Attaching smart push support to the Rollz Motion

APPENDICES

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A.1.1 OCCUPIED VOLUMES

Introduction
Additional components need to be placed on or integrated in the current design of the Rollz Motion to make the motorisation and smartification take place. If possible, adding these components should not affect the use and functionality of the Rollz Motion in a negative way, e.g. limit the foldability or obstruct the user from walking or sitting comfortably. For some of these use scenarios the occupied spaces have been measured to find where the components can be placed without obstruction. A more elaborate explanation of the required components and the (dis)advantages can be found in appendix A.5.1.

Method
First photo and video references were shot and collected in which the user or the product was in a position with a maximum reach or deviation (e.g. pictures of a completely collapsed Rollz Motion, or videos of the user walking behind the Motion). Based on these photo and video references the used spaces were determined for some critical functionalities. The found occupied volume was translated and visualised on the line drawing of the Rollz Motion in front view and in side view. Combining the images of multiple situations led to a conclusion of where the components could be placed best.

Result
The results are shown in the images on the next page.

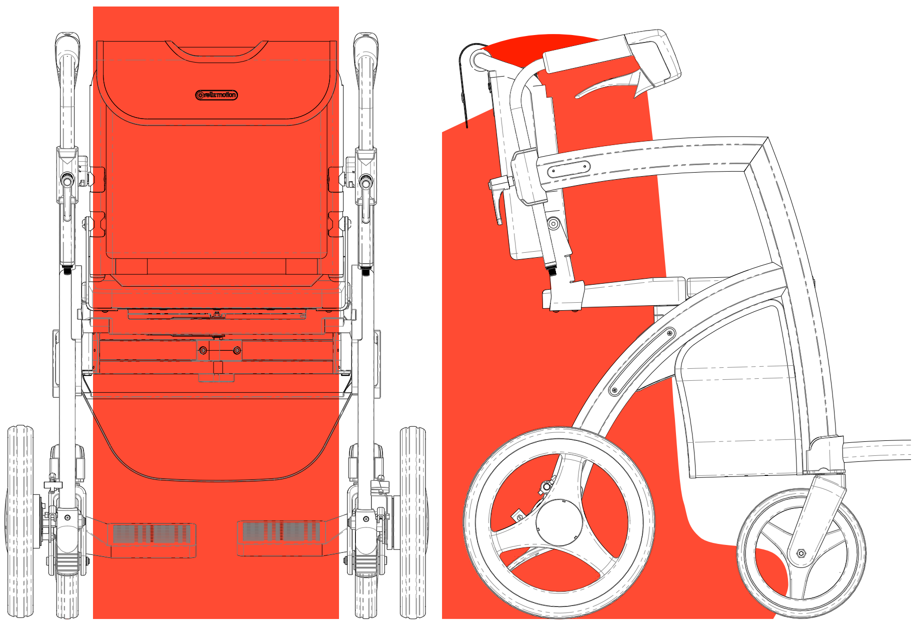
Discussion
Not having any new components that interfere with the current functionalities might be an ideal scenario, but may not be completely necessary. The new components can also make up for some of the functionalities that are restricted as a consequence of their placement. An example would be that the placement of the motors prevents an ideal ergonomic position for the push attendant, so that the push attendant cannot deliver all the required force comfortably. In this situation, however, the motors can deliver all the required force, making the ideal ergonomic position of the push attendant of minor importance.

Furthermore the placement of the components is only critical in specific situations. Design solutions could also involve the relocation of components to allow the intended use in this specific situation. This already happens in the design of the Rollz Motion. It is impossible to fold the Rollz Motion when the backrest of the seat is installed. This part can however be disassembled to enable the folding mechanism to function properly.

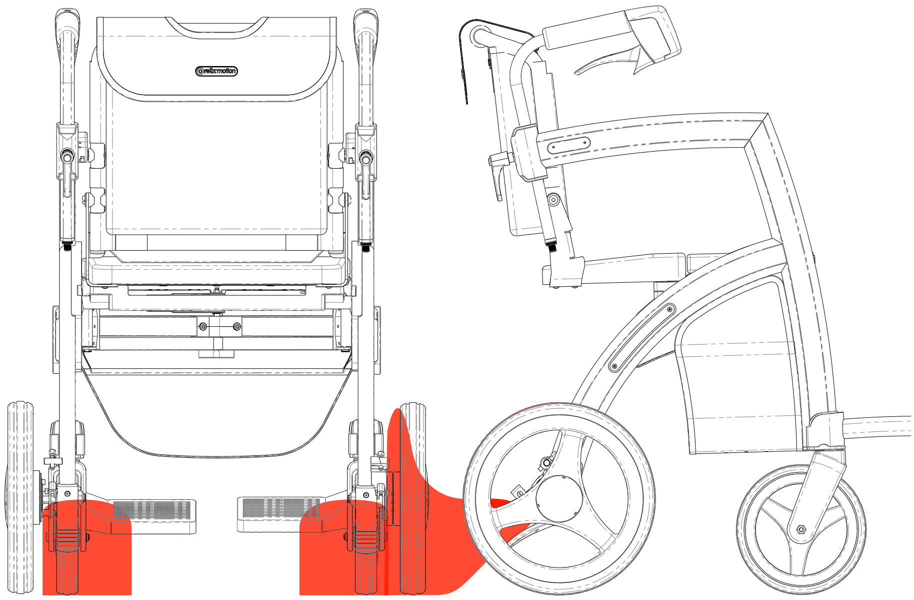
Just the location of the users and the parts of the Rollz Motion in some situations can give an overview of the possible envelope in which components can be placed, but does not say anything about the actual possibilities of placing some components since these components are not specified and the sizes are not known jet. This will be further discussed in appendix A.5.1

Conclusion
Some requirements can be set up in accordance with the found data

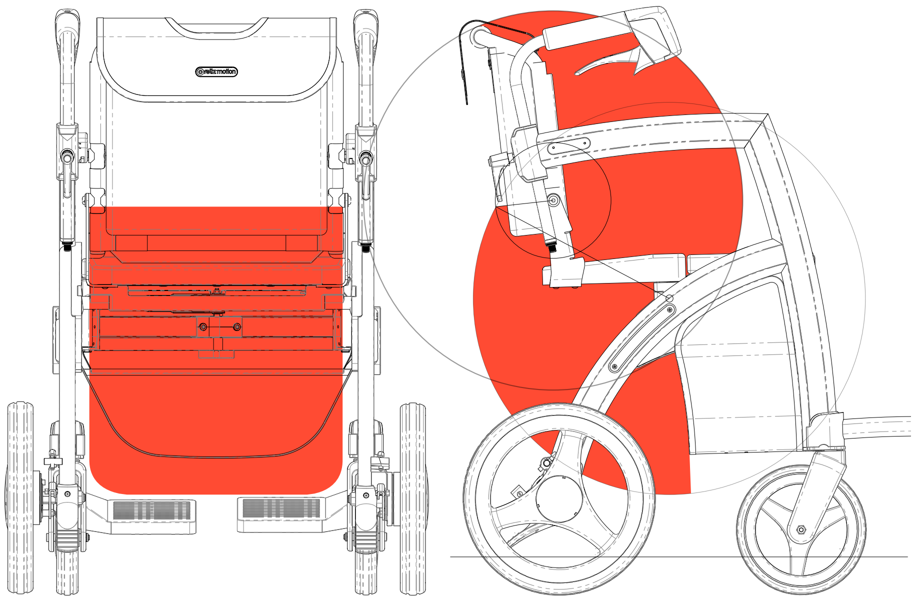
In red: occupied space by the user that is walking behind the Rollz Motion (in rollator configuration)



In red: occupied space when the front casters need to be lifted and the push attendant uses the pedals to make this easier.



In red: occupied space when folding the seat.



A.1.2 STOPPING DISTANCE

Introduction
The ISO-EN 12478 standard specifies maximum allowable stopping distances for electrically powered wheelchairs. This stopping distance may not exceed the set length, while the maximum deceleration is not allowed to surpass 4.0 m/s2 for longer than 0.03s.

Development and manufacturing costs can be saved if the brakes that are already installed on the Rollz Motion can be used in the smart Rollz Motion as well. However, these brakes can only be used if they prove to meet the requirements as set in the standard. The following test specifies the stopping distance for different initial speeds to see whether some of the brake requirements can be met.

Method
The Rollz Motion was placed on a horizontal flat concrete surface and was pushed up to speed alongside measuring tape that was attached to the ground. A test person was sitting in the Rollz Motion. At a certain moment this test person locked both brakes completely. A camera was fixed on the Rollz Motion. This camera recorded both the measuring tape that was attached to the ground and the wheel where the brake was applied.

The recorded videos were analysed afterwards. While analysing, the frame in which the user started braking was looked for, as well as the frame where the user and the Rollz Motion came to a full stop. For both frames the position of the Rollz Motion could be seen on the tape measurer. Subtracting both values gave the total stopping distance.

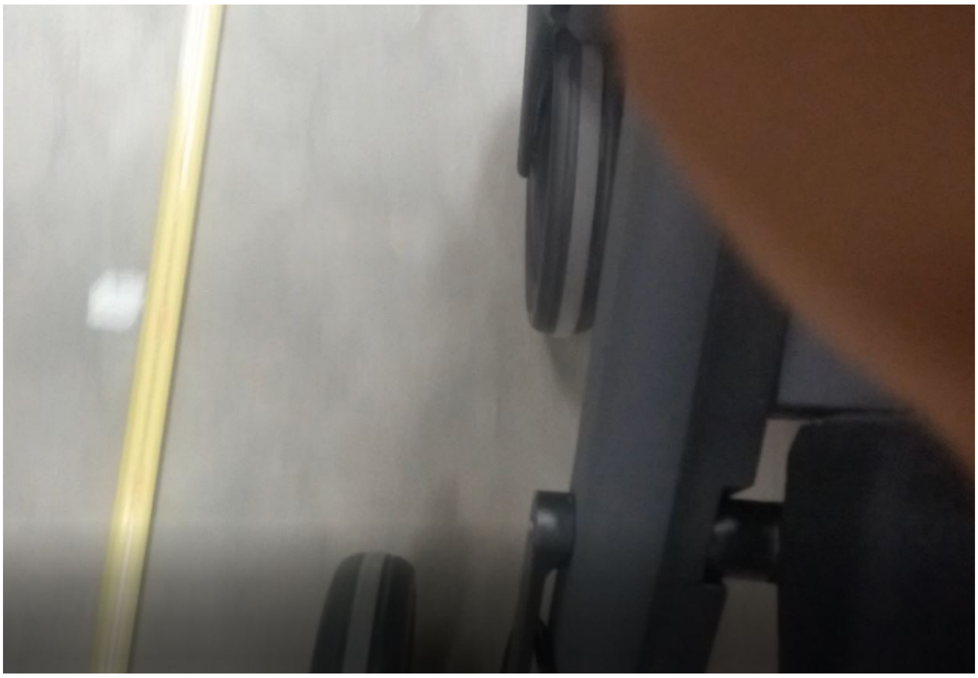
To find the speed of the Rollz Motion at the point where the user started breaking a similar method was used. The travelled distance was being calculated between the frame where the user started braking and 3-10 frames earlier and this distance was divided by the corresponding time difference between these frames.

Result
The results are presented in the graph on the next phase. The videos have been analysed and the data is collected. The calculations at the bottom show that the stopping distance for a 125kg person from the maximum speed (6km/h) will be 0,89m.

Discussion
The stopping distance is mainly based on the friction forces between the ground and the tires of the Rollz Motion. The recorded videos show that the brakes lock completely after the brake handles are being pushed completely. The Rollz Motion keeps on sliding until it stops. This test does therefore not necessarily show the maximum braking force, but rather shows the strength of the friction forces.

Since the test is mainly dependent on the friction forces, other surfaces can show other stopping distances. As mentioned in appendix A.1.4 the rolling resistance will be higher on most of these terrains and therefore the stopping distance shorter. For this reason no additional tests will be done on other terrains.

Conclusion
The brakes are strong enough to match the requirements and could therefore be used in the power assisted Rollz Motion.



	Brake point		Stop point		Speed at start braking		
	time	distance	time	distance	m/s	km/h	avg deceleration (m/s2)
Brake 1.mp4	04:11	1,53	04:25	1,29	1,885714	6,788571	3,327731
Brake 2.mp4	04:25	1,55	05:15	1,14	1,625	5,85	2,4375
					1,5	5,4	
					1,714286	6,171429	2,571429
Brake 3.mp4	03:25	2,1	04:13	1,74	1,333333	4,8	2,222222
Brake 4.mp4	05:03	1,19	05:21	0,77	1,390909	5,007273	2,318182
					1,285714	4,628571	2,142857

Wtot = Ftot * s
Wtot = Ekin2 - Ekin1
1/2 * m * v^2 - Fbreak * witl m=88kg
v=1,88 m/s
s=0,36 m

ma Fbreak = 431,9822
mi Fbreak = 216,1989

Ch m=138kg (mass pers 125kg and wheelchair)
v=1,67m/s (max speed rollator)

s= 0,890079

A.1.3 BRAKE FORCE

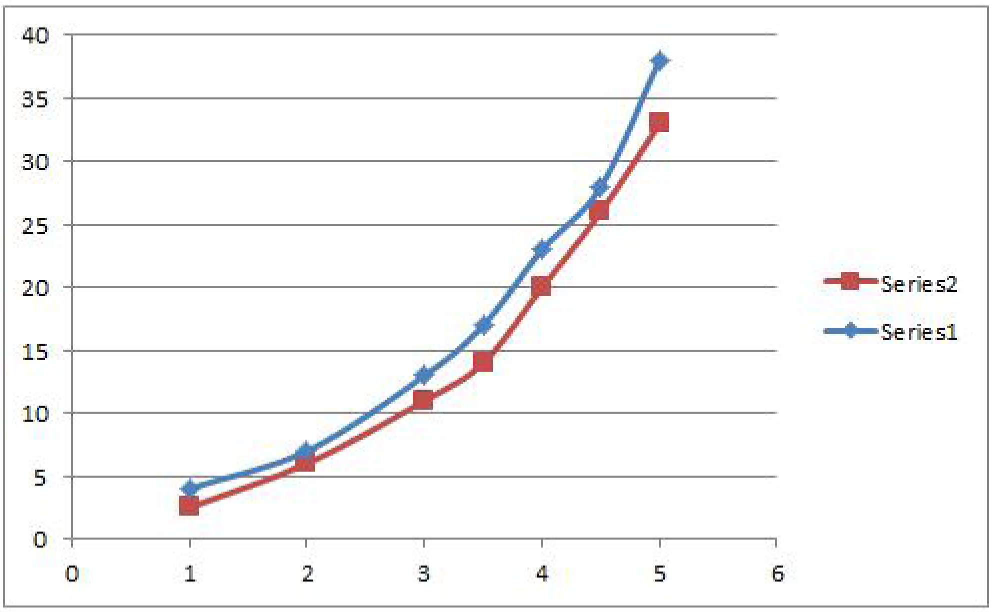
Introduction
The standard NEN-EN 12478 specifies a maximum force that is allowed for operating brake handles. As mentioned in appendix A.1.3: Stopping distance, it can be favourable if the available brake suffices to the requirements of the standard to save development and manufacturing costs. This test tries to find values for the required hand force to operate the brakes. The measurements are done based on the specification in the standard NEN-EN 12478.

