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DUTCH RESEARCH AND STANDARDS ON ACCESSIBILITY

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Summary
Design guidelines and standards can be helpful in enforcing the application of knowledge. However, dissemination of information and standardisation are in themselves insufficient. Prerequisites for a widespread application of knowledge are a clear and attractive presentation, certitude about the correctness of the information and consensus over the objectives. In this paper, a brief review will be given of the history of the development and dissemination of information on accessible environments in the Netherlands. Furthermore, some recommendations will be presented for an international research agenda.

1. Introduction

Designers and developers continued until relatively recently to cater exclusively for people of average height, strength, stamina, and competence, with little regard for preventing the dysfunction of those who failed to match this profile. The accessibility of the built environment for all people, including people with a disability, did not receive serious attention in the Netherlands until the early sixties. Since then an increasing concern has been shown for the special needs of disabled people. This is largely due to the influence handicap organisations have brought to bear on policy and those involved with building the environment. In this paper I will sketch a bird's-eye-view of the main developments and the role of design guidelines, standards and research in this process.

2. Housing: From Unadapted to Adaptable Dwellings

The first publication on *Housing the Disabled* ('Woningen voor Minder Validen') was brought out in 1960 by the Netherlands Association for Care of the Disabled ('Nederlandse Vereniging voor Gebrekkigenzorg'). The study was based on a small study with two wheelchair users and several walking stick users. It published a list of the requirements that a dwelling needed to comply with to be suitable for people in these disability groups. At that time, the only adaptations for disabled people were those individually tailored to the occupant's needs after moving into the dwelling. This posed serious problems for people who were severely disabled. This and the absence of professional domiciliary care meant they were rarely able to live on their own. When parents were unable or could no longer look after them, institutional care was the only alternative.

The year 1962 saw the completion of the first two dwellings which were adapted for wheelchair users during construction. The project was the initiative of a doctor active in rehabilitation.

Based on the recommendations of the 1960 report, he succeeded in restructuring the ongoing construction of three council houses into two adapted homes for families of which the housewives used a wheelchair. During this same period The Village ('Het Dorp') was built, financed mainly with private and corporate donations in response to a well-publicised campaign. The project consisted of 400 independent housing units for disabled people with round-the-clock support available with activities of daily living. Once again, the initiative came from a doctor concerned with improving the living conditions of disabled people.

In 1970, the government installed an Steering Committee on Policy for the Disabled. A study published by the committee (1976) discriminates three adapted dwelling types:
- type A, consisting of a number of independent living units with limited service provision (hot meals, home nursing, light personal care), interspersed (provided they are easy to reach) or clustered among standard housing;
- type B, a small home or hostel accommodating twenty-five to thirty people offering a more extensive package of services than the A-type dwelling, including support with social and cultural activities;
- type C, consisting of independent units forming part of a larger community complex (two to four hundred people) and an extensive service mix including medical assistance and support in relation to the basic living activities.

People with a limited disability who are able with some help to look after themselves qualify for the A-type dwellings. The B type is meant for people with a more severe disability and who are unable or unwilling to live on their own. For those with a very severe disability and limited mobility and range of activity in relation to daytime activities and social contact the C-type dwelling was felt by the committee to be more suitable. Some forty B-type and four C-type projects have been realised in the Netherlands to date. The concept of type C is out of date now. In some of the existing examples the number of units has been reduced.

A milestone in independent living for people with a disability was the completion in 1978 of 15 A-type *Fokus* dwellings and a service centre in the new town of Almere Haven as part of a social housing complex of 205 council homes. The name Fokus derives from the foundation of the same name, established by the Swedish doctor S.O. Brättgard in 1964. The foundation was set up for the purpose of realising accommodation for severely disabled people with round-the-clock support with day-to-day living activities. Meanwhile 42 projects of this type have been realised in the Netherlands, accommodating some 550 disabled people. Each project consists of a maximum of 15 specially adapted rented dwellings integrated in the community. Besides being based on a literature study, the architectural formula of the Fokus dwellings is inspired by research Brättgard carried out at the Department of Handicap Research of Göteborg University. A number of experimental designs have also been tested by people with different disabilities.

A moot point in building dwellings for people with a disability is which adjustments should be incorporated at the design phase and which are better left until later when they can be tailored to the occupant's individual needs. Since the Fokus dwellings are allocated at an early stage and virtually all the occupants are wheelchair users, the wheelchair adjustments are incorporated as standard features of the design. Usually a number of customized adaptations are made on top of this. In a report containing design recommendations for dwellings for wheelchair users, the author (another doctor) argues in favour of one to one-and-a-half per cent of all new housing being purpose-built for wheelchair users (Worisek, 1974).

