BARRIER-FREE HDB KITCHEN DESIGN FOR WHEELCHAIR USERS

Vol. II (Appendices)

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APPENDIX 1. SCOPE OF OPERATIONS AND THE APPLIANCES IN HDB KITCHENS

Kitchen is often used for additional purpose than cooking. According to Grandjean (1973), kitchen can be a place for eating, washing and ironing, hobbies and even children's place. The appliances in kitchen are also varied. In order to clearly define the operations and the appliances in HDB kitchens, a questionnaire was designed and a simple survey was done at the HWA.

There are six questions in the questionnaire. Twenty-five wheelchair users who lived in HDB flat took part in the survey.

The first question is: "The area of your kitchen is: a) 5-8.9 m^2; b) 9-11.9m^2; c) 12-15m^2; d) others ____ m^2". However, for this question, most of the subjects could not tell the precise area of his/her kitchen. Usually the answer was "my kitchen is small/big" and alike. It was found that 7 subjects answered that his/her kitchen is a big kitchen.

The second question is: "What kind of cooking do you often do (If you do not cook, imaging that you cook): a) light cooking; b) moderate cooking; c) heavy cooking? Why do you do this kind of cooking? _____?" For this question, 21 subjects chose the "light cooking". They explained that the light cooking was easy for them. Only 4 subjects chose the "moderate cooking". They said if they cooked for their big family the cooking was impossible to be simple. No subject selected "heavy cooking".

The third question is: "which operations are performed in your kitchen: a) cooking; b) eating; c) laundry; d) others ____". All the 25 subjects selected cooking and laundry. 5 subjects selected eating besides cooking and laundry. They explained that eating could be conducted in kitchen because their kitchens were big. None of the subjects mentioned new operations besides the listed ones.

The fourth question is: "Which appliance is in your kitchen: a) refrigerator; b) oven; c) microwave oven; d) dishwasher; e) washing machine; f) sink; g)cooker; h) others ____". All the 25 subjects selected refrigerator, sink, cooker and washing machine. 14 subjects selected microwave oven. 2 subjects selected oven. None of them selected dishwasher. None of the subjects mentioned new appliance.

The fifth question is: "Is the laundry done in your kitchen? Please state the reason(s) why the laundry is done in the kitchen or not?" All the subjects said that the laundry was done in the kitchen. Explaining the reasons, 23 subjects mentioned that the bathroom was too small to place a washing machine; 3 subjects mentioned that washing machine would be likely broken-down in bathroom; and 1 subjects mentioned that it was dangerous to place a washing machine inside the bathroom because the person can bump on it when taking a bath.

The sixth question is: "Do you do the laundry by yourself? Please state the reason(s) why you do so or not." All the 25 subjects stated that they did not do laundry because they had difficulties in doing it. 5 subjects also stated that because others did the laundry.

Based on the survey result, some conclusions could be drawn:
- Light cooking is preferred by the most of the wheelchair users.
- Besides cooking, laundry is usually done in the kitchen.
- Eating sometimes is done in the kitchen. However, it is only true when the kitchen is relatively big.

- The most used appliances in a kitchen are sink, cooker, refrigerator, and washing machine. Microwave is also often used in kitchen. Oven and dishwasher are seldom used.
- Most of the wheelchair users do not do laundry because they cannot. The laundry is usually done by other family members or maids.

Based on the survey result, the scope of the operations and appliances in HDB kitchens for wheelchair users were set. The scope was only used in this thesis for kitchen floor plan analysis and design. In practice, this scope need not be strictly followed.

The operations consist cooking and laundry

In this thesis laundry was discussed in kitchen because laundry can only be done in the kitchen. In most HDB flats the bathrooms are too small for laundry. Other rooms are not suitable for laundry because the washing machine needs to be located near water pipes for water and drainage. According Wong and Yeh (1985), the kitchen in HDB flats are specially designed for the laundry done inside. “In order to suit the habits of the residents, whose preference is that one bathroom open directly to the kitchen (so that cooking and clothes washing activities may go on simultaneously), the bathroom’s location and these wet elements related to clothes washing and drying activities were generally kept, as much as possible, to a corner of the kitchen” (Wong and Yeh, 1985). Therefore, laundry was considered as an operation in the kitchen.

Whether the laundry is done by a wheelchair user or not is determined by the wheelchair user’s own situation. If the wheelchair user lives with his/her family or a helper (friend or maid), it is not necessary for him/her to do the laundry. However, there are conditions that a wheelchair user lives alone; and because of economic reasons, he/she cannot afford hiring a maid. As a result, he/she must do the laundry by him/herself. Therefore, the kitchen should support them to do laundry independently. In this thesis, it was assumed that the laundry is done by the wheelchair users themselves.

In this thesis eating was not discussed in a kitchen for wheelchair users because of the following considerations:
(1) Eating can also be done in other rooms, such as the living room; (2) If eating is also placed in a kitchen for wheelchair users, the kitchen may be too large. It is not acceptable in HDB flats because the large kitchen may be wasteful for common family; (3) If eating is not placed in a kitchen for wheelchair users, the area for a wheelchair user’s cooking may be approximate to the area suitable for a common family’s cooking and eating. Therefore, the eating area was not considered in a kitchen for wheelchair users.

The appliances include sink, cooker, refrigerator, washing machine and microwave oven.

The sink, cooker and refrigerator are the necessary appliances for cooking. The washing machine is necessary for laundry. It is assumed that these four appliances must be placed in the kitchen. For the microwave oven, because its size is small, it can be put on the countertop or cabinet. Its location is relatively free and its impact on the kitchen floor plan is small. Therefore, the microwave oven was not analyzed through the schematic plans. However, it was tested in the mock-up kitchens too.

Oven (which is a big type under the cooker) and dishwasher were not considered because they are seldom used and not necessary.

APPENDIX 2. CONCEPTS OF THE DISABILITY, ACCESSIBLE, PERSONS WITH DISABILITIES AND WHEELCHAIR USERS

The World Health Organization (WHO) approved the International Classification of Functioning, Disability and Health (ICF) in May 2001. According to WHO (WHO, 2004), the overall aim of the ICF classification is to provide a unified and standard language and framework for the description of health and health-related states. ICF defines components of health and some health-related components of well-being (such as education and labour). The domains contained in ICF can, therefore, be seen as health domains and health-related domains. These domains are described from the perspective of the body, the individual and society in two basic lists: (1) Body Functions and Structures; and (2) Activities and Participation. As a classification, ICF systematically groups different domains for a person in a given health condition (e.g. what a person with a disease or disorder does do or can do). **Functioning** is an umbrella term encompassing all body functions, activities and participation; similarly, **disability** serves as an umbrella term for impairments, activity limitations or participation restrictions. ICF also lists environmental factors that interact with all these constructs. In this way, it enables the user to record useful profiles of individuals' functioning, disability and health in various domains.

Body functions are the physiological functions of body systems (including psychological functions).
Body structures are anatomical parts of the body such as organs, limbs and their components.
Impairments are problems in body function or structure such as a significant deviation or loss.
Activity is the execution of a task or action by an individual.
Participation is involvement in a life situation.
Activity limitations are difficulties an individual may have in executing activities.
Participation restrictions are problems an individual may experience in involvement in life situations.
Environmental factors make up the physical, social and attitudinal environment in which people live and conduct their lives.

In the latest version of the Code on Barrier-Free Accessibility in Buildings, 2002 (Building and Construction Authority, 2002), the concepts of the "accessible", "persons with disabilities" and "wheelchair user" are given as following:

"**Accessible**" describes a site, building, facility or portion thereof that complies with this Code and that can be approached, entered and used by persons with disabilities.

"**Persons with disabilities**" are persons whose mobility and use of a building are affected as a consequence of one or more of the following physical or sensory disabilities or impairments:
(a) ambulant disabled;
(b) wheelchair-bound;
(c) hearing impairment or deafness; or
(d) visual impairment or blindness.

"**Wheelchair user**" is a person who depends on a wheelchair for mobility.

APPENDIX 3. HISTORY OF BARRIER-FREE DESIGN

At the beginning of the 20th century, there were few older adults and people with disabilities. The average human lifespan was only 47 years old (LaMendola, 1998). People who got serious diseases and impairments had only a small chance of survival. But in the late 1990's, the people's average lifespan has increased to 76, mainly because of healthier living, better medicine, and vaccines and sanitation that had virtually eliminated several deadly infectious diseases. In 1997, 4 million people in the United States were over the age of 85 and about 60,000 topped age 100. By 2020, the Census Bureau in USA estimated that about 7 million to 8 million people will be over age 85 and 214,000 will be over age 100 (LaMendola, 1998).

In addition, population living with disabilities increased. A large population of veterans with disabilities was created by two world wars. More people survived accidents and illnesses which were previously fatal due to advanced antibiotics and other medical technologies. In the United States, at the end of 1994, 53.9 million people (20.6% of the population) had some level of disabilities, and 26.0 million (9.9%) had a severe disability (Story et al., 1998). It is estimated that among the population after year 2004, 8.6 million people had difficulty with one or more Activities of Daily Living (ADLs) and 4.1 million needed personal assistance of some kind (McNeil, 1997; Story et al., 1998).

The barrier-free movement began in 1950s in response to demands by disabled veterans and advocates for people with disabilities to have opportunities in education and employment. The movement called for change in public policies and design practices. Physical barriers in the environment were considered as a primary hindrance to people with mobility impairments (Story et al., 1998).

From the 1950s to the 1960s, along with the growing awareness of the need of accessibility, a number of states in USA set up their own accessibility standards (Story et al., 1998). The *Architectural Barriers Act* was put into practice, which mandated removing all the most significant obstacles to employment for people with disabilities. The act required all buildings designed, constructed, altered, or leased with federal funds to be made accessible. In 1961, the American National Standards Institute (ANSI) (1992) published the first design standard on accessibility, *Specifications for Making Buildings and Facilities Accessible to and Usable by the Physically Handicapped*. In 1980, ANSI published a revised standard to get some coherence. In 1984, based on all federal guidelines, *Uniform Federal Accessibility Standards* (UFAS) were created and the ANSI revised standards were incorporated into the UFAS too (Peterson, 1998).

In 1990 the *Americans with Disabilities Act* (ADA) was passed, and guidelines were passed in 1991 (Kearney, 1995). The law prescribed mandatory conditions for public places. It awakened widespread public awareness of the civil rights of people with disabilities and changed the way the built environment was viewed. Equal rights are ensured in employment, access to places of public accommodation, services, programs, public transportation and telecommunications. The ADA has a consistent nationwide mandate that ensures accessibility, regardless of local attitudes (Story et al., 1998).

Architectural Disability, Disablement and Enablement

Architectural disability is a version of the social model of disability. According to Goldsmith (1997),

> "*Architectural disability is, in effect, synonymous with architectural discrimination, the principle being that a building user can be discriminated against on account of a*

building feature that is disabling, whereas he would not have been had the architect, as he might have done, incorporated and enabling feature instead."

The correlation between medical disability and architectural disability is not direct. The medical disability is "*a bodily condition which people possess and always carry with them*" (Goldsmith, 1997). However, the architectural disability varies according to certain environmental circumstances. People meet building impediments which prevent them from social participation (Goldsmith, 1997). Not only persons with disabilities, but also persons with normal functions, can be architecturally disabled. For example, the mother (or father) of an infant in a pushchair can frequently be architecturally disabled by features such as steps and stairs, heavy doors, narrow doors, confined lobbies and inaccessible WC compartments.

The definition of architectural disablement offered by Goldsmith (1997) is as follows:

"*An architecturally disabled person is a person who, when using or seeking to use a building, is confronted by an impediment which would not have been there, or would not have been so irksome, had the architect who designed the building done so in a way which was responsive to his or her particular needs*."

The complementary concept is architectural enablement:

"*An architecturally enabled person is a person who, when using a building, is able to do so on account of a building feature or features without which he would not have been able to use that building, or to do so conveniently*."

According to Goldsmith (1997),

"*…by taking enabling action, the architect can be a preventative therapist; he can prevent people being disabled when they use buildings. For people with medical disabilities, his job is to avoid medical disability being compounded by architectural disability, and for those without, to ensure that architectural disablement does not occur.*" From this viewpoint, an architect could be called a 'preventative therapist'.

From these definitions, it can be easily known that a barrier-free environment is necessary for those who have physical disabilities or impairments. In a barrier-free and supportive home, a person with disability may live independently like a non-disabled person, if the accessible facilities compensate his/her body limitation.

APPENDIX 4. OBSERVATIONS IN THE FIVE INVESTIGATED KITCHENS

Investigations were conducted in five kitchens; the subjects performed certain tasks in the kitchen following the investigator's requests and the main barriers encountered by the wheelchair users were recorded. The details of the kitchens are listed in the Table A4.1.

No.	Owner's name	Age	Health status	Flat address	Flat type	Kitchen area	
1	Mr. Goh Cheng Dong	58	Stroke, Fat	Jurong West Street 81, BLK 852, 03-307	4-room flat	10.8 m^2	Unmodified
2	Ms. Nornilinda	38	Paraplegia, fat	Woolands Ave. 6, BLK 626, 07-876	4-room flat	10.22m^2	Unmodified
3	Ms. Ng Geok Hong	42	Paralysis, thin	Tampines Street 45, BLK 492C, 08-294	4-room flat	13.5m^2	Unmodified
4	Ms. Lin	32	Paraplegia, weak and thin	Toh Guan Road, BLK 273, 08-57	3-room flat	7.53 m^2 (before modification) 14.9m^2 (after modification)	Modified
5	Mr. Yusoff Bin Atan	43	Paraplegia, strong	Bedok North Ave. 1, BLK 521, 11-290	3-room flat	15.69m^2	Modified

Table A4.1: Five investigated kitchens.

1. Floor Level

Among the five kitchens, three (No. 1, 2 & 3) were not very accessible because of the threshold at the entrance from other rooms. Figure A3.1 shows the threshold between the kitchen and bathroom in Kitchen No 1. The threshold was about 12cm high. This height was impossible to access for a wheelchair. Previously, the floor of the balcony was not raised up by a board (Figure A4.1). The owner, Mr. Goh said that when he took a shower, he had to crawl down from the wheelchair in the kitchen by using a small stool, crawl across the balcony, then enter the bathroom. When he finished his shower, he crawled out and climbed up the wheelchair again with another's help. When the kitchen was investigated, the lower part of the balcony was raised up and a simple ramp was made. Mr. Goh could propel the wheelchair in the balcony and get down onto a shower stool in the bathroom (Figure A4.2). However, it was still problematic.

Figure A4.1: Thresholds between kitchen and bathroom made the bathroom inaccessible.

Figure A4.2: A simple ramp made for access.

In Ms. Lin's kitchen the floor had been raised up to the same level as the living room floor (Figure A4.3). After the modification, the kitchen could be accessed smoothly without any barriers. In Mr. Yusoff's kitchen, there had been a fall, leading to a modification of the ramp between the kitchen and the living room. The wall between the kitchen and the living room was also removed for easy movement of the wheelchair. The ramp was more than 120cm wide. The kitchen floor was 6cm lower than the floor in the living room. The gradient was about 1/10. For Mr. Yusoff, this gradient was easy to drive up in a wheelchair by himself (Figure A4.4).

Figure A4.3: In Ms. Lin's kitchen the floor had been raised up to the level of the living room.

Figure A4.4: Gradient was built between kitchen and living room (the distance between white arrows is the original door width).

2. Countertop

The countertop height of each kitchen was measured and the owner's comment was also recorded. The results are listed in Table A4.2.

Kitchen	Owner's name	Countertop height	Owner's comment
No. 1	Mr. Goh Cheng Dong	84cm	A little high
No. 2	Ms. Nornilinda	88cm	Too high
No. 3	Ms. Ng Geok Hong	89cm	Too high
No. 4	Ms. Lin	75cm	Suitable
No. 5	Mr. Yusoff Bin Atan	85cm	Suitable

Table A4.2: Heights of the countertops in the five kitchens.

The owner of Kitchen No. 3, Ms. Ng, suffered most from the high countertop. Figure A4.5 shows that she was cooking at the countertop. The pot was about 18cm high; adding the height of the cooker of about 3cm, the whole distance from the floor to the rim of the pot was around 110cm. It was impossible for her to see inside the pot so she could not know the cooking condition of the food in the pot. It was also difficult for her to stir ingredients in the pot with a ladle because she had to raise her arm very high.

Figure A4.5: (Left) high countertop was difficult for Ms. Ng to cook.
Figure A4.6: (Right) high sink was difficult to use.

Figure A4.6 shows Ms. Ng working at the sink. The sink was too high for her at a height only a little lower than her shoulder. Ms. Ng had great difficulty in reaching the bottom of the sink.

In Ms. Lin's kitchen, the countertop was newly built with the consideration of her sitting situation. The height of the countertop was 75cm, much lower than the normal countertop (the usual practice in Singapore is to set the countertop at a height of about 85-90cm from the floor). At this height, Ms. Lin could cook comfortably (Figure A4.7).

Figure A4.7: Countertop at a proper height for Ms. Lin.

In Mr. Goh's kitchen, as he commented, the countertop was a little high. In Mr. Yusoff's kitchen, the countertop was newly built and the height was suitable for him. It is interesting to note that the countertop heights in Mr. Goh' kitchen (84cm) and Mr. Yusoff's kitchen (85cm) are almost the same, yet Mr. Goh felt the countertop was a little high. This may because Mr. Goh was short and fat; therefore, he preferred a slightly lower countertop.

Besides the suitable heights, knee spaces are desirable at, or adjacent to, all major work centers / appliances in the kitchen, including the sink, cooker, countertop, etc. Deficiency in these knee spaces makes wheelchair users unable to use them frontally and hence they are used laterally.

All the five kitchens including the two modified kitchens were built without knee space. Thus the wheelchair users must sit laterally at the sink, cooker or other appliances. Figure A4.8 shows Mr. Goh brushing his teeth at the sink. Without knee space under the sink, he had to sit laterally and so it was very uncomfortable in this body posture.

Figure A4.8: Mr. Goh sat laterally when brushing his teeth.

Figure A4.9 shows Ms. Nornilinda; because she was short and plump, she was unable to reach the sink faucet when she sat laterally. When asked about how she worked at a cooker, Ms. Nornilinda let her younger brother open the cabinet under the cooker and take items out the cabinet. Then she drove her wheelchair into the cabinet. She said she usually created a knee space by this method to increase accessibility (Figure A4.10).


Figure A4.9: (Left) Ms. Nornilinda could not reach the handle of the faucet while sitting laterally at the sink.
Figure A4.10: (Right) Ms. Nornilinda sometimes created a knee space by taking items out of the cabinet.

3. Wall Cabinet and Corner Cabinet

All the wall cabinets were unreachable by the wheelchairs users in the five investigated kitchens (Figures A4.11 & A4.12). For the lower corner cabinet, the wheelchair users had great difficulty in reaching objects (Figures A4.13 & A4.14).


Figure A4.11: (Left) wall shelves and cabinets were difficult to reach.
Figure A4.12: (Right) Ms. Lin used a stick with hook to open the wall cabinet door to 'see' items stored inside.

Figure A4.13: (Left) it was difficult to reach the corner cabinet for wheelchair users.
Figure A4.14: (Right) lowest drawers were difficult to reach for wheelchair users.

Table A4.3 shows the heights of the bottoms of the wall cabinets in the five kitchens. Except for Kitchen No. 1, all the wall cabinets were unreachable by the owners.

Kitchen	Owner's name	Height of the wall cabinet bottom	Owner's comment
No. 1	Mr. Goh Cheng Dong	No wall cabinet	/
No. 2	Ms. Nornilinda	155cm	Unreachable
No. 3	Ms. Ng Geok Hong	134cm	Unreachable
No. 4	Ms. Lin	135cm	Unreachable
No. 5	Mr. Yusoff Bin Atan	150cm	Unreachable

Table A4. 3: Heights of the bottoms of the wall cabinets.

4. Ventilation hoods, Sockets and Switches

In the two modified kitchens, the ventilation hoods were lowered so that the users could reach them. Figure A4.15 shows Mr. Yusoff switching off the hood. The hood suspended on the cooker was lowered so Mr. Yusoff could reach it.

Figure A4. 15: Lowered hood was easy to reach.

In the unmodified kitchens, the ventilation hoods were mounted too high for wheelchair users to reach. Figure A4.16 shows that Ms. Ng could not reach the hood's switch.

Figure A4.16: (Left) hood was too high to reach.
Figure A4.17: (Right) switches were too high to reach.

The heights of the ventilation hoods in the five kitchens are listed in Table A4.4.

Kitchen	Owner's name	Height of the switches/sockets	Owner's comment
No. 1	Mr. Goh Cheng Dong	145cm	Unreachable
No. 2	Ms. Nornilinda	150cm	Unreachable
No. 3	Ms. Ng Geok Hong	145cm	Unreachable
No. 4	Ms. Lin	115cm	Reachable
No. 5	Mr. Yusoff Bin Atan	120cm	Reachable

Table A4.4: Heights of the ventilation hoods.

The sockets and switches on the wall behind the countertop were very difficult to reach by all the wheelchair users. They were often highly installed, and because of the countertop beneath them, a wheelchair user could not get close to them. As a result, they became even impossible to reach. Figure A4.17 shows that Ms. Nornilinda tried to switch off the electric-cooker by using a plastic stick.

5. Washing and Drying Clothes

In the five houses, all the washing machines were placed in the kitchen. In fact, it is common for laundry to be done in the kitchen in HDB flats.

In the five kitchens investigated, all the washing machines were top-loaded. The opening was too high and it was impossible for wheelchair users to take the washed clothes out of the washing machine. Thus the wheelchair users did not use them (Figure A4.18).

Figure A4.18: Top-loaded washing machine is difficult for wheelchair users to use.

Drying clothes was also impossible for the five wheelchair users. Most Singapore residents in HDB flats use bamboo poles to hang out clothes for drying. The bamboo poles are inserted in short metal tubes (Figure A4.19). For wheelchair users, it is impossible to hang the bamboo poles out with wet clothes through the window.

Figure A4.19: Metal tubes for inserting in bamboo poles.

On rainy days, the clothes are often hung inside the kitchen. But the clothes hanging device was too high for the wheelchair users to reach (Figure A4.20).

Figure A4.20: Hanging device was too high for wheelchair users to reach.

APPENDIX 5. ANTHROPOMETRY PRINCIPLES

Anthropometry is the branch of ergonomics which deals with body measurements, particularly those of size, strength and physical capacity. The term 'anthropometry' is derived from two Greek works: *anthropo(s*)- human, and *metricos*- of, or pertaining to, measurement. According to Damon (1973), *"Anthropometry refers to human body measurement, with which the equipment designer is mainly concerned. Such measurement includes body dimensions and the strength, speed, and range of motions."*

For a population, when considering body dimensions, there is a wide variation between members. Because the population does exhibit such variability in body dimensions, it is normal to indicate both some average figure and the extent of the variability within the population studied whilst reporting anthropometric data. In most ergonomics applications, it is necessary to make provision for the range of variability, in a particular characteristic, which can be encountered in a user population. The normal distribution, a mathematical function which has the form of a bell-shaped curve (see Figure A5.1), may generally describe the variability. Plotted horizontally is the magnitude of the dimension concerned. Plotted vertically is the frequency with which we would expect to encounter a person of that particular size, (or the probability of encountering such a person). The normal distribution is very common in biology in general and anthropometry in particular. It is empirically true that most anthropometric variables conform quite closely to the normal distribution (Pheasant, 1986, p13). The curve is symmetrical about the average (or mean) value which is also the point of maximum probability. This point is called 50^{th} percentile because 50% of the population is smaller than the average value. Ninety percent of the population is between the 5^{th} and 95^{th} percentile.

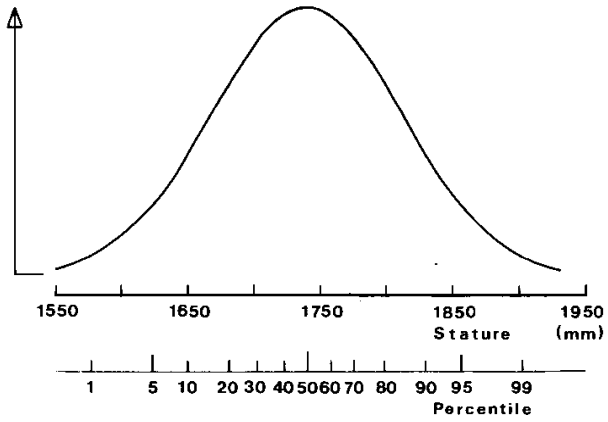


Figure A5. 1. An example of the normal or Gaussian distribution (source: Pheasant, 1986).

There are two important parameters. One is the *mean*, which determines where the distribution is located on the horizontal axis. The other is the *standard deviation* (s), which is an index of the degree of variability in the population concerned, i.e., the "width" of the distribution or the extent to which individual values are scattered about or deviate from the mean. The Standard deviation (s) of a sample of individuals drawn from a population is given by the equation

$$s = \sqrt{\frac{\sum (x-m)^2}{n}}$$

where ***m*** is the mean, ***x*** is any individual value of the dimension concerned and ***n*** is the number of subjects in the sample.

A normal distribution can be completely defined by the mean and standard deviation. If they are known, any percentile of the distribution can be calculated without further reference to the original measurements of individual people. The *p*th percentile of a variable is given by

$$X_p = m + sz$$

where z is a constant for the percentile concerned, which can be looked up in a statistical table (Table A5.1).

p *and* z *values of the normal distribution.*

p	*z*	*p*	*z*	*p*	*z*	*p*	*z*
1	−2·33	26	−0·64	51	0·03	76	0·71
2	−2·05	27	−0·61	52	0·05	77	0·74
3	−1·88	28	−0·58	53	0·08	78	0·77
4	−1·75	29	−0·55	54	0·10	79	0·81
5	−1·64	30	−0·52	55	0·13	80	0·84
6	−1·55	31	−0·50	56	0·15	81	0·88
7	−1·48	32	−0·47	57	0·18	82	0·92
8	−1·41	33	−0·44	58	0·20	83	0·95
9	−1·34	34	−0·41	59	0·23	84	0·99
10	−1·28	35	−0·39	60	0·25	85	1·04
11	−1·23	36	−0·36	61	0·28	86	1·08
12	−1·18	37	−0·33	62	0·31	87	1·13
13	−1·13	38	−0·31	63	0·33	88	1·18
14	−1·08	39	−0·28	64	0·36	89	1·23
15	−1·04	40	−0·25	65	0·39	90	1·28
16	−0·99	41	−0·23	66	0·41	91	1·34
17	−0·95	42	−0·20	67	0·44	92	1·41
18	−0·92	43	−0·18	68	0·47	93	1·48
19	−0·88	44	−0·15	69	0·50	94	1·55
20	−0·84	45	−0·13	70	0·52	95	1·64
21	−0·81	46	−0·10	71	0·55	96	1·75
22	−0·77	47	−0·08	72	0·58	97	1·88
23	−0·74	48	−0·05	73	0·61	98	2·05
24	−0·71	49	−0·03	74	0·64	99	2·33
25	−0·67	50	0	75	0·67		

p	*z*	*p*	*z*
2·5	−1·96	97·5	1·96
0·5	−2·58	99·5	2·58
0·1	−3·09	99·9	3·09
0·01	−3·72	99·99	3·72
0·001	−4·26	99·999	4·26

Table A5.1. P and Z values of the normal distribution (source: Pheasant, 1986).

Accuracy

According to Damon et al., (Damon, Stoudt & McFarland, 1971), the average (mean) value, the standard deviation (s.d.), or some percentile within ±E units, have the equation:

$$N = \frac{K(s.d.)^2}{E^2}$$

Where K = 4 for the mean;
K = 2 for the standard deviation;
K = 7 for percentiles from the 30th through 70th;
K = 8 for the 20th, 25th, 75th, and 80th percentiles;
K = 12 for the 10th and 90th percentiles;
K = 18 for the 5th and 95th percentiles.
N is the sample size.

Therefore, if the mean value, s.d. and sample size are known, the E can be calculated using the following equation:

$$E = \sqrt{\frac{K(s.d.)^2}{N}}$$

For the pilot anthropometric studies wheelchair users, the accuracy of each measurement is calculated and shown in the result tables.

APPENDIX 6. METHODS FOR MEASURING THE REACHES

1. Upward reach


Figure A6.1: (Left) maximum upward reach.
Figure A6.2: (Right) comfortable upward reach.

Figure A6.1 shows the measurement of the maximum upward reach. The subject sat in a wheelchair and raised his/her arm as high as he/she could. Then the grasp reach was recorded from the grid board. The comfortable reach was measured in the same way (Figure A6.2) except that the subject sat erect in his/her chair and lifted his/her arm vertically upwards without stretching. These two dimensions are important to understanding how high a wheelchair user can reach.

2. Up-forward reach to a wall

Figure A6.3 shows a subject making a maximum up-forward reach to a wall. Figure A6.4 shows a subject making a comfortable up-forward reach to a wall. These two dimensions are important in understanding whether a wheelchair user can reach a target on a wall or on other objects alike. The target could be a door handle, a switch/outlet and a shelf etc.


Figure A6.3: (Left) maximum up-forward reach to a wall.
Figure A6.4: (Right) comfortable up-forward reach to a wall.

3. Down-forward reach to a wall

Figure A6.5 shows the subject making a maximum down-forward reach to a wall. Figure A6.6 shows the subject making a comfortable down-forward reach to a wall. These two dimensions are important in understanding how low a wheelchair user can reach a target on a wall or other objects alike.


Figure A6.5: (Left) maximum down-forward reach to a wall.
Figure A6.6: (Right) comfortable down-forward reach to a wall.

4. Downward reach laterally

Figure A6.7 shows the subject making a maximum downward reach laterally. Figure A6.8 shows the subject making a comfortable downward reach laterally. These two dimensions are important in understanding whether a wheelchair user can reach a target below laterally.


Figure A6.7: (Left) maximum downward reach laterally.
Figure A6.8: (Right) comfortable downward reach laterally.

5. Forward reach over a table

Figure A6.9 shows the measurement of the maximum forward reach over a table. The table was set at a height of 86cm. The reason for choosing this height was that it is the maximum height of an obstruction which is recommended in **Singapore Guidelines** (Building and Construction Authority, 2002). Figure A6.10 shows the measurement of the comfortable forward reach over a table. These two dimensions are important in understanding how far a wheelchair user can reach over an obstruction.


Figure A6.9: (Left) maximum forward reach over a table.
Figure A6.10: (Right) comfortable forward reach over a table.

6. Lateral reach over a table

Figure A6.11 shows the measurement of the maximum lateral reach over a table. The table was also set at the height of 86cm. Figure A6.12 shows the measurement of the comfortable lateral reach over a table. These two dimensions are important in understanding whether a wheelchair user can reach a target laterally over an obstruction.

Figure A6.11: (Left) maximum lateral reach over a table.
Figure A6.12: (Right) comfortable lateral reach over a table.

When the subjects made lateral reaches, the plane of the wheelchair hand rim was in line with the edge of the measuring board (Figure A6.13). In reality when a wheelchair user makes a lateral reach over an obstruction, there is often no knee space provided under the obstruction. Therefore, when the lateral reaches were measured, no part of the wheelchair was under the obstruction.

Figure A6.13: Location of the wheelchair hand rim.

APPENDIX 7. ANTHROPOMETRIC DATA OF THE 32 WHEELCHAIR USERS (TABLES)

1. Upward Reach

		Minimum	Maximum	Mean	Accuracy	SD.	5th	50th	95th
Male	Max.	140.0	168.0	154.6	±4.34	8.68	140.0	155.0	168.0
	Com.	130.0	165.0	147.9	±5.07	10.14	130.0	147.5	165.0
Female	Max.	135.0	158.0	146.0	±3.43	6.85	135.0	145.5	158.0
	Com.	128.0	155.0	139.6	±3.90	7.79	128.0	139.5	155.0
Total	Max.	135.0	168.0	150.3	±4.42	8.84	136.3	150.0	167.4
	Com.	128.0	165.0	143.8	±4.93	9.86	128.6	143.0	162.4

Table A7.1: Measurement results of the upward reach.

2. Forward Reach over a Table

		Minimum	Maximum	Mean	Accuracy	SD.	5th	50th	95th
Male	Max.	53.0	72.0	64.1	±3.06	6.12	53.0	64.0	72.0
	Com.	43.0	55.0	50.3	±2.03	4.05	43.0	52.0	55.0
Female	Max.	50.0	70.0	63.6	±2.76	5.51	50.0	65.0	70.0
	Com.	46.0	54.0	51.4	±1.08	2.16	46.0	51.5	54.0
Total	Max.	50.0	72.0	63.9	±2.87	5.73	52.0	64.0	71.4
	Com.	43.0	55.0	50.8	±1.62	3.23	43.0	52.0	55.0

Table A7.2: Measurement results of the forward reach over a table.

3. Up-forward Reach to a Wall

		Minimum	Maximum	Mean	Accuracy	SD.	5th	50th	95th
Male	Max.	125.0	153.0	141.9	±4.03	8.06	125.0	153.0	153.0
	Com.	115.0	140.0	130.6	±3.00	6.00	115.0	130.5	140.0
Female	Max.	121.0	148.0	132.7	±3.68	7.35	121.0	133.0	148.0
	Com.	110.0	139.0	124.7	±4.03	8.05	110.0	123.0	139.0
Total	Max.	121.0	153.0	137.3	±4.47	8.93	121.7	137.5	151.1
	Com.	110.0	140.0	127.6	±3.80	7.59	112.6	130.0	139.4

Table A7. 3: Measurement results of the up-forward reach to a wall.

4. Down-forward Reach to a Wall

		Minimum	Maximum	Mean	Accuracy	SD.	5th	50th	95th
Male	Max.	15.0	35.0	23.6	±3.19	6.38	15.0	21.5	35.0
	Com.	27.0	42.0	34.1	±2.25	4.49	27.0	35.0	42.0
Female	Max.	10.0	35.0	19.4	±2.56	5.11	10.0	20.0	35.0
	Com.	25.0	42.0	33.8	±2.52	5.04	25.0	35.0	42.0
Total	Max.	10.0	35.0	21.5	±3.03	6.06	13.3	20.0	35.0
	Com.	25.0	42.0	33.9	±2.35	4.70	25.0	35.0	42.0

Table A7. 4: Measurement results of the down-forward reach to a wall.

5. Downward Reach Laterally

		Minimum	Maximum	Mean	Accuracy	SD.	5th	50th	95th
Male	Max.	10.0	32.0	22.5	±3.95	7.89	10.0	23.5	32.0
	Com.	30.0	42.0	36.8	±1.56	3.11	30.0	37.0	42.0
Female	Max.	12.0	29.0	21.4	±2.36	4.72	12.0	21.0	29.0
	Com.	25.0	41.0	34.4	±2.31	4.62	25.0	35.5	41.0
Total	Max.	10.0	32.0	21.9	±3.21	6.42	10.0	21.5	30.7
	Com.	25.0	41.0	35.6	±2.03	4.05	28.3	36.5	41.4

Table A7. 5: Measurement results of downward reach laterally.

6. Lateral Reach over a Table

		Minimum	Maximum	Mean	Accuracy	SD.	5th	50th	95th
Male	Max.	53.0	70.0	64.5	±2.56	5.11	53.0	65.5	70.0
	Com.	48.0	60.0	53.5	±1.95	3.90	48.0	52.5	60.0
Female	Max.	50.0	68.0	61.3	±2.80	5.60	50.0	60.5	68.0
	Com.	41.0	59.0	50.2	±2.67	5.34	41.0	50.0	59.0
Total	Max.	50.0	70.0	62.9	±2.77	5.53	52.0	65.0	69.4
	Com.	41.0	60.0	51.8	±2.45	4.90	42.3	51.0	59.4

Table A7. 6: Measurement results of lateral reach over a table.

7. Knee Height

	Minimum	Maximum	Mean	Accuracy	SD.	5th	50th	95th
Male	57.0	70.0	64.1	±1.84	3.67	57.0	65.5	70.0
Female	53.0	68.0	60.2	±2.15	4.29	53.0	60.0	68.0
Total	53.0	70.0	62.2	±2.21	4.41	53.7	62.5	68.7

Table A7. 7: Measurement results of the knee height.

8. Armrest Height

	Minimum	Maximum	Mean	Accuracy	SD.	5th	50th	95th
Total	58.0	75.0	68.9	±2.02	4.03	61.9	69.0	75.0

Table A7. 8: Measurement result of the wheelchair armrest height.

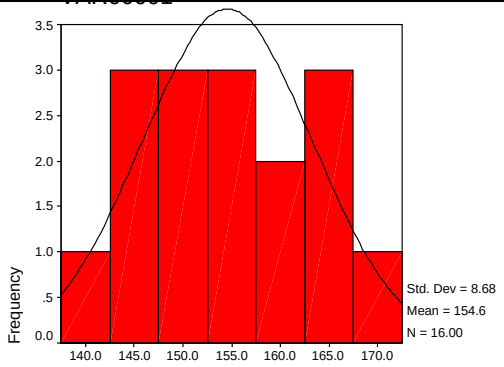
APPENDIX 8. ANTHROPOMETRIC DATA OF THE 16 MALE WHEELCHAIR USERS

	Age	Nation	Health condition	Up reach		Forward reach (over a table)		Up-forward reach to a wall		Down-forward reach to a wall		Downward reach (lateral)		Lateral reach (over a table)		Sitting height	Knee height	Wheelchair rest height
				Max	Com	Max	Com	Max	Com	Max	Com	Max	Com	Max	Com			
M1	35	Ch	Hemiplegia	165	160	72	55	150	125	16	28	30	40	67	58	133	62	65
M2	25	Ch	Neurological disorder	168	165	66	52	153	130	35	42	32	42	69	60	140	66	75
M3	36	Ch	Cerebral palsy	143	139	63	50	135	131	27	36	14	38	63	55	110	57	72
M4	48	Ch	Paraplegia	150	145	70	55	138	133	22	35	10	36	65	52	127	57	69
M5	53	Ch	Neurological disorder	161	150	70	53	146	140	30	38	22	40	68	57	130	66	68
M6	26	Ch	Rt. hemiplegia	167	161	64	52	150	130	33	39	30	40	70	59	131	66	72
M7	63	Ch	Chronic neurological condition	156	153	71	54	146	136	15	27	20	32	65	50	123	67	69
M8	42	Ch	Head injury	158	155	68	52	148	138	28	36	30	38	65	51	128	68	68
M9	57	Ch	Paraplegia	145	135	60	46	137	131	19	31	20	38	55	49	130	66	65
M10	64	Ma	Above knee amputee	140	135	54	43	125	115	20	35	28	30	53	48	126	66	65
M11	37	Ch	Paraplegia	163	156	64	49	147	135	28	30	14	35	68	57	130	63	75
M12	58	Ch	Head injury	156	150	53	45	148	133	29	40	15	35	69	56	128	64	68
M13	21	Ma	Rheumatoid arthritis	154	145	70	54	145	130	19	29	10	37	67	53	129	65	58
M14	61	Ch	Amputee	150	145	63	50	135	129	21	34	30	35	65	50	124	63	69
M15	34	In	Paraplegia	150	143	63	52	138	130	18	35	30	37	66	51	120	60	69
M16	45	Ch	Lt. hemiplegia	147	130	55	43	130	123	17	30	25	35	57	50	125	70	65

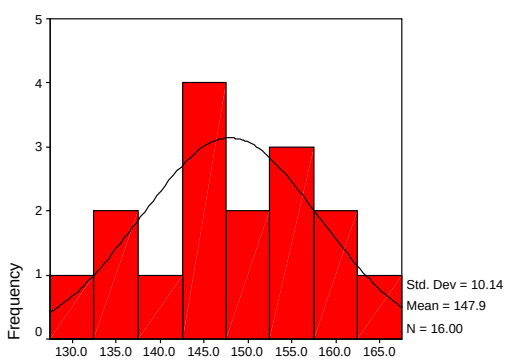
Table A8.1 Measurement result of the male wheelchair users (Ch-Chinese, Ma-Malays, In-Indians) (unit: cm).

Statistics

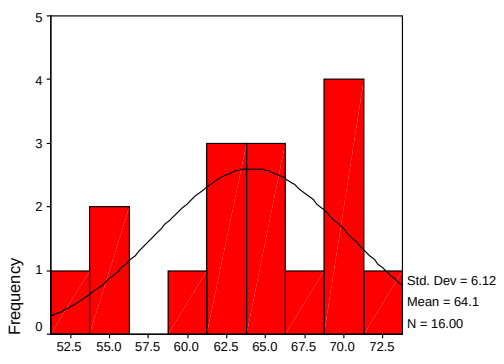
Up reach (Max)		
N	Valid	16
	Missing	0
Mean		154.6
Std. Deviation		8.68
Variance		75.3
Range		28.0
Minimum		140.0
Maximum		168.0
Percentiles	5	140.0
	50	155.0
	95	168.0



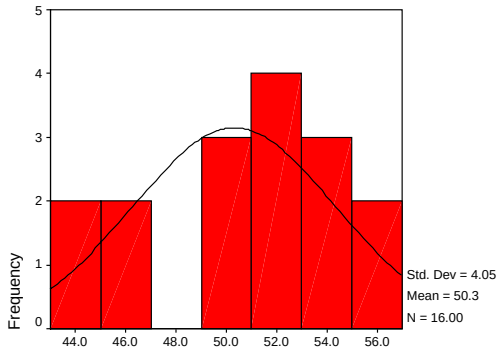
Up reach (Com)		
N	Valid	16
	Missing	0
Mean		147.9
Std. Deviation		10.14
Variance		102.9
Range		35.0
Minimum		130.0
Maximum		165.0
Percentiles	5	130.0
	50	147.5
	95	165.0



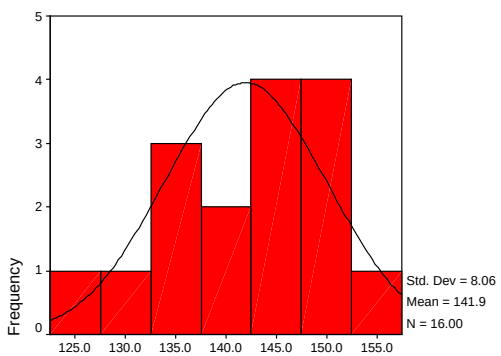
Forward reach over a table(Max)		
N	Valid	16
	Missing	0
Mean		64.1
Std. Deviation		6.12
Variance		37.5
Range		19.0
Minimum		53.0
Maximum		72.0
Percentiles	5	53.0
	50	64.0
	95	72.0



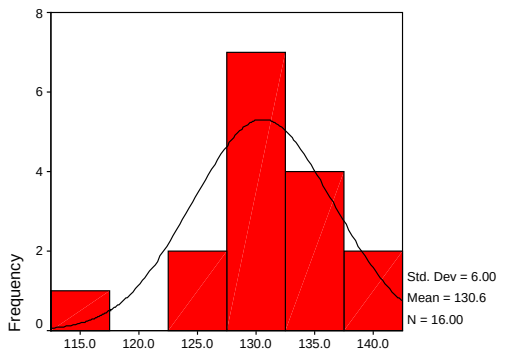
Forward reach over a table (Com)		
N	Valid	16
	Missing	0
Mean		50.3
Std. Deviation		4.05
Variance		16.4
Range		12.0
Minimum		43.0
Maximum		55.0
Percentiles	5	43.0
	50	52.0
	95	55.0



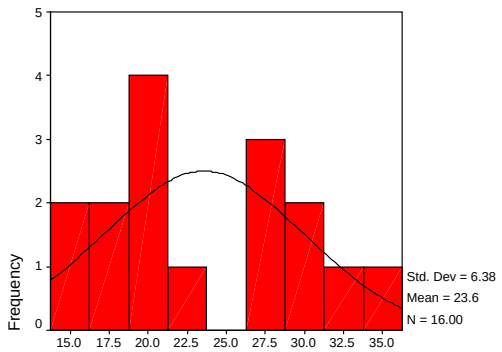
Up-forward reach to a wall (Max)		
N	Valid	16
	Missing	0
Mean		141.9
Std. Deviation		8.06
Variance		65.0
Range		28.0
Minimum		125.0
Maximum		153.0
Percentiles	5	125.0
	50	145.5
	95	153.0



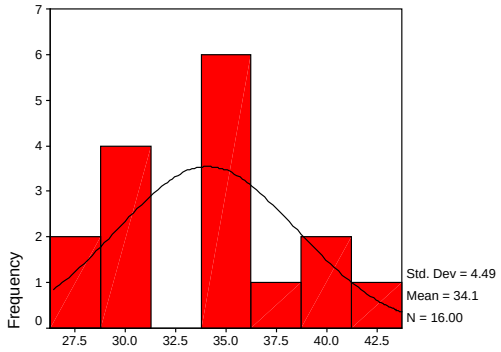
Up-forward reach to a wall (Com)		
N	Valid	16
	Missing	0
Mean		130.6
Std. Deviation		6.00
Variance		36.0
Range		25.0
Minimum		115.0
Maximum		140.0
Percentiles	5	115.0
	50	130.5
	95	140.0



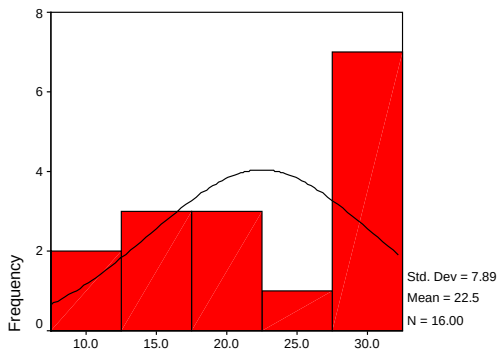
Downward reach to a wall (Max)		
N	Valid	16
	Missing	0
Mean		23.6
Std. Deviation		6.38
Variance		40.7
Range		20.0
Minimum		15.0
Maximum		35.0
Percentiles	5	15.0
	50	21.5
	95	35.0



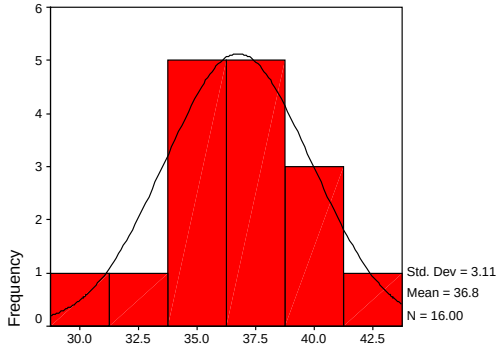
Downward reach to a wall (Com)		
N	Valid	16
	Missing	0
Mean		34.1
Std. Deviation		4.49
Variance		20.2
Range		15.0
Minimum		27.0
Maximum		42.0
Percentiles	5	27.0
	50	35.0
	95	42.0



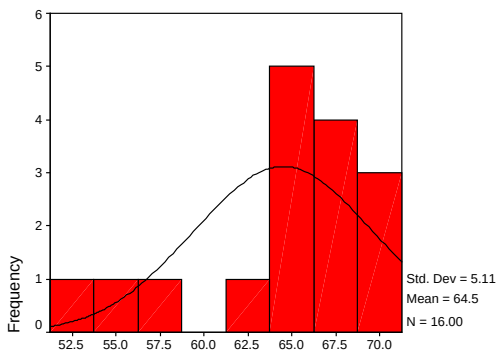
Lateral downward reach (Max)		
N	Valid	16
	Missing	0
Mean		22.5
Std. Deviation		7.89
Variance		62.3
Range		22.0
Minimum		10.0
Maximum		32.0
Percentiles	5	10.0
	50	23.5
	95	32.0



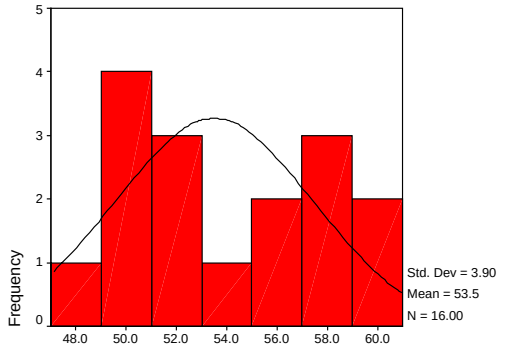
Lateral downward reach (Com)		
N	Valid	16
	Missing	0
Mean		36.8
Std. Deviation		3.11
Variance		9.7
Range		12. 0
Minimum		30.0
Maximum		42.0
Percentiles	5	30.0
	50	37.0
	95	42.0



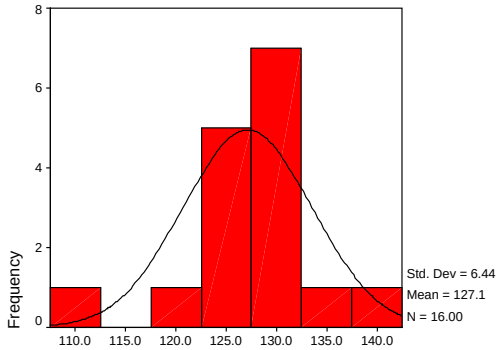
Lateral reach over a table (Max)		
N	Valid	16
	Missing	0
Mean		64.5
Std. Deviation		5.11
Variance		26.1
Range		17.0
Minimum		53.0
Maximum		70.0
Percentiles	5	53.0
	50	65.5
	95	70.0



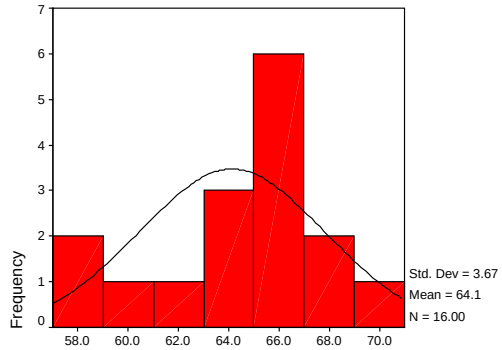
Lateral reach over a table (Com)		
N	Valid	16
	Missing	0
Mean		53.5
Std. Deviation		3.90
Variance		15.2
Range		12.0
Minimum		48.0
Maximum		60.0
Percentiles	5	48.0
	50	52.5
	95	60.0



Sitting height		
N	Valid	16
	Missing	0
Mean		127.1250
Std. Deviation		6.43817
Variance		41.45000
Range		30.00
Minimum		110.00
Maximum		140.00
Percentiles	5	110.0000
	50	128.0000
	95	140.0000



Knee height		
N	Valid	16
	Missing	0
Mean		64.1250
Std. Deviation		3.66742
Variance		13.45000
Range		13.00
Minimum		57.00
Maximum		70.00
Percentiles	5	57.0000
	50	65.5000
	95	70.0000



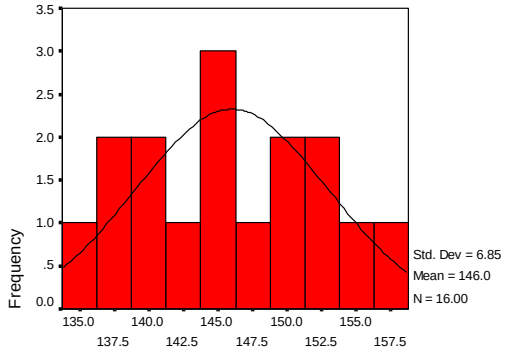
APPENDIX 9. ANTHROPOMETRIC DATA OF THE 16 FEMALE WHEELCHAIR USERS

	Age	Nation	Health condition	Up reach		Forward reach (over a table)		Up-forward reach to a wall		Down-forward reach to a wall		Downward reach (lateral)		Lateral reach (over a table)		Sitting height	Knee height	Wheelchair rest height
				Max	Com	Max	Com	Max	Com	Max	Com	Max	Com	Max	Com			
F1	45	Ch	Cerebral palsy	140	130	55	50	132	123	20	27	25	30	55	49	125	58	72
F2	42	Ch	Neurological disorder	135	129	50	46	123	119	15	35	25	37	50	46	120	54	69
F3	56	In	Lt. Hemiplegia with Rt. Amputee	155	150	68	50	140	132	20	35	21	38	67	50	117	68	73
F4	31	Ch	Head injury	148	143	68	50	134	129	35	40	25	30	68	58	130	58	65
F5	61	Ch	Rt. hemiplegia	150	143	67	51	138	132	18	36	22	38	62	55	110	58	75
F6	68	Ch	Rt. hemiplegia	151	142	61	52	130	123	20	35	21	31	60	52	114	64	75
F7	31	Ch	Cerebral Palsy	145	139	63	50	135	130	15	31	25	40	65	59	123	62	73
F8	25	Ch	Paraplegia	158	155	70	53	148	139	20	36	21	38	68	57	121	63	72
F9	44	Ma	paraplegia	152	147	69	54	138	132	20	37	18	39	67	50	122	61	72
F10	29	Ch	Above knee amputee	145	140	68	53	137	133	18	34	28	32	68	51	120	60	70
F11	21	Ch	Paraplegia	140	132	64	50	121	110	19	39	20	36	60	49	107	60	64
F12	63	Ch	Chronic Neurological condition	153	146	66	52	139	120	23	42	29	41	61	48	122	68	71
F13	33	Ch	Paraplegia	146	135	66	54	129	123	20	25	12	25	60	52	115	57	65
F14	53	Ch	Amputee	138	135	61	50	129	114	10	33	14	31	55	43	110	57	65
F15	57	Ma	Rheumatoid arthritis	137	128	58	53	122	116	18	30	18	35	55	41	109	53	68
F16	48	Ch	Lt. hemiplegia	143	139	64	54	128	120	20	25	18	30	59	43	110	62	65

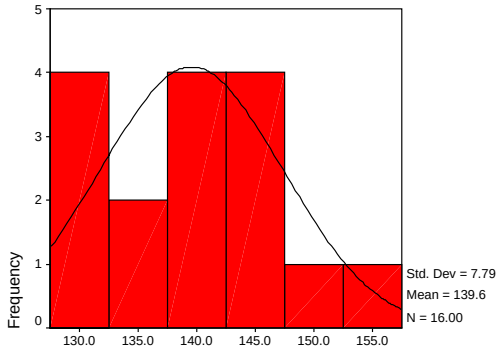
Table A9.1 Measurement result of the male wheelchair users (Ch-Chinese, Ma-Malays, In-Indians) (unit: cm).

