GNG 2101[D]
Project Deliverable E:
Design Constraints and Prototype 2

uOttawa

Faculté de génie
Faculty of Engineering

Professor Rubina Lakhani

Ani Preedom #300253240
Kai Ly #300229297
Kathryne Truong #300257377
Yuteng Li #300210312

GNG 2101 D3.2
03 March, 2023

Table of Contents

1.0 Introduction 2
2.0 Design Constraints 2
2.1 Aesthetics 2
2.2 Material Logistics 2
3.0 Prototype Ⅱ 3
3.1 Client Feedback Ⅲ 3
3.2 Untested product assumptions 4
3.3 Detailed Design of Prototype Ⅱ 4
3.4 Prototype Testing Result and specifications 5
4.0 Wrike 5
5.0 Conclusion 5

1.0 Introduction

In this deliverable, the team creates an updated prototype from the feedback given during the third client meeting. The team also reviews two non-functional design constraints and applies DFX methodology to the second prototype. The client expressed a need for a wheelchair backpack transfer device that would transfer a backpack from the back of a wheelchair to the side of the wheelchair, where it would be more accessible to her. The feedback from client meet 3 has been summarized, and the Wrike overview has been updated to include upcoming tasks, dependencies, and goals.

2.0 Design Constraints

The following design constraints are non-functional, meaning they do not affect the overall usability of the product, but are things needed to be considered when designing our product. The constraints chosen for the project are aesthetics and material logistics.

2.1 Aesthetics

The original design for the prototype was to leave the rail or main structural part of the product as a PVC pipe. PVC is industrial and the overall appearance of such a pipe would not be a pleasant object for someone to porter around while in the comfort of their own home or out in public. The group has instead opted for a steel pipe, which is not only better for the functional constraints of the product, but also the overall aesthetics as well. Although a steel pipe is industrial like the PVC pipe, the material complements the materials of a wheelchair better than a hard plastic. In order to prove this true, a few friends and family were asked about the visual appeal between the choices of materials and it was unanimously decided that the steel was more appealing on a wheelchair. Additionally, further efforts will be made to increase the aesthetic appeal of the device. For example, the team intends on painting or coating the device black to complement the client's wheelchair to increase the device's appeal. Matte or glossy finishes can also be applied to the client's liking. Aesthetics is a critical non-functional design constraint, because a user would be less likely to use the device if it is unappealing.

2.2 Material Logistics

Material logistics is an important non-functional design constraint which affects all aspects of our project, from production to end-of-life. Firstly, the resources used to make the transfer device come from raw resources. Each resource used has a long logistical line until it comes to us; the steel used to create the rail is a non-renewable resource which has to be mined from the Earth. Additionally, the 3D prints require filament made from thermoplastics, which require crude oil extraction and processing. In order for the team to create the transfer device, all components (steel, filament, etc) must be readily available for manufacturing and assembly. This creates dependencies; the team is unable to move forward unless warehouse logistics have been taken care of. This caused us to experience delays in prototyping; it was difficult to source a pipe which fit the client needs, and the team was unable to move forward, as the pulley system and wheels depend on the steel pipe being machined and shaped. This dependency can be eliminated by ensuring that the team has a constant supply of materials (pipe, filament, etc.)

3.0 Prototype Ⅱ

For our second prototype, the team manufactured the main pipe section for our project. This part was quite a challenge to make because of two main reasons. The first is the fact that the pipe needs to bend. This was a challenge because we could not find any off the shelf pipes that were bent in the way that we wanted. We did find one part that would work, however it was $90 and was made of aluminum and would have been hard to work with when welding. The second part was the slot that we needed to cut in the pipe. For this we went to Brunsfield. The volunteers there told us that it would be easiest to cut it with a dremel. Luckily we had an extra piece of pipe to test on and we came up with a process of cutting a guide with the dremel tool then cutting the main channel with an angle grinder. We then smoothed out all the sharp edges with a file. This was important as the grinder created many sharp edges. Unfortunately we were not able to test the strength of the piece for this deliverable, however, the team aims to strength test for Deliverable F.

