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RESEARCH ON SPATIAL DIMENSIONS FOR OCCUPIED MANUAL AND POWERED WHEELCHAIRS PROJECT

FINAL REPORT

DECEMBER 2014

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Executive Summary

This report provides the data derived from research conducted on the spatial dimensions for occupied manual and powered wheelchairs in Australia.

The last comprehensive review of wheelchairs was undertaken by Bails (1983) using qualitative data. Subsequent wheelchair anthropometry projects have been undertaken by Steinfeld (USA, 2005), Ringaert (USA, 2001) and the Department of Environment, Transport and Regions (DETR, UK, 2000). All of these projects measured anthropometry of manual chairs, powered chairs and scooters. In this research project, scooters and mobility devices used by people predominantly confined to nursing homes, aged care facilities, convalescent homes and hospitals were excluded.

A total of 52 participants based in Sydney, Melbourne and Geelong were involved in the current study. This included 31 powered and 21 manual wheelchair participants. Each participant had data items collected, which included personal data, static, and dynamic anthropometry measures. However, in some cases not all data was able to be collected due to participant fatigue or difficulties with completing the tasks.

The static measurements were taken using an anthropometer and tape measure with calibration using a laser beam to ensure accuracy. Dynamic measurements were taken using a fixed video camera on a tripod with large foam blocks as a background whilst participants navigated a range of activities. A 100mm grid on the foam blocks was used to assist in quantification of the measures.

The data derived from this study has been analysed and provided in four separate categories and includes:

- Manual wheelchairs
- Powered wheelchairs
- A combination of manual and powered wheelchairs
- Adjusted combination of manual and powered wheelchairs to reflect estimate of volumetric use in Australia.

Each measure has been analysed to determine the mean, standard deviation and the 90th percentile. An adjusted measure was also introduced to reflect the Australian Bureau of Statistics (ABS) data that 14% of wheelchair users in Australia use powered chairs.

Initial exploration of the data seems to suggest that most of the existing Australian Standard AS 1428.1(2009) requirements for wheelchair access are appropriate. However, there are a range of measurements where the 90th percentile of the powered wheelchairs in particular should be more closely assessed. These include the dimensions required for the 180 degree turning circles and landing length; the dimensions of a lift; the design of hand basins and shower recesses; and the seating spaces in auditoriums of assembly spaces. These could be explored further as part of the first 5 year review of the Disability (Access to Premises – Buildings) Standards.

The project team including Nick Morris, Jodi Oakman, Mike Atherton and Sharon Herbstreit would like to thank the range of community agencies and disability support groups who promoted and supported this project and encouraged wheelchair participants across Australia. We also thank the steering committee from the Australian Building Codes Board (ABCB) for the invitation to conduct this important research project in Australia.

David C. Caple, Project Director

Project Introduction

This project has collected anthropometric data of Australian residents in manual and powered wheelchairs. This anthropometric data incorporates a cross section of the Australian profile of wheelchair users including those with cerebral palsy, quadriplegia and paraplegia, as well as those with acquired brain injuries and other physical and cognitive disabilities.

The sample includes participants between the ages of 11 years and 64 years who are independent users of public spaces, covered by the guidance provided by the ABCB. It was noted that groups within our sample utilised both a manual wheelchair and a powered chair, depending on the activity they are undertaking. Hence, it is not appropriate to separate the users of powered or manual wheelchairs as two distinct populations. Data is provided in this study on 31 powered and 21 manual wheelchair users. It is noted that the ABS report "Disability, Ageing and Carers, Australia (2012) Report Number 44300DO001", indicates that 14.6% of wheelchairs used in Australia are powered with the majority of wheelchairs being manual. The project brief specifically excluded data collection of scooters and mobility devices used by people predominantly confined to nursing homes, aged care facilities, convalescent homes and hospitals.

In Australia, the last comprehensive review was undertaken by Bails (1983). The data derived from this study influenced the anthropometric recommendations utilised in the current edition of AS 1428.1.

The international resources that have been utilised by ergonomics researchers and practitioners during this period have primarily focussed on the wheelchair dimensions provided by Humanscale (Dreyfuss, 1993). More recently, Australian participation in international anthropometry studies under Work Engineering Anthropometric Resource (WEAR) has provided access to three dimensional anthropometry data. This relates to the non-wheelchair applications. However, the future direction in anthropometry is to utilise three-dimensional measurement techniques.

The fundamental difference between the existing anthropometry databases, and the data developed in this project is that the existing anthropometric database are for standing and walking ambulant people. They have different functional needs to the users of manual and powered wheelchairs measured in this project. The anthropometry data collected in this project is a reflection of the design of the wheelchair being utilised, and the capabilities of the person to utilise their wheelchair for mobility. This project has focussed on the actual measurements taken from participants using their own wheelchair in the way that they would set it up to access public building spaces. There were no measurements taken of empty wheelchairs. They were all occupied chairs where the user would position themselves in the wheelchair as they would when accessing public buildings.

The methodology developed for this project has focussed on static one dimensional anthropometry measurements of their body in the wheelchair, as well as dynamic three dimensional anthropometry assessments. The static anthropometry relates to the specific measures of their body whilst seated in their wheelchair. This included dimensions such as head height, thigh clearance, and reach distances. The dynamic anthropometry assessment was conducted using video. This was taken whilst participants undertook activities involving prescribed circulation areas. The video enabled a dynamic measurement of the space required by the participant to move their chair along a prescribed course and to turn their chair through corners up to 360 degrees. The methodology developed for this project provides a more realistic measure of the impact of anthropometry on the spaces required by the participants to navigate their way in their wheelchair through public building spaces.

It is noted that the measurements taken during this study are somewhat dependent on the capacity of the participant to undertake the range of tasks being measured. For example, there is a difference in reaching with left hands and right hands depending on the capability of the participant. It was also noted that the measurements taken of participants such as those with cerebral palsy, can only be approximated. This is due to the constant involuntary movement of their body particularly their head and feet. They were unable to hold still for a more accurate measurement to be undertaken. However, the measurements that were taken are considered realistic and representative of their needs when they are accessing public building spaces.

The measurements taken of the wheelchairs also included equipment that the participant needs to have for their mobility requirements to public buildings. For example, if they need to sit on a particular cushion or carry a particular item such as oxygen bottles, or a table, then these were incorporated as part of the overall anthropometric measurements with their chair. Any loose items such as bags with personal materials were excluded. It was noted that some participants had specific designs of the headrest for their chair, or a frame developed to support their mobile phone to assist them during their mobility activities. These were included where appropriate in the overall dimensions.

The data has been provided using means and percentiles. Percentiles describe a score's position within a distribution. Pheasant (2006), defines percentiles of the population as follows, "In relation to body height the n% of the population are shorter than the nth percentile" (page 18). In considering what constitutes the 90^{th} percentile in terms of height using this definition then 90% of the population will be shorter than the 90^{th} percentile and 10% would be taller. The advantage of percentiles is that they enable a comparison relative to others against a particular measure.

In contrast, percentages are useful for describing distributions. If a normal distribution of data is provided, then 90% of the population would be represented between the 5^{th} percentile and the 95^{th} percentile. In relation to height this means that 5% are shorter and 5% are taller than the range specified.

In the current project, we have analysed the anthropometric data and provided the mean and 90^{th} percentile for each measurement taken. In addition, standard deviations have also been provided and further calculations can be undertaken with the data as required.

In the course of undertaking this project, we became aware of a range of innovative products which are now available as emerging alternatives to the existing traditional manual and powered wheelchairs. The links provided below will take you to suppliers of some products that will potentially impact on the type of mobility aides used by wheelchair users in the forthcoming years.

Products and Links

This YouTube video provides more information on the Segway chair.