Method
A force meter was placed on the bottom side of one of the brake handles 15 mm from the end of it. By pushing the force meter upwards, the force was applied to the brakes through the force meter. Multiple measurements were taken for different pushing forces and deviations. The testing procedure was repeated for the other brake.

Result
The result is presented in the graph on the next page.

Conclusion
The brake force does not exceed the 60N that has been specified in the standard and is therefore light enough to operate. The required force to apply the parking brake is 44N on average.

push distance (cm)	Force (N) Left	Right
1	2,5	4
2	6	7
3	11	13
3,5	14	17
4	20	23
4,5	26	28
5	33	38



A.1.4 ROLLING RESISTANCE

Introduction

One of the reasons to motorise the Rollz Motion is that some users find the force to push the Rollz Motion around with someone in it too high (see appendix A.3.1). The actual height of this force and the factors that influence this force are however unknown. A quick dynamic model showed that resistance forces could have an influence on the total force that is required to push the Rollz Motion (see appendix A.1.5).

This test was executed to find the rolling resistance and the coefficients of friction for different terrains. The found values can be used in the model as presented in appendix A.1.5 to determine the total required force to push the Rollz Motion with and without a person in it.

Method

The Rollz Motion with the wheelchair seat installed was placed on a horizontal flat concrete surface. No additional weights or users were placed in the Rollz Motion at this moment. A force meter was placed under the seat and pushed forward until the Rollz Motion started moving. Before the pushing motion was started, it was made sure that the two front casters were placed parallel to the direction of travel. The force required to start moving was measured three times and the force required to keep on moving at a continuous speed as well.

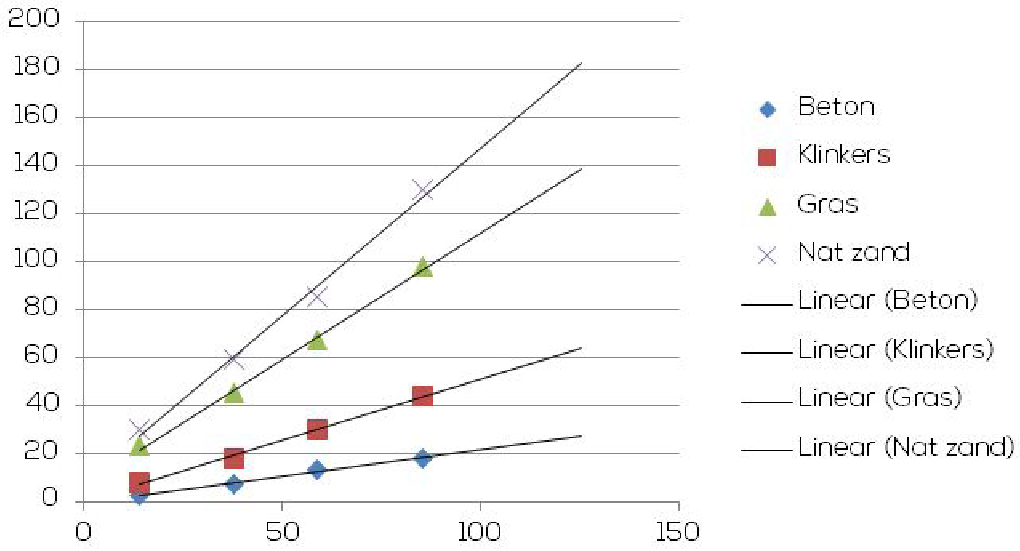
The test was repeated with different weights placed on the Rollz Motion, with increments of approximately 25 kg up to a total added weight of 75 kg. This was also repeated on different terrains (sand, grass, and pavement). Each of the selected terrains was horizontal.

Result

The result is shown in the graph below. The graph shows the relation between the weight of the Rollz Motion (x axis) and the required force to push the Rollz Motion forwards (y axis). Based on this graph the coefficients of friction were determined (0,02 for concrete, 0,04 for cobbles, 0,08 for grass and 0,13 for sand.)

Discussion

It was assumed that the resistance of the casters was similar to the resistance of the two rear wheels and that the placement of the force meter and the location of the centre of gravity of the added weights would just have a marginal effect on the total resistance forces. In reality these two variables will have some influence.




rollz motion

A.1.5 LOCATION CENTRE OF GRAVITY

Introduction
The standard NEN-EN 12478 specified requirements for the static and dynamic stability of the Rollz Motion on sloped surfaces (see appendix A.6.1). These requirements need to be met to remain stable while encountering the obstacles/ slopes when driving the smart Rollz Motion (see appendix A.2.1).

Method
The two front casters of the Rollz Motion were placed on a scale, while the two rear wheels were placed on the ground. A test person was asked to sit in the Rollz Motion in this configuration. While the test person took place and was sitting down without moving the value on the scale was being read. Afterwards the test person was asked to stand on the scale to determine the weight of his/her body. With these measurements two variables in a simple model were known, leaving the location of the centre of gravity as the only unknown variable. Solving the equation gave the approximation of a plane where the centre of gravity should be placed on.

The test was repeated for a configuration where the Rollz Motion was lying on the floor with the top part of the aluminium part of the backrest was placed on the scale and no other part than the two rear wheels were touching the ground. Applying the same method resulted in the approximation of another plane where the centre of gravity should also be placed on somewhere.

Combining the found planes resulted in a point that served as an approximation of the location of the centre of gravity.

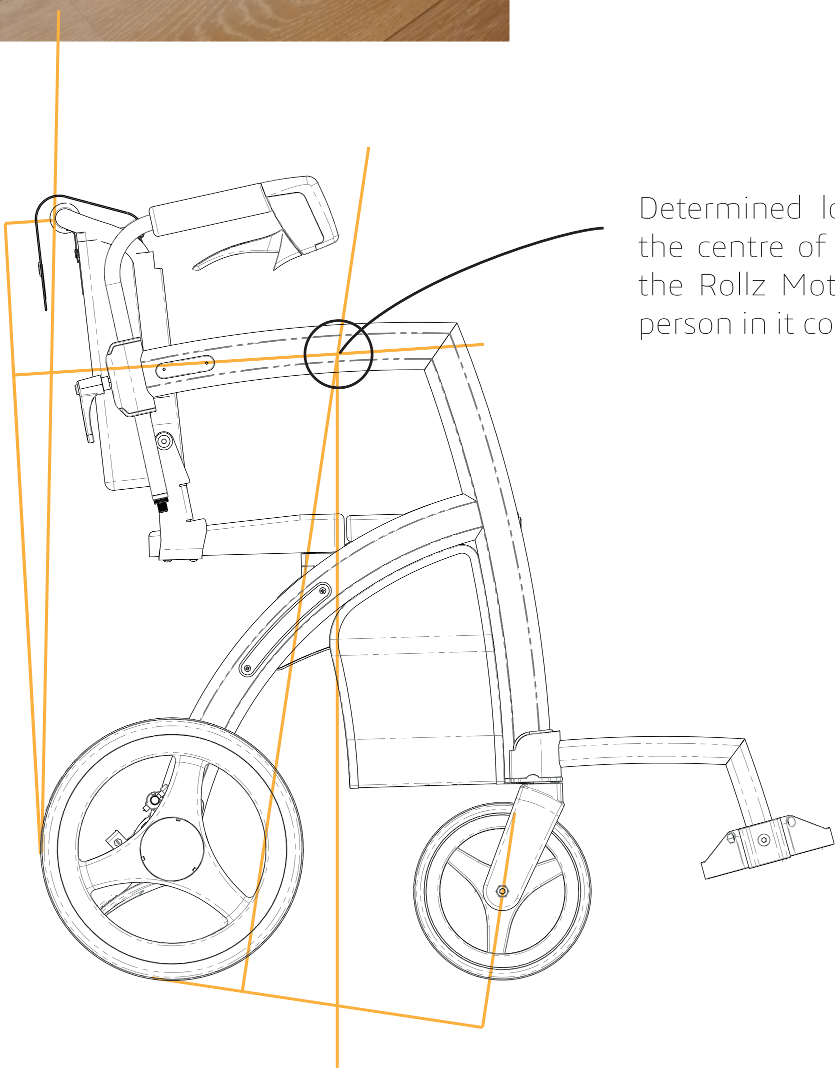
Result
The result is visualised in the image on the next page.

Discussion
It was assumed that the weight of Rollz Motion and the test persons as seen in front view was symmetrically distributed so that the location of the centre of gravity was placed on the centreline in the front view of the Rollz Motion.

No guarantee can be given that the found location of the centre of gravity is also comparable for persons that are missing one or more limbs or other body parts. This insecurity will however not cause problems. Generally users of the Rollz Motion do not miss any limbs since the Rollz Motion is intended for people that can walk and is difficult to control with one hand.

It was assumed that the location of the centre of gravity would not change when both the person sitting in the Rollz Motion and the Rollz Motion itself were lying on their backs compared to the situation where the Rollz Motion was standing on its wheels. In practice, the outcome of this test will probably show a centre of gravity that is placed higher than the real position of the centre of gravity.

Conclusion
With the position of the centre of gravity it is posible to comply with the requirement for static stability on a slope of 9 degrees. No addtional changes are needed to the Rollz Motion.



Determined location of the centre of gravity of the Rollz Motion and a person in it combined.

A.1.6 NEEDED PUSH FORCE (MODEL)

Introduction

One of the reasons to motorise the Rollz Motion is that some users find the force to push the Rollz Motion around with someone in it too high (see appendix A.3.1). The actual height of this force and the factors that influence this force were however unknown. Furthermore, the type and severity of the factors that influence the total pushing force with and without a person in the Rollz Motion are also unknown. These forces can give a basic idea of the severity of the problem and about the needed power that should be supplied by the motor(s).

Method

A model was set up that enabled to calculate the total pushing force required to push a person or a load up a sloped plane.

Result

The result of the necessary pushing force is plotted and shown in the figure on the next page.

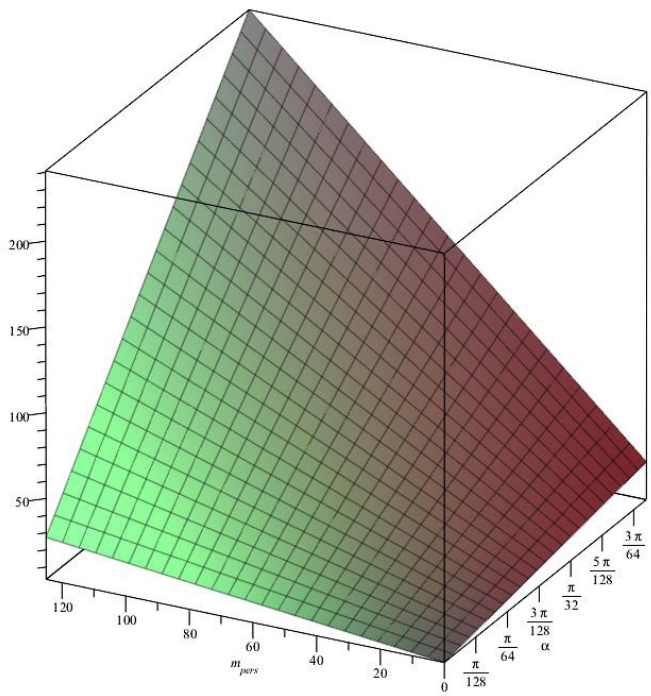
Discussion

The situation for a paved road, with a low friction coefficient has been used. The push force will be higher for other types of terrain as well.

Conclusion

The plotted push force shows that pushing the Rollz Motion on a flat terrain or with a user in it does not cost too much force. If a person has to be pushed uphill this force can exceed 200N. This is too high to be comfortable.