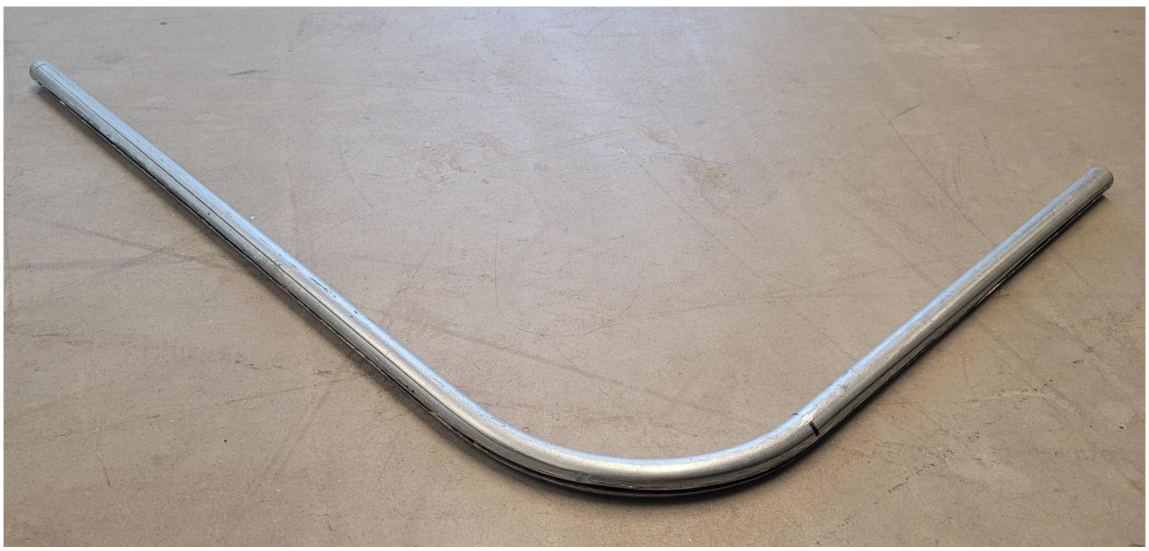

Figure 1: Manufactured steel rail pipe

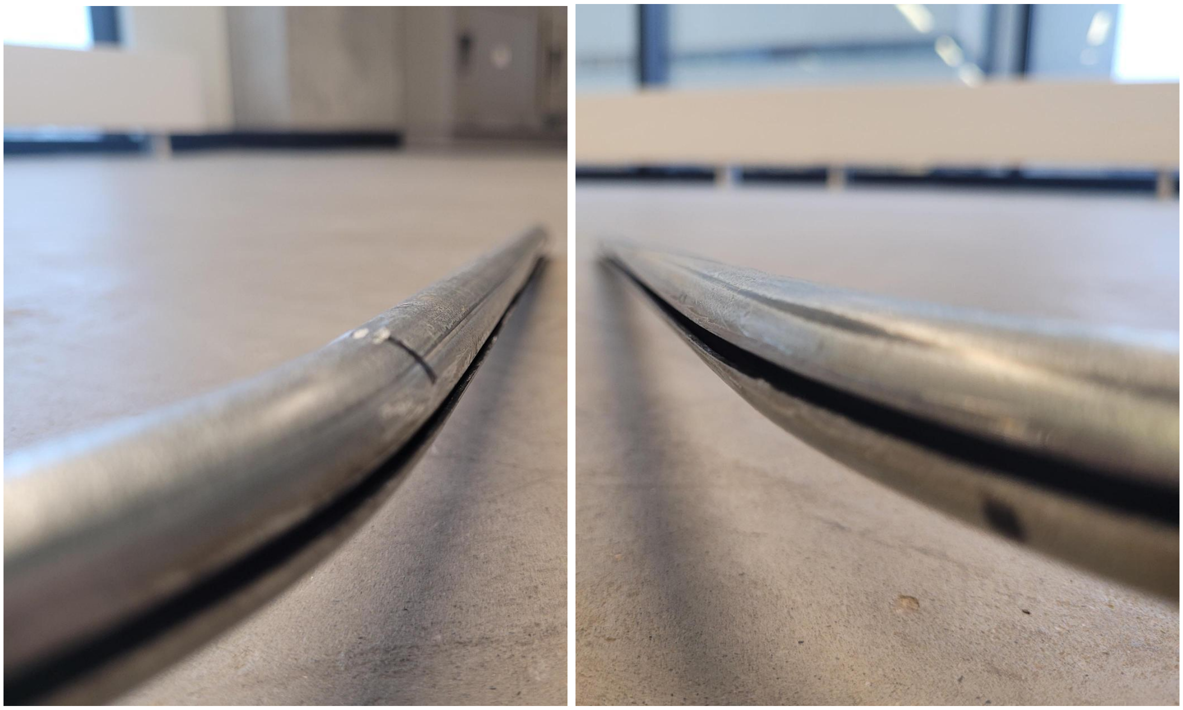

Figure 2: Longitudinal view of rail pipe with slits

3.1 Client Feedback Ⅲ

During the third client meeting, we had the opportunity to enter the client's home to communicate. The client showed us the basic construction of the wheelchair and the problems she encountered in using it, and we also received a lot of valuable comments that were very helpful in improving our product. One of the first points of concern for the client was whether the transfer mechanism would affect the up and down movement of the armrests on both sides. Currently, the team has a physical model of the railing and the team is posed to conduct initial installation tests to determine if there are any issues affecting the movement of the armrests.

