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Inclusive Bike – Design Research Deliverable B

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Abstract

This design research document describes the following: first, it relates the review of a design of the existing prototype, outlines user needs and introduces a list of critical metrics that will be used to measure the performance of both existing and new solutions. Next, it reviews the existing similar products and performs user and technical benchmarking. In other words, after looking at the technical performance of existing similar solutions, it outlines the list of target specifications for a planned solution. Lastly, the document suggests the plan of testing the performance of the existing prototype.

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1 Introduction

Cycling is an activity that is enjoyed by many people in their everyday life. Unfortunately, some individuals are deprived of the chance to take pleasure in going out for a bike ride due to their physical abilities. Our task is to continue developing the initial prototype design to help to bring the opportunity of cycling to the life of people who use a wheelchair. This document introduces the very first stage of the work on the improving the existing prototype – the design review and research on what we can do to make it better.

2 Design Research

2.1. Design status review, user needs and critical metrics.

2.1.1 The review of the initial prototype

The initial problem was to develop a prototype of an attachment for the bicycle to help to bring the opportunity of cycling to the life of people who use a wheelchair within given time and money constrains. The existing prototype made for the Inclusive Bike project by previous team is meant to be attached to the front part of the bicycle and carry a wheelchair with the user on it during bike rides.

Below is the image of the existing prototype.

Figure 1 - The existing prototype

2.1.2 Existing prototype issues and risks

Table 1- Existing prototype issues and risks

Reliability of the design	The assembly of the attachment and the wheels has to be reliable and safe for use, and be able to carry the weight up to 150 kg
Mounting system for the design	The way the attachment has to be mounted on the bike isn't absolutely clear.
Ramp	The prototype needs to have a ramp or some alternative that allows the wheelchair to be placed onto the platform of the attachment easily
Reliable base	The prototype needs to have a platform made of durable material that could carry weight up to 150 kg
Breaking signals and turning signals	The existing prototype doesn't have any indicators for stopping or turning
Safety system	The attachment has no strapping system to secure the wheelchair on the prototype

2.1.3 User needs

Table 2 - User needs

Sr. No	Importance	User Statement	Interpetated Need Statement	Group
1	4	The device attaches to the bike or uses the user's mechanical wheelchair	An attachable item to the bike that the helper can push the user around. Or make a product to attach a regular bike to a mechanical wheelchair	Mechanical aspects
2	5	Light to carry around and for the client to push	Should be **light and durable** so the helper can carry it around and be able to push it with the user on	
3	4	Easy for the helper to control	**Lightweight steering** with wider wheels and three wheels to distribute the weight	
4	4	Long use life with little to no wear and tear or maintenance	**Mechanically simple** to reduce the maintenance needed	
5	5	It should be easy for the wheelchair to climb on and off the attachment	**Getting on and off** the attachment should be simple	

6	4	All types of wheelchair should be able to use the attachment	The attachment should accommodate **all types of wheelchairs** and their riders	
7	5	Should feel safe while touring around	Needs to be a **safe and secure** ride, with straps to keep the user in place. Have locked breaks for when loading.	Safety features
8	3	We should have an emergency option in case of a mishap	The rider should have a **SOS button** to inform their family members.	
9	3	We would like it to be red and make it look good with a cool design	Visually **appearance** is important	User design Preferences
10	5	Lights to be seen	Have front and back **lights** with reflectors around the bike frame so other people can see them	
11	5	Should be easy to get in and out of the bike	**E**asy for the user to **get in and ou**t of	Usability
12	4	It should not be tedious for the owner of the bike to attach the device to their bike	The device should be **easy to attach** to the bike	
13	3	Use it when it's nice outside	Be **durable and strong** to withstand sunlight and road elements	

14	4	Use it when it’s raining lightly	An attachment should be made to the device, that protects the user from rain	
15	5	We want to Communicate with the rider	The wheelchair user should be able to **communicate effectively** with the rider	Communication
16	5	We should be able to indicate to the other riders and vehicles on the road of our change in direction	The rider should have a system to communicate their direction to the other users of the road	

2.1.4 A list of critical metrics that will be used to measure the performance of both existing and new solutions.

Table 3 - List of critical metrics

Metric #	Need #	Metric	Importance (1-5)	Value	Units
1	1, 2, 3, 6, 7, 11	Overall mass	4	15-68	kg
2	3, 7, 11	Maximum weight capacity	5	150	kg
3	6	Max/min wheelchair wheel size	4	91 cm tall, 81 cm long.	cm
4	5, 6, 11	Max/min wheelchair width	4	64 cm wide	cm
5	2, 5, 12	Time to “mount” wheelchair	3	<120	s
6	2, 3	Pedaling force	4	200	N
7	1, 3, 7, 13, 14	Speed ratios	4	2-26	km/h
8	3, 7, 12	Track width	3	84-96	cm
9	7	Strap length	2	1	m
11	3, 7, 14, 16	Braking distance at speed	5	<8-10	m
12	3, 7	Suspension preload (maybe)	1	2.54	cm
13	3, 7	Suspension travel (maybe)	1	100	mm
14	9	Appearance	4	#/10	subj.
15	10, 16	Light brightness	3	100-200	lum.
16	10	Reflector size	2	4	cm^2
17		Additional cargo space	1	0-50	cm^3
18	2, 3	Steering force	2	>10	N

