The Design, Development, and Dissemination of a Small-Business Wheelchair to Empower People with Disabilities in Developing Countries

by

Natasha Scolnik

Submitted to the Department of Mechanical Engineering
in partial fulfillment of the requirements for the degree of

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Abstract

This thesis discusses the design of a small-business wheelchair that empowers disabled people in developing countries to become entrepreneurs. Disabled people in these countries face tremendous discrimination, making it difficult to find employment and further perpetuating the sentiment that they cannot meaningfully contribute to society. This project attempts to change that, providing disabled people with both mobility and a way to generate an income. It was designed in close collaboration with MobilityCare wheelchair workshop in Arusha, Tanzania and tested by five users in a pilot trial that began in July 2008. Each of the participants was given a small-business wheelchair, business training, and seed money to purchase raw materials. In addition, bank accounts were established at a local wheelchair-accessible bank. The success of this trial proved that the small-business wheelchair is a viable way for people with disabilities to generate an income and improve their livelihoods. Several dissemination strategies have been explored so that wheelchair workshops across the developing world can produce this wheelchair. These include the development of a production manual that will be available online as well as at the next Pan African Wheelchair Association meeting, to be held in 2011. In terms of funding, corporate sponsorship has been determined to be an appropriate way to cover the cost of the wheelchair itself. While microfinance is not currently feasible to fund the start-up costs of each business, it is likely to become more appropriate as it grows and expands its services.

Thesis Supervisor: Anette Hosoi
Title: Associate Professor of Mechanical Engineering

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1 Introduction

1.1 Situation of Disabled People in Developing Countries

An estimated 20 million people in developing countries require wheelchairs to be mobile [1]. However, about 95% of these people do not have a wheelchair [2]. Lack of mobility denies these people the essential social right to participate in their communities. Having to rely heavily on family and/or friends to move around, these people quickly become seen as a burden on society and it is common for them to be ostracized or abandoned.

A number of responses have arisen to address the lack of wheelchairs available to disabled people in developing countries. The approach taken by American non-profits has been to mass-produce wheelchairs in China and then ship them to developing countries, where they are distributed for free through churches and local NGOs. One of these organizations is called The Wheelchair Foundation. The cost of the wheelchairs appears to be covered by donors in the US, but the founder/chairman, Kenneth Behring, subsidizes a majority of the cost. Independently wealthy, in 2007 alone Behring contributed $2,027,900 in air travel to the Foundation [3]. The Wheelchair Foundation is further supported by the US State Department from whom they received grants of $4,970,000 in 2004 and $4,960,000 in 2005 [4]. While this model is based on good intentions, it has a number of critical problems. First and foremost, the wheelchair that they distribute simply does not perform well on the rough terrain encountered in most developing countries. As a result, these wheelchairs do not last long. Because they are produced abroad and the organization has no local staff in-country, spare parts are not available, and the user finds him or herself once again without mobility. In an interview with a young Tanzanian who used one of these donated chairs he said, "with my red chair I couldn't even push myself. Everywhere I wanted to go, I needed somebody to push me" [5].

A second approach to providing wheelchairs in developing countries has been to set up small workshops where they can be produced locally. Local technicians who are proficient in metalworking and fabrication staff these workshops. Many of them have attended a certification course in wheelchair technology offered by the Tanzania Training Centre for Orthopedic Technology (TATCOT) at the Kilimanjaro Christian Medical Centre (KCMC) in Moshi, Tanzania. In this one-year course, students learn not only how to fabricate wheelchairs from locally available materials, but also the logistics of setting up and managing a workshop. The wheelchairs produced by these local workshops have been specifically designed for use in developing countries. For example, one of the popular models is a 3-wheeled wheelchair, which provides greater stability on the uneven terrain often encountered in the developing world. Not only do these locally produced wheelchairs last longer than imported ones, but when something breaks, it can easily be repaired locally, further extending the life of the product. Despite this, it is estimated that below 1% of the need for wheelchairs in Africa is being met through local production [6].

1.2 Small-Business Wheelchair Concept

Disabled people in developing countries face a very narrow job market. Often unable to find a way to generate an income, many end up on the streets as beggars. Aside from the discrimination that they face from potential employers, many places of work are not wheelchair accessible. Narrow doorways, tight corridors, and offices on second and third floors further compound the problem. All of this contributes to the fact that in Tanzania, households with disabled members are 20% more likely to be living in poverty [7]. And while a wheelchair can provide mobility and an added sense of dignity, it generally does not resolve the issue of unemployment. But there is no reason why people with disabilities cannot be successful entrepreneurs, if given the tools to do so.

In the summer of 2007 the idea for a small-business wheelchair—one where the user could run a business right from his/her seat—was born. The high prevalence of roadside businesses, combined with the recent success of microfinance [8] gave us the confidence that this idea could succeed in bringing financial stability to people who had, until then, been marginalized by society.

The small-business wheelchair provides users with the mobility they need to move around, as well as a platform from which they can run a business. In a country like Tanzania, where the per capita income is roughly $450 annually [9], purchasing a $300 wheelchair is not financially possible. However, if the wheelchair user is able to use the wheelchair to generate a sustainable income, there is reason to believe that he/she could use that money to slowly repay the cost of the wheelchair over time.

Working with MobilityCare Wheelchairs in Arusha, Tanzania, an alpha prototype was developed that summer. Work on the project continued over the next 2 ½ years, refining the prototype, and distributing several for testing in a pilot project. Today there are five people in the Kilimanjaro region of Tanzania who are running businesses from their wheelchairs. It is hoped that the dissemination of this design to workshops across the developing world will bring many more like them in the years to come.

2 Design

2.1 Key Limitations

The guiding requirement in the design of the small-business wheelchair was that it had to be manufacturable in local wheelchair workshops in developing countries. This meant that it had to be made of locally available materials such as mild steel, wood, and cloth. Additionally, it had to use tools and technologies available in these workshops, which include welding, metal fabrication, and sewing among others.

2.2 User Needs

Next, the wheelchair needed to allow the user to run a simple business from the seat. Possible businesses included selling phone vouchers, shining shoes, repairing radios, and making beaded jewelry. This yielded several additional requirements: safe storage of business materials, surface for working on, and protection from rain and sun.

Above all else, the wheelchair needed to be safe for the user. It had to match their health needs, providing both support and comfort. In 2008 the World Health Organization released a report called "Guidelines on the provision of manual wheelchairs in less resourced settings." These guidelines aim to help those involved in wheelchair production, prescription, and delivery to ensure that the wheelchairs they provide are appropriate. According to the guidelines, "A wheelchair must meet the user's individual needs and environmental conditions, provide postural support, and be safe and durable. The wheelchair must be available and affordable and be maintainable and sustainable in the country of use" [10].