The following YouTube video demonstrates the stand and sit Segway chair. For further information visit the following web page at www.segsolutions.com.

This YouTube video provides more information on the all terrain chair.

This YouTube video provides further information on the e-motion Power Assist.

This YouTube video provides more information on the Smart Drive.

The following YouTube video shows the Accessible Segway models.

This YouTube video shows the Swedish seat for a manual chair.

Table 1. Summary of documents and standards

Pathways Measurement	IDEA (US) and other US	Inclusive mobility (UK)	AS 1428.1-2009	Canada	Best Practice (CHRC)*	Human Scale
Straight pathway width (minimum)	920mm	1000mm	1000mm	920mm	1200mm	915mm
Manual wheelchair 90 degree turn	915 by 915mm	1200 by 1200mm[1]	1500 by 1500mm	1540 by1540mm	1500 by 1500mm	1400 by 1676mm
Manual wheelchair 180 degree turn	1500 by 1500mm	1600 by 2000mm[1]	1540 by 2070mm	*No data*	*No data*	*No data*
Power wheelchair 90 degree turn	*No data*	*No data*	*No data*	2250mm (diameter)	2250mm (diameter)	1638 by 1900mm
Power wheelchair 180 degree turn	*No data*	*No data*	*No data*	*No data*	*No data*	*No data*

Unisex Sanitary facilities (toilet) Measurement	IDEA (US) and other US	Inclusive mobility (UK)	AS 1428.1-2009	Canada	Best Practice (CHRC)*	Human Scale
Clear area at entrance door	1525 by 1065 mm	*No data*	1400 by 1400mm	1500 by 1200mm	1500 by 1500mm	1220 by 1200mm
Centre of pan to adjacent wall	405 - 455mm	500mm	450 - 460mm	460 - 480 mm	460 - 480mm	455mm
Front of seat to back of wall	*No data*	*No data*	800mm	*No data*	*No data*	*No data*
Transfer space along clear side of the toilet (depth x width)	760 by 1220mm	2200 by 1500mm	2300 by 1440mm	1500 by 900 mm	900 by 1500mm	*No data*
Top of toilet seat above floor	*No data*	480mm	460 - 480mm	400 - 460mm	460 - 480mm	455mm
Minimum size (length x width)	1420 by 1525mm (wall) 1525 by 1500mm (floor)	2200 by 1500mm	2300 by 1900 mm	1500 by 1600mm	1700 by 1800mm	2100 by 2337mm

Washbasin Measurement	**IDEA (US) and other US**	**Inclusive mobility (UK)**	**AS 1428.1-2009**	**Canada**	**Best Practice (CHRC)***	**Human Scale**
Height above floor to top of basin	865mm	720 - 740mm	800 - 830mm	810 - 860mm	800 - 850mm	826mm
Centre to side wall	460mm	*No data*	425mm	460mm	460mm	430mm
Wall to front of basin	*No data*	*No data*	300 - 400mm	*No data*	*No data*	*No data*
Clear space in front of washbasin	750 by 1200mm	*No data*	800 by 1000mm	750 by 1200mm	760 by 1370mm	760 by 1219mm
Toe clearance depth under basin	150mm	*No data*	200mm	230mm	230mm	225mm

Unobstructed Reach Envelopes Measurement	**IDEA (US) and other US**	**Inclusive mobility (UK)**	**AS 1428.1-2009**	**Canada**	**Best Practice (CHRC)***	**Human Scale**
Forward	380 - 1220mm	650 - 1150mm	250 - 1200mm	400 - 1200mm	400 - 1200mm	380 - 1219mm
Sideways	380 - 1270mm	630 - 1170mm	230 - 1350mm	230 - 1400mm	300 - 1220mm	230 - 1370mm

Sight Lines for signage (wheelchair) Measurement	**IDEA (US) and other US**	**Inclusive mobility (UK)**	**AS 1428.1-2009**	**Canada**	**Best Practice (CHRC)***	**Human Scale**
Detailed signage	1525mm	1400mm (centre of sign) 900 - 1800mm	1200 - 1600mm	1500mm (centre)	1500mm (centre)	1300mm
Where sign might be obstructed	*No data*	2300mm (clear space below)	*No data*	*No data*	*No data*	*No data*

Lifts Measurement	**IDEA (US) and other US**	**Inclusive mobility (UK)**	**AS 1428.1-2009**	**Canada**	**Best Practice (CHRC)***	**Human Scale**
Doorway width	915mm	900mm	Refer AS 1735	915mm	950mm	Not provided
Doorway height	*No data*	2100mm	No data	*No data*	*No data*	*No data*
Cabin dimension (depth by width)	1525mm (depth)	1400 x 1000mm	*No data*	1525 by 1065mm	1700 by 1065mm	*No data*
Min height of cabin	*No data*	2300mm	*No data*	*No data*	*No data*	*No data*

Door widths Measurement	IDEA (US) and other US	Inclusive mobility (UK)	AS 1428.1-2009	Canada	Best Practice (CHRC)*	Human Scale
Preferred	*No data*	1200mm	*No data*	*No data*	*No data*	915mm
Minimum	815mm	900mm	850mm	810mm	850mm	813mm

Six key documents were reviewed for development of the comparison table provided above (See Steinfeld et al, 2005; Inclusive Mobility, 2005; AS 1428.1- 2009; Canadian Human Rights Commission (CHRC), 200); Dreyfuss et al., 1993). The IDEA data was supplemented with US data where possible. Some data was not provided and as such gaps exist within the table. In particular, the turning circles and passage widths data was not provided in a consistent form in the range of materials reviewed. In some cases powered and manual wheelchairs were differentiated, and in some cases it was not. Where it was not differentiated then the data is included under the manual users section.

[1] The best practice column is defined as building practices and procedures that comply with universal design principles and provide affordable design practices that meet the needs of the widest possible range of people who use a particular facility (according to the Canadian Human Rights Commission, 2006). It was developed by an expert panel that reviewed a range of building codes and standards and selected the best practice example based on a range of considerations, including cost, construction and implementation.

Table 2. Summary of previous anthropometry data collections

The following table summarises the key elements of the previous wheelchair anthropometry studies that have been considered in this literature review.

Report authors and country of data collection	Population	Age range in years (mean)	Chair type	Included conditions	Measurement strategy	Reliability or validity studies	Key points
Bails (1983) (Australia)	Not known, approximately 10-15 wheelchair users	18 - 60	Power and Manual breakdown not known	Not clear	Manual measures	None	Testing of simulations of elements of the built environment Body, wheel chair dimensions, reaching, manoeuvring, door use
Seeger (1994) (Australia)	240 (75% from institutions)	Not clear	209 manual chairs 26 powered chairs 5 scooters	Not specified	Manual measures	None	Body, wheelchair dimensions
IDEA[1] (Steinfield 2005) (USA)	275	18 - 94 (51.4)	151 manual chairs 99 powered chairs 25 scooters	Defined as chronic conditions	Mechanical probe and detailed interviews	Reliability and validity	Body, wheelchair dimensions, reaching, manoeuvring, door use
UDI Study (Ringaert, 2001) (USA)	50	None	35 powered chairs 15 scooters	Range of chronic conditions, not specified	Ruler and tape measures	None	Body, wheelchair dimension, reaching Manoeuvring trials recorded with overhead video cameras
Department of the Environment, Transport and the Regions (DETR) (Stait, Stone and Savill, 2000) (UK)	745 (not all data used in final report)	Not clearly specified	440 manual chairs 253 powered chairs 23 scooters	Not specified	Photography with digital measurements	Reliability	Body, wheel chair dimensions

[1] Seeger results taken from Hunter (2003)

Background

The primary purpose of this review relates to a report from the enquiry into Draft Disability Access to Premises – Buildings (Standards) by the House of Representatives Standing Committee on Legal and Constitutional Affairs (June, 2009). Included in recommendations from the report was the following:

"The Committee recommends that the Australian Government provide funding for new research, to be completed within 12 months of the tabling of this report, into wheelchair sizes and the dimensions of building features necessary to accommodate them. The results and the issue of 90th percentile dimensions should be returned to this Committee for consideration at that time." (Recommendation 13).

