Initial research

Finding the problem

After deciding that we wanted to design a product to help wheelchair users we researched into potential problems faced by a disabled user. This revealed that wheelchair users who live fairly independently find it hard to take out the rubbish. This is because you need two hands to push a wheel chair so it is hard to push it whilst carrying a bin or bag, plus few people want to rest their rubbish on their laps.

The following videos on YouTube demonstrated the struggle wheelchair users face when taking out the waste:
d72466fly (2011) https://www.youtube.com/watch?v=wRZp68q3nN0
d72466fly (2012) https://www.youtube.com/watch?v=8yQ2DlOUeNQ
d72466fly (2014) https://www.youtube.com/watch?v=dF31TN6xXW8
Living Able (2014) https://www.youtube.com/watch?v=rK0fcw2BdLI

Some of these videos focus on taking the wheelie bin to the front of the house, while others such as d72466fly (2014) and Living Able (2014) focus on taking the rubbish from the smaller inside bins to the wheelie bin or dumpster outside. We decided this is what we should focus on first.

Pulling heavy bin with 1 arm leaning to reach.
d72466fly (2011)

d72466fly (2012)
You have little control over wheelchair when using 1 hand to push

Living Able (2014)
To move a waste bag one of the best options this user found was to push it in a cardboard box.

House dimensions

The solution will have to easily fit through doorways and be able to turn within the turning circle of the house in order to be usable. We decided to research into the widths of doorways in order to build up some width restrictions for our product, which would be stated in the design specification.

Doorway width

The width of external doors should have at least a 775mm clear opening *(Simon Polley. 2005)* or 32'' in some American states *(Kochera 2002)* however it is advised to be 800mm wide *(Harlow council 2011; Housing Review 2013).* Internal doorways onto hallways are more complex in their regulation so the information is presented below in a table. If the house has been designed for wheelchair users then the doors will probably be wider than this.

Internal dwelling doors	
Direction and width of approach	Minimum clear opening width (mm)
Straight-on (without a turn or oblique approach)	750
At right angles to a hallway / landing at least 1200mm wide	750
At right angles to a corridor / landing at least 1050mm wide	775
At right angles to a corridor / landing less than 1050mm wide (min. width 900mm)	900

Lifetimehomes (2010)

Turning circle

Turning space allowed in an entrance is likely to be between 1200widex900mm deep or 1500x1500mm if the house has been designed for the disabled *(Housing Review 2013).* Hallways and corridor space shouldn't be a worry as it is generally wider than doorways at 900mm to 1050 (or 1200 if an approach to a doorway) and all outdoor spaces will provide an outdoor turning space of 1500mm if designed to be usable by the disabled. *(Housing Review 2013).*

In the situation of a lobby or porch; ''the doors should be at least 1500mm apart and provide at least 1500mm clear space between door swings. The second door should also provide a minimum clear opening width of 800mm.'' *(Housing Review 2013).*

This indicates that in theory the worst case turning circle we need to design for is 1200x900, however if this is not possible then we need to aim for the tightest turning circle realistically possible.

Wheelchair Dimensions

If the product is to be fastened to a wheelchair then we need to have a good indication of the dimensions of the wheelchair.

Types of wheelchair

According to the UK wheelchairs website there are two main types of wheelchair: Standard Wheelchairs where the user can propel the wheelchair itself (Self Propelled wheelchair) and Transport Wheelchairs, where it must be pushed by a second person because it has smaller wheels. (UK Wheelchairs 2011)

Standard wheelchair

Leeprosthetic; standard wheelchair; Available at: http://leeprosthetic.com/cs-lp809.htmll; last accessed 10/11/2015

Transport wheelchair

Progressmobility; Bariatric Transport Chair
Avalible at:http://www.progressmobility.com/bariatric-transport-chair.html
Last accessed 10/11/2015

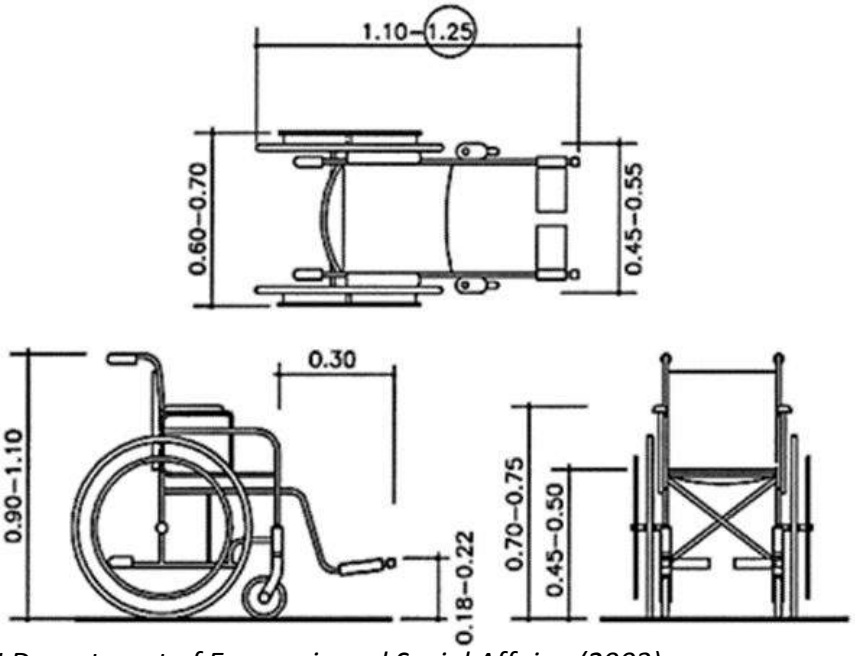
We have decided to design for the standard wheelchairs as we feel our product is aimed for more independent wheelchair users. The nature of the transport wheelchair means that you are required to have someone pushing you and so the user would be less independent.

Dimensions of wheelchairs

The seat height of a wheel chair depends on the user. According to UK wheelchairs it is ''determind by measuring the wheelchair user whilst sitting straight, the knees should be bent at a 90 degree angle. The measurement itself is taken from the heel to the bend in the knee.'' (UK Wheelchairs 2011)

This means the product will either have to work for the average dimensions of a wheelchair user, or be a bisque design focused on one specific user.

The image below shows the Average wheelchair dimensions according to the United nations' Secretariat for the Convention on the Rights of Persons with Disabilities



UN Department of Economic and Social Affairs. (2003)

''The ***wheelbase*** is defined as the distance from the casters to the drive wheels of the chair. The***track width*** is defined as the distance between the two drive wheels or the two casters of the chair at their contact points with the ground'' (Cooper, 1998, p. 37-38).

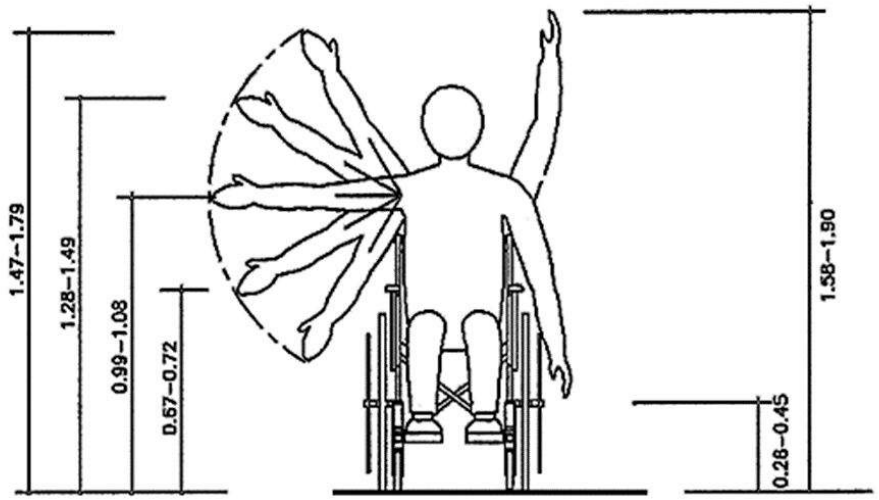
The distance of the ***wheelbase*** will determine the stability and maneuverability of a wheelchair. These two components, stability and maneuverability, are conversely related and the ideal distance will have to be found based on the needs of the person who uses the wheelchair. A larger wheelbase indicates a chair that is more stable, but with less maneuverability. Conversely a chair that maneuvers really easily has a smaller wheelbase, but the risk of instability rises *(Cooper, 1998, p. 38).*

The ***track width*** of the wheels of the wheelchair determines the stability of the chair. The wider or larger the track width, the more stable the chair. This is most important for manual wheelchairs *(Cooper, 1998, p. 37).*

Wheelchair reaching distances

The diagrams below, from the United nations' Secretariat for the Convention on the Rights of Persons with Disabilities, shows the average reaching distances of disabled users. This will be particularly useful since reaching the bin is one of the main issues our product must aim to address.

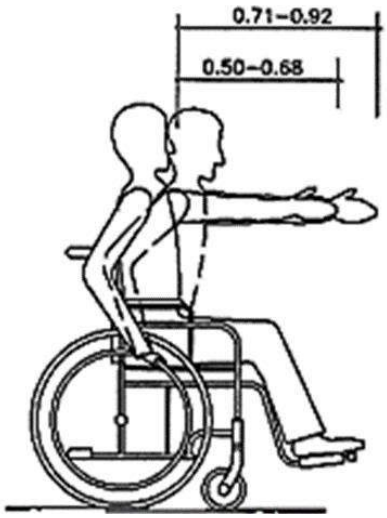
Vertical reaching zones of a wheelchair user



Horizontal forward reach of a wheelchair user (fig. 6)

Eye	1.16 m - 1.33 m
Shoulder	0.99 m - 1.14 m

All diagrams on this page are from: UN Department of Economic and Social Affairs. (2003). Accessibility for the Disabled - A Design Manual for a Barrier Free Environment. Available: http://www.un.org/esa/socdev/enable/designm/AD5-02.htm. Last accessed 08/11/2015.



These reach diagrams not only demonstrate part of the reason for taking the rubbish out being a hard problem, but also provide a good selection of information useful for the design into the ergonomics of our product.
For example if the product requires the user to push it then there must be a handle that is closer than 0.71m to the user.

Market

There is an existing market for helping disabled people live more independently, with many websites to provide advice on how to do this. (*NHS. 2014.; wikiHow 2015; SmartChair. n.d..*) There is also evidence of wheelchair users asking online for help to find houses in areas where they can live without extra help, but with easy access *(arogerskid. (2010)*. However the most related evidence is our user research (shown earlier in the report) and the YouTube videos we used to initially find the problem. *(d72466fly; (2011)d72466fly; (2012) d72466fly; (2014); Living Able (2014))*

To properly understand the scope and magnitude of the market, some calculations can be made to determine the size of it.