19		Operating temperature	2	0-40	ºC
20	15, 16	Communication	4	#5	Subj.
21	8	SOS	3	#4	Sub

2.1.5 Important areas for improvement

- Improve the structure durability, stability and weight capacity (possibly changing wheels and the supporting platform)
- Design breaking and turning signaling system
- Design the system that allows the wheelchair to be placed onto the platform
- Designing the strapping system for the wheelchair to stay safely on the platform during a ride

Ideas to Improvise

- Holder for Drinks and Snacks

  We will have to make a food and drinks holder for the passengers so that they can have food, water, or any refreshments while they enjoy their ride through the cycle trails.

- Weather protector

  We are planning to give a provision for weather protector because just in case the client is traveling and they face harsh sunlight or wind or rainfall this weather protector will protect the client from any such harsh weather condition

- Shock Absorber

  After reviewing a lot of responses from client we are considering to add shock absorbers to the carriage to give a smooth and comfortable ride to the customer.

- Compatible for Heavy weights

  After analyzing the base for different material, we have come up with an idea that we will make a strong steel base for the carriage that will be either bolted or welded to the frame and it will be capable for lifting a weight of 150 kg including the wheel chair.

- Making the Bike Stable

  After studying the design and prototype we came with a conclusion that we will have to shift the front mounted carriage to a rear mounted carriage and we will make some locking mechanism for the wheel chair which will secure the wheelchair a fixed position so that there will be no change in center of gravity.

- LCD display

  We are planning to integrate a GPS system so that the person can get direction for his destination.

2.2 Technical User Benchmarking

This section outlines the technical performance of other products, looks at user perceptions of these existing solutions, discusses additional constraints based on existing solutions, and lists target specifications for our solution.

2.2.1 Technical Performance

In this section, the technical performance of three wheelchair bikes are reviewed in Table 1. The table provides and overview of the metrics that were available online.

Company Nihola Vanraam Mobility & Access Inc

Table 4 - Technical Comparison of Three Existing Products

Company	Nihola	Vanraam	Mobility & Access Inc
Product Name	Nihola Flex 2.0	VeloPlus wheelchair bike	The Duet Wheelchair Bicycle Tandem
Product			
Price (CAD)	14,292.90 $	13,800.00 $	7163.90$
Dimensions (mm)	2150mm * 990mm	2540mm * 1100mm	2235mm * 965mm
Max wheelchair width (mm)	680mm	740mm	N/A
Max Wheelchair Weight (kg)	120 kg	140 kg	125 kg
Power	Manual and/or Electric	Manual and/or Electric	Manual and/or Electric
Materials	Steel Tubes	Unknown	Aluminum Frame
Wheels	508mm (20”) (front) and 660mm (26”) (back)	508mm (20”) (front) and 660mm (26”) (back)	3 x 660mm (26”)
Websites	https://nihola.com/nihola-flex2/	https://www.vanraam.com/en-gb/our-bikes/wheelchair-bikes/veloplus#specifications	https://www.mobilityaccess.com/duet
Similar products	(1) Nihola Flex (2) Christiania Model S (3) Axe-S Wheelchair Transporter		(1) Van Raam O' Pair Wheelchair Trike (2) Freerider Wheelchair Bike (3) Van Raam Chat Rickshaw Bike

2.2.2 User Perception

The overall reviews of the bikes seem relatively positive. Reviews could not be found for the Nihola Flex 2.0. In the case of the VeloPlus, the company does have reviews posted on its website. However, off-site reviews could not be found. User highlights of the VeloPlus include enjoying the feeling of wind blowing through their hair, complements to how well secured the wheelchair was to the bike, enjoying having someone to ride with, and liking how stable the ride was. Many users view access to the bike as a means to facilitate activities outdoors that they would not otherwise do or be able to participate in. Users complained about the lack of a rear-view mirror, and worried about how the design might be prone to punctured tires and kinks in the handlebar. [1] In the case of the Duet Wheelchair Bicycle Tandem, only one review could be found, and the review highlighted the experience of a three-year-old with Rett Syndrome, who enjoyed riding a bike for the first time despite her illness. [2]

2.2.3 Additional Constraints

Based on these reviews, we should consider adding the following constraints to our design:

- Ensure the wheelchair is properly secured so that it does not role during operation.
- Ensure that the user can feel the wind if they want to.
- Make sure the ride is stable and not overly unpleasant for the user.
- Add an optional rear-view mirror.
- Modify the design to avoid flat tires, if possible.
- Be as cheap possible to manufacture and create, as current solutions are very expensive.