The torque that should be delivered by the motors to completely pull a 125kg person on a 8 degree hill is 32Nm. If two motors are used this is 16Nm per motor.



the needed push force

> $restart:$

> $g := 9.81 : m_{Motion} := 14.4 : \mu_{beton} := 0.02; r := 0.15 :$

$$\mu_{beton} := 0.02$$

> $F_w := F_n \cdot \mu_{beton};$

$$F_w := 0.02\, F_n$$

> $F_G := (m_{pers} + m_{Motion}) \cdot g;$

$$F_G := 9.81\, m_{pers} + 141.264$$

> $F_n := F_G \cdot \cos(\mathrm{alpha});$

$$F_n := (9.81\, m_{pers} + 141.264) \cos(\alpha)$$

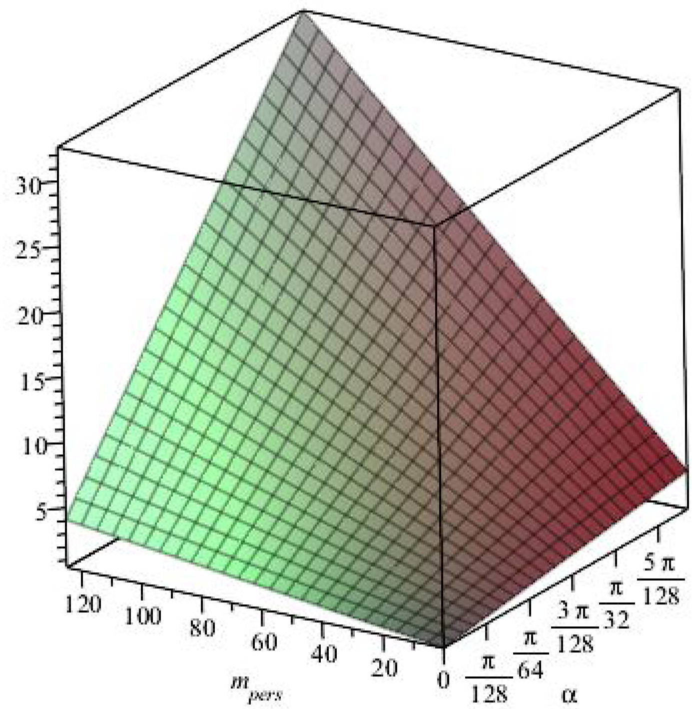
> $F_y := \frac{T}{r} = F_G \cdot \sin(\mathrm{alpha}) + F_w;$

$$F_y := 6.666666667\, T = (9.81\, m_{pers} + 141.264) \sin(\alpha) + 0.02\, (9.81\, m_{pers} + 141.264) \cos(\alpha)$$

> $T := solve(F_y, T);$

$$T := 1.471500000 \sin(\alpha)\, m_{pers} + 21.18960000 \sin(\alpha) + 0.02943000000 \cos(\alpha)\, m_{pers} + 0.4237920000 \cos(\alpha)$$

> $plot3d\left(T, \mathrm{alpha} = 0 .. \frac{8\,\mathrm{Pi}}{180}, m_{pers} = 0 .. 125\right);$



the needed torque

A.1.7 OBSTACLE CLIMBING

Introduction
Generally speaking rollators have problems in climbing obstacles. The size of the wheels seems to be too small to easily and comfortably overcome small bumps. To test whether this would also be the case for the Rollz Motion a test was done.

Method
An 22 mm obstacle was layed flat on a concrete floor. One researcher took place inside the Rollz Motion, while another one held the position as push assistant. The push assistant lined the Rollz Motion up to be placed before the obstacle with enough space between the obstacle and the Rollz Motion to get up to speed before the obstacle would be encountered.

As a next step the push attendant would start pushing the Rollz Motion until a speed of 6 km/h was reached. At this speed the obstacle was hit and the effect filmed.

Result
The result is shown in the images on the next page. The last image shows the reaction of the Rollz Motion when encountering the obstacle. The front casters cannot drive over the obstacle but bump into it. This caused the researcher in the Rollz Motion to be launched.

Discussion
For safety the foot rest plates were not used. These plates could have prevented the researcher to be launched from the Rollz Motion. Still this would not have made the Rollz Motion overcome the obstacle.

Conclusion
The Rollz Motion shows to have problems in climbing obstacles. Since the size of the obstacles on the road can even be higher than the tested 22 mm, a push assistant will be needed to climb the obstacle safely by performing a wheelie.

A.1.7 STATIC AND DYNAMIC STABILITY

Introduction

The Rollz Motion has not been designed with the motorisation in mind. The additional torque that is delivered by a motor could make the system vulnerable to instabilities.

Furthermore, the standard NEN-EN 12478 specifies stability requirements for sloped planes. A model has been created to test whether these requirements can be met.

Method

Maple was used to build this model. The model is based on a semi static model where a Rollz Motion that is placed on a sloped surface is accelerating. The model determines the maximum rate of acceleration (in m/s2) for the steepness of the slope.

Result

The model can be seen on the next page. The graph shows the relationship between the maximum allowable acceleration (in m/s2) for a specific slope (beta in degrees).

Conclusion

The graph shows that both the requirements for static and dynamic stability can be met and that the powered Rollz Motion can suffice to the standard NEN-EN 12478.

The graph highlights that addtional acceleration/torque control will be needed to prevent the vehicle from accelerating too fast and tipping. Especially on steeper hills a low acceleration can result in a tipping motion.

> *restart*;

> $a := 750:$
$b := 200:$

> $F := a \cdot \sin(\text{alpha}) - b \cdot \cos(\text{alpha});$
$c := b \cdot \cos\left(\frac{\text{beta Pi}}{180}\right) - a \cdot \sin\left(\frac{\text{beta Pi}}{180}\right);$

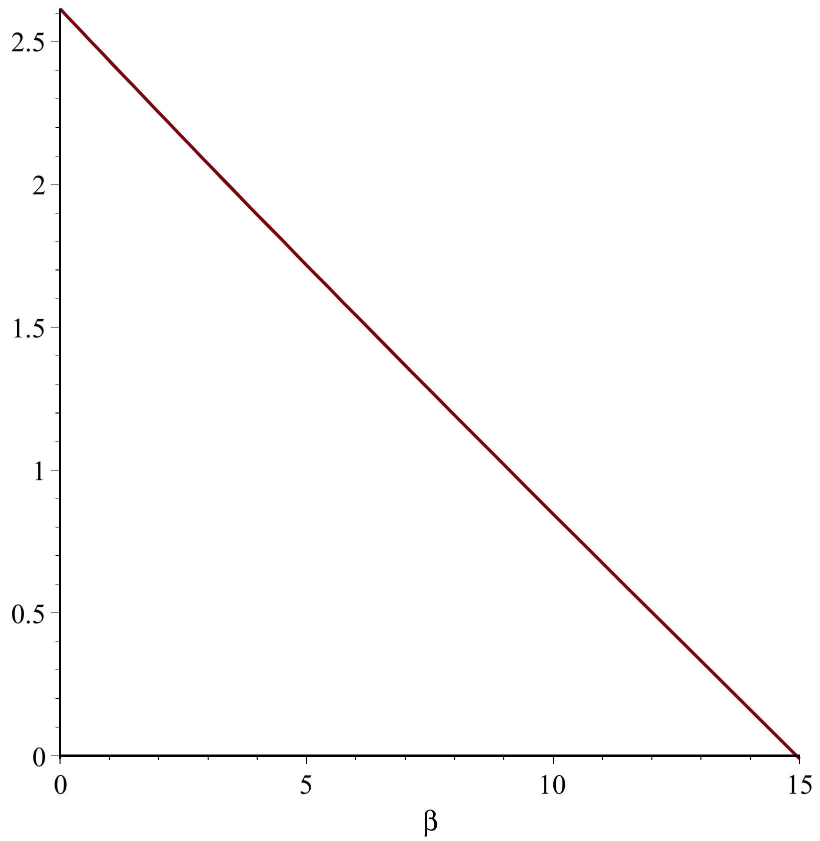
$$F := 750 \sin(\alpha) - 200 \cos(\alpha)$$

$$c := 200 \cos\left(\frac{1}{180} \beta \pi\right) - 750 \sin\left(\frac{1}{180} \beta \pi\right) \quad \textbf{(1)}$$

> $Acc := \frac{\left(b \cdot \cos\left(\frac{\text{beta} \cdot \text{Pi}}{180}\right) - a \cdot \sin\left(\frac{\text{beta} \cdot \text{Pi}}{180}\right)\right) \cdot 9.81}{b \cdot \sin\left(\frac{\text{beta} \cdot \text{Pi}}{180}\right) + a \cdot \cos\left(\frac{\text{beta} \cdot \text{Pi}}{180}\right)};$

$$Acc := \frac{9.81 \left(200 \cos\left(\frac{1}{180} \beta \pi\right) - 750 \sin\left(\frac{1}{180} \beta \pi\right)\right)}{200 \sin\left(\frac{1}{180} \beta \pi\right) + 750 \cos\left(\frac{1}{180} \beta \pi\right)} \quad \textbf{(2)}$$

> plot(Acc, beta = 0 ..15);



A.2.1 OBSTACLES ON THE ROAD

Introduction
As mentioned in the standard as presented in appendix A.6.1 and in the test shown in appendix A.1.7, the vehicle needs to be able to overcome certain obstacles. There could however be a difference between the theoretical obstacles and the obstacles that can be encountered while the vehicle is in use. For that reason some obstacles were searched in and around publically accessible roads and buildings.

Method
The obstacles were searched for by visiting some publically accessible buildings, such as train stations, hospitals, shopping centres, and supermarkets. The height and slope of the encountered obstacles were measured with a tape measure. Furthermore, building standards were addressed to find maximum allowable slopes.

Result
The results are shown in the images. These images show that several bumps are being detected that will make the Rollz Motion stop.

Discussion
Comparing the situations in the context with the situation of the norms

Conclusion
The steepness of obstacles can easily be overcome by the Rollz Motion.

The height of obstacles will be a larger problem. Since the Rollz Motion will bump against them.






A.3.1 INTERVIEW AT ROLLZ

Introduction

To gain a basic understanding about the needs and wants of the users of the Rollz Motion and the situation of the company, an interview was held at the main office of Rollz in Diemen.

Method

A semi-structured interviewing method was used to have a general lead during the interview and to ask further on subjects that prove to be interesting. The interviewees were one of the owners of Rollz (Arjan Muis) and a customer relations employee (Bram Pepping).

Conclusion

Some product requirements can be made up based on this interview:

The smart Rollz Motion needs to be allowed on an airplane.

The smart Rollz Motion needs to suffice to the European laws, regulations and standards.

The product should show the class that can be found in the Rollz Motion.

A.3.2 USER INTERVIEWS

Introduction
To gain a basic understanding about the needs and wants of the users these have been interviewed. These interviews took place with both users of the Rollz Motion: both the person that needs the Rollz Motion as a rollator and that sits inside the wheelchair, and the push attendant that pushes the Rollz Motion when the other person is sitting.

Method
A semi-structured interviewing method was used to have a general lead during the interview and to ask further on subjects that prove to be interesting. Some of the interveiws were held via phone, other participants were visited.

Notes were taken during the interviews about some quotes were documented as well.

Result
A summary of the interviews can be found below. The summary is, just like the interview was, in Dutch.

> Dhr Roos (80 jaar),
> Deze man is zelf goed ter been, zijn vrouw is in bezit van een Rollz Motion vanwege haar MS.
>
> Ze gebruiken de Rollz Motion als het product bedoeld is: de vrouw begint zelf met lopen en als ze vermoeid raakt duwt deze man haar voort. Hij geeft aan dat de Rollz Motion de actieradius vergroot en dat het fijn werkt op deze manier.
>
> Hij vindt het leuk om de Rollz Motion met zijn vrouw erin te duwen en om er samen met zijn vrouw op uit te gaan. Hij geeft wel aan dat het duwen zwaar wordt na een tijdje. Het maakt hem niet uit of dit tijdens boodschappen of een wandeling ergens is. Hij is te spreek over het ontwerp en over de looks van de Rollz Motion. Hij trekt veel bekijks en veel mensen vinden hem interessant.
>
> Mevr. Roos (74 jaar)
> Heeft een Rollz Motion vanwege haar MS. Ze begint vaak zelf met lopen achter de Motion als rollator en gaat erin zitten als ze vermoeid is. Op dit moment wordt ze meestal voortgeduwd door haar man.
>
> Hoewel ze weet dat haar man het geen probleem vindt om haar voort te duwen, voelt ze zich soms toch bezwaard om dit te vragen. Dit is omdat ze weet dat het soms best zwaar kan zijn. Zelf vindt ze de Rollz Motion ook aan de zware kant
>
> Als ze plaats heeft genomen in de Rollz Motion voelt ze zich hulpeloos en als een patient die zelf niets meer kan. Ze is tevreden over hoe de Rollz Motion eruit ziet en hoe het product werkt,
>
> Mevr. Booij (75 jaar)
> Deze vrouw geeft aan dat ze soms moeite heeft om haar stabiliteit te bewaren. Voor deze reden heeft ze een Rollz Motion aangeschaft.
>
> In augustus vorig jaar is ze gevallen tijdens het lopen met de Motion. Zowel zij als haar man hadden een hobbel over het hoofd gezien waar de Rollz Motion tegenaan reed. Als gevolg kiepte zowel de Rollz Motion als zij voorover. Ze vertelde dat ze geluk heeft gehad om niks te breken. Het is gebruikelijk dat zowel zij als haar man op zoek zijn naar hobbels tijdens het wandelen.
>
> Haar man is niet sterk genoeg meer om de RM voor grotere stukken voort te duwen. En mevrouw voelt zich bezwaard om dit steeds te moeten vragen. Ze vinden het gewicht van de RM te hoog om eenvoudig in de

auto te tillen. Zonder de Rollz Motion kan mevrouw niet langer dan 5 min aaneengesloten wandelen.

Deze vrouw vindt het fijn dat ze de mogelijkheid heeft om te gaan zitten als ze vermoeid is, maar probeert dit zo min mogelijk te doen. Gedeeltelijk is dit omdat ze haar man niet wil belasten en gedeeltelijk omdat ze zelf wil blijven bewegen.

Ze vindt de remmen te zwaar om eenvoudig te gebruiken. Ze heeft redelijk kleine handen en het gebruik van de remmen kost haar hierdoor veel kracht.

