TRICYCLE FRAME

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IDES4310 | WINTER 2013

HARAMBEE >>> PULLING TOGETHER

ABSTRACT

IDES4310
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Winter 2013
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This report outlines the design process, testing and final design of the “Design Innovation for Kasese: Tricycle Frame, Redesign for Manufacture” project, taking place January to April 2013. The concept development, includes using tools such as computer simulation and the development of the design. The testing includes the methods and results of the user testing done in Uganda, as well as, the design modifications done due to the feedback and results of testing. The final design has the features outlined, and specification is included for the frame and all parts.

ACKNOWLEDGMENTS

This project has involved a great number of partners. The closest of these being my team members, Carmen Liu, Ruby Hadley and Andrew Theobald, with whom I have worked closely and all have made great contributions to my individual project.

Other very important partners that have made this project possible include Navin Parekh, from Canugan and Bjarki Hallgrimsson, lead investigator on the Design Innovation in Kasese project. They have brought this project to us and given us the opportunity to work on it as our fourth year thesis project, along with the Read Initiative at Carleton and especially Dean Mellway.

In Uganda, I must thank Kio, with whom I was able to work with closely and he has made my project what it is. I also thank Robert from Canugan, as well as, Peter and other members of Kadupedi who were all fantastic before and during our trip.

I must also thank and acknowledge the advice and guidance of Aaron Wieler and Noel Wilson, who have provided valuable feedback and insight into this project.

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IDRC CRDI

(left to right) Ruby Hadley, Carmen Liu, Stephen Field, Bjarki Hallgrimsson, Alyssa Wongkee and Andrew Theobald

EXECUTIVE SUMMARY

DESIGN DEVELOPMENT

Based on the research, the goal was to design an improved tricycle frame. Through sketching, desktop modeling and CAD, different ideas and concepts were explored for the frame. The concepts were based around decreasing the cost and improving the strength of the frame. It was important to always consider the cost and manufacturing capabilities for the frame. The designs needed to be economical with material, as they were to be hand-made they needed to be customizable at the time of fabrication for every user.

TESTING PLANS

Prior to user testing, it was vital to plan how the testing would take place and prepare for the testing. This included making models and prototypes. The first was fabricated in Canada, it was a scale model for the purpose of communicating the proposed design. The second was a prototype which was made in Uganda by the manufacturer. Drawings needed to be sent via email, they needed to be clear as communication was limited.

TESTING IN KASESE, UGANDA

Testing took place in Kasese, Uganda during a two week field trip. While in Uganda, the testing was done through talking to the manufacturer and end-users. We used the prototype to primarily create discussion about the tricycle design, it's features and this was the catalyst for several design changes.

FINAL DESIGN OF TRICYCLE

The final design was completed once back in Canada. The final design was influenced by the insight gained from the prototype and testing in Uganda. Some of the key features were; reduced material use, which reduced the cost; improved rigidity, making it stronger and require fewer repairs; more cargo space, potentially allowing the user to have more economic opportunities; and easier handling, which improves user comfort.

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BACKGROUND

What's the context of the project?

There are over 5 million Ugandans living with disabilities. Many of these people are mobility impaired because of diseases like polio and cerebral palsy, which leaves many trapped in a cycle of poverty. Hand-pedalled tricycles have proven useful in helping those with impaired mobility. They are an appropriate solution in Uganda and much of developing world, because they are more suitable for the rough terrain and more afford-ably built than most wheelchairs. These tricycles are manufactured in many developing countries in small shops and at a low cost.

Currently, in the Kasese district of Uganda, hand-pedalled tricycles are manufactured by a local craftsman. The users of these hand-pedalled tricycles are people with disabilities who live locally in the district. The Canugan project has been funding for the tricycles to be given to potential users them through Ugandan and Canadian NGOs. Having a tricycle as a vehicle they can use independently gives them mobility, freedom and independence.

Most of the current users, many affected by either polio or cerebral palsy, have some core strength which is able keep them steady on the tricycle, and are able to climb in and out of it without aid.

The craftsman who makes the tricycles is a self-taught welder, who has owned a metal shop for years. Two years ago he was hired to build his first tricycle for a woman who was disabled by polio. He now makes can make up to three per week, and uses steel tubing, and bicycle parts to make the tricycles. The shop where he manufactures the tricycles is very basic, he mainly uses a locally made tube bender and vice as well as a stick welder, and cuts the pieces to size using a hacksaw. Every tricycle is a one-off, custom design that the craftsman makes from memory and experience. The manufacturing of the tricycle relies heavily on the immense skill and experience of this single craftsman.

The first section of this project, research was conducted, it was discovered that opportunity existed to improve the tricycle frame design, so that it would be more easily manufactured, cheaper and also provide improvement to the user. From the research, measures of success were defined. Several preliminary concepts were generated, which aimed to change the structure of the frame.

REQUIREMENTS

Measures of Success and Considerations

From the initial research, measures of success and design considerations were outlined. These would help to guide and inform the rest of the design process.

MEASURES OF SUCCESS

1. Ability to be made locally in Kio's shop
2. Reduction of time required for manufacture
3. Materials must be easily sourcable and available in the Kasese region.
4. Able to withstand harsh climate
5. Simplicity of manufacturing
6. Enables some adjustability for user
7. Quality and consistent parts produced