Based on the key limitations and user needs, the functional requirements for small-business wheelchair were the following:

1. The wheelchair must match the health needs of the user
2. The materials must be available locally
3. It must draw on production methods used in developing country workshops
4. There must be storage space for business related materials
5. There must be a workspace on which to conduct business
6. The wheelchair must provide protection from rain and sun

2.3 Product Testing

Wheelchair users in Tanzania tested the small-business wheelchair at various stages in the design. In the summer of 2008, a pilot trial involving five users commenced. This trial was conducted to gather feedback on the design, but also served as a proof of concept for the wheelchair-bound business idea in itself. The table below summarizes the users involved in the trial:

User	Gender	Disability	Previous mobility aid	Business started
A	M	Congenital	Imported wheelchair	Shoe making
B	M	Congenital	Wooden crutches	Beaded jewelry
C	M	Spinal injury	Local 3-wheeler	Radio repair
D	M	Spinal injury	Local 3-wheeler	Shoe shining
E	F	Spinal injury	Imported wheelchair	Batik cloth making

Table 2-1: Important characteristics of users who participated in pilot trial

2.4 First Prototype

2.4.1 Design Details

The first prototype was designed in the summer of 2007 together with technicians from MobilityCare Wheelchairs in Arusha, Tanzania. The storage space consists of wooden drawers that slide on metal guides beneath the seat. These drawers were envisioned as a place for the user to store materials for his/her business that may include polishes for a shoe shiner or screwdrivers for an electronics repair person.

Figure 2-1: Prototype of drawers used as storage beneath the seat.

Protection from the elements is in the form of an umbrella that simply fit into an existing piece of pipe in the back of the chair.

Figure 2-2: Photo of umbrella that provides protection to the user.

However, the bulk of the design work focused on a table that serves as a work surface. Inspired by the tray tables that fold out of armrests on airplane seats, this table involves a number of hinges in different orientations that allow it to be a) stored behind the seat, and then b) unfolded to be used over the user's lap. The table is made from wood and steel rod.

Figure 2-3: Photos of the first table prototype showing how it functions

2.4.2 Testing Results and User Feedback

Much was learned from the development of this first prototype. First, the design of this table focused on the fact that it should remain attached to the wheelchair at all times—whether in use or stowed. This design parameter arose from the notion that it would be safe from theft it if it were continuously attached. However, after discussions with the local wheelchair technicians and potential users of the small-business wheelchair, it was realized that continuous attachment was actually not a desired characteristic of this table. This wheelchair would likely be the user's sole mobility aid, and they would not always want to be running their business. Outside of working hours they would not want to be carrying the extra weight of the table. In fact, a table that could be easily detached and stored at home would be more desirable.

Second, the emphasis on making a table that was aesthetically pleasing ended up taking away from its actual performance. The table was designed to be sleek and required a complicated series of hinges to allow for proper unfolding. As a result, the structural stability of the table was limited and additional support structures had to be added to keep it from bending when weight was added. "Form follows function" was the guiding adage for the second prototype that followed.

2.5 Second Prototype

2.5.1 Design Details

Designed during the fall 2007 semester and then manufactured at MobilityCare during January 2008, this design maintains the same storage drawers and protective umbrella. Design work focused on improving the table, with an emphasis on stability and strength. A coupling on the central beam of the three-wheeled wheelchair provides the mounting point. A connection tube is then used to attach the table, which itself has a 2-axis coupling, allowing the table to be mounted in two orientations— parallel

to the ground as a work surface, or perpendicular as an advertisement. Each coupling has a butterfly bolt to hold it in place when mounted.

a) Work surface orientation b) Advertisement orientation

Figure 2-4: Photo showing key elements of table redesign

This design was an improvement over the previous one in that it was easy to disassemble. If the user did not want to use the table, she could simply remove the wooden surface and connection tube and store them at home. They would then be left with only the bottom coupling on their wheelchair. Because this design had few moving parts, it was much more stable than the previous one. The user could do work on the table without it wobbling at all. Additionally, it was fairly easy to customize the position of the table to fit the size of the user by adjusting the location of the bottom coupling and/or the length of the connection tube.

2.5.2 Testing Results and User Feedback

Three users tested this design during the pilot trial that began in the summer of 2008. General feedback was that they appreciated the sturdiness of the table and felt comfortable doing various types of work on it. They also liked how easy it was to set-up and remove. The biggest complaint received was that the fixed coupling on the main beam often got in the way. Located directly above the footrest, it was too easy for the user's foot or ankle to inadvertently bump against it. Although all effort was made to ensure that there were no sharp edges, even dull ones can harm the user, who in most instances has no feeling in her legs and thus would not know that she is bumping into the coupling.

This feedback reinforced the fact that careful attention must be paid to the full scope of how the user will interact with the product. In the next iteration, effort was made to ensure that no piece of the design would get in the way of the user's regular activity, striking a better balance between sturdiness and ease of use.

2.6 Third Prototype

2.6.1 Design Details

The next iteration of the design took place during the spring 2008 semester, and involved the support of a team of students in the MIT class SP.784, Wheelchair Design in Developing Countries (WDDC). The project plan was to test this new design, along with the second prototype, in the upcoming pilot trial that would see five of these small-business wheelchairs distributed. As such, it was developed as an alternative, and not as a replacement, for the second prototype.

Just as the second prototype used the wheelchair frame to its advantage, the third prototype relied on existing tubing to form the basis of its attachment point. It consists of the same wooden table, this time connected via 2 U-shaped bars that slide into the wheelchair seat tubing on one side, and into a tubular bracket on the table on the other side. Butterfly bolts are used to secure the brackets into the tubes.