Dhr. Peeters
Deze man is alleenstaand. Hij wordt zelden voortgeduwd in de Rollz Motion.

Hij gebruikt de Rollz Motion als luxe visstoel. Als hij van huis weg gaat zet hij zijn visspullen in de Rollz Motion en duwt deze voort naar een visplek. Daar aangekomen laadt hij de spullen uit en installeert deze en gaat zelf in de Rollz Motion zitten.

Hij geeft aan tevreden te zijn over de Rollz Motion. Hij vindt de stabiliteit goed en vindt het fijn dat hij hem ook tijdens het vissen kan gebruiken. Hij geeft wel aan dat hij nog steeds wat onzeker kan zijn tijdens het gebruik en dat hij angstig is om zijn stabiliteit te verliezen

Discussion

Only Dutch participants have been interviewed which lived in the flattest part of the country. Users that live in more hilly areas can have different views and/or more desire for a push support/self controllable Rollz Motion.

The amount of interviewed users is too small to base the conclusions upon, but the results do correspond with the views of the empoyees of Rollz about the problems and with the received e-mails by users (see appendix A.3.3)

Conclusion

The interviews create a basic understanding about the views of the users. It highlighted how the Rollz Motion is currently used and showed a fear to move for the users even while they are using the product. While these users are positive about the product they feel a dependency on the push attendant and sometimes feel sorry to make the push attendant do a heavy job.

The push attendants indeed claimed that pushing the Rollz Motion around with a person in it is a heavy job, but that they generally want to do this for their relatives.

A.3.3 USER EMAILS

Introduction

Users get in contact with Rollz about the problems they face while using the Rollz Motion. Many of these emails are related to the force that is needed to push the Rollz Motion with a person inside forwards.

These e-mails are shown below and on the next page.

Conclusion

Looking a both the interviews and the received e-mails a trend can be spotted in the people that have problems with pushing the Rollz Motion forwards. Generally it is a couple of which one of the two has a degenerative disease. The other person is quite vital, but usually at age.

The diseased person uses the Rollz Motion as a rollator and takes place in it when they are tired or in pain. Most of the times their partner will take the role of the push attendant and push them forwards. Because of their own physical state, and because of the high forces that are needed to push this is a heavy task for them.

These findings correspond to the findings in the interview, where the users that experience the pushing problems are all having a partner that takes on the role of push assitant when necessary.

Verzonden: Monday, 15 January 2018 15:26
Aan: Info Rollz International <info@rollz.com>
Onderwerp: hulpmotortje voor Rollz rolstoel

Mijn man heeft sinds ruim een jaar een Rollz rolstoel, waardoor hij mobieler is
en wij samen wat kunnen wandelen.
Bij langere afstanden echter wordt het duwen achter de rolstoel wel wat zwaar.
Daarom vraag ik mij af of het mogelijk is een hulpmotortje op het frame te plaatsen,
waardoor het duwen verlicht wordt.

Er zijn diverse motortjes in de handel, maar ik weet niet welke geschikt is voor
deze rolstoel.

Kunt u mij adviseren?

Uw antwoord zie ik met belangstelling tegemoet.

met vriendelijke groet

Vraag/opmerking:

I have just bought the Rollz Motion for my wife who has Alzheimer's. I think it is a fantastic wheelchair and I am hoping it will help us both to get about a little more for longer walks. What I would like to know is, have you thought or started to think about an electric motor to power the wheels so that I get a little help when pushing the Wheelchair up hills?
I thought that attaching a device to the frame, adjacent to the rear wheels, with a small driving wheel which would rest on top of the wheel chair wheels would give that little extra help.
Hope you can help.
Best regards
Peter

Vraag/opmerking:

Goedemiddag, enkele maanden geleden heb ik voor een tante de Rolzz Motion gekocht en zij heeft er veel plezier van. Nu gaan enkele zussen(op leeftijd) met haar op pad en ervaren zij met name buiten dat het duwen erg zwaar is voor hen. Is er een mogelijkheid van rolstoelondersteuning voor de Rolzz Motion en hebben jullie daar al ervaringen mee?

Met vriendelijke groet,

A.3.4 EXPERT INTERVIEWS

Introduction

Some experts were contacted to find their views on the current mobility assitive device market and to discover the needs and wants of the users.

Interview with a doctor about the users of mobility aids

People that use rollators still are quite mobile and able to walk 100m without support, but usually have problems in keeping their balance. They probably fell down one or more times and do not want this to happen again. This means that these users are sometimes afraid to walk as well. Other solutions for these users are the use of walking canes or getting support from relatives or other people.

Wheelchair users are way less mobile than rollator users. Most of them are completely unable to walk and the users that can walk are struggling hard to even reach 2m.

Interview with Patrick Turpijn (Mobility aid reseller)

The latest trends within the market are about lightweight design and offering comfort. People want tires with air in them, instead of solid ones to have more damping and more comfort. People want a lightweight wheelchair and rollator that can be handled without any effort and lifted in the car easily. Furthermore more and more mobility assistive vehicles are being powered. It looks like the market for these vehicles is becoming more accessible and growing rapidly. Especially the Asian market is pushing towards electrically powered mobility assistive vehicles.

These low weight and comfort are important characteristics for the users as well. A lot of product choices are based upon these characteristics. Apparently these characteristics are easy to distinguish from competitors.

People who use rollators are looking for more stability. They are able to walk without their support for 50m. People that buy wheelchairs are lacking this mobility. They can only move themselves for 5 meter without support. The users of mobility scooters have different mobility issues. Some can only walk for a couple of meters and need the mobility scooter to move around, while others are capable to walk and use the mobility scooter to reach destinations that are further away (+5km).
Patrick thinks that it is safe for the users to operate the powered wheelchairs and mobility scooters. While controlling the vehicle can be a bit difficult at first, people learn quickly. Besides, speed limits are quite low (6km/h).

A.4.1 PRODUCT OVERVIEW

		Battery type	Volts	Capacity (mAh)	Motor type	Power (W)	Gearbox	Max speed (km/h)	Range (km)	Costs (€)	Weight (kg)
Bicycles		Li-ion/									
Ordinary electric	on chain	NiMh/	24 - 36	8000 - 14500	Brushless DC	1x 200 - 250		25	80 - 130	600 - 2000	
	in wheel/hub	LiFePo4									
Electric tricycles		Li-ion	36	10000		350		19	25	2000	
Race bicycles											
	Speed pedelec	Li-ion	36 - 48	12500 - 21000	Brushless DC	1x 350 - 500		45	100 - 180		
	in frame	Li-ion	30	5500 - 8250	Brushless DC	200			25 - 60	2500	
Personal mobility electric vehicles											
	Electric skate/longboards	Li-ion	24 - 36	4400 - 5500	Brushless DC	2x 250 / 1x 1000	Yes	40	40	200 - 600	
	Hoverboard	Li-ion	24 - 36	4400	Brushless DC	2x 350	No	15	15	200	
	Airwheel x3	Li-ion	42 - 60	3000 - 4000	Brushless DC	400	No	18	20	500	
Wheelchairs											
Push support for attendants	In rim (AAT V max)	Lead acid	24	16000 - 22000	DC	(2x?) 130 - 419		6	11,5	2680	
	Additional wheels (Merits	Lead acid	12	20000	DC	120 (225 max)		5	16	700	14 kg
Push support for users	In wheel (Alber e-motion)	Li-ion	24	2x 6000		2x 60		6	25		21 kg
Self controlled motorisation kits	On wheel (Light drive 2)	LiFePo4	24	15000		2x 130	Yes	6	15	4900	
	Nino One	Li-ion	24	7400	Brushless DC	250		10	20	4000	
	Additional wheels (SmartD	Li-ion	36			250		9	20	6000	5,7 kg
Self controlled unfoldable	B&B Eltego	Lead acid	24	50000		2x 250		6	25	2200	74,5 kg
	2GOability	Lead acid		36000				5,5	20	1700	55 kg
	Kymco Vivio	Lead acid	24	36000				6	32	2000	
	Shoprider Dieksand		48	36000		2x 350		6	28	6099	127 kg
Autonomous foldable	Skyline Mobility Smart Cha	Li-ion	24	20000		2x 180		6	18	2579	25 kg
	Zinger Chair	Li-ion	36	6600		250		6	13	2690	18 kg
Self balancing	Ogo technology	Li-ion						20		17000	65 kg
	Nino robotics					2x 1350		9	38	9000	39kg
	Genny Urban	Li-ion				2x 1500		12	25	17900	
	Twizzler	LiFePo4				2x 750		20	30	15999	84kg
Manual foldable (hoepelonderste	Dortmund									339	14,3kg
	Freetec									279	11,5kg
Manual foldable push	Antilope									199	13,4kg
	Sterre									190	11kg

Unmotorised walking aids		Battery type	Volts	Capacity (mAh)	Motor type	Power (W)	Gearbox	Max speed (km/h)	Range (km)	Costs (€)	Weight (kg)
Walking canes		none							6	10-100	
Rollator wheelchair hybrids	Drive Medical Diamond Deluxe									190	8,8
Rollators		none							6	100-1000	
	Quatro Z400E									78	9,7
	Dietz Driewiel									90	7,4
	Premis Provo G2									100	10,15
	CHK Elephantje									139	7,3
	Modelito Classic									149	7,2
	Cemex Let's Go									169	7
	Invacare Dolomite Legacy									184	7,1
	ExcelCare XL-90									199	8
	ExcelCare Travel Eaze									199	8
	Volaris Smart									268	7,5
	Gemino 20									295	7,1
	Volaris Discovery									298	8
	Medipoint Travixx									299	7,4
	Gemino 30									299	7,4
	WheelzAhead Track									299	7,4
	Topro Troja									299	7,4
	Volaris Patrol									329	8,4
	Dietz Taima XC									340	8,2
	Topro Olympos									369	8,3
	Topro Troja 2G									369	7,3
	Gemino 60									385	8,8
	Rollz Motion									749	10,6
	Trionic Veloped Sport									898	11,8
Walking frames		none							6	50-500	
Walking bike	NRG Bike									495	8

Mobility scooters		Battery type	Volts	Capacity (mAh)	Motor type	Power (W)	Gearbox	Max speed (km/h)	Range (km)	Costs (€)	Weight (kg)
Autonomous foldable	MobiGo F7	Lead acid	24	20000				6	12	549	
	Life & Mobility Vivo	Lead acid		22000				8	22	1495	58
	Heartway Brio S19+	Li-ion		11500				8	20	1999	27,3
Autonomous unfoldable	Invacare Leo 3			34000				8	36	1995	83
	Excel Entice 4	Lead acid	24	50000		2x 295		12	35	2495	98
	Primo 4			100000				12	50	3595	85

A.4.2 PERCEPTUAL MAPPING

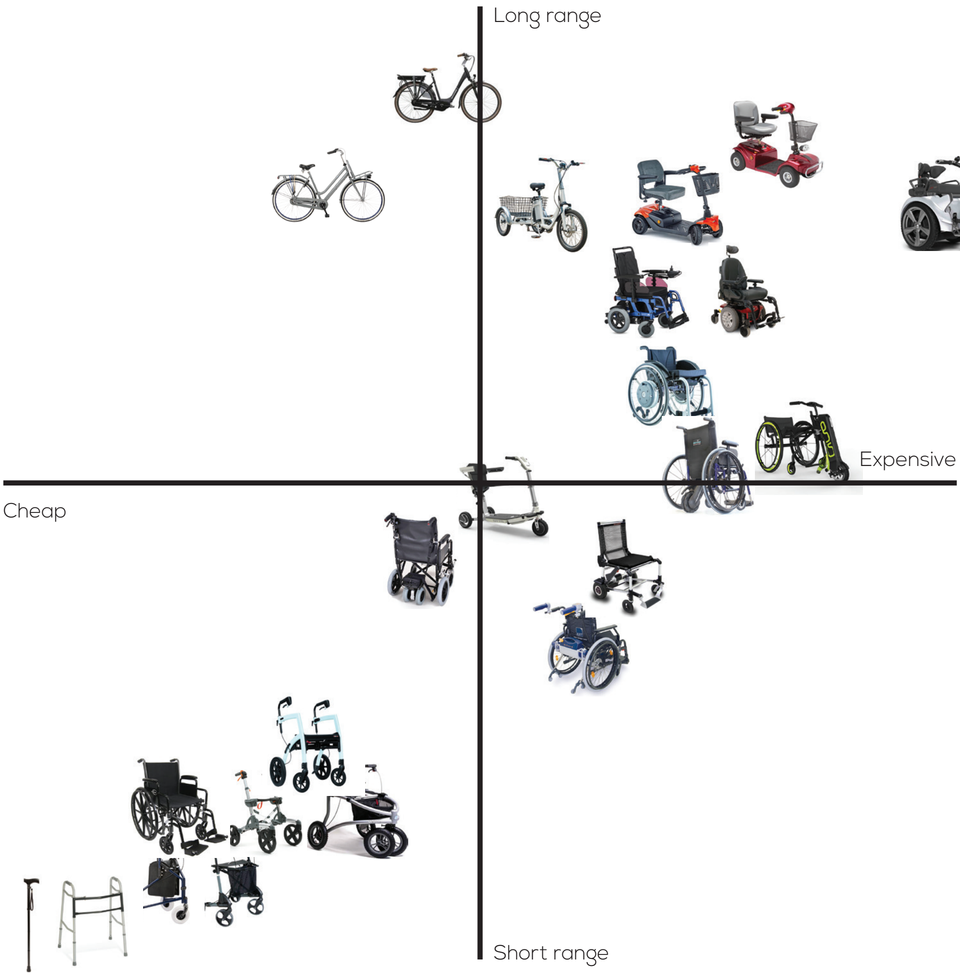
Introduction
Perceptual maps were created to create an overview of the market of mobility assistive devices and to find room for new product innovation.