Various municipalities adopted this recommendation. The strategy proved problematical with regard to fine-tuning of supply and demand in terms of both quantity and quality. Like everyone else, disabled people have different preferences in housing depending on the composition of the household, income and lifestyle. This has resulted in long waiting lists for some wheelchair dwellings while others have been left vacant. After carrying out an extensive investigation in 1984, the government decided to abandon the policy of building a specialist housing stock.

An entirely different approach is *Adaptable Housing*; new build or refurbished housing which is not purpose-built or specially adapted for disabled people but which is designed in such a way that adaptations can be made relatively simply and cheaply at a later stage if the occupant becomes disabled or a disabled person wishes to move into the dwelling. This concept was championed in the early eighties by the architect Job Kroon. Initially his ideas met with much scepticism: too complicated, too costly. He endeavoured to convince his critics of the technical and economic feasibility by applying the principle in his own architectural practice. In the mid-eighties, the National Housing Council ('Nationale Woningraad') instigated a large-scale experiment in Adaptable Housing. In the theoretical phase, a list of *Requirements for Adaptable Housing* was drawn up based on a literature study and interviews with people with disabilities and their organisations. Forty projects implementing these requirements were then realised, providing for a total of some 1200 dwellings. Parallel to this experiment, Delft University of Technology calculated whether implementation of the adaptable housing requirements necessitated building larger dwellings compared with other standard systems. The results were by and large favourable and would seem to indicate that adaptable housing is feasible in many cases (Van der Voordt 1990/1992). The National Housing Council with Delft University of Technology and other organisations launched a follow-up project on *Adaptable Renovation*. The theoretical phase has since been concluded, resulting in a check list of adaptability requirements and a phased refurbishment plan (Nolte et al, 1993; Van der Voordt et al, 1995).

3. Public Provisions: Towards an Integrated Approach

In addition to the studies on accessible housing, considerable research has been carried out into other areas directly or indirectly affecting the general accessibility of the environment. Table 1 specifies the items examined. The research methods employed vary from written questionnaires and interviews on space requirements to laboratory research and field tests, and from desk research into the costs of accessibility provisions in public buildings to practical experiments with acoustic signals for traffic lights on the public highway. The scale of the research varied considerably, too, from experiments involving a handful of test subjects to large-scale questionnaires. Large-scale empirical studies on space requirements are rare. As far as is known, only two such studies have been conducted in the Netherlands, one into the use of ramps and the second into the space needed for opening and shutting doors (Werkgroep Bouwen voor Iedereen, 1979/1983). Another relatively large research project evaluated users' experience of a specially adapted route in Gouda, a fairly large town in the west of the Netherlands. As well as reviewing the provisions for wheelchair users, the study evaluated a footpath for visually impaired people. For this, a fairly long 60-centimetre-wide path in Gouda town centre was surfaced in a distinctive material (ribbed paving). The study revealed that while helpful to the nearly-blind, the path was less suitable for blind people, who often wandered off it. Blind people expressed a clear preference for a guide line along the facades of buildings, without interruptions or obstacles such as parked bicycles and displays of goods outside shops.

Table 1: Aspects of accessibility being studied in the Netherlands

* number of disabled people, total as well as in each category
* anthropometric data on elderly and disabled people
* needs of disabled people, including mobility needs, priorities of accessibility of facilities
* actual obstacles encountered by disabled people, differentiated according to type of disability
* accessibility and inaccessibility of specific buildings and outdoor spaces
* accessibility criteria with respect to functional principles and space requirements
* criteria for adaptability
* frequency of individual adaptations
* alternative transport provisions
* product development (ergonomic wash basin, suspended lift)

Striking is the tendency towards an *integrated* approach. Instead of individual adaptations or categorial provisions such as special ramps for wheelchair users, there is an increasing tendency to seek solutions which are acceptable to *everyone*, such as an entrance with automatic doors and no threshold. In a recent study for the Ministry of Housing and Construction integrated accessibility was defined as "that which can be used readily and - as far as possible - unassisted by everyone alike" (Wijk, 1992). `Everyone' is understood to mean `every person, with or without personal aids or belongings (wheelchair, crutch, luggage, pram) who is represented by the broad average. The latter encompasses that group of people implicitly represented by a system of measurement based on the principle that people differ in size and physical ability. For instance, if the clear width of a doorway was set at 850 mm, everyone who could pass through this would fall under the broad average for purposes of this activity. People in too wide a wheelchair or with too wide a pram would by definition not qualify. Within the frame of an European Manual for an Accessible Built Environment, a group of experts is currently engaged on formulating standard international measurements (CCPT, 1990).