Additionally, the client told the team about the limited extra space available around the chairs and the need to be aware of the size of the transfer unit by showing the use of the porch elevator unique to her home. The client also gave the example of the restroom door, where there would be only 2 inches of space on each side when passing through the restroom door, again cautioning us that in actual daily use, there is not a large margin of space available for movement. The client also expressed concern about the weight the unit could bear. She didn't want to have to calculate the weight every time she placed something, and based on the weight the client suggested placing the unit as close to the cushion as possible, both to strengthen the center of gravity and to increase the space available for movement.

Paul expressed his preference again for a motor to replace the pulling motion, such as an on/off button, which the team plans to implement using an arduino and a simple joystick, if time allows. Ultimately, the customer raised concerns about damage to the wheelchair components, stating that damage to wheelchair components is often costly and that our team would then test the safety of the product to reduce the likelihood of damage.

All in all, the third client meeting went very well and the team was able to collect feedback, advice, concerns, and wheelchair measurement. The client supported the design and showed great confidence that the team is on the right path to building a wheelchair backpack transfer device.

3.2 Untested product assumptions

For this project, the team is making some assumptions about the product. One of these assumptions is that the wheel chair will have suitable mounting points for our product. While all wheelchairs are similar, they are not all identical. Not every chair will have the mounting points in the same places. This is especially true in the lab space; there are three wheelchairs and all wheelchairs are vastly different from one another. While this could be tested, it will take up a lot of time that could be put to better use elsewhere in the project. It would also be required to obtain and measure each chair. Another untested assumption is the width of the device; if the device adds too much width to the chair it will have trouble going through doors. A normal door when opened and the hinge is in the way, measures 28 inches wide. If the device adds too much width to the chair, maneuvering it around obstacles and through doors will be more difficult. The client restated this concern in the third client meeting.

3.3 Detailed Design of Prototype Ⅱ

The following is the code for the motors being controlled using the joystick, the joystick is an analog device to be set up to the arduino using the A0 pin. The forward and backwards motions of the joystick will control the forward and backwards movements of the bag along the pipe. The motor will be attached to the wheel of the pulley to move the bag if the mechanical version isn’t desired.

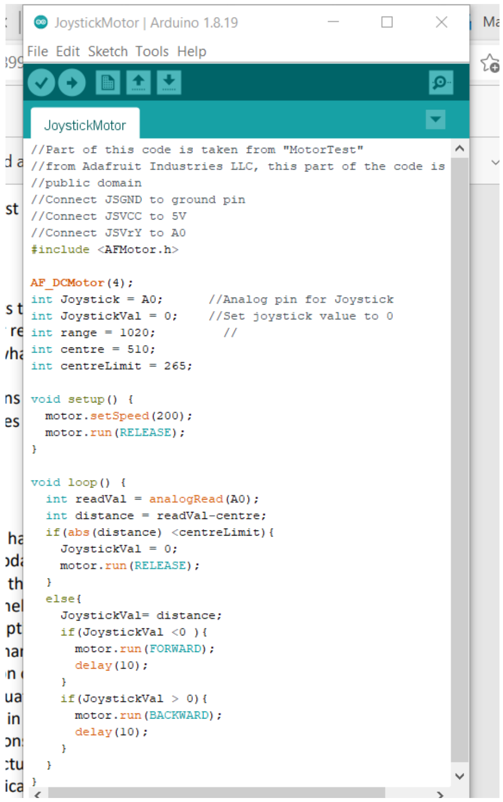

Figure 3: Prototype of Arduino code for joystick control

3.4 Prototype Testing Result and specifications

For this prototype, the team was not able to test any of the components. This was due to the fact that the prototypes were all low-fidelity and had not yet been manufactured. The pipe-rail system has been manufactured, and a bolt is able to move freely in the longitudinal slit in the pipe. The team had plans to test the rollers at the end of the pipe, however the design changed and the wheels had to be re-manufactured. Once they are done being made, their durability will be tested by connecting them to an electric motor and spinning them for a prolonged amount of time. This will accelerate the wear on the parts and give the team a good idea on how they will fail. The wheels will be printed from PLA. This test will determine whether they are durable enough to be used the whole lifetime of the product.

4.0 Wrike

The Wrike plan was updated to include assignments, milestones, and due dates. [Click here for a link to the Wrike.]

5.0 Conclusion

In this deliverable, two non-functional constraints (aesthetics and material logistics) were first outlined, based on the aesthetic appeal of replacing PVC with steel as the raw material for the pipe, and the material logistics dependency. Based on feedback from Client Meeting III, the team needs to pay more attention to the volume of the backpack transfer unit, as there is a small amount of width (i.e., door frames, etc.) in the client's daily life. Also, based on Paul's expectations, the team is developing a motor control alongside the regular manufacturing of the transfer device. Untested assumptions include the mounting point of the device onto the wheelchair, and strength tests. For the second prototype, the team manufactured the main rail for the project and created code for the joystick to operate the motor. As always, the Wrike was updated to reflect completed tasks and upcoming tasks.