A subsequent document was tabled with the House of Representatives Standing Committee on Legal and Constitutional Affairs with the Government Response. The legal framework for addressing access for individuals with disability is addressed in the Disability Discrimination Act (1992). This Act outlines the prohibition of disability discrimination in work, provision of goods and services and in other areas including access to premises. This includes the provision for the Minister to formulate Standards, to be known as "*Disability Standards*" in relation to any area in which it is unlawful for a person to discriminate against another person on the grounds of a disability of the other person.

In 2010, the Australian Government introduced the Disability (Access to Premises – Buildings) Standards under the Disability Discrimination Act (1992). This Standard, which had a commencement date of 1 May 2011, calls up sections of Australian Standard AS 1428.1. The current version of this Standard is AS 1428.1-2009 "Design for Access and Mobility Part 1: General Requirements for Access – New Building Work". This incorporates Amendment Number 1 introduced on the 26th November 2010. The previous edition of this Standard was AS 1428.1-2001.

The aim of the Disability Access to Premises Building Standard was to align the National Construction Code (NCC) and Australian Standards with the Disability Discrimination Act.

It is noted that the scope of AS 1428.1-2009 covers design guidance for people with a range of disabilities including mobility and visual disabilities in a range of applications. The literature reviewed for this project has focused on the requirements of people with mobility impairments with a specific focus on anthropometry requirements for wheelchair users and the consequent requirements for the built environment. Hence, not all sections of AS 1428.1 have been covered in this particular project. It should also be noted that, in accordance with the project brief, findings have been made on spatial dimensions for circulation spaces including doorways, corridor widths, landings, sanitary facilities and lifts; not all parameters for which data was collected.

Previous work

Work undertaken by John Bails of the Public Buildings Department of South Australia, commissioned by the Australian Uniform Building Regulations Coordinating Council in October 1983, subsequently referred to as the "Bail's A80 Wheelchair Research", has been the most significant thus far in an Australian context. However, it has been noted that this work has some considerable methodological flaws:

1. The study is not repeatable due to a lack of clarity around the methodology.
2. The study population is not clearly defined and included participants with a range of disabilities.
3. Some subjects were in wheelchairs, but the actual numbers of these is not clear (somewhere between 10 and 15).

Hunter (2003) provided a comprehensive review of the work undertaken by Bails (1983), Seeger (1994)* and Steinfield (1979) and its contribution to the development of AS 1428.1 In relation to Bails, Hunter's review was critical of the work undertaken and outlined a number of reasons to support his criticisms. A key issue, claimed by Hunter (2003), was the incomplete nature of the data and lack of clear linking to the outcomes. This is complicated by the fact that the raw data is apparently not retrievable to address these issues. Issues highlighted by Hunter in relation to the use of the work to inform the development of AS 1428.1 was that only 10 to 15 wheelchair users were included in the project, and none were over 60 years of age. Both quantitative and qualitative measures were used to collect data.

However, Hunter is critical of the over reliance on qualitative responses for some of the measures where it would have been more appropriate to use quantitative measures. Many of the measures were taken using the current standards at the time as a basis for the measurements. Thus generalisations for this data to determine ideal spaces are not possible. Despite these limitations the work by Bails was important and provided one of the first platforms for arguing that minimum spaces were needed to improve access for people who used wheelchairs. Bails' research should be recognised for its contribution to the field of access for people who use wheelchairs and the platform it provided for future discussion and debate (Hunter, 2003). Bradtmiller (2003) also undertook a critical review of wheeled mobility aids and a key message from his report was the need for clear descriptions of populations and methods so that these data sources can be updated as needed and separate to the standards.

Other significant work has been undertaken by Steinfield and colleagues (2005) who made important contributions to the field. The IDEA study (2005) included 275 participants recruited through outreach efforts with several organisations in New York and also via the mass media.

One of the largest sample groups in the area covered in this review is from the Department of Environment, Transport and Regions (DETR) in the UK (2000). This used photography with digital measurements of 740 attendees to a Mobility Road Show, a trade display of equipment for people using wheeled mobility devices. Not all of the data was usable due to quality issues (see Table 2).

Another study was the UDI (Universal Design Institute) study by Ringaert et al (2001). The sample population for this study was 50 participants, and only included powered chair users.

Review of Methodologies

Populations

Recruitment of study participants varies across the studies included in this review. Some studies (Bails, 1983 and Seeger, 1994) were drawn from institutional settings, whilst the DETR study—the largest sample size—used self selected participants. IDEA and UDI used a diverse sample and provided transportation in an effort to reduce bias due to lack of mobility. However, bias remains a significant issue in all studies as numbers of manual verses powered chairs were not controlled for, and sampling was often opportunistic. An additional issue in relation to sample bias is the range of disabilities included in the samples; this was not well described again limiting the generalisability of the results. Many of these issues are difficult to control for but greater clarity in the description of population samples would enable more informed use of the data collected.

Review of Measurements taken

A range of different population groups and methodologies have been used across the studies reviewed in this report, creating challenges for comparisons between data sets. A few authors [11,19] have provided comparisons across a number of data sets, policies and procedures in areas relevant to access for people who use wheelchairs.
Measurements were undertaken using manual and mechanical measures (see Table 2). However, clear descriptions of methodologies and reliability studies are often missing. Some studies specifically reference reliability methods (IDEA and DETR), whilst others do not (UDI, Seeger and Bails).

Manual measures

Several of the studies used methods involving manual measures (see Table 2). These measures were taken using tape measures, steel squares and spirit levels. In general, landmarks used to take measures from is not well described, thus repeatability is somewhat of an issue.

The UDI study (Ringaert et al, 2001) used manoeuvring trials, which were recorded with overhead video cameras. Measurements were taken of the video tapes but the method used to do this was not described.

In the IDEA study (Steinfield et al, 2005) lightweight movable walls were used which were gradually moved until a particular manoeuvre could be conducted without participants moving the walls. Tape and markers were used and wall locations were recorded after each trial.

Mechanical measures

An electromechanical probe was used in the IDEA study (Steinfeld et al., 2004), where three-dimensional locations of body and wheelchair landmarks were collected. In addition, the authors outline a reliability study undertaken prior to data collection.

Steinfield et al (2005) raises a further methodological concern in relation to the IDEA and UDI samples which were drawn from cold weather cities, as such the equipment may be biased towards larger and more durable types of chairs.

Limitations of previous studies

Limitations exist in the currently available data sets and are likely to influence generalisability of the data. These include:

- an inability to accurately compare data due the differences in measurement techniques used;

- small sample sizes which don't represent a range of wheelchairs, and disability types;
- the influence of an individual's condition on mobility and balance. Variations are related to an individual's disability rather than their stature. That is, a very tall individual may have very limited reach due to their condition.

To address some of these limitations appropriate sample sizes are needed and the inclusion of a diverse range of users is important—including differences in mobility and size. Wheelchair technology has changed significantly since some of the early work undertaken in this field and is likely to impact how individuals interact with their physical environment.

New measurement technologies have evolved since much of the work reviewed here has been undertaken and will provide opportunities for 3D measurements. Methods such as this will enable larger population groups to be measured with a higher degree of accuracy. In addition, use of comparable technologies with higher degrees of reliability should improve the comparability between data sets — internationally and nationally.

