into each severity category within each disability type (See tables 41– 44). This provides an indication of how many people there are with particular impairments as it does not aggregate information for people who have more than one disability.

The percentages shown provide an indicative guide to the proportion of the adult population who have each impairment at each level of severity. This can only be indicative because our information is based on raw data from the survey. A complex series of weights and corrections were applied to the data for the published report [29] which took account of differential response rates for sub groups of the sample and population data for particular groups in the sample. We do not have sufficiently detailed access to this data to apply these weights for this report.

Table 44

	OPCS severity score	No in sample	Proportion of those interviewed
Dexterity impairments			
Base:			7249
No impairment		5225	72.1%
Cannot pick up and hold a mug of coffee with either hand	10.5	141	1.9%
Cannot turn a tap or control knobs on a cooker with either hand	9.5	139	1.9%
Cannot pick up and carry a pint of milk or squeeze the water from a sponge with either hand	8.0	354	4.9%
Cannot pick up a small object such as a safety pin with either hand	7.0	134	1.8%
Has difficulty picking up and pouring from a full kettle or serving food from a pan using a spoon or ladle	6.5	648	8.9%
Has difficulty unscrewing the lid of a coffee jar or using a pen or pencil	5.5	335	4.6%
Cannot pick up and carry a 5lb bag of potatoes with either hand	4.0	90	1.2%
Has difficulty wringing out light washing or using a pair of scissors	3.0	101	1.4%
Can pick up and hold a mug of tea or coffee with one hand but not with the other	2.0	31	0.4%
Can turn a tap or control knob with one hand but not with the other	1.5	24	0.3%
Can squeeze the water from a sponge with one hand but not the other			0.0%
Can pick up a small object such as a safety pin with one hand but not the other	0.5	27	0.4%
Can pick up and carry a pint of milk with one hand but not the other			
Has difficulty tying a bow in laces or strings			

Table 45

	OPCS severity score	No in sample	Proportion of those interviewed
Reaching and stretching			
Base:			7256
No impairment	0.0	6071	83.7%
Cannot hold either arm in front to shake hands	9.5	32	0.4%
Cannot put either arm up to head to put hat on	9.0	50	0.7%
Cannot put either hand behind back or put jacket on or tuck shirt in	8.0	108	1.5%
Cannot raise either arm above head to reach for something	7.0	64	0.9%
Has difficulty holding either arm in front to shake hands with someone	6.5	90	1.2%
Has difficulty putting either arm up to head to put a hat on	5.5	108	1.5%
Has difficulty putting either hand behind back to put jacket on or tuck shirt in	4.5	209	2.9%
Has difficulty raising either arm above head to reach for something	3.5	78	1.1%
Cannot hold one arm out in front or up to head (but can with other arm)	2.5	262	3.6%
Cannot put one arm behind back to put on jacket or tuck shirt in (but can with other arm) Has difficulty putting one arm behind back to put jacket on or tuck shirt in or putting one arm out in front or up to head (but no difficulty with other arm)	1.0	184	2.5%

Table 46

Locomotion impairments	OPCS Severity score	No in sample	Proportion of those interviewed
Base:			7256
No impairment	0.0	3093	42.6%
Cannot walk at all	11.5	134	1.8%
Can only walk a few steps without stopping or severe discomfort Cannot walk up and down one step	9.5	568	7.8%
Has fallen 12 or more times in the last year	7.5	144	2.0%
Always needs to hold onto something to keep balance	7.0	178	2.5%
Cannot walk up and down a flight of 12 stairs	6.5	159	2.2%
Cannot walk 50 yards without stopping or severe discomfort	5.5	400	5.5%
Cannot bend down far enough to touch knees and straighten up again	4.5	258	3.6%
Cannot bend down and pick up something from the floor and straighten up again	4.0	282	3.9%
Cannot walk 200 yards without stopping or severe discomfort Cannot only walk up and down a flight of 12 stairs if holds on and takes rest Often needs to hold onto something to keep balance Has fallen 3 or more times in the last year	3.0	985	13.6%
Cannot only walk up and down a flight of 12 stairs if holds on (doesn't need a rest)	2.5	533	7.3%
Cannot bend down and sweep something from the floor and straighten up again	2.0	75	1.0%
Can only walk up and down a flight of stairs if goes sideways or one step at a time	1.5	27	0.4%
Cannot walk 400 yards without stopping or severe discomfort	0.5	420	5.8%