Statistics

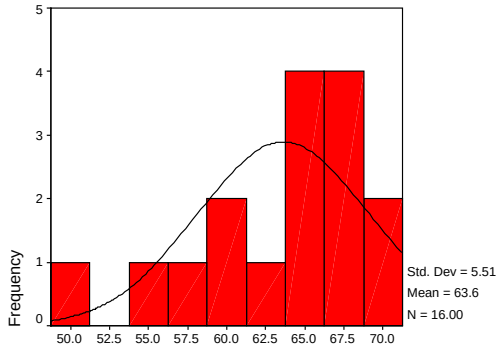
Up reach (Max)		
N	Valid	16
	Missing	0
Mean		146.0
Std. Deviation		6.85
Variance		46.9
Range		23. 0
Minimum		135.0
Maximum		158.0
Percentiles	5	135.0
	50	145.5
	95	158.0



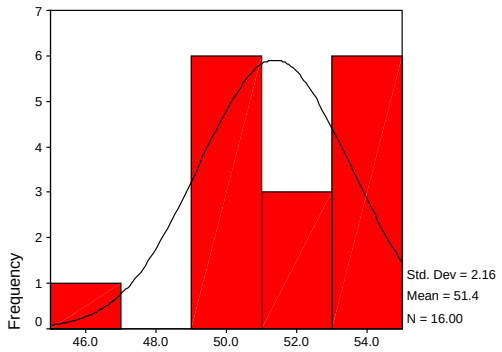
Up reach (Com)		
N	Valid	16
	Missing	0
Mean		139.6
Std. Deviation		7.79
Variance		60.7
Range		27.0
Minimum		128.0
Maximum		155.0
Percentiles	5	128.0
	50	139.5
	95	155.0



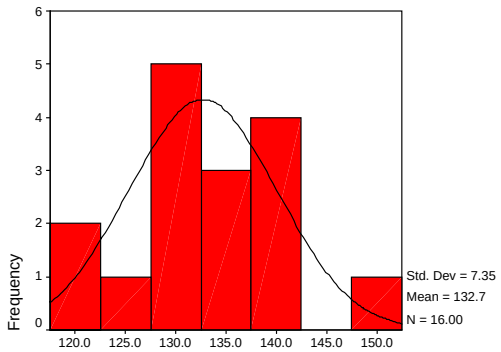
Forward reach over a table(Max)		
N	Valid	16
	Missing	0
Mean		63.6
Std. Deviation		5.51
Variance		30.4
Range		20.0
Minimum		50.0
Maximum		70.0
Percentiles	5	50.0
	50	65.0
	95	70.0



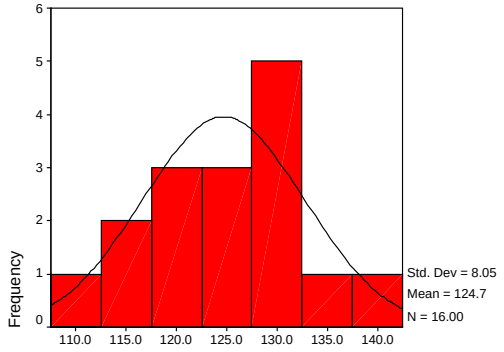
Forward reach over a table (Com)		
N	Valid	16
	Missing	16
Mean		51.4
Std. Deviation		2.16
Variance		4.7
Range		8.0
Minimum		46.0
Maximum		54.0
Percentiles	5	46.0
	50	51.5
	95	54.0



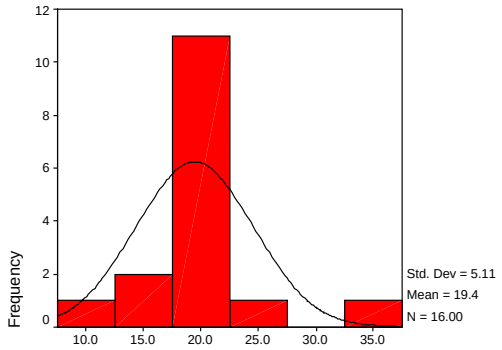
Up-forward reach to a wall (Max)		
N	Valid	16
	Missing	16
Mean		132.7
Std. Deviation		7.35
Variance		54.1
Range		27.0
Minimum		121.0
Maximum		148.0
Percentiles	5	121.0
	50	133.0
	95	148.0



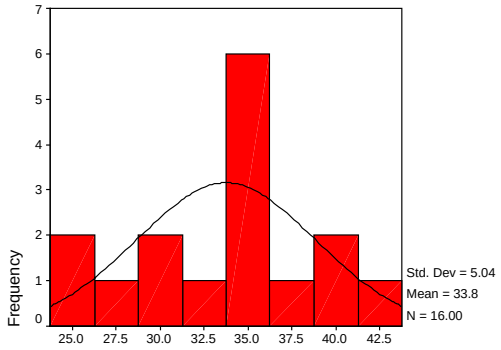
Up-forward reach to a wall (Com)		
N	Valid	16
	Missing	16
Mean		124.7
Std. Deviation		8.05
Variance		64.8
Range		29.0
Minimum		110.0
Maximum		139.0
Percentiles	5	110.0
	50	123.0
	95	139.0



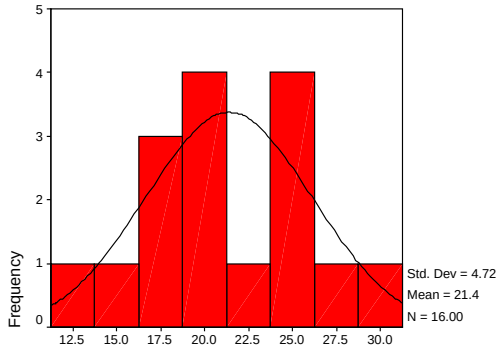
Downward reach to a wall (Max)		
N	Valid	16
	Missing	16
Mean		19.4
Std. Deviation		5.11
Variance		26.1
Range		25.0
Minimum		10.0
Maximum		35.0
Percentiles	5	10.0
	50	20.0
	95	35.0



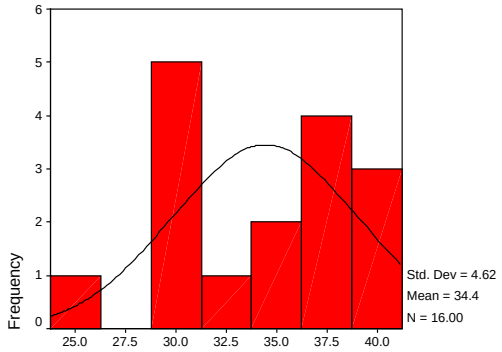
Downward reach to a wall (Com)		
N	Valid	16
	Missing	16
Mean		33.8
Std. Deviation		5.04
Variance		25.4
Range		17.0
Minimum		25.0
Maximum		42.0
Percentiles	5	25.0
	50	35.0
	95	42.0



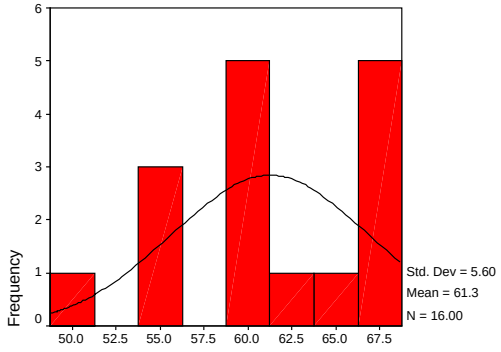
Lateral downward reach (Max)		
N	Valid	16
	Missing	16
Mean		21.4
Std. Deviation		4.72
Variance		22.3
Range		17.0
Minimum		12.0
Maximum		29.0
Percentiles	5	12.0
	50	21.0
	95	29.0



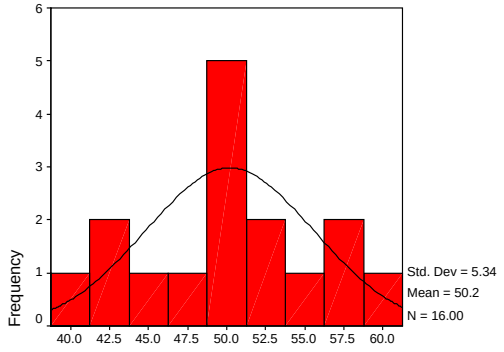
Lateral downward reach (Com)		
N	Valid	16
	Missing	16
Mean		34.4
Std. Deviation		4.62
Variance		21.3
Range		16.0
Minimum		25.0
Maximum		41.0
Percentiles	5	25.0
	50	35.5
	95	41.0



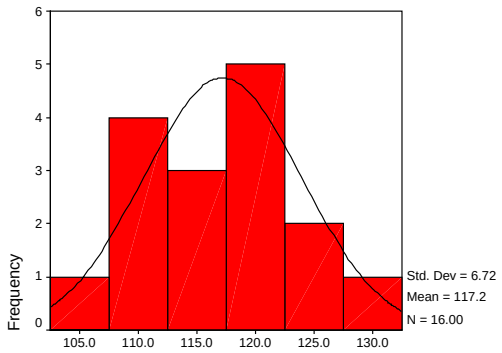
Lateral reach over a table (Max)		
N	Valid	16
	Missing	16
Mean		61.3
Std. Deviation		5.60
Variance		31.4
Range		18.0
Minimum		50.0
Maximum		68.0
Percentiles	5	50.0
	50	60.5
	95	68.0



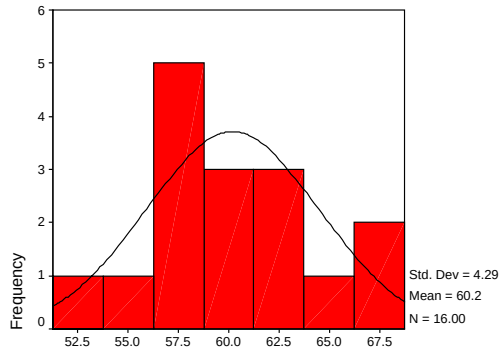
Lateral reach over a table (Com)		
N	Valid	16
	Missing	16
Mean		50.2
Std. Deviation		5.34
Variance		28.6
Range		18.0
Minimum		41.0
Maximum		59.0
Percentiles	5	41.0
	50	50.0
	95	59.0



Sitting height		
N	Valid	16
	Missing	16
Mean		117.2
Std. Deviation		6.72
Variance		45.1
Range		23.0
Minimum		107.0
Maximum		130.0
Percentiles	5	107.0
	50	118.5
	95	130.0

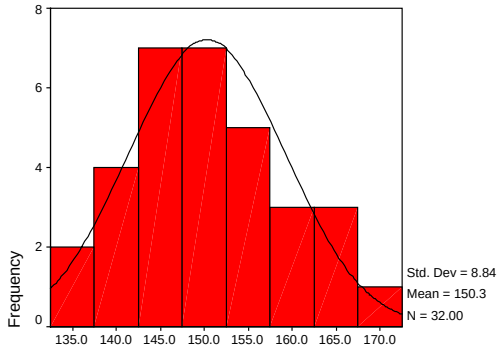


Knee height		
N	Valid	16
	Missing	16
Mean		60.2
Std. Deviation		4.29
Variance		18.4
Range		15.0
Minimum		53.0
Maximum		68.0
Percentiles	5	53.0
	50	60.0
	95	68.0

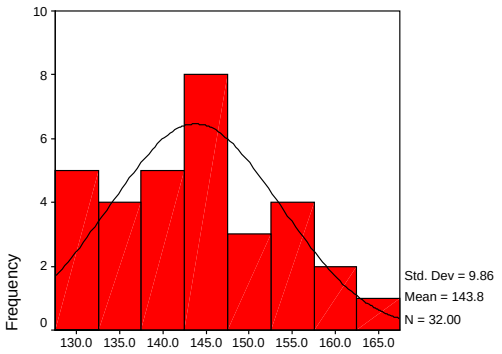


APPENDIX 10. ANTHROPOMETRIC DATA OF THE 32 WHEELCHAIR USERS

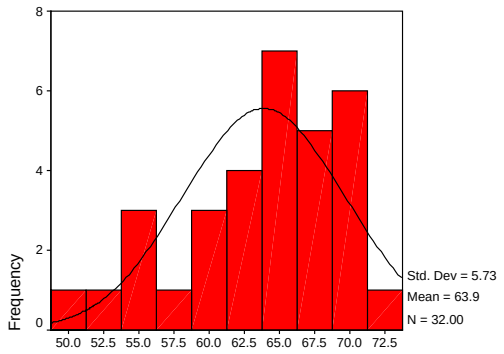
Up reach (Max)		
N	Valid	32
	Missing	0
Mean		150.3
Std. Deviation		8.84
Variance		78.1
Range		33.0
Minimum		135.0
Maximum		168.0
Percentiles	5	136.3
	50	150.0
	95	167.4



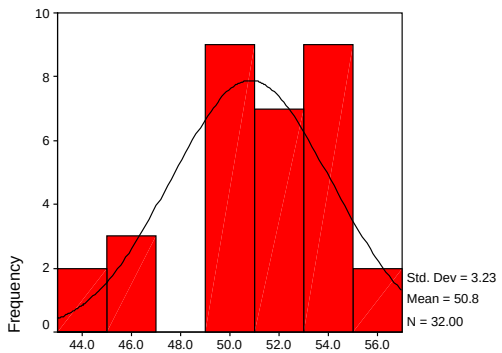
Up reach (Com)		
N	Valid	32
	Missing	0
Mean		143.8
Std. Deviation		9.86
Variance		97.2
Range		37.0
Minimum		128.0
Maximum		165.0
Percentiles	5	128.6
	50	143.0
	95	162.4



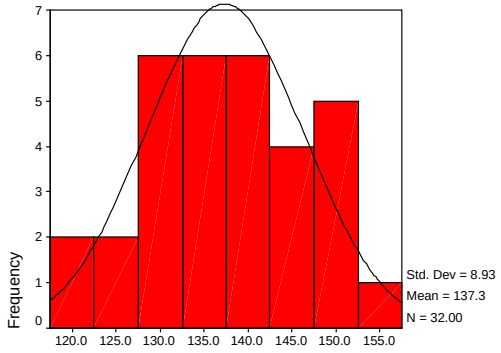
Forward reach over a table(Max)		
N	Valid	32
	Missing	0
Mean		63.9
Std. Deviation		5.73
Variance		32.9
Range		22.0
Minimum		50. 0
Maximum		72.0
Percentiles	5	52.0
	50	64.0
	95	71.4



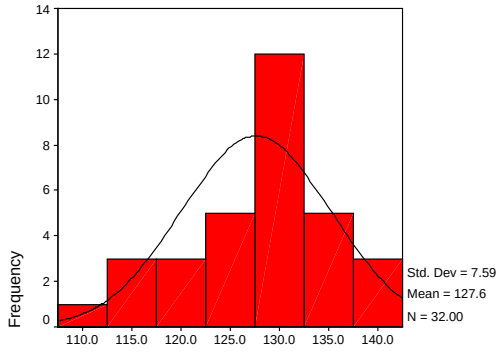
Forward reach over a table (Com)		
N	Valid	32
	Missing	0
Mean		50.8
Std. Deviation		3.23
Variance		10.3
Range		12.0
Minimum		43.0
Maximum		55.0
Percentiles	5	43.0
	50	52.0
	95	55.0



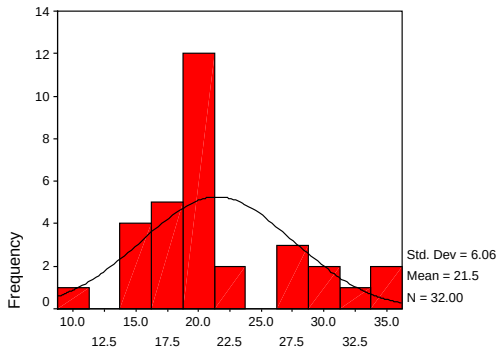
Up-forward reach to a wall (Max)		
N	Valid	32
	Missing	0
Mean		137.3
Std. Deviation		8.93
Variance		79.7
Range		32.0
Minimum		121.0
Maximum		153.0
Percentiles	5	121.7
	50	137.5
	95	151.1



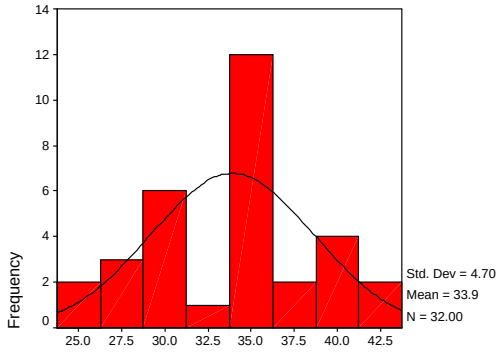
Up-forward reach to a wall (Com)		
N	Valid	32
	Missing	0
Mean		127.6
Std. Deviation		7.59
Variance		57.7
Range		30.0
Minimum		110.0
Maximum		140.0
Percentiles	5	112.6
	50	130.0
	95	139.4



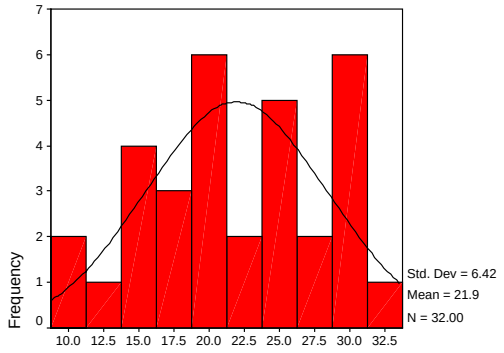
Downward reach to a wall (Max)		
N	Valid	32
	Missing	0
Mean		21.5
Std. Deviation		6.06
Variance		36.7
Range		25.0
Minimum		10.0
Maximum		35.0
Percentiles	5	13.3
	50	20.0
	95	35.0



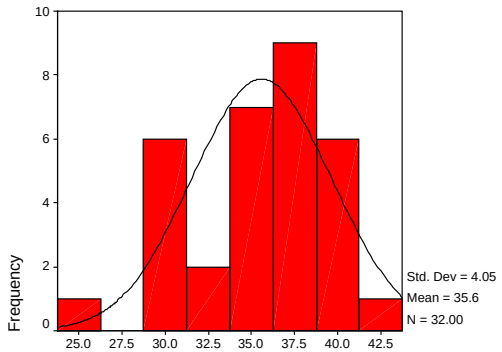
Downward reach to a wall (Com)		
N	Valid	32
	Missing	0
Mean		33.9
Std. Deviation		4.70
Variance		22.1
Range		17.0
Minimum		25.0
Maximum		42.0
Percentiles	5	25.0
	50	35.0
	95	42.0



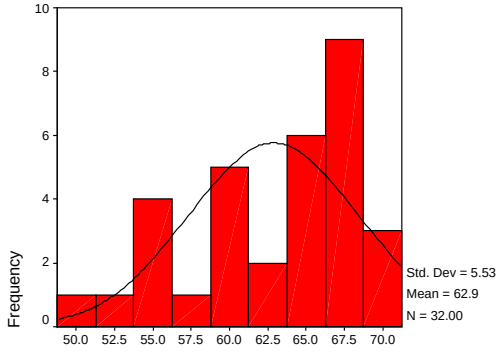
Lateral downward reach (Max)		
N	Valid	32
	Missing	0
Mean		21.9
Std. Deviation		6.42
Variance		41.2
Range		22.0
Minimum		10.0
Maximum		32.0
Percentiles	5	10.0
	50	21.5
	95	30.7



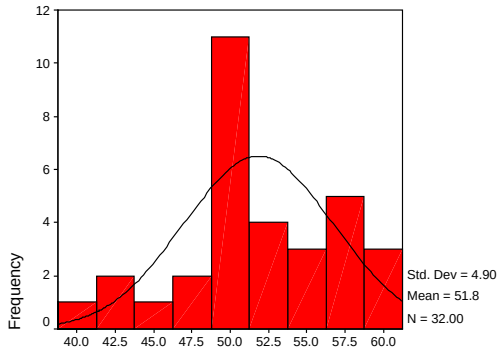
Lateral downward reach (Com)		
N	Valid	32
	Missing	0
Mean		35.6
Std. Deviation		4.05
Variance		16.4
Range		17.0
Minimum		25.0
Maximum		42.0
Percentiles	5	28.3
	50	36.5
	95	41.4



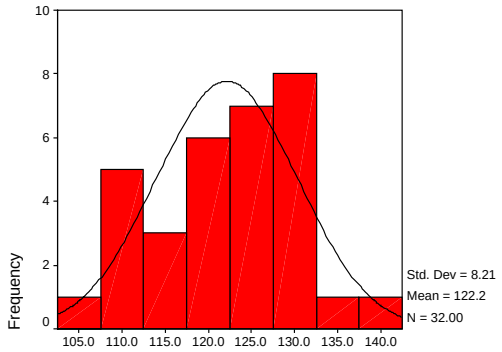
Lateral reach over a table (Max)		
N	Valid	32
	Missing	0
Mean		62.9
Std. Deviation		5.53
Variance		30.6
Range		20. 0
Minimum		50.0
Maximum		70.0
Percentiles	5	52.0
	50	65.0
	95	69.4



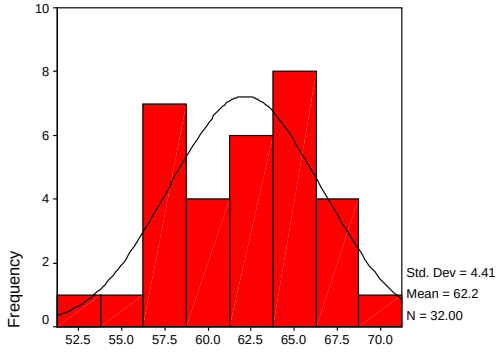
Lateral reach over a table (Com)		
N	Valid	32
	Missing	0
Mean		51.8
Std. Deviation		4.90
Variance		24.0
Range		19.0
Minimum		41.0
Maximum		60.0
Percentiles	5	42.3
	50	51.0
	95	59.4



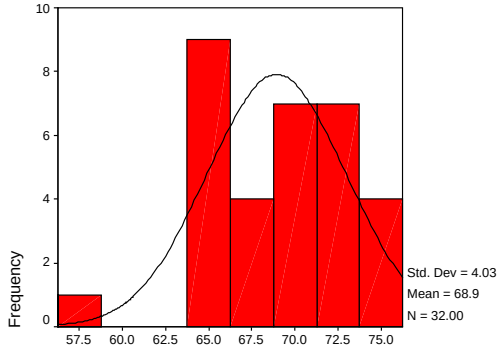
Sitting height		
N	Valid	32
	Missing	0
Mean		122.1563
Std. Deviation		8.20743
Variance		67.36190
Range		33.00
Minimum		107.00
Maximum		140.00
Percentiles	5	108.3000
	50	123.0000
	95	135.4500



Knee height		
N	Valid	32
	Missing	0
Mean		62.2
Std. Deviation		4.41
Variance		19.4
Range		17.0
Minimum		53.0
Maximum		70.0
Percentiles	5	53.7
	50	62.5
	95	68.7



Wheelchair rest height		
N	Valid	32
	Missing	0
Mean		68.9
Std. Deviation		4.03
Variance		16.1
Range		17.0
Minimum		58.0
Maximum		75.0
Percentiles	5	61.9
	50	69.0
	95	75.0



APPENDIX 11. KNEE HEIGHT

The measurement results of the knee height of the wheelchair users are listed in Table A11.1. The maximum knee height is of a man whose legs are deformed, warping up to 70 cm. Therefore, in order to accommodate most of the wheelchair user's leg, the minimum height of knee space should be at least 70cm high. This value is the same as the recommendation of **Singapore Guidelines** (Building and Construction Authority, 2002). According to the guideline, a clear knee space should be at least 900 mm wide, 480mm deep and 700mm high.

	Minimum	Maximum	Mean	Accuracy	SD.	5th	50th	95th
Male	57.0	70.0	64.1	±1.84	3.67	57.0	65.5	70.0
Female	53.0	68.0	60.2	±2.15	4.29	53.0	60.0	68.0
Total	53.0	70.0	62.2	±2.21	4.41	53.7	62.5	68.7

Table A11.1: Measurement results of the knee height.

The knee height is also highly correlated with the height of the working surface for wheelchair users. According to **NKBA Guidelines** (Peterson, 1998),

> "*For seated users, ANSI recommends 28"-34" (71cm-86cm) high counters. If you start with 27"-29" (69mm-74mm) high knee space (as per ANSI), add 1 ½" (4cm) for an apron to hide support for the counter over a knee space, and 1 ½" (4cm) for the thickness of the counter, this places the counter height at 30"-32" (76cm-81cm) which is comfortable and workable for most seated users…If a person is using a wheelchair, the armrest height will determine the optimum knee space and counter height… Standard table height of 30" (76cm) is the most preferred lowered countertop height and works well for a person in standard seating. This counter height is also recommended for a baking or chopping center for the average height of cook*" (Peterson, 1998, p80-81).

For a cook top, the optimum height recommended by **NKBA Guidelines** (Peterson, 1998) is 30" – 34" (76cm – 86cm) with a 27" (69cm) minimum high knee space for seated cooks.

According to Peterson (1998, p113-114), for the sink height, both the depth of the sink and knee height should be considered. The sinks used for wheelchair users are shallower than traditional ones. The depths are usually 5"-6 ½" (13cm-17cm) (Peterson, 1998). For most seated users, 32" (81cm) is the preferred counter height. A minimum knee space is 27" (69cm) high. For most people, the knee space preferred is 29" (74cm) to clear wheelchair armrests. Thus this combination will leave only 3" (8cm) for the sink depth which is obviously not enough. Therefore, the height of the sink should be determined by the users' special needs. The height varies to suit different users.

From the descriptions above, it is noted that the countertop's heights are mainly decided by the wheelchair user's knee height, the depth of the sink or cooker as well as the wheelchair armrest height (Figure A11.1).

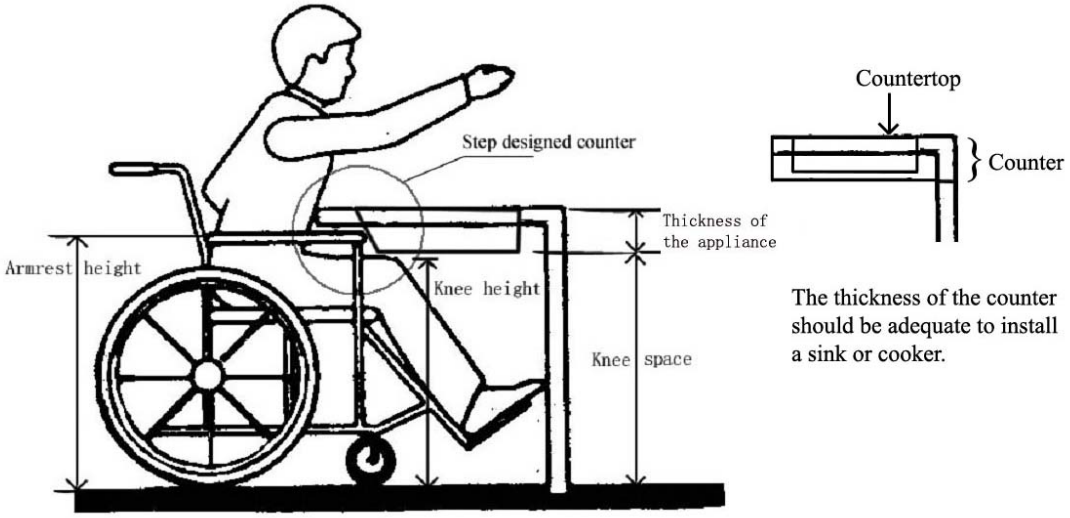


Figure A11.1: The countertop height is decided by the appliance depth, knee height and armrest height.

The measurement of the 32 wheelchair users' knee heights and the armrest heights shows that the wheelchair's armrests are higher than the users' knee. If the countertop height is determined by the armrest height plus the depth of the appliance, it could be too high for a wheelchair user. For example, according to Peterson (1998), the knee space preferred is 29" (74cm) to clear wheelchair armrests for most people. If a sink is about 15cm in depth, then the total height of the countertop will be 89cm. This height is much higher than the preferred countertop height for most seated user (81cm according to Peterson (1998)).

In the author's opinion, this problem may be settled by the "step-designed counter" (Figure A11.1). The appliance is installed a little distance apart from the countertop edge; thus, the armrest can be under the counter, and the bottom of the appliance can be lower than the armrest.

Another solution is to choose a different wheelchair type (Figure A11.2). Besides standard wheelchairs, there are wheelchairs with "desk arms". "Desk arms" is the wheelchair in which the front armrest drops down. Some wheelchairs have "sport model arms" that slop from rear to front. Both types will require less knee space clearance and will fit under lower counters. When designing a kitchen for a particular wheelchair user, determination of the type of wheelchair may allow more flexibility in setting heights and clearances.

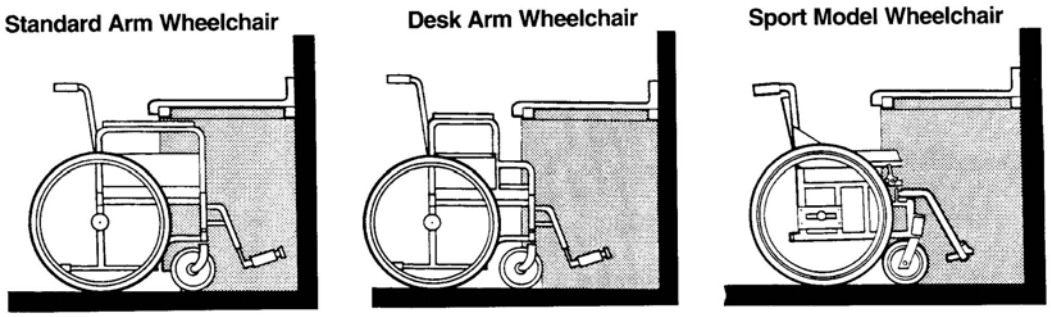


Figure A11.2: Different types of the wheelchair. (Source: Barrier Free Environments, Inc., 1991)

According to **Singapore Guidelines**, the maximum wheelchair armrest is around 76cm high. When the 32 wheelchair users' reaches were measured at HWA, the armrest heights of the

wheelchairs were also measured. The distribution is listed in Table A11.2. The result is approximately consistent with **Singapore Guidelines**.

	Minimum	Maximum	Mean	Accuracy	SD.	5th	50th	95th
Total	58.00	75.00	68.9	±2.02	4.03	61.9	69.0	75.0

Table A11.2: Measurement result of the wheelchair armrest height.

According to Peterson (1998), the depths of the sink for wheelchair are usually 5"-6 ½" (13cm-17cm). Other literatures also recommend that the sink's depth should be in this range (British Standard Institution, 2000; Barrier Free Environments, Inc., 1991; The Board of the Registration of Architects, 2002). Therefore, 13-17cm was used as the sink's depth in this study for estimations and designs.

No specific recommendations could be found on the cooker's depth for the wheelchair users through the literature review or web search. Therefore, the normal cooker's dimensions were checked on the Haier home production list and the production of some other enterprises (Haier Group Company, 2003; CNBMB, 2003). The Haier home production list was selected because the Haier Group Company is one of the largest enterprises in Asia where kitchen appliances are produced. The check indicated that most of the cooker's depths are less than 15cm.

Because a barrier-free kitchen in HDB flat is mainly used by a specific wheelchair user or by the wheelchair user with his/her family, the design should be different for different cases. If the kitchen is mainly used by a wheelchair user, the countertop should be determined by the wheelchair user's knee height and his/her wheelchair's armrest. For example, if a wheelchair user's knee height is a little less than 65cm, and his/her wheelchair armrest is 70cm, considered 15cm for the depth of the cooker and sink, the countertop should be around 80-85cm. If the wheelchair's armrest is "desk arm" or the armrest is detachable, or the counter is "step designed", then the countertop could be as low as 80cm.

If the kitchen is used not only by the wheelchair user him/herself, but also his/her family, then the countertop should consider other person's usage too. An adjustable countertop may be a good solution if the cost is not considered. Another solution is to provide countertops at different heights to meet different person's needs. The simplest solution is to design the countertop to meet the wheelchair user's needs while others compromise to use it.

APPENDIX 12. ACCESSIBLE CABINETS

1. Rotating cabinet

In L-shaped and U-shaped kitchens, the common corner cupboards are difficult to reach by wheelchair users. Application of a rotating storage unit (or called “Corner Lazy Susan”) could increase access to the interior of the cupboard at the corner (Figure A12.1& A12.2).

Figure A12.1: Rotating storage unit could increase the access to the interior of the cupboard at the corner (Source: Joliet Cabinet Company, 2003).

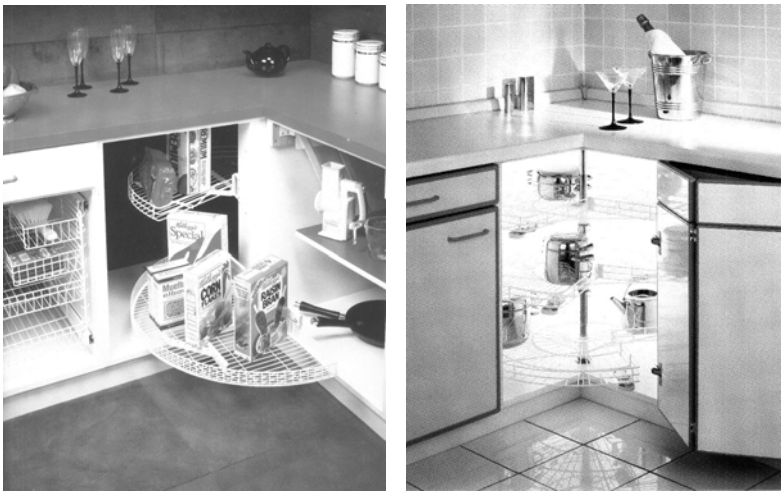
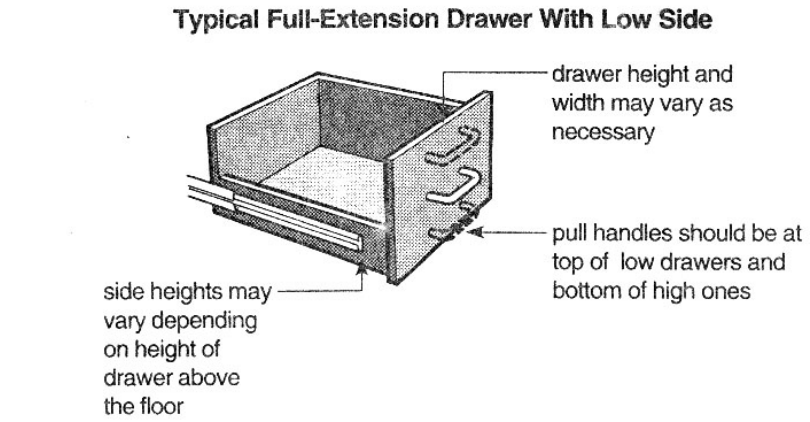


Figure A12.2: Two examples of the rotating cabinets (Source: Leibrock, 1993).

2. Full-extension drawers

Drawers, which extend the full depth of the base cabinets and are mounted on full-extension slides, make the best use of available storage space. When fully extended, these drawers display their entire contents and place them within easy reach (Figure A12.3).

Banks of full-extension drawers can make the total volume of base cabinet’s space access to most users. Drawers can be of any size and proportion to suit the contents. Such drawers can be used for storing pots and pans, bowls, kitchen utensils, dry food, or small appliances.



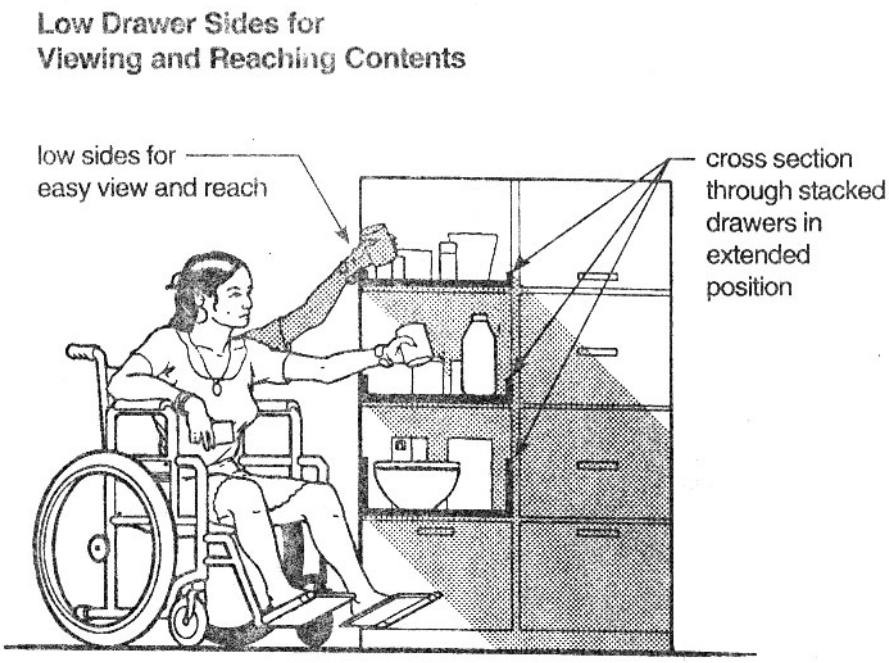


Figure A12.3: Illustration of the full-extension drawers (Source: Barrier Free Environments, Inc. 1991).

APPENDIX 13. APPROACHING SPACES AT DOORS

Usually, there are at least two doors to an HDB kitchen: one is to the living room or dining room, the other is to a bathroom attached to the kitchen. Sometimes there are three or even four doors to a kitchen, one more for a balcony and one more for a civil defense room. In designing these doors the space for a wheelchair approaching must be considered. There are three types of doors usually used in domestic home: a swinging door, a sliding door or a folding door.

If a kitchen is small and compact, the door should swing out so that the person inside the kitchen does not fall against the door and block it. Sliding or folding doors are preferred in terms of their accessibility for a wheelchair user. Removing the door between a kitchen and living room is also a good solution in terms of wheelchair users' accessibility.

1. Door Width

The first consideration of a door is the clear opening at the door. Because a standard internal timber-framed door has a certain thickness, the clear opening width is approximately 45mm less than the width of the door leaf. Therefore, whether a wheelchair can get through a door is determined by the clear opening width instead of the door-set width (Goldsmith, 1997, p 333).

In **Singapore Guidelines 3.5.2**, it is recommended that "*the minimum clear opening of doorways shall be 900mm measured between the face of the door stop with the door open at 90 degrees. Both for swing doors and sliding/folding doors"* (Figure A13.1).

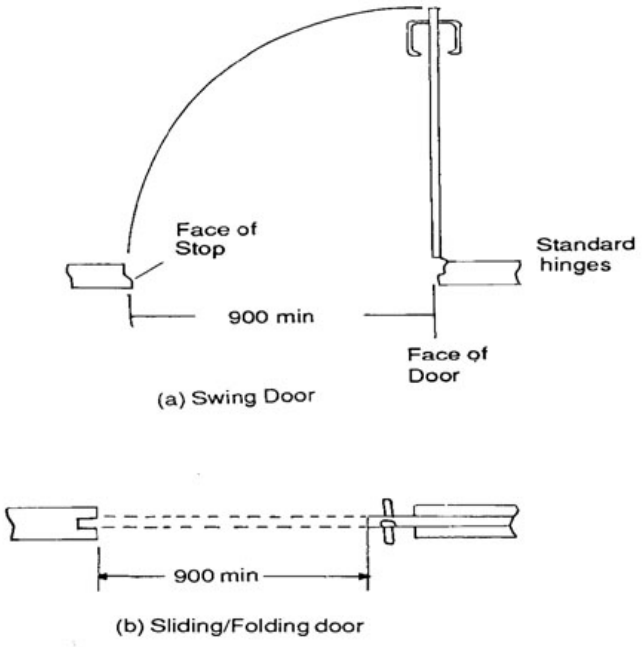


Figure A13. 1: The minimum clear opening at doors (source: Building and Construction Authority, 2002).

NKBA Guidelines recommends 810mm for the minimum clear opening at the door (Peterson, 1998, p.12). The **ADA Guidelines 4.13.5** recommends that "*Doorways shall have a minimum clear opening of 815mm with the door open 90 degrees, measured between the face of the door and the opposite stop*" (Kearney, 1995).

The recommendation on door width given by **Singapore Guidelines** is greater than that in **NKBA Guidelines** and the **ADA Guidelines**. A wider door opening provides more accessible

way for wheelchair users. Hence 900mm will be adopted for doors in an accessible HDB kitchen in this thesis. This door opening width will permit a wheelchair user to pass through without striking the door, door frame or door hardware.