"Many live alone: 37 percent of cane and crutch users; 35% of walker users and 26% of wheelchair users." (Lezzoni, 2003, P183)

Less than 8 per cent of disabled people use wheelchairs.
Disability is strongly related to age

2.1 per cent of 16-19 year olds
31 per cent of 50-59 years;
78 per cent of people aged 85 or over

- People are more likely to become disabled if they have a low income, are out of work or have low educational qualification.
- There are around 1.2 million wheelchair users in the UK, roughly 2 per cent of UK population.
- Only 28 per cent of wheelchair users are under 60.

(Efds.co.uk, 2010)

As the population of the UK increases, so should the number of wheelchair users. Therefore using data from 2003 to find a percentage for a market percentage magnitude is not an issue.

Using data from 2003;
The market for wheelchair users that live alone is 26%, and the number of people who use wheelchairs in the UK is equal to 1.2 million - of which there was a population of 59.6 million in the UK in 2003 (Data.worldbank.org, 2003).

Therefore we can work out that the market share of this product in the UK is equal too;

26% of 1.2 million people = 312,000 people in the UK.

Existing wheelchair attachments

There is all ready a range of various wheelchair attachments. Researching into these will provide a potentially useful insight into how existing products attach themselves to the wheelchair. Some of these methods could be used for our product. This research is also useful in case an existing attachment could potentially interfere with how our product is attached or even used, knowing this we can try to avoid this problem when designing it.

	Product	Description	How/where it attaches to the wheelchair	Source	Cost
	Wheelchair anti-fold device (1800wheelchair, 1997)	A device that stops the wheelchair from folding up to prevent theft/loss	Screwed onto the bottom of the wheelchair	1800wheelchair.com	£25.63
	Freedom Trax (1800wheelchair, 1997)	A motorized wheelchair track attachment designed to transform a manual wheelchair into an off-road vehicle	Straps onto the wheels on manual wheelchairs	1800wheelchair.com	£3283
	Multi-mount drink holder (Quickiewheelchairs, 2015)	A bracket mounted to the wheelchair to allow the user to hold their drinks in the wheelchair	Screw fitted onto the wheelchair	quickie-wheelchairs.com	£24.30
	Wheelchair fishing pole holder (1800wheelchair, 1997)	A clamp that attaches to the wheelchair so it can hold a fishing rod in a suitable postion	Screw fitted onto the wheelchair	1800wheelchair.com	£30.20
	Wheelchair Umbrella (1800wheelchair, 1997)	An umbrella that attaches to the wheelchair to protect the user form rain and sunlight	Clamps to the wheelchair handle	1800wheelchair.com	£25.60

User Research:

One of first the things we did for primary research is email many local wheelchair societies, groups etc. such as, the NHS mobility centre, Disability direct, Red cross, Nottingham wheelchair blazers club, Nottingham wheelchair football association and the Nottingham wheelchair basketball club, to try and organise an interview with at least one independent wheelchair user. The email we sent said:

"Dear Sir or Madam,
I am writing to you because, I am a Bsc Product Design student at Nottingham Trent University and our group is working on a project for the company Demand which is a charity that designs products for disabled people. Our group is looking into how adults in wheelchairs take out their wheelie bins outside for collection and how we could help make process easier. I was wondering if one of our colleagues would be able to interview a few adults to get better understanding of their experience with moving wheelie bins outside and inserting their rubbish so we can create a concept (hopefully a model) that would be viable".

We managed to get a response from the Nottingham wheelchair basketball club and they said we could attend one of their training sessions to interview any independent wheelchair users. Before going to interview we prepared some questions to ask the users to further understand the problem and their perspective of the issue.

We proceeded with interviewing an independent wheelchair user, Aaron Martin on 6th November, we asked them the questions above and here is a summary of their responses:

1. "It's very difficult to move the wheelie bin independently, so I always ask a neighbor to help wheel it out for me"

2. "Normally I would have to pick up the bin in my hands and place it in front of my wheelchair then push if forward a short distance. When there are any corners I have to readjust the position of the bin and my wheelchair, continue pushing it forward and keep doing that until I get outside and reach the wheelie bin".

3. "The main obstacles are the furniture in my house, although the furniture is arranged in way that I can move around my house freely a lot more easily"

4. "Opening the wheelie bin isn't too difficult because it's a similar height to me sitting in the wheelchair but it is difficult to lift the dustbin and empty it into the wheelie bin or even remover the bag.

5. "You could possibly attach a lifting mechanism that makes it easier to pick up the dust bin and raise it so its easier to empty it in the wheelie bin, similar to a fork lift.

6. "A thing to keep in mind is that when I try and take the dustbin out, it take a long time because of the obstacles in my house, so a process of traversing my living space with more effectively to reduce the time of the process would be helpful

(Aaron Martin, 2015)

To expand on our primary research we got in contact the creator of the videos of the independent wheelchair user, John Wheelchair, via facebook. John graduated from the University of Arizona in 2001 with a degree in Material Science and Engineering. John (1992) had his accident when he

"fell 3 stories landed on my head on bricks 5/2/1992; got over 100 fractures in my skull;crushed my Lumbar Vertebrae 1;was in coma for around 2 & 1/2 months at UMC after accident;am paraplegic now;thought process slowed down from Traumatic Brain Injury". (Wheelchair, 1992, p.1)

We managed to get a hold of John and he said he would be happy to help us the project. Because John lives in Tucson, Arizona, it would be very expensive and time consuming to travel all the way there to physically interview him ourselves. Therefore John agreed to answer our interview questions via facebook which may be challenging due to the time difference of approximately six hours. We asked John the same questions we asked from the previous interview with the Nottingham wheelchair basketball club.

Below is the Facebook conversation Nathan had with John. The sections in blue are the questions we agreed to ask. The sections in white are John's responses.

"Dear John, I am writing to you because, I am a Bsc Product Design student at Nottingham Trent University in the UK and our group is working on a project for the company Demand which is a charity that designs products for disabled people. Our group is looking into how independent adults in wheelchairs take out their bins to the wheelie bin (dumpster) and how we could help make process easier. Our group seen a few you youtube videos and saw this as an issue. I was wondering if I could ask you a few questions to get better understanding of your experience with moving bins outside and putting the rubbish in the wheelie bin (dumpster) so we can create a concept (hopefully a model) that would be viable. Yours Faithfully Nathan Gibbons P.S our deadline is for 18th November so hopefully you could help us before then"

MON 5:38AM

"sounds interesting .. i would not mind answering some questions for You Nathan Gibbons"

MON 12:23PM

"Thank you for replying John. My first question is..... When it comes to bin collection days do you normally get some else to take the wheelie bin to the front of your house for you? e.g Next door neighbour, family member"

MON 11:24PM

"actually my Nephew (He lives with us right now) has been taking the wheelie bin to the front. If He can't though then i do or my Mother-In-Law (that also lives with us) takes the wheelie bin out front".

"When you are on your own how would describe your experience of carry your rubbish from the dustbin to the wheelie bin?"

"it takes a bit of time but not that bad .. hardest part is pushing the wheelie bin out to the front.
please look at my video: University of Arizona vs Utah Runnin' Utes - why Wildcats won - Taking out Trash - L1 injury 1-17-15
look at about 5:10 into the video
scratch the audio of course
also look at my video: Wheelchair style - Taking Out Trash To Street & Azucar Pissing - L1 injury 7-19-14"

"In the first video at about 11:40 you were taking out dustbin. Does your home environment have many obstacles to get past that make it difficult for you to take the bin out?"

5:09PM

"We keep most of our bins in the kitchen/dining area. There is a small utility room between the kitchen/dining area & the outside. At 11:40 in the video i'm going through the door that seperates the small utility room from the outside."

"Do you find it hard to put bin bags into the wheelie bin? e.g. reaching to lift/lower the bin lid to put rubbish in"

(John Wheelchair, 2015, wheelchairstyle)

Unfortunately, John didn't reply to the last question that we asked him for unknown reasons. Although, the videos he advised us to watch in the conversation gave us a better perspective of what its like for john in particular to take out the dustbin, in addition to the responses he gave us. Furthermore, we still had the full interview from the other independent wheelchair user in the Nottingham wheelchair basketball club, Aaron Martin, so we still had a solid amount of primary research to help develop our ideas.

Empathy research

In order to fully understand the difficulties people in wheelchairs go through on a daily basis we had to try and see from their perspective by doing empathetic research. This research is done by trying to imitate their circumstances and get a first-hand experience, this aids the design process by giving a better insight into what the problem is.
The aim of our research is to gain an understanding of how wheelchair users may struggle with the task of taking the rubbish from their dustbins to the wheelie bins outside. To do this we performed various scenarios in which a wheelchair user may take out their rubbish.

Control Test:

The control test was used to get an idea of how easy or difficult it is just simply move from one room to another. To give us the best results we decided to set up a 'track' for us to follow in each scenario, which involved going through tight doorways and spaces. Using tight doorways and spaces gave us the worst case scenario type of situation as trying to pull/push a dustbin through a doorway while trying to control a wheelchair is one of the biggest struggles.
During this test we timed how long it would take to get from one room to another in five separate tests, the times were then averaged to give the best representation. On average it took us 33 seconds, with some struggle of fitting through doors and turning through tight spaces, to finish the track we set out.
Even during this simple test without any added challenges of transporting rubbish there was some difficulty. The doorway was only just wider than what the wheelchair was and so required slower movement to navigate as to prevent damaging our knuckles on the door frame. The tight spaces also provided a challenge as we were required to continuously stop, reverse and change angle.






With a full Dustbin:

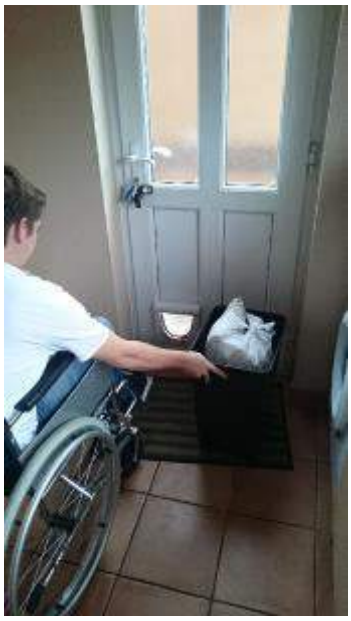
With this test we repeated the course, as done before, but in this case we tried to take a full dustbin with us. This allowed us to see how difficult it might be to pull or push a dustbin while controlling a wheelchair through tight doorways and spaces. Early on in this test we knew it was going to be a lot more challenging as the process of edging the dustbin forward every time you moved was very tedious and slow. The task only got harder as we went through the tight corners and gaps, the dustbin had to either be lifted over the obstacle or we left it behind and moved forward and the had to reach back and bring it through.