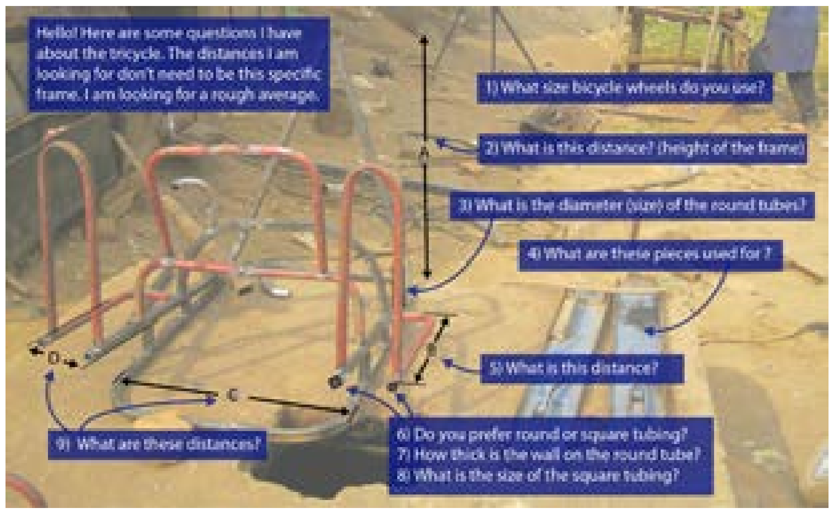
DESIGN GUIDELINES

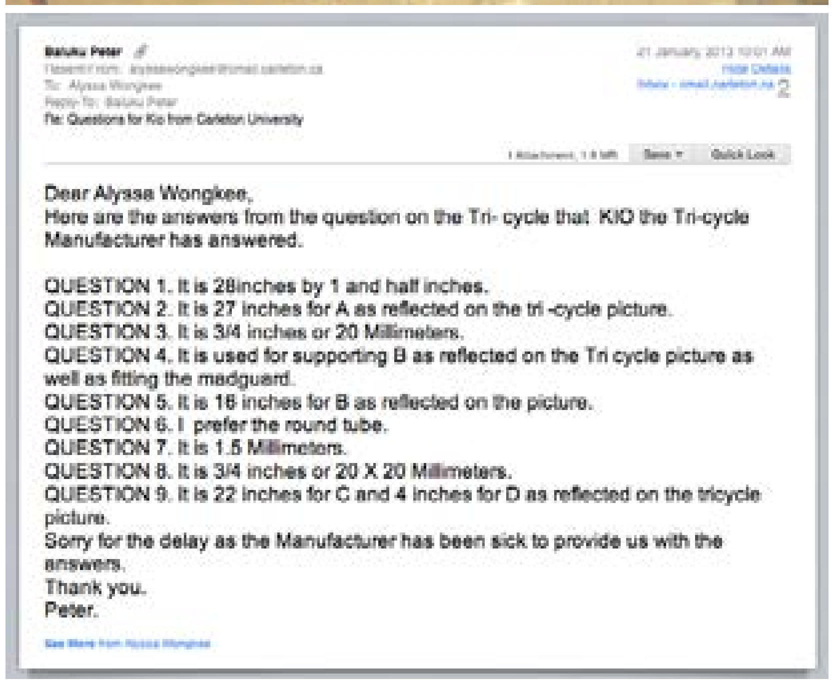
Decreasing the skill required for manufacture, should be done through the use of fixtures which discourage misuse and requires little skill to set-up and operate. No fixtures should easily be mistaken for one another and it should be impossible to mount a part into the fixture in the wrong orientation.

Decreasing the cost of the tricycle is done by decreasing the cost of materials or labour. Decreasing labour costs can be accomplished by decreasing the number of welds and cuts needed. Creating identical parts eliminates the labour needed to for fittings.

Two of the most time consuming tasks can be improved. The brakes can be simplified to use fewer parts, which also require less labour to adjust and fit. The use of a fixture to expedite the wheel alignment should be considered. Making the design adjustable for the user can be done in two ways. The first being making the design simple to change and adjust systematically in the manufacturing phase, so that the tricycle is customized to each user. Alternatively all the tricycles can be manufactured identically and can be adjusted by the user during ownership.

Email communications with the manufacturer:





Baluku Peter

To: Alyssa Wongkee

Reply-To: Baluku Peter

Re: Questions for Kio from Carleton University

21 January 2013 10:01 AM

Dear Alyssa Wongkee,
Here are the answers from the question on the Tri- cycle that KIO the Tri-cycle Manufacturer has answered.

QUESTION 1. It is 28inches by 1 and half inches.
QUESTION 2. It is 27 inches for A as reflected on the tri -cycle picture.
QUESTION 3. It is 3/4 inches or 20 Millimeters.
QUESTION 4. It is used for supporting B as reflected on the Tri cycle picture as well as fitting the madguard.
QUESTION 5. It is 16 inches for B as reflected on the picture.
QUESTION 6. I prefer the round tube.
QUESTION 7. It is 1.5 Millimeters.
QUESTION 8. It is 3/4 inches or 20 X 20 Millimeters.
QUESTION 9. It is 22 inches for C and 4 inches for D as reflected on the tricycle picture.
Sorry for the delay as the Manufacturer has been sick to provide us with the answers.
Thank you.
Peter.

DESIGN DEVELOPMENT

Concept Development - FEA Testing

After the Initial research and concept ideation, the design needed to be further developed and a testing plan conceived.

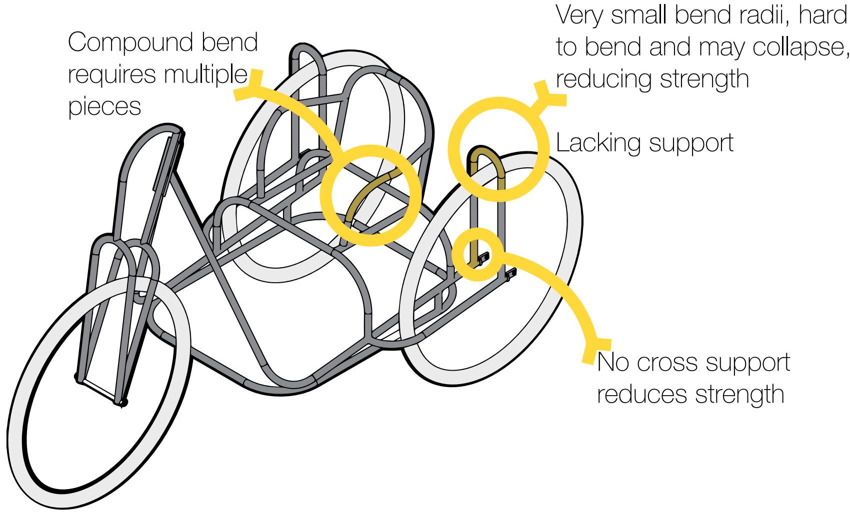
One of the challenges faced was that, being in Canada, we did not have access to the specifications of Kio's tricycle frame design. This meant that it would be challenging to be able to compare the improved design with the original design if tested in Canada prior to the Kasese trip. Due to this restriction, it was then decided to create the definitive design prior to departure, and then test a working prototype in Uganda in late February.

After deciding to create a definitive design without user testing, it was decided that computer testing could be used in order to assess the design throughout the development of the tricycle frame design.

The main goals at this stage was to improve the structure of the tricycle, while also making the manufacturing more efficient. In order to determine the current weakness in the tricycle frame, it was modeled in Solidworks, based on photographs and dimensions acquired through email communications. Using Solidworks Simulation and Finite Element Analysis, the largest stress points were determined.

In Figure 1, it is possible to see the areas of the largest stress, with the most stress being represented in green. Three areas were noticed; the bend which attaches to the front fork; where the main frame attaches to the axle of the rear wheel; and where the "wing" for the wheel attached to the main frame. The two areas near the rear wheels were of particular concern, because if these pieces were to warp or bend, it would mean that the wheels would fall out of alignment. This would cause problems for the functioning of the tricycle, and also damage the wheel rims, eventually leading to breakage and necessary repair.

Figure 1: Kio's Tricycle Frame in Solidworks Simulations



Design Development - FEA Testing

Several simulations were run without major changes to the design (Figure 2). For example, adding an extra cross beam for the extra wheel supports. These were done to further understand the structure of the tricycle frame, and to see the importance of various parts.

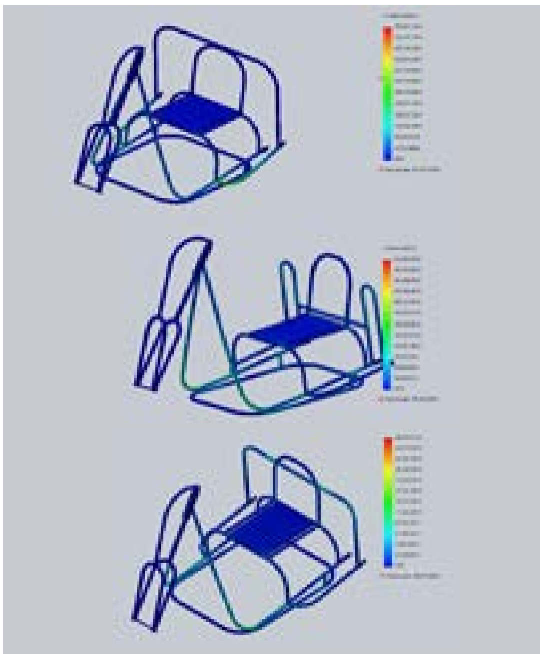


Figure 2: Solidworks Simulations

After a basic understanding of the structural elements of Kio's design, two designs developed. They were based on two principles which would use less material and also create more efficient manufacturing. These were to use fewer pieces and to use fewer bends. This was based on the assumption that the more complex part of the manufacturing process was to measure, cut and weld pieces together and to create the bends.