3. Design guidelines and Standards

In order to ensure that knowledge gleaned from research and practical experiments finds its way to designers' drawing boards and policy-makers' desks it has to be presented in a form accessible to them. An important publication is *Call for Admittance* (`Geboden Toegang'), issued by the Dutch Council for the Disabled ('Gehandicaptenraad'). The first edition of this manual for the design and construction of practicable and accessible buildings for disabled people appeared in 1973. The information was based largely on existing literature and practical experience of specialists, supplemented by small-scale studies at a rehabilitation centre. Originally, the manual consisted primarily of standard solutions for interior spaces such as the entrances to dwellings and public buildings, living rooms, bedrooms, toilets, and solutions for moving between levels (stairs, lifts, ramps) both indoors and outdoors. Also it was initially concerned primarily with people with a motor impairment, in particular wheelchair users. The reasons for a given solution were not always clear. This meant that designers had insufficient information with which to generate their own design solutions and test the workability of these. Later versions devoted more attention to the functional principles underpinning designing an accessible environment. Furthermore, it has since been expanded with information on the accessibility requirements of sensory disabled people.

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Guidelines from Call for Admittance

In the meantime *Call for Admittance* has become a household word in the Netherlands. It is cited regularly by developers, designers, and those responsible for assessing plans and compiling legislation. Despite its merits, in practice there was a need for information on specific building categories. To this end a *Prototype Guide for Accessibility* was developed (CCPT, 1984). On the basis of this, guidelines were drawn up for office buildings, shop amenities, health care buildings and recreational facilities. As for traffic measures for people with a disability, the Ministry of Transport and Public Works published a separate manual.

Information on its own is not enough. A certain amount of force is needed to ensure that planning takes account of accessibility at all levels. In 1987 the Union of Netherlands Municipalities ('Vereniging van Nederlandse Gemeenten') incorporated a selection of accessibility requirements in its *Model Building Regulations*. Until the end of 1992, this formed a basis for the building regulations which the local councils were obliged to draw up for their own municipality. Under the current policy of deregulation, which seeks to reduce government prescription and to increase the individual responsibility of the relevant parties, the municipal building regulations have since been abolished and replaced by a national *Building Decree* '(Bouwbesluit'). This stipulates a limited number of requirements pertaining to the accessibility of public buildings and communal areas in residential buildings.

In addition to the Building Decree, the Dutch Standards Institute's standard sheet no. *NEN 1814* of 1989 wields a certain amount of influence. This standard sheet, which concerns the accessibility of buildings and outdoor spaces, was compiled by a committee of experts whose members include designers, researchers and representatives of handicap organisations. The present standard is mainly based ont the guidelines in Call for Admittance. No specific additional research has been done. Although not legally binding, the standard sheets published by the Dutch Standards Institute are frequently taken as a guideline in Dutch building practice.

4. Recent Research on Accessibility

A new edition of the manual Call for Admittance is due to appear at the end of 1995. The revised edition will give greater prominence to the integrated approach. It also incorporates the findings on adaptable housing and takes account of technological innovations and current research. In order to strengthen the scientific base for the measurements and also to ascertain whether further empirical research on space requirements is desirable before rewriting Call for Admittance, Delft University of Technology and the National Housing Council have recently taken stock of the research carried out to date. No more than forty studies were traced, half of which were either not relevant or outdated. In some studies the number of test subjects was too small. Others (e.g. from Finland or Sweden) had not been translated, or the original research report was unavailable. Nineteen publications were selected for in-depth analysis of usefulness to establishing building standards for integral accessibility (Van der Voordt et al, 1993).

In addition to this review, a series of simulation studies were made of the space requirements of wheelchair users for the use of toilet, shower and wash basin, vertical transport by lift, and opening and closing of doors (Van der Voordt et al, 1993). We examined the sub-activities from which an activity is built up, their sequence and their space requirements. For instance, the use of the toilet can be broken down into opening and closing the door, transfers to and from the toilet, using the toilet, washing hands, and leaving the bathroom. Variations were considered, such as activities with or without assistance, and different transfer techniques. Information on the movements required for computer simulations were found in publications and in discussions with an expert from the Community Medical Service (responsible for person-environment adaptations) and an experienced occupational therapist, supplemented where needed with wheelchair experiments of the activities by the researchers themselves. The space required was analyzed with computer generated drawings in AutoCad version 12.