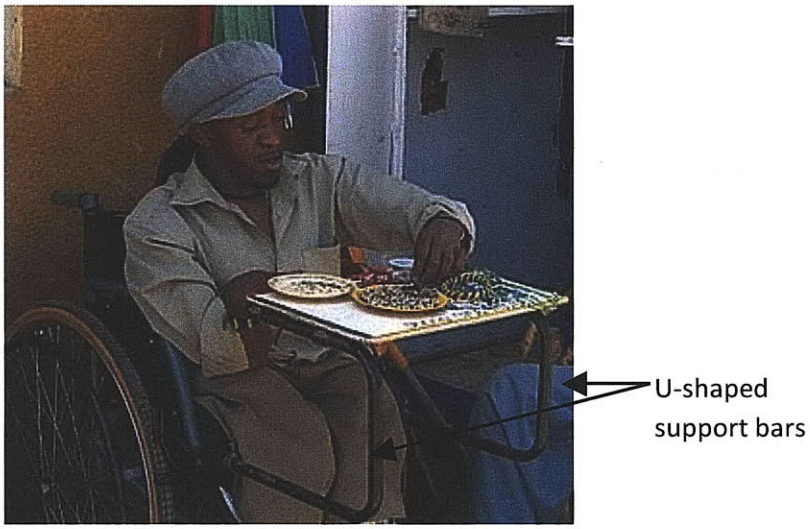


Figure 2-5: Photo showing the table in use

The previous prototypes were designed to fit on a 3-wheeled wheelchair, popular in Tanzania. However, recognizing that this project could expand into other developing countries where the 3-wheeler is not as popular, this prototype was designed to fit onto both 4-wheelers and 3-wheelers. A majority of wheelchairs have tubing running parallel to the ground that forms the bottom edges of the seat. Thus this prototype could be adapted to fit most wheelchairs found in developing countries, whereas the two earlier prototypes were much more difficult to adapt to four-wheeled chairs.

2.6.2 Testing Results and User Feedback

Users A and B (see Table 2-1) tested the third prototype during the pilot trial. While they appreciated how strong and sturdy the table was, they were concerned that it took too long to remove. For example, if you want to get out to go to the bathroom, you have to completely remove the table and U-shaped

support bars. A suggestion was made that perhaps the table could be turned or slid out of the way, to make quick exits easier. Additionally, we noticed that the butterfly bolts that hold the table in place seemed to loosen over time. After a few months of use, it was quite easy to twist the table back and forth, even when the bolts had been twisted tightly. While this was convenient for user B, who could twist the table down and climb out over it, it was problematic for user A, whose work involves some heavy forces that resulted in unwanted movement of the table.

The two trial users liked the painting on the table and said that it not only helped draw the attention of potential customers, but also helped to legitimize their businesses. It was also very useful for certain tasks, such as making beaded jewelry. User B had previously struggled to spread his beads out on his lap, but the table made this much easier and increased the overall efficiency of his beading.

Based on the above feedback, it was clear that the set-up and removal process needed to be easier than it currently was. Additionally, the number of parts that came together to form each mounting point— one tube inside of another tube, held together with a butterfly bolt, repeated on each side of the table— allowed for too much unwanted movement of the table, and made it more time consuming to both set-up and remove.

Lastly, further conversations with these two users reinforced the fact that not all businesses may require the same attachments. For user A, who makes beaded jewelry in his wheelchair and can climb out of it with some assistance, this particular table was great. The table allowed him to do his work comfortably and efficiently, and could be pushed to the side when he wanted to climb out. However, for User B, who makes shoes in his wheelchair and cannot get out unless the table is completely removed, it did not work as well. The shoemaking process really demands a workspace larger than the wheelchair can accommodate, and involves hammering with a significant force. As such, User B's table broke after approximately 8 months of use.

2.7 Current Design

The current design incorporates suggested design changes from previous trials, and most importantly, from the pilot trial. It was developed during the spring 2010 semester in Tanzania with MobilityCare. Based on feedback received from users who were testing the second and third prototypes, as well as the wheelchair technicians who had built them, a number of factors were balanced to create an improved set of business attachments. These factors included:

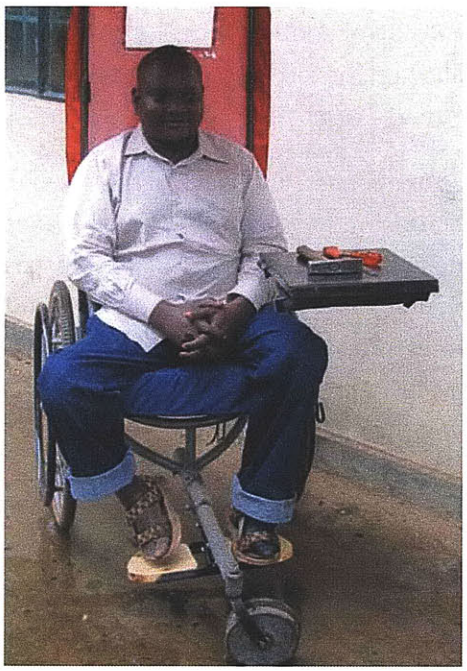
- ease of use,
- ease of manufacture,
- ability to facilitate business,
- cost, and

- weight.

Work on this design also included research on how the attachments would be used by different people, such as those with polio versus those with a spinal injury. Recognizing that different businesses may require different attachments and that people may have different tastes, styles, and spending points, these attachments were designed to accommodate a wide range of users.

The table redesign focused on making it easy to insert and remove, while also adding the function of rotation so the table could be quickly moved aside in the case when the user needs to get out of the chair briefly, or if he/she prefers to have the workspace on the side of the chair while doing other work. The current design is built from 1.5mm thick sheet metal, reinforced on all edges with 1" x ¼" flat bar. It has a 12.5" long, 5/8" diameter steel pipe that connects to a complimentary coupling that is fixed to the wheelchair. This coupling is built against the armrest to ensure that it does not get in the user's way.

a) Table in front position



b) Table rotated to side position

Figure 2-6: Photos showing how table is used

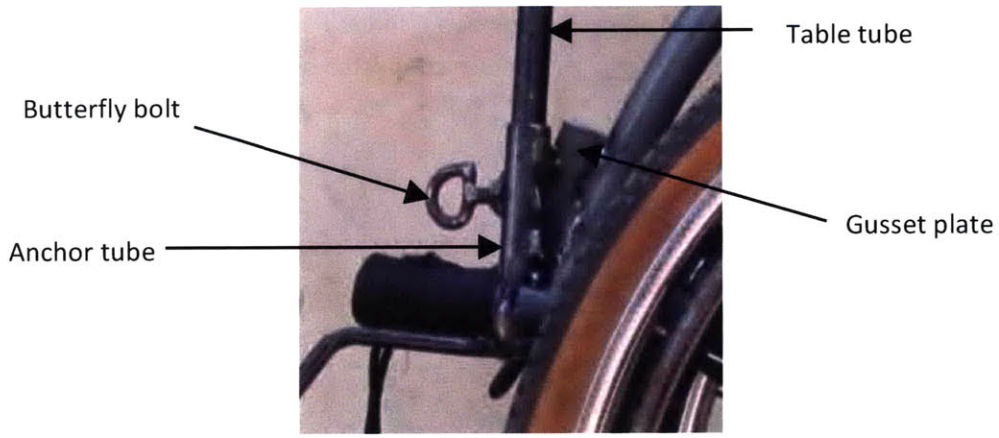
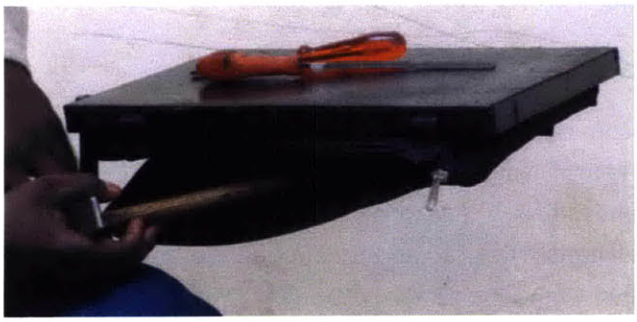