Compared to the quick time of 33 seconds for the control this test was a lot slower, averaging a time of 1 minutes 30 seconds, almost 3 times slower. In an attempt to achieve a quicker time for this test we tried to push, using the foot rests, the dustbin ahead of the wheelchair. This actually ended up in disaster because even if there was small amount of friction the dustbin would topple forward, emptying all its contents.







Trash Bag

There were actually two tests involved here, one where we pulled and pushed the bag along and the other where we attempted to hang the bag to the wheelchair.

Pushing/Pulling:

Again this test involved following the same 'course' as before and was timed to compare to previous tests.

To our surprise this test was in fact more difficult than pushing the dustbin along. This was because you have to be careful not to roll too close to the bag as it gets caught under the foot rest and may rip. This means that it is a lot easier to navigate with the trash bag alongside the wheelchair, although you are still forced to push the bag ahead of you when you go through doorways and tight spaces. To try and make this task easier we were going to try navigate the course with the bag on our lap but decided against it as we thought it to be too unhygienic.

Although this test felt a lot more difficult than previous tests it took the same time to complete as what the dustbin test did. On average it took 1 minutes 30 seconds to get from one room to another, which also included time where the bag was caught underneath the foot rests.











Carrying:

The first step of this test was to find somewhere on the wheelchair to hang the bag, which was difficult in itself. The only place where the bag could hang was on the handle bars but even then the bag was on the edge of the handle and always at risk of slipping off. Early into this test we knew that it was not going to be a suitable solution as the bag was always rubbing against the wheel, increasing chance of it ripping.

This was the easiest method of them all as there was no pushing or pulling, we just had to wheel along as normal. This meant we recorded an average time of 43 seconds, being slightly slower than just wheeling as normal. Although this was the easiest the cons heavily outweigh the pros as the risk of ripping the bag is not worth being it being easier.

Conclusion:

We have found from these tests that taking the trash out of the dustbin and taking it to the wheelie bin outside is not the best method. This is because it is not easy to pull or push along with you and cannot hang it on the wheelchair without risk of ripping it.

The obvious best solution is to the trash out while it is still in the dustbin and then once reaching the wheelie bin take the bag out. The process of pushing the dustbin is still quite difficult and tedious, taking a lot longer than it should to take the trash out. This process would be a lot better if there was a way of navigating the wheelchair with the dustbin attached to the bin. This attachment would have to be attached from the side, as its easier to reach from a wheelchair, and then possibly rotated to the front so the door frames are not in the way.

Product Specification

Through our research we have found key problems for wheelchair users when taking out the trash. In order to design a solution that meet all of these problems we must have a product specification to follow. This will not only help us design the best solution we can but also help our ideas follow a similar path.

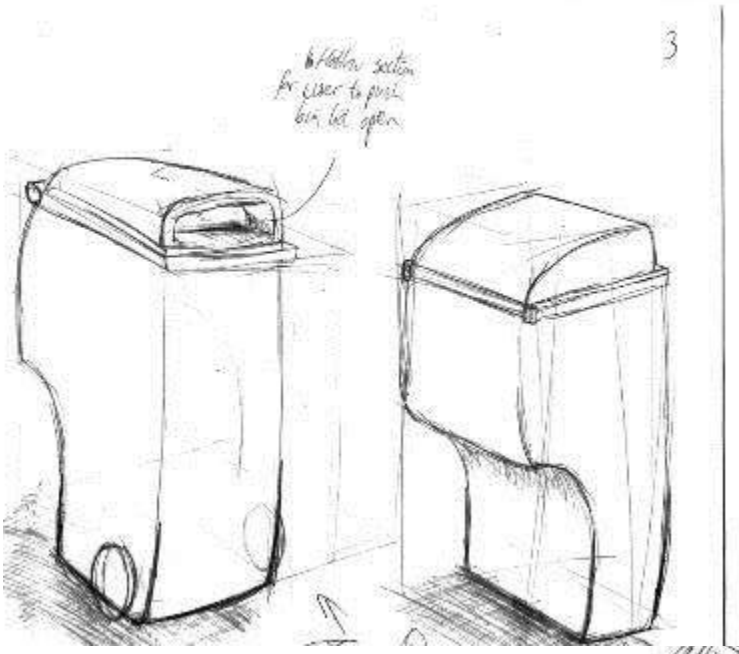
The key problems are:

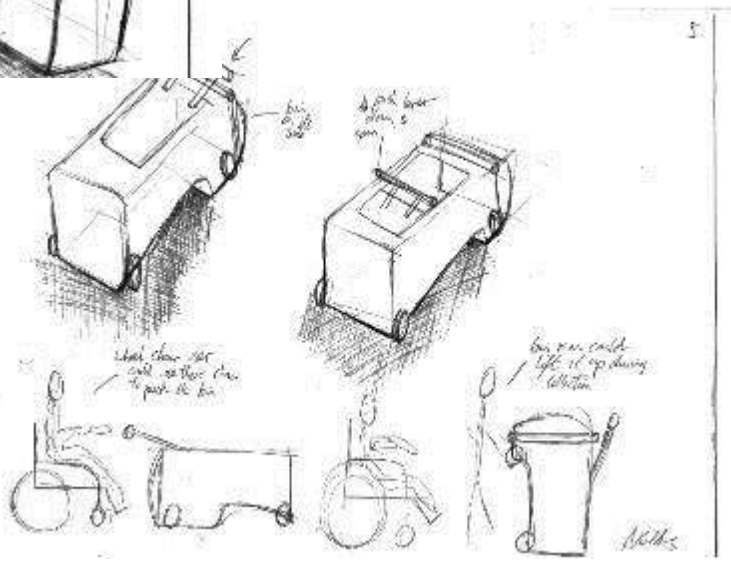
- Having complete control over wheelchair while carrying dustbin/trash bag
- Picking up and pushing dustbin/trash bag in front of wheelchair
- Fitting easily through doorways and tight spaces
- Getting the trash into the wheelie bin
- Hygiene when carrying bags of trash on lap

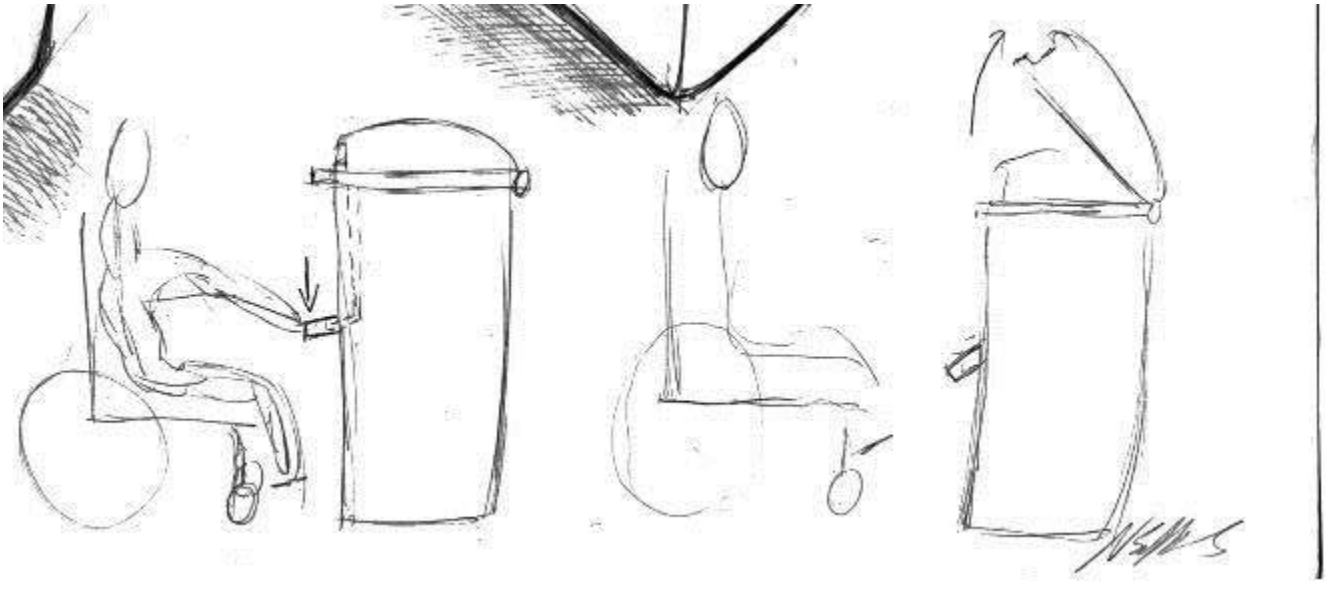
The design specification we came up with is as follows:

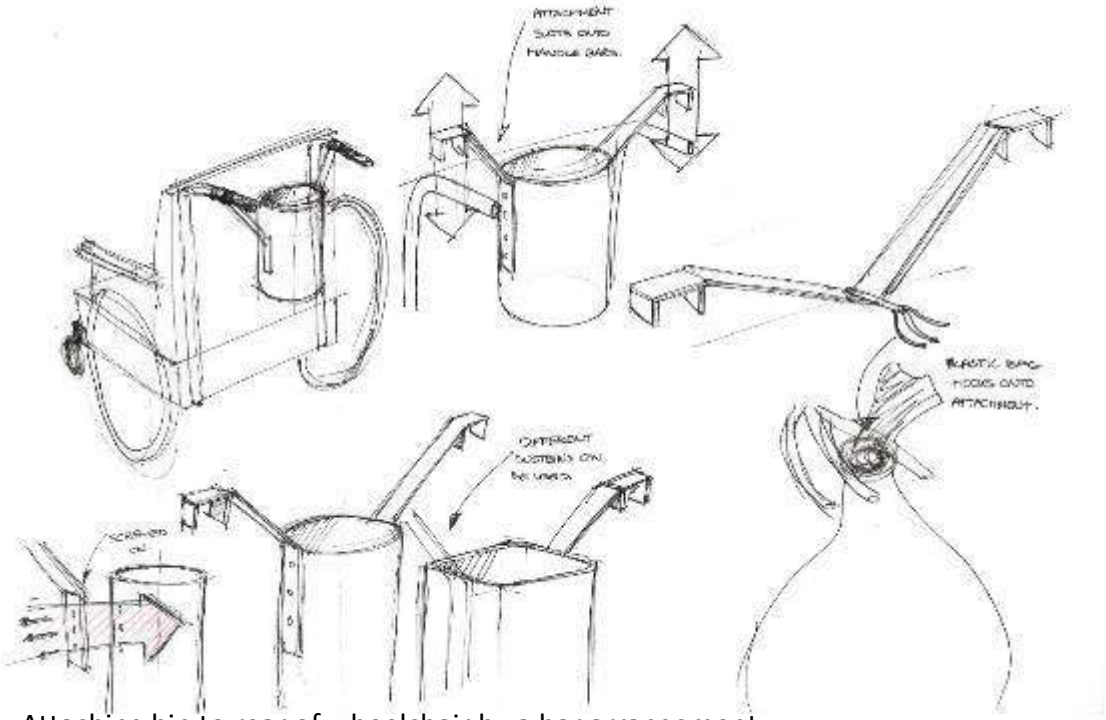
- Nothing coming out to the sides of the wheelchair
- Make the process of emptying the trash easier
- Allow for full control of wheelchair while carrying the trash
- Must not add too mush additional weight to wheelchair
- Must not affect the comfort of the user in any way
- Space efficient, be fairly compact
- Both attach and detach easily
- Manufactured through batch or one-off production
- Easy to operate
- Cost effective