2. Approaching Space at Doors

The maneuvering space for a wheelchair user turning through a door is determined by both the opening width of the door and the space available for approaching the door.

> "*Basically, a large clear floor space must be allowed on the pull side of the door beyond the latch to allow space to operate the door and move out of the door swing. A narrower clear floor space will be needed on the push side of the door, depending on approach*" (Peterson, 1998, p12).

In **Singapore Guidelines**, only two types of approaches are illustrated with given dimensions. One is the front approach with the door opening toward the users and the other is the front approach with the door opening away from the users (Figure A13.2). From the push side the clear space requirement is 1200mm×1200mm. From the pull side the clear space requirement is 1500mm×1500mm.

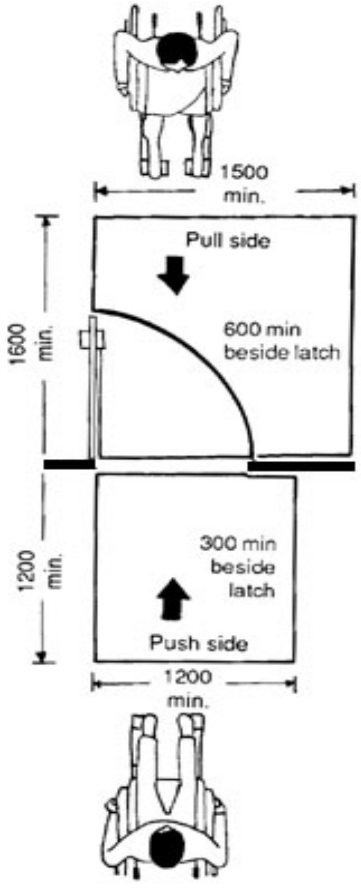


Figure A13. 2: Approaching space at doors (source: Building and Construction Authority, 2002).

In **NKBA Guidelines**, the clear floor space for a number of different approaches is recommended according to both push side and pull side, swing direction and door types. The illustrations show that the approach direction of the wheelchair and rotation of the door can tremendously affect the space required to open and close a door (Figure A13.3).

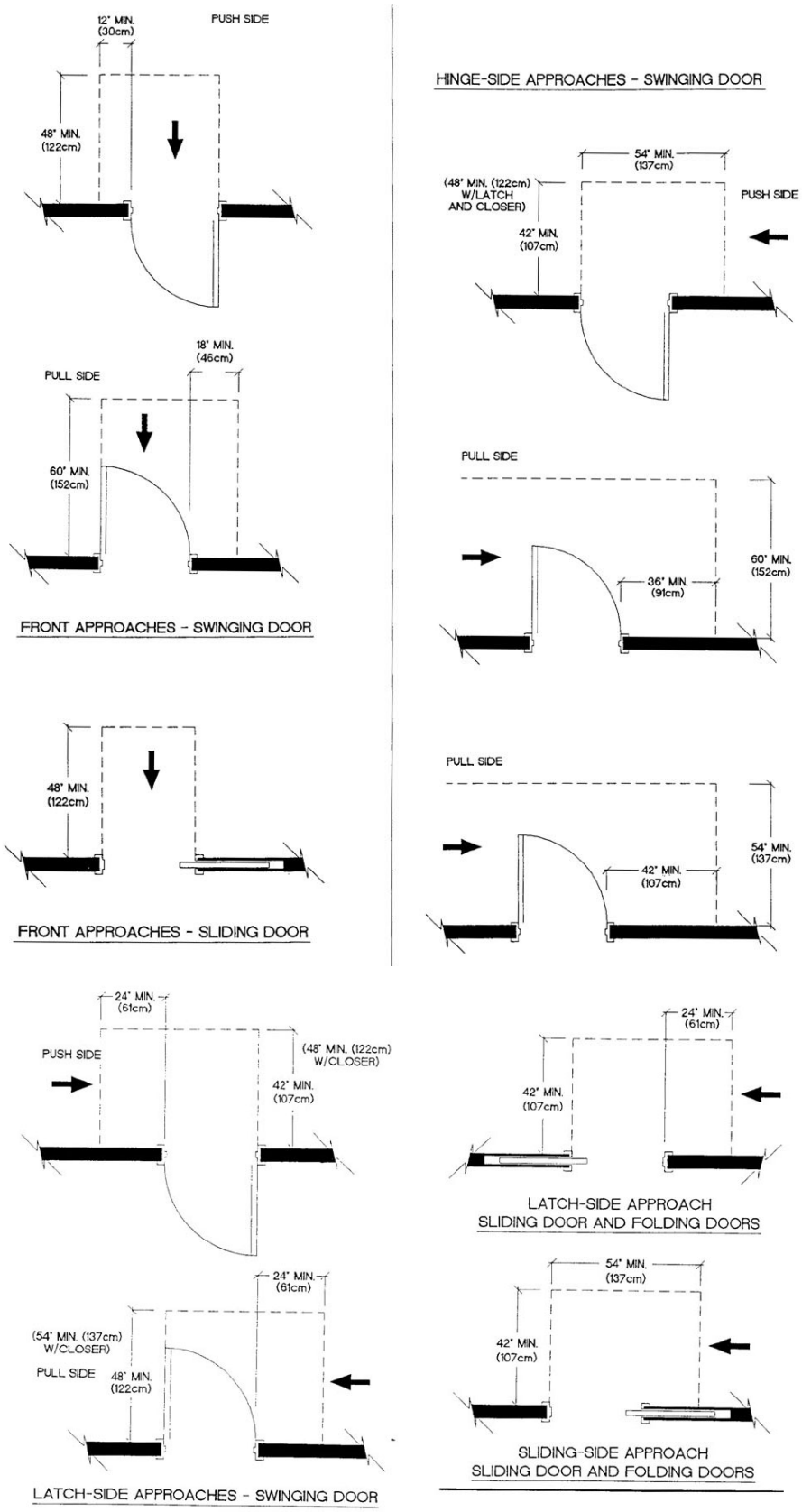


Figure A13.3: Approaching space at doors (source: Peterson, 1998).

In the **ADA Guidelines**, the recommendations for maneuvering space at doors with different approaches are the same as those in **NKBA Guidelines.**

APPENDIX 14. SPACE FOR WHEELCHAIR TURNING

For wheelchair users there are two types of turn: circle turn and T-turn. In **Singapore Guidelines**, it is recommended that the minimum clear floor or ground area for a wheelchair to turn should be a circle with diameter of 1800mm (Figure A14.1). No recommendation about the T-turn appears in **Singapore Guidelines**.

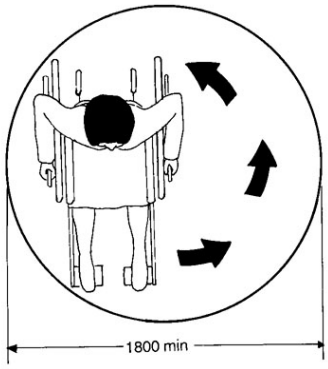


Figure A14.1: Circle turning space (Source: Building and Construction Authority, 2002).

The clearance between counters is also related to the turn methods between the counters. In **NKBA Guidelines** there are two types of turn recommended – circle turn and T-turn. According to this guideline, if ample space is available in the kitchen, the best way is to provide a 152cm (60") diameter turning space. If a kitchen space is limited, a space for the T-turn can also work. For the T-turn (Figure A14.2), the minimum clear floor space is 91cm×91cm×152cm (36"×36"×60") and the preferred one is 91cm×91cm×183cm (36" ×36" ×72"). The T-shape turning space allows a three point turn to be made by pulling into one arm of the "T" and backing out into the other. In limited spaces, one leg of the "T" can be placed within a knee space minimum 36" (91cm) wide (Figure A14.3).

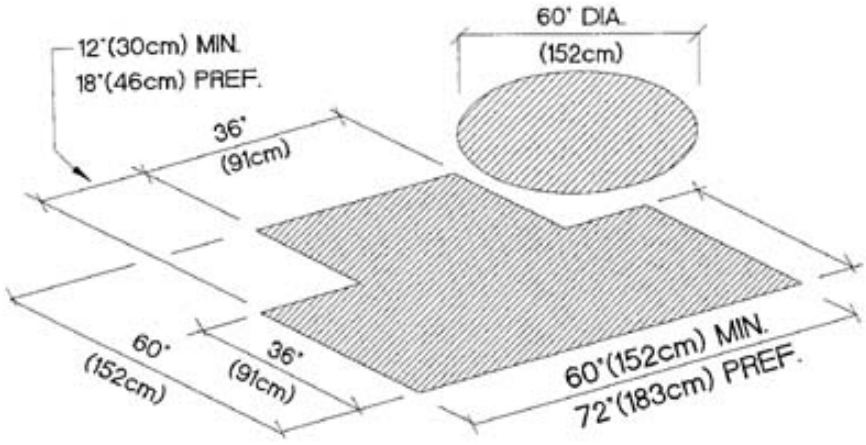


Figure A14.2: Clear floor space for turning wheelchairs (Source: Peterson, 1998).

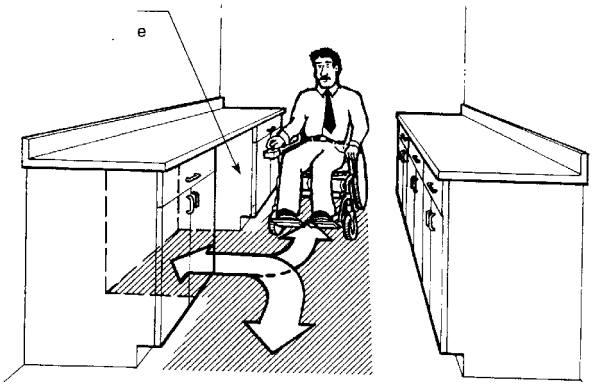
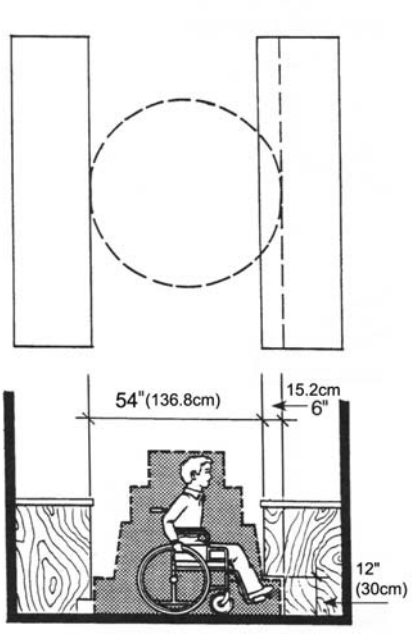


Figure A14.3: One leg of the "T" can be placed within a knee space minimum 36" (91cm) wide (source: Barrier Free Environments, Inc., 1991).

For the circle turn, when space is limited, a minimum 30cm (12") high and 15.2cm (6") deep toe space can be part of the turning space (Figure A14.4). In very small kitchens, if the knee space is at least 122cm-137cm (48"-54") wide, as much as 48cm (19") of the 152cm (60") turning space can be part of the knee space under tables or countertops (Figure A14.5).



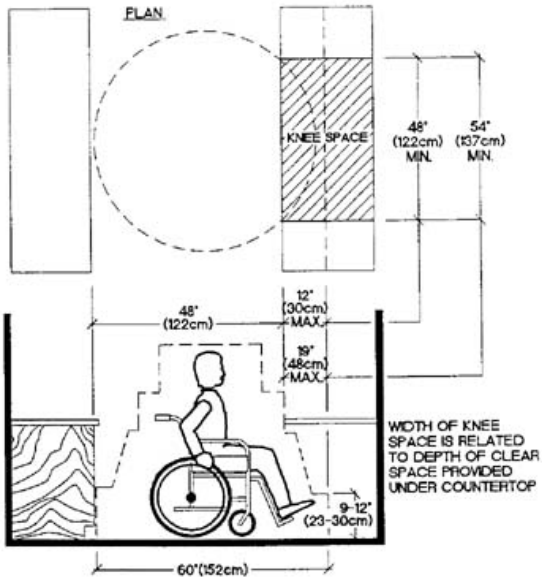


Figure A14.4: (Left) clear floor space with enlarged toe space (Source: Barrier Free Environments, Inc., 1991).
Figure A14.5: (Right) clear floor space with enlarged knee space (Source: Peterson, 1998).

In the **ADA Guidelines** it is recommended that the space required for a wheelchair to make a 180-degree turn be a clear space of 1520mm (60in) diameter.

Comparing the recommendations of the circle turn in the three guidelines, the recommendation of **Singapore Guidelines** is larger. According to Julius Panero and Martine Zelnik (1979), when a wheelchair makes a turn based on moving wheels in opposite directions and pivoting about center, the diameter for average turning space is about 160.0cm (63in). When a wheelchair makes a turn based on locking one wheel and turning the other with the pivot point on the locked wheel, the diameter for average turning space is about 182.8cm (72in) (Figure A14.6). The recommendation of **Singapore Guidelines** allows a wheelchair turn when one

wheel is locked (or just remains still) and the other turns. Sometimes a wheelchair user who has only good functions on one body side uses this kind of turn. The recommendation of **NKBA Guidelines** and **ADA Guidelines** allows a wheelchair to turn by moving the wheels in opposite directions and pivoting about the wheelchair's center. This kind of turning requires the user to be more careful and to use equal force on both wheels.

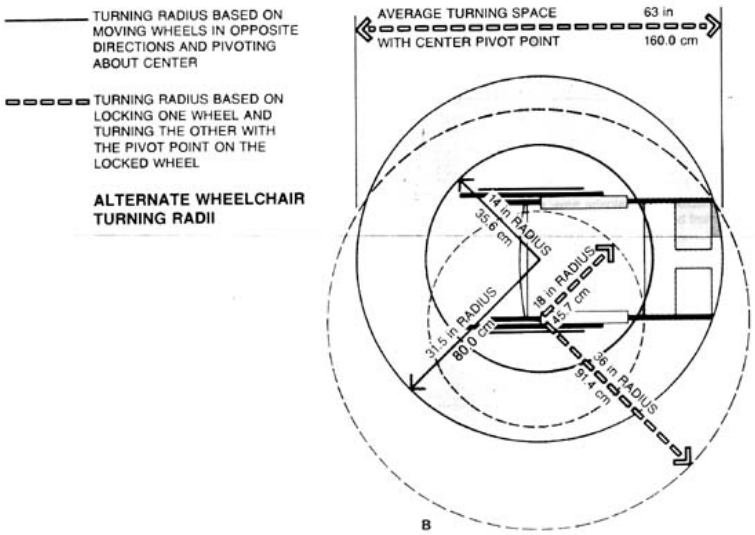


Figure A14.6: Turning radius based on different pivot points (Source: Panero & Zelnik, 1979).

APPENDIX 15. MINIMUM WIDTH OF THE DIFFERENT KITCHEN LAYOUTS

If a kitchen is used by a wheelchair user, it must provide adequate space for the wheelchair to move and turn. There are mainly four types of kitchen plan: one-sided kitchen, two-sided kitchen, L-shaped kitchen, and U-shaped kitchen (in a spacious kitchen, an islanded working center can be combined with a one-sided kitchen and an L-shaped kitchen. However, since an island kitchen is not fit for a small kitchen and seldom occurs in HDB kitchens, this kind of kitchen is not discussed in this thesis).

Based on the dimensional requirements of a wheelchair user, the minimum widths of the four kitchen types are deduced here.

1. One-sided Kitchen

According to Singapore Guidelines, assuming that the countertop is 60cm in depth, plus 180cm of the space for a wheelchair circle turning, the minimum width for a one-sided kitchen is 240cm (Figure A15.1. a). If a knee space is provided and it is more than 122cm-137cm wide, then 48cm of the turning space can be under the countertop. The minimum width for a one-sided kitchen is 192cm (Figure A15.1. b).

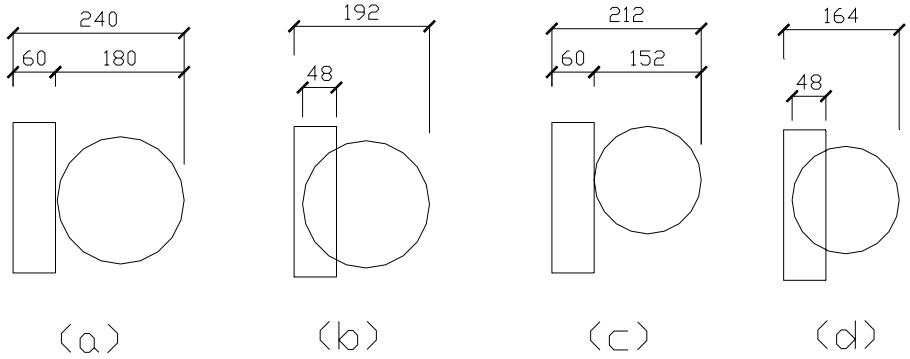


Figure A15.1: The minimum width for a one-sided kitchen (unit: cm).
a) According to Singapore Guidelines, without knee space.
b) According to Singapore Guidelines, with enlarged knee space.
c) According to NKBA Guidelines, without knee space.
d) According to NKBA Guidelines, with enlarged knee space.

According to **NKBA Guidelines**, assuming that the countertop is 60cm in depth, plus 152cm of the space for a wheelchair circle turning, the minimum width for one-sided kitchen is 212cm (Figure A15.1. c). If a knee space is provided and it is more than 122cm-137cm wide, the minimum width for a one-sided kitchen is 164cm (Figure A15.1. d). The final recommendations are listed in Table A15.1.

2. Two-sided Kitchen

According to **Singapore Guidelines**, assuming that the width of the two countertops is 120cm (60cm×2), plus 180cm of the space for a wheelchair circle turning, the minimum width for a two-sided kitchen should be 300cm (Figure A15.2. a). If knee space is provided under the counter, the minimum width for a two-sided kitchen is 252cm (Figure A15.2. b).

According to **NKBA Guidelines**, assuming that the width of the two countertops is 120cm (60cm×2), plus 152cm of the space for a wheelchair circle turning, the minimum width for a two-sided kitchen should be 272cm (Figure A15.2. c). If knee space is provided under one

counter, the minimum width for a two-sided kitchen is 224cm (Figure A15.2. d). The final recommendations are listed in Table A15.1.

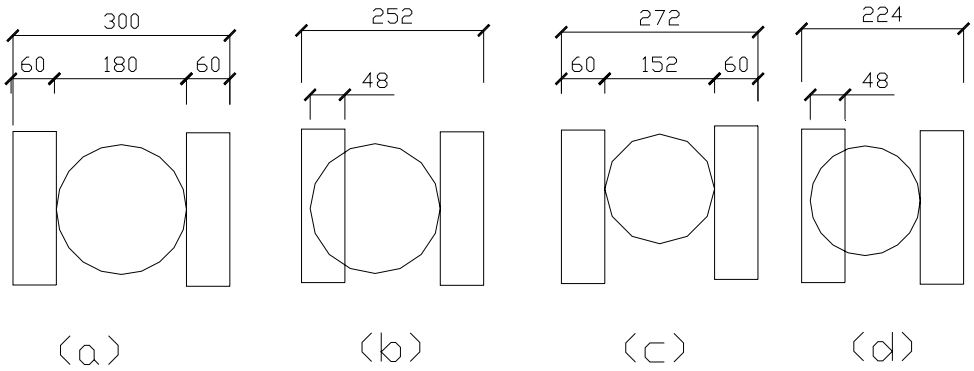


Figure A15.2: The minimum width for a two-sided kitchen (unit: cm).
a) According to Singapore Guidelines, without knee space.
b) According to Singapore Guidelines, with enlarged knee space.
c) According to NKBA Guidelines, without knee space.
d) According to NKBA Guidelines, with enlarged knee space.

3. L-shaped Kitchen

With work centers on two adjacent walls, the L-shaped kitchen keeps the work triangle free of through-room traffic and allows an efficient arrangement of the work centers.

In the L-shaped kitchen, usually a sink or a cooker is installed on the leg of the "L". Therefore, the minimum width of an L-shaped kitchen should be enough to contain one work center.

When the minimum length of the leg of "L" is discussed (Figure A15.3), **NKBA Guidelines** is consulted to determine the minimum allowable space beside the cooker and sink (indicated as "A" and "B" in Figure A15.3). No such recommendation could be found in the local guidelines. These dimensions are slightly related to the dimensions of the human body. The width of the space is mainly determined by the usage itself: whether there is enough space to put a basin and vegetables adjacent to the sink, a pot adjacent to a cooker and whether it can be used safely, etc. Therefore, the dimensions of the spaces "A" and "B" recommended in **NKBA Guidelines** were applied to estimate the whole length of the leg of "L".

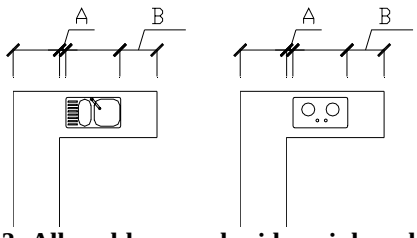


Figure A15.3: Allowable space beside a sink and a cooker.

When a sink is installed on the leg of "L", the minimum length of the leg must allow the sink to be installed. In **NKBA Guidelines** there are two guidelines relevant to the determination of the minimum counter length for a sink:
1) There should be at least 61cm (24") of countertop frontage to one side of the primary sink, and 46cm (18") on the other side. The counter-top frontage may be a continuous surface, or the total of two angled countertop sections (Figure A15.4).
2) The minimum allowable space from a corner to the edge of the primary sink is 8cm (3"); it should also be a minimum of 38cm (15") from that corner to the sink centerline (Figure A15.5).

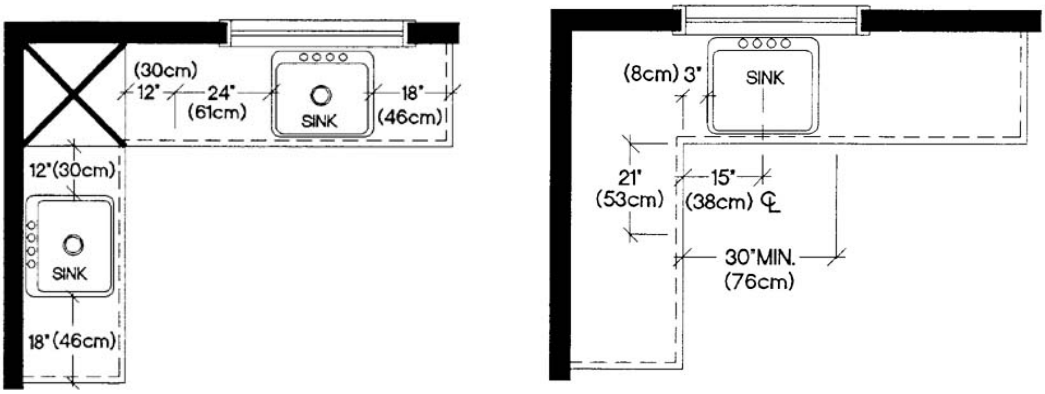


Figure A15.4: (Left) the counter-top frontage may be a continuous surface, or the total of two angled countertop sections (Source: Peterson, 1998).
Figure A15.5: (Right) the minimum allowable space from a corner to the edge (Source: Peterson, 1998).

A common home sink is usually around 45-80cm in length according to Haier home production list and the production of other enterprises (Haier Group Company, 2003; CNBMB, 2003).

The minimum width of the leg of the L-shaped counter used as a sink center should be 184cm (60+8+80+46=194cm) (Figure A15.6), considering 60cm for a countertop depth, 8cm for the space between corner and the edge of the sink, 80cm for a sink and 46cm for the counter beside the sink.

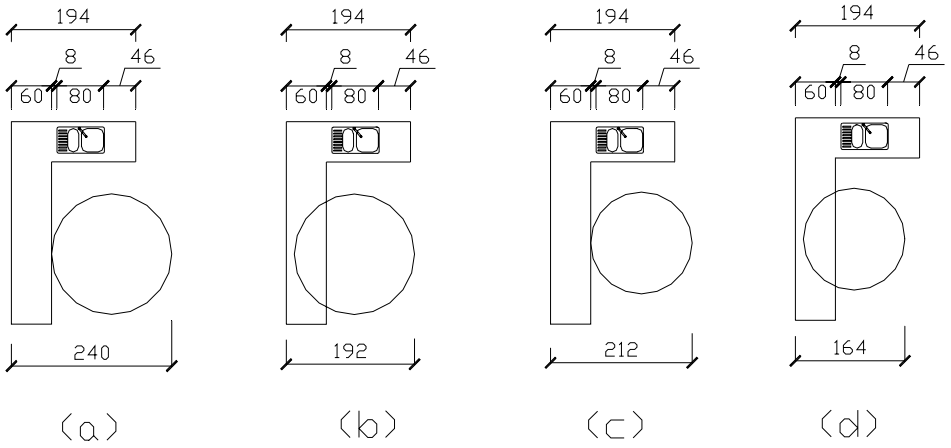


Figure A15.6: The minimum width for an L-shaped kitchen (when a sink is installed on the leg of "L") (unit: cm).
a) According to Singapore Guidelines, without knee space.
b) According to Singapore Guidelines, with enlarged knee space.
c) According to NKBA Guidelines, without knee space.
d) According to NKBA Guidelines, with enlarged knee space.

According to **NKBA Guidelines** (Figure A15.7), in an open-ended kitchen configuration, at least 23cm (9") of counter space should be allowed on one side of the cooking surface and 38cm (15") on the other side at the same counter height. For an enclosed configuration, at lease 8cm (3") of clearance space should be planned at an end wall protected by flame-retardant surfacing material and 38cm (15") should be allowed on the other side of the appliance, at the same counter height as the appliance (Peterson, 1998, p61).

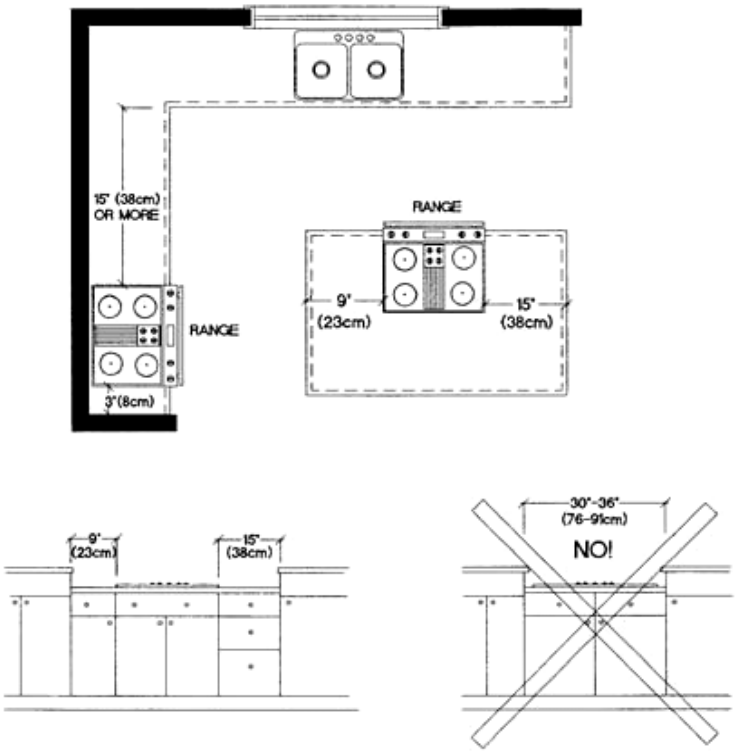


Figure A15.7: The requirements of the counters adjacent to cooker (Peterson, 1998).

There is no recommendation for the situation where a cooker is set near a corner. By comparing the distance between a sink edge and a corner (Figure A15.5) and the distance between the end wall and a cooker edge (Figure A15.7) it is found that the distances are the same (8cm).

A common home cooker is around 65-75cm in length according to Haier home production list and the production of other enterprises (Haier Group Company, 2003; CNBMB, 2003). Therefore, the minimum length of the leg of the L-shaped countertop used as a cooker center should be 181cm (60+8+75+38cm=181cm) (Figure A15.8), if the cooker is 75cm in length.

The minimum width of the L-shaped kitchen is decided by two requirements. One is the minimum length of the leg of "L"; the other is the minimum width for a circle turn of a wheelchair beside a counter. The second requirement for an L-shaped kitchen is the same as that for a one-sided kitchen. The bigger one of the two requirements is selected as the minimum width for an L-shaped kitchen. The final recommendations are listed in Table A15.1.

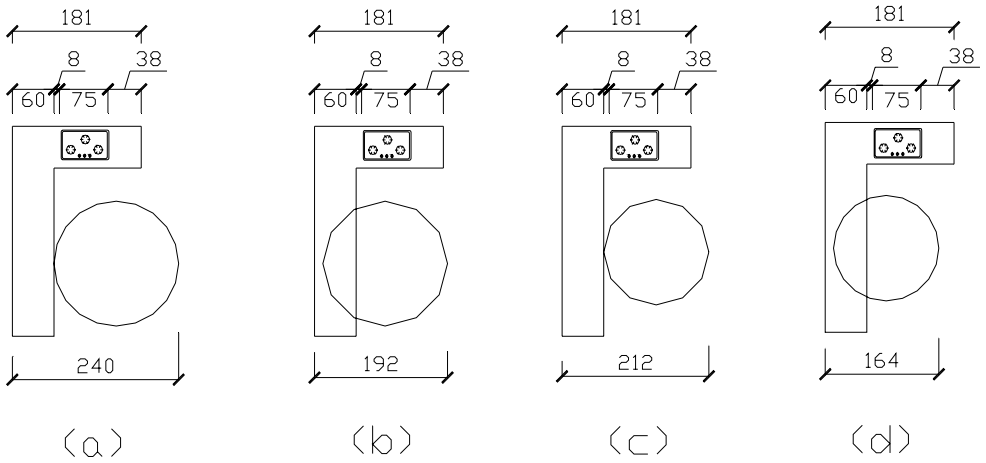


Figure A15.8: The minimum width for a L-shaped kitchen (when a cooker is installed on the leg of the "L") (unit: cm).
a) According to Singapore Guidelines, without knee space.
b) According to Singapore Guidelines, with enlarged knee space.
c) According to NKBA Guidelines, without knee space.
d) According to NKBA Guidelines, with enlarged knee space.

4. U-shaped Kitchen

For the U-shaped arrangement, the work center and their appliances are divided and arranged in a "U" configuration along three walls. Usually the sink / cleanup center is set at the base of the "U", with the refrigerator and cook center on the other two legs. U-shaped kitchen creates a tight work triangle which has a short distance between work centers. Traffic will be naturally outside the work area because of the shape.

The minimum width of the U-shaped kitchen is deduced based on the minimum width of the two-sided kitchen. Since the minimum width of the two-sided kitchen allows a wheelchair's circle turn inside, what should be examined is whether the distance between the two counters is long enough for a working center (either sink or cooker). If the distance meets the dimensional requirements of a working center, then the minimum width of the U-shaped kitchen is the same as that of the two-sided kitchen.

According to **NKBA Guidelines** (Figure A15.4), for a sink, "the counter-top frontage may be a continuous surface, or the total of two angled countertop sections." A minimum distance of 8cm (3") between the edge of the sink and the counter corner is also required (Figure A15.5) (Peterson, 1998, p.57, p.58). Based on these guidelines, in the U-shaped kitchen, when a sink or a cooker is set at the base of the "U" and the base counter-top is not long enough for the required counter-top frontage, part of the counter-top frontage can be on the side counters of the "U". Assuming that a sink is 70cm wide, then the base counter-top of the "U" should be more than 86cm (8cm+70cm+8cm=86cm) (Figure A15.9). This distance is less than the minimum distance between the two counters in a two-sided kitchen (180cm, 132cm, 152cm and 104cm respectively.

For the same reason, the minimum distance between the two counters in a two-sided kitchen is adequate for installing a cooker center. Finally, it is found that the minimum widths of both the U-shaped kitchen and the two-sided kitchen are the same. The results are shown in Table A15.1.

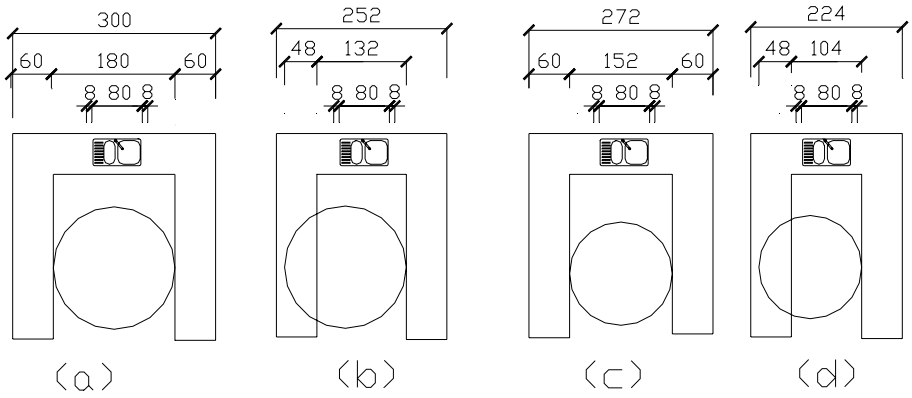
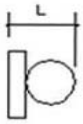
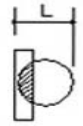
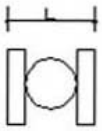


Figure A15.9: The minimum width for a U-shaped kitchen (unit: cm).
a) According to Singapore Guidelines, without knee space.
b) According to Singapore Guidelines, with enlarged knee space.
c) According to NKBA Guidelines, without knee space.
d) According to NKBA Guidelines, with enlarged knee space.

Kitchen Type	Layout	According to **Singapore Guidelines**	According to **NKBA Guidelines**
One-sided Kitchen		L=240cm	L=212cm
		Minimum width is 240cm	Minimum width is 212cm
		L=192cm	L=164cm
		Minimum width is 192cm	Minimum width is 164cm
Two-sided Kitchen		L=300cm	L=272cm
			Minimum width is 272cm
		L=252cm	L=224cm
		Minimum width is 252cm	Minimum width is 224m
L-shaped Kitchen		S=194cm (sink)	
		L=240cm	L=212cm
		Minimum width is 240cm	Minimum width is 212cm
		S=194cm (sink)	
		L=192cm	L=164cm
		Minimum width is 194cm	Minimum width is 194cm

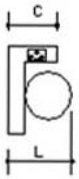
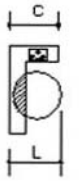
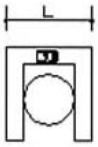
Kitchen Type	Layout	According to **Singapore Guidelines**	According to **NKBA Guidelines**
		C= 181cm (cooker)	
		L=240cm	L=212cm
		Minimum width is 240cm	Minimum width is 212cm
		C=181cm (cooker)	
		L=192cm	L=164cm
		Minimum width is 192cm	Minimum width is 181cm
U-shaped Kitchen		L=300cm	L=272cm
		Minimum width is 300cm	Minimum width is 272cm
		L=252cm	L=224cm
		Minimum width is 252cm	Minimum width is 224m

Table A15.1: The minimum width for different kitchen layouts.

APPENDIX 16. CLEAR FLOOR SPACE FOR A WHEELCHAIR USER AT APPLIANCES

In **Singapore Guidelines** it is recommended that the seating space, such as those provided at counters, tables, or work surfaces for persons in wheelchairs, shall have a clear floor space of not less than 900mm×1200mm. This space allows access for both forward and side approach. When a wheelchair user uses a forward approach to a table or a counter, a clear knee space of at least 900mm wide, 480mm deep and 700mm high should be provided (Figure A16.1).

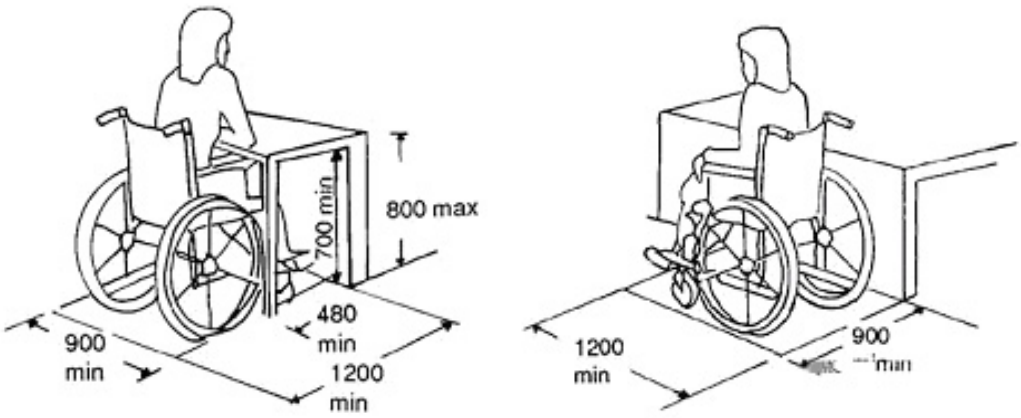


Figure A16.1: Clear floor space for a wheelchair (source: Building and Construction Authority, 2002).

In **NKBA Guidelines** it is recommended that the minimum clear floor space required for a wheelchair user is 76cm×122cm (30"×48"). This can be used for a parallel approach or a perpendicular (forward) approach. In Guideline 14, it says that a clear floor space of 76cm×122cm (30"×48") should be provided at the sink, dishwasher, cooker, oven and refrigerator (measure from face of cabinet or appliance if toe kick is less than 23cm (9") high) (Figure A16.2). If the toe kick of the cabinet is higher than 23cm (9"), the depth of the toe kick can be figured as part of the clear floor space. The reason for this is that a 23cm-30cm (9"-12") toe kick allows clearance for the footrest on most wheelchairs (Figure A16.3). If a knee space is provided, the clear floor space may extend under a counter no more than 48cm (19") (Figure A16.4).

In the **ADA Guidelines,** the clear floor space for a wheelchair is 76cm×122cm (30"×48"). This requirement is the same as the recommendation provided by **NKBA Guidelines**.

In this thesis, both the recommendations on the clear floor space at appliances given by **Singapore Guidelines** and **NKBA Guidelines** were adopted for the graphic analysis of the kitchen floor plans. In fact, because the difference between the two recommendations was small, the kitchen analysis results showed that there was no much difference between the analysis based on either **Singapore Guidelines** or **NKBA Guidelines**.

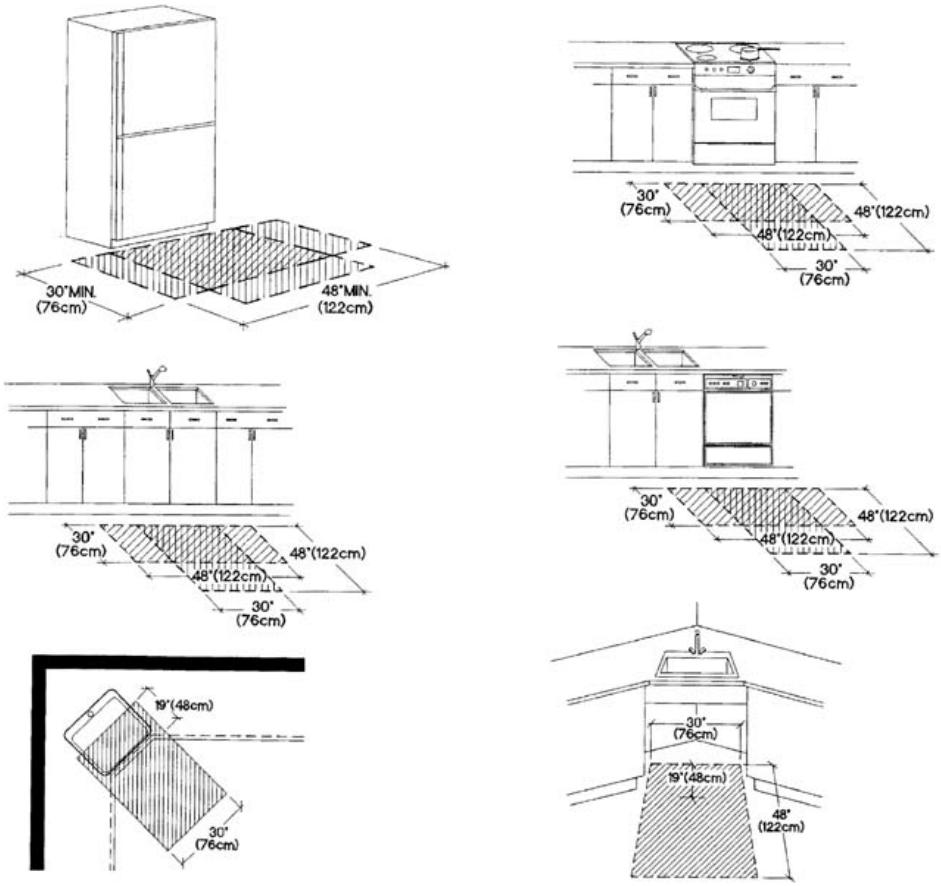


Figure A16.2: A clear floor space at appliances (Source: Peterson, 1998).

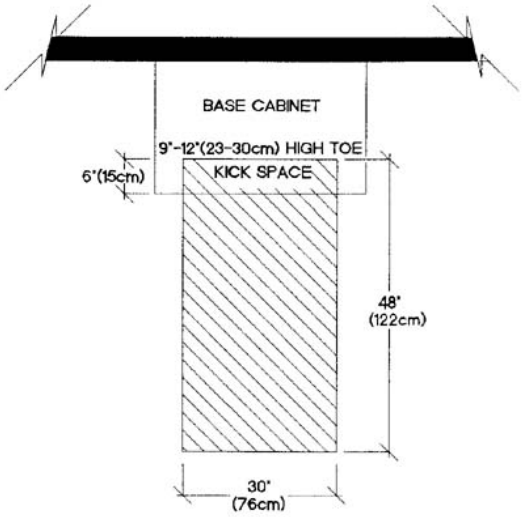


Figure A16.3: If the toe kick of the cabinet is higher than 23cm (9"), the depth of the toe kick can be figured as part of the clear floor space (Source: Peterson, 1998).

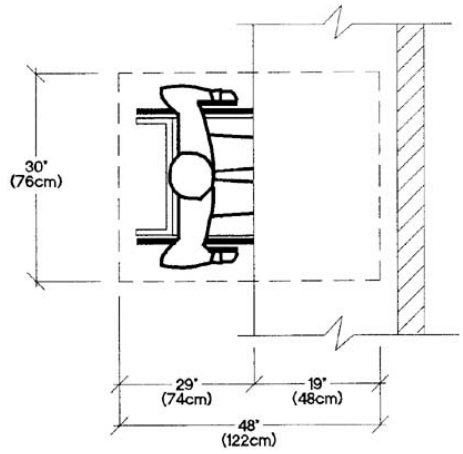


Figure A16.4: Clear floor space under work surface (Source: Peterson, 1998).

APPENDIX 17. DEVELOPMENT OF HDB FLATS AND KITCHENS

1. Background of HDB Flats

Singapore is a small island nation with a total area of only 614 km^2. Land is, therefore, always at a premium for any building development, and thus high-rise, high-density, housing became the first and majority choice for the population over the last fifty years (Lam, 1988).

The Housing and Development Board (HDB) in Singapore is the sole national authority responsible for the physical planning and implementation of public housing development in Singapore. Over 86% of the total populations (3.2 million) live in housing produced by the HDB and 95.2% of the units have been purchased by the occupiers (Housing & Development Board, 1998).

2. Development of HDB Flats

When designing flat floor plans, the HDB considered two factors. One was to keep the cost of the flat as low as possible, for they must consider the residents' affordability and keep the government subsidy within a reasonable limit. The other was to maintain the standards of accommodation at reasonable levels. From the start, HDB adopted the principle that the flat is to be self-contained with its own kitchen and shower/toilet cum wash area (Wong and Yeh, 1985).

From 1960 to 1975, there were three major phases for HDB to build standardized flats. Between 1960 and 1965, which was the *First Five-Year Building Program*, the standard one-room, two-room and three-room flats were introduced. After 1965, improved one-room, two-room and three-room flats were built with new features such as larger floor space, some new fixtures and separate bathrooms and toilets for two- and three-room flats. The four-room was introduced in 1968 (Yeh, 1975).

By 1970, more than one-third of Singaporeans were living in Public housing. The housing shortage was not so serious anymore. Since the economy was booming and living standards rising, HDB committed itself to improving the living environments as well as providing more choices of flats. Again, in 1973, based on residential feedback, a new series of prototype three-room, four-room and five-room flats in slab blocks were set (Housing & Development Board, 1998).

In 1979, the executive flat type was introduced to cater to a new group of middle-income public housing applicants. In 1980s, there were three quarters of the population living in HDB flats. Emphasis turned naturally towards building communities, and creating an environment that nurtured family and community life (Housing & Development Board, 1998).

The occurrence of different flat types from 1978 to 1999 is charted (Figure A17.1.) and shows that before 1980, mainly 1, 2 and 3-room flats were built. During 1980 to 1986, more 3 and 4-room flats were built instead of 1 and 2-rooms. After 1986, only 4 and 5-room flats were built, since the resident's needs have shifted to bigger flats.

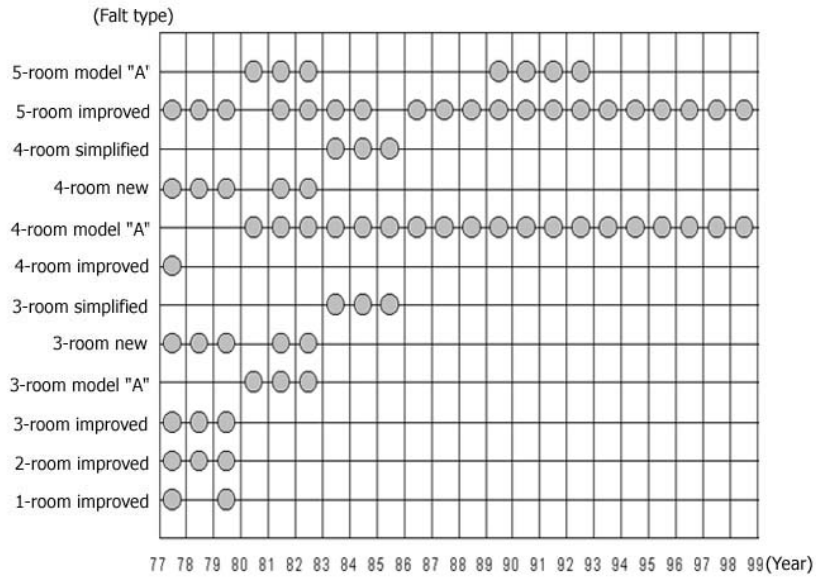


Figure A17.1: Occurrence of different flat types during 1978 to 1999.

The 4-room flat exceeds the 3- room flat in popularity at present. According to the statistics of the residents living in HDB flats (HDB, 2000), "*The Population living in HDB continued to shift upwards from smaller to bigger flats*." In 1993 the largest proportion of population (about 39.0%) lived in 3-room flats. However, in 1998 the proportion of population living in 3-room flats had declined to 27.8%. The 4-room flats accommodated the largest part of population (39.0%). The data also show that only 6.6% of the population lived in 1-room and 2-room flats in 1993 and the amount of the population declined to 5.1% in 1998. On the other hand, those occupying 4-room and bigger flats had increased from 54.4% in 1993 to 67.1% in 1998.

3. Trend of the HDB Kitchen Area

From the start, HDB adopted the principle that the flat is to be self-contained with its own kitchen and shower / toilet cum wash area. The kitchen of the one room flat is 9 m^2. The kitchen in the improved model of 2-room flats has been enlarged by absorbing the rear balcony of the standard model. In the 3-room flat, the kitchen has been further enlarged. In the improved model, by incorporating a dining area catering for the residents' preference, the kitchen is almost as large as the living room (Wong and Yeh, 1985).