In addition, wheelchair technology — powered and manual — is improving, so that chairs for some conditions are now smaller and more mobile than they were previously. The availability of mid wheel drive chairs has greatly improved the turning circle of powered chairs in comparison to previous generations of chairs.
Regardless of the data collection method, sample size or measures taken, the principles of accessibility required remain the same; to ensure people who use wheelchairs or mobility aids are able to independently, functionally and equitably access the community, as would anyone else without a disability.

Methodology

The methodology for this project has primarily focussed on obtaining anthropometric data from manual and powered wheelchair users who utilise public spaces independently. If the operation of the chair was primarily the responsibility of their support person, these potential participants were excluded from the project. Similarly, in accordance with the project scope, scooters and other mobility aids used by people predominantly confined to nursing homes, aged care facilities, convalescent homes and hospitals were excluded.

1. Ethics approval was provided for this project from La Trobe University, Melbourne. A copy of this is provided as an Appendix 2 to this report.

2. Prior to the commencement of the trial, a Participant Consent Form was signed. A copy of this is provided as an Appendix 3 to this report.

3. Basic demographic data was collected on each participant using a Data Collection Sheet. A copy of this is provided as an Appendix 4 to this report.

4. The sampling methodology used for this project included:

    a. Contact with the wheelchair suppliers to identify the range of manual and powered wheelchairs currently provided to users in Australia. This identified that the majority of powered chairs sold are now the mid wheel drive but we needed to sample rear wheel and front wheel drive as well.
    b. The nature of the disability of the participants was diverse and related to the size of the wheelchair used and the accessories such as oxygen bottles / ventilators required. A cross section of disability types to reflect the user needs was selected.
    c. Sampling included a mixture of gender, age and number of years using a wheelchair.
    d. Participants who were totally dependent on a support worker to assist their chair movement were excluded as they were not independent when accessing public building spaces.
    e. Contact was made with the groups listed below to identify suitable participants. They promoted the project in their newsletters and websites. The interested participants contacted the researchers and suitable venues were arranged to obtain their data. Where required travel expenses for the participants were reimbursed.

5. Contact was made with the major disability support agencies such as:

    - Australian Quadriplegics Association (AQA)
    - Spinal Cord Industry Australia (SCIA)
    - Yooralla
    - Parasport
    - Scope
    - Assistive Technology Suppliers Australasia (ATSA)
    - Royal Talbot / Austin Hospital
    - Australian Institute of Architects National Access Workgroup
    - Independent Living Centre, Brooklyn, Victoria

- Australian Paralympic Committee

- Disability Sport and Recreation Victoria

Through the generous support of the contacts at each of these locations, we were able to communicate with participants in this study.

6. The sampling criteria also included a spread of:

   - Age;
   - Gender;
   - Years on the wheelchair;
   - Types of disability.

7. The static and dynamic anthropometry measurements were undertaken at locations convenient for the participants. These locations were in:

   - Sydney;
   - Melbourne;
   - Geelong.

   Individual participants in Queensland also submitted their data based on the methodologies used by the researchers.

8. The static anthropometric measurements were taken using an anthropometer and a large print metric measurement tape. Both systems were necessary due to the ease of taking the measurements whilst minimising the intrusion and potential distress to the participants. A laser beam was used in the initial trials to ensure the accuracy of the measurements was optimised.

   NOTE: A summary of the measurements taken and the description for the static anthropometry with photos is provided as an Appendix 5 to this report.

9. The collection of the static and dynamic data took between 30 minutes to 60 minutes depending on the capacity of the participant to understand the instructions and to move their chair to the required measurement positions. There were some participants who were unable to complete all the measurements due to fatigue.

10. The dynamic anthropometry was a video based assessment technique. Large foam blocks 1200mm by 1000mm and 100mm wide were used to map out the dynamic assessment courses. The front surface of these blocks had been marked in 100mm grids to enable a background to be detected by the video camera to assist in subsequent measurements.

    Multiple researchers were present during each assessment. This enabled visual confirmation of the movement of the chair through the required course, and the participant was often asked to stop to enable more accurate measurements to be taken.

    Each participant was required to move their chair through the nominated spaces and to not make contact with the foam blocks as they moved their chair around the corners and through the course. If contact was made, or they were required to adjust the position of their chair, then the foam blocks were moved in 50mm increments to make the course wider.

    For the interstate assessments, the foam blocks were replaced with large sheets of cardboard to simulate the same spaces and turning circles for the measurements to be made.

11. At the completion of the data collection phase, a general discussion was held with the participant on any issues they would like to raise in relation to difficulties and accessing public spaces.

Project Assumptions

The following assumptions were made in undertaking this research project.

- All participants were tested using their "everyday" wheelchairs;
- All participants were independently mobile and had a reasonable level of mobility;
- The participants were able to understand directions and what they were being asked to do;
- No participants used scooters or were assisted with their mobility by a carer, associate or family member;
- All participants were sitting in a comfortable position that allowed them to perform everyday tasks and mobility;
- The participant did not change their position between the static and dynamic measures;
- The participants equipment was in good working order to allow freedom of movement;
- All participants were randomly selected or volunteered;
- The cross section of participants included powered wheelchair users (front, mid and rear wheel drive) and manual wheelchair users.

Results

1. Wheelchair anthropometric data.

The raw data for each participant has been summarised in an Excel spreadsheet and is provided as an Appendix 7 to this report. A total of 52 participants were involved in this study. This project has quantified wheelchair anthropometric data for a total of 31 powered wheelchair and 21 manual wheelchair participants.

A full set of data was not collected for all participants due to fatigue or difficulties with completing the tasks. However, the data collected is considered to be accurate of their capacity to undertake the various dynamic activities and their static anthropometry. There were 51 data items for each participant. This included participant demographics, details of their wheelchair, static anthropometric measures and results of the dynamic anthropometry assessments.

2. Determination of the 90th Percentile measurements

A total of 21 measurements were statically analysed to determine the 90th percentiles. The Appendix 7 in this report provides a scattergram with individual data points displayed for each participant measured. It also shows the measurements separated between the manual and the powered wheelchairs. The mean and 90th percentile for each of these measures is provided. The data for a combined data set including manual and powered wheelchairs together is also provided including mean and 90th percentile.

A comparison of the 90th percentile length and width dimensions from the current Australian Standard AS 1428.1-2009, and those calculated using data from this research is contained in the following table. Due to the dynamic anthropometry data collected, the table also includes the 90th percentile for the widest width of the user in the chairs. For a manual wheelchair this is measured when their elbows are out and pushing down on the wheels. For the powered chair this is when their hand is on the controller and their wrist and forearm are outside the armrest.

Current AS 1428.1	**90th percentile of the 21 manual chairs in sample**	**90th percentile of the 31 powered chairs in sample**	**90th percentile of the combined sample**	**90th percentile of the adjusted combination**
1300mm length by 800mm width	992mm by 736mm	1373mm by 729mm	1343mm by 733mm	1216mm by 734mm
Widest width	828mm	765mm	813mm	813mm

Note: Adjusted Combination.
Because the relative numbers of the two types of wheelchairs has a direct effect on the 90th percentile for the combined group, and it does not necessarily represent the 90th percentile for all wheelchairs in the Australian community, an adjusted combination has been included. This was obtained by selecting 14% of the powered chairs assessed in the overall sample. A selection of 7 chairs was sampled from all of the powered chairs sorted from shortest to the longest. Similarly a sample of 7 chairs was sampled from all of the powered chairs sorted from narrowest to widest.

Consideration will need to be given to the proposed application for the data collected in this study to determine which set(s) of measurements are appropriate for the respective issues of concern.