Some other details were that all the bends were 90 degrees and all had the same radii. Both designs eliminated the smallest radii needed in the wheel supports. It also eliminated complex bends, where if there is multiple bends on one piece, they were all in the same plane.

The designs improved on the two weak points discovered using Solidworks Simulation. This was done by attaching the wheel supports to the seat. This allows the seat, which is a rigid element to absorb the stress. The design in Figure 3 focuses on using straight pieces that can be cut to length to construct the seat. This means that all the bent pieces can be the same size for all tricycles, and only the straight pieces must change depending on the size of the end-user. This would allow the possibility for jigs and fixtures to be made for the cutting and bending the complex pieces.
The design in Figure 4 has fewer pieces, this means that less electricity would be used for welding, and less time would be needed for cutting. However, this means that there are more complex pieces, and these pieces would need to be different lengths depending on the size of the end-user

Using Solidworks Simulation, the two designs were assessed. Both improved the stress levels on the weak points. The first design, in Figure 3, was selected. This is because it provided more advantages for manufacturing.
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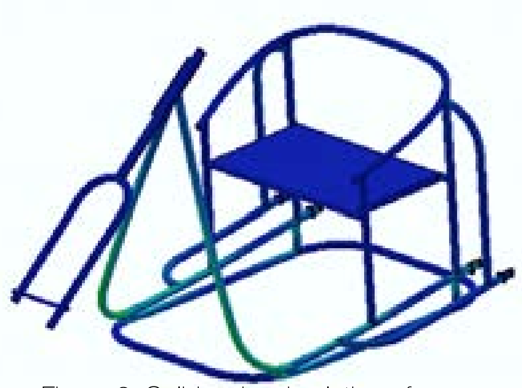


Figure 3: Solidworks simulation of an improved design.

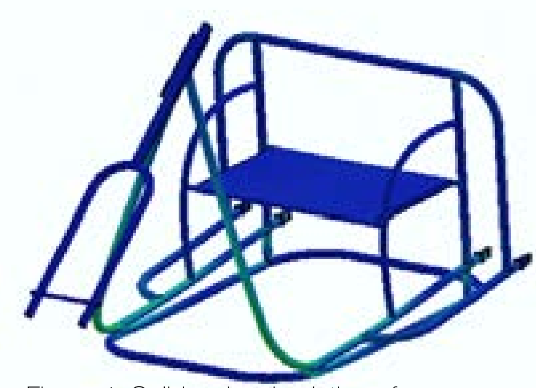


Figure 4: Solidworks simulation of an improved design.

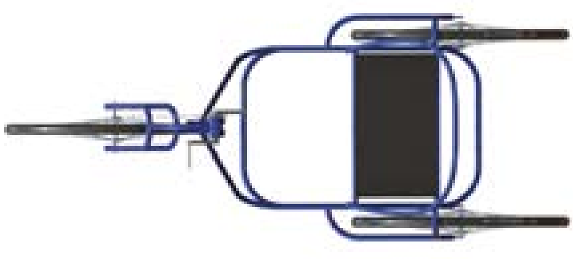
DESIGN DEVELOPMENT

Definitive Design

Using the same front fork and drive system as Kio's design.

28 Inch tires, the ones that are currently used, since they are the most easily sourced

The improved design narrows the frame slightly, allowing the seat to become a more integral part of the structure of the frame. This also reduces the material used because the seat acts as a structure element for the overall frame.



EASIER MANUFACTURING

Use of fewer bends,
All bends are 90 degree
Larger bend radii possible
All bends have constant radii of 5"
All bends are on one plane.

LESS MATERIAL USE

Improved design requires less steel tubing due to the seat being more integral to the structure.

STRUCTURAL RIGIDITY

Improved due to the seat's integration into the frame, giving the frame additional cross beams.

TESTING PLANS

Scale Model

In preparation for the trip to Uganda, plans were made for user testing. The goal being to confirm the manufacturability of the improved tricycle frame design. Discover the manufacturing methods for building the tricycle. Which would be achieved through one-on-one interviews with the manufacturer and users, the commission of a prototype to be built and direct observation of the manufacturing process and conditions.

The biggest thing that needed to happen was for the definitive design to be communicated to the manufacturer and the users. This would be done by a full scale prototype manufactured in Uganda. However, since the accurate representation of the definitive design was not guaranteed through the commissioned prototyped, a scale model was built in Canada that would be flat packed in case it was needed to communicate the design to users and manufacturers in Uganda.

The model was made 2/3 scale, out of galvanized conduit. It was attached using cable ties, so that it would be able to be disassembled for travel.

There were two main purposes of this model. The first being for communication of the frame design. The second being to test the complexity of the manufacturing. The manufacturing process was validated, because I was able to build the model in two days, using a pipe cutter and tube bender. For the cable ties I needed to use a milling machine, but that would not be needed for the actual manufacturing, as it would using welding to assemble.