There were some key principles taken into account when the kitchen's functional plan and dimensions were set. First, in order to suit the habits of the residents, whose preference that one bathroom opens directly to the kitchen (so that cooking and clothes washing activities may go on simultaneously), the bathroom's location and these wet elements related to clothes washing and drying activities were generally kept, as much as possible, to a corner of the kitchen. Second, in small flats, the kitchen is preferred as a dining area, thus kitchen size and arrangement of the kitchen fittings such as sinks were considered to provide adequate area for a dining table and chairs (Wong and Yeh, 1985).

Rubbish chutes had been placed directly in kitchens before 1990, each chute serving two back-to-back flats. But from 1989-90, in the newly built HDB flats, the design reverted to a centralized refuse chute system (HDB, 1990). This change is probably due to environmental health considerations (odor, fogging to kill vermin, etc.).

Areas of kitchens from the year 1978 to 1999 were compared to find out how the kitchen area changed. Comparisons show that for flats 1-room improved, 2-room improved, 3-room improved, 3-room model "A", 3-room new, 3-room simplified, 4-room simplified, 4-room improved, and 4-room new, the kitchen area changed little. Some types of flats (e.g. 3-room simplified, 3-room model "A", 4-room simplified) continued for only a few years, thus there were no clear developing trends.

Yet for those flats which had been built for a long period of time, for example 4-room model "A", 5-room improved, 5-room model "A", kitchen areas decreased obviously. From 1991 to 1996, for the 4-room model "A", a small balcony was attached to the kitchen. The balcony may serve as a laundry place with a washing machine. After 1995, for the 4-room model "A", the kitchen did not include the dining space (Figures A17.2, A17.3 & A17.4).

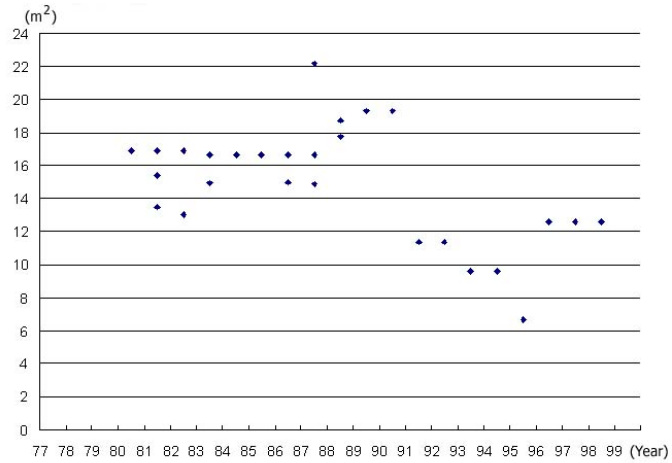


Figure A17.2: The area of kitchens in 4-room model "A" flats from 1978 to 1999 (before 1995, the kitchens included dining space; after 1995, the kitchens did not include the dining space).

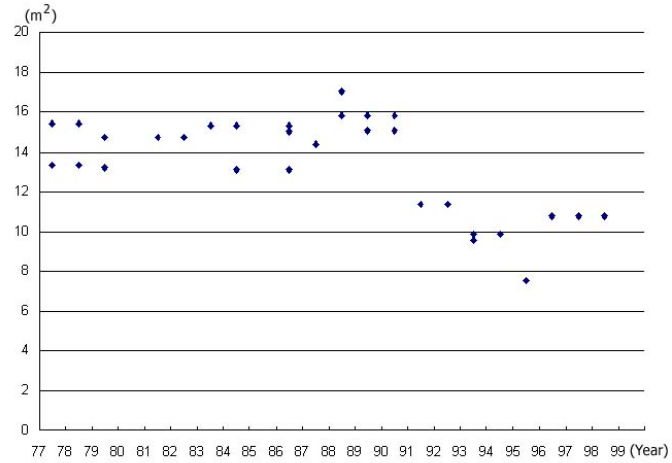


Figure A17.3: The area of kitchens in 5-room improved flats from 1978 to 1999 (all the kitchens without dining space).

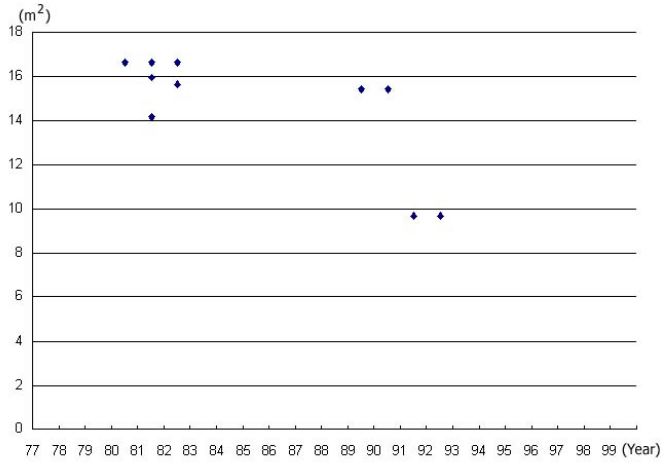


Figure A17.4: The area of kitchens in 5-room model "A" flats from 1978 to 1999 (all the kitchens without dining space).

This trend of kitchen area decline is perhaps not by accident, since 1993 the HDB has reduced the size of its flats (Lim, 2000). A four-room flat is now $90m^2$ (969 sq ft), down from $100m^2$ (1,076 sq ft); A five-room flat is $110m^2$ (1,184 sq ft), compared to $120m^2$ (1,292 sq ft) about a decade ago. Even in the future, "*as family size shrinks, Singaporeans may have to brace themselves for smaller homes*" (Lim, 2000). By adopting smaller flats, the kitchen area is likely to be reduced accordingly (Figures A17.5, A17.6 & A17.7).

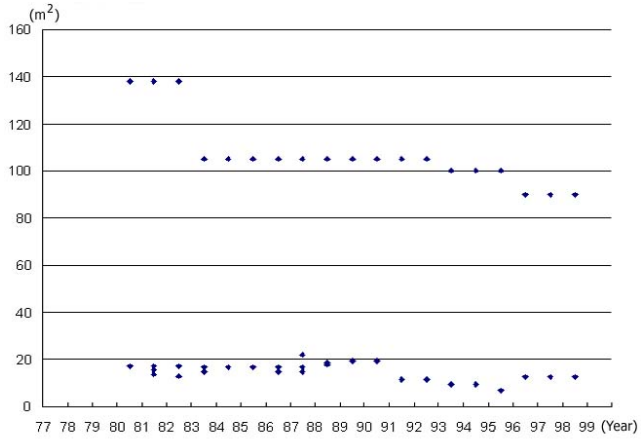


Figure A17.5: Both the flat area and the kitchen area decline (4-room model "A"). (Upper dots – flat area, lower dots – kitchen area).

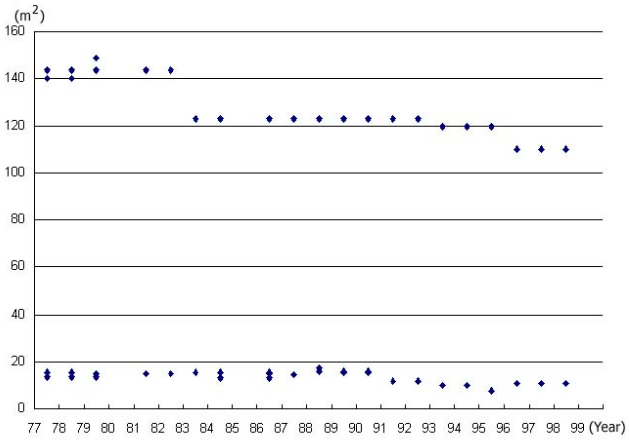


Figure A17.6: Both the flat area and the kitchen area decline (5-room improved). (Upper dots – flat areas, lower dots – kitchen areas).

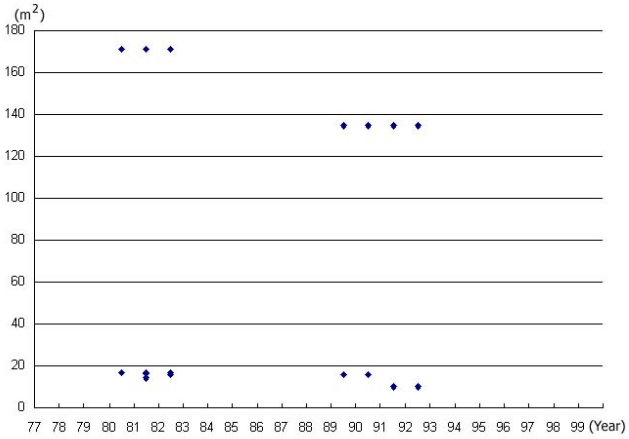


Figure A17.7: Both the flat area and the kitchen area decline (5-room model "A"). (Upper dots – flat area, lower dots – kitchen area).

But any further reduction in kitchen area needs more consideration. Since barrier-free kitchens may require them to be of certain minimum dimensions (to allow a wheelchair to turn for example).

APPENDIX 18. KITCHEN DATABASE

Table 18.1 lists the HDB Kitchens which were selected from HDB Annual Report from 1977 to 1999.

	Serial Number	Flat Type	Kitchen Area (m^2)	Length (m)	Width (m)	Isomorphic shape	Flat Area (m^2)
1	7778-01	1-room improved	5.5	2.7	2.2	s3	42
2	7778-02	2-room improved	12.67	5	2.9	s4	65
3	7778-03	3-room improved	14.06	5	2.9	s1	69
4	7778-04	3-room new	15.41	5.7	2.8	s1	89
5	7778-05	4-room improved	15.41	5.7	2.8	s1	99
6	7778-06	4-room new	15.41	5.7	2.8	s1	110
7	7778-07	5-room improved	15.41	5.7	2.8	s1	144
8	7778-08	5-room improved	13.12	5.5	2.45	s1	140
9	7879-01	2-room improved	11.22	4.5	2.9	s4	65
10	7879-02	3-room improved	14.06	5	2.9	s1	73
11	7879-03	3-room new	14.4	5.3	2.8	s1	89
12	7879-04	4-room new	15.41	5.7	2.8	s1	110
13	7879-05	5-room improved	15.41	5.7	2.8	s1	144
14	7879-06	5-room improved	13.12	5.5	2.45	s1	140
15	7980-01	1-room improved	5.5	2.7	2.2	s3	51
16	7980-02	2-room improved	12.67	5	2.9	s4	65
17	7980-03	3-room improved	14.06	5	2.9	s1	73
18	7980-04	3-room new	14.4	5.3	2.8	s1	89
19	7980-05	4-room new	15.41	5.7	2.8	s1	113
20	7980-06	4-room new	14.71	5.8	2.85	s4	117
21	7980-07	5-room improved	14.71	5.8	2.85	s4	144
22	7980-08	5-room improved	13.24	5.4	2.6	s2	149
23	8081-01	3-room model ‘A’	15.77	6	3	s4	105
24	8081-02	4-room model ‘A’	16.88	6.2	2.8	s1	138
25	8081-03	5-room model ‘A’	16.64	6	3.1	s4	171
26	8182-01	3-room new	14.4	5.3	2.8	s1	89
27	8182-02	3-room model ‘A’	15.77	6	3	s4	105
28	8182-03	4-room new	16.95	7.1	2.45	s1	121
29	8182-04	4-room model ‘A’	16.88	6.2	2.8	s1	138
30	8182-05	5-room improved	14.71	5.8	2.85	s4	144
31	8182-06	5-room model ‘A’	16.64	6	3.1	s4	171
32	8182-07	3-room model ‘A’	13.05	4.7	4	s5	NA
33	8182-08	3-room model ‘A’	8.3	4.6	2	s6	NA
34	8182-09	4-room model ‘A’	15.41	5.7	2.8	s1	NA
35	8182-10	4-room model ‘A’	13.49	4.6	3.6	s7	NA
36	8182-11	5-room model ‘A’	14.16	4.5	4	s8	NA
37	8182-12	5-room model ‘A’	15.98	6	3.4	s9	NA
38	8283-01	3-room new	14.4	5.3	2.8	s1	89
39	8283-02	3-room model ‘A’	15.77	6	3	s4	105

	Serial Number	Flat Type	Kitchen Area (m^2)	Length (m)	Width (m)	Isomorphic shape	Flat Area (m^2)
40	8283-03	4-room new	16.95	7.1	2.45	s1	121
41	8283-04	4-room model ‘A’	16.88	6.2	2.8	s1	138
42	8283-05	5-room improved	14.71	5.8	2.85	s4	144
43	8283-06	5-room model ‘A’	16.64	6	3.1	s4	171
44	8283-07	3-room model ‘A’	11.07	3.7	3.6	s10	NA
45	8283-08	4-room model ‘A’	13.05	4.7	4	s5	NA
46	8283-09	5-room model ‘A’	15.62	5.5	3.3	s12	NA
47	8384-01	3-room simplified	12.7	5.5	3	s13	65
48	8384-02	4-room simplified	12.9	6.2	2.5	s14	85
49	8384-03	4-room model ‘A’	16.64	6.8	2.5	s1	105
50	8384-04	4-room model ‘A’	14.95	6	2.7	s4	105
51	8384-05	5-room improved	15.32	6.4	2.45	s1	123
52	8485-01	3-room simplified	12.7	5.5	3	s13	65
53	8485-02	4-room simplified	12.91	6.1	2.5	s15	85
54	8485-03	4-room model ‘A’	16.64	6.8	2.5	s1	105
55	8485-04	5-room improved	15.32	6.4	2.45	s1	123
56	8485-05	5-room improved	13.12	5.5	2.45	s1	123
57	8586-01	3-room simplified	12.7	5.5	3	s13	65
58	8586-02	4-room simplified	12.91	6.1	2.5	s15	85
59	8586-03	4-room model ‘A’	16.64	6.8	2.5	s1	105
60	8687-01	4-room model ‘A’	16.64	6.8	2.5	s1	105
61	8687-02	4-room model ‘A’	14.97	5.8	3.6	s5	105
62	8687-03	5-room improved	15.32	6.4	2.45	s1	123
63	8687-04	5-room improved	13.12	5.5	2.45	s1	123
64	8687-05	5-room improved	15.05	5	3.4	s4	123
65	8788-01	5-room improved	14.36	5.87	3.12	s16	123
66	8788-02	4-room model ‘A’	22.14	7.8	3.4	s11	105
67	8788-03	4-room model ‘A’	16.66	5.87	3.25	s16	105
68	8788-04	4-room model ‘A’	14.86	5.5	3.4	s11	105
69	8889-01	5-room improved	17.07	5.5	3.9	s11	123
70	8889-02	5-room improved	15.83	6.25	3.1	s14	123
71	8889-03	4-room model ‘A’	18.74	6.8	3.4	s11	105
72	8889-04	4-room model ‘A’	17.72	6.5	3.4	s11	105
73	8990-01	5-room model ‘A’	15.43	5.25	3.4	s10	135
74	8990-02	5-room improved	15.83	6.25	3.1	s14	123
75	8990-03	5-room improved	15.05	5	3.4	s4	123
76	8990-04	4-room model ‘A’	19.3	6.25	3.4	s4	105
77	9091-01	5-room model ‘A’	15.43	5.25	3.4	s10	135
78	9091-02	5-room improved	15.05	5	3.4	s4	123
79	9091-03	5-room improved	15.83	6.25	3.1	s14	123
80	9091-04	4-room model ‘A’	19.3	6.25	3.4	s4	105
81	9192-01	4-room model ‘A’	11.35	3.35	3.35	s1	105

	Serial Number	Flat Type	Kitchen Area (m^2)	Length (m)	Width (m)	Isomorphic shape	Flat Area (m^2)
82	9192-02	5-room improved	11.35	3.35	3.35	s1	123
83	9192-03	5-room model 'A'	9.66	3.4	3.4	s10	135
84	9293-01	4-room model 'A'	11.35	3.35	3.35	s1	105
85	9293-02	5-room improved	11.35	3.35	3.35	s1	123
86	9293-03	5-room model 'A'	9.66	3.4	3.4	s10	135
87	9394-01	4-room model 'A'	9.57	3.3	2.9	s1	100
88	9394-02	5-room improved	9.57	3.3	2.9	s1	120
89	9394-03	5-room improved	9.88	3.8	2.6	s1	120
90	9495-01	4-room model 'A'	9.57	3.3	2.9	s1	100
91	9495-02	5-room improved	9.88	3.8	2.6	s1	120
92	9596-01	4-room model 'A'	6.67	2.9	2.3	s1	100
93	9596-02	5-room improved	7.54	2.9	2.6	s1	120
94	9697-01	4-room model 'A'	12.6	6	2.1	s1	90
95	9697-02	5-room improved	10.81	4.7	2.3	s1	110
96	9798-01	4-room model 'A'	12.6	6	2.1	s1	90
97	9798-02	5-room improved	10.81	4.7	2.3	s1	110
98	9899-01	4-room model 'A'	12.6	6	2.1	s1	90
99	9899-02	5-room improved	10.81	4.7	2.3	s1	110

Table 18.1: Kitchens from 1977 to 1999.

Table 18.2 lists the kitchens according to floor area. The kitchens which were selected for schematic analyses are listed in the last column.

	Serial Number	Flat Type	Kitchen Area (m^2)	Length (m)	Width (m)	Isomorphic shape	Flat Area (m^2)	Analyzed Kitchen
1	7778-01	1-room improved	5.5	2.7	2.2	s3	42	7778-01
15	7980-01	1-room improved	5.5	2.7	2.2	s3	51	
92	9596-01	4-room model 'A'	6.67	2.9	2.3	s1	100	9596-01
93	9596-02	5-room improved	7.54	2.9	2.6	s1	120	9596-02
33	8182-08	3-room model 'A'	8.3	4.6	2	s6	NA	8182-08
87	9394-01	4-room model 'A'	9.57	3.3	2.9	s1	100	9495-01
88	9394-02	5-room improved	9.57	3.3	2.9	s1	120	
90	9495-01	4-room model 'A'	9.57	3.3	2.9	s1	100	
83	9192-03	5-room model 'A'	9.66	3.4	3.4	s10	135	9293-03
86	9293-03	5-room model 'A'	9.66	3.4	3.4	s10	135	
89	9394-03	5-room improved	9.88	3.8	2.6	s1	120	9394-03
91	9495-02	5-room improved	9.88	3.8	2.6	s1	120	
95	9697-02	5-room improved	10.81	4.7	2.3	s1	110	9697-02
97	9798-02	5-room improved	10.81	4.7	2.3	s1	110	
99	9899-02	5-room improved	10.81	4.7	2.3	s1	110	
44	8283-07	3-room model 'A'	11.07	3.7	3.6	s10	NA	8283-07
9	7879-01	2-room improved	11.22	4.5	2.9	s4	65	7879-01
81	9192-01	4-room model 'A'	11.35	3.35	3.35	s1	105	9293-02

	Serial Number	Flat Type	Kitchen Area (m^2)	Length (m)	Width (m)	Isomorphic shape	Flat Area (m^2)	Analyzed Kitchen
82	9192-02	5-room improved	11.35	3.35	3.35	s1	123	
84	9293-01	4-room model 'A'	11.35	3.35	3.35	s1	105	
85	9293-02	5-room improved	11.35	3.35	3.35	s1	123	
94	9697-01	4-room model 'A'	12.6	6	2.1	s1	90	
96	9798-01	4-room model 'A'	12.6	6	2.1	s1	90	9798-01
98	9899-01	4-room model 'A'	12.6	6	2.1	s1	90	
2	7778-02	2-room improved	12.67	5	2.9	s4	65	7980-02
16	7980-02	2-room improved	12.67	5	2.9	s4	65	
47	8384-01	3-room simplified	12.7	5.5	3	s13	65	8586-01
52	8485-01	3-room simplified	12.7	5.5	3	s13	65	
57	8586-01	3-room simplified	12.7	5.5	3	s13	65	
48	8384-02	4-room simplified	12.9	6.2	2.5	s14	85	8384-02
53	8485-02	4-room simplified	12.91	6.1	2.5	s15	85	8485-02
58	8586-02	4-room simplified	12.91	6.1	2.5	s15	85	
32	8182-07	3-room model 'A'	13.05	4.7	4	s5	NA	8182-07
45	8283-08	4-room model 'A'	13.05	4.7	4	s5	NA	
8	7778-08	5-room improved	13.12	5.5	2.45	s1	140	8485-05
14	7879-06	5-room improved	13.12	5.5	2.45	s1	140	
56	8485-05	5-room improved	13.12	5.5	2.45	s1	123	
63	8687-04	5-room improved	13.12	5.5	2.45	s1	123	
22	7980-08	5-room improved	13.24	5.4	2.6	s2	149	7980-08
35	8182-10	4-room model 'A'	13.49	4.6	3.6	s7	NA	8182-10
3	7778-03	3-room improved	14.06	5	2.9	s1	69	7980-03
10	7879-02	3-room improved	14.06	5	2.9	s1	73	
17	7980-03	3-room improved	14.06	5	2.9	s1	73	
36	8182-11	5-room model 'A'	14.16	4.5	4	s8	NA	8182-11
65	8788-01	5-room improved	14.36	5.87	3.12	s16	123	8788-01
11	7879-03	3-room new	14.4	5.3	2.8	s1	89	7980-04
18	7980-04	3-room new	14.4	5.3	2.8	s1	89	
26	8182-01	3-room new	14.4	5.3	2.8	s1	89	
38	8283-01	3-room new	14.4	5.3	2.8	s1	89	
20	7980-06	4-room new	14.71	5.8	2.85	s4	117	7980-07
21	7980-07	5-room improved	14.71	5.8	2.85	s4	144	
30	8182-05	5-room improved	14.71	5.8	2.85	s4	144	
42	8283-05	5-room improved	14.71	5.8	2.85	s4	144	
68	8788-04	4-room model 'A'	14.86	5.5	3.4	s11	105	8788-04
50	8384-04	4-room model 'A'	14.95	6	2.7	s4	105	8384-04
61	8687-02	4-room model 'A'	14.97	5.8	3.6	s5	105	8687-02
64	8687-05	5-room improved	15.05	5	3.4	s4	123	Not analyzed
75	8990-03	5-room improved	15.05	5	3.4	s4	123	
78	9091-02	5-room improved	15.05	5	3.4	s4	123	

	Serial Number	Flat Type	Kitchen Area (m^2)	Length (m)	Width (m)	Isomorphic shape	Flat Area (m^2)	Analyzed Kitchen
51	8384-05	5-room improved	15.32	6.4	2.45	s1	123	Not analyzed
55	8485-04	5-room improved	15.32	6.4	2.45	s1	123	
62	8687-03	5-room improved	15.32	6.4	2.45	s1	123	
4	7778-04	3-room new	15.41	5.7	2.8	s1	89	Not analyzed
5	7778-05	4-room improved	15.41	5.7	2.8	s1	99	
6	7778-06	4-room new	15.41	5.7	2.8	s1	110	
7	7778-07	5-room improved	15.41	5.7	2.8	s1	144	
12	7879-04	4-room new	15.41	5.7	2.8	s1	110	
13	7879-05	5-room improved	15.41	5.7	2.8	s1	144	
19	7980-05	4-room new	15.41	5.7	2.8	s1	113	
34	8182-09	4-room model ‘A’	15.41	5.7	2.8	s1	NA	
73	8990-01	5-room model ‘A’	15.43	5.25	3.4	s10	135	Not analyzed
77	9091-01	5-room model ‘A’	15.43	5.25	3.4	s10	135	
46	8283-09	5-room model ‘A’	15.62	5.5	3.3	s12	NA	Not analyzed
23	8081-01	3-room model ‘A’	15.77	6	3	s4	105	Not analyzed
27	8182-02	3-room model ‘A’	15.77	6	3	s4	105	
39	8283-02	3-room model ‘A’	15.77	6	3	s4	105	
70	8889-02	5-room improved	15.83	6.25	3.1	s14	123	Not analyzed
74	8990-02	5-room improved	15.83	6.25	3.1	s14	123	
79	9091-03	5-room improved	15.83	6.25	3.1	s14	123	Not analyzed
37	8182-12	5-room model ‘A’	15.98	6	3.4	s9	NA	Not analyzed
25	8081-03	5-room model ‘A’	16.64	6	3.1	s4	171	Not analyzed
31	8182-06	5-room model ‘A’	16.64	6	3.1	s4	171	
43	8283-06	5-room model ‘A’	16.64	6	3.1	s4	171	
49	8384-03	4-room model ‘A’	16.64	6.8	2.5	s1	105	Not analyzed
54	8485-03	4-room model ‘A’	16.64	6.8	2.5	s1	105	
59	8586-03	4-room model ‘A’	16.64	6.8	2.5	s1	105	
60	8687-01	4-room model ‘A’	16.64	6.8	2.5	s1	105	
67	8788-03	4-room model ‘A’	16.66	5.87	3.25	s16	105	Not analyzed
24	8081-02	4-room model ‘A’	16.88	6.2	2.8	s1	138	Not analyzed
29	8182-04	4-room model ‘A’	16.88	6.2	2.8	s1	138	
41	8283-04	4-room model ‘A’	16.88	6.2	2.8	s1	138	
28	8182-03	4-room new	16.95	7.1	2.45	s1	121	Not analyzed
40	8283-03	4-room new	16.95	7.1	2.45	s1	121	
69	8889-01	5-room improved	17.07	5.5	3.9	s11	123	Not analyzed
72	8889-04	4-room model ‘A’	17.72	6.5	3.4	s11	105	Not analyzed
71	8889-03	4-room model ‘A’	18.74	6.8	3.4	s11	105	Not analyzed

	Serial Number	Flat Type	Kitchen Area (m^2)	Length (m)	Width (m)	Isomorphic shape	Flat Area (m^2)	Analyzed Kitchen
76	8990-04	4-room model 'A'	19.3	6.25	3.4	s4	105	Not analyzed
80	9091-04	4-room model 'A'	19.3	6.25	3.4	s4	105	
66	8788-02	4-room model 'A'	22.14	7.8	3.4	s11	105	Not analyzed

Table 18.2: Kitchens are listed according to their ascending areas.

The different types of shape are illustrated in Table 18.3.

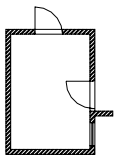
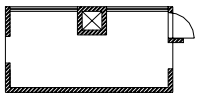
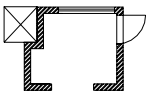
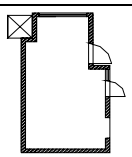
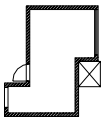
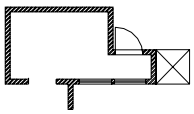
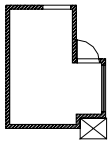
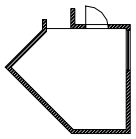
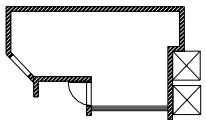
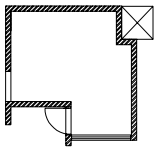
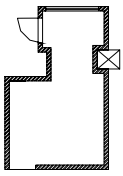
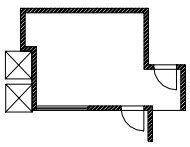
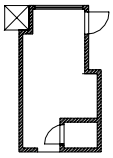
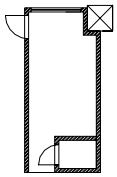
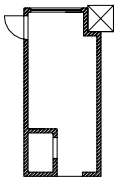
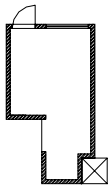
Shape		Sample	Shape		Sample
s1 Regular		Kitchen 9394-03	s2 Regular		Kitchen 7980-08
s3 Irregular		Kitchen 7778-01	s4 Irregular		Kitchen 7980-07
s5 Irregular		Kitchen 8182-07	s6 Irregular		Kitchen 8182-08
s7 Irregular		Kitchen 8182-10	s8 Irregular		Kitchen 8182-11
s9 Irregular		Kitchen 8182-12	s10 Irregular		Kitchen 8283-07
s11 Irregular		Kitchen 8788-04	s12 Irregular		Kitchen 8283-09
s13 Irregular		Kitchen 8586-01	s14 Irregular		Kitchen 8384-02
s15 Irregular		Kitchen 8485-02	s16 Irregular		Kitchen 8788-01

Table 18.3: Different shapes of the kitchen.

APPENDIX 19. AREA CRITERION FOR CHOOSING KITCHEN

According to Peterson (1998), a small kitchen is equal or less than 14 m^2 (150 sq.ft) and a large kitchen is over 14m^2 (150 sq.ft). According to the Scottish Housing Handbook (Scottish Development Department, 1979), the area for a typical standard kitchen for a wheelchair user is about 8.64m^2 (without dining space inside the kitchen) (Figure A19.1). This typical standard kitchen incorporates almost all the appliances similar to the HDB kitchens (such as sink, cooker, refrigerator, washing machine, etc.).

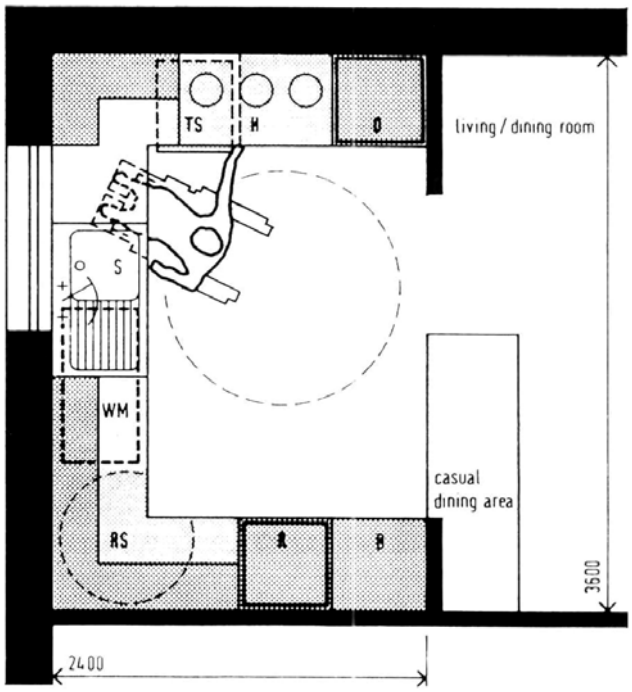


Figure A19.1: Kitchen layout to suit a wheelchair user (Scottish Development Department, 1979) (O – oven; H – hob; C – cooker; TS - trolley storage unit; B – broom cupboard; WM – washing machine; R – refrigerator; RS – rotating storage unit; S – sink).

One kitchen example provided by the Barrier Free Environments, Inc. (1991) without dining space has an area of 10.15m^2 (Figures A19.2 & A19.3). Another example incorporating a food serving area is 11.9m^2 (Figures A19.4 & A19.5). In these two examples, more appliances are accommodated such as dishwasher and oven.

Since the area 14m^2 is much bigger than the recommendations for a wheelchair user, a premise was set that a large kitchen (area over 14m^2) is big enough for a wheelchair user. Yet, in order to cover more types of the HDB kitchen, finally the kitchens whose areas are less than 15m^2 were selected. Using this criterion aimed to exclude some kitchens whose areas are too big to avoid unnecessary work. This usage did not bring any bias or mistakes into the research. Therefore, it is acceptable in this thesis.

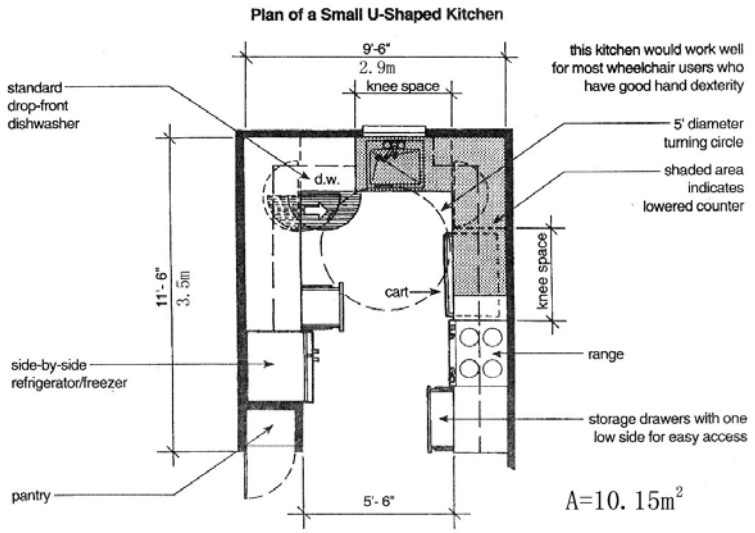


Figure A19.2: kitchen example without dining space (area is 10.15m^2) (source: Barrier Free Environments, Inc., 1991).

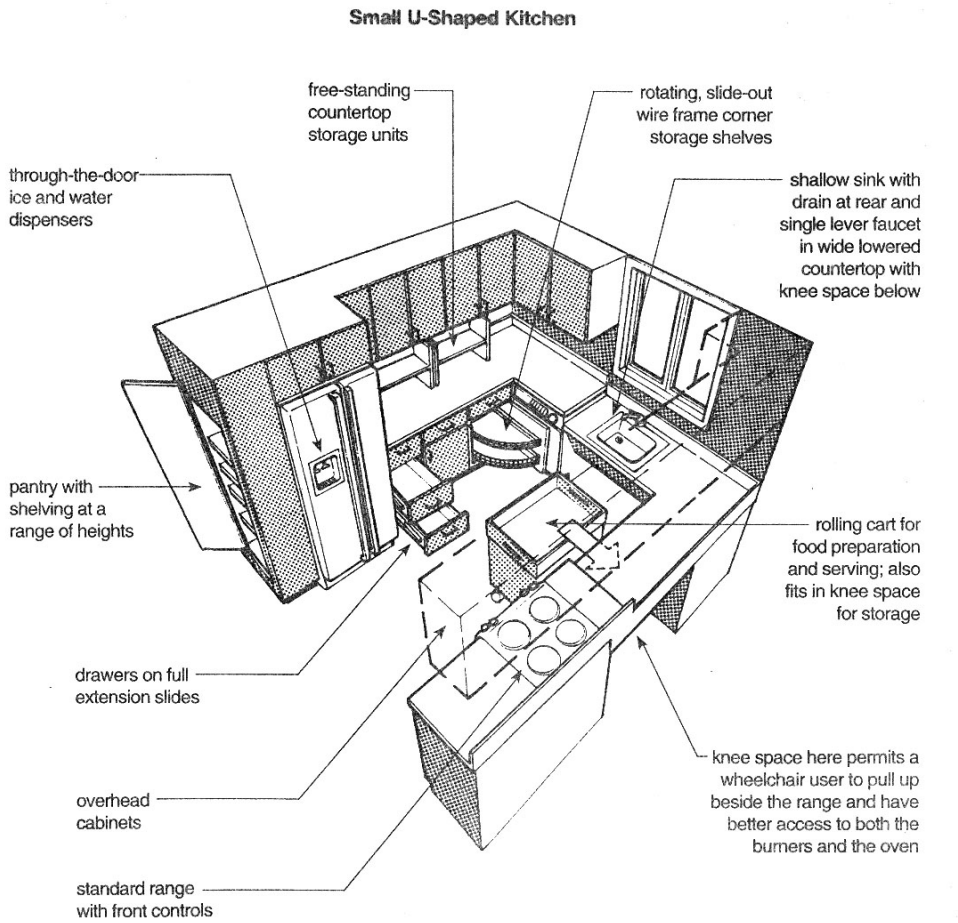


Figure A19.3: Perspective of the kitchen example without dining space (source: Barrier Free Environments, Inc., 1991).

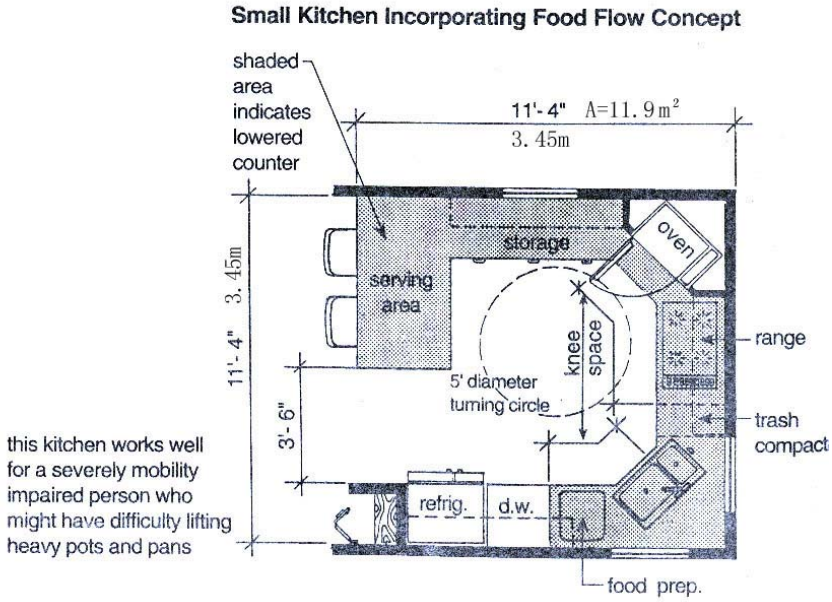


Figure A19.4: kitchen example with a food serving area (area is 11.9m^2) (source: Barrier Free Environments, Inc., 1991).

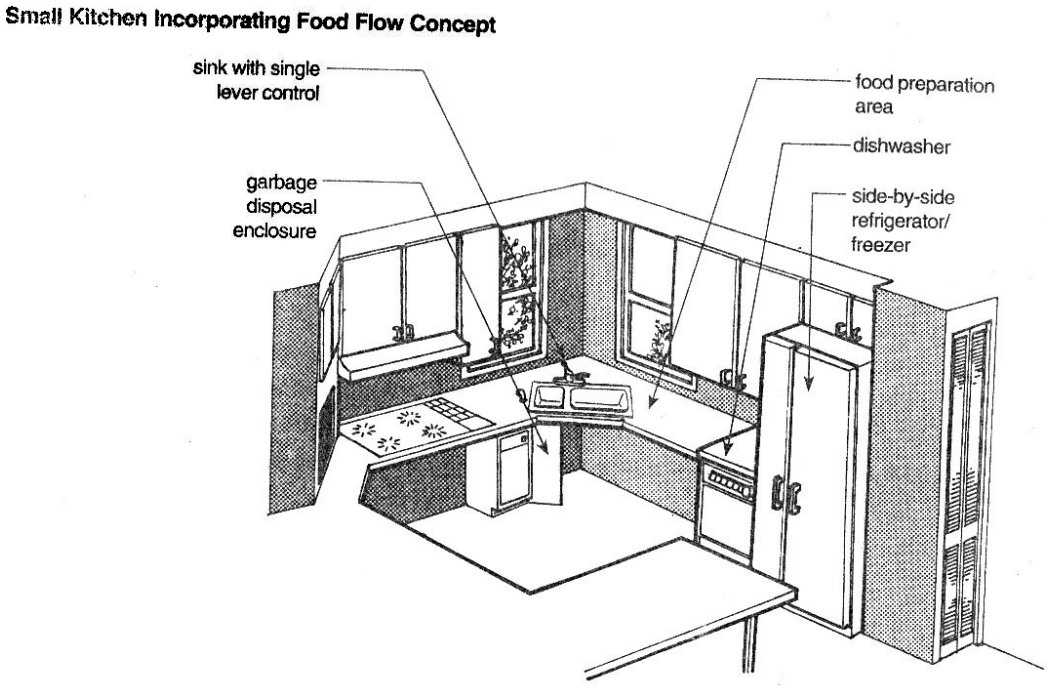


Figure A19.5: Perspective of the kitchen example with a food serving area (source: Barrier Free Environments, Inc., 1991).

APPENDIX 20. EXAMPLES OF SCHEMATIC ANALYSIS ABOUT THE KITCHEN AREA

Kitchen 7778-01 (For the code meaning please refer to Chapter V, Section 5.2: Setting up the database of the kitchen)

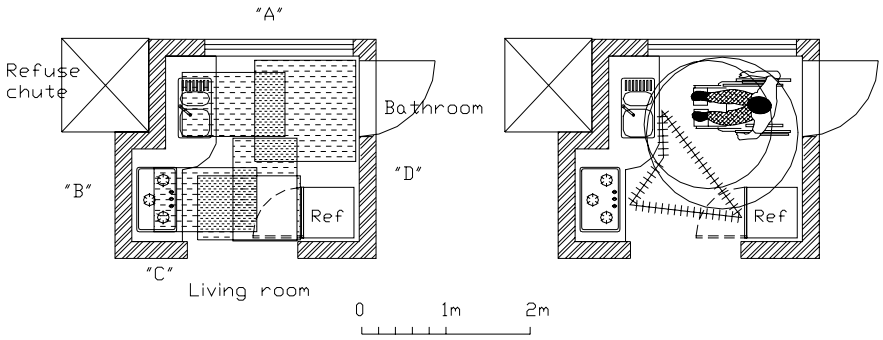


Figure A20.1: Floor layout analysis of Kitchen 7778-01.

Figure A20.1 is the floor layout analysis of Kitchen 7778-01. The kitchen area is about 5.5m^2. Since there are two doors to the kitchen (one to the living room and the other to the bathroom) only the "B" wall and right-down corner are left for countertops and appliances. Because the "B" wall is short, when the sink and cooker are installed, no adequate countertop is available. Not enough counter space is provided on either side of the cooker. The storage space is also inadequate. If the wheelchair user is working at the cooker, the entrance to the living room is blocked. Thus no one else can enter the kitchen or use the bathroom. There is no space for large circular wheelchair turning. If knee space is provided under the sink, part of the turning space can be under the sink. For this situation, a large circle turn can be made. No space is available for the washing machine or for drying clothes.

Kitchen 9596-01

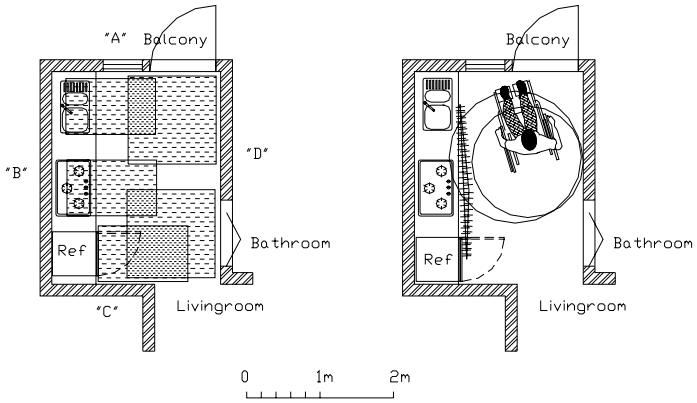


Figure A20.2: Floor layout analysis of Kitchen 9596-01.

Figure A20.2 is the floor layout analysis of Kitchen 9596-01. The kitchen area is about 6.67m^2. Compared with Kitchen 7778-01, the kitchen shape is more regular. In the right part of the kitchen there are three doors (to the bathroom, the living room, and the balcony respectively). Considering the approaching spaces to doors, actually nothing can be located against the "D" wall. The sink, cooker and refrigerator can only be installed along the "B" wall. The net length of the "B" wall is about 2.9m. Excluding the length of the refrigerator (about 60cm), cooker (about 70cm), sink (about 70cm), the distance (estimated 20cm) between the cooker and

refrigerator and the distance (estimated 20cm) between the sink and the “A” wall, only 50cm length is available for countertop. This length is not adequate for cooking preparation. If the refrigerator is located under the counter, longer countertop is acquired. However, it is still not enough. The storage space is also inadequate.

There is no place for placing the washing machine and drying clothes. The service balcony may be a place for clothes washing and drying, but it is often difficult to access by wheelchair users. The distance between the countertop and “D” wall is about 1.7m. This distance is enough for a large circle turning only when knee space is provided under the countertop.

The “C” wall is too short for a “leg” of the “L” shaped countertop. Figure A20.3 shows that if a refrigerator is placed at the right end of the “C” wall, the bathroom will be inaccessible for a wheelchair user since the space in front of the bathroom entrance is smaller than 1.2m×1.2m (the area needed for entering a door).

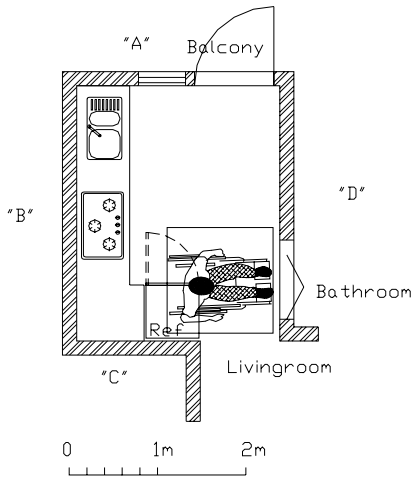


Figure A20.3: “L” shaped countertop is impossible in Kitchen 9596-01.

Kitchen 9596-02

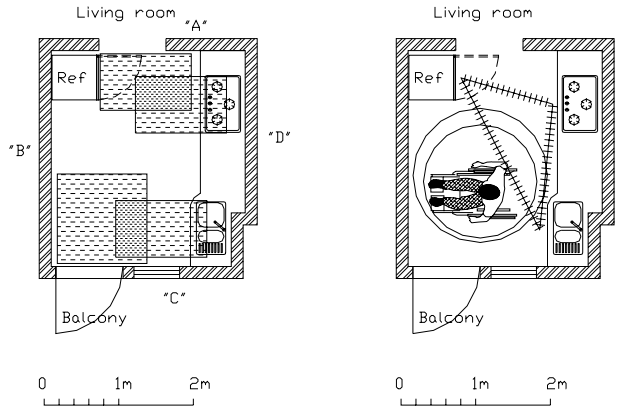


Figure A20.4: Floor layout analysis of Kitchen 9596-02.

Figure A20.4 is the floor layout analysis of Kitchen 9596-02. The kitchen area is about 7.54m^2. The analysis shows that the space between counter and wall is enough for circular turning. However, when a wheelchair user is working at the cooker, he/she will block the entrance to the living room. It seems that there is adequate countertop for cooking but only for the simplest appliances (only sink and cooker). There is no landing place for placing items when putting them in or taking them out of a refrigerator. Similar to Kitchen 9596-01, there is no space for a

washing machine. If a small washing machine is located under the countertop between the sink and cooker, then no storage is available.

Kitchen 8182-08

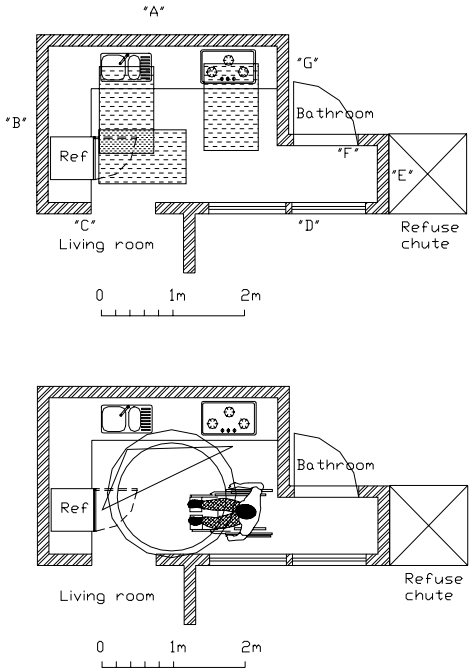


Figure A20.5: Floor layout analysis of Kitchen 8182-08.