Discussion

The following observations were made from the participants in this study:

- People with more significant or multiple disabilities, i.e. cerebral palsy and quadriplegia, are more likely to use electric wheelchairs.
- People who use manual wheelchairs are unlikely to have a table on their wheelchair, and keep their knee clearance under 700mm to be able to use fixed tables and get under basins.
- Some participants tried to perform excessive or extreme movement, particularly in reach ranges, rather than comfortable movement.
- The largest manual wheelchairs are generally the hospital type wheelchairs i.e. steel folding type. These chairs were rarely used by people with long-term injuries or illness. These wheelchairs are generally either hired or sourced from hospitals and used with a support person.
- The participants moved through the test course at their own pace.
- People who use manual wheelchairs are more likely to have a smaller wheelchair footprint to minimise weight to transfer in and out of cars, maximise manoeuvrability around objects and for ease of mobility.
- People who use powered wheelchairs have a larger footprint and circulation space requirements than do manual wheelchair users.
- The majority of people who used manual wheelchairs in the review had customised "light weight" alloy wheelchairs.
- The most common fixtures for a manual wheelchair are a bag on the back, crutches holder or net underneath.
- The most common fixtures for an electric wheelchair are back pack, head rest and table. Two test participants used an oxygen bottle and ventilator.
- Mid drive electric wheelchairs are the most manoeuvrable of the powered wheelchair types. They were the majority of the powered wheelchairs assessed. There were some rear wheel drive and no front wheel drive chairs assessed.
- Only the powered wheelchairs tested had joysticks and arm rests. Arm rests are generally more prevalent on "hospital type" manual wheelchairs.
- People who use powered wheelchairs have the greatest difficulty with the following tasks that have relevance to the Australian Standards:
    - Ability to grasp objects or apply significant force through their limbs to open doors as the reach range, strength and balance is generally less than a manual wheelchair user.
    - Latchside clearance on the pull side due to limited reach range, hand dexterity and strength to engage the door. Often requires multiple actions to open the door.
    - Doors with a latch that automatically engage due to the door closer.
    - Access to basins as the average height of the wheelchair measured at the knees was 703mm. The vast majority have no ability to get under basins.
    - Forward or side reach to get objects due to limited limb strength and core balance.
- Most manual wheelchair users were unable to reach forward with both hands up above shoulder height due to balance issues of core strength. Side use of kitchenettes, ATM's, servery and reception counters were mentioned as problematic for the majority of participants due the lack of knee clearance.

It was evident from the anthropometry data that the dimensions of the powered wheelchair users were consistently greater than the manual wheelchair users due to the size and manoeuvrability of their chairs. It was also noted that the type of disability of the user also influences the type and size of the chair. For example those with C2/C3 injuries had larger chairs due to the support required for their whole body and also storage access to ventilators.

Sample Size

The sample size of 52 participants is relatively small compared to the DETR study in the UK and Steinfield IDEA study in USA. However the small Standard Deviations with most of the measurements would indicate a level of confidence that the data is relatively consistent across similar profiles of participants. Whilst a larger sample size would confirm that the statistical validity of the sample size was repeatable, the consistency in the measurements taken would indicate that the sample size did provide a representative data set of wheelchair anthropometric measurements. This data includes the 51 individual data items for each participant plus the video of their dynamic anthropometry plus the photos of them undertaking these activities.

It is noted that the quantitative data provides greater technical rigour for determining future building requirements than the subjective qualitative data collected by Bails in 1983. Rather than measuring the anthropometric data for the participants, the Bails study asked the participants if they could use the spaces and pathways under assessment. This subjective feedback does not meet the technical rigour of actually measuring the anthropometric dimensions covered in our study.

In the Bails study there were less than 10 manual and powered wheelchairs in the datasets included. That study included a wide range of ambulant users and other disability types such sight and hearing impaired. These were out of scope in our study. Only manual and powered wheelchair participants were included.

The data provided in this study is the “raw” measurements taken of the participants. Further analysis may be required before the implications of this data to the NCC and related Australian Standards is extrapolated. Comments are provided in the Appendices about the data to assist with this determination.

Conclusion

This study has quantified the wheelchair anthropometric data for the sample of 52 participants. The data includes the outcomes from both static and dynamic anthropometric measurements and provides quantitative data for use in determining future requirements. It can be concluded that the requirements of wheelchair users to safely access public buildings will need to include the anthropometric measurements from this study.

I would like to acknowledge the many agencies that assisted us in obtaining participants across Australia. Their interest and passion for involvement in the study is a reflection of the high interest in this area.

I also thank the ABCB steering committee for their guidance, and the key members of the project team who assisted with the project including Nick Morris, Jodi Oakman, Mike Atherton and Sharon Herbstreit.

Yours sincerely,

David C Caple
Director
David Caple & Associates Pty Ltd
B.Sc.(Hons), Dip. Ed., M.Sc.(Erg.).UK
Past President – International Ergonomics Association (IEA)
Fellow of IEA and Fellow of HFESA, Australia
Fellow Ergonomics Society, UK
Fellow, Ergonomics Society, Sweden
M. Human Factors Society, USA
Certified Ergonomist, Australia
Certified Professional Ergonomist USA
Senior OHS Auditor, Australia
Adjunct Professor, La Trobe University,
Melbourne Australia
Senior Research Fellow, Federation University
Ballarat, Australia
Link to David Caple website www.davidcaple.com.au

Appendix 1: ***References***

Appendix 2: ***Copy of Ethics Approval, La Trobe University***

Appendix 3: ***Copy of Participant Consent Form***

Appendix 4: ***Copy of Data Collection Sheet***

Appendix 5: ***Testing Variables and Clarifications***

Appendix 6: ***Brief Comments on Data in Relation to Australian Standards***

Separate Appendix:

Appendix 7: ***Excel spreadsheet with the wheelchair anthropometric data, and Graphs and statistical analysis for mean and 90th percentile data – separate document***

Appendix 1: References

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Appendix 2: Ethics Approval

FACULTY OF HEALTH SCIENCES

MEMORANDUM

To: **Jodi Oakman – Department of Human Biosciences**

From: **Chair, Faculty Human Ethics Committee**

Participant: **Review of Faculty Human Ethics Committee Application No. FHEC14/151**

Title: **Spatial Dimensions for Occupied Manual and Powered Wheelchairs**

Date: **25 June, 2014**

Thank you for your recent correspondence in relation to the research project referred to above. The project has been assessed as complying with the *National Statement on Ethical Conduct in Human Research*. I am pleased to advise that your project has been granted ethics approval and you may commence the study now.

The project has been approved from the date of this letter until 1 February, 2015.

Please note that your application has been reviewed by a sub-committee of the University Human Ethics Committee (UHEC) to facilitate a decision before the next Committee meeting. This decision will require ratification by the UHEC and it reserves the right to alter conditions of approval or withdraw approval at that time. You will be notified if the approval status of your project changes. The UHEC is a fully constituted Ethics Committee in accordance with the National Statement under Section 5.1.29.

The following standard conditions apply to your project:

- **Limit of Approval.** Approval is limited strictly to the research proposal as submitted in your application while taking into account any additional conditions advised by the Faculty Human Ethics Committee (FHEC) .

- **Variation to Project.** Any subsequent variations or modifications you wish to make to your project must be formally notified to the FHEC for approval in advance of these modifications being introduced into the project. This can be done using the appropriate form: *Ethics - Application for Modification to Project* which is available on the Research Services website at http://www.latrobe.edu.au/researchers/starting-your-research/human-ethics. If the FHEC considers that the proposed changes are significant, you may be required to submit a new application form for approval of the revised project.

- **Adverse Events.** If any unforeseen or adverse events occur, including adverse effects on participants, during the course of the project which may affect the ethical acceptability of the project, the Chief Investigator must immediately notify the FHEC Secretary on telephone (03) 9479 3570 or at fhechealth@latrobe.edu.au.Any complaints about the project received by the researchers must also be referred immediately to the FHEC Secretary.