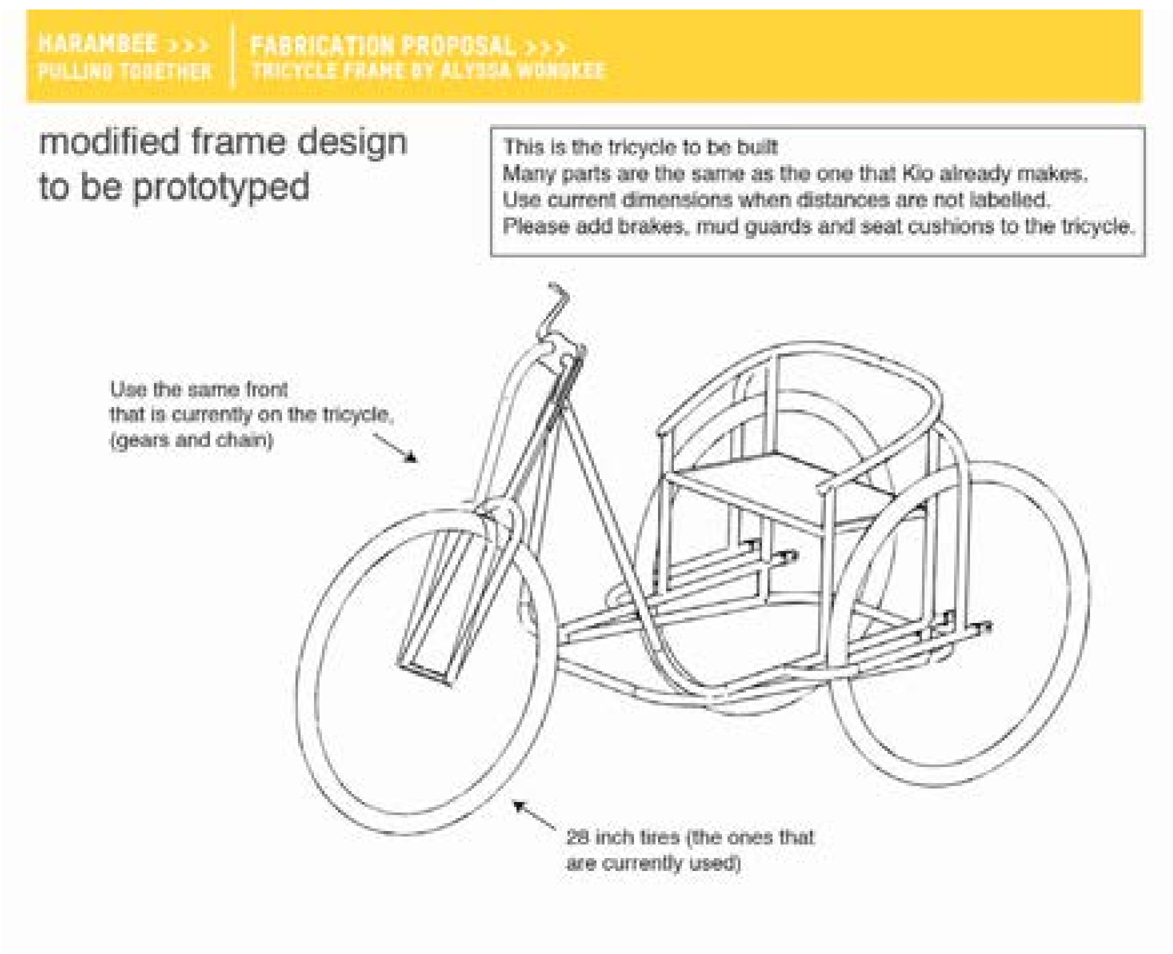
TESTING PLANS

Fabrication Proposal

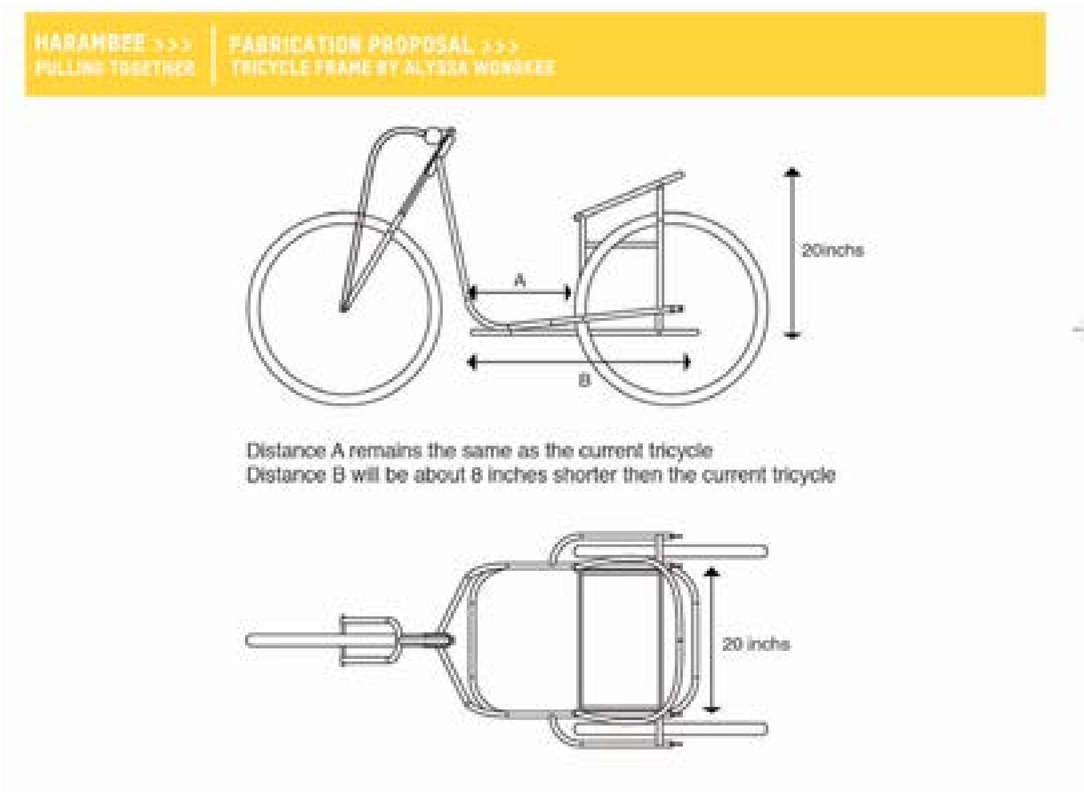
The biggest challenge for testing of the design, was communication. It was vital to be able to communicate to the manufacturer, and when in Uganda, to users, in order to receive feedback about the frame design.

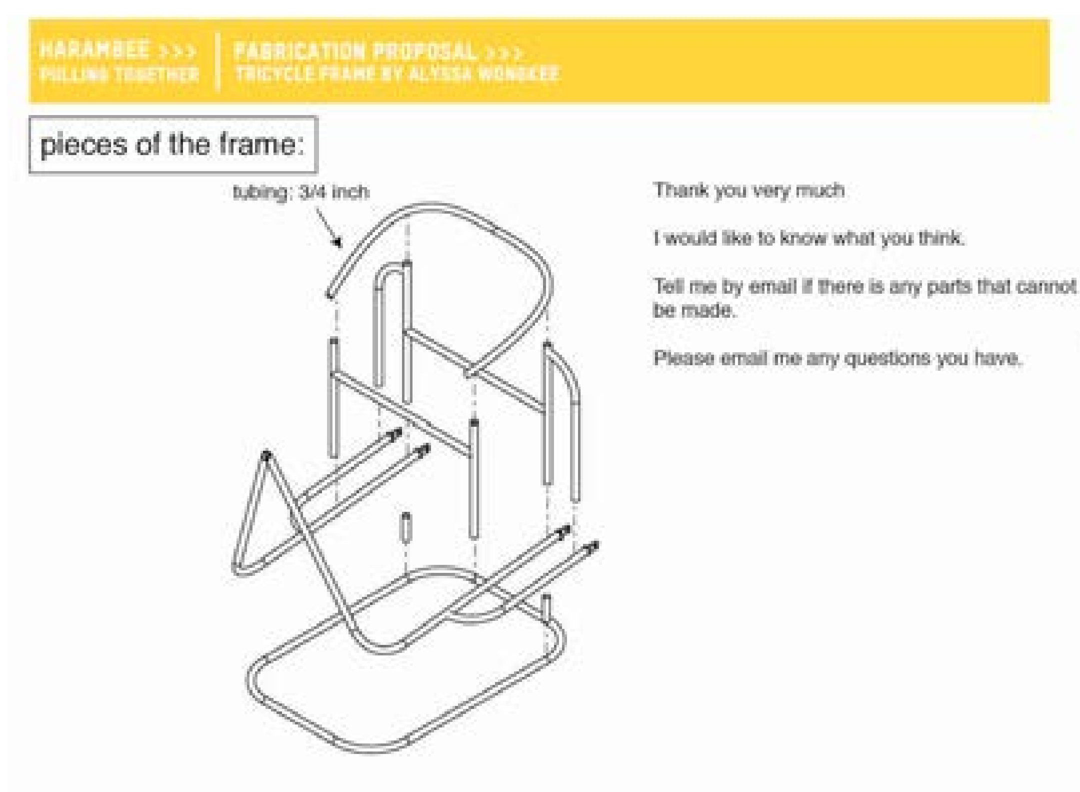
A full scale prototype was to be manufactured in Uganda. The fabrication proposal consisted of three pages of drawing, which included a line drawing of the tricycle, front and top views, and an exploded view. There were only overall dimensions included, because it was unclear if providing detailed specifications would be unclear to the manufacturer. Some dimensions were also omitted because not all the dimensions of the original tricycle frame were clear.