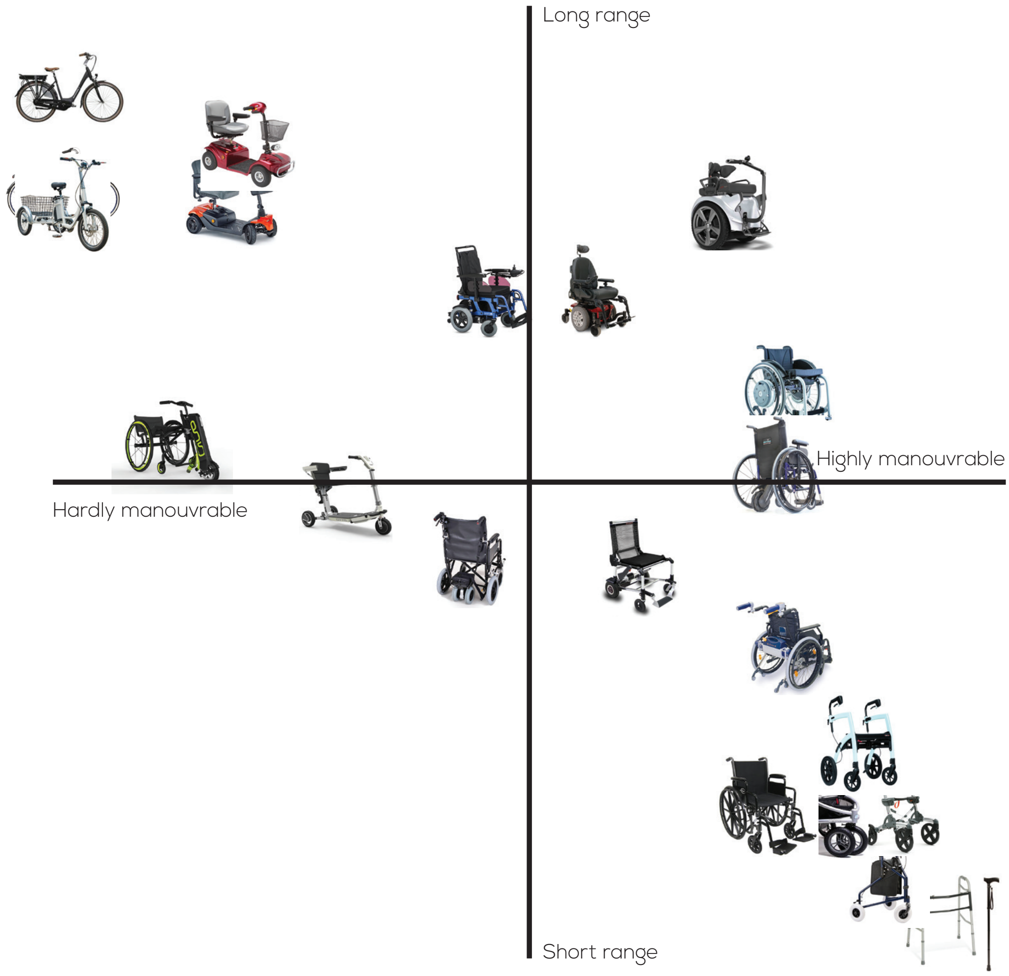
Method
First an overview was created about the different (types of) commercialised products. This overview can be seen in figure ... All different types of mobility assistive devices were taken into account. These systems were then mapped in a graph with two axles. The axles represented product features like attached stigma, or ease of operation. This created an overview of the performance of the product.

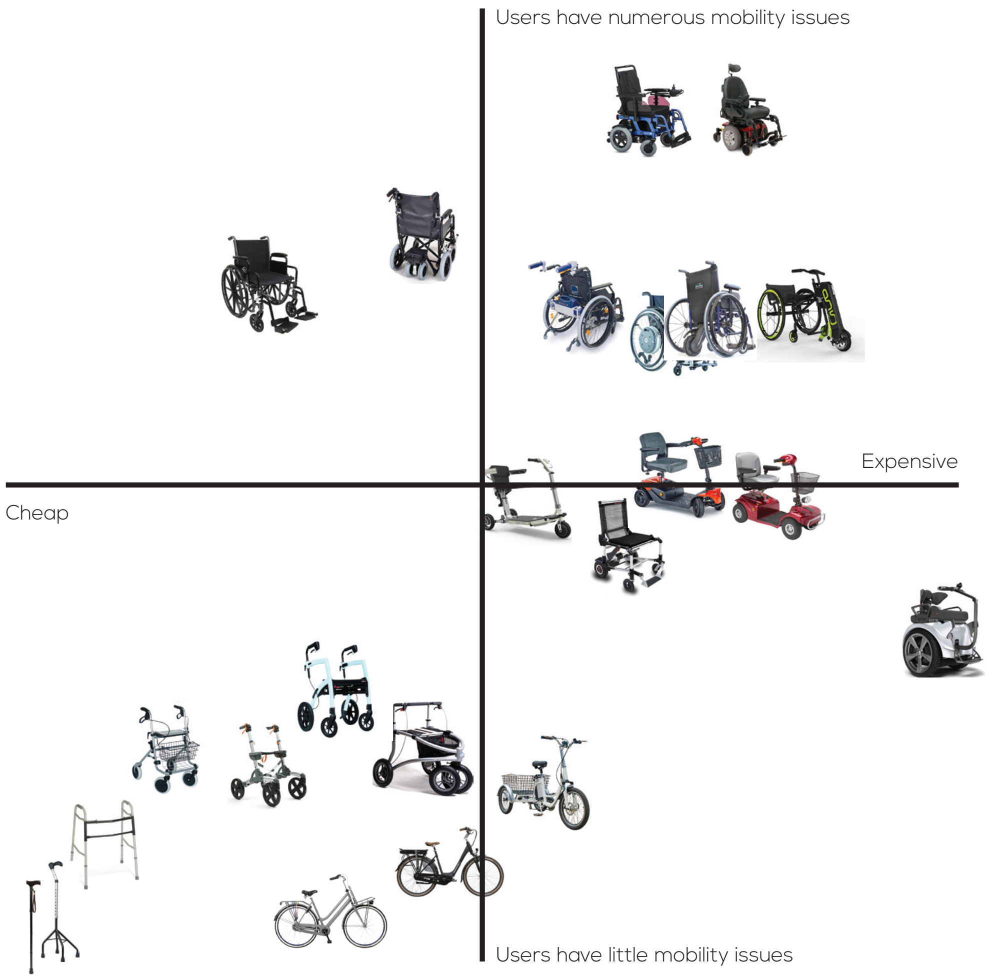
Result
The results are presented in te perceptual maps below and on the next page.

Discussion
Most of the axles are measureable product features. Real perceptual maps should contain non-measureable factors that are based on the perception of a person.

Conclusion
While the created maps are not really perceptual, these still map out the available products. It mainly shows a difference between unpowered and powered vehicles. Based on these differences the additional features of a powered Rollz Motion could be better determined. This allowed to set requirements for these features to create a system that is competitive to or better than other mobility assistive products.




Long range
Highly manouvrable
Hardly manouvrable
Short range

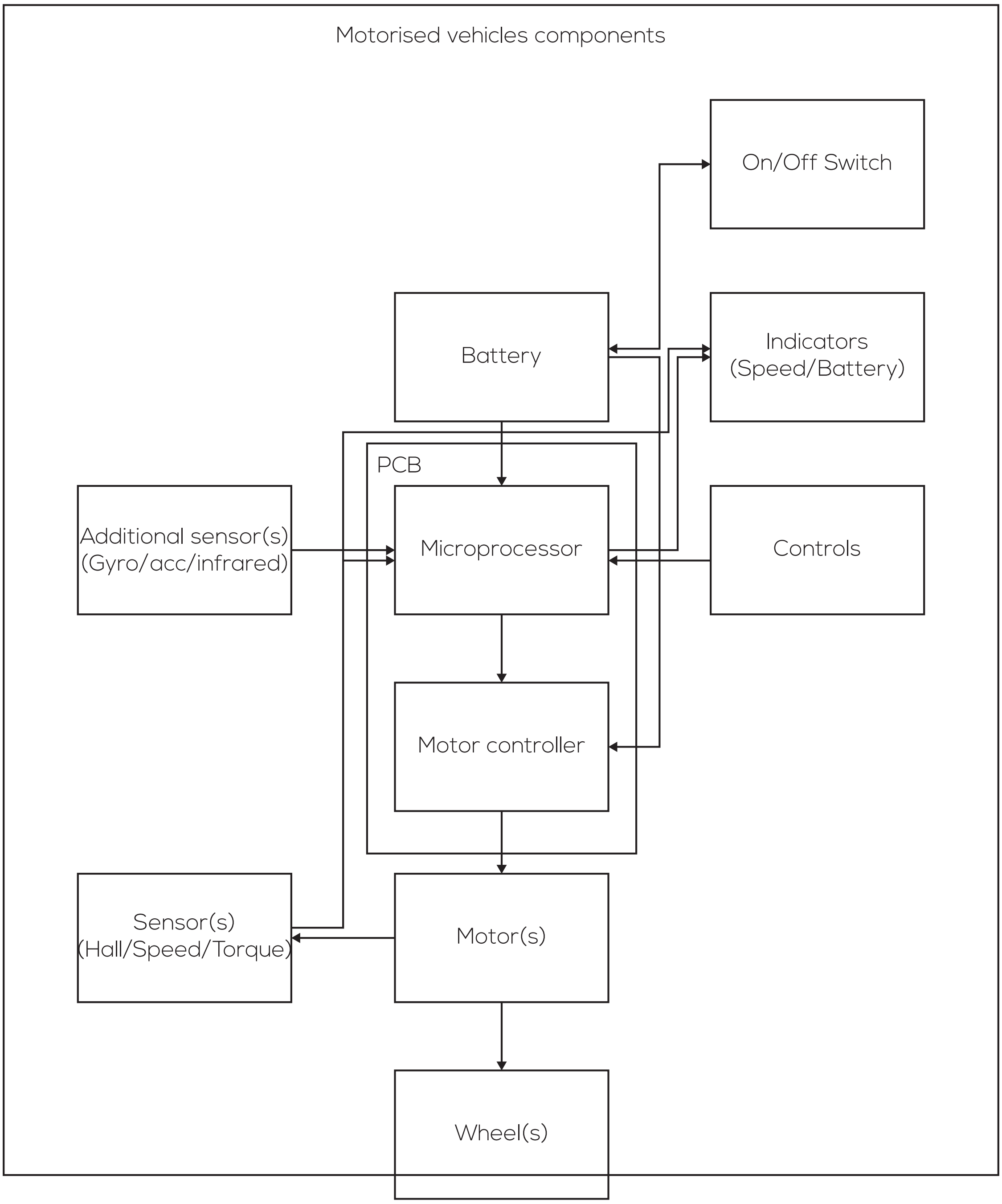

Users have numerous mobility issues
Expensive
Cheap
Users have little mobility issues

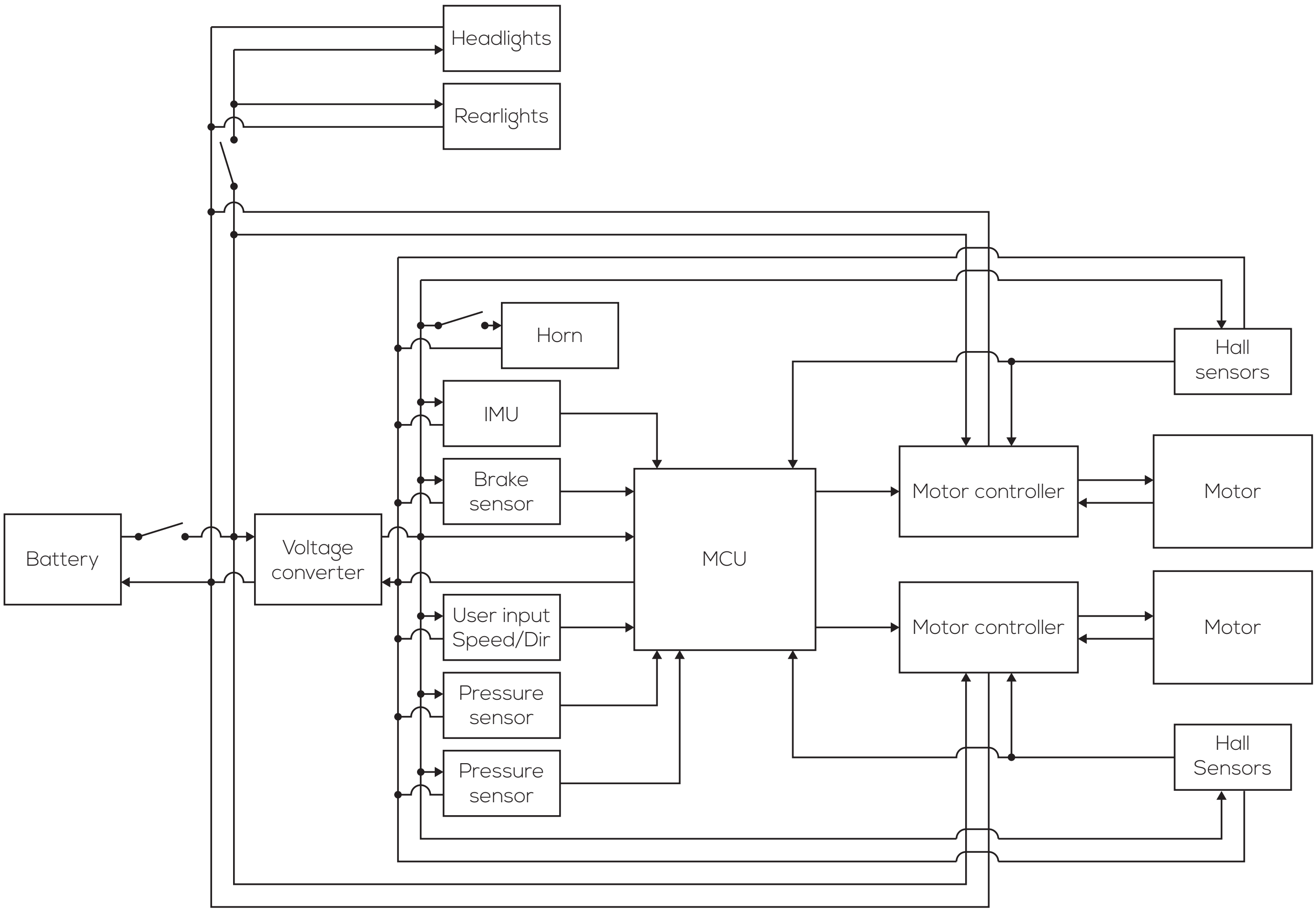
A.5.1 BASIC ARCHITECTURE

Introduction

A system will be needed to fulfill the desired functions. This system needs to be integrated within the product that will be designed and needs to possess the necessary sensor technology, the required decision making protocols and components to actuate a specific movement or feedback action.