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Example of a simulation study: oblique transfer, assisted

Results

First the results of the completed empirical research on opening and closing of doors will be discussed, in combination with the results from the simulation studies. Second we will describe some methodological issues that stroke us by comparing the reports.

User space required for the opening and closing of doors

The space requirements for the opening and closing of doors have been studied by Nichols et al (1966), Walter (1971), Ownsworth et al (1973), Brättgard et al (1974), Steinfeld et al (1979) and Werkgroep Bouwen voor Iedereen (1983). The dimensions recommended in these studies and other publications were widely divergent (Table 2). For instance, the space needed to open a door approached from the hinge side toward the user amounted to 1200 x 2000 mm in a study by Brättgard (1974), but should be 1485 x 2220 mm according to the current Australian Standard AS 1428.1-1993.

The scope of the studies also varied widely with reference to yes or no paying attention to the space required to close a door and the effect of the direction of approach, whereas others did not. The simulation studies on the opening and closing of doors showed very clearly that the direction of approach of the wheelchair and rotation of the door determined to a large extent the amounts of space needed for manoeuvring. Another important aspect is the way of manoeuvring. For instance, in case of a hinge-side approach and a door which opens toward the user, a wheelchair user has two options for opening and moving through the doorway:

- passing by the door entirely (parallel to the door), turning backward (perpendicular to the door) while opening the door until one is in front of the doorway, moving forward and passing through the doorway,
- turning in front of the closed door, moving backward while opening the door, moving forward and passing through the doorway.

The latter option requires less space at the latch side and more in front of the door. So the required amount of space parallel to the door and perpendicular to the door are closely related. This makes it hard to determine the measurements of one integral user space. It may also explain why the various studies resulted in such diverse measurements. Nevertheless we tried to summarize the results of empirical research and simulation studies in a limited number of recommended measures (Table 3).

The measures of Table 3 refer to net manoeuvring space from a fixed start position (a person in a wheelchair gripping the latch to open the door) to a fixed end position (the person letting go of the latch after closing the door). The required space for approaching or leaving should be added to this manoeuvring space. The recommended measures are minimum measures for adaptable housing. For public buildings a bit more space is recommended, both because people are less accustomed with the situation and in view of the use of electric wheelchairs. The space which is required to close a door while leaving at the hinge side is very large. Therefore it is recommended to avoid such situations. For instance in case of a bathroom door opening into a corridor, one could better change the hinge side and latch side.

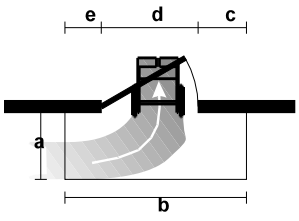
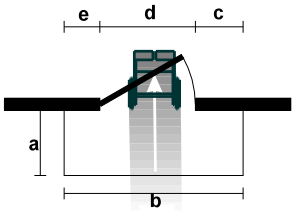
Table 2a: Space Requirements for Opening and Closing of Doors by Wheelchair Users
Door opening toward the user