Table 47

	OPCS Severity score	No in sample	Proportion of those interviewed
Visual impairments			
Base:			7252
No impairment		5922	81.7%
Cannot tell by the light where the windows are	12.5	32	0.4%
Cannot see the shapes of furniture in a room	11.0	15	0.2%
Cannot see well enough to recognise a friend if close to his face	10.0	50	0.7%
Cannot see well enough to recognise a friend if he is at arms length away	8.0	45	0.6%
Cannot see well enough to read a newspaper headline	5.5	82	1.1%
Cannot see well enough to read a large print book	5.0	47	0.6%
Cannot see well enough to recognise a friend across a room	4.5	42	0.6%
Cannot see well enough to recognise a friend across a road	1.5	600	8.3%
Has difficulty seeing ordinary newspaper print	0.5	417	5.8%

5 References and endnotes

1 Oxley, P. and Stahl.A (2001) Taxis for All. Final report to the Directorate General for Transport, CEC

2 Stait, Stone and Savill, a survey of occupied wheelchairs to determine their overall dimensions and weight: 1999 survey. Project report, PR/SE/622/99, Transport Research Laboratory, 2000

3 Grundy, Ahlburg, Ali, Breeze and Sloggett, Disability in Great Britain, Research report 94, DSS 1999

4 Does not add up to 100 because one person could not manage any step

5 Department for Transport Inclusive mobility

6 Rail Vehicle Accessibility Regulations, Guidance

7 PSV Accessibility Regulations

8 Stait, Stone and Savill, A survey of occupied wheelchairs to determine their overall dimensions and weight: 1999 survey. Project report, PR/SE/622/99, Transport Research Laboratory, 2000

9 Figures show means and maximum for largest group tested. Scooters not shown because taxis are not obliged to carry them

10 Note that the findings of these tests would not apply to rear entry vehicles. In these the wheelchair is pushed straight in from behind and is anchored in the forward facing position. Providing other factors (such as ramp angles) are equal, this is an easier access arrangement than is possible in a side entry vehicle. However, other considerations may limit its suitability

11 This test was performed by only one pair of users. This was because it was intended to provide dimensional information related to a wheelchair of a particular size, which should not vary between users. However it should be borne in mind that other users might get slightly different results, particularly if they had little experience of manoeuvering a wheelchair.

12 PeopleSize 1999, Open Ergonomics Ltd, Melton Mowbray

13 Problems Experienced by Disabled and Elderly People Entering and Leaving Cars. Institute of Consumer Ergonomics, TRRL Research Report 2, 1985.

14 Manual Handling Operations Regulations 1992 – Guidance on Regulations; Health and Safety Executive.

15 A survey of occupied wheelchairs to determine their overall dimensions and weight: 1999 survey; Stait, Stone and Savill; TRL; Project report PR/SE/622/99.

16 From: Inclusive mobility – A guide to best practice on access to Pedestrian and Transport |Infrastructure; Department for Transport, 2002.

17 From Attitudes of disabled people to public transport in England and Wales 2001/2. MORI survey carried out for DPTAC

18 Elsewhere the only provision made by law is that taxis are obliged to carry assistance dogs at no extra charge unless the driver has a medical

19 Under Hackney Carriage Law

20 The Public Carriage Office do not know of any instance where taxi drivers have been penalised solely for refusing to accept a disabled passenger, although this has counted against them along with other misdemeanours

21 Driver training is already provided in some parts of Warwickshire

22 More detail on this can be found in Legal framework of taxi and PHV licensing in the UK, Office of Fair Trading, November 2003

23 Taxi and Private Hire Vehicles in England & Wales 200-02 DfT

24 For example, DPTAC recognized that ambulant disabled people especially had difficulty using 'London' taxis and where possible booked a private hire vehicle instead as saloon cars are normally used. From their response to OFT consultation.

25 By licensed we mean taxis which can ply for hire – taxis that can pick up passengers from a rank or in the street or be pre-booked. This contrasts with private hire vehicles that can only legally pick up passengers who have pre-arranged and booked a journey.

26 OPCS surveys of disability in Great Britain. The Prevalence of disability among adults. Martin J et al, OPCS Social Survey Division, 1988

27 Disability in Great Britain: results from the 1996/97 disability follow-up to the family resources survey, Grundy et al, Social Security Research Report No 94, DSS 1999

28 A panel of some 300 disabled and older people who were recruited to carry out user tests at the Intertek laboratory in Milton Keynes

29 See page 138-145, *Disability in Great Britain: results from the 1996/97 disability follow-up to the family resources survey*, Grundy et al, Social Security Research Report No 94, DSS 1999