Initial Concepts



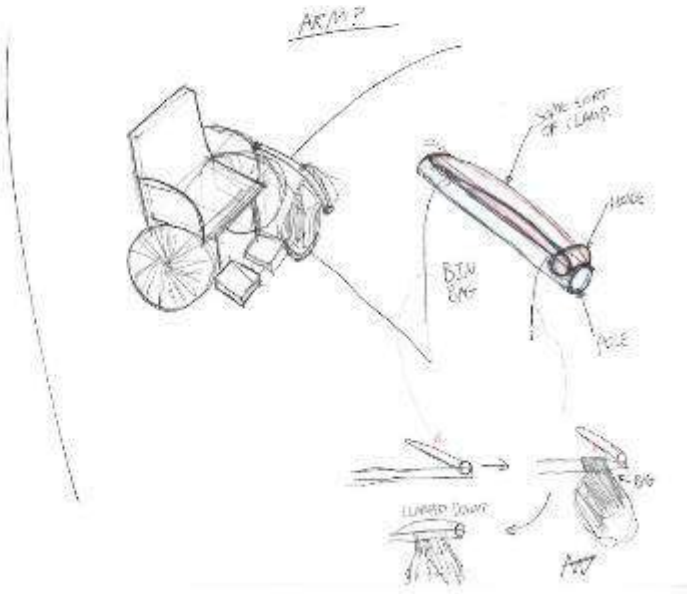




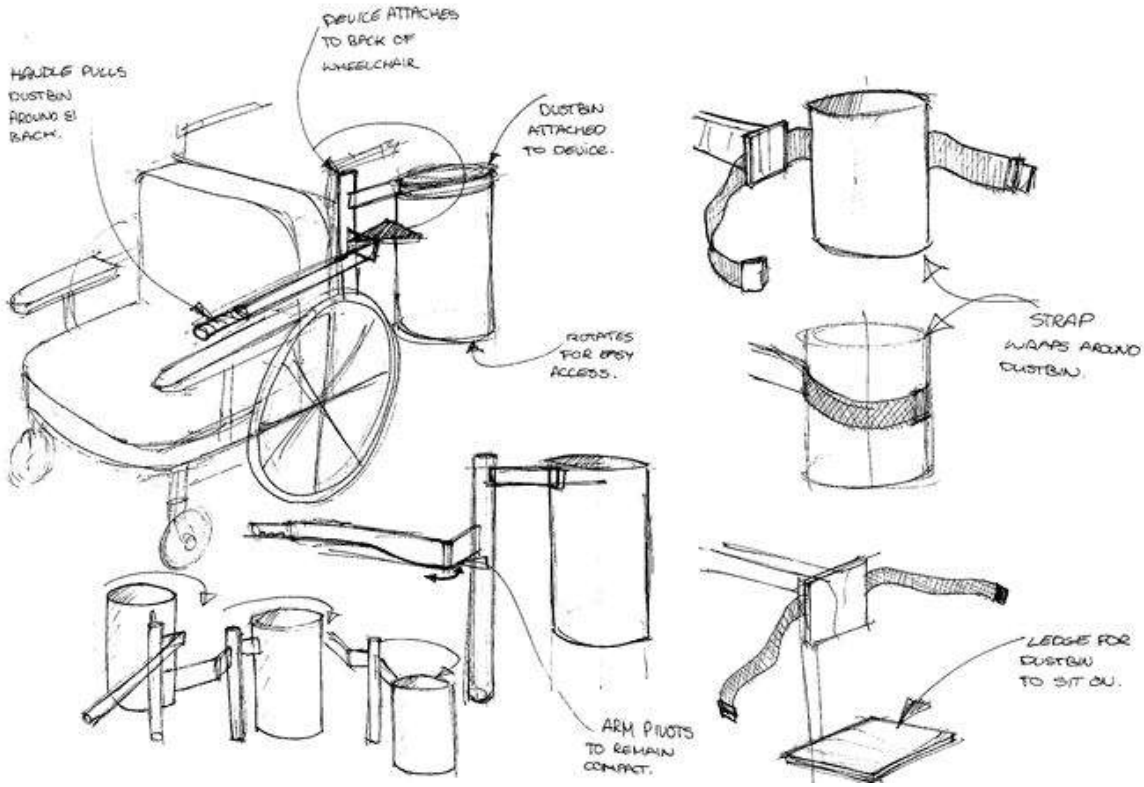


Attaching bin to rear of wheelchair by a bar arrangement.

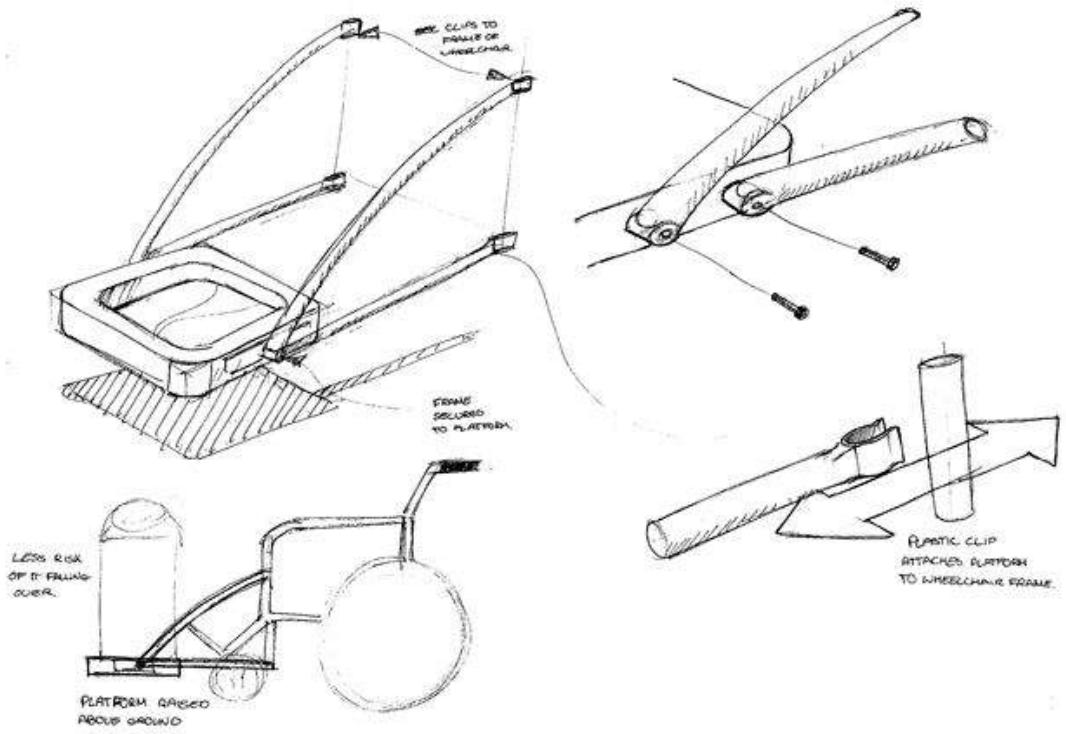
Roller platform to help the bin be easy to push.



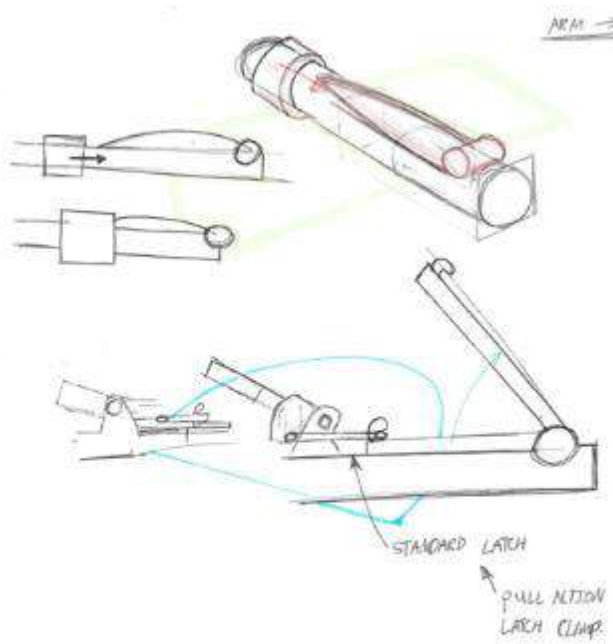
Arm clamp attachment to carry a bin bag.