Situation	Research	a	b	c	d	e	m^2
	Walter (1971)	-	-	-	-	-	-
	Brättgard (1974)	1200	2000	1100	780	-	2.4
		1400				-	2.8
	Steinfeld (1979)	1525	-	1065	760	-	2.8
	ANSI A 117.1 (1986)	1525	-	915	815	-	2.6
		(1365)		(1065)	(815)	-	2.5
	DIN 18025 (1989)	1500	1500	-	900	-	2.3
	NEN 1814 (1989)	-	-	-	-	-	
	Geboden Toegang (1990)	1950	1450	500	850	-	2.8
	Australia AS 1428.1 (1993)	1485	2220	850	760	610	3.3
		(1570)	(2270)	(810)	(850)	(610)	3.6
	Simulation studies,	1500	1500	600	850	0	2.3
	van der Voordt et al (1993)	(1250)	(1800)	(900)	(850)	(0)	2.3
		[1250]	[2100]	[1200]	[850]	[0]	2.6
		([1250])	([2900])	([0])	([850])	([2000])	3.6
	Walter (1971)	2070	1420	300	800	320	2.9
		[1870]	[2300]	[750]	[800]	[750]	4.3
	Brättgard (1974)	1200	2000	300	780	-	2.4
		1250				-	2.5
	Steinfeld (1979)	1525	-	610	760		2.1
	ANSI A 117.1 (1986)	1525	-	455	815	-	1.3
				610		-	2.2
	DIN 18025 (1989)	1500	1500	-	900		2.3
	NEN 1814 (1989)	1500	1500	500	850	-	2.3
	Geboden Toegang (1990)	1450	1450	500	850	-	2.1
	Australia AS 1428.1 (1993)	1350	1350	480	760	110	1.8
		(1350)	(1420)	(460)	(850)	(110)	1.9
	Simulation studies,	1800	1250	350	850	0	2.3
	van der Voordt et al (1993)	(1500)	(1500)	(600)	(850)	(0)	2.3
	Walter (1971)	1270	-	-	800	550	
		[1350]	[2540]	[970]	[800]	[770]	3.4
	Brättgard (1974)	1000	2200	-	780	-	2.2
		1250					2.5
	Steinfeld (1979)	1220	-	0	760	-	0.9
	ANSI A 117.1 (1986)	1220	-	610	815	-	1.7
	with door closer	1370					2.0
	DIN 18025 (1989)	1500	1500	-	900	-	2.3
	NEN 1814 (1989)	-	-	-	850	-	
	Geboden Toegang (1990)	1100	2100	1200	850	-	2.3
	Australia AS 1428.1 (1993)	1485	1720	850	760	110	2.6
		(1570)	(1770)	(810)	(850)	(110)	2.8
	Simulation studies,	1500	1500	600	850	0	2.3
	van der Voordt et al (1993)	(1800)	(1250)	(900)	(850)	(0)	2.3

Maneuvering space excluding space for approach
999 = required space for opening of doors
(999) = alternative (depending on way of approach)
999 = preferred space for opening of doors
[999] = required space for closing of doors; - = no data available

Table 2b:

Table 2b: Space Requirements for Opening and Closing of Doors by Wheelchair Users
Door opening away from the user

Situation	Research	a	b	c	d	e	m^2
	Walter (1971)	1200	1500	400	800	300	1.8
		[1970]	[3010]	[1120]	[800]	[1050]	5.9
	Brättgard (1974)	1000	1500	-	780	-	1.5
		1200					1.8
	Steinfeld (1979)	1065	-	0	810	-	0.9
	ANSI A 117.1 (1986)	1065	1370	-	815	-	1.5
	with door closer	1220					1.7
	DIN 18025 (1989)	1500	1500	-	900	100	2.3
	NEN 1814 (1989)	-	-	-	-	850	
	Geboden Toegang (1990)	1100	2000	500	850	-	2.2
	Australia AS 1428.1 (1993)	1240	1660	290	760	610	2.1
		1120	1650	190	850	610	1.8
	Simulation studies, van der Voordt et al (1993)	1100	1200	0	850	300	1.3
	Walter (1971)	[2250]	[1830]	[370]	[800]	[650]	4.1
	Brättgard (1974)	1200	1100	200	780	-	1.3
			1115				1.3
	Steinfeld (1979)	1525	-	305	760	-	1.6
	ANSI A 117.1 (1986)	1220	-	-	815	-	1.0
	with door closer			305			1.4
	DIN 18025 (1989)	1500	1500	-	900	-	2.3
	NEN 1814 (1989)	1500	1500	500	850	--	2.3
	Geboden Toegang (1990)	1150	1450	500	850	-	1.7
	Australia AS 1428.1 (1993)	1350	1240	480	760	0	1.7
		(1350)	(1310)	(460)	(850)	(0)	1.8
	Simulation studies, van der Voordt et al (1993)	1200	900	0	850	0	1.1
	Walter (1971)	1200	1500	400	800	300	1.8
		[1970]	[3010]	[1120]	[800]	[1050]	5.9
	Brättgard (1974)	1000	1550	-	780	-	1.6
		1100					1.7
	Steinfeld (1979)	1065	-	0	810	-	0.9
	ANSI A 117.1 (1986)	1065	-	610	815	-	1.5
	with door closer	1220					1.7
	DIN 18025 (1989)	1500	1500	-	900	-	2.3
	NEN 1814 (1989)	-	-	-	-	-	
	Geboden Toegang (1990)	1100	1600	700	850	-	1.8
	Australia AS 1428.1 (1993)	1285	1660	610	760	290	2.1
		(1140)	(1550)	(610)	(850)	(95)	1.8
	Simulation studies, van der Voordt et al (1993)	1100	1200	300	850	0	1.3