- **Withdrawal of Project.** If you decide to discontinue your research before its planned completion, you must advise the FHEC and clarify the circumstances.

- **Monitoring.** All projects are participant to monitoring at any time by the Faculty Human Ethics Committee.

- **Annual Progress Reports.** If your project continues for more than 12 months, you are required to submit an *Ethics - Progress/Final Report Form* annually, **on or just prior to 12 February**. The form is available on the Research Services website (see above address). Failure to submit a Progress Report will mean approval for this project will lapse.

- **Auditing**. An audit of the project may be conducted by members of the FHEC.

- **Final Report.** A Final Report (see above address) is required within six months of the completion of the project**.**

If you have any queries on the information above or require further clarification please contact me at fhechealth@latrobe.edu.au.

On behalf of the Faculty of Health Sciences Faculty Human Ethics Committee, best wishes with your research!

Owen M Evans, PhD
Chair
Faculty Human Ethics Committee
Faculty of Health Sciences

Appendix 3: Participant Consent Form

LA TROBE UNIVERSITY

FACULTY OF HEALTH SCIENCES

SCHOOL OF PUBLIC HEALTH & HUMAN BIOSCIENCES

Consent Form

Title	Spatial Dimensions for Occupied Manual and Powered Wheelchairs
Project Sponsor	David Caple & Associates Pty Ltd (on behalf of Australian Building Codes Board (ABCB))
Principal Investigator	Dr Jodi Oakman, Department of Human Biosciences & Public Health, La Trobe University

<u>Declaration by Participant</u>

I have read the Participant Information Sheet.

I understand the purposes, procedures and risks of the research described in the project.

I agree that research data provided by me or with my permission during the project may be included in a thesis, presented at conferences and published in journals on the condition that neither my name nor any other identifying information is used.

I have had an opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in this research project as described and understand that I am free to withdraw at any time during the project without affecting my future care.

I understand that I will be given a signed copy of this document to keep.

I agree to have photographs and video recordings taken for data analysis purposes.

☐ Yes

☐ No

Name of Participant (please	______________________		
Signature	______________________	Date	______________________

Name of Researcher (please print)	______________________		
Signature	______________________	Date	______________________

Note: All parties signing the consent section must date their own signature.

Appendix 4: Data Collection Sheet

Data Collection Sheet

Section 1: DEMOGRAPHIC DATA

NAME: (Optional)…………………………………………… GENDER: M / F

AGE: ………………..

DISABILITY TYPE: Progressive neurological; spinal cord; cerebral palsy; cognitive impairment; ABI/TBI; spina bifida; other (specify)

Primary: ………………………………………………

Secondary: ………………………………………………

How long have you been in a: Manual Wheelchair; ..…Years: Powered Wheelchair; ………Years

How long have you used the current type of chair: ………. Years

VOCATION: Work; Day Program; School/Training; Home duties; Other (specify)……………

HEIGHT: (mm)……………. WEIGHT :(kg) …………………including chair :(kg)…………..

SEATED EYE HEIGHT (in chair) (mm)…………………………

SHOULDER WIDTH (mm)……………………ELBOW TO ELBOW WIDTH (mm)………………..

WIDEST WIDTH WHEN DRIVING CHAIR: (mm)……………………

TOP OF THIGH HEIGHT (mm) …………TOP OF FOOT FROM FLOOR (mm) ………………..

UNDERSIDE CLEARANCE OF FOOT SUPPORT (mm)………………

Section 2: DETAILS OF WHEELCHAIR

Manual / Powered / Carer Assisted:

Chair Brand………………………………… Model………………………Age………………………….

Chair Accessories; Headrest; Table; Oxygen bottles; Crutches; Other………….

Position of drive wheels: Mid wheels Rear wheels

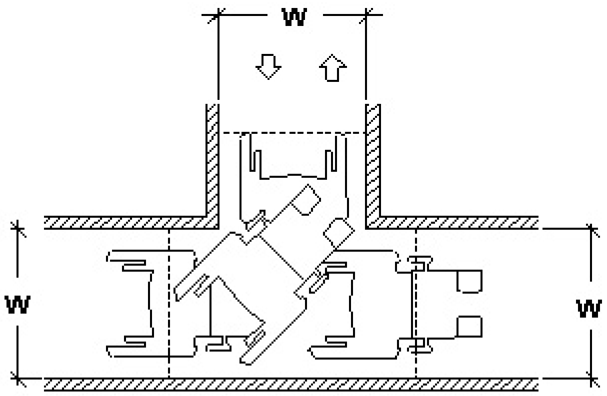
Chair dimensions

Dimension	***Measurement mm***	***Comments***	***Additional findings***
1. Overall length of the wheelchair.		Measurement taken from the farthest permanent structure at the head end to the foot end including handles, head support, foot support, fixed tables and rear stabilizers.	
2. Overall width of the wheelchair		The widest measurement including the wheels and any other protruding structures such as arm supports.	
3. Turning circle / diagonal of the chair.		Measure the diameter of a circle drawn by the wheelchair spinning on the one spot.	Measure the diagonal length of the chair. i.e. one corner to the other; (mm)
4. Height of the wheelchair seat.		Measure from the ground to the compressed front edge of the seat cushion and back support.	Compressed height of the rear of the seat.(mm)
5. Height of wheelchair push handles.		Measure from the floor to the top edge of the push handles.	
6. Maximum height of the wheelchair structure.		Measure from the floor to the top of the chair construction e.g. head support.	Height including other fixed items such as phones, oxygen bottles: (mm)
7. Arm support height		Measure from the floor to where the elbow is supported on the arm support	
8. Top of joystick from the floor		No data	
9. Seated head height		No data	
10. Seating reference point to the toes		Measure from the seating reference point (SRP) to the toes.	
11. Front of torso to the toes		Measure from the most frontal position of the torso to the toes.	
12. Inner width of arm supports		Measure the inner width of the arm supports	

Section 3: DYNAMIC ANTHROPOMETRIC DATA

Pathway width and turning circles

The following data will be collected from a simulated activity.

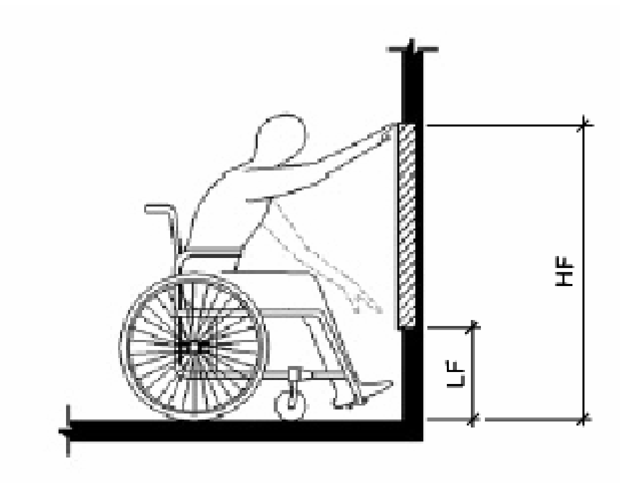
Dimension	*Measurement mm*	*Comments*
1. Minimum width of a pathway to enable the dynamic movement of the arms to propel a manual wheelchair forwards or for a powered wheelchair to move along a straight pathway.		
2. Area to turn the wheelchair 90 degree without multiple corrections. 		
2.1 Width of access corridor.		
2.2 Length of entered corridor.		
3. Area to turn the wheelchair 45 degree without multiple corrections.		
3.1 Width of access corridor.		
3.2 Length of entered corridor.		
4. Area to turn the wheelchair 180 degree without multiple corrections.		
4.1 Width of access corridor.		