Figure 2-7: Photo showing how table tube is inserted into the anchor, which is held then held in place with a butterfly bolt; a gusset plate further supports the anchor

Two types of storage are offered in this design. A user can select the wooden drawers that were developed in the first prototype, or choose to add a nylon pouch to the bottom of the table—or both. Both the drawers and pouch can be easily removed, should they need to be cleaned, or should the user choose to store them inside at night. User A, who shines shoes in his chair, prefers the drawers because he can store all of his cloths and polishes in them, whereas User B, who makes beaded jewelry, likes the pouch because he can easily access samples that he stores in it.



a) Pouch option

b) Drawers option

Figure 2-8: Photos showing two options for storage

Lastly, this design features two types of overhead protection. On the low end of the price spectrum is the umbrella attachment developed in the first prototype which attaches via a coupling behind the chair. Slightly more expensive but more functional is an awning that covers the user's back, as well as his/her head. Made from sturdy, water-repellant nylon, this awning features a transparent section in the back to allow the user to easily see behind. It also includes optional transparent, roll-down sides to be

used in heavy rain. It connects to the wheelchair using two L-shaped pipes that fit into existing tubing in the back of the chair, and is held stable with a lengthwise connector tube. All of these pieces can be easily removed for storage.

a) Umbrella option

b) Awning option

Figure 2-9: Photos showing two options for overhead protection

As stated above, the aim of this design was to accommodate a whole range of user needs. It does this by balancing various factors that are important to the user, while offering different options that the user can choose from to customize his/her business wheelchair. The idea is that a user can come into a workshop and choose which attachments he/she wants. They can add them one-by-one as they have the money to do so, and similarly, they can upgrade as business improves.

A production manual to guide the manufacture of the current table design and the awning was produced with assistance from the technicians at MobilityCare (see Appendix B).

3 Dissemination

3.1 Distribution of Design

The first step in disseminating the small-business wheelchair is making sure that local wheelchair workshops have access to the design and accompanying drawings and plans. Working with the technicians at MobilityCare, a design manual has been developed. It is available for download at mlab.mit.edu (see Appendix B).

To ensure that workshops across Africa know about this design and to give them an opportunity to see it firsthand, a demonstration is being planned for it at the next Pan-African Wheelchair Association (PAWA) Conference, to be held in 2011. The conference will draw those involved in the wheelchair industry from across the continent and is a great opportunity to share this design with a wide audience. Printed copies of the manual will be made available, and a physical prototype will be on-hand.

Additionally, future WDDC students who travel abroad to implement their own projects will be able to take this manual and share it with their community partners.

3.2 Access to Seed Money

The success of these wheelchair micro-enterprises depends heavily on access to seed capital. The business wheelchair provides mobility and a platform for the venture. But in order to get the business off the ground, each entrepreneur needs some start-up money to purchase raw materials. For the entrepreneur who wants to run a phone recharge business, this allows her to purchase vouchers at wholesale. For the entrepreneur who wants to shine shoes, seed money means he can equip himself with the necessary tools, polishes, and materials to do the job right.

Local wheelchair workshops are currently not equipped to fill the role of providing seed money. However, several other local organizations may be able to close this gap. These include microfinance institutions (MFIs), Savings and Credit Cooperative Societies (SACCOS), and mainstream banks. Below the pros and cons of each of these sources are considered. Information gathered from meetings with representatives of these organizations is also included.

Microfinance institutions first came to mind when considering sources of seed money. Microfinance has become a buzz word in development and MFIs seem to be springing up all over the world. Connected to the West through websites like Kiva.org [8], microfinance is on its way to becoming a household word. As such, it seemed like the logical choice to support the disabled entrepreneurs. In the Kilimanjaro region of Tanzania where the pilot trial of the small-business wheelchair started, there are at least a half dozen MFIs alone, if not more. Yet somehow, the trial participants did not qualify for a microloan from any of them. A majority of them cater only to women, which immediately excluded the four male

participants. Beyond that, most of them require you to form a loan group before you can sign up. As the Arusha-based MFI PRIDE explained, the group serves to provide a guarantee on each loan that a member receives and is common practice amongst MFIs. Unfortunately, the female trial participant found it challenging to start a group of her own.

Beyond that, the loan size starts off very small, at approximately $40. Each time a loan is successfully repaid, a woman can take out a larger one. In other words, as she proves to be a trustworthy client, the MFI will lend her greater amounts. Again the reasoning behind this rule is clear, however it does not work for certain businesses. User E's business was dying batik cloth and fashioning it into clothing, skills she learned from the Kilimanjaro Association of the Spinally Injured (KASI). A $40 loan would not be enough for her to buy the necessary color dies and material to get started. While microfinance institutions were not able to provide seed money for the pilot trial, as they continue to grow and expand their services over the next few years, they may be able to fund future wheelchair enterprises.

The next type of organization considered was a SACCOS. These savings and credit cooperative societies are formed by a group of people with some common link coming together and deciding to all pool their money, with the idea being that each person will get a chance to take a larger loan from the group's pooled money. They are fairly common in Tanzania, often formed around occupations, i.e. a teacher's SACCOS or a farmer's SACCOS. The group aspect helps hold every person accountable, and interest rates are low because there is little overhead—usually just a minimal amount to cover the cost of an accountant who tracks the money. This is a simple model and seemed like a good prospect to support the wheelchair enterprises. If we could get a big enough group together, they could pool their money and then each take turns having a loan and getting started. The problem here was getting a big enough group. The pilot trial that started in 2008 involved only five participants—not enough to start a successful SACCOS. So while this may be a good option when there are more wheelchair enterprises on the road, it was not an option for this trial.