As a first step towards such a system, first an overview has been created. This overview can be found on the image. The overview is composed based on the functionalities and components in other products. Afterwards this architechture has been elaborated to better fit the situation of the Rollz Motion. This image can be found on the next page. It gives a first indication of the needs to make the system operational. As a next step ideas were generated to place these components on the Rollz Motion.




Headlights
Rearlights
Horn
IMU
Brake sensor
Battery
Voltage converter
MCU
User input Speed/Dir
Pressure sensor
Pressure sensor
Hall sensors
Motor controller
Motor
Motor controller
Motor
Hall Sensors

A.5.2 DIFFERENCES BETWEEN PUSH SUPPORT AND SELF CONTROLLABLE SYSTEMS

Controls

The main difference in controlling the different types of wheelchairs can be found in the person who controls it. The push support wheelchairs are being controlled by an attendant who pushes the wheelchair, while the self-controlled wheelchairs are controlled by the person that is sitting in the wheelchair.

Since the person that is walking behind the push support wheelchair can steer the wheelchair by varying the force between the two handlebars, no electric or mechanical steering mechanism is needed. This can be seen in the push support products that are available. These kits offer no steering functionality and only allow speed control. For the self-controlled wheelchair it is impossible to steer for the person sitting in the wheelchair without an electric or mechanical steering mechanism. This urges for additional controls that allow this steering motion.

As a result of the additional steering mechanism, not just the components are needed that can facilitate this steering, but also a more advanced control system. This system that maintains the dynamic behaviour of the vehicle will be necessary for the self-controlled vehicles. Where the stability control of the push support product can just focus on the pitching rotation (forwards or backwards) to maintain stable, the stability control of the self-controlled vehicles have to focus on the roll and yaw as well.

Sensors

Either of the systems will need enough sensors to guarantee dynamic stability in any normal given situation. These sensors need to generate data to base the actions of the motors upon. The placement, type and amount of sensors are dependent on the design choices that have not been made at this stage of the process. So not much can be concluded at this point.

Motors

Motors used in self-controlled wheelchairs are stronger than the motors in push support wheelchairs. The motors in the push support wheelchairs can be smaller since they just have to deliver part of the force required to move around. The user can rely on the attendant to accelerate or decelerate when needed. For the self-controlled wheelchairs this backup is missing, so all movement is dependent on the power of the motor.

The larger rear wheels of the Rollz Motion are not connected and the wheels spin independently. If no other wheels will be added, both wheels need to be powered. If the generated power is only directed to one wheel, the user will not be able to control the vehicle since it will just spin in circles. A push attendant will have to eliminate this spinning motion to regain control. In this situation the motor will work as a push support kit, but the attendant still has to deliver force to eliminate the spinning motion. For that reason powering only one of the existing wheels without adding other wheels will not be beneficial.

A.5.3 COMPONENTS

On/Off Switch
Almost all of the found vehicles have on/off switches, especially vehicles that are self-balancing like hover boards and the OneWheel x3. It needs to be at an accessible location, but it should be prevented that this button/switch will be pushed on accident

Indicators
Some vehicles use indicators to feedback the battery level or speed. This is done in numerous ways. One of the simplest solutions is to use a LED that starts blinking when the battery runs dry, while more sophisticated solutions are using lcd-screens.

Human machine interface
Various control technologies can be found in the analysed vehicles. This variation is mainly due to the large difference in vehicles.
A lot of the found electric self-controlled wheelchairs make use of joysticks to control their movement. These seem to give the user the desired amount of control to steer, accelerate and decelerate. For this solution usually a control panel is placed near the location of the user's left or right hand. This panel does usually not just contain a joystick, but a battery indicator and speed control as well.

Some smart self-balancing vehicles like hover boards or OneWheels are controlled without a physical controller. These devices use the position of the user to base the actions of the motors upon. This could be advantageous for the motorized version of the Rollz Motion since this will save the costs of buying or designing a controller and a mount. Further research is needed to find out how this technology can be used to control a vehicle that is not self-balancing. A possibility is to use this technology as stability control, to prevent the Rollz from tipping over.

Most electric longboards use wireless Bluetooth controllers to regulate the speed. These wireless controllers let the user regulate the speed and can even provide feedback about i.e. the battery level. While this solution is interesting since the user can just hold the remote wherever they want, and users could even guide the Rollz towards them when they are not in it. Disadvantages of such a system are that the Bluetooth signal can be hacked or interfere with other devices making the control impossible. https://electricskateboardreviews.net/hackers-hijacking-electric-skateboards-is-now-a-thing/

A rather innovative and different way of controlling is used by the Zinger Chair. This electric self-controlled wheelchair can be powered using two levers. Each wheel can be accelerated by moving a lever: pushing the right lever forward will power up the right wheel. When the levers are moved backwards, the wheels start braking.

Battery
Numerous battery technologies can be found available on the market. The cheap Lead Acid type is sometimes used for wheelchair push support products. For lighter products like hover boards, the Li-ion batteries are the first choice because of their high power capacity and therefor lower weight.

Motor
All researched vehicles use brushless DC motors. These differ in their position on the vehicle and in the way the power is transferred to the wheels.

The Vivax Assist uses an in frame motor to secretly generate power to help a cyclist. The motor is hidden in the frame and connected to the crankshaft of the bicycle using bevel gears. The motor and the attached gearbox can be fitted in seat tubes with a diameter larger than 30,9 mm. Further research is needed to test whether these in frame motors will be small enough to fit the frame of the Rollz Motion.

Direct drive motors are used in hover boards. Advantages of this type of hub motor include that these are fast, quiet and durable. However, when the motor is not turned on these motors tend to drag. They are also larger and heavier compared to geared hub motors.

Geared hub motors can deliver more torque compared to their gearless variant. This type of motor is also more efficient, smaller and lighter and has little drag when turned off. However, top speeds are lower and they produce more sound. https://blog.e-bikerig.com/2016/04/21/electric-bike-motor-hubs-gearless-is-not-more/

Another option would be not to place the motor directly in the wheel, but next to the wheel. Also for this option, numerous techniques are being used. A gearbox or a belt could for example be used. A belt provides a good transmission and is very precise, but is more fragile than gears, which are heavier.

For a solution that is also used by some electric self-controlled wheelchairs, the motor axles are placed on the tires. This solution can be easily mounted on every wheel, but could decrease the lifespan of the wheel.

Motor sensors

Some sensors could be linked to motors to provide feedback about the motor position, the motor speed, or the delivered torque. This information can be used to control the motor and vehicle better. Hall sensors are usually used to detect the motor position and speed. The use of hall sensors is especially useful for more precise control of motors with low RPM. By measuring the current, the torque can be estimated.

Additional sensors

Some vehicles use additional sensors. Gyroscopes are for example used in self-balancing vehicles, but also in some electric wheelchairs. These can help in keeping the vehicle balanced or to react on slopes. Some hoverboards use infrared/pressure sensors to detect whether the user is standing on top of the vehicle with both feet, to prevent it from moving away without the user. Using these additional sensors can help in gaining more information about the use of the vehicle and can therefor help in controlling it better.

A.5.4 TRENDS/INTERESTING TECHNOLOGIES

AirWheel x3

The Airwheel is an intelligent self-balancing electric unicycle. Using a gyroscope it detects the angle and balances itself according to the inverted pendulum mechanism. When a user is on the Airwheel it can maneuver by leaning forward, backward and sideways. The more the user will lean, the faster the vehicle will go.

To prevent injuries while using the Airwheel, the motor stalls when the tilt angle exceeds 45 degrees. A limiter prevents the vehicle from exceeding its speed limit by rising the angle of the pedals, forcing the users to lean more backwards and slow down.

Electric longboards

Numerous electric longboards are available on the market using different technologies. Some use (single or dual) geared in wheel motors; others use belt systems to transfer the motor power to the wheel through pulleys. One of the systems even powers the wheel itself (on wheel). A belt provides a good transmission and is very precise, but is more fragile than gears. On wheel can be easily mounted on every wheel, but could decrease the lifespan of the wheel. Hub motors in a skateboard wheel do need an additional transmission in order to get the desired torque, but are lighter than the other options.

Most boards have their batteries below the deck. Some newer conceptual models use thinner battery packs that enable to be placed inside the deck.

Hover board

A hover board is a self-balancing smart scooter. Although it grew quite popular amongst children, it is not allowed on the Dutch public roads. In other European countries these vehicles are still allowed.
Some models use infrared sensors on the foot pads to check whether the user is standing on it or not. After it has detected whether the user is on the board, it starts balancing. Some hover boards have lights built in.

AAT V max

The AAT V max is a wheelchair push support product that does not limit the use of the wheelchair itself, since it can be detached from the wheels. Furthermore it has a detachable battery.

The motors directly power the wheels using gears. This means that the wheels need to be changed in order to work. To prevent users from falling over backwards, the vehicle does have small wheels behind the large wheels.

Merits power pack

The Merits power pack is a wheelchair push support that consists of two additional wheels that can be mounted behind a wheelchair. A controller can be fixed to the handles of the wheelchair. The way these additional wheels are added decreases the maneuverability of the wheelchair. It is impossible to rotate around your own axis while these wheels are in use. The product does have a function that can lift the wheels so that the wheelchair can be used in smaller environments as well.

Alber e-motion

These smart in wheel wheelchair motors are placed in the large wheelchair wheels. They register when the user is applying force to start moving and increase the strength of this movement. In order to make this work the wheels of the wheelchair need to be replaced for wheels with motors in them. The li-ion batteries are also placed inside these wheels.

This vehicle does also come with additional small wheels that prevent the vehicle from tipping backwards.

The system is smart enough to detect the slope on which the wheelchair is riding and smartly responds to this. So when the user is driving uphill and stops pushing for a moment, the system immediately activates the brakes to prevent the vehicle from moving backwards downhill.

SmartDrive MX2

The SmartDrive can be seen as an innovative version of the Merits Power Pack. It works similar as the Power Pack by adding two wheels at the back of the wheelchair. These additional wheels can be powered. But the SmartDrive can be used as a self-controllable solution, without someone who needs to push. The SmartDrive records the speed of the pushes by the user, and maintain that speed. The user wears a watch that is used to stop the wheelchair by tapping the watch. One of the disadvantages of the Power Pack is that it limits the maneuverability. The SmartDrive solves this by using omni-wheels that can also move sideways.

Light drive 2

Another interesting solution can be found in the Light Drive 2. The motors of this detachable electric drive system are placed directly on the tires. One of the main advantages of such a system is that it fits most wheelchairs, without having to replace the wheels. For the Rollz Motion such a drive system could be attached and detached easily, and could fit previous versions as well. The weight of this additional kit is however quite high. Adding the 14 kg to the Rollz Motion would double the total weight.

Zinger Chair

The zinger chair is a folding mobility chair that is powered through the tires as well. Each wheel can be accelerated by moving a lever: pushing the right lever forward will power up the right wheel. When the levers are moved backwards, the wheels start braking.

Advantages of this system are a low turning radius, just one motor is needed, and the system is light and easy to handle and fold. Disadvantages are wear on the motorized wheels, two hand control, little speed control (basically on or off, with 3 speed options)

Electric bicycles

Vivax assist The Vivax assist seems to be the most lightweight electric bicycle kit that is available on the market. With a weight of just 1,8 kg it can transform a regular race bike in an e-bike. Besides it is almost invisible since the motor can be placed inside the bicycle frame and the battery can be hidden in a saddlebag. With a simple on/off switch that can be placed on the steer, the motor can be controlled. The system can detect the RPM of the cyclist and adjust its own speed to match this.

This technology of in frame motors gained quite some publicity when some professional cyclists were accused of using these motors hidden in their bikes.