Figure 5: Fabrication Proposal



Fabrication Proposal





Fabrication Proposal

Using the fabrication proposal, the manufacturer was able to send a picture of the nearly completed tricycle before we left Canada.

Figure 6: Photo received from Kio via email

TESTING IN KASESE

Prototype used for Testing

Upon arrival the prototype was completed. It very accurately represented the design intent and fabrication proposal. Kio had made it from the drawing, and I saw that he had with his pen added dimensions.

Prototype for Testing

CHANGES MADE

Kio was able to make the prototype using the dimensions and the drawings that were sent to him.

He made a few small changes in order to improve the prototype:

He moved the seat forward, so that the pedals could be reached.

He shortened the tubing attaching the front fork so that it would be stronger.

Kio changed the width of the tricycle, he had misread the drawings, he thought the width of the base was supposed to be 16 inches instead of the 20 inches. He made a judgment call and constructed the prototype with an 18 inch width.

The drawing of the seat was unclear, so it was built with a straight back, instead of an incline.

TESTING IN KASESE

User Feedback

LEARNING FROM OTHER TRICYCLES

In Uganda, there was also an opportunity to test and learn from other tricycle designs.

To the left, is a tricycle fabricated in Jinga, Uganda. It is four years old and is used by a farmer, Saidi. It was very evident that it had been repaired many times, and entire sections had to be replaced.

It was discovered that where the front tubing attaches to the main frame is, in fact, a concern because it had broken many times. The wheel alignment was also a concern, as the frame had been modified several times to realign the wheels.

Below are the tricycles that Kio makes. I was able to take the measurements and compare them to the new design. They had the same comfort and similar handling. This meant that the improvements had not sacrificed user comfort or usability.

TALKING TO USERS

Having the prototype was a perfect way to initiate dialogue with users about the tricycle.

Bwambale Saidi Kibandeya (Figure 7) is a 60 year old farmer who became disabled later in life. He has had his tricycle for four years and must replace parts often, the tires once every three months and brakes once a year. Saidi will carry 20 kg by himself but if he has help can carry up to 80 kg, he would like to be able to carry 100 kg. When going up hill he needs help. He travels 5km to his farm each day.

Muhithane Elisha (Figure 8), suffered from polio and has been a tricycle user for ten years. He repairs shoes using his tricycle as a business platform. He noted that the brakes must be easy to reach.

Mark (Figure 10) reinforced the importance of the brakes being easy to use, also adding they should be easy to push

Margaret (Figure 9) commented on the arm rests on the prototype was difficult to use, and was not very comfortable.

Figure 7: Saidi-Tricycle User

Figure 8: Elisha-Tricycle User

Figure 9: Margret -Tricycle User

Figure 10: Mark-Tricycle User

User Feedback

We also had the opportunity to visit with people with disabilities in two different villages. Firstly we visited with a partner organization, and talked to people with different types of disabilities, many of them with mobility impairments.

We were also able to talk to and visit the homes of some other people with a variety of disabilities.

One of the main comments heard over and over again was the desire to be able to make money. They wanted mobility aids that would not only help them get around but also empower them to be able to make a living and contribute to their families and communities.

TESTING IN KASESE

Co-Design

COLLABORATION

One of the main advantages of being able to go to Uganda for testing was to be able co-design with the manufacturer. Because of the length of the visit, and the close proximity of the end-users to the manufacturer, it was easy to talk to the manufacturer throughout the testing phase and have his input.

There were some changes that Kio had made before I arrived in Uganda, discussed in a previous section. In addition to that there were some other improvements that we discussed and found solutions for together.

With the manufacturer, we were able to solve the problem with the uncomfortable arm rests. He had made the suggestion of lowering the wheel supports, and then together we discussed lowering the arm rests at the same time. We were also able to discuss the width and the position of the seat.

He was also able to explain the reasoning behind some of the design features of his design, which allowed for more educated decisions when making modifications, for example, the extra front fork, and why it wasn't welded together.

TESTING IN KASESE

Findings and Proposed Changes

SUMMARY OF FINDINGS

Need for extra cargo space.

The arm rests could not be used, they were too high.

It was difficult to steer because the wheels flopped from one side to the other.

Repairs were done frequently

The front of the frame was a weak point and can be broken.

In the original tricycle frames, back wheels would become unaligned, and they would be fixed by adding steel to the supports to straighten it out

The backrest is too low to be comfortable to sit in all day.

Tires are replaces once every three months.

The tires are often used when flat, wearing out the tire more quickly

When manufacturing, Kio uses parts from India and from China, having to modify them to fit together. It costs money for every bend he makes, and also for the electricity he uses when welding.

The 18 inches was too narrow

The seat is uncomfortable with a straight back and with no dump angle.

PROPOSED CHANGES

While in Uganda, some of the solutions were discovered in the process of co-design with Kio and with users. Talking to users, we discovered that extending the cargo basket would benefit them by allowing them to hold more goods. The extension of the backrest was also discussed. In collaboration with Kio we found a solution to the arm rests, we would be able to cut the back posts for the seat shorter, this would also save material on the seat and the wheel supports. it was also determined that the changes to the arm rests did not need to have any affect on the size of the back rest.   We also discussed width of the tricycle, which could easily be extended by two more inches.

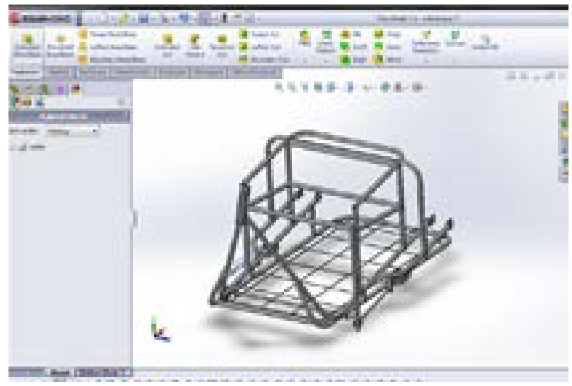
FINAL DESIGN

Finalizing the design and making modifications

Once the testing phase was complete. Modifications based on the findings needed to be made and the design finalized. This was done primarily using Solidworks, and also sketching. Creating a new model based on the new design.

Figure 12: Roadster Tricycle

Figure 11: Tricycle Frame in Solidworks



An assembly of the tricycle was made, using the modeled frame and parts from an existing roadster bicycle assembly.