Figure A20.5 is the floor layout analysis of Kitchen 8182-08. The kitchen area is about 8.3m^2. The analysis shows that when a knee space is provided under the countertop, a large circle turn is allowed. The width between the "D" and "F" wall is only 0.9m and the door to bathroom is on the side (on "F" wall). This bathroom cannot be used by a wheelchair user because 1.67m×1.2m space (latch-side approach to a swing door) is not available.

Comparing Kitchen 8182-08 (area 8.30m^2) with the SDD typical kitchen layout (area 8.64m^2) (Figure A20.6), we see that the SDD typical layout is more accessible although the two kitchens' areas are close. There are two reasons: 1) Kitchen 8182-08 is irregular in shape and the passage to bathroom wastes some area; 2) for a Singapore HDB kitchen, a bathroom is usually attached to it, sometimes a balcony too. Therefore, the kitchen has at least two doors. As a result, the wall length available for placing countertop is shorter than that of the SDD typical layout.

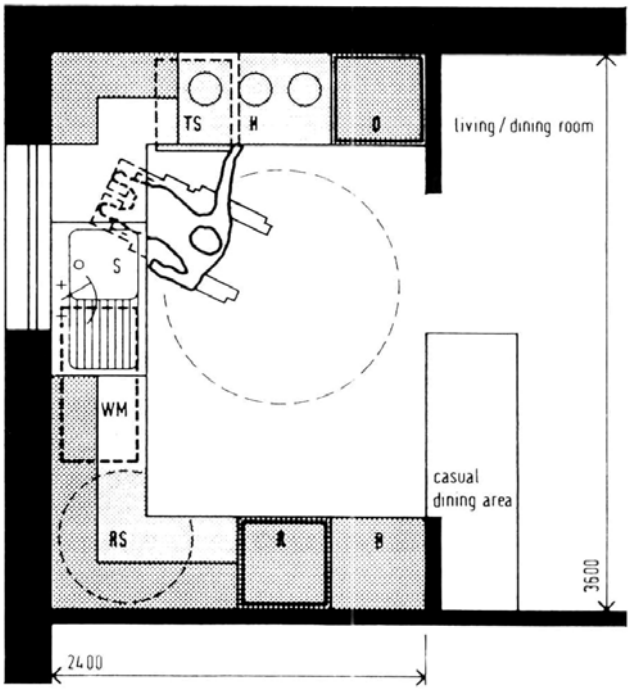


Figure A20.6: Kitchen layout to suit a wheelchair user (Scottish Development Department, 1979) (O – oven; H – hob; C – cooker; TS - trolley storage unit; B – broom cupboard; WM – washing machine; R – refrigerator; RS – rotating storage unit; S – sink).

Kitchen 9495-01

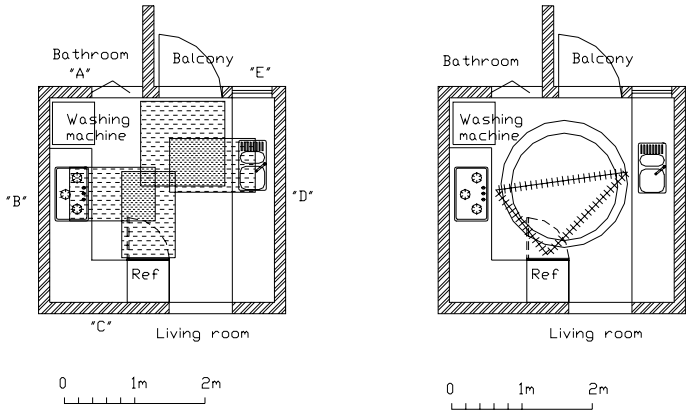


Figure A20.7: Floor layout analysis of Kitchen 9495-01.

Figure A20.7 is the floor layout analysis of Kitchen 9495-01. The kitchen area is about 9.57m^2. The distance between “B” and “D” wall is about 3.3m. The width is enough for large circular wheelchair turning.

Considering that the countertop is usually 0.6m deep and the dimensions of the refrigerator and the washing machine, the “A” and “E” walls must be at least 0.6m each. The door approaching space is 1.2m×1.2m for wheelchair accessibility. Therefore, the whole distance between the “B” and “D” walls should be more than 3.6m (0.6m×2 + 1.2m×2). However, the distance between the “B” and “D” wall (3.3m) is not long enough for two countertops and two doors in terms of the wheelchair users’ needs.

Considering the whole kitchen layout, we observe that this kitchen is fundamentally accessible for a wheelchair user except that he/she cannot enter the bathroom.

Kitchen 9293-03

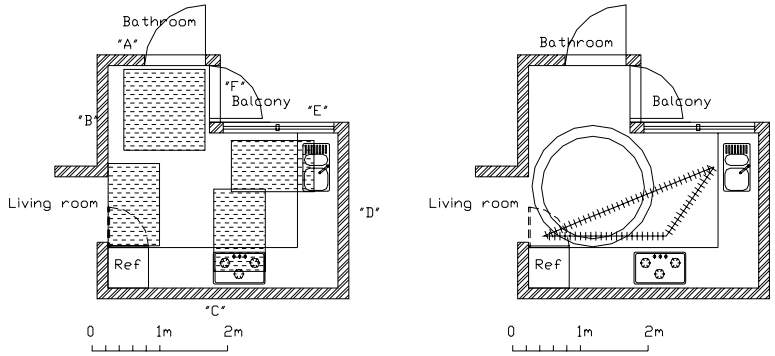


Figure A20.8: Floor layout analysis of Kitchen 9293-03.

Figure A20.8 is the floor layout analysis of Kitchen 9293-03. The kitchen area is about 9.66m^2. The places of refrigerator, cooker and sink are suitably placed and the working triangle avoids interruption by routes from the living room to the bathroom or balcony. There is also enough space for circular wheelchair turning.

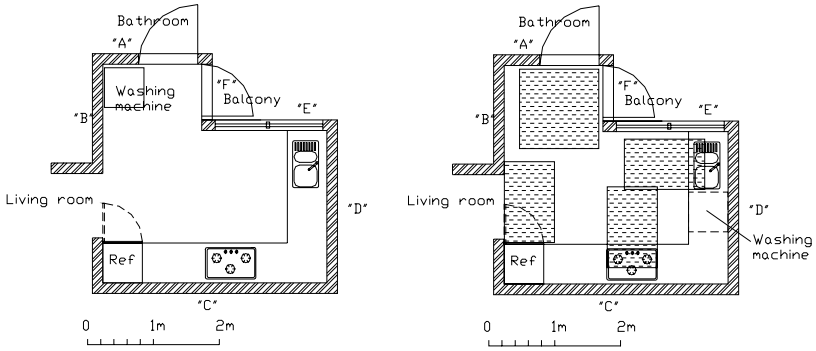


Figure A20.9: Floor layout analysis of Kitchen 9293-03.

The distance between the “B” and “F” walls is about 1.5m. For ambulant users this distance is enough for a door (usually 0.8m) and a washing machine (or a cabinet) (Figure A20.9 Left). But for a wheelchair user, this width is only enough for a wheelchair user approaching the door (Figure A20.9 Right). If a washing machine (supposed to be 0.6m wide) needs to be placed near the bathroom, the distance between the “B” and “F” walls must be at least 1.8m (1.2m + 0.6m). Therefore, if a washing machine is put at the corner of walls “A” and “B”, the bathroom can not be used by a wheelchair user. Then the washing machine can only be put adjacent near the sink.

Kitchen 9394-03

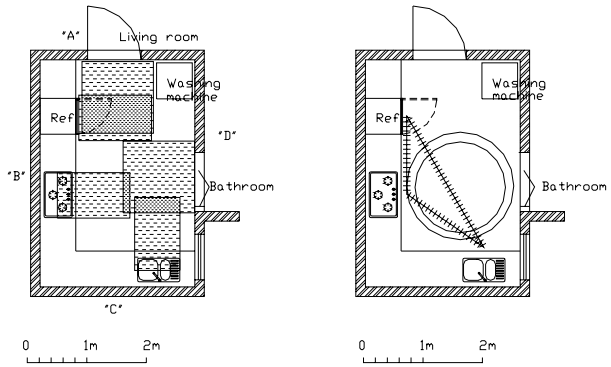


Figure A20.10: Floor layout analysis of Kitchen 9394-03.

Figure A20.10 is the floor layout analysis of Kitchen 9394-03. The kitchen area is about 9.88m^2. The locations of the refrigerator, cooker and sink are suitable. There is enough space for circular wheelchair turning. The working triangle is not interrupted. The distance between the "B" and "D" walls is 2.6m and this distance is just enough for a countertop, a washing machine and a wheelchair approaching the door, (0.6m + 0.6m + 1.2m). In general, this kitchen basically meets the space requirements of a wheelchair user.

APPENDIX 21. EXAMPLES OF SCHEMATIC ANALYSIS ABOUT THE KITCHEN SHAPE

Narrow kitchen

Figure A21.1 is the floor layout analysis of Kitchen 9798-01. The kitchen area is about 12.6m^2. The distance between walls "B" and "D" is about 2.1m. When we subtract the depth of the countertop (about 0.6m), only 1.5m is left. This width is enough for the large circle turning only when the knee space is provided under the countertop. If a washing machine is placed against the "D" wall, there is only about 0.9m left between the washing machine and the countertop. Thus the shift of the wheelchair between the sink and the cooker becomes inconvenient and needs more care. Another location for the washing machine is under the countertop beside the sink. In this situation, the movement between the sink and cook is easier.

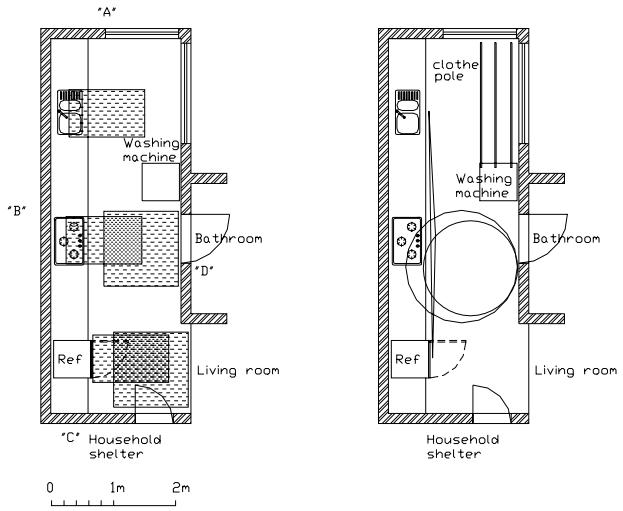


Figure A21.1: Floor layout analysis of Kitchen 9798-01.

Compared with Kitchen 9394-03 (Figure A21.2), Kitchen 9798-01 is bigger; but when we consider the usage of a wheelchair user, it is less accessible. The reason for this is that Kitchen 9798-01 has an ineffective ratio of length to width.

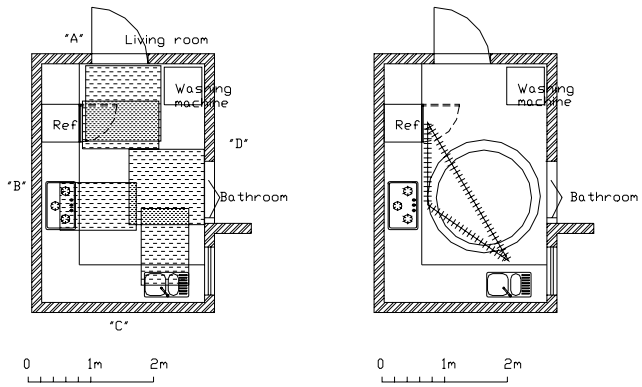


Figure A21.2: Floor layout analysis of Kitchen 9394-03 (area is 9.88m^2).

Irregular kitchens

Figure A21.3 is the floor layouts analysis of Kitchen 8687-02. The kitchen area is about 14.97m^2. The shape is irregular with a storeroom and a bathroom on the corner. The floor layout analysis shows that the working centers can only be placed on opposite countertops. The work triangle is interrupted by the route from the living room to bathroom.

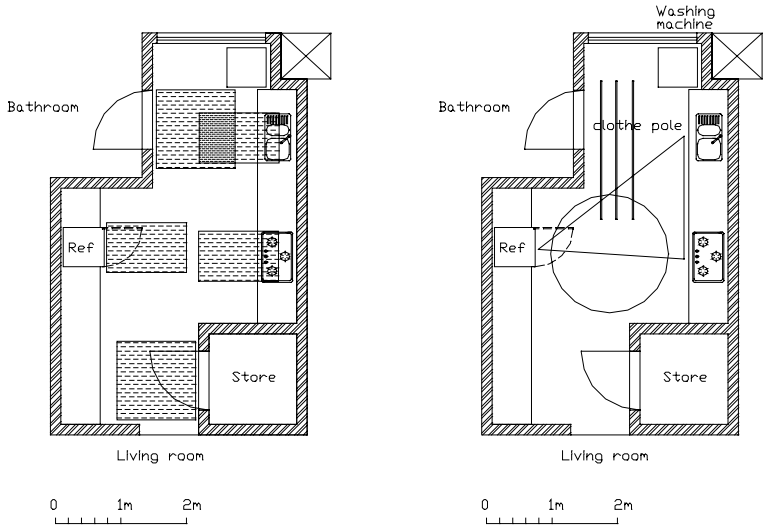


Figure A21.3: Floor layout analysis of Kitchen 8687-02, layout 1.

Figure A21.4 is the floor layout analysis of the kitchen 8586-01. Its area is 12.7m^2. Because the kitchen shape is very irregular, the space is divided into several parts (which are indicated as shaded area in Figure A21.4 Right). In fact in this kitchen only the central part of the space can be used for arranging countertop. The wheelchair users can only use this central part.

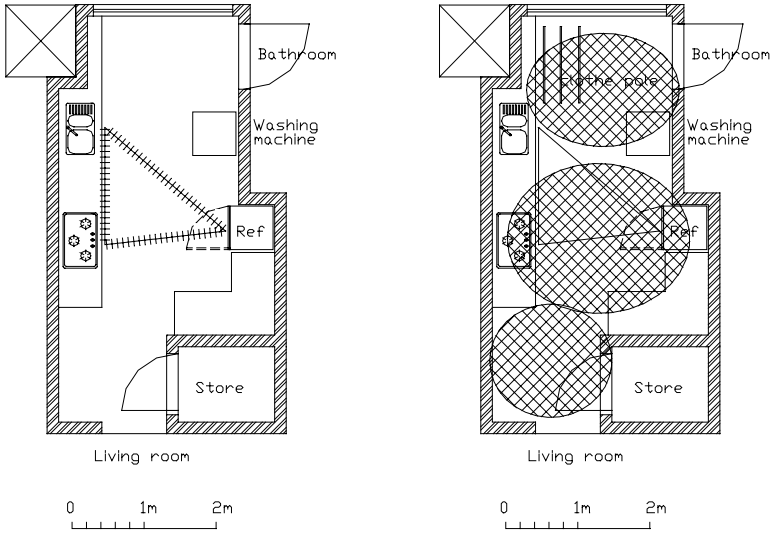


Figure A21.4: Floor layout analysis of Kitchen 8586-01.

Figure A21.5 is the floor layout analysis of the kitchen 8182-07. Its area is 13.05m^2. Similarly, because the kitchen is irregular, the space is roughly divided into two parts (which are indicated as shaded area in Figure A21.5 Right). The part near the doors cannot be used to

arrange the countertop because of the doors. Only the part with walls can be used for arranging the countertops.

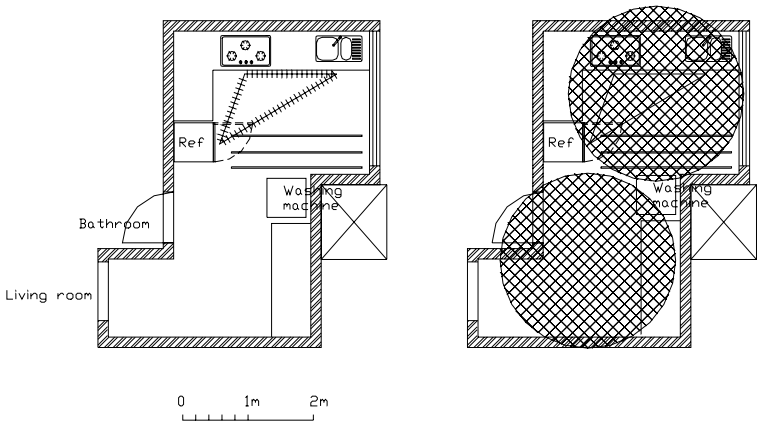


Figure A21.5: Floor layout analysis of Kitchen 8182-07, layout 1.

APPENDIX 22. EXAMPLE OF SCHEMATIC ANALYSIS ABOUT THE BAD LOCATION OF A SINK

Bad location of a sink can cause bad working route. For example, for Kitchen 8788-01 (5-room improved) in the HDB Annual Report 1987/1988 (Housing & Development Board, 1988), the sink is marked at the place just in front of the kitchen entrance from the living room (Figure A22.1).

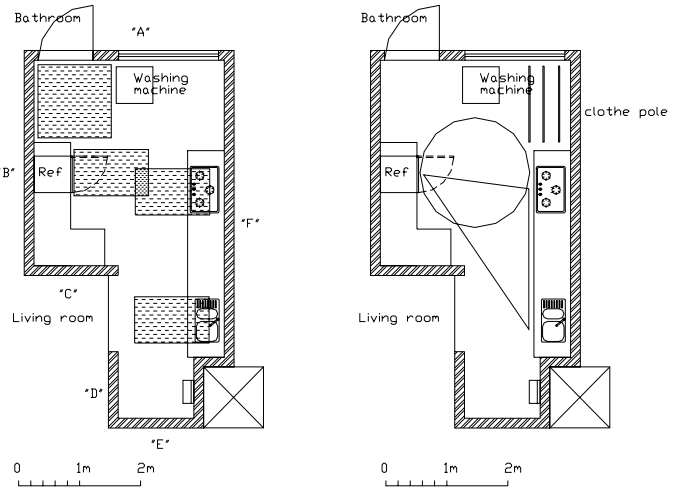


Figure A22.1: Floor layouts analysis of Kitchen 8788-01, layout 1.

A possible reason for the sink's location is adjacency to the rubbish chute. It is convenient for disposing rubbish. But considering the working triangle of sink, cooker and refrigerator, the location of the sink is not good because it makes the working route longer. The triangle is also somewhat interrupted by the wall "C" (indicated in Figure A22.1 Left). For a wheelchair user, it is even worse because it is difficult for him / her to transfer between the sink and cooker. Another problem with the sink's location is that when the wheelchair user is working at the sink, he /she will block the kitchen's entrance. Thus no other person can enter or exit the kitchen.

A better location for the sink in the kitchen is at the corner of walls "A" and "F", just near the window (Figure A22.2). Compared with the former layout, the improved layout has a better working triangle and commodious room for wheelchair's transferring.

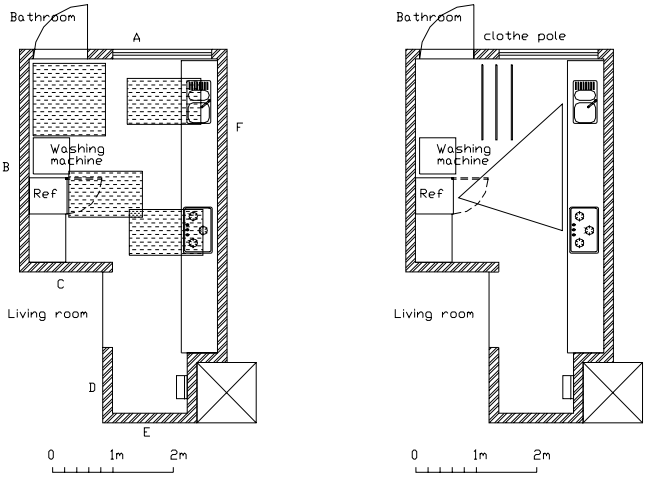


Figure A22.2: Better location of the sink in Kitchen 8788-01, layout 2.

APPENDIX 23. METHOD FOR ROUTE TESTING

The method for testing the layouts and routes of HDB kitchens is based upon the idea that "with a suitable kitchen lay-out the amount of walking could be reduced and working time shortened" (Grandjean, 1973, p86). A study (Ward, 1971) shows that the most frequent movements occur between sink, working surface and cooker. In Germany, a method called "Fadenstudie" (line-studies) has often been used (Grandjean, 1973, p86). In this method, all the paths followed in the procedure of a certain job are recorded and drawn as lines in the kitchen ground plan. If a path is marked more often, that means this path is more important on the ground plan. Figure A23.1 demonstrates two examples of line-studies. The following criteria were used to assess the results of a "Fadenstudie" (Grandjean, 1973, p87):

- There should be few paths crossing each other.
- Fewer long paths are preferred.
- Paths to a few working-places should have a high density.
- Starting points should be closely adjacent – but nevertheless not closer than 60cm to each other – with dense bundles of lines radiating from them, so as to allow ample freedom of movement.

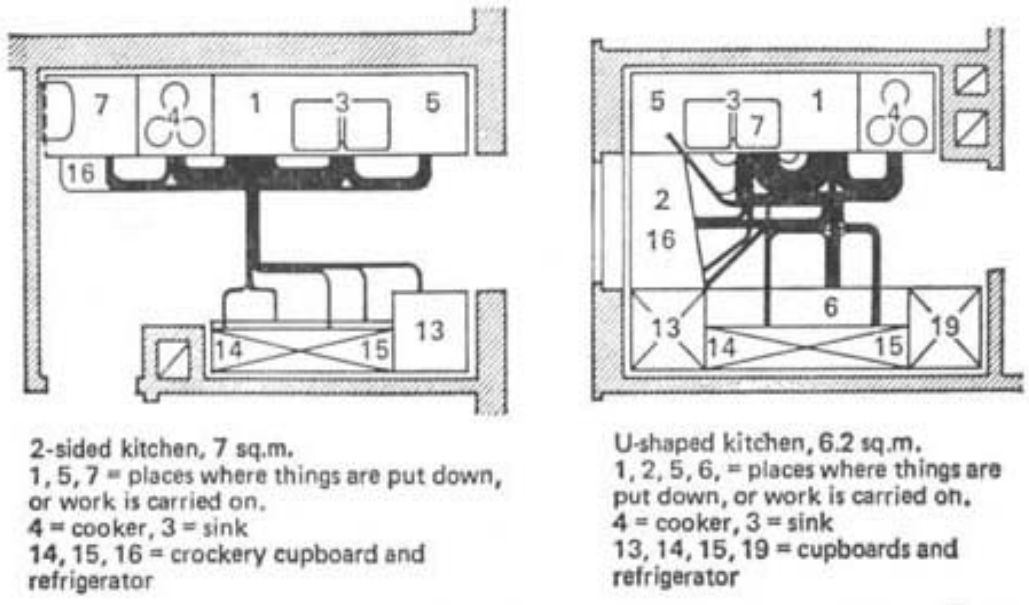


Figure A23.1: Comparative line-study (Fadenstudie) of a working kitchen, 2-sided and U-shaped. Thick lines lead to the cooker, sink and major working places. The superiority of the first arrangement is shown by the smaller number of crossing paths, and the relaxed progress of the work (Source: Grandjean, 1973, p87).

According to Conran (1977), the tea making is usually used for testing route. "*A good test for checking the effectiveness of your kitchen is to examine the steps involved in making a cup of tea. When spelled in detail, what superficially appears to be a very ordinary, simple task is in fact a surprisingly complex manoeuvre*".

Figure A23.2 shows two diagrams of a same kitchen. The dotted line traces the process of a tea-maker. The diagrams show that in a well-organized kitchen (Figure A23.2 Right) the route of tea making is shorter than a haphazard arrangement (Figure A23.2 Left).

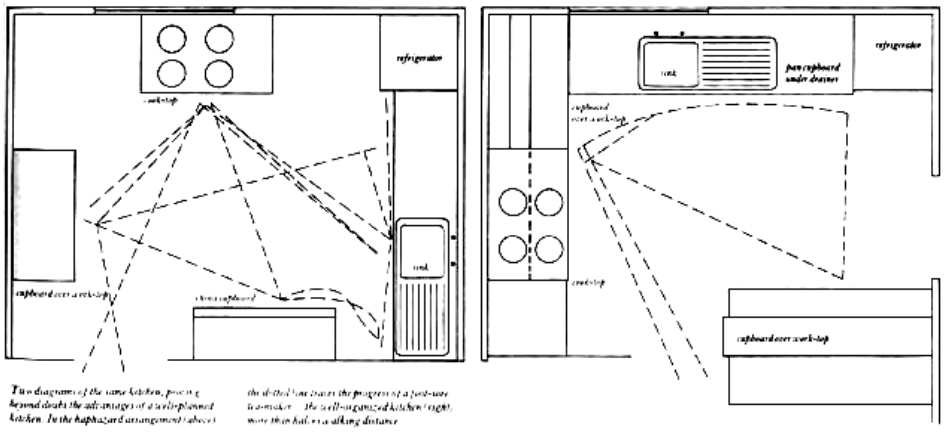


Figure A23.2: Tea making route analysis (Conran, 1977).

APPENDIX 24. REFRIGERATOR'S PLACE RELATED TO THE SINK AND COOKER

In HDB kitchens, there are three possible locations of the refrigerator related to the sink and cooker. The first location is at the end of a continual countertop in which the sink and cooker are installed together. The countertop can be L-shaped or "one wall".

For example, Figure A24.1 shows the two layouts of Kitchen 7879-01. The left one is "L-shaped" and the refrigerator is on an open end of the countertop. The right one is "one wall" layout and the refrigerator is at the close end of the countertop (at the corner of two walls). It should be noticed that in this kind of location the latch side of the refrigerator should be on the work triangle. When a refrigerator is placed at the corner of walls, a certain distance must be left between the refrigerator and the end wall (noted as "D" wall in Figure A24.1 Right) if the refrigerator door can be opened more than 90 degrees and even at a full 180 degrees.

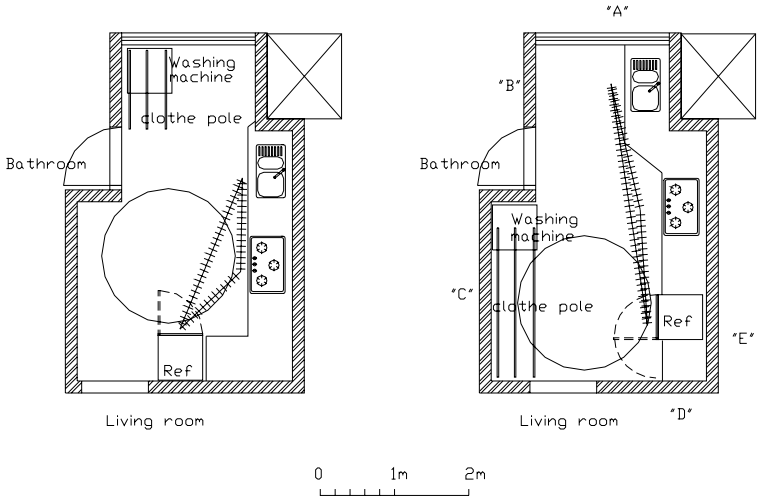


Figure A24.1: (Left) L-shaped countertop (Kitchen 7879-01, layout 2); (Right) one wall countertop (Kitchen 7879-01, layout3).

The second possible location of a refrigerator is with an appliance on a continual countertop and the other appliance on the opposite countertop (Figure A24.2). In this kind of layout attention should be paid to both the refrigerator door's direction and clearance between the refrigerator and the end wall. Adequate countertop should also be provided between the refrigerator and the other appliances.

The third possible location for a refrigerator is that the refrigerator is freestanding apart from the sink and the cooker. For example, in Kitchen 8586-01 (Figure A24.3), the refrigerator is placed opposite the cooker and the sink. In this case, a landing place for refrigerator on the latch side must be provided. Figure A24.4 shows two examples where the refrigerator does not have landing space adjacent because the space is limited.

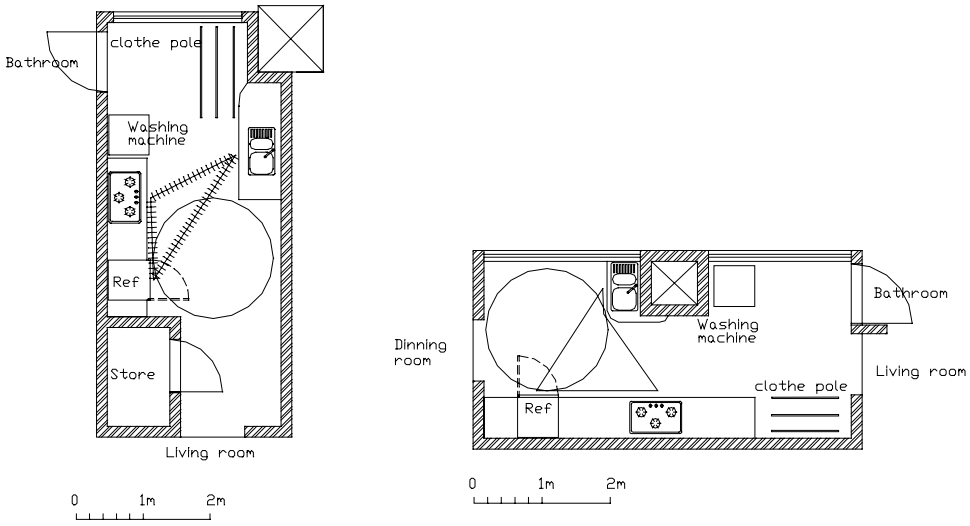


Figure A24.2: Refrigerator with one appliance on one countertop and the other appliance on the opposite countertop. (Left: Kitchen 8485-02, layout 2; Right: Kitchen 7980-08, layout 1).

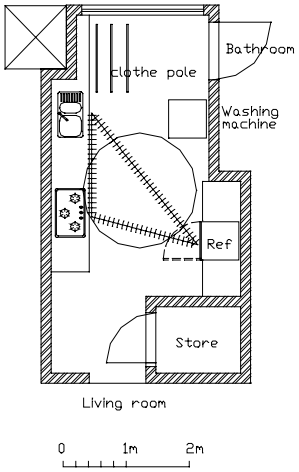


Figure A24.3: Refrigerator placed opposite the sink and cooker (Kitchen 8586-01).

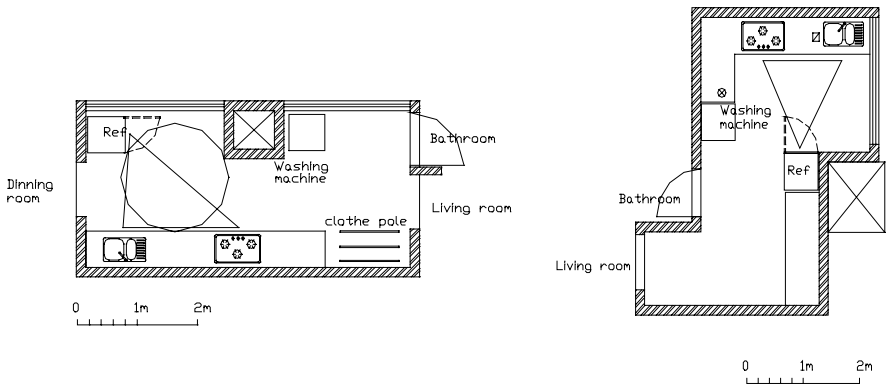


Figure A24.4: No landing space adjacent to a refrigerator (Left: Kitchen 7980-08, layout 2; Right: Kitchen 8182-07, layout 2).

APPENDIX 25. EXAMPLE OF SCHEMATIC ANALYSIS ABOUT THE REFRIGERATOR DOOR AND LANDING SPACE

Analysis of the HDB kitchen plans showed that in a constrained space, the refrigerator is often located at an unsuitable place. For example, in a plan like Kitchen 8182-08, a refrigerator is possibly located just near the entrance (Figure A25.1). In a small kitchen this location is still acceptable for an ambulant user. But when the kitchen is used by a wheelchair user, this location must be avoided, for there is not enough space for a wheelchair to approach the refrigerator. It is even worse when the refrigerator is hinged on the right. A better location for the refrigerator is away from the entrance. The refrigerator's door direction should be changed and the latch side should be on the work triangle.

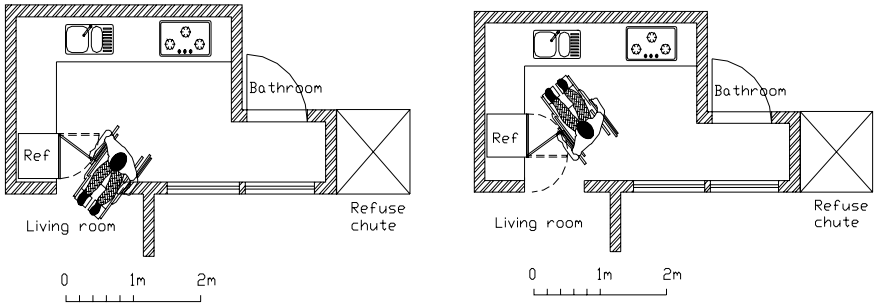


Figure A25.1: Refrigerator near an entrance (Kitchen 8182-08). (Left) bad location and door direction; (Right) better location and door direction.

Another example is the plan of Kitchen 7980-08. There are two possible layouts, considering a wheelchair user's access (Figure A25.2). The first layout is putting the sink at the window against the rubbish chute (Figure A25.2 Top). The second layout differs from the first by placing the refrigerator on the window side. In this layout, no accessorial counter is available for landing items near the refrigerator because the space is constraint (Figure A25.2 Bottom).

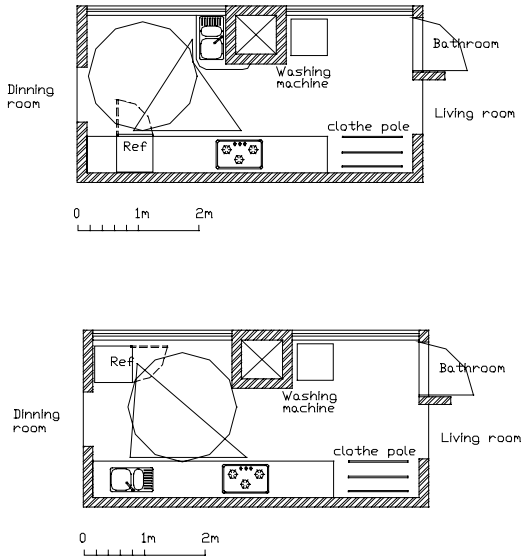


Figure A25.2: (Top) first layout of Kitchen 7980-08. (Bottom) when refrigerator is apart from sink and cooker, no accessorial counter is available for landing items.

APPENDIX 26. PLACE OF WASHING MACHINE AND CLOTHES DRYING

Location of washing machine

The location of a washing machine should not block the ways of the wheelchair user. For example, in Kitchen 9293-01, a washing machine cannot be placed at the corner of wall “A” and “B” when a wheelchair approaching space to the bathroom is considered (Figure A26.1). A better location of the washing machine could be adjacent to the sink under the counter.

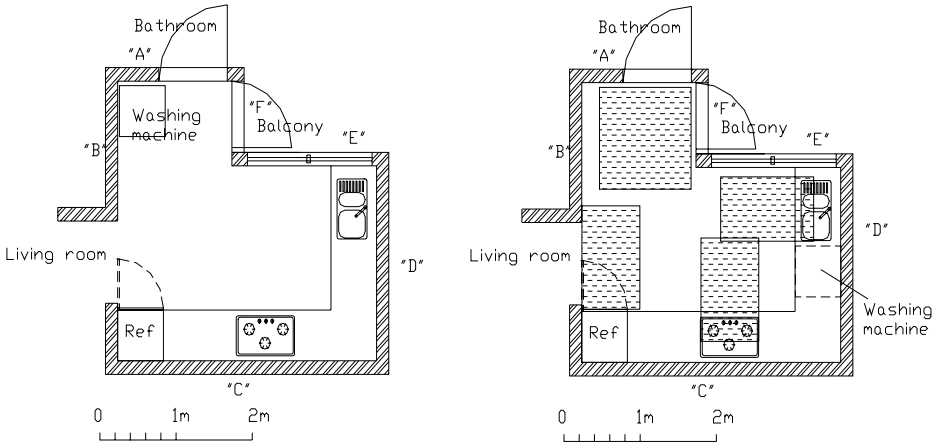


Figure A26.1: Washing machine cannot be placed near the bathroom door (Kitchen 9293-01).

Usually the washing machine is placed near the bathroom door for easy water access and drainage. It should be noticed that in front of the bathroom door, a clear floor space must be provided for a wheelchair to approach. But in some kitchen plans the washing machine cannot be placed near the bathroom door. For example, in the layout of Kitchen 7980-08 (Figure A26.2), there are two entrances on the “D” wall. Thus the washing machine is placed at the corner of the rubbish chute. It will cause much trouble to install pipes for water supply and drainage.

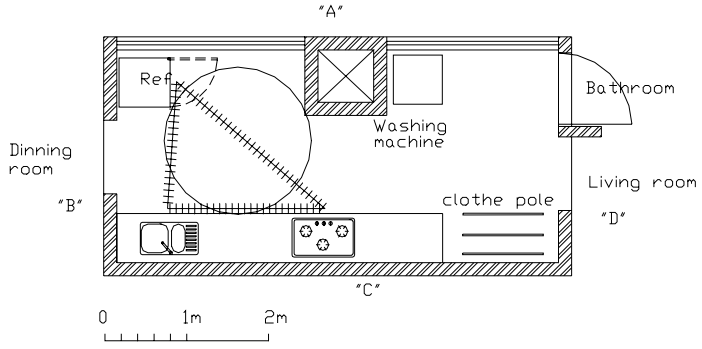


Figure A26.2: Washing machine can only be placed away from bathroom door (Kitchen 7980-08).

Another example is Kitchen 8788-04. A washing machine can be placed at wall “B” near the bathroom door if only normal users are considered (Figure A26.3 Left). The net distance between the washing machine and the rubbish chute is about 0.85m. If a wheelchair user needs to use the bathroom, he cannot get across the narrow passage. Other location choices are the corner between walls “A” and “G” (Figure A26.3 Middle) and the corner between walls “C” and “D” (Figure A26.3 Right). When the washing machine is located at the corner of walls “C” and “D”, water supply and drainage can be solved by installing pipes to the bathroom.

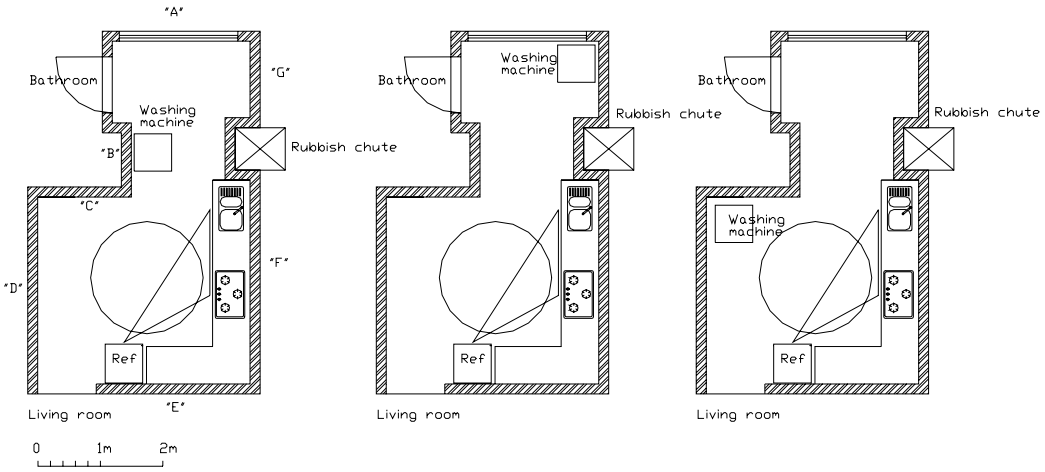


Figure A26.3: Three locations of washing machine in Kitchen 8788-04.

To sum up, a washing machine should be placed according to following principles: (1) the washing machines should be placed near the bathroom or under the countertop adjacent to the sink; (2) when the washing machines is freestanding, it should not block the way for wheelchair users; (3) clear floor space should be provided at the washing machine.

Clothes drying

If clothes drying is done by others rather than wheelchair users themselves, then there is no problem in adopting the common methods used by the HDB resident (hanging clothes outside the window with poles).

However, if drying clothes is done by the wheelchair users themselves, more accessible device must be provided. One solution is to place a clothes rack on the floor. The rack can be folded when it is not in use. Another solution is to provide an adjustable device suspended from the ceiling. After hanging the clothes, the device can be raised again in order to free the space below.

Whether the device is floor-mounted or adjustable, it should be easy for a wheelchair user to transfer clothes from the washing machine to the device. For example, in Kitchen 8182-07 (Figure A26.4), when the device is lowered down, the distance between the device and refrigerator must be more than 0.9m for a wheelchair to get through.

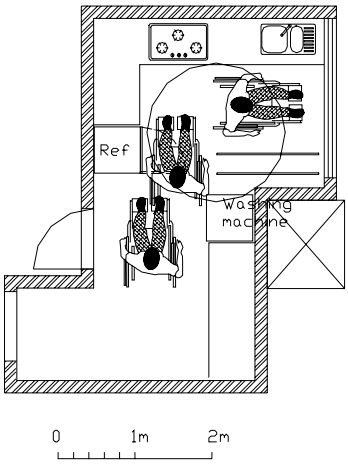


Figure A26.4: Transferring space around clothes rack is needed when the device is lowered down (Kitchen 8182-07).

In Kitchen 8485-05 (Figure A26.5) the washing machine and clothes pole are put close. Moving between the washing machine and clothes pole is easy.

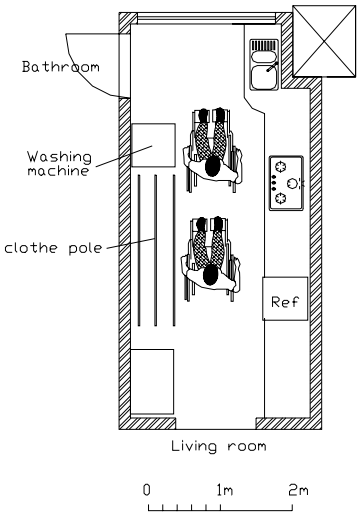
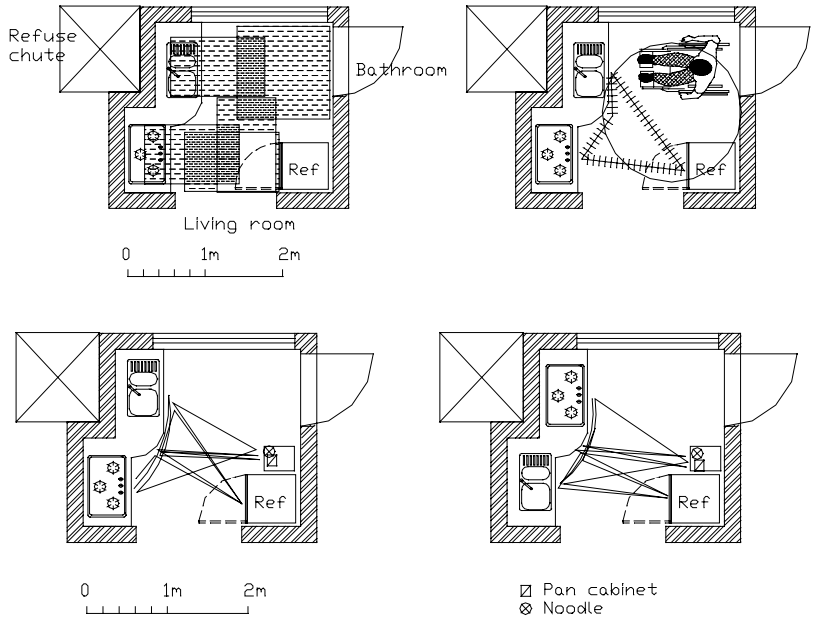


Figure A26.5: Moving between the washing machine and cloths pole is easy (Kitchen 8485-05).