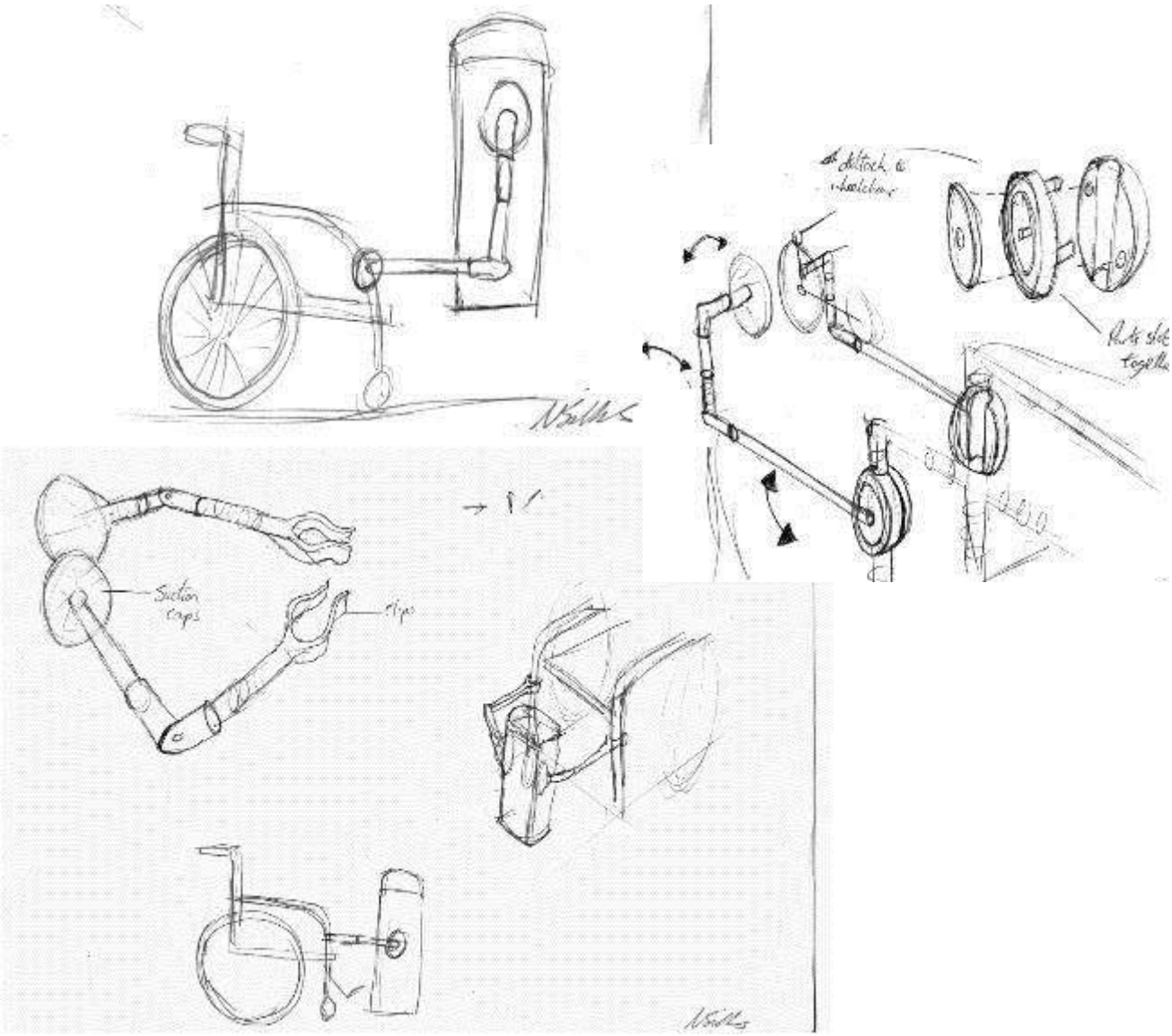
An arm attachment that allows the bin to be swung around to make loading it easier.



An attachment to carry the bin in front of the user.



A bit more development into how to clamp a bin bag to a pole.



Bins

We decided to study the bins in two different local shops which would give a representation of two different market areas in small household dustbins:

John Lewis which mostly had high quality metal bins of which the price ranged from £20-£295 *(John Lewis. 2015)*
Wilko which had simple plastic bins for as low as £5 (Wilko. 2015)

Large metal two section bin. Heavy but easy to get a good fastening to.

Round single bin with soft close lid.

Large selection of fairly heavy cylindrical metal bins, Mostly with plastic inserts as shown below:

If fastening to a bin like this we will have to consider what protrudes to the inner edge, because it would most likely interfere with the plastic insert.

The plastic insert itself is almost a bin, which gives an indication of the quality in these products.

Also the mechanism for the foot pedal present on most these bins would need to be considered, although it is unlikely a wheelchair user would own a bin that requires the use of a foot pedal to open it.

There was about an equal ratio of round to square plastic bins, but only 1 metal foot pedal bin in store, although the website (wilko 2015) lists a range of metal bins similar to the john Lewis ones but only up to £75.

These plastic bins are much lighter and more likely to be feasible to carry by an attachment to a wheelchair.

All the plastic bins have a lip around the top, this is to increase strength and mask any sharp edges away from where the user may get caught.

The capacity of these bins were mostly 25 litre although there were some larger 45 and 50 litre options.

There is a variety of lid arrangements, none of which interfere with the side of the bin, which means for easy fastening options. These bins would also be practical to a wheelchair user since thy can be opened without the use of a foot pedal, and are much lighter than the metal bins, making for easier lifting from a sitting position.

Weight of bin

I have collected the weights of a number of bins around the capacity the product is aimed at. I tried to focus on the simple plastic bins, but also having a variety since the product can be aimed at different users.

Capacity (l)	Weight (kg)	Material	Type	source
40	1.5	metal	pedal	Indoor Dustbins. (2011).
10	1.4	plastic	Inside door	Brabantia. (2007).
30	0.839	plastic	Simple lid	Whitefurze. (2010).
1.5	0.145	plastic	Swing lid	Wenko (2012)
50	1.7	plastic	Swing lid	Wham 2007
8	0.304	Plastic	No lid	Safco (2011)
50	1.7	Plastic	Hinged	Wham (2011)
50	3.2	Plastic	pedal	Simplehuman (2015)
30	0.898	Metal (steel)	pedal	Harewood. (2011).
50	2.6	Plastic (metal look)	pedal	Curver (2012)
40	3.2	plastic	pedal	Curver (2015)

This shows that there is a large variety in the weights of bins of this size, and that being plastic doesn't always mean lightweight. The heavest bin I recorded was 3.2kg, however the average worked out at 1.544kg.

Further research

Weight of bin

Maximum weight of waste in a bin

The maximum weight of a bin will be essential to know since we will be designing our product to potentially have to carry this weight without fracture or damage to it or the wheelchair, and most importantly be safe for the user.

The sizes of kitchen bins in terms of their storage ranges from 30 Litres to 70 Litres; with some extra large bins can reach up to 80 Litres. In a disabled household, the user will most likely not have anything greater than a 60l bin, also considering the end user of this particular project would be living alone. Note that all these bottles are empty.

With glass bottles, 1/3 of the area would be space between the bottles. If the average weight of a glass bottle is 0.511 kilograms, and if the bottle is 350ml in size, then;

30 Litre (small end)

30000/350 = 85 (Rounded)
2/3 of 85 = 56 bottles
56 Bottles * 0.511kg (Average Bottle weight) *(packaging-gateway; 2015)*
= 28.6 Kilograms

70 Litre (large end)

70000/700 = 200
2/3 of 200 = 133 bottles (Rounded)
133 Bottles * 0.511kg (Average Bottle weight) *(packaging-gateway; 2015)*
= 67.9 Kilograms

From this information, we can see that a small, 30 Litre bin would weigh 28.6 Kilograms if filled with glass bottles – and a 70 Litre bin would weight 67.9 if filled with the same.

From the research I found most the bins available are closer to 40 Litre, using this with the same calculation arrives at 38.93kg

More likely weight of waste in a bin

We can now do the same with a lighter material. For this example I will be using plastic bottles as an alternative. Using the bottle information provided from *(aspower n.d.)* , a 500ml bottle weighs 26 grams. Plastic bottles can also be crushed into a smaller shape – so a leftover space of 1/5 is fair. Note that all these bottles are empty and not including lids.

30 Litre (small end)

30000/500 = 60
4/5 of 60 = 48 bottles
48 Bottles * 0.026kg (Average Bottle weight)
= 1.25 Kilograms

70 Litre (large end)

70000/500 = 140
4/5 of 140 = 112 bottles (Rounded)
112 Bottles * 0.026kg (Average Bottle weight)
= 2.9 Kilograms

Waste weight conclusion
From this information, we can see that a small, 30 Litre bin would weigh 28.6Kg if filled with plastic bottles – and a 70 Litre bin would weight 67.9kg if filled with the same.
This gives a combination of a worst case scenario (the glass filled bin) and a case where the weight of the bin is much less. In a real life situation there is probably a mixture of waste including cardboard and food waste, however this is very hard to work out.

I worked out a normal Glass weight to be 38.93kg on the previous page, and using the same method I arrived at 1.664kg for plastic bottles.

Average weight: (38.93+1.664)/2 = 20.297kg

Overall weight the product needs to support:

Average weight of a bin (from previous table): 1.544kg
Max weight of a bin: 3.2kg
Average weight of waste: 20.297kg
Max weight (40 litre bin filled with glass): 38.93kg

Average: 1.544+20.297=21.841kg

Max: 3.2+38.93=42.13kg

Hinges

Component		Dimensions	Costs
	Adjustable Knuckle: Used to obtain different degrees of angles.	Inner Diameter: 33.7 – 60.3mm Length of elbow: 78 – 110mm	Ranges from: £6.49 - £13.44
	Double Swivel Connection: Connects poles at awkward angles.	Inner Diameter: 26.9 – 60.3mm Total Length: 202 – 300mm	Ranges from: £5.25 - £11.24
	Corner Double Swivel Combination: Similar to Double Swivel Connection, adjusts for even more awkward angles.	Inner Diameter: 26.9 – 60.3mm Pivot Length: 101 – 149mm	Ranges from: £6.99 - £16.81
	Swivel Wall Fixing: Connects pole to wall and allowing for a pivot.	Inner Diameter: 26.9 – 60.3mm Pivot Length: 61 – 89mm Base width: 112mm Height: 93 – 121mm	Ranges from: £3.35 - £6.72
	Single Swivel Combination: Connected through middle of pole and allowing pivot.	Inner diameter: 26.9 – 60.3mm Pivot Length: 61 – 89mm	Ranges from: £2.82 - £7.73

Source: The Metal Store. (2011); Interclamp UK. (2015).

Solid connections

Component		Dimensions	Costs
	Short Tee: Simply connects end of one pole to the middle of the another.	Inner Diameter: 26.9 – 60.3mm	Ranges from: £0.95 - £3.25
	3 Way Through: Essentially 2 short tees together	Inner Diameter: 26.9 – 60.3mm Pivot Length: 41 – 84mm	Ranges from: £1.84 – £5.59
	Angle Elbow: Fixes two pole at angle to each other.	Inner Diameter: 33.7 – 48.3mm Height: 134mm	Ranges from: £5.66 - £7.14
	Wall Plate: Fixes end of pole to a flat surface.	Inner Diameter: 26.9 – 60.3mm	Ranges from: £1.56 - £5.30
	Retro Fit Clamp: Adjustable clamp suitable for various diameter poles.	Inner Diameter: 26.9 -60.3mm Clamp Height: 51 – 91mm	Ranges from: £2.35 - £7.88
	Clamp-On Crossover: Used to clamp two poles perpendicular to each other.	Inner Diameter: 48.3mm Distance between poles: 55mm	Ranges from: £9.84
	Cradle Clamp: Allows poles to just rest inside it.	Inner Diameter: 48.3mm	Ranges from: £5.47

Source: The Metal Store. (2011); Interclamp UK. (2015).