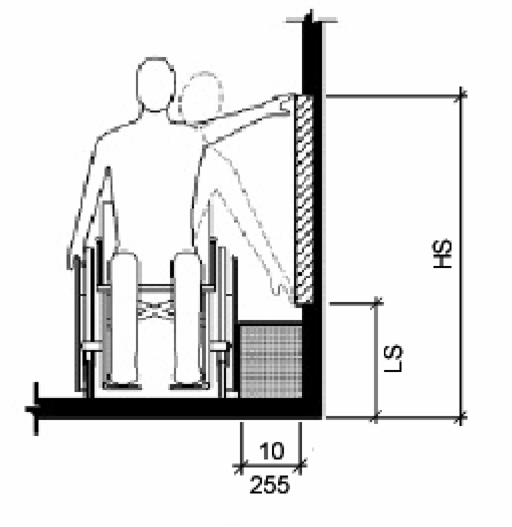
Section 4: LATCHSIDE CLEARANCES

Dimension	***Measurement mm***	***Comments***
4.1 Corridor width required to open door when approaching from latch side.		
4.2 Corridor width required to open door when approach from hinge side.		
4.3 Corridor width required to open door approaching directly to the door.		

Section 5: REACH DISTANCES

These reach distances are from the floor to the hand held grip.





David Caple & Associates Pty Ltd
PO Box 2135
East Ivanhoe,
Victoria 3079, Australia
Tel: 3 9499 9011
Fax: 3 9499 9022
Email: david@caple.com.au

Dimension	*Measureme nt mm - LHS*	*Measurement mm - RHS*	*Both hands mm*	*Comments*
5.1 Height of comfortable forward highest reach.(HF)				
5.2 Height of comfortable forward lowest reach.(LF)				
5.3 Height of comfortable side highest reach 300mm from the side of the chair. (HS)			N/A	
5.4 Height of comfortable side lowest reach 300mm from the side of the chair. (LS)			N/A	

Section 6: SIGHT LINES

A vision board would be placed 2 metres in front of the participant. They will be requested to view markings towards the top and the bottom of the board.

Dimension	*Distance above floor level mm*	*Measurement degrees*	*Comments*
7.1 Comfortable downward viewing location.			
7.2 Comfortable upward viewing location.			

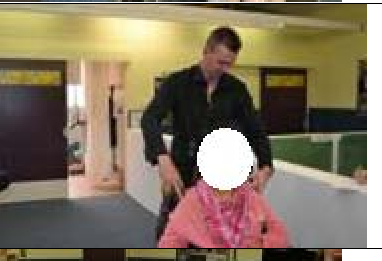
Section 7: LIST OF EQUIPMENT

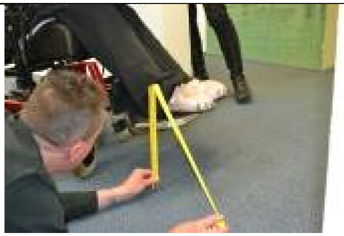
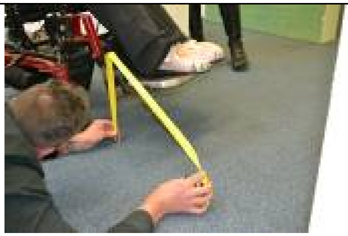
The following equipment will be utilised for the collection of data. This will be light weight and portable to enable data collection to occur in multiple locations across Australia.

- Tape measure.
- Laser line beam generator.
- Morant board (large board marked in cm and mm for background measurement).
- Camera.
- Video camera.
- Inclinometer for measuring angles.
- Floor tape.
- Phone blocks for pathway clearances.
- Single hinged door with latch.
- Participant consent forms.

Appendix 5: Testing variables and clarifications

Test	Photo	Method	Comments
Stature height	No photo provided	Provided by the participant	As these participants are unable to leave their wheelchair we cannot measure their standing stature height. Most seem to know their height so record their answer.
Weight	No photo provided	Provided by the participant if known.	No comments provided.
Chair weight	No photo provided	Noted if labelled on the chair.	Details of the chair model are noted. Later checks of weights can be obtained from the manufacturer. It was noted that some participants have "hybrid" chairs which are basically a combination of parts.
Seated eye height		Vertical height from the ground to the mid eye	An estimate as some participants, due to the nature of their condition are unable to remain in a static position some measurements have some imprecision.
Weight	No photo provided	Provided by the participant if known.	No comments provided.
Chair weight	No photo provided	Noted if labelled on the chair.	Details of the chair model are noted. Later checks of weights can be obtained from the manufacturer. It was noted that some participants have "hybrid" chairs which are basically a combination of parts.

Seated eye height		Vertical height from the ground to the mid eye	An estimate as some participants, due to the nature of their condition are unable to remain in a static position some measurements have some imprecision.
Static Shoulder width		Distance between each acromion process of left and right shoulders	Standard anthropometric measure which can be related back to population data.
Static elbow to elbow width		Distance between the left and right elbow	No comments provided.

Widest width when driving		Measured from the most outer point between the left and right side of the body or the chair	Depending on the nature of the physical disability, the hand or elbow will often protrude further than the widest part of the wheelchair
Mid Thigh height		Vertical distance from the ground to the top of the thigh	Measured from the point on the thigh where the hands could normally reach to from a relaxed elbow position. (The primary reach zone)
Top of foot height		Vertical distance from the ground to the top of the foot	Measured from the ground to where it connects with the most forward part of the leg.
Underside clearance of foot support		Vertical height from the ground to the most underside point of the foot support.	Measured to determine the clearance of the underside of the foot support.

Overall length of chair		Horizontal distance from the most forward point of the chair to the most rear point	Measurement is taken from the most prominent point at the front. This could be the foot support or the protruding feet.
Overall width of chair		Horizontal distance between each side of the chair	Taken from the armrests unless another object permanently fixed such as a table.
Overall diagonal of chair		Horizontal distance of the diagonal of the chair	The diameter of the turning circle that would be created from the most outer point of the chair

Height of seat		Vertical distance from the ground to the highest and lowest part of the compressed seat	Measurements include the use of cushions and lamb's wool covers that are always used by the participant.
Height of push handles	No photo provided	No method provided	No comments provided
Max height of wheelchair		This is the vertical distance from the ground to the highest part of the wheelchair structure.	This can include additional permanent attachments to the chair, specifically the head support and bracket.

Arm support height		This is the vertical distance from the ground to the highest point on the arm support.	No comments provided
Height of joystick control		This is the vertical distance from the ground to the top of the joystick or control mechanism	At times, the highest part of the controller will be the feedback display and at other times, it will be the top of the joystick

Seated head height		This is the vertical distance from the ground to the top of the head	No comments provided
Front of torso to toes		This is the horizontal distance from the front of the torso to the most forward point of the wheelchair	No comments provided
Inner width of arm supports		This is the horizontal distance between the arm supports	No comments provided

Height of forward high and low reach, left hand, right hand, both hands		This is the vertical distance from the ground to the highest and lowest reach.	As some of the participants are unable to reach the wall in this test. In this situation the vertical height is measured away from the wall to the point of comfortable reach.
Height of left and right side high and low reach		This is the vertical distance from the ground to the highest and lowest reach.	This measurement is done on both the left and the right hand sides. This was due to the different reach capacities on each side of their body.
Comfortable upward viewing height	No photo provided	An object was moved up to the currently recommended height and the participant read the sign to confirm they could see it.	No comments provided
Comfortable downward viewing height	No photo provided	An object was moved down to the currently recommended height and the participant read the sign to confirm they could see it.	No comments provided