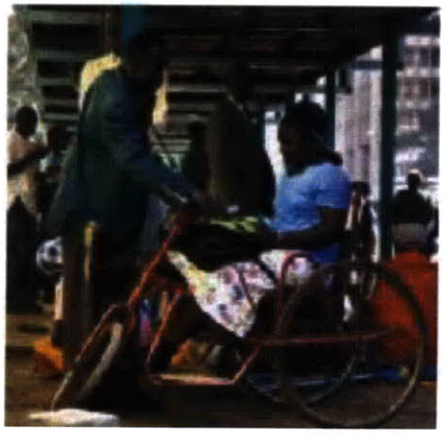
The last option considered for seed money was the mainstream banking system. After visiting several banks in the area, the National Microfinance Bank (NMB) was seriously considered [note: not an MFI, but a really a regular bank, despite the name]. NMB is the largest bank in Tanzania with 120 branches that cover 80% of the districts in Tanzania. Unfortunately, they only extend microloans to those people who have been running a business successfully for a full year already. According to a representative there, applicants are required to present a business license and tax identification number. The disabled entrepreneurs work largely through the informal sector, without the above paperwork, thus disqualifying them from such a loan.

Because none of these options were viable for the pilot trial, a system was devised whereby funding from the MIT Public Service Center was used to start a small-business wheelchair fund at Exim Bank, one of the only wheelchair-accessible banks in town. After a brief business training, each of the participants created a budget for his/her business, and was given a loan from this account to get started. Additionally, as none of the participants had bank accounts, an account was opened for each one. These accounts would help them save and track their income, and when they were ready to start repaying their loans, they could do so into the original wheelchair fund account.

3.3 Corporate Sponsorship

While distributing the design to workshops and securing access to microfinance are both critical to the successful dissemination of the small-business wheelchair, somebody still has to pay for these wheelchairs to be produced. Wheelchair financing in developing countries is a complex subject. In theory, Ministries of Health should have access to government money to fund wheelchairs, but in reality this is rarely the case. Most often wheelchairs are purchased by NGOs whose beneficiaries include the physically challenged. In rare cases they are purchased by the family of the user, but financial constraints have limited this. Compound that with the fact that disability is both a cause and consequence of poverty, and it becomes even more difficult for a disabled person to purchase his/her own wheelchair.

Over the past several years there have been a few instances where large companies sponsored wheelchairs. Safaricom, the largest mobile phone provider in Kenya, sponsored tricycles through the Association of the Physically Disabled of Kenya in 2007 [11]. In Tanzania, NMB sponsored 20 wheelchairs through MobilityCare in 2008. Each of these sponsored wheelchairs was complete with the NMB logo spray-painted onto the back of each seat.



a) Simu ya Jamii project sponsored by Safaricom

b) Wheelchairs sponsored by NMB in Tanzania

Figure 3-1: Photos showing examples of mobility aids funded through corporate sponsorship

Corporate sponsorship of wheelchairs has benefits for everybody involved. First and foremost, people who need wheelchairs get a quality product from a local manufacturer. The sponsoring company gets good PR and also spreads their logo throughout the country, often into rural villages. This is important when one considers that an estimated 70% of disabled people in developing countries live in rural areas [12]. Most of the large, local companies have corporate social responsibility offices, and operating in a developing country makes it even more pertinent that they give back to their community. As such,

corporate sponsorships are fairly common and include such things as textbooks for local schools, HIV testing services, and sports equipment for at-risk youth groups.

While there have been a few instances of corporate sponsorship of wheelchairs, there is still untapped potential here. There are a half dozen other mobile phone providers and banks that have not yet been approached in Tanzania. And beyond that, there are local organizations such as the Rotary Club and Lions Club that could be targeted too. These last two present a very valuable opportunity because they have worked with the American organization Wheelchair Foundation to import wheelchairs in previous years. A chance to expose them to the quality wheelchairs being produced locally opens up the possibility of a larger conversation about where wheelchairs come from.

Aside from the positive PR, wheelchair sponsorship is in fact a cost-effective method of advertising. With the company's logo painted on the back of the chair, everywhere the user goes, people will be exposed to that logo. Based on the costs of various types of advertisement and the number of people who would be exposed to it, one can estimate the cost of each exposure.

	Radio advertisement	Sponsored wheelchair with logo
Cost	$22 [13]	$350
Days in use	[One 30-second advert.]	1825
Number of people who see/hear it each day	300	20
Cost per day	NA	$0.19
Cost per exposure	$0.07	Less than $0.01

Table 3-1: Cost comparison of radio advertisement versus wheelchair sponsorship

While admittedly a radio advertisement is able to convey more information than a simple painted logo, it can only reach those who have access to a radio. Meanwhile, the logo on a wheelchair can be carried into the rural areas where many wheelchair users live and bring greater exposure to the company. Not only is the cost per exposure with a wheelchair advertisement less than with a radio advertisement, but the positive image it generates for the company adds even more value to the investment.

4 Conclusion

More often than not, disabled people in developing countries are part of a marginalized group. They are frequently left out of mainstream development interventions and their problems are compounded by poor infrastructure and facilities. A wheelchair provides mobility; a small-business wheelchair provides a platform to use that mobility to generate an income. When disabled people are seen as valuable, contributing members of society, their communities are more likely to accept and treat them as they deserve to be treated.

The business attachments that have been developed meet the functional requirements that were described in this thesis. The technology is locally manufacturable and provides the user with storage space for materials, a workspace to conduct business, and overhead protection. These attachments can be fitted to virtually any wheelchair found in developing countries.

After conducting a pilot trial of the product, it is clear that the small-business wheelchair provides people with disabilities with a viable way to generate income. Running a small business from a wheelchair can have a drastic effect on the life of the user. It brings financial stability, which in turn helps to elevate the user's status in his community. As a growing number of people with disabilities become successful entrepreneurs, communities will learn to seem them as productive members.

Consider the story of Frank[1], a young wheelchair user in Arusha, Tanzania. If you pass through town, you're likely to find him working at his "shop" where he makes shoes, shines them, and does basic repairs. Frank's shop consists of his wheelchair, with drawers under the seat where he stores material and a large awning that protects him from the hot African sun and occasional pounding rain. He has recently started producing beaded sandals for women, purchasing the necessary tools with profit from the previous months' business. In his first month of sandal production he sold 10 pairs. Frank takes his new status as a successful businessman seriously and has recently started training a disabled friend to join him.