Types of Poles

Component		Dimensions	Costs
	Copper pipe Fairly cheap solution. Does provide good strength and is fairly easy to work with.	Length: 3m Diameter: 22mm	£4.26 per meter.
	PVC pipe PVC is a lot cheaper but isn't as strong.	Length: 3m Diameter: 22mm	£2.66 per meter
	Steel round tube Again pretty expensive but is very strong and reliable.	Length; 1m Diameter: 20mm	£6.62 per meter
	Aluminium Pipe Lightweight but strong, durable and affordable.	Length: 1m Diameter: 22mm	£5.58 per meter

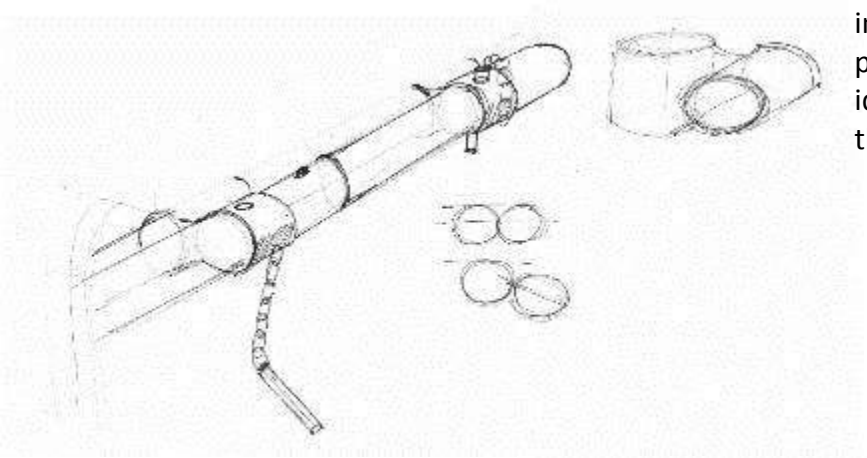
Source: The Metal Store. (2011); Interclamp UK. (2015); Jawacorner. (2012).

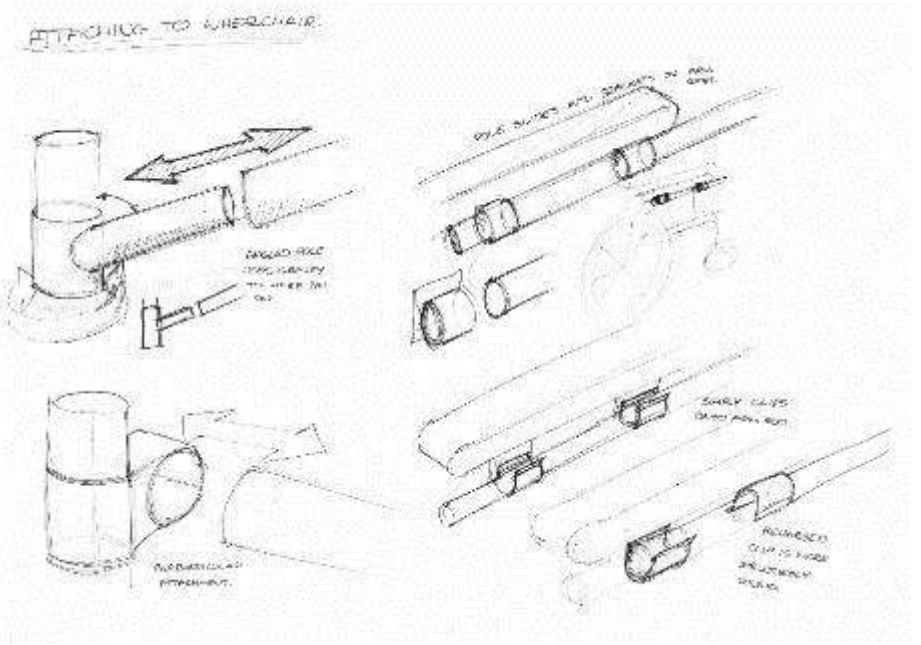
Additional Components

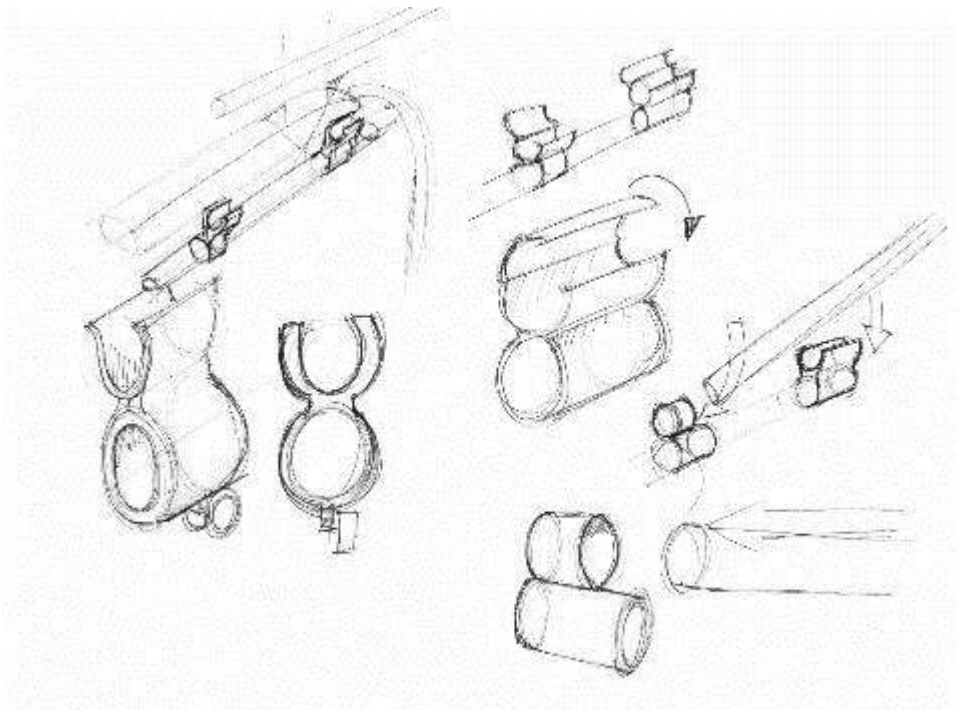
Component		Costs
	The mechanism we are taking inspiration from a crutch as we feel the mechanism is already present as well as too much tampering would not be necessary. Also an added positive is that the length of the pipe is also adjustable if need be.	Rough estimate of a crutch: £10 – 15
	This component a double button spring steel clip, which can be found inside many different crutches as a method of changing the length.	From eBay: £3.99 for 5
	Rubber plug can be used to seal up the end of the pipes . This will make them safer and improve the aesthetics.	Ranges from: £0.16 – 0.32

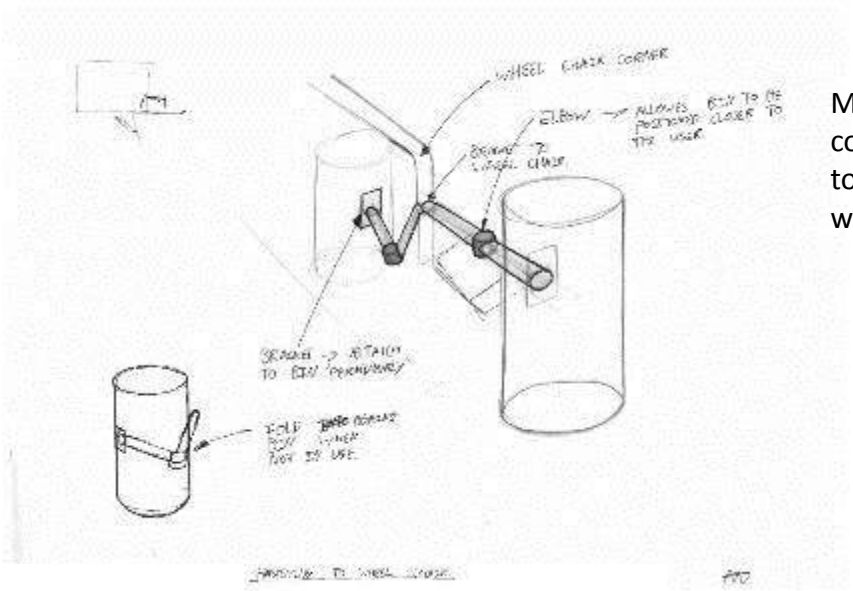
Further Development Sketches

This page shows our development into how we could fasten the product to the wheelchair using an idea of the products available thanks to our components research.

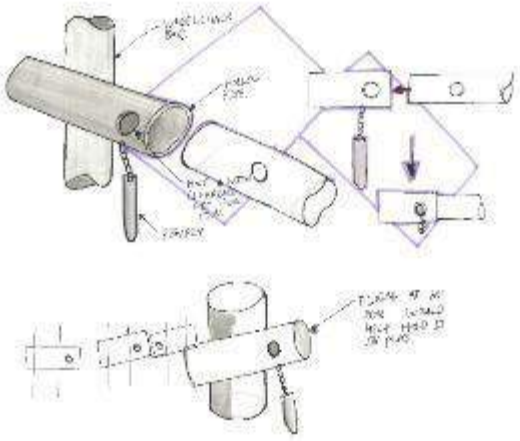




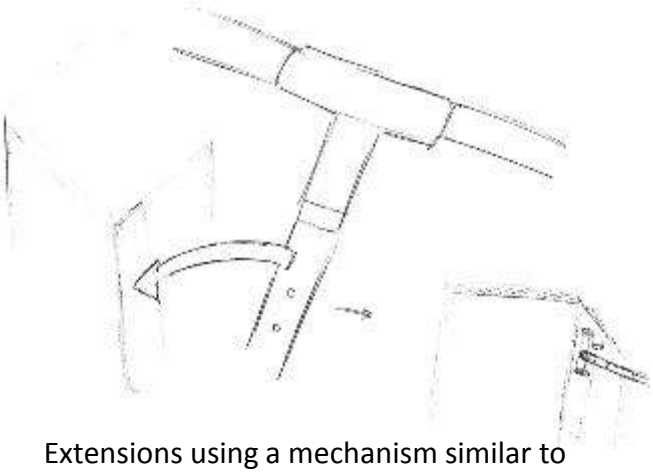




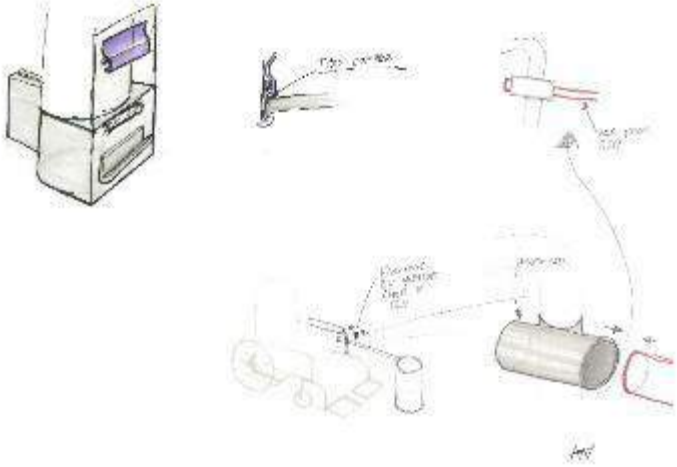
More development into trying to come up with a suitable system to connect the product to the wheelchair

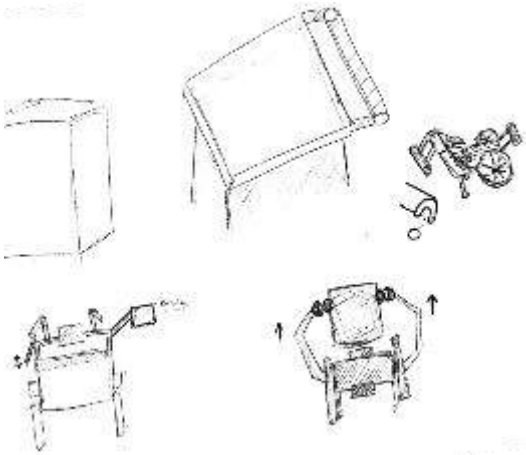


Simple tubular pipe connection is possible.