A.6.1 STANDARDS

EN 12184:2009 (E)

12 Tables

Table 1 — Requirements and tests for driving characteristics of type classes

Driving characteristics	Test	Requirement		
		Class A	**Class B**	**Class C**
Maximum safe slope	8.8.2.2	minimum 3°	minimum 6°	minimum 10°
Dynamic stability	8.8.5.2			
- starting forwards uphill		3° minimum slope	6° minimum slope	10° minimum slope
- stopping forwards uphill		3° minimum slope	6° minimum slope	10° minimum slope
- stopping forwards downhill		3° minimum slope	6° minimum slope	10° minimum slope
- stopping backwards downhill		3° minimum slope	6° minimum slope	10° minimum slope
- turning on a slope		No tipping beyond balance point shall occur	No tipping beyond balance point shall occur	No tipping beyond balance point shall occur
Static stability	8.8.7.2			
- all directions		6° minimum slope **or** the maximum safe slope claimed by the manufacturer if greater	9° minimum slope **or** the maximum safe slope claimed by the manufacturer if greater	15° minimum slope **or** the maximum safe slope claimed by the manufacturer if greater
Maximum operating forces				
Brake levers	8.4.2.1			
Freewheel lever and controls	8.5.2			
- single finger operation		5 N	5 N	5 N
- one hand operation		13,5 N	13,5 N	13,5 N
- combined hand and arm operation		60 N	60 N	60 N
- foot operation, pushing operation		100 N	100 N	100 N
- foot operation, pulling operation		60 N	60 N	60 N
Parking brake effectiveness	8.4.2.3 and 8.4.2.6	6° **or** the maximum safe slope claimed by the manufacturer if greater	9° **or** the maximum safe slope claimed by the manufacturer if greater	15° **or** the maximum safe slope claimed by the manufacturer if greater
Maximum speed	8.8.8			
- forwards horizontal		15 km/h	15 km/h	15 km/h
- reverse horizontal		70 % of maximum forward speed of the wheelchair **or** 5 km/h whichever is lower	70 % of maximum forward speed of the wheelchair **or** 5 km/h whichever is lower	70 % of maximum forward speed of the wheelchair **or** 5 km/h whichever is lower
Obstacle climbing and descending ability	8.8.6.2			
- minimum obstacle height		15 mm	50 mm	100 mm
Minimum theoretical continuous driving distance range	8.8.9.2	15 km	25 km	35 km
Ground unevenness	8.8.3.3	10 mm	30 mm	50 mm

A.6.2 LAWS

Earlier reseach by inMarket showed the laws that are applicable to the mobility assistive devices:

Voor het besturen van een elektrische rolstoel en gesloten gehandicaptenvoertuig gelden dezelfde regels als voor een scootmobiel. Om een scootmobiel die harder dan 10 km/u rijdt te mogen besturen moet je een minimale leeftijd hebben van 16 jaar. Gaat de scootmobiel langzamer, dan geldt er geen minimumleeftijd. Ben je ouder dan 16 jaar, dan heb je geen (bromfiets)rijbewijs nodig om een scootmobiel te mogen besturen.

Waar mag een elektrische rolstoel rijden
Een elektrische rolstoel mag op de stoep, het voetpad, het fiets/bromfietspad en de rijbaan, behalve op auto- en snelwegen. Als deze wegonderdelen allemaal aanwezig zijn, mag er zelf worden bepaald welke weg je neemt.

Op een fiets/bromfietspad en de rijbaan heeft een elektrische rolstoel dezelfde rechtspositie als een fietser. Op het voetpad en de stoep hebben ze dezelfde rechtspositie als een voetganger. Van de bestuurder van een elektrische rolstoel wordt verwacht zijn snelheid in de gaten te houden bij het maken van de keuze.

Maximumsnelheid
Voor een scootmobiel zijn er vaste maximumsnelheden in de wet opgesteld. Een elektrische rolstoel valt onder een scootmobiel, dus voor een elektrische rolstoel gelden dezelfde regels.
Maximumsnelheden scootmobiel:
- Op de stoep mag je maximaal 6 km/u rijden.
- Op het (brom)fietspad binnen de bebouwde kom mag je maximaal 30 km/u rijden. Buiten de bebouwde kom is dat 40 km/u.
- Op de rijbaan, behalve op autowegen en autosnelwegen, mag je maximaal 45 km/u. Dat geldt zowel binnen als buiten de bebouwde kom.

Scootmobielen hebben in de praktijk een constructiesnelheid tussen de 6 tot 20 km/u.

Verlichting
Op een elektrische rolstoel moet je overdag bij slecht zicht en 's nachts voorlicht en achterlicht voeren, mits je op de rijbaan rijdt. Dit geldt niet als je op de stoep rijdt.

Verzekering
Voor een elektrische rolstoel heb je geen kenteken nodig. Wel moet je een verzekering tegen wettelijke aansprakelijkheid(WA) hebben. Ook wanneer deze niet de openbare weg op gaat en alleen binnen wordt gebruikt is een verzekering noodzakelijk, dit geldt voor zowel gemotoriseerde als niet gemotoriseerde rolstoelen.
Wordt de rolstoel ook op de openbare weg gebruikt, dan is voor de gemotoriseerde rolstoel een burgerlijke aansprakelijkheidsverzekering verplicht (zoals dit voor een auto of bromfiets wettelijk verplicht is). Voor de niet gemotoriseerde rolstoel is er niets wettelijk verplicht, maar het is raadzaam om na te kijken of de rolstoel in de familiale verzekering verzekerd is voor de burgerlijke aansprakelijkheid.
Een verzekerd voertuig heeft een verzekeringsplaatje aan de achterzijde.

Afmetingen
Dit geldt voor een gehandicaptenvoertuig met motor. Hieronder valt ook de elektrische rolstoel.
Gehandicaptenvoertuigen met motor mogen:
- niet breder zijn dan 1,10 meter;
- niet langer dan 3,50 meter;
- niet hoger dan 2,00 meter.

Een elektrische rolstoel die wordt bestuurd door een persoon die achter de rolstoel loopt mag niet op de openbare weg. Aangezien de persoon achter de rolstoel loopt mag de rolstoel alleen op het voetgangers pad.

The RDW has been contacted to validate these laws, see the answer below. They turned out to be indeed applicable.

Indien de snelheid van de rollator (ondersteund, danwel zelfstandig bewegend) max. 6 km/h bedraagt, valt deze niet onder de eisen van EU Kaderverordening 168/2013 (voorheen 2002/24). Het is dan aan het Ministerie van I&M om te bepalen of er eisen aan gesteld worden en wat deze dan zijn. Dit is bijvoorbeeld gebeurd bij de Segway, waarvoor de minister eisen heeft laten opstellen opdat het voertuig toegelaten kon worden voor gebruik op het trottoir bij lage snelheid en op de rijbaan bij hogere snelheid.

Indien de rollator zelfstandig kan bewegen is deze te vergelijken met een elektrische rolstoel. Op overheid.nl vind je regels hiervoor.
https://www.rijksoverheid.nl/onderwerpen/bijzondere-voertuigen/vraag-en-antwoord/wat-zijn-de-verkeersregels-voor-een-gehandicaptenvoertuig-met-een-motor

Omdat de snelheid max. 6 km/h zal bedragen, is RDW geen partij in deze.

Ik hoop dat je hier mee verder kunt. Mocht je nog vragen of opmerkingen hebben, laat het me weten.

Met vriendelijke groet / with kind regards / mit freundlichen Grüßen,

Hans Lammers
Manager Operations
Vehicle Admission & Supervision – Product Assessment Department
Passenger Cars, Light Commercial Vehicles and Motorcycles

RDW

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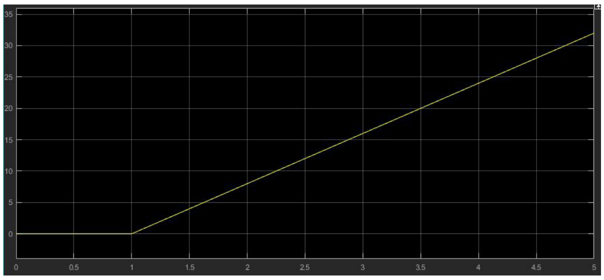
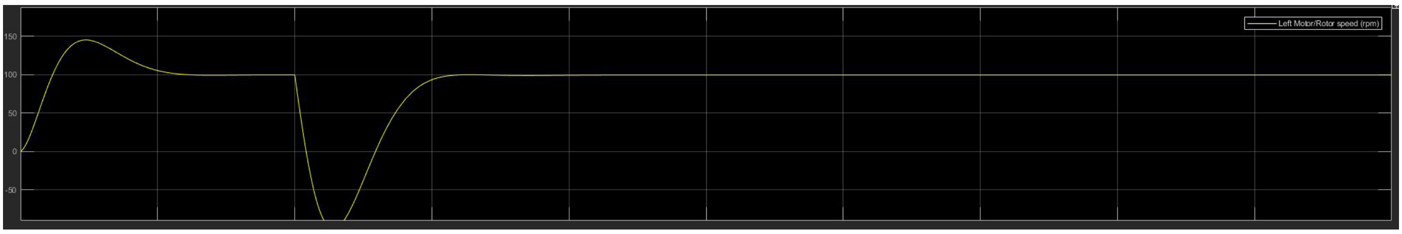
I www.rdw.nl

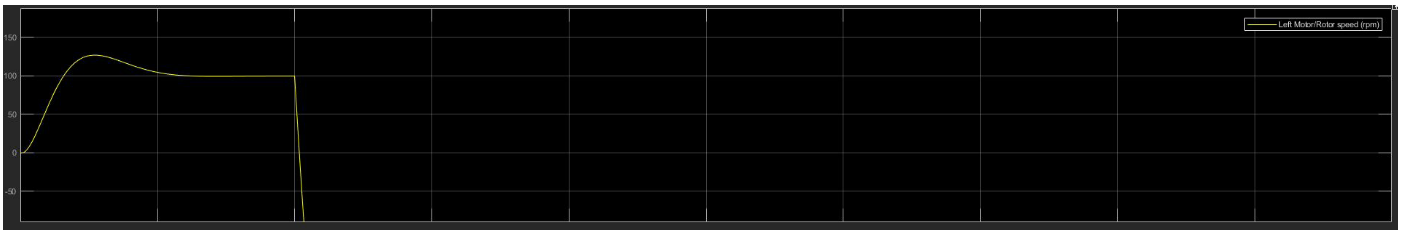
A.7.1 MATLAB/SIMULINK MODEL

A Matlab/Simulink model was used to simulate a PI controlled system. An overview of the system can be found on the next page. This system was first tuned, before it was able to model the situation where a wheelchair with a user in it would encounter an 8 degree slope, as shown in the image below.



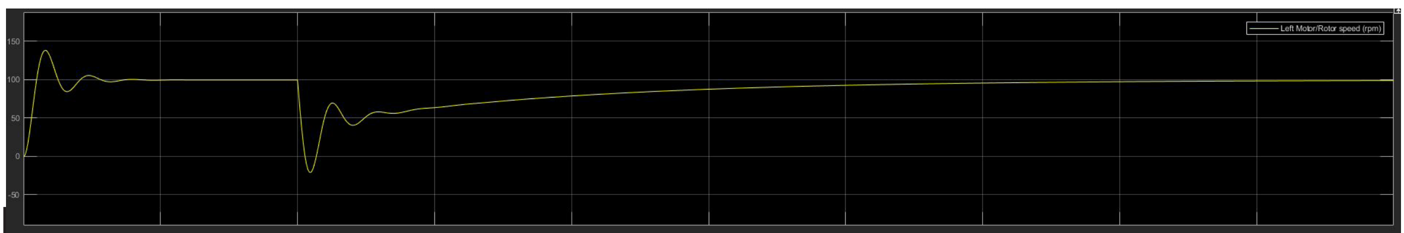
The reaction of the vehicle was determined and plotted in the graphs below. This was repeated for a different user with a different weigth. The first graph below shows the vehicle speed for a user of 50 kg, and the second graph for a 120 kg user. The tuning parameters for the PI controller were similar for the two simulations. In both simulations the wheelchair correctly accelerates, but when the hill is encountered the reaction is different. Where the 50kg loaded model slows down for a moment and slowly reaches the desired speed again, The 120 kg loaded model cannot climb the hill.

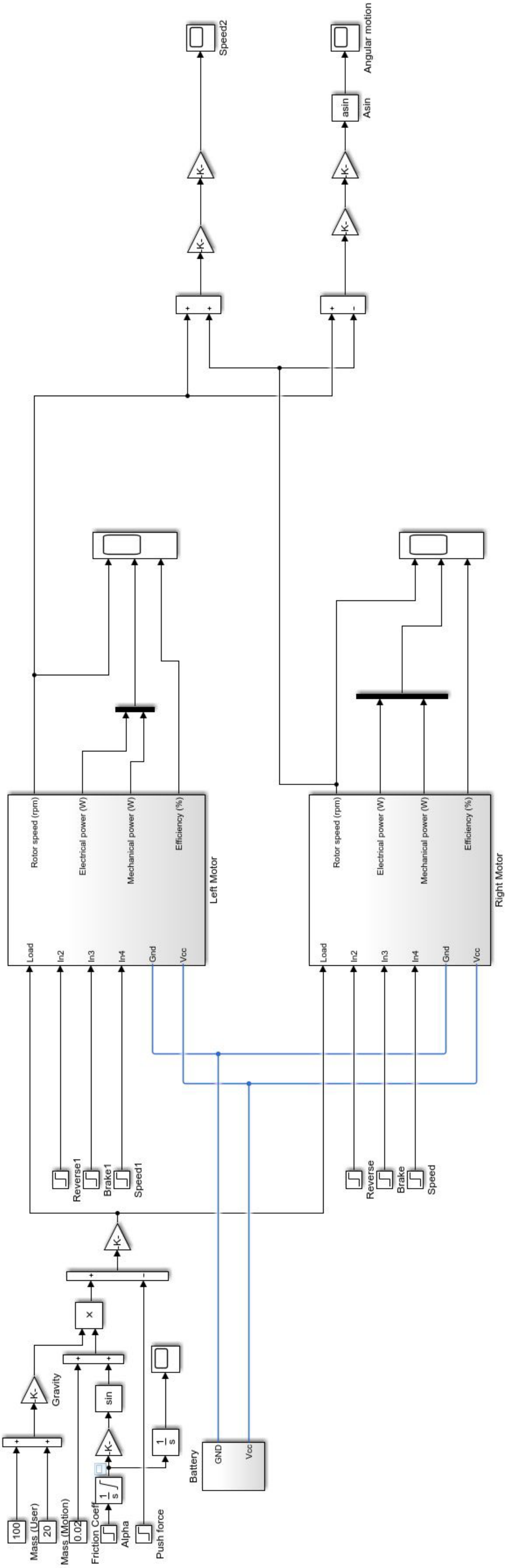




After retuning the PI controller, it proved to be possible for the 120kg loaded model to climb the hill as well.This can be seen in the graph below.