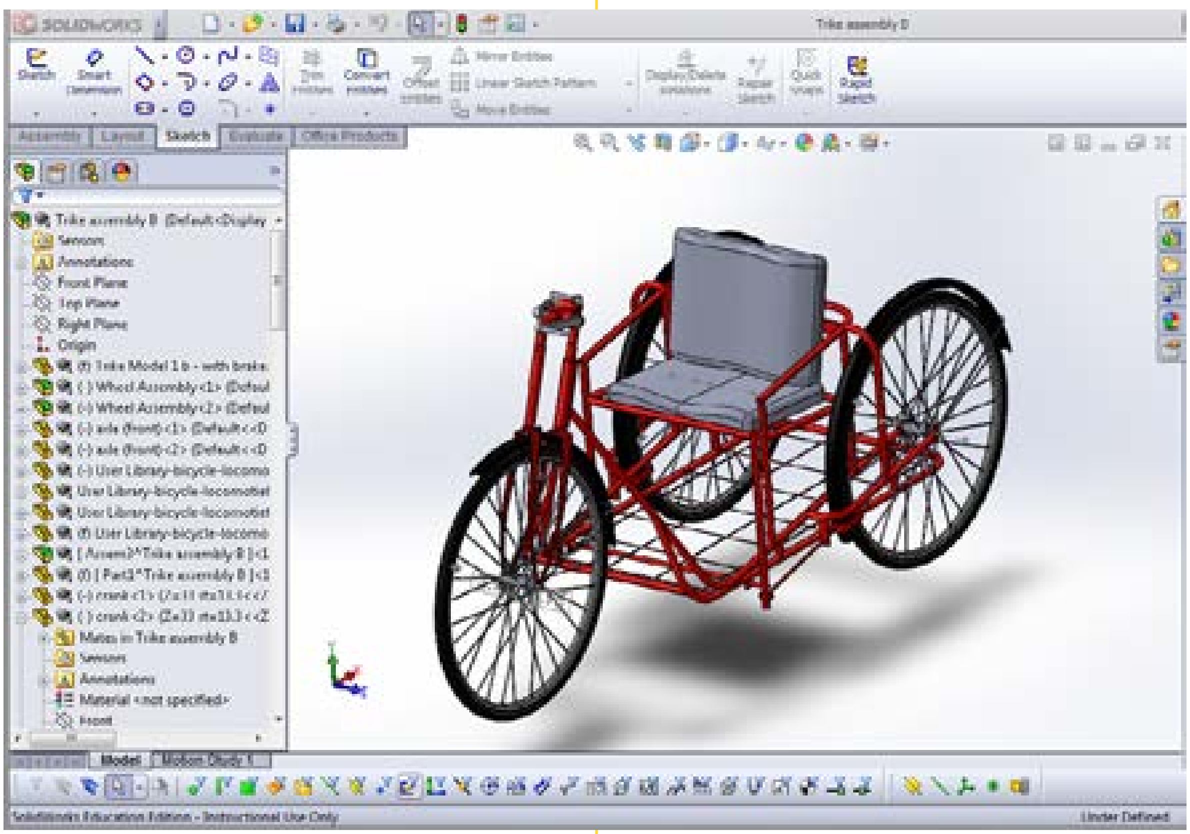


Figure 13: Tricycle Assembly

FINAL DESIGN

Key Elements

The final design included the tricycle frame, but also encompassed the seat cushions and braking system.

The tricycle was painted red, this was chosen as a group. Red being a bright color, and also a good color to represent Canada. The seat fabric was sourced in Uganda, and gave it an Ugandan aesthetic.

Key Elements

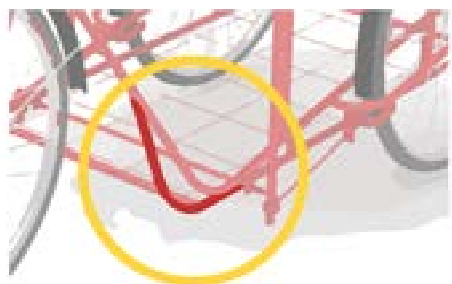
STRUCTURAL IMPROVEMENTS

SEAT STRUCTURE

The seat structure was an improvement to the tricycle. Having the seat frame act as crossbars for tricycle made it more rigid, and it will remove stress from other areas of the tricycle. This design decision was covered in the section on the definitive design, and was made prior to testing in Uganda. The improvement was proved using FEA analysis

REINFORCEMENT

Reinforcing the front tubes will reduce the repairs needed. This adds some material to the design, but it will prevent breakage and repairs needed to the frame. This problem was evident in the FEA analysis and confirmed during user feedback and research in Uganda.



STEERING COLUMN

Increasing the angle of the steering column reduces the risk of the load of the tricycle deforming the wheel. This is because, when the angle is increased, the frame has a smaller displacement when the wheel is turned side to side. This means that there is less force pushing the wheel into the turning position. When the tricycle is at rest and the wheel is turned to the right or the left, all the weight is pushing on the side of the rim. This causes the wheel to be pushed out of line, which means it needs to be adjusted to be made true again, without any replacement of parts. However if it could also bend the rim, which would mean the rim would need replacement.

Key Elements

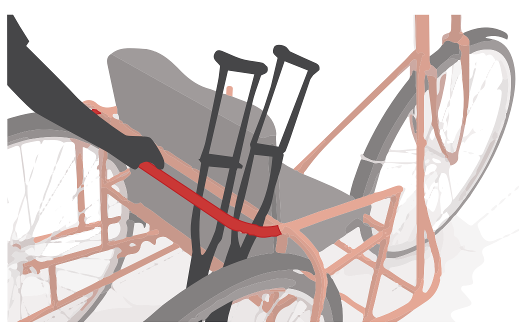
USABILITY IMPROVEMENTS

MORE CARGO SPACE
Extended bottom rack and more storage under the seat.

PULL-LEVER BRAKES
Reduces risk of falling forward while braking and sudden stop.

EASIER TO STEER
Increasing the angle of the steering column makes it easier to handle the tricycle.

PUSH BAR



Used to push user. Can also be used to attach bags or to strap in cargo

ECONOMICAL IMPROVEMENTS

LESS MATERIAL
A more simplified design reduces the material used. The new design eliminates the use of a spring in the braking system.

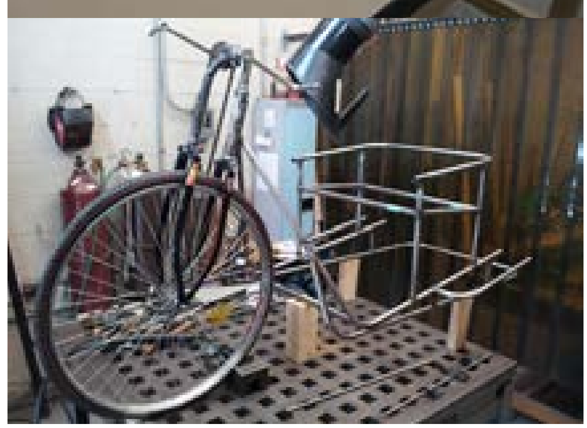
SIMPLE MANUFACTURING
Reducing the complexity of parts and number of bends results in cheaper manufacturing

FINAL DESIGN

Final Prototype

The building of the final model started in Uganda. Kio was commissioned to make the front fork of the tricycle. This was done because many of the parts required would need to be sourced in Uganda, He used the required bicycle parts and made the gear and chain function when pedalled. He attached the angle iron to the steering column so the front would be able to be attached to the main frame.