APPENDIX 27. KITCHEN LAYOUT ANALYSES

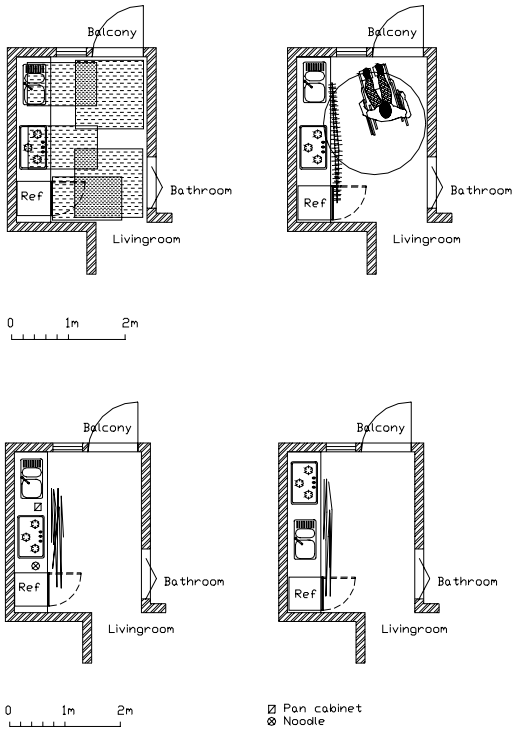
Index:

Kitchen 7778-01			
Area	5.5m^2	Layout	1



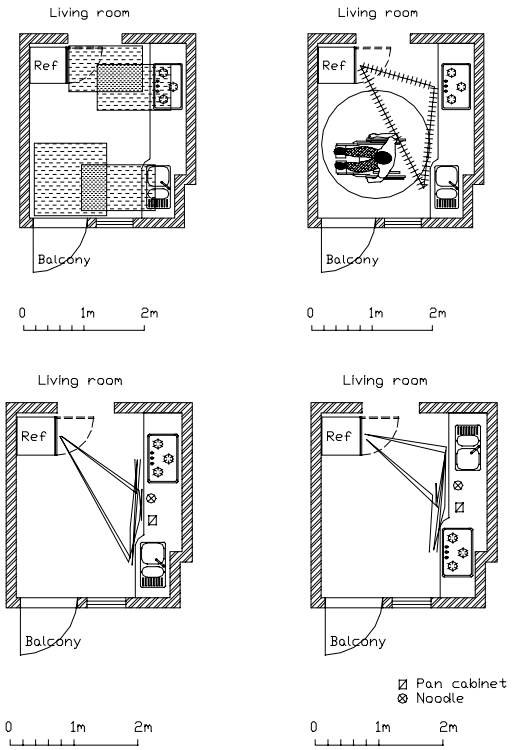
Triangle Total Length (TTL)	4.16m	Length of the Shortest Leg (LSL)	1.33m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		16.61m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		16.64m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			Yes
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	No		No
Is there enough space for “T” turning	Minimum (152×152)		Optimum (152×183)
	Yes		Yes
Whole frontage length	0.74m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	Yes	Yes
Eating table	Not available	Washing machine	Not available
Writing table	Not available	Drying clothes	Not available

Kitchen 9596-01					
Area	6.67m^2		Layout	1	



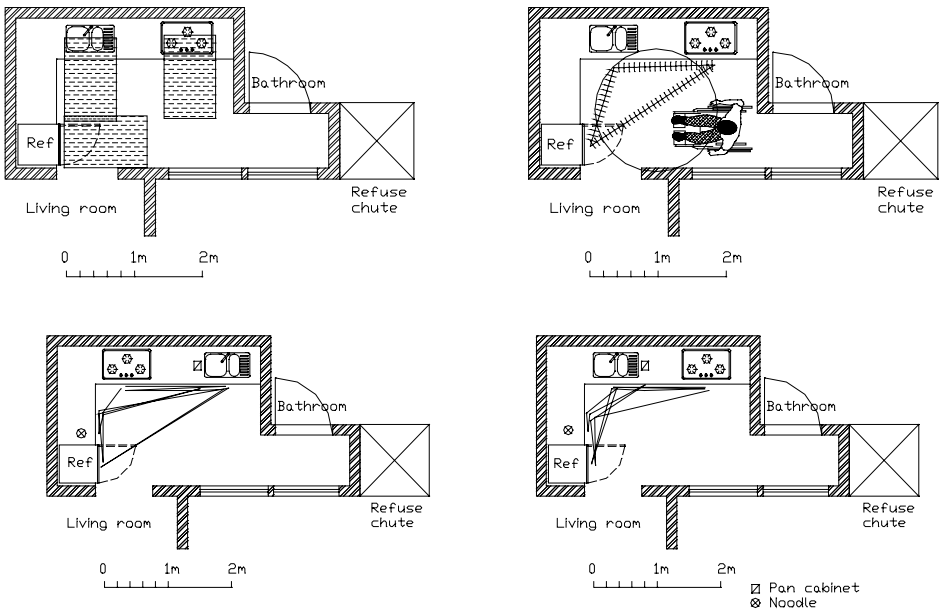
Triangle Total Length (TTL)	4.23m	Length of the Shortest Leg (LSL)	1.0m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		13.03m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		11.42m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			No
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		No
Is there enough space for “T” turning	Minimum (152×152)		Optimum (152×183)
	Yes		Yes
Whole frontage length	0.8m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	Yes
Eating table	Not available	Washing machine	Not available
Writing table	Not available	Drying clothes	Not available

Kitchen 9596-02			
Area	7.54m^2	Layout	1



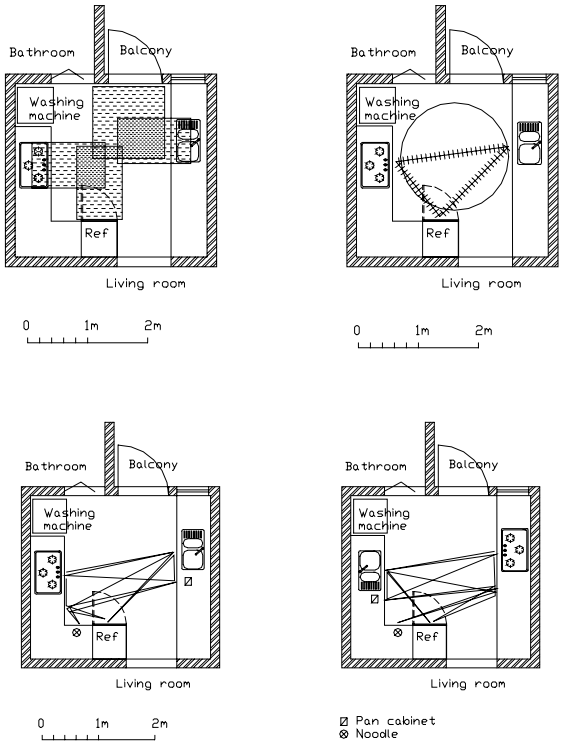
Triangle Total Length (TTL)	5.27m	Length of the Shortest Leg (LSL)	1.28m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		14.96m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		12.67m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			Yes
Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)	
	Yes	Yes	
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)	
	Yes	Yes	
Whole frontage length	1.44m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	Yes
Eating table	Not available	Washing machine	Not available
Writing table	Not available	Drying clothes	Not available

Kitchen 8182-08			
Area	8.3m^2	Layout	1



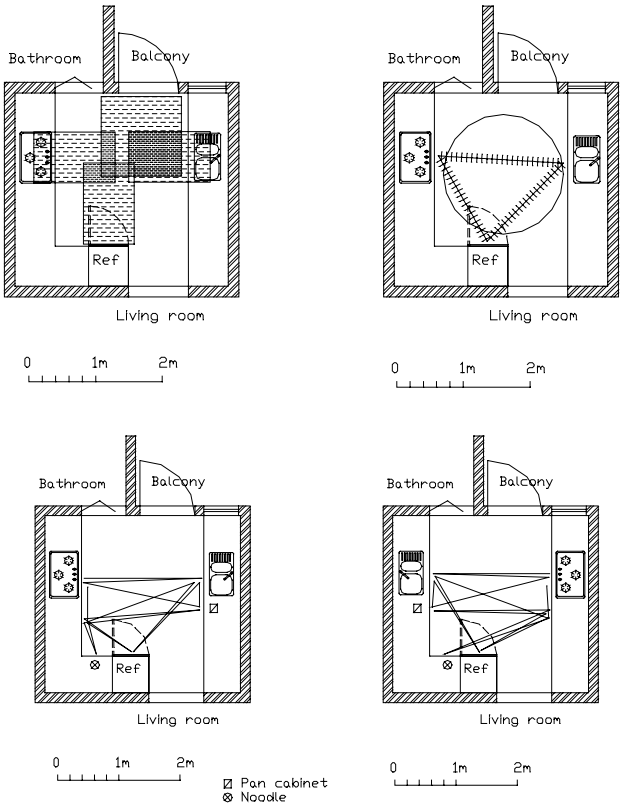
Triangle Total Length (TTL)	4.86m	Length of the Shortest Leg (LSL)	1.21m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		17.20m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		13.26m
Entrance	To living room		OK
	To bathroom		Not accessible
	To balcony		/
Is working triangle interrupted by any other route?			No
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		No
Is there enough space for “T” turning	Minimum (152×152)		Optimum (152×183)
	Yes		No
Whole frontage length	2.09m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	Yes
Eating table	Not available	Washing machine	Not available
Writing table	Not available	Drying clothes	Not available

Kitchen 9495-01			
Area	9.57m^2	Layout	1



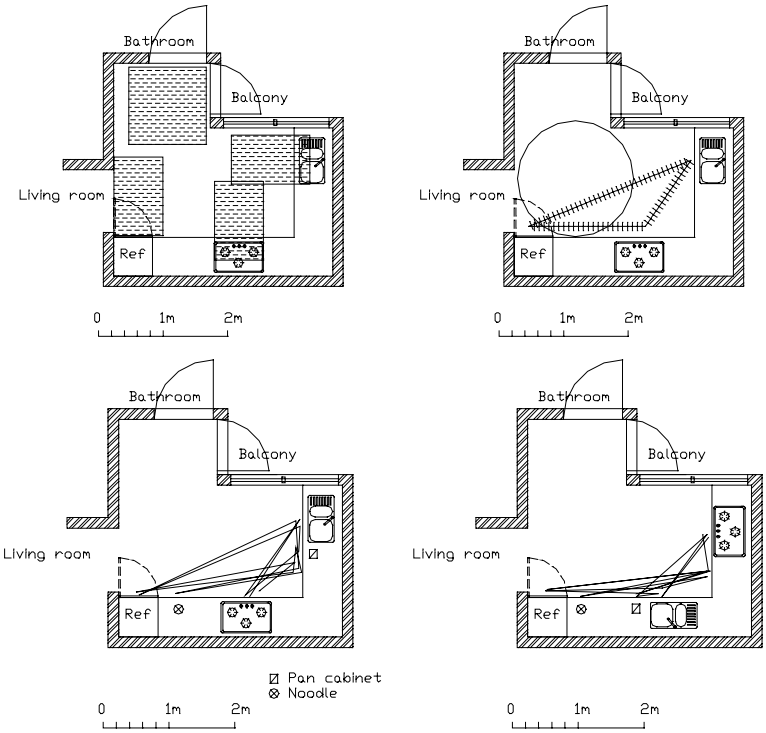
Triangle Total Length (TTL)	4.70m	Length of the Shortest Leg (LSL)	1.17m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		18.23m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		21.54m
Entrance	To living room		OK
	To bathroom		Not accessible
	To balcony		OK
Is working triangle interrupted by any other route?			Yes
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		No
Is there enough space for “T” turning	Minimum (152×152)		Optimum (152×183)
	Yes		No
Whole frontage length	3.52m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Not available

Kitchen 9495-01			
Area	9.57m^2	Layout	2



Triangle Total Length (TTL)	4.98m	Length of the Shortest Leg (LSL)	1.47m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		18.33m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		21.28m
Entrance	To living room		OK
	To bathroom		Not accessible
	To balcony		OK
Is working triangle interrupted by any other route?			Yes
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		Yes
Is there enough space for “T” turning	Minimum (152×152)		Optimum (152×183)
	Yes		Yes
Whole frontage length	4.12m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Not available	Washing machine	Not available
Writing table	Not available	Drying clothes	Not available

Kitchen 9293-03			
Area	9.66m^2	Layout	1

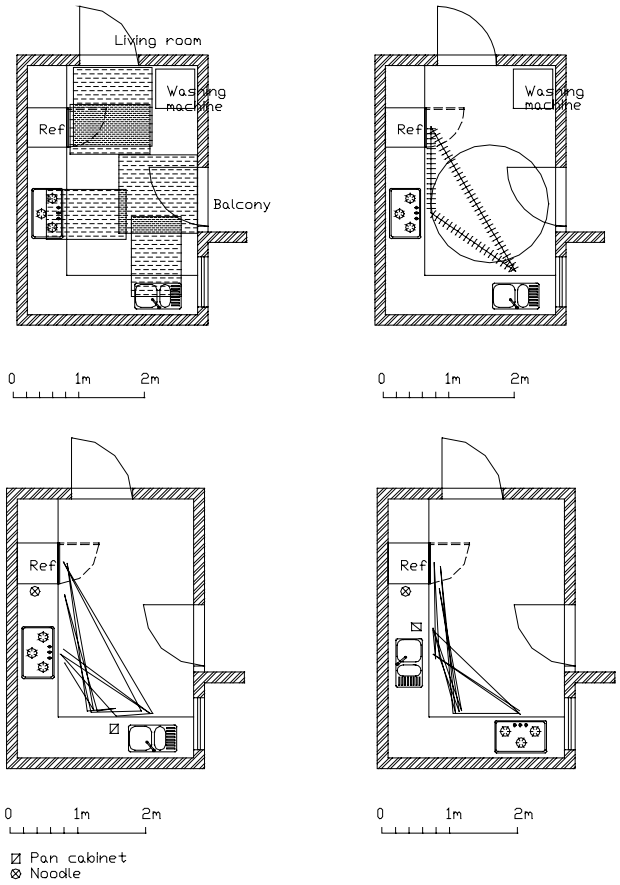


Triangle Total Length (TTL)	5.77m	Length of the Shortest Leg (LSL)	1.23m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		20.44m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		19.86m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		OK
Is working triangle interrupted by any other route?			No

Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)
	Yes	Yes
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)
	Yes	Yes
Whole frontage length	2.44m	

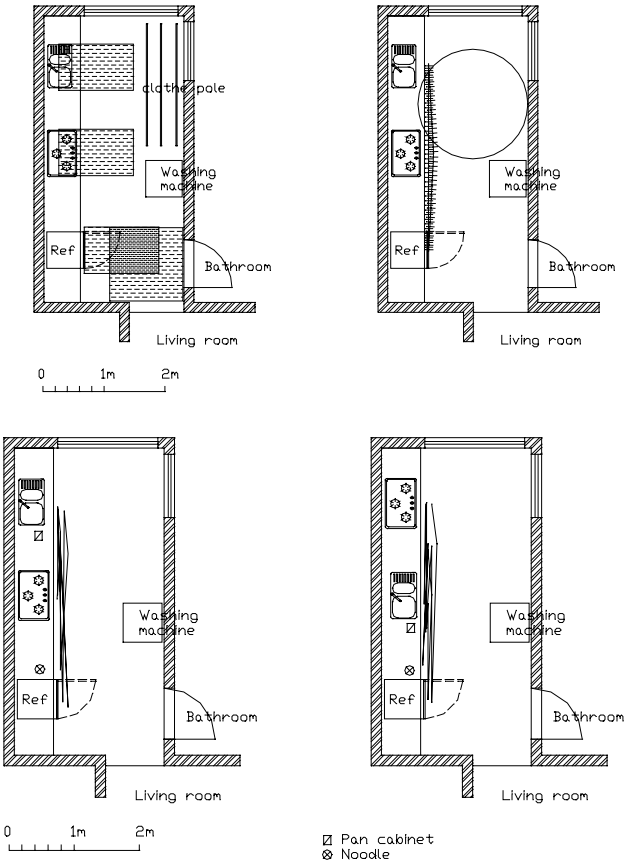
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	Yes
Eating table	Not available	Washing machine	Not available
Writing table	Not available	Drying clothes	Not available

Kitchen 9394-03			
Area	9.88m^2	Layout	1



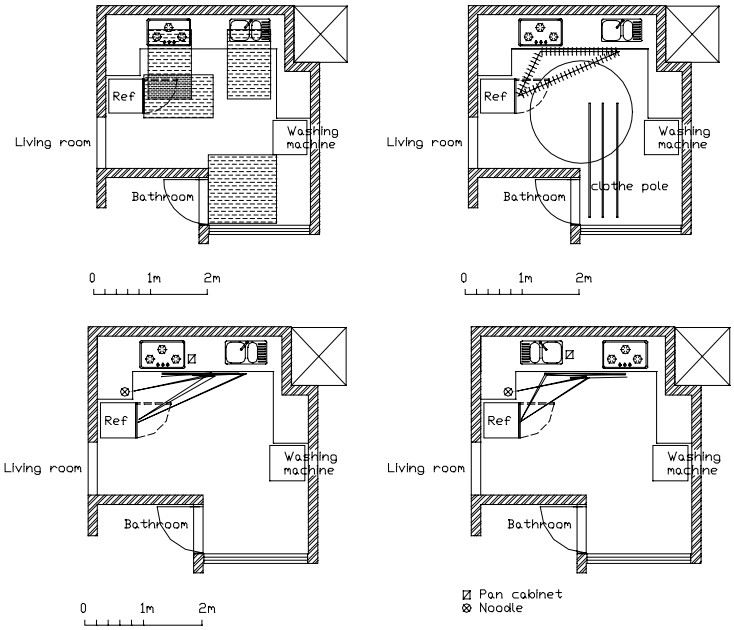
Triangle Total Length (TTL)	5.43m	Length of the Shortest Leg (LSL)	1.31m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		20.10m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		20.36m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		OK
Is working triangle interrupted by any other route?			No
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		Yes
Is there enough space for “T” turning	Minimum (152×152)		Optimum (152×183)
	Yes		Yes
Whole frontage length	3.14m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Not available

Kitchen 9697-02			
Area	10.81m^2	Layout	1



Triangle Total Length (TTL)	6.14m	Length of the Shortest Leg (LSL)	1.45m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		20.20m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		20.84m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		OK
Is working triangle interrupted by any other route?			No
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		No
Is there enough space for “T” turning	Minimum (152×152)		Optimum (152×183)
	Yes		Yes
Whole frontage length	2.64m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	Yes	No
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

Kitchen 8283-07			
Area	11.07 m^2	Layout	1

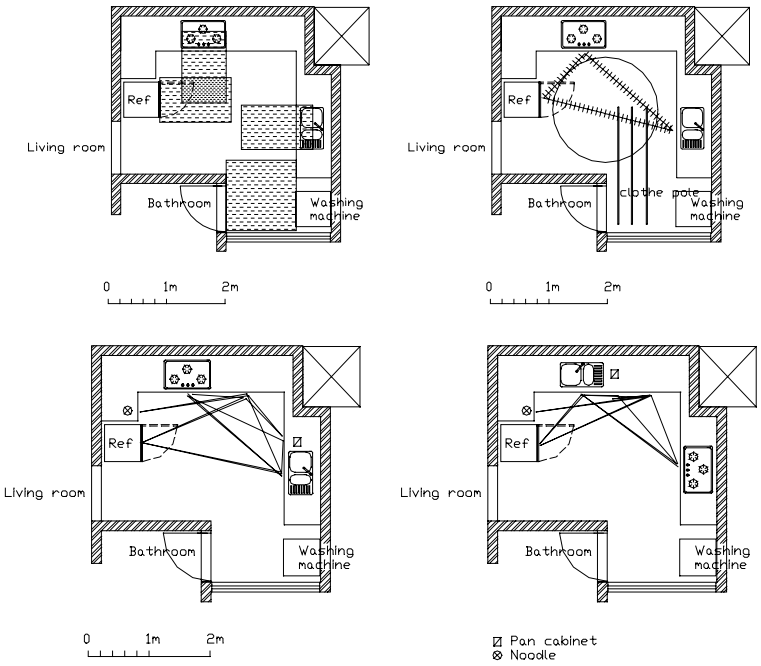


Triangle Total Length (TTL)	4.19m	Length of the Shortest Leg (LSL)	0.87m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		15.76m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		12.84m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			No

Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)
	Yes	Yes
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)
	Yes	Yes
Whole frontage length	2.62m	

Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

Kitchen 8283-07			
Area	11.07 m^2	Layout	2



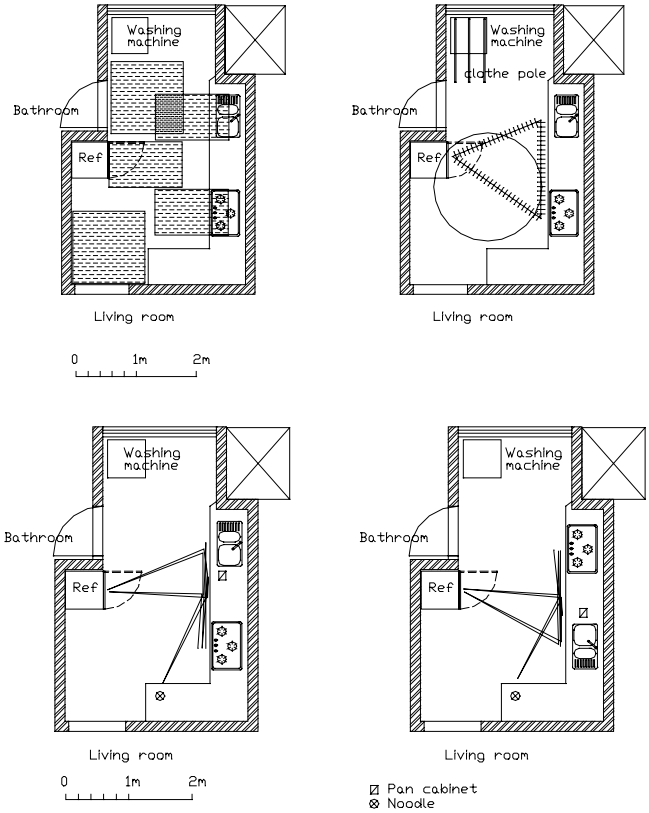
Triangle Total Length (TTL)	5.31m	Length of the Shortest Leg (LSL)	1.03m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		22.10m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		19.07m

Entrance	To living room	OK
	To bathroom	OK
	To balcony	/
Is working triangle interrupted by any other route?		No

Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)
	Yes	Yes
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)
	Yes	Yes
Whole frontage length	2.62m	

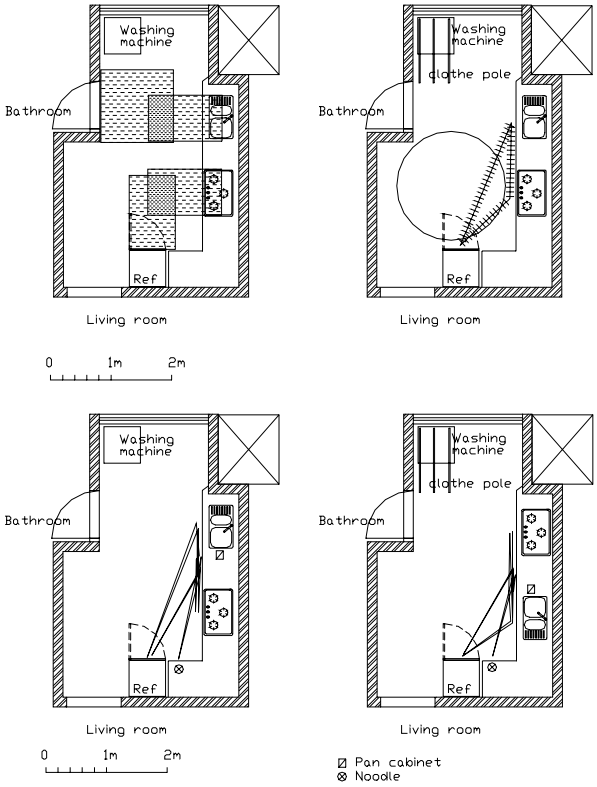
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

Kitchen 7879-01			
Area	11.22 m^2	Layout	1



Triangle Total Length (TTL)	5.02m	Length of the Shortest Leg (LSL)	1.59m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		15.94m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		16.50m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			Yes
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		No
Is there enough space for "T" turning	Minimum (152×152)		Optimum (152×183)
	Yes		Yes
Whole frontage length	2.69m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

Kitchen 7879-01			
Area	11.22 m^2	Layout	2



Triangle Total Length (TTL)	4.56 m	Length of the Shortest Leg (LSL)	1.59m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		16.88m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		14.33m

Entrance	To living room	OK
	To bathroom	OK
	To balcony	/

Is working triangle interrupted by any other route?	No

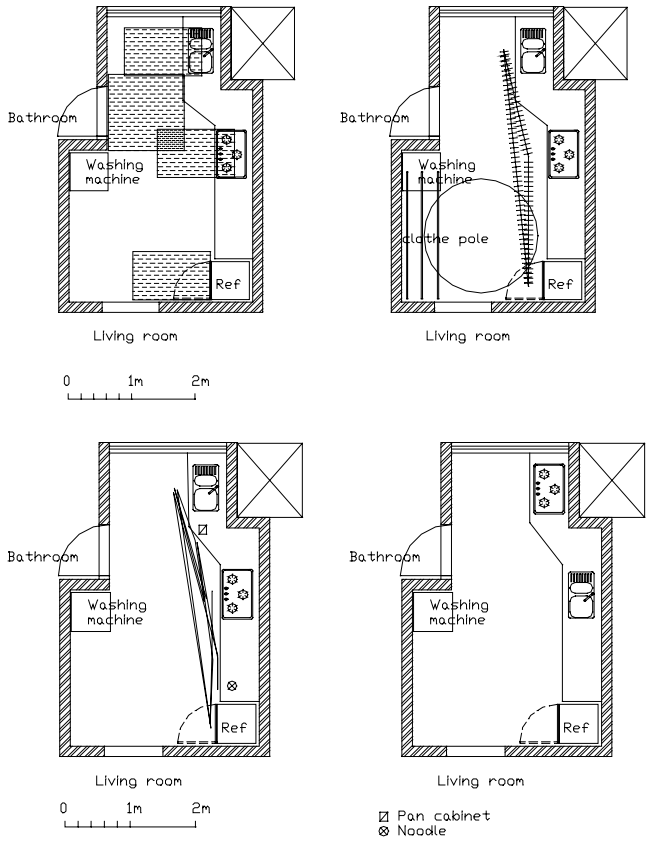
Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)
	Yes	Yes
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)
	Yes	Yes

Whole frontage length	1.9m

Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No

Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

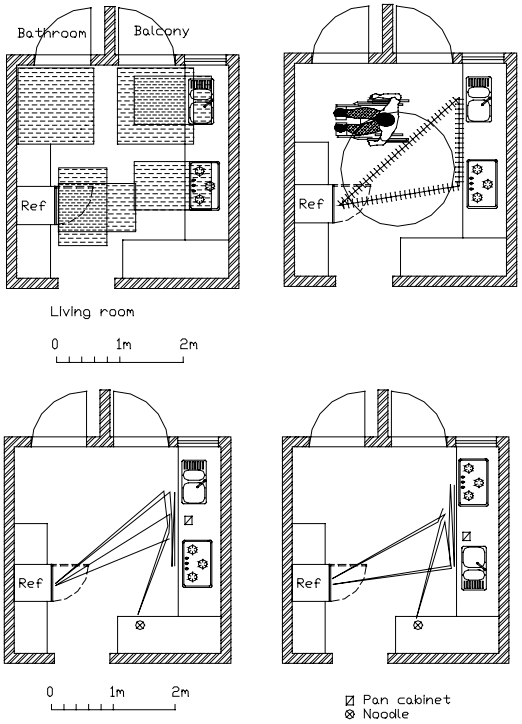
Kitchen 7879-01			
Area	11.22 m^2	Layout	3



Triangle Total Length (TTL)	7.53 m	Length of the Shortest Leg (LSL)	1.73m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		22.96
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		/
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			No
Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)	
	Yes	Yes	
Is there enough space for "T" turning	Minimum (152×152)	Optimum (152×183)	
	Yes	Yes	
Whole frontage length	2.35m		

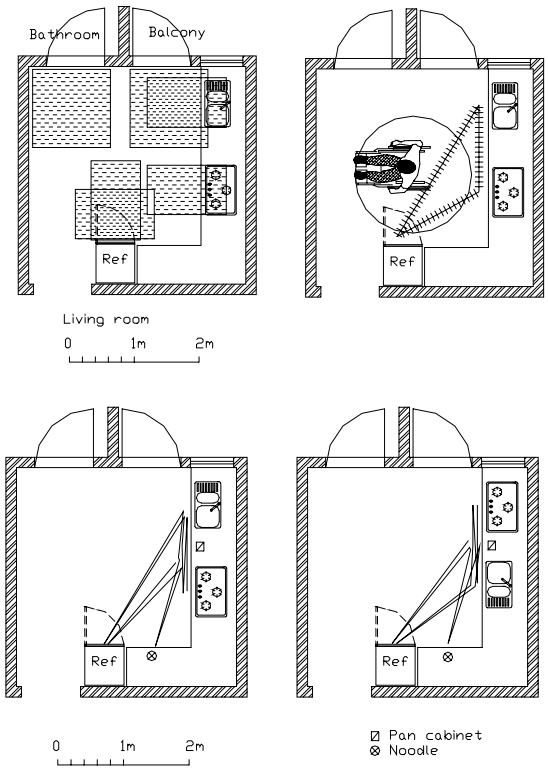
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

Kitchen 9293-02			
Area	11.35m^2	Layout	1



Triangle Total Length (TTL)	5.84m	Length of the Shortest Leg (LSL)	1.39m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		16.29m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		16.26m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		OK
Is working triangle interrupted by any other route?			Yes
Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)	
	Yes	Yes	
Is there enough space for "T" turning	Minimum (152×152)	Optimum (152×183)	
	Yes	Yes	
Whole frontage length	3.18m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	Yes	No	Yes
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

Kitchen 9293-02					
Area	11.35m^2		Layout	2	

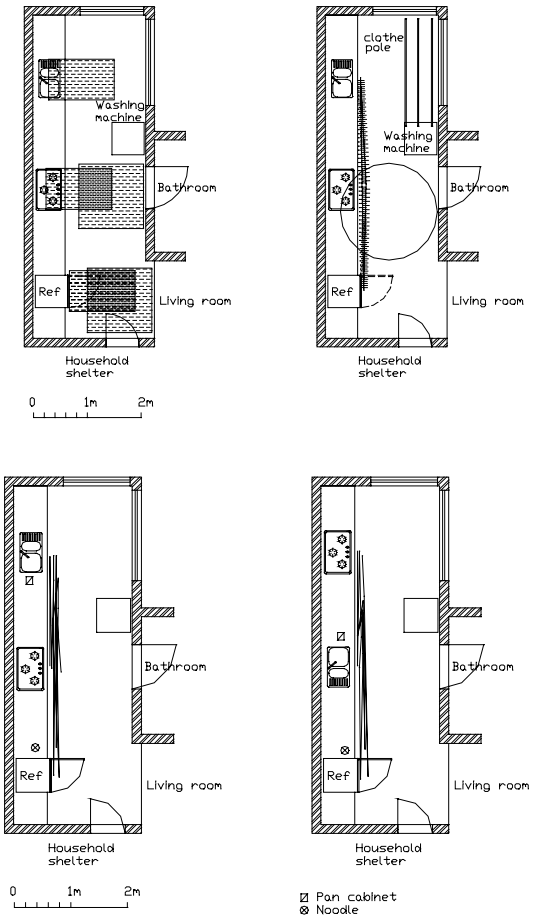


Triangle Total Length (TTL)	5.15 m	Length of the Shortest Leg (LSL)	1.33m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		14.72m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		14.06m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		OK
Is working triangle interrupted by any other route?			No

Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)
	Yes	Yes
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)
	Yes	Yes
Whole frontage length	2.27m	

Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	Yes	No	No
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

Kitchen 9798-01			
Area	12.6 m^2	Layout	1



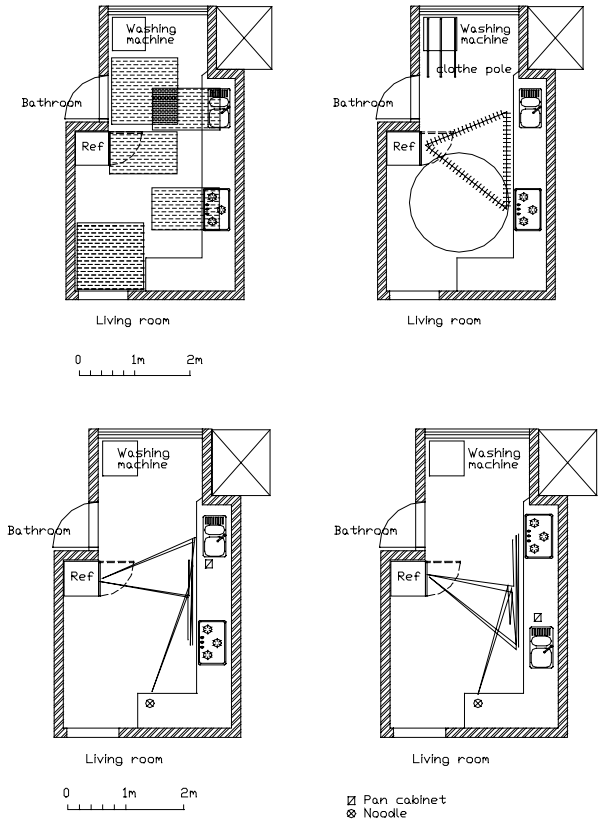
Triangle Total Length (TTL)	7.91m	Length of the Shortest Leg (LSL)	1.85m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		27.71m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		24.01m

Entrance	To living room	OK
	To bathroom	OK
	To balcony	/
Is working triangle interrupted by any other route?		No

Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)
	Yes	No
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)
	Yes	Yes
Whole frontage length	3.94m	

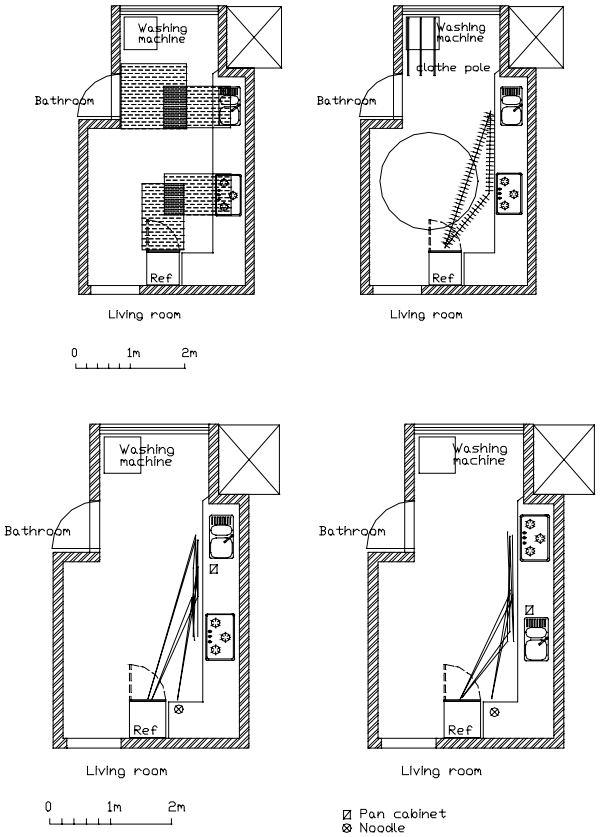
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	Yes
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

Kitchen 7980-02			
Area	12.67 m^2	Layout	1



Triangle Total Length (TTL)	5.21m	Length of the Shortest Leg (LSL)	1.59m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		19.57m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		18.37m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			Yes
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		Yes
Is there enough space for "T" turning	Minimum (152×152)		Optimum (152×183)
	Yes		Yes
Whole frontage length	2.40m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

Kitchen 7980-02			
Area	12.67 m^2	Layout	2



Triangle Total Length (TTL)	5.47m	Length of the Shortest Leg (LSL)	1.29m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		20.04m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		17.40m

Entrance	To living room	OK
	To bathroom	OK
	To balcony	/

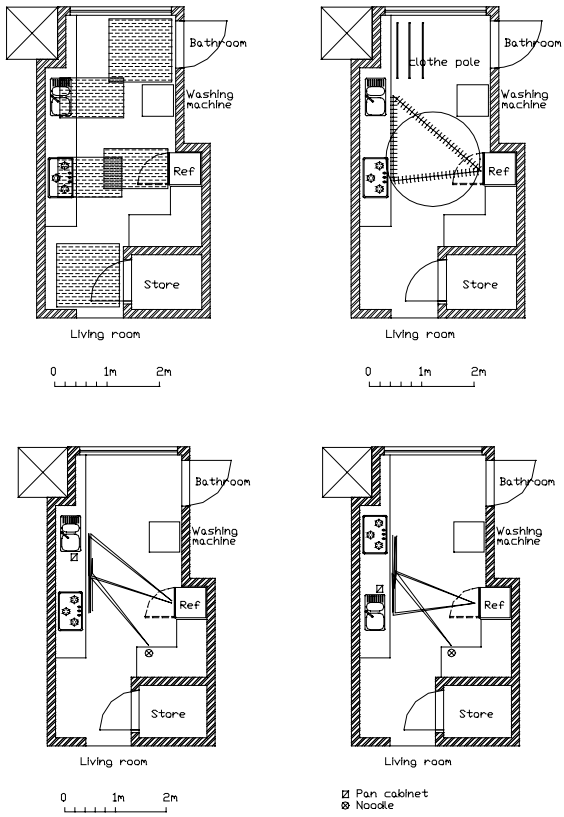
Is working triangle interrupted by any other route?	Yes

Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)
	Yes	Yes
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)
	Yes	Yes

Whole frontage length	2.86m

Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

Kitchen 8586-01			
Area	12.7m^2	Layout	1



Triangle Total Length (TTL)	5.51m	Length of the Shortest Leg (LSL)	1.69m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		17.94m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		16.95m

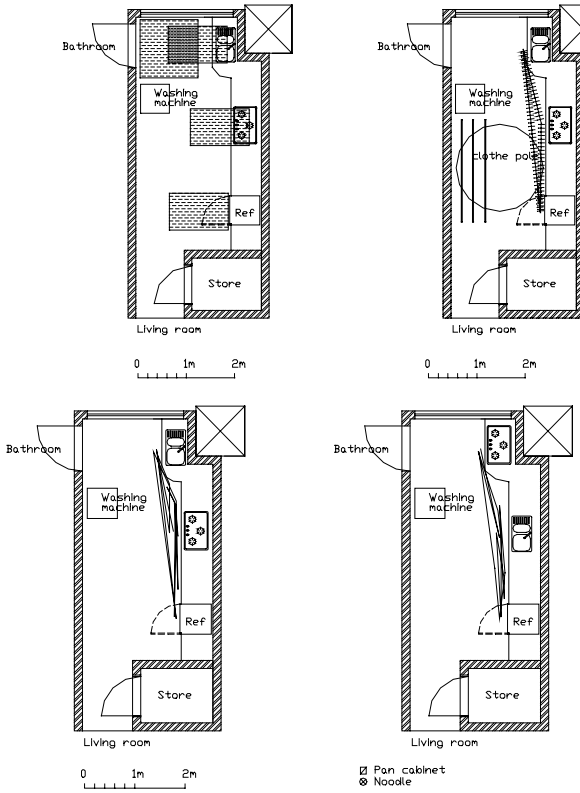
Entrance	To living room	OK
	To bathroom	OK
	To balcony	/

Is working triangle interrupted by any other route?	Yes

Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)
	Yes	No
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)
	Yes	Yes
Whole frontage length	2.75m	

Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	Yes	No
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

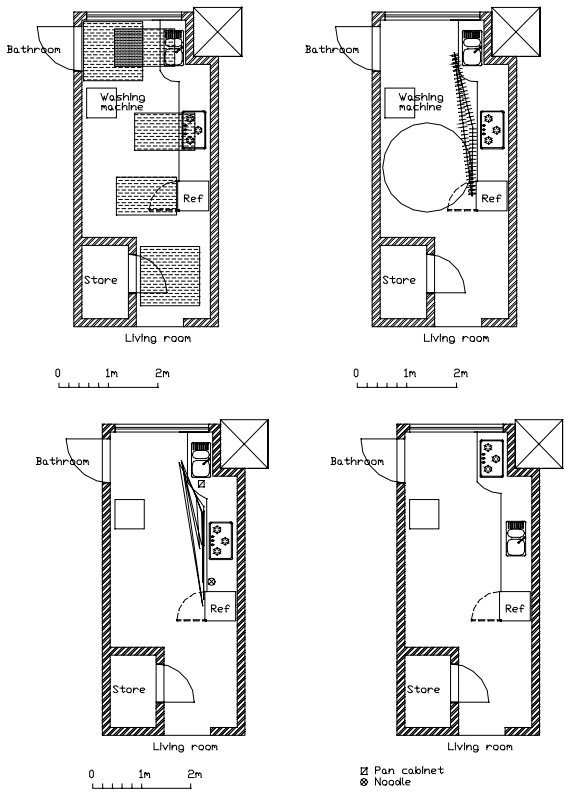
Kitchen 8384-02			
Area	12.9m^2	Layout	1



Triangle Total Length (TTL)	6.79m	Length of the Shortest Leg (LSL)	1.57m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		21.94
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		17.40
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			No
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		No
Is there enough space for “T” turning	Minimum (152×152)		Optimum (152×183)
	Yes		Yes
Whole frontage length	2.74m		

Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	Yes	Yes	No
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

Kitchen 8485-02			
Area	12.91m^2	Layout	1



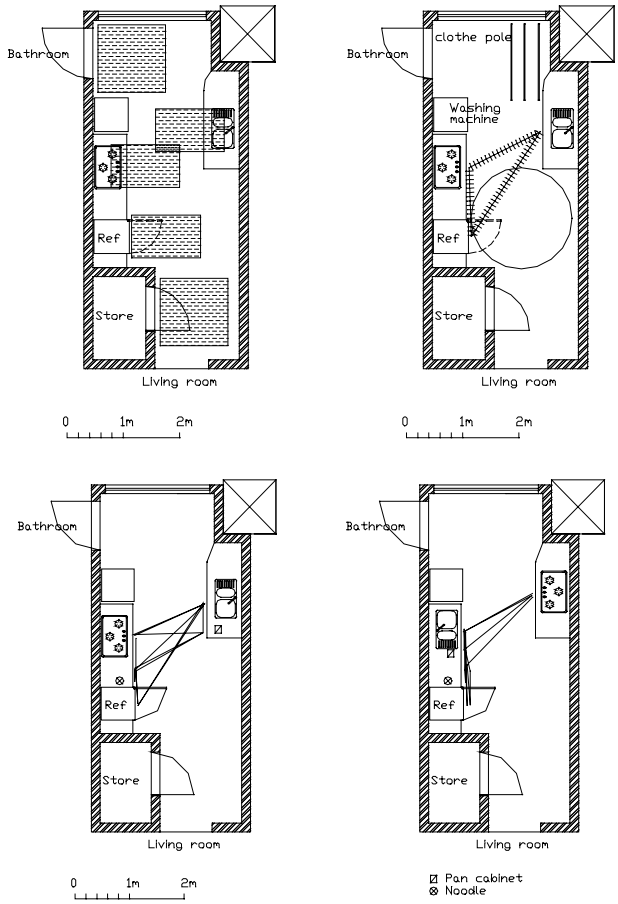
Triangle Total Length (TTL)	5.86m	Length of the Shortest Leg (LSL)	1.37m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		20.40m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		/

Entrance	To living room	OK
	To bathroom	OK
	To balcony	/

Is working triangle interrupted by any other route?		No
Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)
	Yes	Yes
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)
	Yes	Yes
Whole frontage length	1.75m	

Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	Yes	No
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

Kitchen 8485-02			
Area	12.91m^2	Layout	2

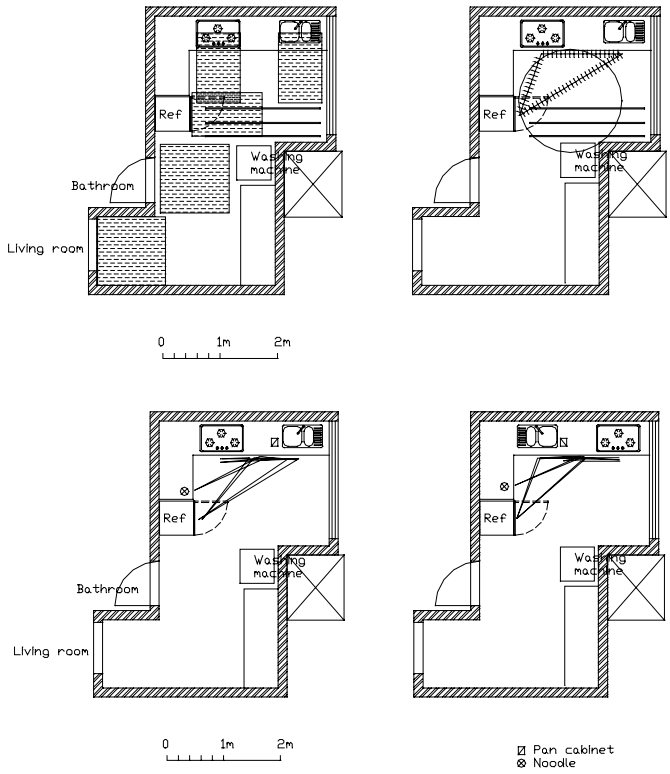


Triangle Total Length (TTL)	4.87m	Length of the Shortest Leg (LSL)	1.22m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		15.90m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		12.52m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			Yes

Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)
	Yes	Yes
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)
	Yes	Yes
Whole frontage length	1.65m	

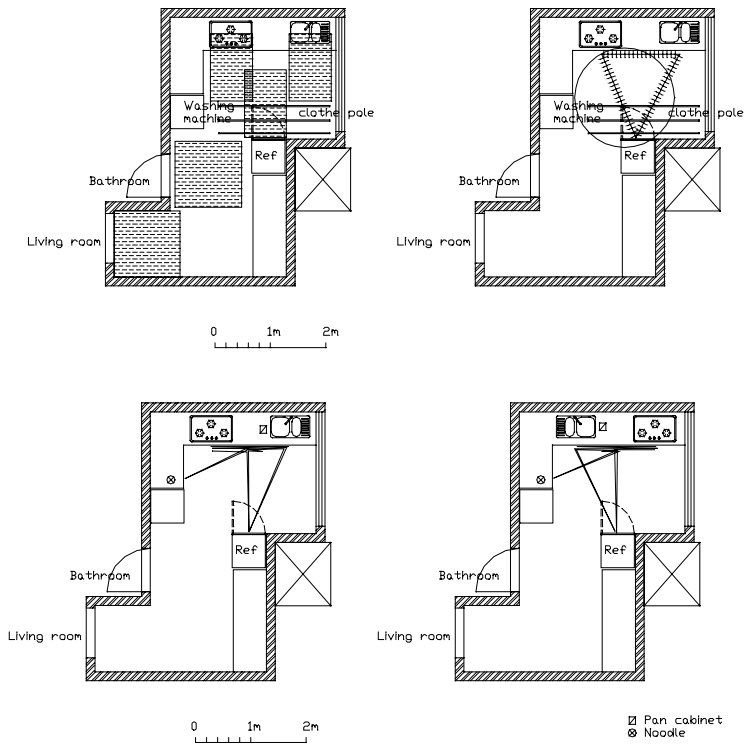
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

Kitchen 8182-07			
Area	13.05m^2	Layout	1



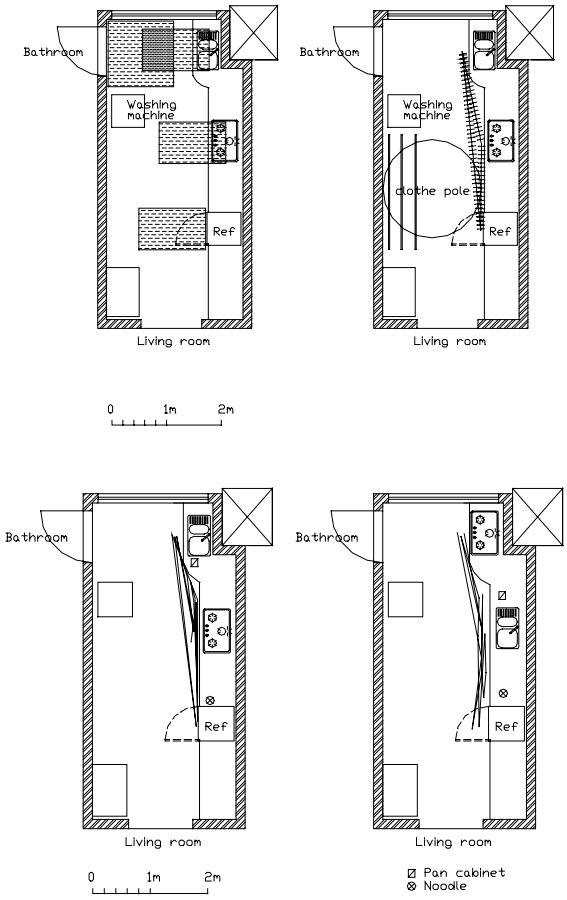
Triangle Total Length (TTL)	4.64m	Length of the Shortest Leg (LSL)	1.14m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		15.17m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		14.33m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			No
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		No
Is there enough space for “T” turning	Minimum (152×152)		Optimum (152×183)
	Yes		Yes
Whole frontage length	3.46m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Available	Washing machine	Available
Writing table	Available	Drying clothes	Available

Kitchen 8182-07			
Area	13.05m^2	Layout	2



Triangle Total Length (TTL)	4.74m	Length of the Shortest Leg (LSL)	1.40m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		14.68m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		15.26m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			No
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		No
Is there enough space for "T" turning	Minimum (152×152)		Optimum (152×183)
	Yes		Yes
Whole frontage length	3.48m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Available	Washing machine	Available
Writing table	Available	Drying clothes	Available