Appendix 6: Brief Comments on Data in Relation to Australian Standards

Category	Issue	Validity based on combined manual and powered data
2. Application		
AS 1428.1 2009 - Figure 1 - Wheelchair footprint	Confirm current sizes as being relevant to 2014	Doesn't support the current standard wheelchair length - 1343mm 90% ile length Doesn't support current standard wheelchair width 817mm 90% ile – widest width with arms in working position
AS 1428.1 2009 Section 6 - Continuous Accessible pathway		
AS 1428.1 2009 - Figure 3 - Wheelchair passing space – two wheelchairs	No issue	Supports current standard - 1346mm 90% ile wheelchair length.
AS 1428.1 2009 - Section 6.5.1 - Wheelchair turning space 60 – 90 degrees	No issue	Supports current standard - 90% confirmed by right and left hand turn through 1000mm pathway intersection – refer video
AS 1428.1 2009 - Section 6.5.3 - Wheelchair turning space 90 – 180 degrees	Clarify 1540 X 2070mm as to how this was arrived at	Supports current standard - 1540 X 2070mm was achievable to the majority of those surveyed – refer video. The longest powered chairs required one or more corrections to complete the turns.
AS 1428.2 2009 – Section 7 - Floor or Ground surfaces on continuous accessible paths of travel		
AS 1428.1 2009 – Section 7.2 - Construction tolerances for abutment of surfaces	No issue	Not Tested
AS 1428.1 2009 – Section 7.3 - Changes in level	No issue	Not tested
AS 1428.1 2009 – Section 7.4.1 - Carpets and other soft flexible materials	Clarify how underlay can significantly increase rolling friction	Not tested
AS 1428.1 2009 – Section 7.4.2 - Recessed matting	No issue	Not tested

Category	Issue	Validity based on combined manual and powered data
AS 1428.1 2009 – Section 7.5 – Grates	Clarify the width of the grates being 13mm for wheelchairs that use roller blade wheels which may be smaller than 13mm	Not tested
10. Walkways, Ramps and Landings - AS 1428.1 2009 – Section 10 Walkways		
AS 1428.1 2009 – Section 10.1 - General	No issue	Not tested
AS 1428.1 2009 – Section 10.2 – Walkways	No issue	Not tested
AS 1428.1 2009 – Section 10.3 - Ramps	No issue	Not tested
AS 1428.1 2009 Section 10.5 - Threshold ramps	No issue	Not tested
AS 1428.1 2009 Section 10.5 - Step ramp	Clarify why 190mm was agreed as the limit for 1 in 10 step ramp lengths	Not tested
AS 1428.1 2009 – Section 10.8 – Landings		
AS 1428.1 2009 – Section 10.8.1 - Landings - Walkways and ramps	Confirm that circulation space can be 1500 X 1500mm as a consistent dimension to turn 90 degrees	Supports current standard - Confirmed by right and left hand turn through 1000mm pathway for the majority of users– refer video. All were able to turn in a 1200mm X 1200mm task.
AS 1428.1 2009 – Section 10.8.2 - Landings - Step ramps	Clarify landing of 1200mm at step ramps	Does not support current standard length – 1346mm 90% ile. Landings should reflect wheelbase not necessarily wheelchair length. Wheelchair wheel base not assessed
AS 1428.1 2009 – Section 10.8.1 - Landings - Kerb ramps	Confirm that circulation space can be 1500 X 1500mm as a consistent dimension to turn 90 degrees	Supports current standard - Confirmed by right and left hand turn through 1000mm pathway for the majority of users– refer video. All were able to turn in a 1200mm X 1200mm task.

Category	Issue	Validity based on combined manual and powered data
AS 1428.1 Section 13 - Doors, Doorways and Circulation space at doorways		
AS 1428.1 2009 - Section 13.2 - Doors, Doorways and Circulation space at doorways – Clear opening at Doorways	Clarify if a 300mm depth is allowable to the latchside of the swing door and not just a sliding door	Not tested
AS 1428.1 2009 - Section 13.3.1 - Doors, Doorways and Circulation space at doorways – Circulation spaces at doorways on a continuous path of travels		
AS 1428.1 2009 - Section 13.3.2 - Doors, Doorways and Circulation space at doorways – Circulation spaces at doorways on a continuous path of travels	Clarify all latchside clearances for appropriate widths and depths	Not tested formally -Confirmed in general – refer video. Dynamic video testing indicated that the latchside clearances with a 540mm distance between the latch and the closest wall was difficult for the powered wheelchair users – particularly the larger chairs and users with limited reach capacity. Further work is recommended on the issues of latchside clearances.
AS 1428.2 2009 13.3.3 Doors, Doorways and Circulation space at doorways – Sliding doors	Clarify if automatic sliding doors should allow a significantly decreased landing prior to the door rather than the current 1450mm as there is no mechanism to operate	See comments above on latchside clearances.
AS 1428.2 2009 13.4 Doors, Doorways and Circulation space at doorways - Distance between successive doorway in passages in an accessible path of travel	Confirm 1450mm depth between doors	Supports current standard – 90% ile wheelchair is 1346mm
AS 1428.2 2009 13.5 Doors, Doorways and Circulation space at doorways – Door controls	Clarify inconsistent heights between controls and door handles	Supports current standards - the 90% ile over 300mm left side upper – 1586mm left side lower – 359mm right side upper – 1617mm right side lower – 374mm

Category	Issue	Validity based on combined manual and powered data
AS 1428.2 2009 13.5.3 Doors, Doorways and Circulation space at doorways – Location	Clarify Inconsistent heights of controls	Supports current standards - the 90% ile over 300mm left side upper – 1586mm left side lower – 359mm right side upper – 1617mm right side lower – 374mm
AS 1428.1 2009 – Section 14 – Switches and General Purpose Outlets (Power points)		
AS 1428.1 2009 – Section 14.1 – Switches and General Purpose Outlets (Power points) – General	Clarify Inconsistent heights of controls	Supports current standards - the 90% ile over 300mm left side upper – 1586mm left side lower – 359mm right side upper – 1617mm right side lower – 374mm
AS 1428.1 2009 – Section 15 – Sanitary facilities		
AS 1428.1 2009 – Section 15.2.8.1 – Circulation space	Clarify circulation spaces – 1400mm is the predominant clearance dimension for a wheelchair in a unisex toilet	Supports current standard - as the 90% ile is 1346mm
AS 1428.1 2009 – Section 15.2.8.2 – Baby Change tables		Not tested
AS 1428.1 2009 – Section 15.3 – Washbasins	Washbasin clearance is not sufficient Width of basin is not sufficient i.e. front of basin to the furthest knee clearance point under the basin	Top of thigh height 90% ile is 745mm and front of torso to toes is 674mm. The front of knees to toes 90%ile is 354mm. There was significant variation in the forward and sideways reaches amongst the participants.
AS 1428.1 2009 – Section 15.3.2 Accessible sole occupancy unit	Clarify why there is difference between the sole occupancy unit and a standard basin	Refer AS 1428.1 2009 (15.3)

Category	Issue	Validity based on combined manual and powered data
AS 1428.1 2009 – Section 15.5 – Showers	Clarify Figure 47b as the A90 width for a wheelchair is 800mm however 1160 – 390 – 400mm for a shower seat = 760mm which is not sufficient to allow a 90 degree transfer or assistance from a carer, particularly if there is a wall.	Not tested
AS 1428.1 2009 – Section 15.5.3 – Opening shower screens		Not tested
AS 1428.1 2009 – Section 15.6 Circulation spaces in accessible sanitary facilities	No issue	Supports current standard - as the 90% ile is 1346mm
AS 1428.1 2009 – Section 15.6 Circulation spaces in accessible sanitary facilities	Confirm circulation spaces within unisex accessible toilets	Supports current standard - 1346mm 90% ile length will be able to circulate
AS 1428.1 2009 – Section 18 – Assembly Buildings	Confirm current widths for dual and single wheelchair spaces being sufficient	Doesn't support current standard for single wheelchair width - 817mm 90% ile – widest width or 1346mm 90% ile length