While we will do our best to keep these additional constraints in mind, the client has specific specifications that she would like to see us fulfill over the course of the next few weeks. Given the time constraints of the project, we will focus our attention on the specifications listed out in the next section.

2.2.4 Target Specifications for Our Solution

Below in **Error! Reference source not found.** are some base specifications for the project. These specifications are based on the main requests of the client, and encapsulates what the client mainly wants us to add to the prototype in its current state. Unfortunately, we have not had the chance to speak directly with a wheelchair user yet. We may further narrow down these specifications based on the feedback we receive from a prospective user once we have had the opportunity to speak with one.

Table 5 – Specifications and Details of Our Modifications to the Prototype

Specification	**Details**
Attach to the bicycle	One of the main goals of the project is to have a device that latches to a typical bicycle to help reduce costs. Attaching the device should consume as little time as possible.
Able to carry a wheelchair user	Due to one of the user's disability, we need to re-design the device such that a wheelchair user can ride with an abled user.
Add a platform	One of two of the clients main mechanical requests. The platform should be able to support the user and their wheelchair.
Add a ramp	The other of the two main mechanical requests of the client. The current design lacks a ramp to allow a wheelchair user to easily get on and off the device.
Brake lights	One of two of the clients main electrical requests. The brake lights should turn on whenever the bike is decelerating.
Driver-Rider Communication	The last of the two main electrical requests of the client. The driver rider communication should enable the rider to communicate basic things to the driver, like "go/stop" and "left/right".

2.3 Test plan for the existing prototype.

1. **Testing attachability of the prototype to a bike**

   Requirement

   The protype is attachable to the bike that the helper can push with the user around.

   Test Method

   The prototype is designed to be attached to the front fork of the bike. The front pole on the prototype, that is used for the attaching to the bike, is secured with the existing attaching equipment and connected to the front fork of the bicycle.

2. **Testing of the lightweightness of the prototype**

   Requirement

   Should be lightweight so the helper can carry it around and be able to push it with the user on.

   Test Method

   The prototype weight is measured or estimated and compared to the nominal value.

3. **Testing the ability to mount the wheelchair and mounting time onto the platform of the prototype**

   Requirement

   The wheelchair is mountable on the prototype for a nominal value of time

Test Method

The prototype is designed to carry the wheelchair on its platform. Tilt the prototype towards the non-barred end and push the wheelchair onto the floor of the prototype. Measure the time it took to perform the operation and compare it to the nominal value.

4. **Testing of the maximum weight capacity of the prototype**

Requirement

Should be durable so the helper can carry it around and be able to push it with the user on.

Test Method

The load that is less than the nominal weight capacity of the prototype is being placed on the prototype platform by increasing the weight each time. The testing is performed until the signs of overloading become present, for example the wheels become too flat or the platform starts making cracking noise. The final applied weight is compared to the required nominal value.

5. **Testing prototype for turning ability and turning angle**

Requirement

Lightweight steering with wider wheels

Test Method

The prototype is being pushed forward and attempted to steer it

a) Right

b) Left

Afterwards the angle of deviation from the initial direction of the movement is measured and compared to the nominal value.

6. **Testing of the stopping ability and breaking distance of the bicycle with the prototype attached**

Requirement

After breaks are applied by the biker, the breaking distance should be less than 8-10 meters

Test Method

After the prototype is attached to the bike, the biker mounts the bike and accelerates to achieve the speed around 10 km/h, then the rider applies the breaks. The breaking distance is measured after full stop of the bike from the point of applying the breaks and to the point where the bike came to a full stop.

3 Conclusion

Throughout preparation of this document, we reviewed the existing prototype of the attachment for a wheelchair to a bike. We outlined its major issues and problems, defined user needs and set a list of critical metrics that will be used to measure the performance of both existing and improved solutions. Based on acquired information we outlined the important areas for improvement of the existing prototype. After that we looked at existing similar products, evaluated their performance and set the list of target specifications we want to achieve while working on our project. In the last section we developed the test plan, which will help us compare the prototype performance against target specifications and performance requirements.

4 Bibliography

[1] https://www.vanraam.com/en-gb/our-bikes/wheelchair-bikes/veloplus/customer-experiences

[2] https://www.especialneeds.com/shop/mobility/duet-wheelchair-bicycle-tandem.html