Using solidworks drawings, the first step was to create life sized drawings. Top and front views were drawn. Then tubing was cut and bent to the correct dimensions. Using a minimal amount of fixtures, the tubing was welded together. Because of the drawings, all the tubing was able to be cut and bent before welding started, with only minor adjustments being made to make it fit together.



Final Prototype

SEAT CUSHION DESIGN

The design for the seat cushion was very similar to how they are in Africa. There is a wooden base, covered in foam, and upholstered with a thick vinyl. There are two sections, the backrest and seat.

The vinyl is used because it is weatherproof, the wood provides the support needed, and the foam the comfort desired. I made a change of adding the raised side so that the user would feel more secure in the seat.

BUILDING THE SEAT

The base was out of plywood, and the dip was made by adding a wedge of wood to each side. The foam didn't need to be cut because of the shape of the wood, a curve was created in the foam.

Piping was also added for aesthetic purposes and sewn together. It was upholstered onto the wood using staples, and in the Ugandan context would have been done with nails. It was then secured to the crossbar on the tricycle.

BRAKES AND WELDING

The last part welded was the brakes. Other then the front fork, which was made by Kio, the brakes were the only part that has moving pieces. All pieces that were moving were attached together before the rigid pieces were welded and it was attached to the frame. This was to prevent any alignment issues.

PAINTING PREP

Prior to painting, the frame was washed and sanding, making sure there wasn't any left over debris from the welds.

Final Prototype

PAINTING

The model was first painted using a water based primer, it needed to be tinted pink in order for the red to have a better finish. It was covered in three coats of red paint.

True to Kio's handy work, some of the bicycle parts and bolts were painted. However, there were some changes to the painting scheme. The mudguards and tube end-caps were left in their original form, and hand pedals were also not painted. These were design choices because a much brighter red was used, and having the black pieces broke up the tricycle. This is much more appealing to look at

CONCLUSION

In conclusion, the redesign of the hand-pedalled tricycle frame was successful, using manufacturing principles and design thinking, it was possible to make improvements to the existing design. As specified in the design guidelines, the new design meets the requirements to be manufactured at a cheaper cost, improve the structural strength of the frame and offer improvements for the end-user.

This design project was also a good exercise in co-design where the all parties had an influence on the final design. Kio, the manufacturer, and end-users where able to work closely with the designer during the trip to Kasese, Uganda, as well as, using email and skype to communicate prior to the trip. Kio was able to adopt and implement aspects of the design immediately, which showcases the relevance of the design solutions.

The hand-pedalled tricycle frame is an example of incremental innovation, where small changes made a positive difference in the design of a product. This is an appropriate type of change where the infrastructure and other resources or support are lacking, making radical innovation an impossible or impractical design solution. This example of incremental innovation show the positive influence that design can have.

APPENDIX

Supporting Documents

HARAMBEE >>>
PULLING TOGETHER

PROJECT BRIEF >>>
TRICYCLE FRAME BY ALYSSA WONGKEE

Background

In Uganda, over 5 million people are living with disabilities, trapped in a cycle of extreme poverty. The CanUgan Project raises money, and funds hand-pedalled tricycles to be given to people with disabilities in the Kasese Region of Uganda. They are made by a local craftsman, who makes the tricycles using bicycle parts and creating a simple, crude, yet effective design from memory, using basic tools and a stick welder.

Opportunity

Currently, the manufacturing of the tricycle depends on the expertise of one person, and the method is very labour intensive and inexact, making each tricycle a one-off. There exists an opportunity to design the tricycle frame so that it would be more easily manufactured, by simplifying the frame. Increasing the strength of the frame would reduce the repair needed.

Objectives

To improve upon the existing tricycle frame, by reducing cost of the tricycle frame and complexity while increasing the structural rigidity and usability. While still using stock bicycle parts and easily sourceable base materials.

Users

The users are people with mobility impairment. This design of the frame must also consider those manufacturing the tricycles. These would be adult members of the community in which the tricycle is distributed. Both groups would most liking be living in poverty and have a limited amount, if any, of formal education or vocational training.

Considerations

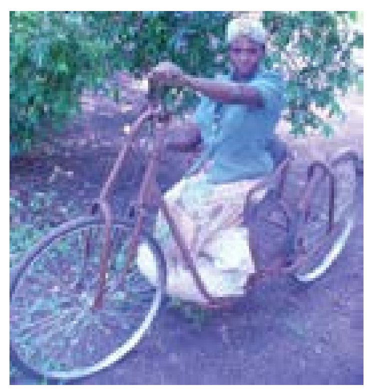
Climate: Able to withstand the harsh Ugandan environment

Cost: Made at a lower cost then the current design

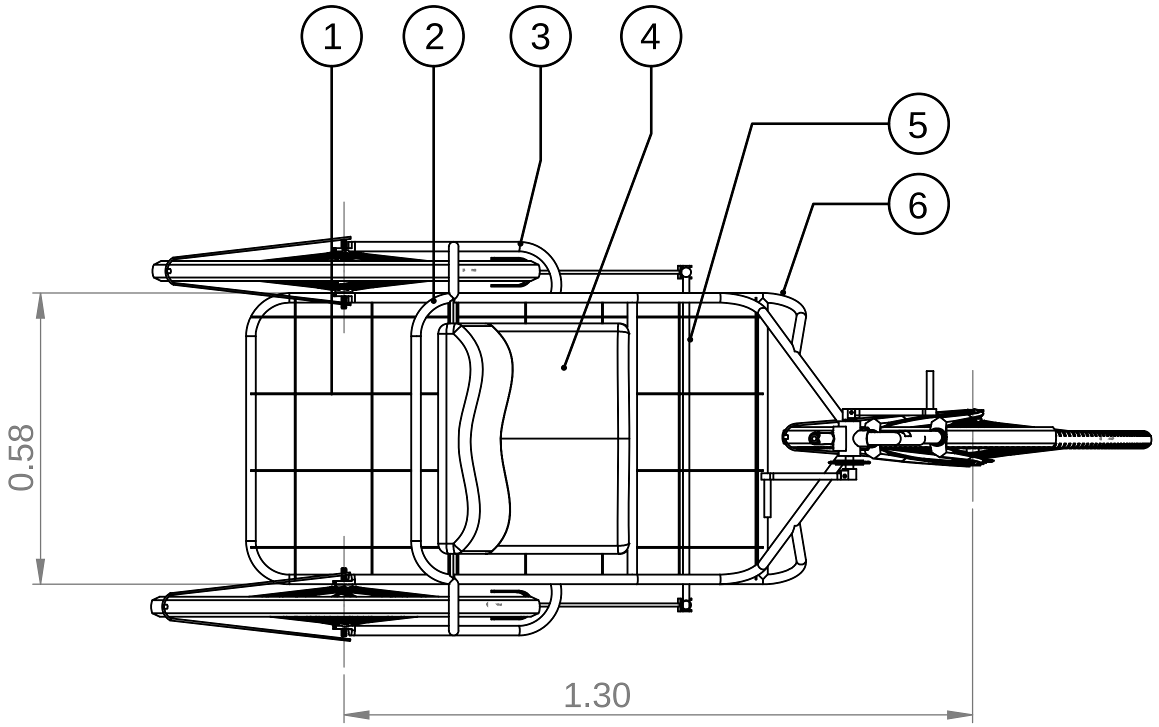
Materials: Widely sourceable materials, in case of replacement or repair

Change: Be universal enough to accomadate design changes without a large cost to redesign fixtures and tools.