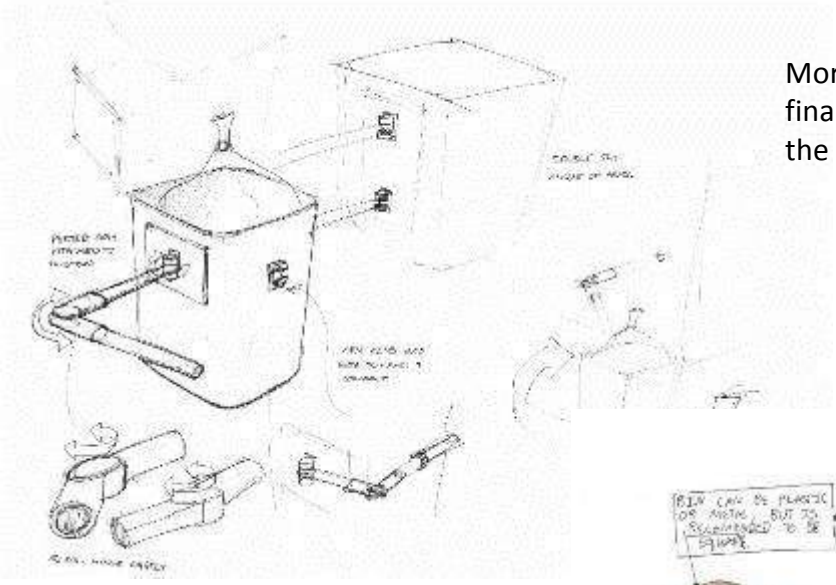


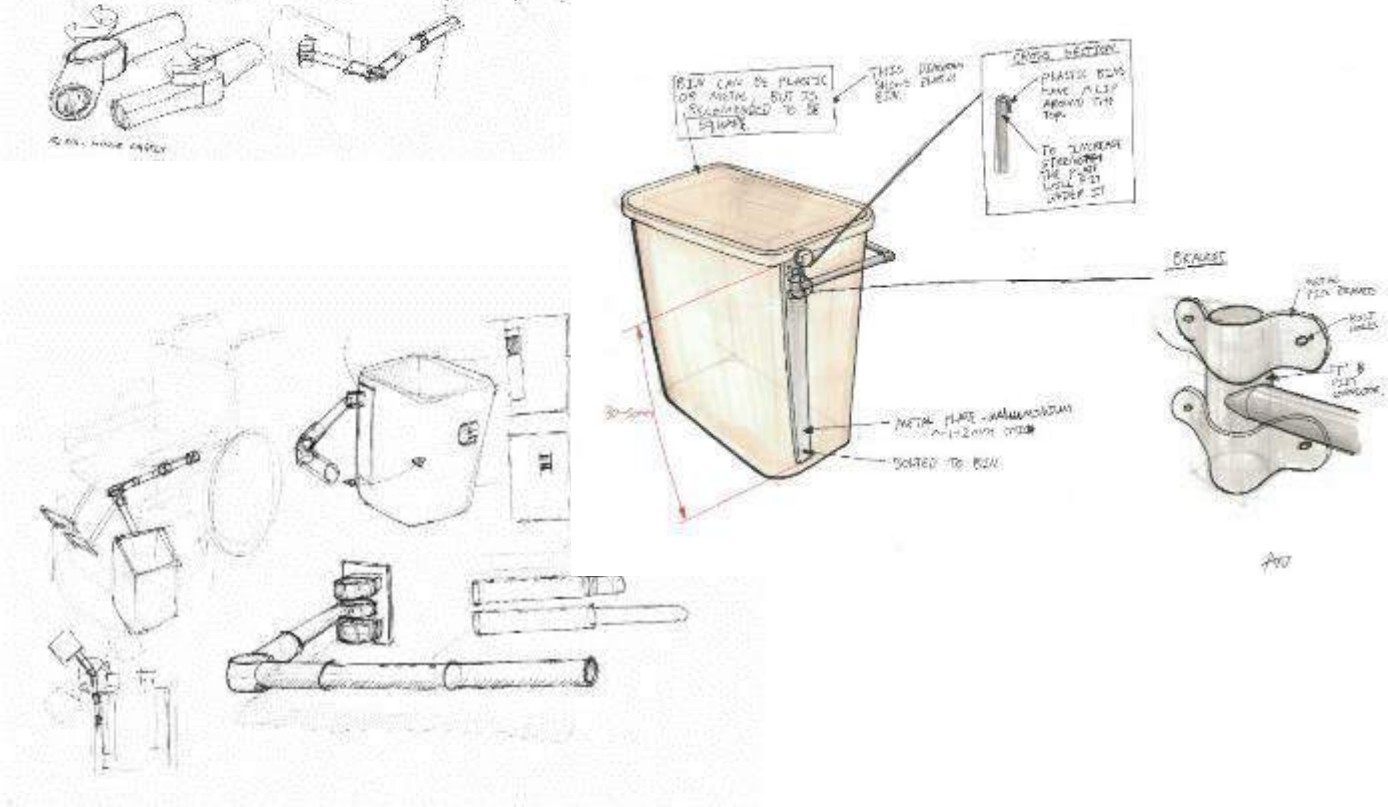
Extensions using a mechanism similar to that from a crutch may be necessary.

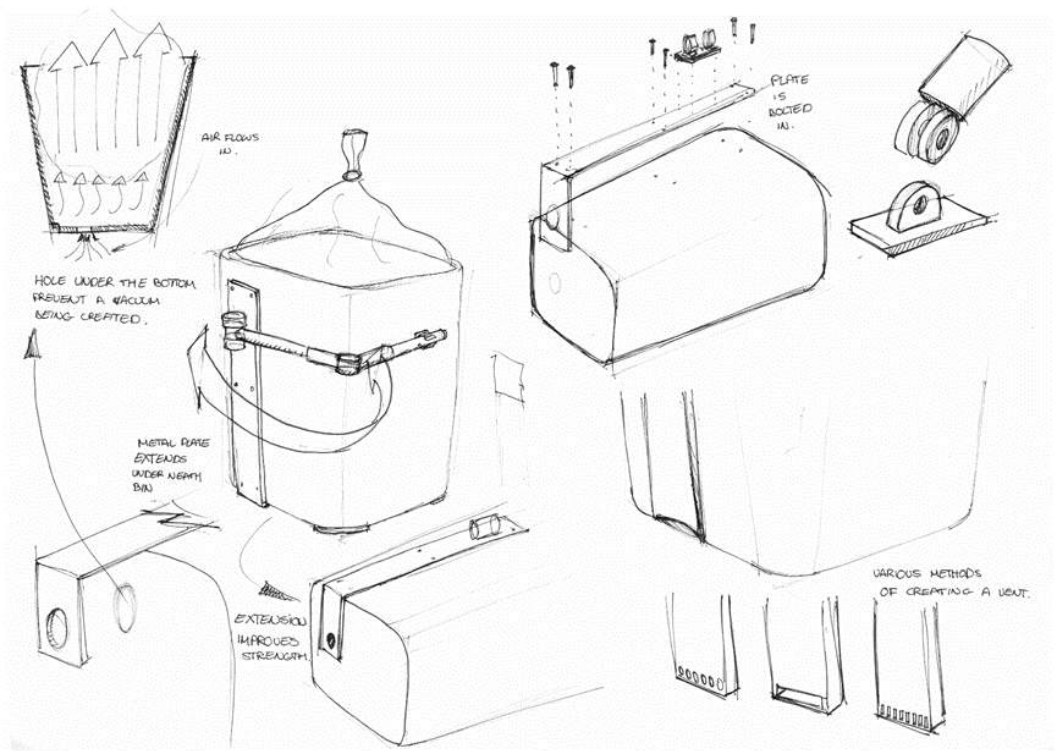




More considerations to be made to the final design, particularly how to fasten the product to the bin.







Prototyping

The prototype shown was made by cutting PVC piping into a two different lengths; of which including one of 360mm and one of 230mm – both having a radius of 11mm.

A wooden panel is made for the prototype, which allows the PVC component to be fastened onto the bin using screws – at the same time allowing the part to rotate horizontally.

The pivoting component used in this prototype is an adjustable knuckle hinge – used to connect both PVC pipes to allow them to rotate on a horizontal angle.

There would be 2 permanent components fastened onto the underside of the metal pipe underneath the armrest. This would mean it's out of sight and not intrusive to the user of the wheelchair.

When trying to take the bins out without our ‘Easy-Bin’ product, the user would have 2 options when taking a kitchen bit outside.

•One option being to balance the bin itself on the users feet or on the users lap.

•The other being to take the plastic bin bag out and to balance it on the users lap once again.

Testing the prototype

Once the model was made we acquired our wheelchair and began to test our final outcome. The process of utilising our product starts off with the user travelling towards the bin lifting it up and clipping the bar in the clips attached to the wheelchair. Connecting the bar to the clips wasn't a smooth process when we tested it but it was a simple process. Baring in mind we intend to make the actual product out of a metal such as aluminium because metals tend to have a more polished surface finish, so there would be less friction between the bar and the clip. Therefore connecting the pieces together should be an smother process.

After the bar is attached to the wheelchair, we tested if the arm would swivel at approximately 90° so the bin was in front of the user and seemed easy to swivel round and operate. Also we inserted objects in the bin that were a similar mass to the average mass of a full bin while it was attached to the wheelchair. The wheelchair stability didn't seem to be affected by the weight of the bin much due to the weight of the user counteracting the downwards force. Also the bar stayed attached to the wheelchair and the bin which means our product should be viable for a independent wheelchair occupant to utilise.