Further dissemination of the small-business wheelchair is contingent upon funding, both for the wheelchair itself and for the seed money that allows the entrepreneur to purchase raw materials. A number of financial options have been explored, and while none were appropriate at the time of the pilot trial, the combination of corporate sponsorship and microfinance provides a promising opportunity. As corporations in places like Tanzania continue to prosper financially, they will not only be more compelled to contribute to local poverty alleviation efforts, but will also have more money to do so. At the time of writing, MobilityCare has begun reaching out to local corporations to both raise awareness about the issue of disability and also to offer companies a chance to sponsor wheelchairs from their workshop.

[1] Name changed to protect privacy.

Microfinance can close the loop, providing people with disabilities with the seed money they need to get their businesses off the ground. With only five participants in the pilot trial, it was difficult to form a loan group— a necessary step at most MFIs. However, if a company sponsors upwards of 20 small-business wheelchairs, the recipients of those wheelchairs can work together to form their own group. Financial services are expanding in Tanzania as an increasing number of MFIs open up. This expansion is likely to create opportunities for more Tanzanians to access these services, including those people with disabilities who want to start businesses on their wheelchairs.

With the dissemination of this design and likelihood of corporate sponsorships on the way, hopefully the small-business wheelchair can offer many more disabled people in developing countries a helping hand.

Appendix A: Important Acronyms

KASI	Kilimanjaro Association of the Spinally Injured
KCMC	Kilimanjaro Christian Medical Centre
MFI	Microfinance institution
M-Lab	Mobility Lab at MIT
PAWA	Pan-African Wheelchair Association
TATCOT	Tanzania Training Center for Orthopedic Technologists
WDDC	Wheelchair Design in Developing Countries class taught at MIT

Appendix B: Production Manual

This appendix has the production manual for the small-business wheelchair. It is aimed at wheelchair workshops across the globe, and will be available online at: mlab.mit.edu

Business Wheelchair

Production Manual

Includes engineering drawings,

step-by-step instructions, and sample photos

Table of Contents

1 Introduction to Product

The business wheelchair was developed in order to enable disabled people to become entrepreneurs. Wheelchair users already face a lot of discrimination in the workplace, making it difficult to find a steady job. This product aims to bring the business right onto the wheelchair, with the user in charge.

It was developed as a collaboration between students at the Massachusetts Institute of Technology (MIT) in the United States, and technicians at MobilityCare Wheelchairs in Arusha, Tanzania.

This product has been designed as a series of attachments that can be added to wheelchairs commonly produced in developing countries. If an attachment mechanism described here does not fit with the model of wheelchair you produce, feel free to modify it as you see fit.

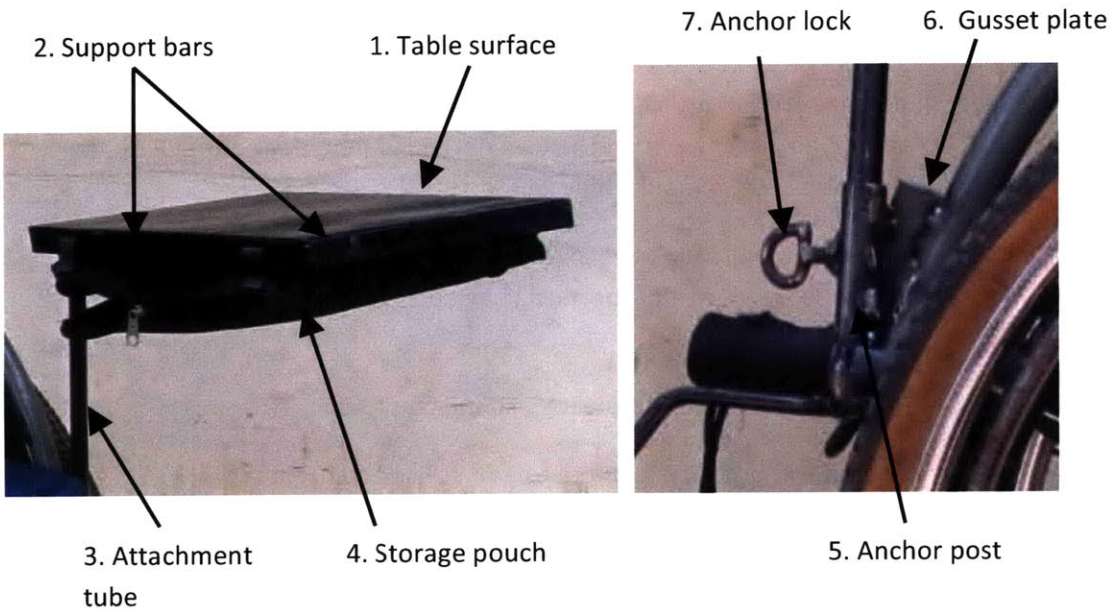
This manual will walk you through the production of each attachment. Engineering drawings are included to aid in production, and photos of the final products have been included to give you a clear idea of what they look like.

For more information about the business wheelchair please visit mlab.mit.edu

And if you have any questions about this product, feel free to e-mail Tish Scolnik at tishscolnik@gmail.com

2 Table Attachment

2.1 Items

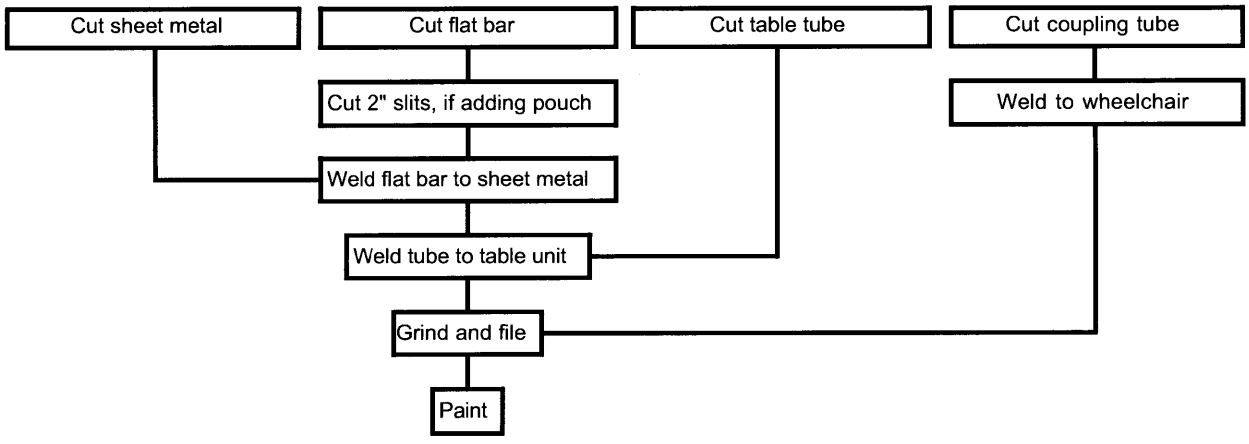


Item	Description
1	Table surface
2	Support bars
3	Attachment tube
4	Storage pouch (optional)
5	Anchor post
6	Gusset plate
7	Anchor lock