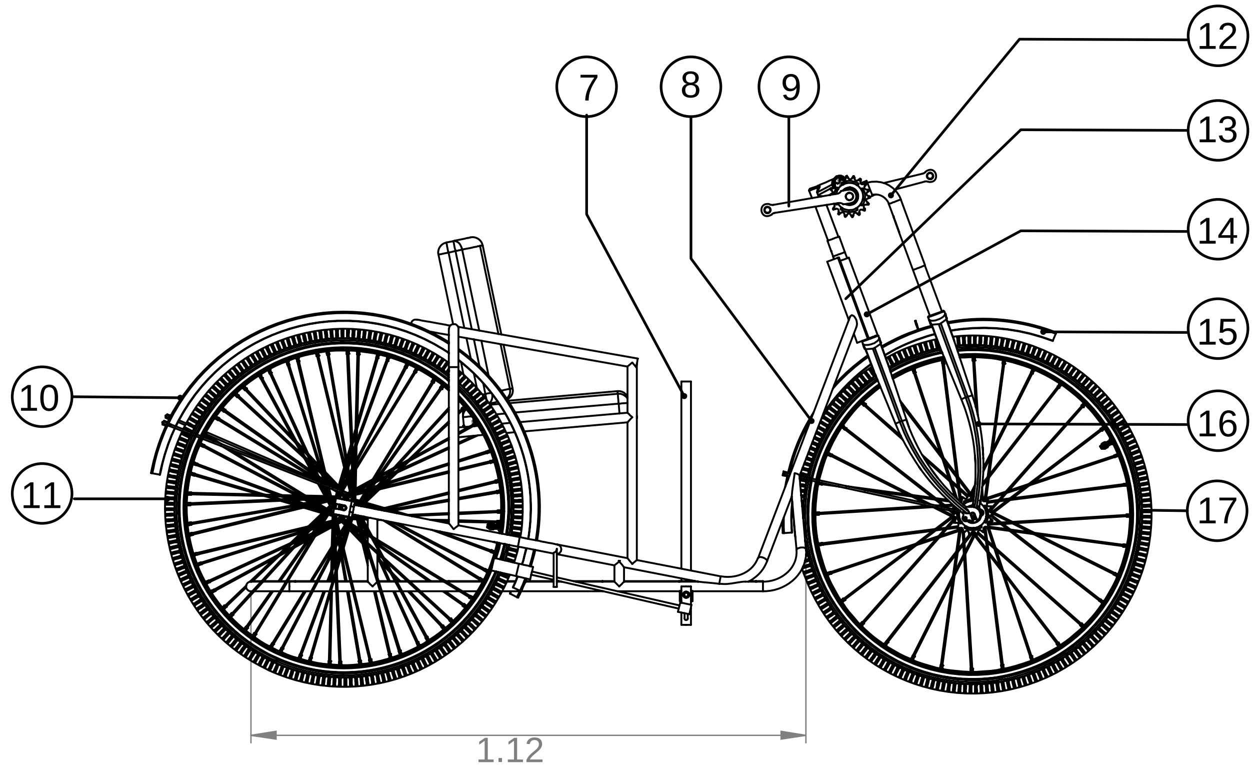
Manufacture: Design respects manufacturing principles and affords the use of fixtures or jigs.



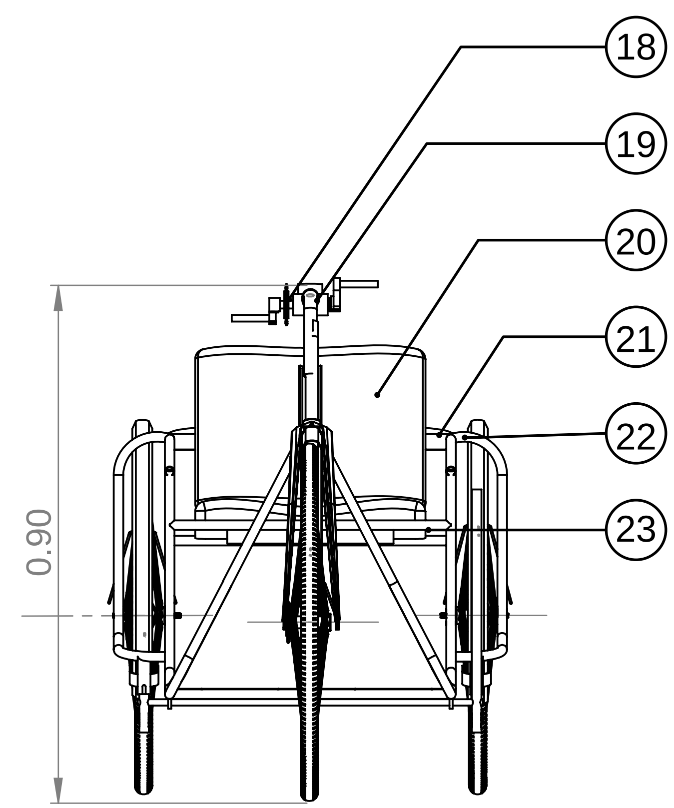
Original Tricycle



TOP



RIGHT



FRONT

NO.	PART	DESCRIPTION	QTY.
1	GRATE	40X24 6” GRATE	1
2	ARM REST	3/4” TUBING	1
3	SUPPORT A	3/4” TUBING	2
4	CUSHION A	BOTTOM CUSHION	1
5	BRAKE BAR	1/2 STEEL BAR	1
6	FRAME PC1	BOTTOM OF FRAME	1
7	BRAKE LEVER	HANDLE-3/4” TUBE	1
8	FRAME PC2	TOP OF FRAME	1
9	PEDALS	BICYCLE PEDALS	2
10	MUDGUARD-1	REAR MUDGUARD	2
11	WHEEL	REAR WHEEL	2
12	FORK SUPPORT	1” TUBING	1
13	ATTACHMENT	1 1/2” ANGLE IRON	1
14	24” FORK	24” BICYCLE FORK	1
15	MUDGUARD-2	FRONT MUDGUARD	1
16	16” FORK	16” BICYCLE FORK	1
17	FRONT WHEEL	40X24 6” GRATE	1
18	FREE WHEEL	FREE WHEEL	2
19	CRANK HOUSE	BICYCLE CRANK	1
20	CUSHION B	BACKREST	1
21	CROSS BAR A	BACKREST CROSSBAR	1
22	SUPPORT B	3/4” TUBING	1
23	CROSS BAR B	CUSHION CROSS BAR	2

CARLETON SCHOOL OF INDUSTRIAL DESIGN
OTTAWA, CANADA

TITLE: HAND PEDALLED TRICYCLE		TOLERANCES: DECIMAL ± 0.25 ANGLE ± 2 °	
DRAWN: ALYSSA WONGKEE			
CLIENT: STEPHEN FIELD		MATERIAL: STEEL	
CHECKED:	DATE: 01/01/10	SHEET 1 OF 1	1
DWG. #: 000-001	SCALE: 1:15	B 11x17	