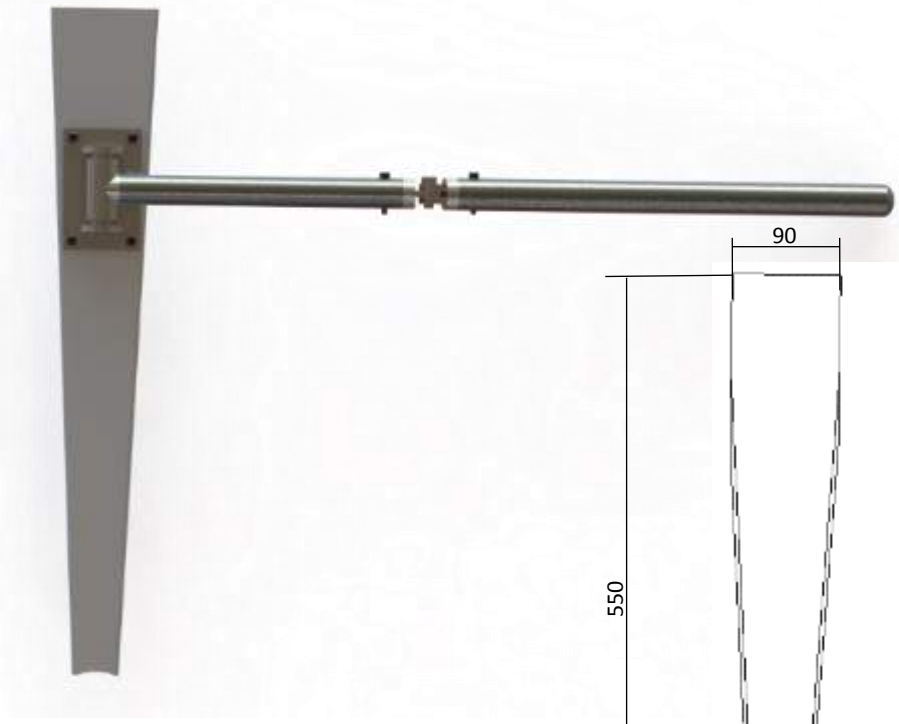
Finally we tested if you could utilise the wheelchair with our model attached. Because the bin can placed in front of the user it doesn't cause much of an obstruction. We discovered the wheelchair was still usable with our attachment on and the performance of the wheelchair seemed the same as before which is dependent of the users physicality. Therefore it was very easy to manoeuvre through doorways and past other obstacles with the bin

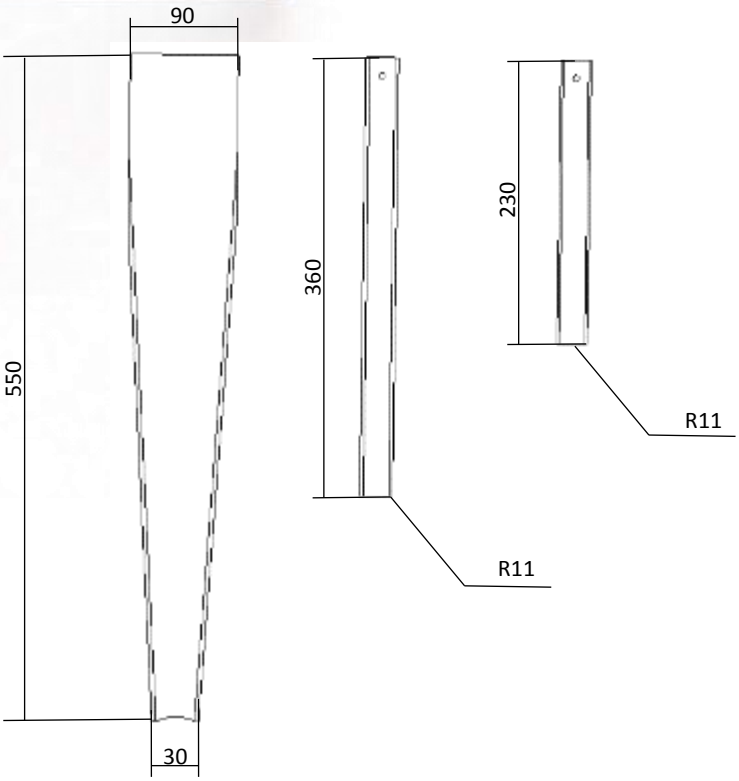
Final Product

Manufacture

This product uses material and components that are easy obtainable from any hardware or DIY store. This means that actually making the product is simple because it mostly involves attaching components in various ways.

For a dustbin with dimensions of: 600mm x 400mm x 400mm





The size of the product is very dependent on the size of the dustbin and wheelchair being used. These three components are the most varied and would need to be adjusted.

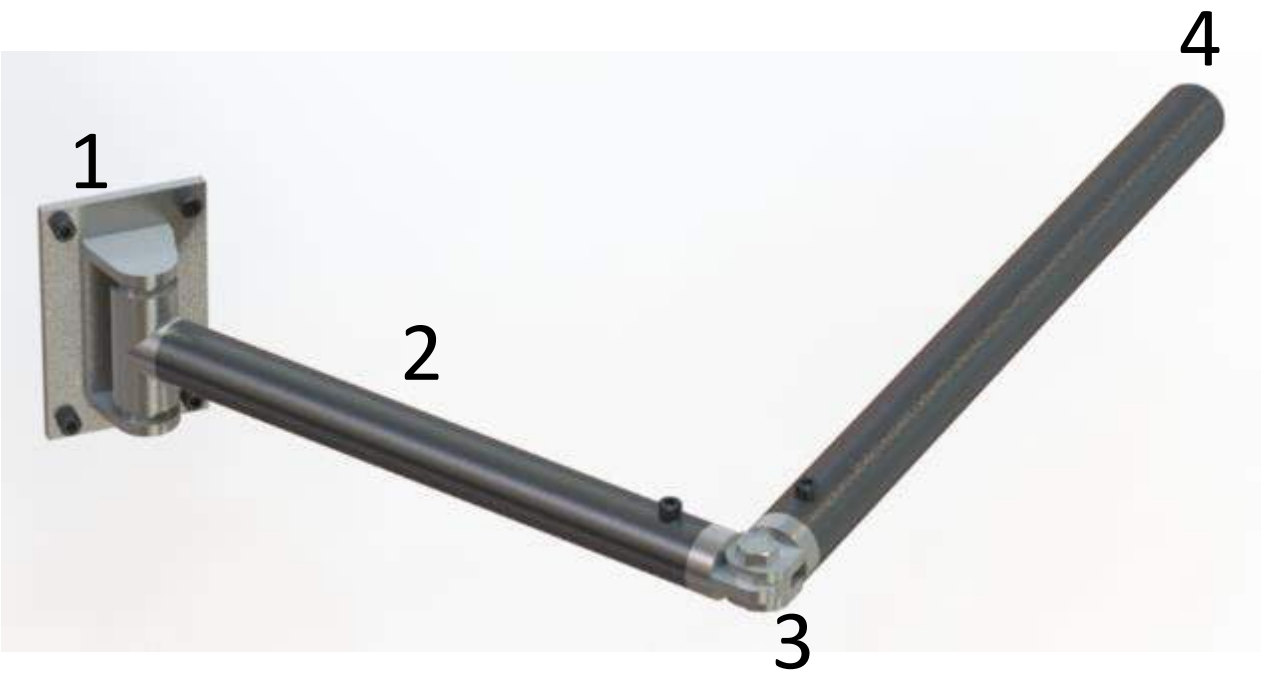
Where as these components are bought in and would just need to be in the right size for the wheelchair and dustbin being used.

Feasibility

The product must be feasible to be made in a workshop. So no parts designed for this product that must be manufactured by processes that are only economic to use in mass production. This means no Injection moulded products that cant be just brought in, etc. This is so Demand can manufacture the product.

Our product is fairly feasible for demand to produce since (as the manufacturing page shows) we have designed it to use existing parts that can be brought in. The manufacturing process is fairly simple, involving cutting, drilling and bolting parts together. There is no need manufacture their own parts because they are all available, and if the part listed becomes unavailable there is some alternatives in the table of potential parts shown early on in the report.

Since the product would be manufactured in fairly small quantities it is possible to tailor the dimensions to specific wheelchairs or bins that the user uses/ prefers. This is because it would only require Demand to cut the pipes to different lengths.
The product can be fastened to the bin simply with bolts. This means that the user has a fairly large choice of bins, so they should be happy.



Component sourcing			
Component		Feasibility of sourcing	Reference
1		**Swivel Wall Fixing:** Interclamp manufacturer these for handrails. It is slightly different to the one shown in the model but it functions the same and actually looks more elegant.	
2		A simple Aluminium tube will do this job, and can be brought from a variety of suppliers. It might even be possible to use some plastic tubes if they are strong enough.	
3		**Swivel Wall Fixing:** Interclamp also manufacturer and sell these.	
4		**Rubber Plug** A fairly simple component, various sizes can be found easily online and in local suppliers for fairly low cost.	

Conclusion

The final solution we have come up with is a combination of arms and hinges which are permanently attached to a dustbin and then lifted up and attached to a wheelchair. The arm has the ability to fold up against the bin and clip into place, this keeps the product compact and out of the way. *When the user wants to take out the trash all they do is simply go to the dustbin, unclip the first arm, lift the bin up and slot the arm into the attachments on the wheelchair, they can then twist the bin around in front of their legs. This product follows the design specification that we have set out for and so we feel that it is the perfect solution for taking the trash out for people in wheelchairs*.

The simple design of the product allows for easy manufacture, which is then made easier by the materials being easy to obtain. This means that anyone could make it, someone could make it easily at home or a company or charity could make them without it being to expensive. The design can also be adapted to suit anyone's preferences, if they want a cylindrical bin then they can, if they have a bespoke wheelchair it can be adapted to that. There is no need for mass manufacture for this design and can be produced using one-off or batch production.

The materials and components have been thoroughly researched in order to keep the product affordable and remain easy to manufacture. Below is the average costings for each component and material that will be used (depending on size of dustbin and wheelchair):

Material/Component	Cost
Adjustable Knuckle	£6.49
Swivel Wall Fixing	£3.35
Aluminium Pipe	£5.58 (for 1 Meter)
Rubber Plug	£0.16
Plate	£2.15
Pipe Clips	£0.60
Screws/Bolts	£1.30
Total Cost:	£19.63

Of course the price per product would be cheaper as there would be excess for the aluminium pipe, pipe clips and screws/bolts.

Source: The Metal Store. (2011); Interclamp UK. (2015); Jawacorner. (2012); Wickes. (1972

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