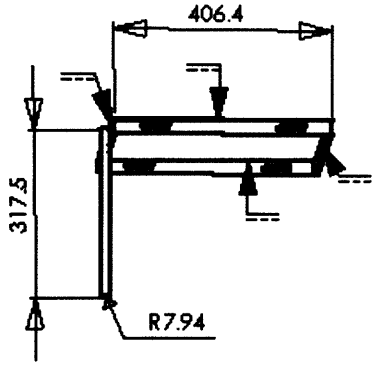
2.2 Parts List

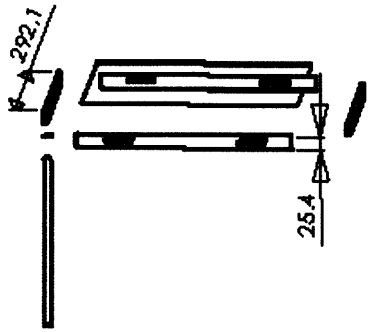
Item	Component	Number needed	Material	Cutting Length
Table Surface		1	1.5mm thick sheet metal	12" by 16"
Support bars	Long supports	2	¼" thick by 1" high flat bar	16"
	Short supports	2		11.5"
Attachment tube	Tube	1	5/8" OD	12.5"
Pouch	Bag	1	Nylon	1 meter
	Zipper	1	--	1.5 ft
	Velcro	4	--	12"
Anchor post, support and lock	Tube	1	19mm ID tube	72 mm
	Nut	1	M8	
	Bolt	1	M8 x __ mm	
	Handle (?)	1	7mm D metal rod	
	Support	1		

2.3 Production Steps for Table

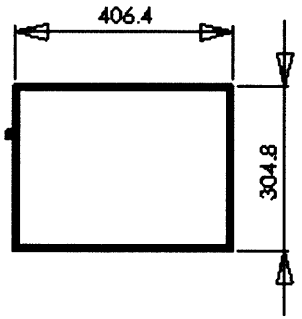


2.4 Drawing of Table





Note: The above slots are for the optional pouch to be strapped through



Notes:
1) Sheet metal should be flattened at start
2) Slots in long support bars should be just large enough for strap to pass through