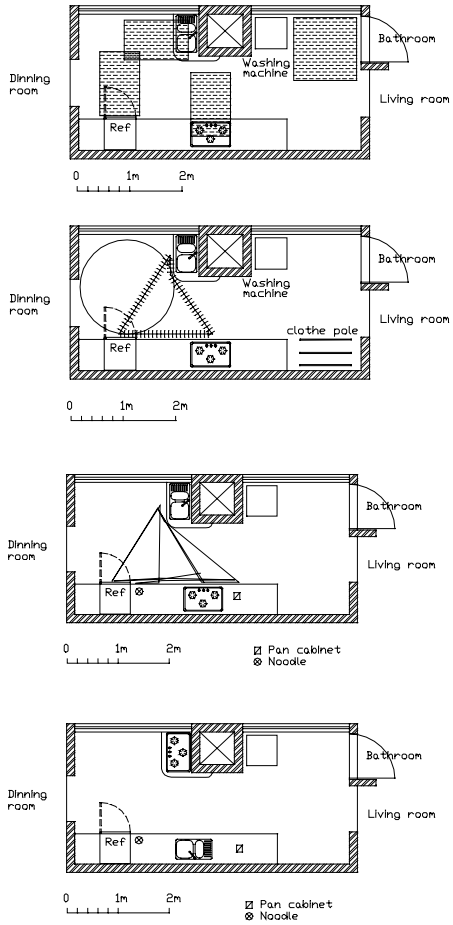
Kitchen 8485-05			
Area	13.12m^2	Layout	1



Triangle Total Length (TTL)	6.59m	Length of the Shortest Leg (LSL)	1.58m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		21.95m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		17.17
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			No

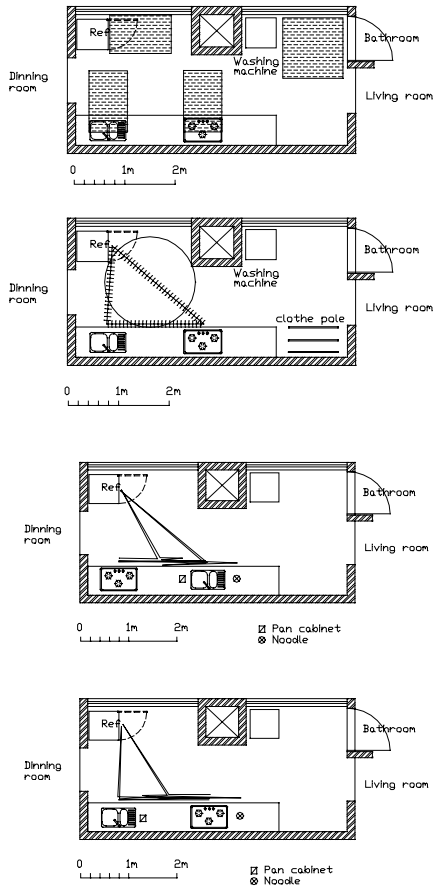
Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)	
	Yes	Yes	
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)	
	Yes	Yes	
Whole frontage length	3.44m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	Yes	No
Eating table	Available	Washing machine	Available
Writing table	Available	Drying clothes	Available

Kitchen 7980-08			
Area	13.24m^2	Layout	1



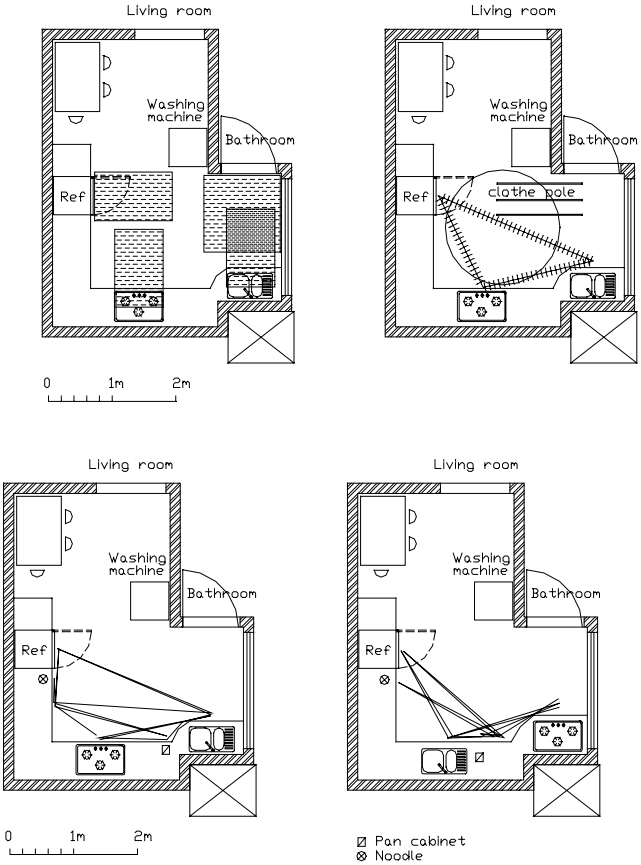
Triangle Total Length (TTL)	5.33m	Length of the Shortest Leg (LSL)	1.78m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		17.82m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		/
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			Yes
Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)	
	Yes	Yes	
Is there enough space for "T" turning	Minimum (152×152)	Optimum (152×183)	
	Yes	Yes	
Whole frontage length	4.04m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	Yes	Yes
Eating table	Available	Washing machine	Available
Writing table	Available	Drying clothes	Available

Kitchen 7980-08			
Area	13.24m^2	Layout	2



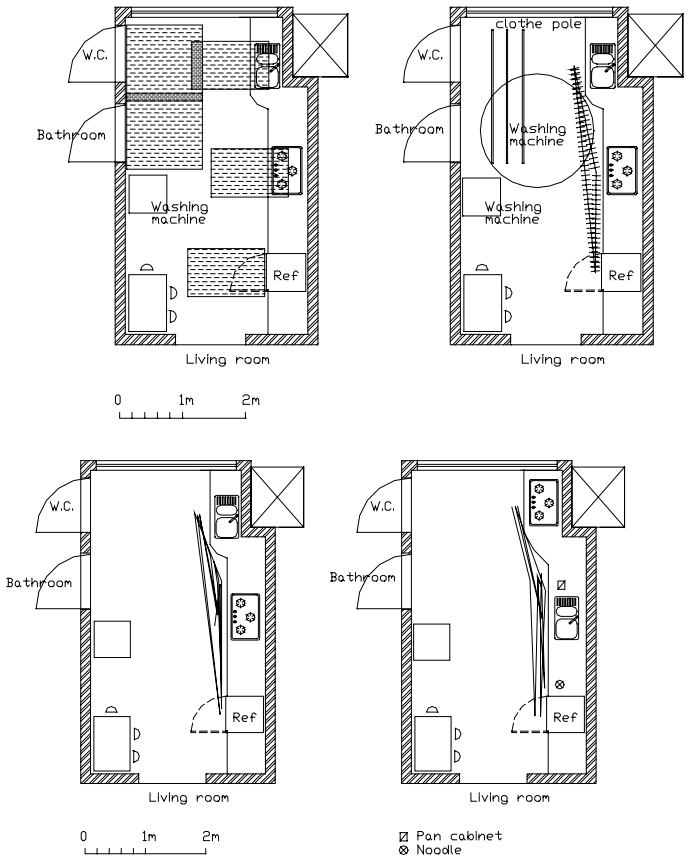
Triangle Total Length (TTL)	5.87m	Length of the Shortest Leg (LSL)	1.55m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		19.16m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		18.13m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			Yes
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		Yes
Is there enough space for "T" turning	Minimum (152×152)		Optimum (152×183)
	Yes		Yes
Whole frontage length	2.53m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	Yes	Yes	No
Eating table	Available	Washing machine	Available
Writing table	Available	Drying clothes	Available

Kitchen 8182-10			
Area	13.49m^2	Layout	1



Triangle Total Length (TTL)	5.98m	Length of the Shortest Leg (LSL)	1.59m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		20.17m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		18.67m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			No
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		Yes
Is there enough space for “T” turning	Minimum (152×152)		Optimum (152×183)
	Yes		Yes
Whole frontage length	2.91m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	Yes	No	No
Eating table	Available	Washing machine	Available
Writing table	Available	Drying clothes	Available

Kitchen 7980-03			
Area	14.06m^2	Layout	1

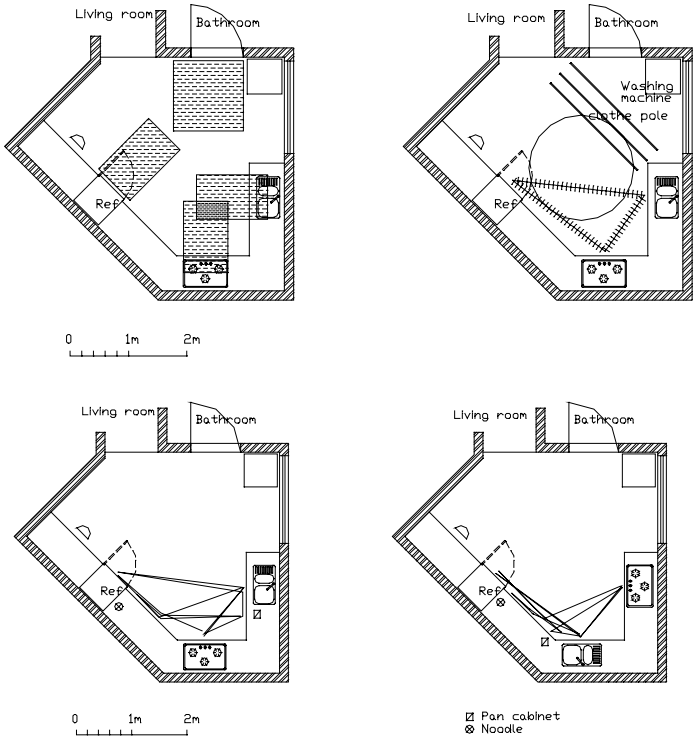


Triangle Total Length (TTL)	6.59m	Length of the Shortest Leg (LSL)	1.58m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		21.95m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		19.62m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			No

Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)
	Yes	Yes
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)
	Yes	Yes
Whole frontage length	2.95m	

Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Available	Washing machine	Available
Writing table	Available	Drying clothes	Available

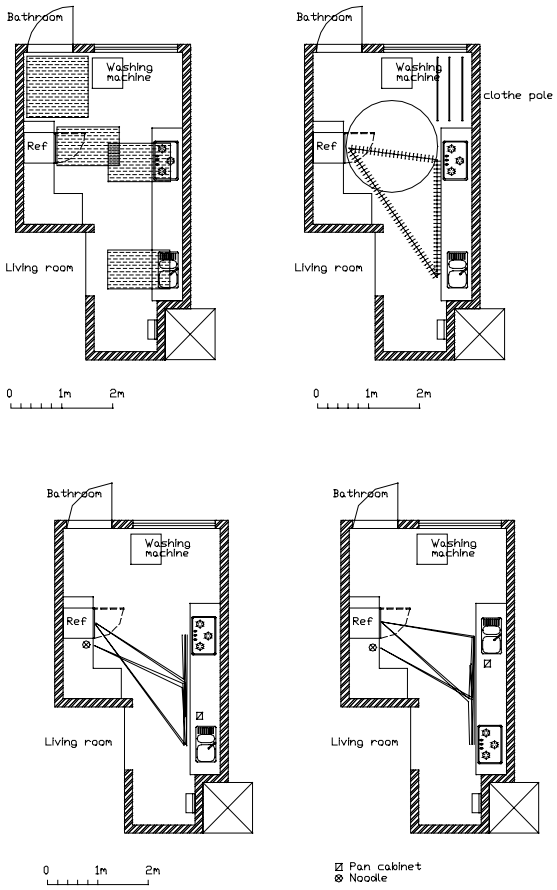
Kitchen 8182-11					
Area	14.16m^2		Layout	1	



Triangle Total Length (TTL)	5.45m	Length of the Shortest Leg (LSL)	1.17m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		16.63m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		14.97m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			No

Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)	
	Yes	Yes	
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)	
	Yes	Yes	
Whole frontage length	3.43m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Available	Washing machine	Available
Writing table	Available	Drying clothes	Available

Kitchen 8788-01			
Area	14.36m^2	Layout	1

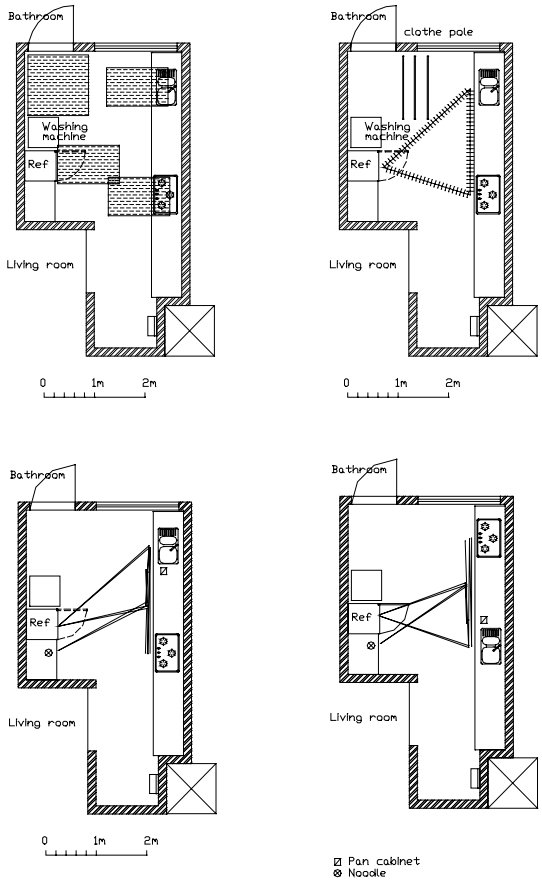


Triangle Total Length (TTL)	7.11m	Length of the Shortest Leg (LSL)	1.74m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		23.80m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		22.16m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			Yes

Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)
	Yes	Yes
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)
	Yes	Yes
Whole frontage length	3.09	

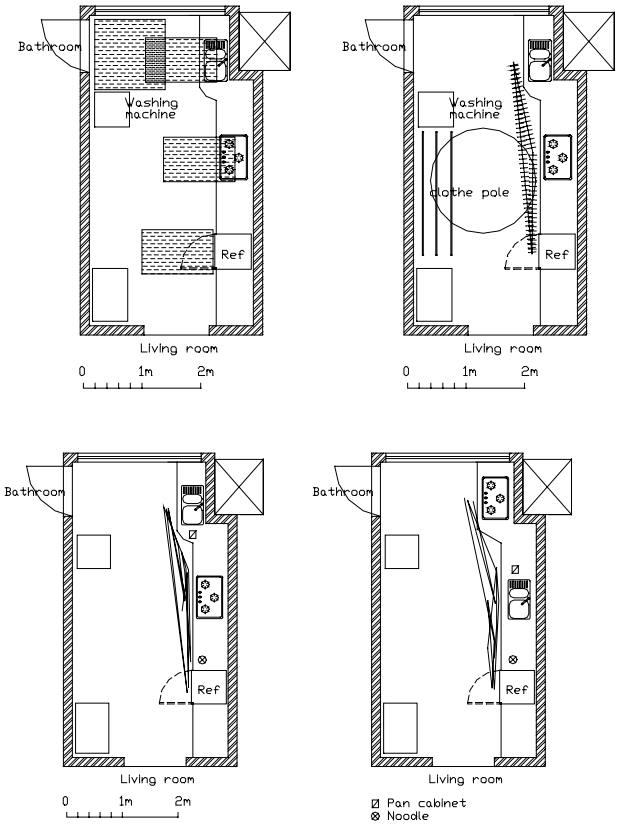
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	Yes	No	No
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

Kitchen 8788-01			
Area	14.36m^2	Layout	2



Triangle Total Length (TTL)	6.22m	Length of the Shortest Leg (LSL)	1.80m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		21.96m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		21.48m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			Yes
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		Yes
Is there enough space for “T” turning	Minimum (152×152)		Optimum (152×183)
	Yes		Yes
Whole frontage length	4.19m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	Yes	No
Eating table	Not available	Washing machine	Available
Writing table	Not available	Drying clothes	Available

Kitchen 7980-04			
Area	14.4m^2	Layout	1

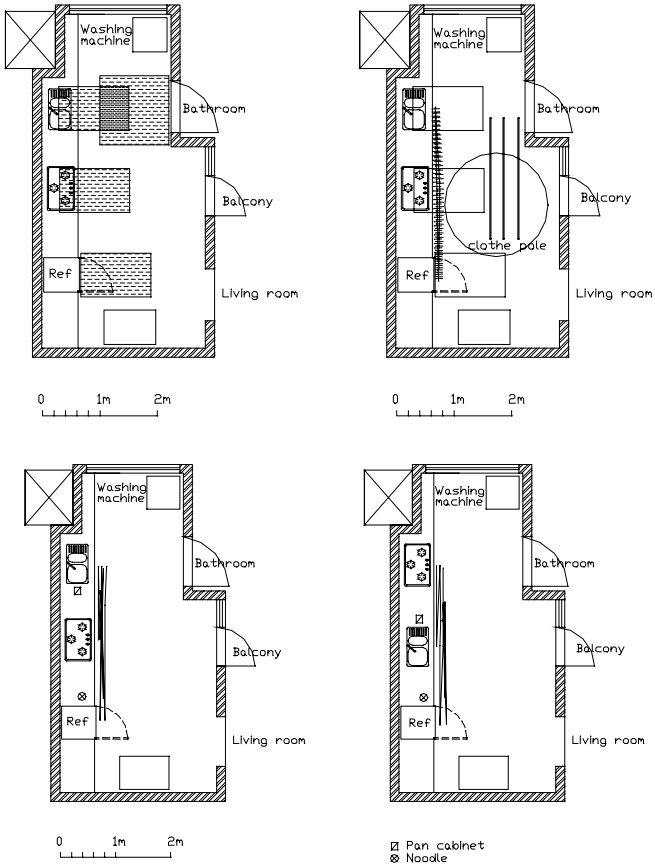


Triangle Total Length (TTL)	6.59m	Length of the Shortest Leg (LSL)	1.58m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		21.84m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		17.22m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			No

Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)
	Yes	Yes
Is there enough space for "T" turning	Minimum (152×152)	Optimum (152×183)
	Yes	Yes
Whole frontage length	3.24m	

Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	Yes	No	Yes
Eating table	Available	Washing machine	Available
Writing table	Available	Drying clothes	Available

Kitchen 7980-07			
Area	14.71m^2	Layout	1



Triangle Total Length (TTL)	6.04m	Length of the Shortest Leg (LSL)	1.41m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		18.97m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		17.15m

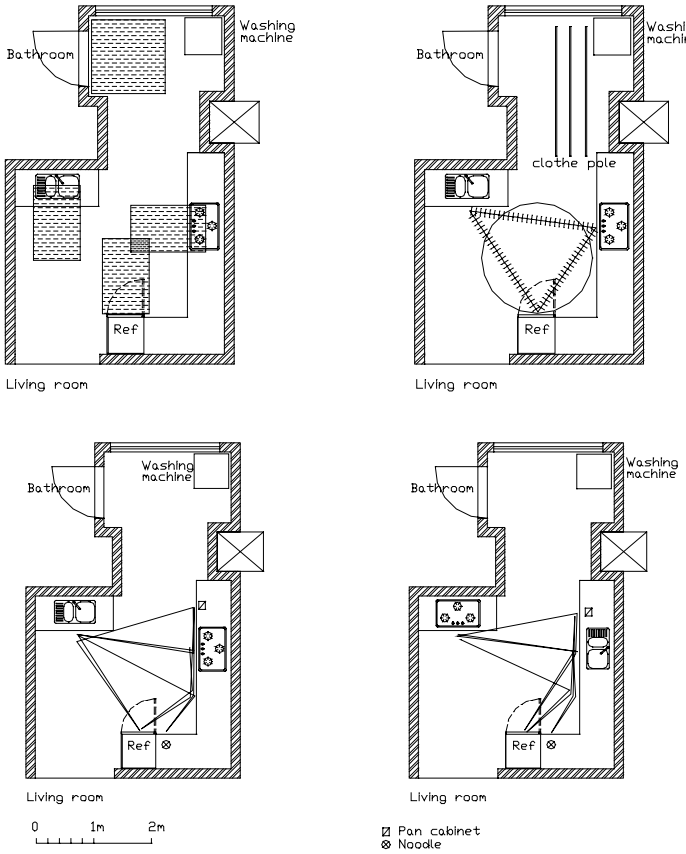
Entrance	To living room	OK
	To bathroom	OK
	To balcony	OK

Is working triangle interrupted by any other route?	No

Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)
	Yes	Yes
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)
	Yes	Yes

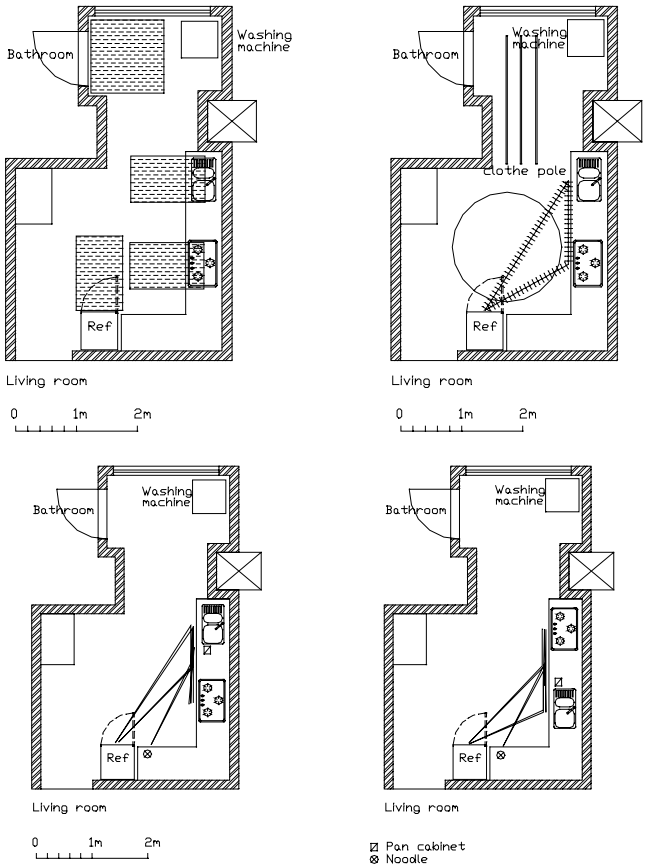
Whole frontage length	2.64m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Available	Washing machine	Available
Writing table	Available	Drying clothes	Available

Kitchen 8788-04			
Area	14.86m^2	Layout	1



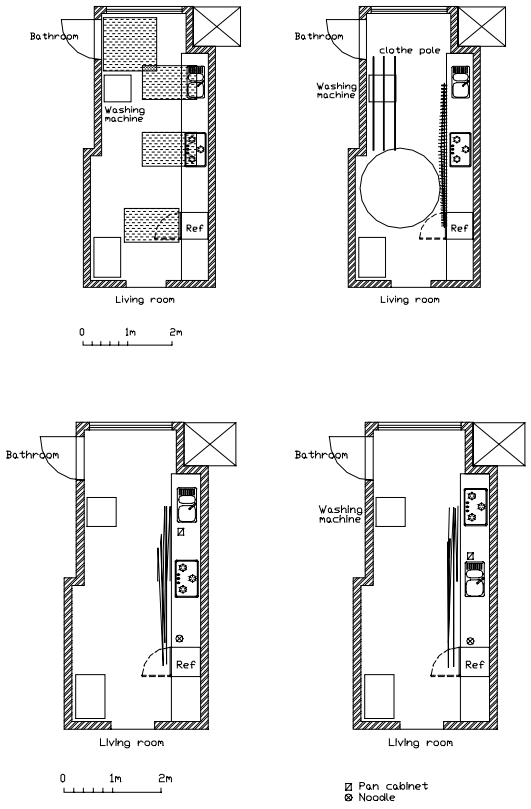
Triangle Total Length (TTL)	5.70m	Length of the Shortest Leg (LSL)	1.66m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		20.69m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		19.35m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			Yes
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		Yes
Is there enough space for “T” turning	Minimum (152×152)		Optimum (152×183)
	Yes		Yes
Whole frontage length	3.19m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Available	Washing machine	Available
Writing table	Available	Drying clothes	Available

Kitchen 8788-04			
Area	14.86m^2	Layout	2



Triangle Total Length (TTL)	5.45m	Length of the Shortest Leg (LSL)	1.37m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		18.21m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		16.55m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			Yes
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		Yes
Is there enough space for “T” turning	Minimum (152×152)		Optimum (152×183)
	Yes		Yes
Whole frontage length	3.20m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	Yes	No	No
Eating table	Available	Washing machine	Available
Writing table	Available	Drying clothes	Available

Kitchen 8384-04			
Area	14.95m^2	Layout	1



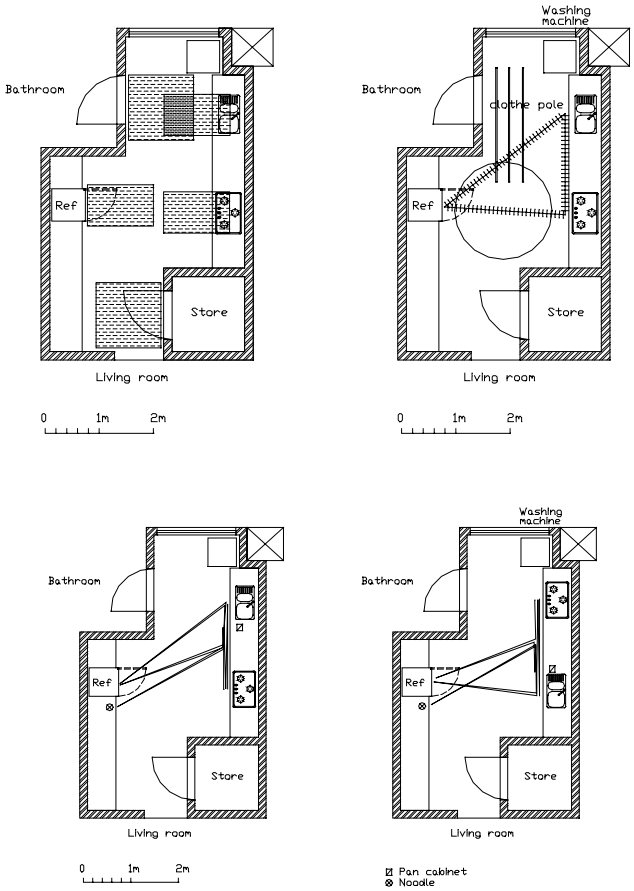
Triangle Total Length (TTL)	6.50m	Length of the Shortest Leg (LSL)	1.50m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		21.96 m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		21.14 m

Entrance	To living room	OK
	To bathroom	OK
	To balcony	/
Is working triangle interrupted by any other route?		Yes

Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)
	Yes	Yes
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)
	Yes	Yes
Whole frontage length	3.04m	

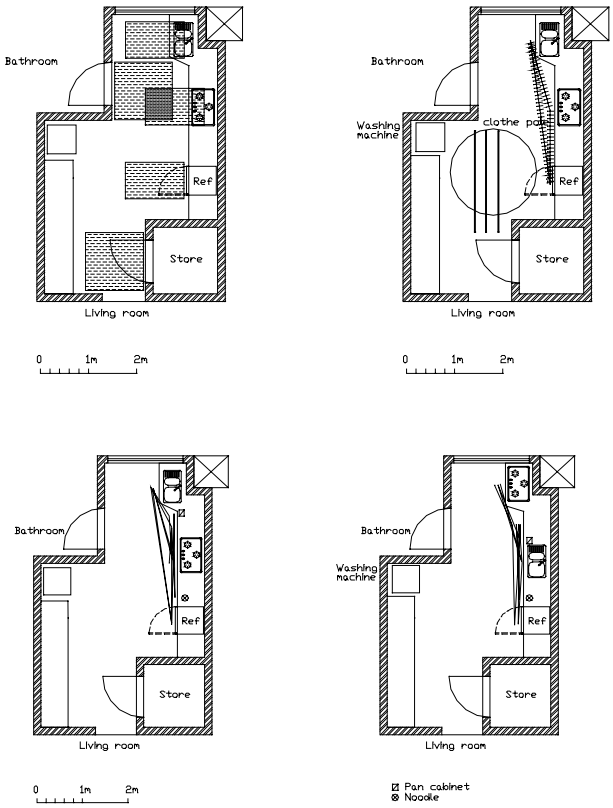
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	Yes	No	No
Eating table	Available	Washing machine	Available
Writing table	Available	Drying clothes	Available

Kitchen 8687-02			
Area	14.97m^2	Layout	1



Triangle Total Length (TTL)	6.91 m	Length of the Shortest Leg (LSL)	1.87m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		23.34 m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		22.99 m
Entrance	To living room		OK
	To bathroom		OK
	To balcony		/
Is working triangle interrupted by any other route?			Yes
Is there enough space for circle turning	Minimum radius (152cm)		Optimum radius (180cm)
	Yes		Yes
Is there enough space for “T” turning	Minimum (152×152)		Optimum (152×183)
	Yes		Yes
Whole frontage length	4.50m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Available	Washing machine	Available
Writing table	Available	Drying clothes	Available

Kitchen 8687-02			
Area	14.97m^2	Layout	2



Triangle Total Length (TTL)	6.04 m	Length of the Shortest Leg (LSL)	1.55 m
Noodle making route length	NL_1 (the distance between cooker and refrigerator is shorter than that between sink and refrigerator).		20.30 m
	NL_2 (the distance between cooker and refrigerator is longer than that between sink and refrigerator)		18.34 m

Entrance	To living room	OK
	To bathroom	OK
	To balcony	/

Is working triangle interrupted by any other route?	No

Is there enough space for circle turning	Minimum radius (152cm)	Optimum radius (180cm)
	Yes	Yes
Is there enough space for “T” turning	Minimum (152×152)	Optimum (152×183)
	Yes	Yes

Whole frontage length	4.09m		
Dose the wheelchair user block the door or way when using the sink or cooker, or refrigerator?	Sink	Cooker	Refrigerator
	No	No	No
Eating table	Available	Washing machine	Available
Writing table	Available	Drying clothes	Available

APPENDIX 28. TEST SCENARIOS

There were four test scenarios in each kitchen mock-up. For each kitchen layouts, the four scenarios were tested and the subjects were asked supporting questions.

Scenario 1

The subjects start from the door of the living room, take an object from the refrigerator, wash it at sink, cut it on the countertop, put it in a pot on the cooker, reach the ventilation hood switch.

Observations:

a) How do they approach the refrigerator? During the approach, does any problem occur? How do they react to the problem?
b) Let the subjects try other approaching methods. Do the same observations stated in item “a)” again.
c) How do they carry the food to the sink? (Do they put the food on leg or push it along the countertop?)
d) How do they move from sink to countertop? How do they move from countertop to cooker? Where do they put utensils and pans?
e) Do they use the pullout countertop?
f) Can they reach the ventilation hood?

Questions:

a) Which approaching method is easier to the refrigerator for you? Why?
b) Do you carry items on your legs when they are big and moderate heavy?
c) Under what conditions do you not carry items on your legs?
d) Is it good to use a trolley or to push the food along the counter? Why is it good or not?
e) How do you feel when using the sink? (Choices: very difficult, difficult, moderate, easy, very easy)
f) How do you feel about the pullout countertop? (Choices: very bad, bad, moderate, good, very good)
g) How do you feel about the cooker? (Choices: very bad, bad, moderate, good, very good)
h) How do you feel about the height of the ventilation hood? (Choices: very bad, bad, moderate, good, very good)
i) Do you think the space is adequate? (Choices: very inadequate, inadequate, just adequate, adequate, very adequate)

Scenario 2

The subjects put the bowl from countertop into the microwave oven, then take it out and place it on the countertop.

Observations:

a) How do they approach the microwave oven? Is there any problem while it is being used?
b) Let the subjects try other approaching methods. Do the same observations stated in item “a)” again.
c) Does any trouble occur during the procedure?
d) After they get the bowl out, which countertop do they put the bowl on?

Questions:

a) Which approaching method to the microwave oven is easier for you? Why?
b) From which appliance do you often get the food to the microwave?
c) Which countertop do you put the bowl on after you get it out of the microwave oven? Why?
d) How do you feel about the door of the microwave oven? (Choices: very bad, bad, moderate, good, very good)

e) How do you feel about the pull-out countertop? (Choices: very bad, bad, moderate, good, very good)

Scenario 3

The subjects take one object from the wall cabinet; one from the base cabinet and one from the rotating cabinet.

Observations:

a) How do they approach the cabinets? Is there any problem?
b) Let the subjects try other approaching methods. Do the same observations stated in item “a)” again.
c) Is it easy for the wheelchair users to pick objects from these cabinets?
d) How do they approach the cabinets? When they open the doors or drawers, does any problem occur? What are their reactions to the problems?

Questions:

a) Which method is easier for you in approaching the cabinets?
b) (For the cabinet near the cooker) is it easy for you to pick items from the drawers? (Choices: very difficult, difficult, moderate, easy, very easy)
c) (For the cabinet near the cooker) how do you comment on the knee space beside?
d) (For the rotating cabinet near the refrigerator) is it easy for you to pick items from the drawers? (Choices: very difficult, difficult, moderate, easy, very easy)
e) How do you feel about the rotating cabinet? (Choices: very bad, bad, moderate, good, very good)
f) (For the wall cabinet) is it easy for you to pick items from the drawers? (Choices: very difficult, difficult, moderate, easy, very easy)
g) How do you feel about the wall cabinet? (Choices: very bad, bad, moderate, good, very good)
h) Do you want the wall cabinet installed in your kitchen? Why?
i) (For the cabinet right to the refrigerator) is it easy for you to pick items from the drawers? (Choices: very difficult, difficult, moderate, easy, very easy) (This question is unsuitable for the two minimum small kitchens because this cabinet was not included).
j) Do you think the storage is adequate? (Choices: very inadequate, inadequate, just adequate, adequate, very adequate)

Scenario 4

The subjects open the door of the washing machine, put clothes into the door. Take clothes out of the washing machine and hang it on a clothes-drying pole.

Observations:

a) How do they approach the washing machine? Is there any problem?
b) Let the subjects try other approaching methods. Do the same observations stated in item “a)” again.
c) Does any problem occur? What is their reaction?
d) Is the washing machine easy for them to use?

Questions:

a) Which method is easier for you while approaching the washing machine? Why?
b) How do you feel about the location of the washing machine? (Choices: very bad, bad, moderate, good, very good)
c) How do you feel about the height of the washing machine? (Choices: very bad, bad, moderate, good, very good)
d) Where do you prefer the pole to be when hanging clothes? (The special device for hanging clothes was explained to the subjects before asking this question).

APPENDIX 29. OBSERVATIONS AND QUESTIONS IN TESTING KITCHEN O1M1

Observations:

a) How do they approach the refrigerator? During the approach, does any problem occur? How do they react to the problem?
b) How do they approach the microwave oven? Is there any problem while they are using it?
c) How do they use the washing machine?

Questions:

a) Is it easier to approach the refrigerator when the knee space is provided beside it? Why?
b) Is the microwave oven easier to use here than in its original place? Why?
c) Is the washing machine easier to use when it is raised up?
d) How do you feel that the countertop be separated into two parts when the washing machine is raised up? Why? (Choices: very bad, bad, moderate, good, very good)
e) How do you feel about the provision of knee space beside the refrigerator to reduce the storage room? Why? (Choices: Very unacceptable, unacceptable, acceptable, very acceptable)
f) Do you think the present storage is adequate? (Choices: very inadequate, inadequate, just adequate, adequate, very adequate)
g) The present sink is 10cm smaller than that of O1. How do you feel about the smaller sink? Why? (Choices: worse, the same, better)

APPENDIX 30. OBSERVATIONS AND QUESTIONS IN TESTING KITCHEN

O1M2

Observations:

a) How do they approach the refrigerator? During the approach, does any problem occur? How do they react to the problem?
b) How do they approach the microwave oven? Is there any problem while they are using it?
c) How do they use the washing machine?
d) How do they use the rotating cabinet at the corner?

Questions:

a) How do you feel about the present location of the refrigerator compared with the location in Kitchen O1? Why?
b) Is it easier to approach the refrigerator?
c) Is the microwave oven easier to use here than in its original place? Why?
d) Is the washing machine easier to use when it is raised up?
e) How do you feel about the location of the washing machine? (Choices: very bad, bad, moderate, good, very good)
f) Is the rotating cabinet at the corner easy to access? (Choices: very difficult, difficult, moderate, easy, very easy)
g) Do you think the present storage is adequate? (Choices: very inadequate, inadequate, just adequate, adequate, very adequate)

APPENDIX 31. OBSERVATIONS AND QUESTIONS IN TESTING KITCHEN M1M1

Observations:

a) How do they approach the refrigerator? During the approach, does any problem occur? How do they react to the problem?
b) How do they approach the microwave oven? Is there any problem while they are using it?
c) How do they use the washing machine?

Questions:

a) Is it easier to approach the refrigerator when the knee space is provided beside it? Why?
b) Is the microwave oven easier to use? Why?
c) Is the washing machine easier to use when it is put at the corner?
d) Is the present storage adequate? (Choices: very inadequate, inadequate, just adequate, adequate, very adequate)

APPENDIX 32. OBSERVATIONS AND QUESTIONS IN TESTING KITCHEN M2M1

Observations:

a) How do they approach the refrigerator? During the approach, does any problem occur? How do they react to the problem?
b) How do they approach the microwave oven? Is there any problem while they are using it?
c) How do they use the washing machine?

Questions:

a) Is it easier to approach the refrigerator when the knee space is provided beside it? Why?
b) Is the microwave oven easier to use? Why?
c) Is the washing machine easier to use when it is put at the corner?
d) Is the present storage adequate? (Choices: very inadequate, inadequate, just adequate, adequate, very adequate)

APPENDIX 33. TEST RESULTS OF THE MOCK-UP KITCHENS

Kitchen O1

Kithcen O1, scenario 1.

Questions	1. Mr. Yusoff (paraplegia, strong, big size)	2. Ms. Chun (paraplegia, strong, big size)	3. Mr. Foo (paraplegia, strong, small size)	4. Ms. Ng (paraplegia, strong, small size)	5. Mr. Low (meningitis, weak, big size)	6. Ms. Bao Lin (epilepsy, weak, big size)	7. Mr. Wee (cerebral palsy, weak, small size)	8. Ms. Jennies (epilepsy, Weak, small size)	9. Mr. Salaam (hemiplegia, prefer to use right hand)	10. Ms. Sabiah (rheumatoid arthritic, prefer to use right hand; she can use feet to push wheelchair)	11. Mr. Yow (meningitis, prefer to use left hand)	12. Ms. Edel (rheumatoid arthritic, prefer to use left hand; she can use feet to push wheelchair)
Which approaching method to the refrigerator is easier for the subject? Why?	Front approach, refrigerator on his front-right. Because it is easy to collide with the cabinet with backward approach.	Front approach, refrigerator on her front-right. Because she can see the refrigerator and know how to adjust the wheelchair.	Front approach, refrigerator on the front-right of him.	Front approach, refrigerator on her front-right; it is easy for her to collide with the cabinet with backward approach; she must adjust her wheelchair more times.	Front approach, refrigerator on his front-right. Because he can see the refrigerator, and know how to adjust the wheelchair.	Front approach, refrigerator on her front-right. Because it is easy to collide with the cabinet with backward approach.	Front approach, refrigerator on his front-right. Because it is easy to collide with the cabinet with backward approach.	Front approach, refrigerator on her front-right.	Front approach, refrigerator on his front-right.	Front approach, refrigerator on her front-right.	Front approach, refrigerator in the front of him. Because he can see the refrigerator, and know how to adjust the wheelchair.	Backward approach, Refrigerator on her front-left. This approach allows her to use her left hand better.
How does the subject carry the object to the sink?	Pushes the bowl on the countertop	On legs	On legs	On legs	On legs	On legs	On legs	On legs	On legs	Puts the bowl on countertop and drags it; moves backward.	On legs	On legs
Does the subject still carry items on his/her legs when the items are big and moderate heavy?	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No, she seldom puts items on legs because she uses legs to push wheelchair.	Yes	No, when the items are big and heavy, she pushes or drags them along the countertop.
Under what conditions does the subject not carry items on his/her legs?	When carrying hot and heavy items.	When carrying hot and heavy items.	When carrying hot or too cold items. When carrying brittle items.	When carrying water.	When carrying water.	When carrying water.	When carrying water; because it is easy to spill water on his legs, especially when the water is hot.	Carrying frozen meat or water.	Carrying frozen meat or water.	She never carries items on her legs.	Carrying frozen meat or water.	When carrying water and heavy items.
Will the subject use trolley to carry the food?	No, because it is difficult to push the trolley while pushing the wheelchair.	No, because it is too difficult to do so.	No, because it is difficult to push the trolley while pushing the wheelchair	No, because it is too difficult to do so.	No, because it is difficult to push the trolley while pushing the wheelchair	No, because it is too difficult to do so.	No, because the place will be too congested.	No, because it is too difficult to do so.	No, because it is too difficult to do so.	No, because the trolley will block the refrigerator's door.	No, because the trolley will block the refrigerator's door.	No, because it is difficult to push the trolley while pushing the wheelchair.
How does the subject feel about the sink? (Choices: very difficult, difficult, moderate, easy, very easy)	Easy	Easy	Easy	Easy	Easy	Easy	Moderate	Easy	Easy	Easy	Easy	Easy
How does the subject feel about the pullout countertop? (Choices: very bad, bad, moderate, good, very good)	Good	Very good	Good	Good	Good	Good	Very good, countertop at this height is more comfortable for him.	Good	Good	Moderate. The pull-out countertop is unnecessary because it is too low for her.	Very good	Very good

How does the subject feel about the cooker? (Choices: very bad, bad, moderate, good, very good)	Good	Good	Good	Good	Very good	Good	Good	Good	Good	Good	Very good	Good
How does the subject feel about the height of the ventilation hood? (Choices: very bad, bad, moderate, good, very good)	Very good	Good	Very good	Good	Very good	Very good	Good (it will be very good if the switches are on the countertop)	Good	Good	Very good	Very good	Very good
Does the subject think the space is adequate? (Choices: very inadequate, inadequate, just adequate, adequate, very adequate)	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate

Kitchen O1, Scenario 2.

Questions	1. Mr. Yusoff	2. Ms. Chun	3. Mr. Foo	4. Ms. Ng	5. Mr. Low	6. Ms. Bao Lin	7. Mr. Wee	8. Ms. Jennies	9. Mr. Salaam	10.Ms. Sabiah	11. Mr. Yow	12. Ms. Edel
Which approaching method to the microwave oven is easier for the subject? Why?	Backward approach, the microwave oven on his right side. It is easy for him to see inside the oven.	Backward approach, the microwave oven on her right side.	Backward approach, the microwave oven on his right side.	Backward approach, the microwave oven on her right side.	It is the same from either side. Because he can use both hands.	Backward approach, microwave oven on her right side. Because the door of the microwave oven blocks her left arm with front approach.	Backward approach, microwave oven on his right side. Because he can see inside the microwave oven.	Backward approach, microwave oven on his right side. Because she can see inside the microwave oven.	Backward approach, he can use his right hand better.	Backward approach, the microwave oven on her right side. It is easy for her to pick items in and out of the microwave oven.	Front approach, the microwave oven on his left side.	Front approach, the microwave oven on her front-left.
From which appliance does the subject often get the food?	Refrigerator	Sink	Refrigerator	Sink	Refrigerator	Refrigerator	Refrigerator	Sink	Sink	Refrigerator	Refrigerator	Refrigerator
Which countertop does the subject put the bowl on after he/she gets it out of the microwave oven? Why?	The countertop right to the microwave oven. Because the microwave oven's door blocks him from putting the bowl on the countertop near the sink.	Both	The countertop right to the microwave oven. Because the microwave oven's door blocks him from putting the bowl on the countertop near the sink.	Both	The countertop near the sink. After meat thaws in the microwave oven, the meat must be washed in the sink and cut at the countertop.	The countertop right to the microwave oven. This countertop is more convenient.	The countertop right to the microwave oven. This countertop is more convenient.	Both	The countertop right to the microwave oven. This countertop is more convenient.	The countertop near the sink. Because she feels that bending forward is easier than turning right backward.	The countertop right to the microwave oven. Because he feels that bending forward is easier than turning left backward.	The countertop right to the microwave oven. Because the microwave oven's door blocks her from putting the bowl on the countertop near the sink.
How does the subject feel about the door of the microwave oven? (Choices: very bad, bad, moderate, good, very good)	Moderate	Bad	Bad He must move food around the door to the countertop near the sink	Moderate	Moderate. If the door is top hinged or bottom hinged, it will be much better.	Moderate	Good. If the door is top hinged or bottom hinged, it will be much better.	Moderate	Bad	Good She prefers this door type because she has used this type for many years.	Moderate. If the door is opened downward, it will be much better.	Bad She must move food around the door to the countertop near the sink
Does the subject use the pull-out countertop?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes

How does the subject feel about the pull-out countertop? (Choices: very bed, bad, moderate, good, very good)	Good	Good	Moderate	Good	Good	Good	Very good	Good	Good. It is safer when getting hot bowl out of the microwave oven.	Moderate. It seems no much necessary and it can hinder the user from getting close to the microwave.	Good	Good

Kitchen O1, Scenario 3.

Questions	1. Mr. Yusoff	2. Ms. Chun	3. Mr. Foo	4. Ms. Ng	5. Mr. Low	6. Ms. Bao Lin	7. Mr. Wee	8. Ms. Jennies	9. Mr. Salaam	10.Ms. Sabiah	11. Mr. Yow	12. Ms. Edel
(For the cabinet near the cooker) which approaching method is easier for the subject?	Front approach, cabinet on his left.	Front approach, cabinet on her left.	Front approach, cabinet on his left.	Front approach, cabinet on her left.	Front approach, cabinet on his left.	Front approach, cabinet in front of her.	Front approach, cabinet on his left.	Front approach, cabinet on her left.	Front approach, cabinet on his right.	Front approach, cabinet in front of her.	Front approach, cabinet on his left.	Front approach, cabinet on her left.
(For the cabinet near the cooker) is it easy for the subject to pick objects from the drawers? (Choices: very difficult, difficult, moderate, easy, very easy)	For the lowest drawer, moderate; For the higher drawers, very easy.	For the lowest drawer, moderate; For the higher drawers, very easy.	For the lowest drawer, very difficult; For the higher drawers, easy.	For the lowest drawer, very difficult; For the higher drawers, easy.	For the lowest drawer, difficult; For the higher drawers, easy.	For the lowest drawer, difficult; For the higher drawers, moderate.	For the lowest drawer, difficult; For the higher drawers, easy.	For the lowest drawer, very difficult; For the higher drawers, easy.	For the lowest drawer, difficult; For the higher drawers, easy.	For the lowest drawer, very difficult; For the higher drawers, moderate.	For the lowest drawer, difficult; For the higher drawers, easy.	For the lowest drawer, difficult; For the higher drawers, easy.
(For the cabinet near the cooker) how does the subject comment on the knee space beside?	The knee space beside the cabinet makes it easier for him to open the drawers because he can get closer to the cabinet. The wheelchair doesn't block the drawers.	The knee space beside the cabinet makes it easier for her to open the drawers.	The knee space beside the cabinet makes it easier for him to open the drawers because he can get closer to the cabinet. The wheelchair doesn't block the drawers.	The knee space beside the cabinet makes it easier for her to open the drawers.	The knee space beside the cabinet makes it easier for him to open the drawers because he can get closer to the cabinet.	She doesn't use the knee space because if she utilizes the knee space, she must bend left laterally to open the drawers. Because of her pain in the waist, she is unable to do so.	The knee space beside the cabinet makes it easier for him to open the drawers because he can get closer to the cabinet. The wheelchair doesn't block the drawers.	The knee space beside the cabinet makes it easier for her to open the drawers because he can get closer to the cabinet.	He doesn't use the knee space because he uses his right hand to get items.	She doesn't use the knee space because she uses her right hand to get items. If the knee space is on the left side of the cabinet, she will use the knee space.	The knee space beside the cabinet makes it easier for him to open the drawers because he can get closer to the cabinet. The wheelchair doesn't block the drawers.	The knee space is good for her because she can get closer to the cabinet and use her left hand to open the drawers and get items.
(For the rotating cabinet near the refrigerator) is it easy for the subject to pick objects from the shelves? (Choices: very difficult, difficult, moderate, easy, very easy)	Moderate for the lowest shelf; Very easy for the higher shelves.	Moderate for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Easy for the higher shelves.	Moderate for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Very Difficult for the lowest shelf; easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.
(For the rotating cabinet near the refrigerator) Which approaching method is easier for the subject?	Both	Both	Both	Both	Both	Both	Both	Both	The cabinet on the subject's right.	The cabinet on the subject's right.	The cabinet on the subject's left.	The cabinet on the subject's left.
How does the subject feel about the rotating cabinet? (Choices: very bed, bad, moderate, good, very good)	Very good	Good	Good	Good	Very good.	Very good.	Very good.	Good	Good	Good	Very good	Very good
(For the wall cabinet) is it easy for the subject to pick objects from the shelves? (Choices: very difficult, difficult, moderate, easy, very easy)	Easy to get objects from the lowest shelf. Difficult to get objects from the upper shelf.	Easy to get objects from the lowest shelf. Difficult to get objects from the upper shelf.	Very difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Very difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Moderate to get objects from the lowest shelf. The upper shelf cannot be reached.	Easy to get objects from the lowest shelf. The upper shelf cannot be reached.	Difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Easy to get objects from the lowest shelf. The upper shelf cannot be reached.	Difficult to get objects from the lowest shelf. The upper shelf cannot be reached.