Maneuvering space excluding space for approach
999 = required space for opening of doors,
(999) = alternative (depending on way of approach)
999 = preferred space for opening of doors
[999] = required space for closing of doors
- = no data available

Table 3: Recommended minimum Measures for Opening and Closing of Doors

Conditions:
- wheelchairs propelled manually by the user
- space between doorframe = 900 mm; clear opening = 850 mm
- no thresholds

Methodological issues

Besides for opening and closing of doors the recommended measurements for other activities too showed to be widely divergent in various studies, standards and design guides. The major explanations for these variations appear to be:

a different basic assumptions:
for instance it makes a great deal of difference whether the design of an integral accessible toilet incorporates all methods of transfer or disregards certain transfer techniques;

b different samples;
in some studies subjects were selected at random from the disabled population, in others they were all recruited from one rehabilitation center, leading to dissimilar abilities to cope with physical barriers;

c different types of wheelchair;
some studies only include manual wheelchairs, other ones include also electric wheelchairs and push chairs, in several cases the wheelchairs used are outdated nowadays; as far back as 1966, a study by Nichols et al clearly demonstrated that about fifty per cent of the variation in space use was caused by the different sizes of wheelchairs;

d social and cultural differences;
anthropometrics, transfer techniques (inter alia by different training methods), and the relationship of fixtures differ from country to country (see table 1);

e research methods;
most studies made use of full-scale models; some studies used fixed constructions with various dimensions, others used movable partitions to vary the measurements, a few studies were executed in real-life situations; the presence of partitions, whether movable or fixed, causes people to 'shy away' for fear of bumping into them, which will slightly increase the space required compared to studies with no partitions;
another aspect is the interpretation of "fit" between the environment and the people by whom it is intended to use: standards on the basis of observed task performance may differ, according to whether the criterium is the ability to perform the task anyhow versus task performance within reasonable limits of time and strain or task performance in the way the subjects preferred;

f abstracting recommendations from research data;
some recommendations were based on minimum dimensions required by 80% of the sample, others on the criterion that 95% of the sample should be able to perform the task.

It is urgently recommended that researchers provide clear information on their basic assumptions, research protocols, subjects, wheelchairs etcetera. For reasons of comparability standards for the description of subjects and wheelchairs are important, too. The same holds true for research protocols and abstracting recommendations from research data. Developing standardized consensus based protocols could remove a lot of bias, just like standard tests do for flame spread or noise transmission.

Another observation concerns the use of computer generated drawings, which can be used as:
- a research tool to analyze space requirements, by simulation of movements and use of space,
- a tool to present research data in pictures, taking into account the dynamics of task performance by presenting various sub-activities,
- a design tool; the simulation studies are executed in AutoCad, so that a designer can include the pictures in his design drawings in order to assess accessibility issues in various design options, provided that the drawings are also executed in AutoCad.

Simulation studies can not completely replace empirical research, but should be used in combination with literature review, experts' opinions and empirical research in laboratory settings or real-life situations. In real life people are used to making a lot of adjustments, e.g. moving back and forth to fit into a small space. Simulations may exaggerate the minimum space needed if they are based on smooth movements without such adjustments. Another issue is, which tolerance should be added for the distance that people keep between themselves and walls. But simulation studies can indeed reduce the need for costly and time-consuming empirical research in full-scale models, inter alia by analyzing the influence of different wheelchair sizes on space requirements, or the influence of different ways of maneuvering. Then field experiments can be concentrated on testing design options by people with different disabilities and types of aids.

5. Towards an international research agenda

The review of completed empirical research and the simulation studies have indicated that more data are needed on the following issues:
- space requirements for use of bedrooms and bathrooms, particularly when supports and/or hoisting equipment are needed;
- space requirements for exceptionally tall or short people;
- space requirements for people in new types of electric mobility devices (e.g. scooters);
- space requirements for people with very severe disabilities, for instance people without hand and/or arm functions;
- space requirements for opening and closing of doors, including measurements on the hinge side and the latch side of the doorway;
- popularity of different transfer techniques and the feasibility of alternatives;
- application of technological innovations and the consequences for the measurements of buildings and outdoor spaces.

Knowledge on space requirements of people with different types of disabilities is extremely important with reference to adaptable renovation of the housing stock. If adaptability to the level of wheelchair use is not possible at all, one needs to know for which people with disabilities adaptability is still possible. Apart from empirical research through full-scale models and simulation studies, the study of real-life situations (e.g. in adapted or adaptable housing) should not be neglected, as these will yield invaluable information as to how people with disabilities cope with the reality of available space and appliances.

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