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Natasha Scolnik

Table

SIZE	DWG NO	REV
A		
SCALE: 1:0	WEIGHT:	SHEET 1 OF 1

2.5 Photos of Completed Table

Close view of table anchor

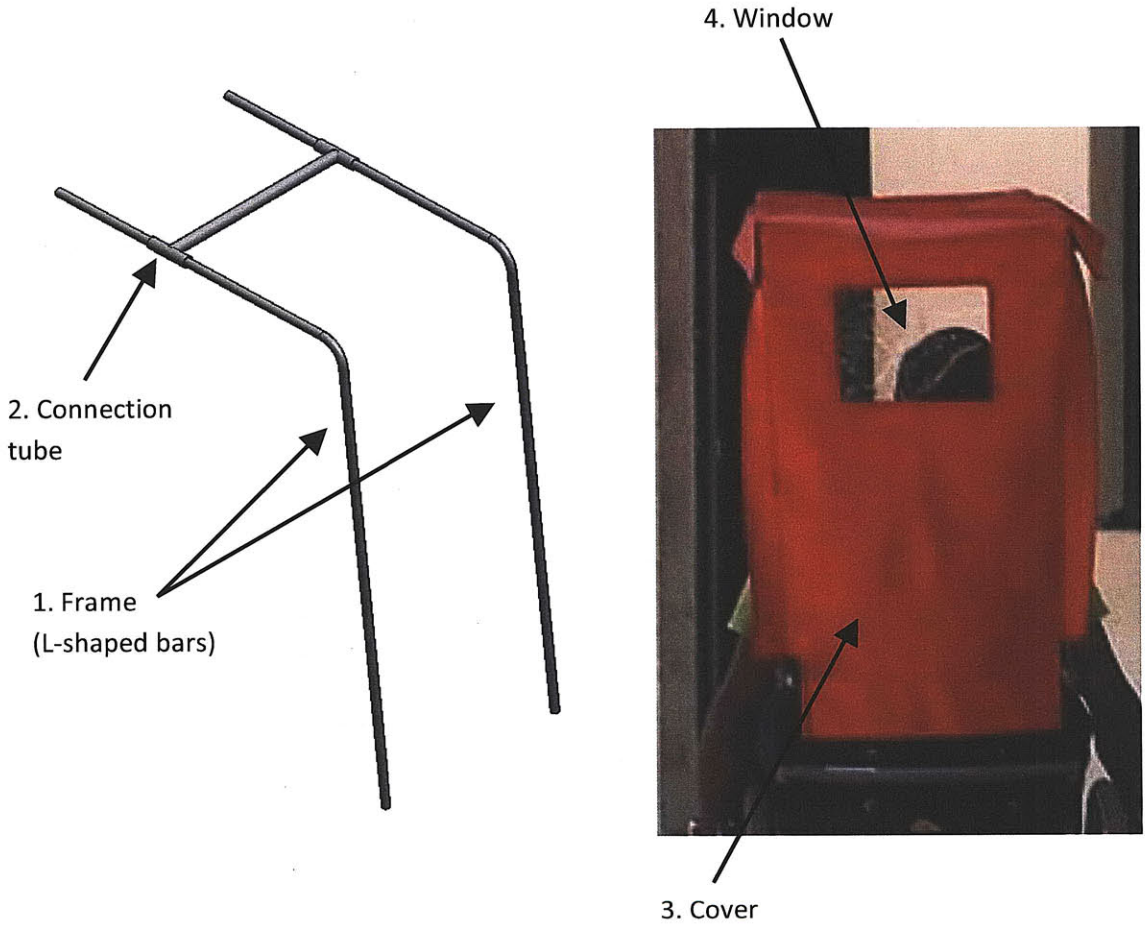
Storage pouch, under table

Table in front position

Table in side position

3 Roof Attachment

3.1 Items

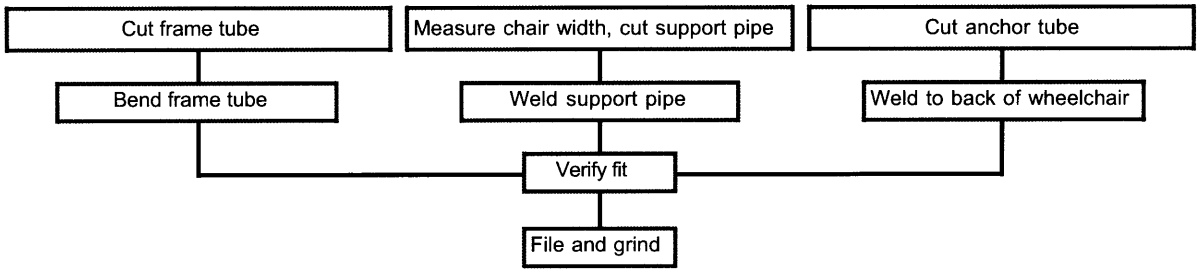


Item	Description
1	Frame (L-shaped bars)
2	Connection tube
3	Cover
4	Window

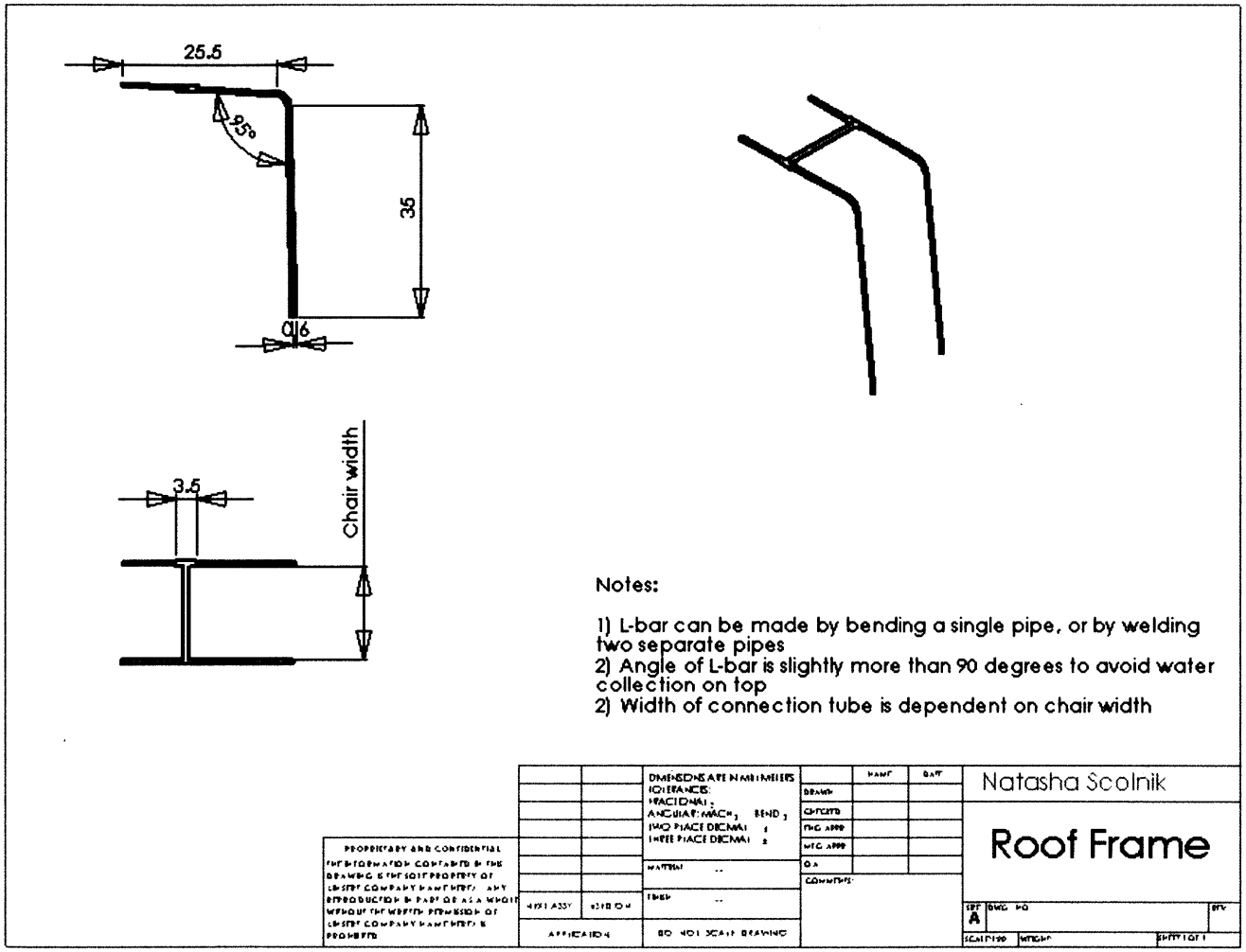
3.2 Parts List

Item	Component	Number needed	Material	Cutting Length
Frame	L-shaped tube	2	16 mm OD tube	60.5" long
Reinforcement	Connection tubes	2	19mm ID tube	3.5" long
	Lengthwise tube	1	19mm ID tube	Width of chair
Anchor coupling	Anchor tube	2	19mm ID tube	150 mm
Cover	Main cover	2 meters	Waterproof fabric	
	Back window	1	Transparent plastic	24mm by 17 mm

3.3 Production Steps for Roof



3.4 Drawing of Roof



3.5 Photos of Completed Roof

Front view

Back view

Roof frame, connection tube, and cover spread out

4 Frequently Asked Questions

What if I don't have the tube sizes used in this manual? Can I still make these attachments?

> Don't worry if you don't have the exact tube sizes used here. The important thing is that tubes which have to fit inside each other match. Where one tube is designed to fit inside another, they should slide easily, while extra space is minimized.

The wheelchairs I produce either don't have round tubing in the back to insert the roof frame, or the frame is not accessible there. What can I do?

> If existing rear tubing cannot be used, you can add your own connection brackets. Take the anchor tubing that would have been welded into the existing tube, and add it onto the outside. Be careful to keep the fabric of the seat intact. Note: If they have square tubing which is accessible, you can modify the roof frame to have square pipe at the connection area.

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