How does the subject feel about the wall cabinet? (Choices: very bed, bad, moderate, good, very good)	Good	Moderate	Bad	Bad	Moderate	Good	Bad	Bad	Bad	Bad	Moderate	Bad
Does the subject want the wall cabinet installed in his/her kitchen? Why?	Yes, because more items can be stored and the kitchen looks tidy.	No, because it is difficult to use.	No, because it is difficult to use.	No, because it is difficult to use and wastes money.	No, because it has no much use and wastes money.	Yes, because more items can be stored.	No, because it is difficult to use.	No, because it is difficult to use.	No, because it is difficult to use and wastes money.	No, because it is difficult to use.	No, because it is difficult to use.	No, because it is difficult to use.
(For the cabinet right to the refrigerator) is it easy for the subject to pick objects from the drawers? (Choices: very difficult, difficult, moderate, easy, very easy)	For the lowest drawer, moderate; For the drawers higher than the lowest one, easy.	For the lowest drawer, moderate; For the drawers higher than the lowest one, easy.	For the lowest drawer, very difficult; For the higher drawers easy.	For the lowest drawer, very difficult; For the higher drawers easy.	For the lowest drawer, difficult; For the drawers higher than the lowest one, easy.	For the lowest drawer, difficult; For the drawers higher than the lowest one, easy.	For the lowest drawer, difficult; For the drawers higher than the lowest one, easy.	For the lowest drawer, difficult; For the drawers higher than the lowest one, easy.	For the lowest drawer, difficult; For the drawers higher than the lowest one, easy.	For the lowest drawer, difficult; For the drawers higher than the lowest one, easy.	For the lowest drawer, difficult; For the drawers higher than the lowest one, moderate.	For the lowest drawer, very difficult; For the drawers higher than the lowest one, difficult.
(For the cabinet right to the refrigerator) which approaching method is easier for the subject?	Frontward approach, facing the cabinet	Frontward approach, facing the cabinet	Frontward approach, facing the cabinet	Frontward approach, facing the cabinet	Frontward approach, facing the cabinet	Frontward approach, facing the cabinet	Frontward approach, facing the cabinet	Frontward approach, facing the cabinet	Frontward approach, facing the cabinet	Frontward approach, facing the cabinet	Lateral approach, cabinet on the user's left.	Lateral approach, cabinet on the user's left.
Does the subject think the storage is adequate? (Choices: very inadequate, inadequate, just adequate, adequate, very adequate)	Very adequate	Adequate	Adequate	Adequate	Very adequate	Adequate	Very adequate	Adequate	Adequate	Adequate	Adequate	Adequate

Kitchen O1, Scenario 4.

Questions	1. Mr. Yusoff	2. Ms. Chun	3. Mr. Foo	4. Ms. Ng	5. Mr. Low	6. Ms. Bao Lin	7. Mr. Wee	8. Ms. Jennies	9. Mr. Salaam	10.Ms. Sabiah	11. Mr. Yow	12. Ms. Edel
Which method to approach the washing machine is easier for the subject? Why?	Front approach, the washing machine on his front-right.	Front approach, the washing machine on her right.	Front approach, the washing machine on his right.	Front approach, the washing machine on her right.	Front approach, the washing machine on his front-right. Because he can see and feels easy to adjust the wheelchair.	Front approach, the washing machine on her right.	Front approach, the washing machine on his front-right. Because he can see inside the washing machine.	Front approach, the washing machine on her right.	Front approach, the washing machine on his right.	Front approach, the washing machine in front of her.	Front approach, the washing machine on his left.	Front approach, the washing machine on her front-left.
How does the subject feel about the location of the washing machine? (Choices: very bed, bad, moderate, good, very good)	Moderate	Moderate	Bad	Moderate	Moderate If it is near the bathroom it will be better.	Moderate	Moderate	Moderate	Moderate	Good	Good, because the location is convenient for him to approach.	Moderate
How does the subject feel about the height of the washing machine? (Choices: very bed, bad, moderate, good, very good)	Bad	Bad	Very Bad	Bad	Moderate	Bad	Bad	Bad	Bad	Bad	Moderate	Bad Because it is too low.
Where does the subject prefer the clothes pole to be?	Just on his front-left when he sits at the washing machine.	Just on her front-left when she sits at the washing machine.	Just on his front-left when he sits at the washing machine.	Just on her front-left when she sits at the washing machine.	Just on his font-left when he sits at the washing machine.	Just on her font-left when she sits at the washing machine.	Just on his font-left when he sits at the washing machine.	Just on her front-left when she sits at the washing machine.	Just on his front-left when he sits at the washing machine.	Just on her right when she sits at the washing machine.	Just on his font-right when he sits at the washing machine.	Just on her font-right when she sits at the washing machine.

Kitchen O1m1

Questions	1. Mr. Yusoff	2. Ms. Chun	3. Mr. Foo	4. Ms. Ng	5. Mr. Low	6. Ms. Bao Lin	7. Mr. Wee	8. Ms. Jennies	9. Mr. Salaam	10.Ms. Sabiah	11. Mr. Yow	12. Ms. Edel
Is it easier to approach the refrigerator when the knee space is provided beside it? Why?	Yes, because he can get closer to the refrigerator to open the door. And there is more space available to adjust the wheelchair.	Yes, because she can get closer to the refrigerator to open the door. And there is more space available to adjust the wheelchair.	Yes, because the door is easier to open. He can reach many items in the refrigerator even sits with his legs in the knee space.	Yes, because there is more space available to adjust the wheelchair.	Yes, because there is more space available to adjust the wheelchair.	Yes, because she can get closer to the refrigerator to open the door.	Yes, because he can get closer to the refrigerator to open the door.	Yes, because there is more space available to adjust the wheelchair.	Yes, because there is more space available to adjust the wheelchair.	Yes, the refrigerator is easier to use because she can get close to the refrigerator and put the bowl on the counter beside the refrigerator.	No, because he uses left hand to open the refrigerator door and get items. In the knee space, he cannot use his left hand.	No, because she prefers to open the refrigerator and get items with the left hand. If the knee space is provided at the right side of the refrigerator and the door is left hinged, it will be much better.
Is the microwave oven easier to use here than in its original place? Why?	Yes, it is easier to use because the subject can sit facing the microwave oven. It is easy to reach the countertop on the left.	Yes, it is easier to use because the subject can sit facing microwave oven.	Yes, it is easier to use because the subject can sit facing the microwave oven. It is easy to reach the countertop on the left.	No, because the microwave oven is far from the sink. Inconvenient.	Yes, it is easier to use because the subject can sit facing the microwave oven. The oven is also near the refrigerator now.	Yes, it is easier to use because the subject can sit facing the microwave oven. It is easy to reach the countertop on the left.	Yes, it easier to use because the subject can sit facing the microwave oven. It is easy to reach the countertop on the left.	No, because the microwave oven is far from the sink. Inconvenient.	No, because putting the bowl to the countertop left is difficult for him.	No, because putting the bowl to the countertop left is difficult for her.	No, because the microwave oven is far from the sink. Inconvenient.	Yes, it is easier to use because the subject can sit facing the microwave. It is easy to reach the countertop on the left.
Is the washing machine easier to use when it is raised up?	Yes	Yes	Yes	Yes	Yes, it is much easier.	Yes, it is much easier.	Yes	Yes	Yes	Yes	Yes,	Yes
How does the subject feel about the location of the washing machine? (Choices: very bad, bad, moderate, good, very good)	Good	Good	Good	Good	Good	Good	Moderate	Bad	Good	Moderate	Moderate	Bad
How does the subject feel that the countertop is separated into two parts when the washing machine is raised up? Why? (Choices: very unacceptable, unacceptable, acceptable, very acceptable)	Unacceptable, Because he cannot push or drag bowls along the countertop.	Acceptable	Unacceptable, Because he cannot push items along the countertop.	Acceptable	Acceptable, because the washing machine can be easier to use.	Acceptable	Acceptable, because the washing machine can be easier to use.	Acceptable	Acceptable	Unacceptable, Because it separates the countertop thus she cannot push or drag bowls along the countertop.	Unacceptable, because the microwave oven must change to another place.	Unacceptable, Because she cannot push or drag bowls along the countertop.
How does the subject think about the provision of knee space to reduce the storage room? Why? (Choices: Very unacceptable, unacceptable, acceptable, very acceptable)	Very acceptable	Acceptable	Acceptable	Acceptable	Very acceptable, because the storage is adequate already even one cabinet is reduced. The knee space is more important.	Acceptable, because the knee space is important for approaching the microwave oven.	Very acceptable, because the storage is already adequate .	Acceptable	Acceptable	Acceptable	Acceptable, because a countertop with knee space allows him to eat simple meal in the kitchen.	Acceptable
How does the subject feel about the smaller sink? (Choices: worse, the same, better)	The same	The same	The same	The same	The same	The same	The same	The same	The same	The same	The same	The same

Kitchen O1m2

Questions	1. Mr. Yusoff	2. Ms. Chun	3. Mr. Foo	4. Ms. Ng	5. Mr. Low	6. Ms. Bao Lin	7. Mr. Wee	8. Ms. Jennies	9. Mr. Salaam	10.Ms. Sabiah	11. Mr. Yow	12. Ms. Edel
How does the subject feel about the present location of the refrigerator compared with the location in Kitchen O1? Why?	Better than that in O1. Because it is near the sink and microwave oven. It is easier to be approached.	Better than that in O1. Because it is near the sink and microwave oven. It is easier to be approached.	Better than that in O1. Because it is near the sink and microwave oven. He can push a bowl from the refrigerator to sink.	Better than that in O1. Because it is near the sink and microwave oven. It is easier to be approached.	Better than that in O1. Because it is near the sink and microwave oven. When he approaches from the refrigerator to sink, less turn of the wheelchair is required.	Better than that in O1. Because it is near the sink and microwave oven.	Better than that in O1. Because it is near the sink and microwave oven.	Better than that in O1. Because it is near the sink and microwave oven. It is easier to be approached.	Better than that in O1. Because it is near the sink and microwave oven. It is easier to be approached.	Better than that in O1. Because it is near the sink and microwave oven. She can push a bowl from the refrigerator to sink.	Better than that in O1. Because it is near the sink and microwave oven. It is easier to be approached.	Better than that in O1. Because it is near the sink and microwave oven. She can push a bowl from the refrigerator to sink.
Is it easier to approach the refrigerator?	Yes, because there is more space available to adjust the wheelchair.	Yes, it is easy to approach the refrigerator from the door.	Yes, because there is more space available to adjust the wheelchair.	Yes, it is easy to approach the refrigerator from the door.	Yes, because there is more space available to adjust the wheelchair.	Yes, because there is more space available to adjust the wheelchair.	Yes, because there is more space available to approach the refrigerator.	Yes, it is easy to approach the refrigerator from the door.	Yes, it is easy to approach the refrigerator from the door.	Yes, because there is more space available to adjust the wheelchair.	Yes, he makes less turn approaching the refrigerator from the door.	Yes, she makes less turn approaching the refrigerator from the door.
Is the microwave oven easier to use here than in its original place? Why?	Yes, it is easier to be used because he can sit facing the microwave oven.	Yes, it is much easier to be used because she can sit facing the microwave oven.	Yes, it is much easier to be used because he can sit facing the microwave oven.	Yes, it is much easier to be used because she can sit facing the microwave oven.	Yes, it is easier to be used because he can sit facing the microwave oven. Now the microwave is also near the sink and refrigerator.	Yes, it is easier to be used because she can sit facing the microwave oven. Now the oven is also near the sink and refrigerator.	Yes, it is much easier to be used because he can sit facing the microwave oven.	Yes, it is much easier to be used because she can sit facing the microwave oven.	Yes, it is much easier to be used because he can sit facing the microwave oven.	Yes, it is easier to be used because she can sit facing the microwave oven. Now the oven is also near the sink and refrigerator.	Yes, it is easier to be used because he can sit facing the microwave oven. Now the oven is also near the sink and refrigerator.	Yes, it is easier to be used because she can sit facing the microwave oven. Now the oven is also near the sink and refrigerator.
How does the subject feel about the door of the microwave oven? (Choices: very bad, bad, moderate, good, very good)	Good	Good	Good	Good	Good	Moderate	Good	Moderate	bad	bad	good	good
Is the washing machine easier to use when it is raised up?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
How does the subject feel about the location of the washing machine? (Choices: very bad, bad, moderate, good, very good)	Good	Good	Very good	Good	Very good, because it is easy to access the washing machine.	Very good, because it is easy to access the washing machine.	Very good, because it is easy to access the washing machine.	Good	Good	Good	Very good.	Very good
(For the rotating cabinet near the refrigerator) Which approaching method is easier for the subject?	Frontward approach	Frontward approach	Frontward approach	Frontward approach	Frontward approach	Frontward approach	Frontward approach	Frontward approach	Frontward approach	Frontward approach	Frontward approach	Frontward approach
It the rotating cabinet at the corner easy to access? (Choices: very difficult, difficult, moderate, easy, very easy)	Easy	Easy	Easy	Easy	Easy	Easy	Very easy	Easy	Moderate	Moderate	Very easy	Very easy

(For the rotating cabinet near the refrigerator) is it easy for the subject to pick objects from the shelves? (Choices: very difficult, difficult, moderate, easy, very easy)	Moderate for the lowest shelf; Very easy for the higher shelves.	Moderate for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Easy for the higher shelves.	Moderate for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Very Difficult for the lowest shelf; easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.
Does the subject think the present storage is adequate? (Choices: very inadequate, inadequate, just adequate, adequate, very adequate)	Adequate	Adequate	Just adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Just adequate	Inadequate	Adequate

Kitchen M1 (the middle one)

<u>Kitchen M1, Scenario 1.</u>

Questions	1. Mr. Yusoff	2. Ms. Chun	3. Mr. Foo	4. Ms. Ng	5. Mr. Low	6. Ms. Bao Lin	7. Mr. Wee	8. Ms. Jennies	9. Mr. Salaam	10.Ms. Sabiah	11. Mr. Yow	12. Ms. Edel
(For the refrigerator) which approaching method is easier for the subject? Why?	Front approach, refrigerator on his front-right.	Front approach, refrigerator on her front-right.	Front approach, refrigerator on his front-right. It is easy for him to approach the refrigerator and to use his right hand.	Front approach, refrigerator on her front-right.	Front approach, the refrigerator on his front-right.	Front approach, the refrigerator on her front-right. It is easy for her to open the door and get items.	Front approach, the refrigerator on his front-right. It is easy for him to open the door and get items.	Front approach, refrigerator on her front-right.	Front approach, refrigerator on his front-right.	Front approach, the refrigerator on her front-right.	Front approach, the refrigerator on his left side It is easy for him to approach the refrigerator and to use his left hand.	Backward approach, refrigerator on her front-left. This approach allows her to use her left hand better.
How does the subject carry the food to the sink?	Pushes the bowl on the countertop. Because there is a continuous countertop from the refrigerator to the sink.	On legs	Pushes the bowl on the countertop. Because there is a continuous countertop from the refrigerator to the sink.	On legs	On legs	On legs	On legs	Pushes the bowl on the countertop.	On legs	She holds the bowl in hands, some times puts the bowl on countertop and drags it; moves backward.	On legs	She drags the bowl along the countertop to sink.
Is it easy for them to move from the refrigerator to sink? (Choices: very difficult, difficult, moderate, easy, very easy)	Moderate	Easy	Easy	Moderate	Moderate	Moderate	Easy	Moderate	Moderate	Moderate	Moderate	Moderate
How does the subject feel about the sink? (Choices: very difficult, difficult, moderate, easy, very easy)	Easy	Easy	Easy	Easy	Easy	Easy	Moderate	Easy	Easy	Easy	Easy	Easy
How does the subject feel about the pullout countertop? (Choices: very bad, bad, moderate, good, very good)	Good	Very good	Good	Good	Good	Good	Very good	Good	Good	Moderate The pull-out countertop is unnecessary because it is too low for her.	Very good	Very good

How does the subject feel about the cooker? (Choices: very bad, bad, moderate, good, very good)	Good	Good	Good	Good	Very good	Good	Good	Good	Good	Good	Very good	Good
How does the subject feel about the height of the ventilation hood? (Choices: very bad, bad, moderate, good, very good)	Very good	Good	Very good	Good	Very good	Very good	Good (it will be very good if the switches are on the countertop)	Good	Good	Very good	Very good	Very good
Does the subject think the space is adequate? (Choices: very inadequate, inadequate, just adequate, adequate, very adequate)	Adequate	Just adequate	Just adequate	Just adequate	Just adequate	Just adequate	Adequate	Just adequate	Adequate	Just adequate	Adequate	Just adequate

Kitchen M1, Scenario 2.

Questions	1. Mr. Yusoff	2. Ms. Chun	3. Mr. Foo	4. Ms. Ng	5. Mr. Low	6. Ms. Bao Lin	7. Mr. Wee	8. Ms. Jennies	9. Mr. Salaam	10.Ms. Sabiah	11. Mr. Yow	12. Ms. Edel
Which approaching method to the microwave oven is easier for the subject?	Front approach, the microwave oven on his front-left.	Backward approach, the microwave oven on her right side.	Backward approach, the microwave oven on his right side.	Backward approach, the microwave oven on her right side.	It is the same from either side. He can use both hands.	Backward approach, microwave oven on her right side. Because the door of the microwave oven blocks her left arm if the microwave oven is on her left side.	Backward approach, microwave oven on his right side. Because he can see inside the microwave oven.	Front approach, the microwave oven on her left side.	Backward approach, the microwave oven on his right side. He can use his right hand better.	Backward approach, the microwave oven on her right side.	Front approach, the microwave oven on his left side. He can use his left hand better.	Front approach, the microwave oven on her front-left.
From which appliance does the subject often get the food?	Refrigerator	Sink	Refrigerator	Sink	Refrigerator	Refrigerator	Refrigerator	Sink	Sink	Refrigerator	Refrigerator	Refrigerator
Which countertop does the subject put the bowl on after he/she gets it out of the microwave oven? Why?	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.
How does the subject feel about the door of the microwave oven? (Choices: very bad, bad, moderate, good, very good)	Bad, because he must move the food around the door to the countertop.	Moderate	Bad, because he must move the food around the door to the countertop.	Moderate	Moderate. If the door is top hinged or bottom hinged, it will be much better.	Bad, because she must move the food around the door to the countertop.	Good. If the door is top hinged or bottom hinged, it will be much better.	Moderate	Moderate	Good, because she prefers this door type because she has used this type for many years.	Bad, because he must move the food around the door to the countertop.	Bad, because she must move food around the door to the countertop near the sink
Does the subject use the pull-out countertop?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
How does the subject feel about the pull-out countertop? (Choices: very bad, bad, moderate, good, very good)	Good	Good	Good	Good	Good	Very good	Very good	Good	Good	Good. Because the bowl can be put on the countertop when opening and closing the microwave oven's door.	Good	Good. It is safer when getting hot bowl out of the microwave oven.

Kitchen M1, Scenario 3.

Questions	1. Mr. Yusoff	2. Ms. Chun	3. Mr. Foo	4. Ms. Ng	5. Mr. Low	6. Ms. Bao Lin	7. Mr. Wee	8. Ms. Jennies	9. Mr. Salaam	10.Ms. Sabiah	11. Mr. Yow	12. Ms. Edel
(For the cabinet near the cooker) which method is easier for the subject to approach the cabinet?	Front approach, cabinet on his left.	Front approach, cabinet on her left.	Front approach, cabinet on his left.	Front approach, cabinet on her left.	Front approach, cabinet on his left.	Front approach, cabinet in front of her.	Front approach, cabinet on his left.	Front approach, cabinet on her left.	Front approach, cabinet in front of him.	Front approach, cabinet in front of her.	Front approach, cabinet on his left.	Front approach, cabinet on her left.
(For the cabinet near the cooker) is it easy for the subject to pick objects from the drawers? (Choices: very difficult, difficult, moderate, easy, very easy)	For the lowest drawer, moderate; For the higher drawers, very easy.	For the lowest drawer, moderate; For the higher drawers, very easy.	For the lowest drawer, very difficult; For the higher drawers, easy.	For the lowest drawer, very difficult; For the higher drawers, easy.	For the lowest drawer, difficult; For the higher drawers easy.	For the lowest drawer, difficult; For the higher drawers, moderate.	For the lowest drawer, moderate; For the higher drawers, easy.	For the lowest drawer, difficult; For the higher drawers, easy.	For the lowest drawer, difficult; For the higher drawers, easy.	For the lowest drawer, difficult; For the higher drawers, moderate.	For the lowest drawer, difficult; For the higher drawers, easy.	For the lowest drawer, difficult; For the higher drawers, easy.
(For the cabinet near the cooker) how does the subject comment on the knee space beside?	The knee space beside the cabinet makes it easier for him to open the drawers because he can get closer to the cabinet. The wheelchair doesn't block the drawers.	The knee space beside the cabinet makes it easier for her to open the drawers.	The knee space beside the cabinet makes it easier for him to open the drawers because he can get closer to the cabinet. The wheelchair doesn't block the drawers.	The knee space beside the cabinet makes it easier for him to open the drawers.	The knee space beside the cabinet makes it easier for him to open the drawers.	She doesn't use the knee space because if she drives her wheelchair into the knee space, she must bend left to open the drawers. Because of her pain in the waist, she is unable to do so.	The knee space is good for him to open the drawers.	The knee space beside the cabinet makes it easier for her to open the drawers because she can get closer to the cabinet.	He doesn't use the knee space because he uses his right hand to get items.	She doesn't use the knee space because she uses the right hand to fetch items. If the knee space is on the left side of the cabinet, she will use the knee space.	The knee space beside the cabinet makes it easier for him to open the drawers because he can get closer to the cabinet. The wheelchair doesn't block the drawers.	The knee space is good for her because she can get closer to the cabinet and use her left hand to open the drawers and get items.
(For the rotating cabinet near the refrigerator) is it easy for the subject to pick objects from the shelves? (Choices: very difficult, difficult, moderate, easy, very easy)	Moderate for the lowest shelf; Very easy for the higher shelves.	Moderate for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Easy for the higher shelves.	Moderate for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Very Difficult for the lowest shelf; easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Moderate for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.
(For the rotating cabinet near the refrigerator) which approaching method is easier for the subject?	approaching it on its left	approaching it on its left	approaching it on its left	approaching it on its left	approaching it on its left	approaching it on its left	approaching it on its left	approaching it on its left	approaching it on its right	approaching it on its right	approaching it on its left	approaching it on its left
How does the subject feel about the rotating cabinet? (Choices: very bad, bad, moderate, good, very good)	Very good	Good	Good	Good	Very good.	Very good.	Very good.	Good	Good	Good	Very good.	Very good
(For the wall cabinet) is it easy for the subject to pick objects from the shelves? (Choices: very difficult, difficult, moderate, easy, very easy)	Easy to get objects from the lowest shelf. Difficult to get objects from the upper shelf.	Easy to get objects from the lowest shelf. Difficult to get objects from the upper shelf.	Very difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Very difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Moderate to get objects from the lowest shelf. The upper shelf cannot be reached.	Easy to get objects from the lowest shelf. The upper shelf cannot be reached.	Difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Moderate to get objects from the lowest shelf. The upper shelf cannot be reached.	Difficult to get objects from the lowest shelf. The upper shelf cannot be reached.
How does the subject feel about the wall cabinet? (Choices: very bad, bad, moderate, good, very good)	Good	Moderate	Bad	Bad	Moderate	Good	Bad	Bad	Bad	Bad	Moderate	Bad

Does the subject want the wall cabinet installed in his/her kitchen? Why?	Yes, because more items can be stored and the kitchen looks tidy.	No, because it is difficult to use and wastes money.	No, because it is difficult to use and wastes money.	No, because it is difficult to use and wastes money.	No, because it has no much use and wastes money.	Yes, because more items can be stored.	No, because it is difficult to use.	No, because it is difficult to use; waste money.	No, because it is difficult to use and wastes money.	No, because it is difficult to use.	No, because it is difficult to use and wastes money.	No, because it is difficult to use and wastes money.
Does the subject think the storage is adequate? (Choices: very inadequate, inadequate, Just adequate, adequate, very adequate)	Adequate	Adequate	Just adequate	Just adequate	Adequate	Just adequate	Just adequate	Just adequate	Just adequate	Just adequate	Inadequate	Just adequate

Kitchen M1, Scenario 4.

Questions	1. Mr. Yusoff	2. Ms. Chun	3. Mr. Foo	4. Ms. Ng	5. Mr. Low	6. Ms. Bao Lin	7. Mr. Wee	8. Ms. Jennies	9. Mr. Salaam	10.Ms. Sabiah	11. Mr. Yow	12. Ms. Edel
Which method to approach the washing machine is easier for the subject? Why?	Front approach, the washing machine on his front-right.	Front approach, the washing machine on her right.	Front approach, the washing machine on his right.	Front approach, the washing machine on her right.	Front approach, the washing machine on his front-right.	Front approach, the washing machine on her right.	Front approach, the washing machine on his front-right.	Front approach, the washing machine on her right.	Front approach, the washing machine on his right.	Front approach, the washing machine in front of her.	Front approach, the washing machine on his left.	Front approach, the washing machine on her front-left.
How does the subject feel about the location of the washing machine? (Choices: very bad, bad, moderate, good, very good)	Moderate	Moderate	Bad	Moderate	Moderate If it is near the bathroom it will be better.	Moderate	Moderate	Moderate	Moderate	Good	Good, because the location is convenient for him to approach.	Moderate
How does the subject feel about the height of the washing machine? (Choices: very bed, bad, moderate, good, very good)	Bad	Bad	Very Bad	Bad	Moderate	Bad	Bad	Bad	Bad	Bad	Moderate	Bad Because it is too low.
Where does the subject prefer the clothes pole to be?	Just on his front-left when he sits at the washing machine.	Just on her front-left when she sits at the washing machine.	Just on his front-left when he sits at the washing machine.	Just on her front-left when she sits at the washing machine.	Just on his font-left when he sits at the washing machine.	Just on her left when she sits at the washing machine.	Just on his font-left when he sits at the washing machine.	Just on her front-left when she sits at the washing machine.	Just on his front-left when he sits at the washing machine.	Just on her right when she sits at the washing machine.	Just on his font-right when he sits at the washing machine.	Just on her font-right when she sits at the washing machine.

Kitchen M1m1

Questions	1. Mr. Yusoff	2. Ms. Chun	3. Mr. Foo	4. Ms. Ng	5. Mr. Low	6. Ms. Bao Lin	7. Mr. Wee	8. Ms. Jennies	9. Mr. Salaam	10.Ms. Sabiah	11. Mr. Yow	12. Ms. Edel
Is the refrigerator easier to approach when the knee space is provided beside it? Why?	Yes, because he can get closer to the refrigerator to open the door. And there is more space available to adjust the wheelchair.	Yes, because she can get closer to the refrigerator to open the door.	Yes, because he can get closer to the refrigerator to open the door.	Yes, she can get the object from the refrigerator while sitting in the knee space without further adjustment.	Yes, because there is more space available to adjust the wheelchair.	Yes, because she can get closer to the refrigerator to open the door.	Yes, because he can get closer to the refrigerator to open the door.	Yes, she can get the object from the refrigerator while sitting in the knee space without further adjustment.	Yes, he can get the object from the refrigerator while sitting in the knee space without further adjustment.	Yes, because she can get closer to the refrigerator to open the door.	There is no much difference because he approaches the refrigerator sideways and the refrigerator is on his left. He doesn't use the knee space.	No, because she prefers to open the refrigerator and get items with left hand.
Is the microwave oven easier to use? Why?	Yes, it is easier to be used because he can sit facing the microwave.	Yes, it is easier to be used because she can sit facing the microwave.	Yes, it is easier to be used because he can sit facing the microwave.	Yes, it is easier to be used because she can sit facing the microwave.	Yes, it is easier to be used because he can sit facing the microwave.	Yes, it is easier to be used because she can sit facing the microwave.	Yes, it is easier to be used because he can sit facing the microwave.	Yes, it is easier to be used because she can sit facing the microwave.	Yes, it is easier to be used because he can sit facing the microwave.	Yes, it is easier to be used because she can sit facing the microwave.	Yes, it is easier to be used because he can sit facing the microwave.	Yes, it is easier to be used because she can sit facing the microwave.
Is the washing machine easier to use when it is raised up?	Yes	Yes	Yes	Yes	Yes, it is much easier	Yes	Yes	Yes	Yes	Yes	Yes, much better.	Yes, much better
How dose the subject approach the washing machine?	Backward approach, washing machine on his right.	Frontward approach, washing machine on her left.	Backward approach, washing machine on his right.	Frontward approach, washing machine on her left.	Frontward approach, washing machine on his left.	Frontward approach, washing machine on her left.	Frontward approach, washing machine on his left.	Frontward approach, washing machine on her left.	Backward approach, washing machine on his right.	Backward approach, washing machine on her right.	Frontward approach, washing machine on his left.	Frontward approach, washing machine on her left.
Is the washing machine put at the corner easy to access? (Choices: very difficult, difficult, moderate, easy, very easy)	Easy	Easy	Moderate	Easy	Easy	Easy	Easy	Easy	Moderate	Moderate	Easy	Easy
How does the subject feel about the location of the washing machine? (Choices: very bad, bad, moderate, good, very good)	Good	Good	Good	Good	Good	Good	Moderate	Bad	Good	Moderate	Moderate	Bad
Does the subject think the present storage is adequate? (Choices: very inadequate, inadequate, just adequate, adequate, very adequate)	Just adequate	Inadequate	Inadequate	Inadequate	Just adequate for one person, inadequate for a big family.	Inadequate	Inadequate	Inadequate	Inadequate	Very inadequate	Very inadequate	Very inadequate

Kitchen M2 (the narrowest one)

Kitchen M2, Scenario 1.

Questions	1. Mr. Yusoff	2. Ms. Chun	3. Mr. Foo	4. Ms. Ng	5. Mr. Low	6. Ms. Bao Lin	7. Mr. Wee	8. Ms. Jennies	9. Mr. Salaam	10.Ms. Sabiah	11. Mr. Yow	12. Ms. Edel
(For the refrigerator) which approaching method is easier for the subject? Why?	Front approach, refrigerator on his front-right.	Front approach, the refrigerator on her front-right.	Front approach, the refrigerator on his front-right.	Front approach, the refrigerator on her front-right.	Front approach, the refrigerator on his left side. It is easy to approach the refrigerator and adjust the wheelchair.	Front approach, the refrigerator on her left side It is easy for her to open the door and get items.	Front approach, the refrigerator on his left side. It is easy for him to open the door and get items.	Front approach, the refrigerator on her front-right.	Front approach, the refrigerator on his front-right.	Front approach, the refrigerator on her front-right.	Front approach, the refrigerator on his left side. It is easy for him to approach the refrigerator and to use his left hand.	Backward approach, Refrigerator on her front-left. This approach allows her to use her left hand better.
How does the subject carry the food to the sink?	Pushes bowl on the countertop. Because there is a continuous countertop from the refrigerator to the sink.	On legs	Pushes bowl on the countertop.	On legs	On legs	On legs	On legs	Pushes bowl on the countertop.	On legs	She holds the bowl in hands, some times puts the bowl on countertop and drags it; moves backward.	On legs	She drags the bowl along the countertop to sink.
Is it easy for the subject to move from the refrigerator to sink? (Choices: very difficult, difficult, moderate, easy, very easy)	Difficult	Moderate	Moderate	Difficult	Difficult	Difficult	Moderate	Difficult	Difficult	Very difficult	Difficult	Very difficult
How does the subject feel about the sink? (Choices: very difficult, difficult, moderate, easy, very easy)	Easy	Easy	Easy	Easy	Easy	Easy	Moderate	Easy	Easy	Easy	Easy	Easy
How does the subject feel that there is no pull-out countertop between the sink and cooker? (Choices: very bad, bad, moderate, good, very good)	Moderate	Bed	Moderate	Bed	Bad	Moderate	Bad	Bad	Bad	Moderate	Bad	Bad
How does the subject feel about the cooker? (Choices: very bad, bad, moderate, good, very good)	Good	Good	Good	Good	Very good	Good	Good	Good	Good	Good	Very good	Good
How does the subject feel about the height of the ventilation hood? (Choices: very bad, bad, moderate, good, very good)	Very good	Good	Very good	Good	Very good	Very good	Good (it will be very good if the switches are on the countertop)	Good	Good	Very good	Very good	Very good

Does the subject think the space is adequate? (Choices: very inadequate, inadequate, just adequate, adequate, very adequate)	Just adequate, uncomfortable to turn.	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate	Just adequate	Inadequate	Inadequate	Inadequate	Inadequate	Inadequate

Kitchen M2, Scenario 2.

Questions	1. Mr. Yusoff	2. Ms. Chun	3. Mr. Foo	4. Ms. Ng	5. Mr. Low	6. Ms. Bao Lin	7. Mr. Wee	8. Ms. Jennies	9. Mr. Salaam	10.Ms. Sabiah	11. Mr. Yow	12. Ms. Edel
Which approaching method to the microwave oven is easier for the subject?	Front approach, the microwave oven on his front-left.	Backward approach, the microwave oven on her right side.	Backward approach, the microwave oven on his right side.	Backward approach, the microwave oven on her right side.	It is the same from either side. He can use both hands.	Backward approach, microwave oven on her right side. The door of the microwave oven blocks her left arm if the microwave oven is one her left side.	Backward approach, microwave oven on his right side. Because he can see inside the microwave oven. It is easy for him to get items from the microwave oven.	Front approach, the microwave oven on her left side.	Backward approach, the microwave oven on his right side.	Backward approach, the microwave oven on her right side.	Front approach, the microwave oven on his left side.	Front approach, the microwave oven on her front-left.
From which appliance does the subject usually get the food?	Refrigerator	Sink	Refrigerator	Sink	Refrigerator	Refrigerator	Refrigerator	Sink	Sink	Refrigerator	Refrigerator	Refrigerator
Which countertop does the subject put the bowl on after he/she gets it out of the microwave oven? Why?	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.	The countertop near the sink. This is the only choice in this plan.
How does the subject feel about the door of the microwave oven? (Choices: very bad, bad, moderate, good, very good)	Bad, because he must carry the food around the door to the countertop.	Moderate	Bad, because he must move the food around the door to the countertop.	Moderate	Moderate. If the door is top hinged or bottom hinged, it will be much better.	Bad, because she must carry the food around the door to the countertop.	Good. If the door is top hinged or bottom hinged, it will be much better.	Moderate	Moderate	Good	Bad, because he must carry the food around the door to the countertop.	Bad, She must move food around the door to the countertop near the sink
Does the subject use the pull-out countertop?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
How does the subject feel about the pull-out countertop? (Choices: very bad, bad, moderate, good, very good)	Good	Good	Good	Good	Good	Very good	Very good	Good	Good	Good. Because it is safer.	Good	Good.

Kitchen M2, Scenario 3.

Questions	1. Mr. Yusoff	2. Ms. Chun	3. Mr. Foo	4. Ms. Ng	5. Mr. Low	6. Ms. Bao Lin	7. Mr. Wee	8. Ms. Jennies	9. Mr. Salaam	10.Ms. Sabiah	11. Mr. Yow	12. Ms. Edel
(For the cabinet near the cooker) which method is easier for the subject to approach the cabinet?	Front approach, cabinet on his left.	Front approach, cabinet on her left.	Front approach, cabinet on his left.	Front approach, cabinet on her left.	Front approach, cabinet on his left.	Front approach, cabinet in front of her.	Front approach, cabinet on his left.	Front approach, cabinet on her left.	Front approach, cabinet in front of him.	Front approach, cabinet in front of her.	Front approach, cabinet on his left.	Front approach, cabinet on her left.
(For the cabinet near the cooker) is it easy for the subject to pick objects from the drawers? (Choices: very difficult, difficult, moderate, easy, very easy)	For the lowest drawer, moderate; For the higher drawers, very easy.	For the lowest drawer, moderate; For the higher drawers, very easy.	For the lowest drawer, very difficult; For the higher drawers, easy.	For the lowest drawer, very difficult; For the higher drawers, easy.	For the lowest drawer, difficult; For the higher drawers easy.	For the lowest drawer, difficult; For the higher drawers, moderate.	For the lowest drawer, difficult; For the higher drawers, easy.	For the lowest drawer, difficult; For the higher drawers, easy.	For the lowest drawer, difficult; For the higher drawers, easy.	For the lowest drawer, difficult; For the higher drawers, moderate.	For the lowest drawer, difficult; For the higher drawers, easy.	For the lowest drawer, difficult; For the higher drawers, easy.
(For the cabinet near the cooker) how does the subject comment on the knee space beside?	The knee space beside the cabinet makes it easier for him to open the drawers because he can get closer to the cabinet. The wheelchair doesn't block the drawers.	The knee space beside the cabinet makes it easier for her to open the drawers.	The knee space beside the cabinet makes it easier for him to open the drawers because he can get closer to the cabinet. The wheelchair doesn't block the drawers.	The knee space beside the cabinet makes it easier for her to open the drawers.	The knee space beside the cabinet makes it easier for him to open the drawers because he can get closer to the cabinet.	She doesn't use the knee space because if she drives her wheelchair into the knee space, she must bend left to open the drawers. Because of her pain in the waist, she is unable to do so.	The knee space is good for him to open the drawers.	The knee space beside the cabinet makes it easier for her to open the drawers because she can get closer to the cabinet.	He doesn't use the knee space because he uses his right hand to get items.	She doesn't use the knee space because she uses the right hand to fetch items. If the knee space is on the left side of the cabinet, she will use the knee space.	The knee space beside the cabinet makes it easier for him to open the drawers because he can get closer to the cabinet. The wheelchair doesn't block the drawers.	The knee space is good for her because she can get closer to the cabinet and use her left hand to open the drawers and get items.
(For the rotating cabinet near the refrigerator) which approaching method is easier for the subject?	approaching it on its left	approaching it on its left	approaching it on its left	approaching it on its left	approaching it on its left	approaching it on its left	approaching it on its left	approaching it on its left	approaching it on its right	approaching it on its right	approaching it on its left	approaching it on its left
(For the rotating cabinet near the refrigerator) is it easy for the subject to pick objects from the shelves? (Choices: Very difficult, difficult, moderate, easy, very easy)	Moderate for the lowest shelf; Very easy for the higher shelves.	Moderate for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Easy for the higher shelves.	Moderate for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Very Difficult for the lowest shelf; easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.	Moderate for the lowest shelf; Very easy for the higher shelves.	Difficult for the lowest shelf; Very easy for the higher shelves.
How does the subject feel about the rotating cabinet? (Choices: very bad, bad, moderate, good, very good)	Very good	Good	Good	Good	Very good.	Very good.	Very good.	Good	Good	Good	Very good.	Very good
(For the wall cabinet) is it easy for the subject to pick objects from the shelves? (Choices: very difficult, difficult, moderate, easy, very easy)	Easy to get objects from the lowest shelf. Difficult to get objects from the upper shelf	Easy to get objects from the lowest shelf. Difficult to get objects from the upper shelf.	Very difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Very difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Moderate to get objects from the lowest shelf. The upper shelf cannot be reached.	Easy to get objects from the lowest shelf. The upper shelf cannot be reached.	Difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Difficult to get objects from the lowest shelf. The upper shelf cannot be reached.	Moderate to get objects from the lowest shelf. The upper shelf cannot be reached.	Difficult to get objects from the lowest shelf. The upper shelf cannot be reached.

How does the subject feel about the wall cabinet? (Choices: Very bad, bad, moderate, good, very good)	Good	Moderate	Bad	Bad	Moderate	Good	Bad	Bad	Bad	Bad	Moderate	Bad
Does the subject want the wall cabinet installed in his/her kitchen? Why?	Yes, because more items can be stored and the kitchen looks tidy.	No, because it is difficult to use and wastes money.	No, because it is difficult to use and wastes money.	No, because it is difficult to use and wastes money.	No, because it has no much use and wastes money.	Yes, because she can store more items.	No, because it is difficult to use.	No, because it is difficult to use and wastes money.	No, because it is difficult to use.	No, because it is difficult to use.	Yes, because more items can be stored.	No, because it is difficult to use.
Does the subject think the storage is adequate? (Choices: very inadequate, inadequate, just adequate, adequate, very adequate)	Adequate	Adequate	Just adequate	Just adequate	Adequate	Just adequate	Just adequate	Just adequate	Just adequate	Just adequate	Inadequate	Just adequate

Kitchen M2, Scenario 4.

Questions	1. Mr. Yusoff	2. Ms. Chun	3. Mr. Foo	4. Ms. Ng	5. Mr. Low	6. Ms. Bao Lin	7. Mr. Wee	8. Ms. Jennies	9. Mr. Salaam	10.Ms. Sabiah	11. Mr. Yow	12. Ms. Edel
Which method is easier for the subject to approach the washing machine? Why?	Front approach, the washing machine on his front-right.	Front approach, the washing machine on her right.	Front approach, the washing machine on his right.	Front approach, the washing machine on her right.	Front approach, the washing machine on his front-right.	Front approach, the washing machine in front of her.	Front approach, the washing machine on his front-right.	Front approach, the washing machine on her right.	Front approach, the washing machine on the right.	Front approach, the washing machine in front of her.	Front approach, the washing machine on his left.	Front approach, the washing machine on her front-left.
How does the subject feel about the location of the washing machine? (Choices: Very bad, bad, moderate, good, very good)	Moderate	Moderate	Bad	Moderate	Moderate If it is near the bathroom it will be better.	Moderate	Moderate	Moderate	Moderate	Good	Good, because the location is convenient for him to approach.	Moderate
How does the subject feel about the height of the washing machine? (Choices: very bed, bad, moderate, good, very good)	Bad	Bad	Very Bad	Bad	Moderate	Bad	Bad	Bad	Bad	Bad	Moderate	Bad
Where does the subject prefer the clothes pole to be?	Just on his front-left when he sits at the washing machine.	Just on her front-left when she sits at the washing machine.	Just on his front-left when he sits at the washing machine.	Just on her front-left when she sits at the washing machine.	Just on his font-left when he sits at the washing machine.	Just on her left when she sits at the washing machine.	Just on his font-left when he sits at the washing machine.	Just on her front-left when she sits at the washing machine.	Just on his front-left when he sits at the washing machine.	Just on her right when she sits at the washing machine.	Just on his font-right when he sits at the washing machine.	Just on her font-right when she sits at the washing machine.

Kitchen M2m1

Questions	1. Mr. Yusoff	2. Ms. Chun	3. Mr. Foo	4. Ms. Ng	5. Mr. Low	6. Ms. Bao Lin	7. Mr. Wee	8. Ms. Jennies	9. Mr. Salaam	10.Ms. Sabiah	11. Mr. Yow	12. Ms. Edel
Is the refrigerator easier to approach when the knee space is provided beside it? Why?	Yes, because he can get closer to the refrigerator to open the door. And there is more space available to adjust the wheelchair.	Yes, because she can get closer to the refrigerator to open the door.	Yes, because he can get closer to the refrigerator to open the door.	Yes, she can get the object from the refrigerator while sitting in the knee space without further adjustment.	Yes, because there is more space available to adjust the wheelchair.	Yes, because she can get closer to the refrigerator to open the door.	Yes, because he can get closer to the refrigerator to open the door.	Yes, she can get the object from the refrigerator while sitting in the knee space without further adjustment.	Yes, he can get the object from the refrigerator while sitting in the knee space without further adjustment.	Yes, because she can get closer to the refrigerator to open the door.	There is no much difference for him because he approaches the refrigerator sideways and the refrigerator is on his left. He doesn't use the knee space.	No, because she prefers to open the refrigerator and get items with the left hand.
Is the microwave oven easier to use? Why?	Yes, it is easier to use because he can sit facing the microwave.	Yes, it is easier to use because she can sit facing the microwave.	Yes, it is easier to use because he can sit facing the microwave.	Yes, it is easier to use because she can sit facing the microwave.	Yes, it is easier to use because he can sit facing the microwave.	Yes, it is easier to use because she can sit facing the microwave.	Yes, it is easier to use because he can sit facing the microwave.	Yes, it is easier to use because she can sit facing the microwave.	Yes, it is easier to use because he can sit facing the microwave.	Yes, it is easier to use because she can sit facing the microwave.	Yes, it is easier to use because he can sit facing the microwave.	Yes, it is easier to use because she can sit facing the microwave.
Is the washing machine easier to use when it is raised up?	Yes	Yes	Yes	Yes	Yes, it is much easier	Yes, it is much easier.	Yes	Yes	Yes	Yes	Yes	Yes
How dose the subject approach the washing machine?	Backward approach, washing machine on his right.	Frontward approach, washing machine on her left.	Backward approach, washing machine on his right.	Frontward approach, washing machine on her left.	Frontward approach, washing machine on his left.	Frontward approach, washing machine on her left.	Frontward approach, washing machine on his left.	Frontward approach, washing machine on her left.	Backward approach, washing machine on his right.	Backward approach, washing machine on her right.	Frontward approach, washing machine on his left.	Frontward approach, washing machine on her left.
Is the washing machine put at the corner easy to access? (Choices: very difficult, difficult, moderate, easy, very easy)	Easy	Easy	Moderate	Easy	Easy	Easy	Easy	Easy	Moderate	Moderate	Easy	Easy
Dose the subject think the present storage is adequate? (Choices: very inadequate, inadequate, just adequate, adequate, very adequate)	Just adequate	Inadequate	Inadequate	Inadequate	Just adequate for one person, inadequate for a big family.	Inadequate	Inadequate	Inadequate	Inadequate	Very inadequate	Very inadequate	Very inadequate