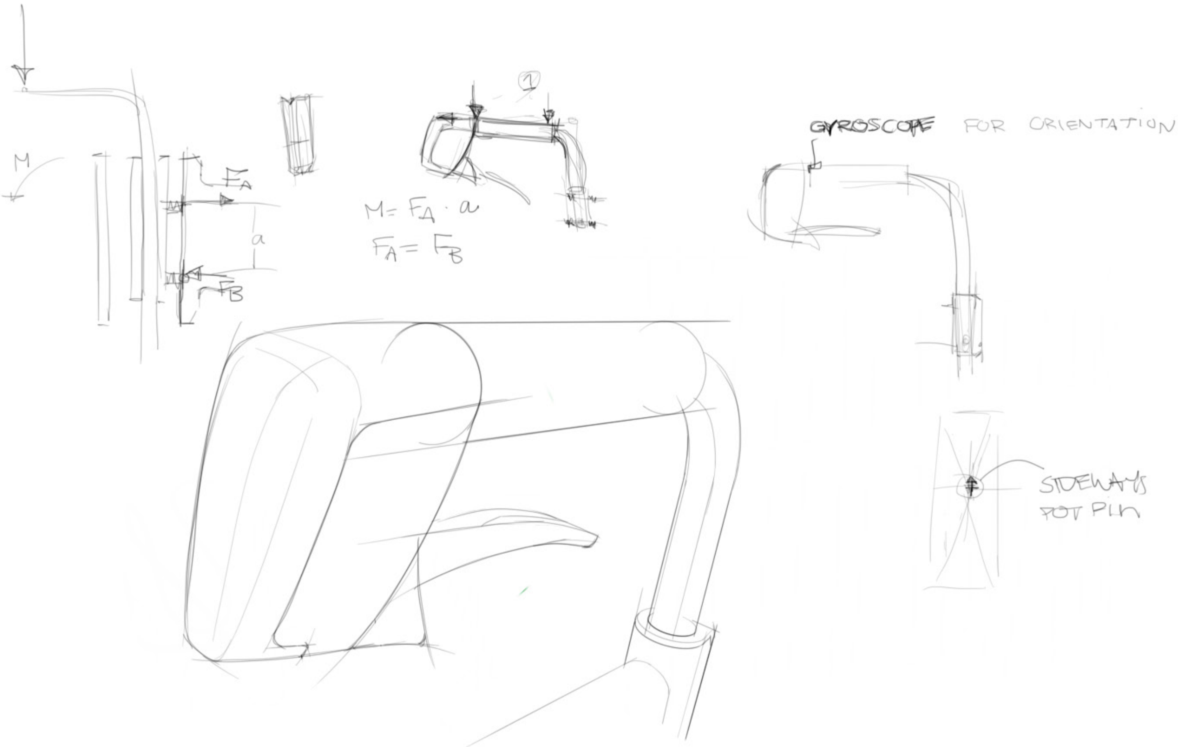
This shows that an adaptively tuned PI controlled system could make an PI controller work within the context of the Rollz Motion.

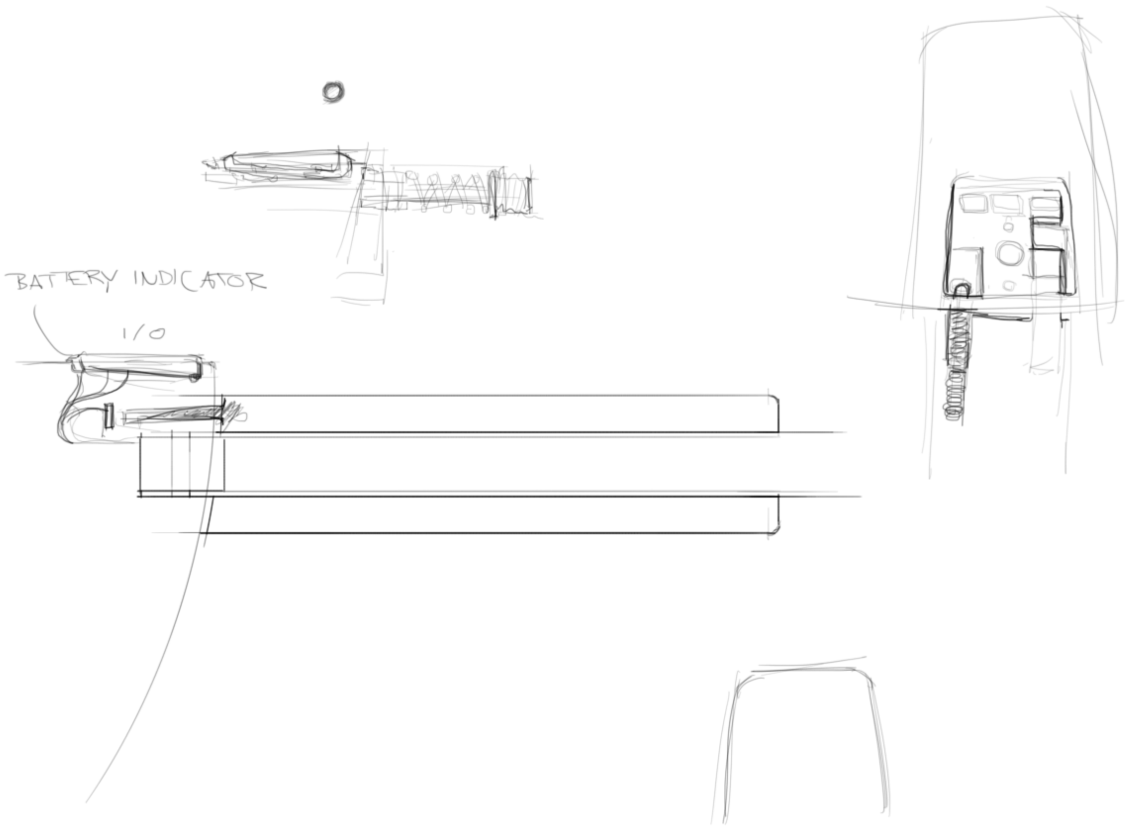


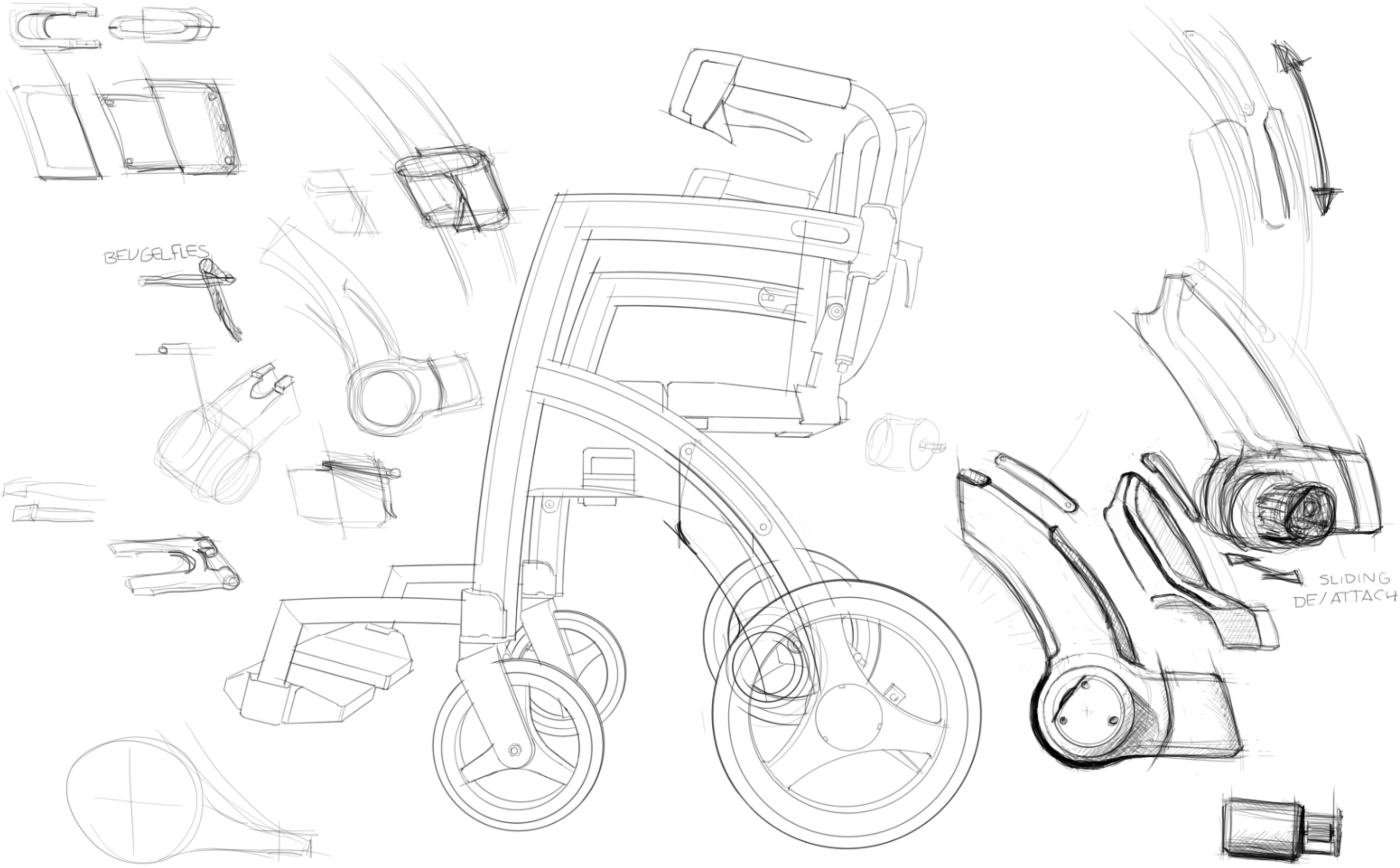


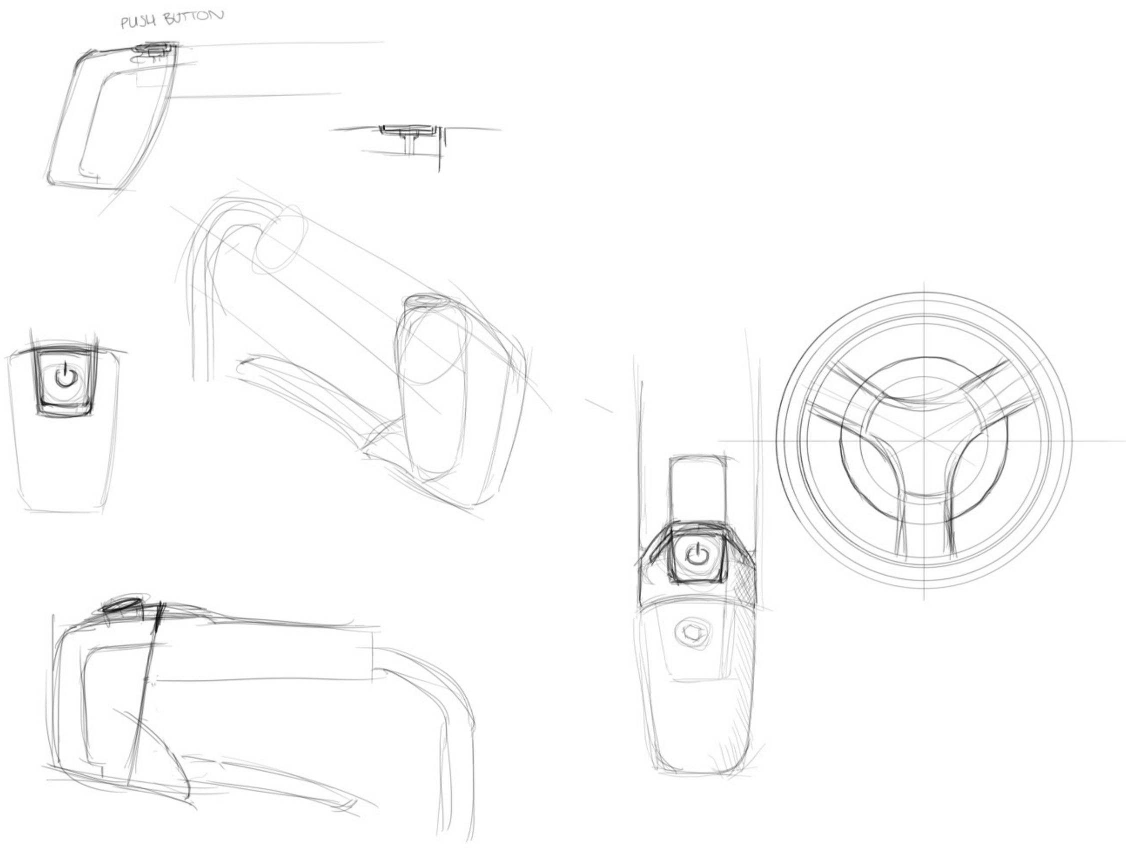
Speed2
Angular motion
asin
Asin
-K-
Rotor speed (rpm)
Electrical power (W)
Mechanical power (W)
Efficiency (%)
Left Motor
Load
In2
In3
In4
Gnd
Vcc
Right Motor
Reverse1
Brake1
Speed1
Reverse
Brake
Speed
Gravity
sin
Battery
GND
Vcc
100
Mass (User)
20
Mass (Motion)
0.02
Friction Coeff
Alpha
Push force

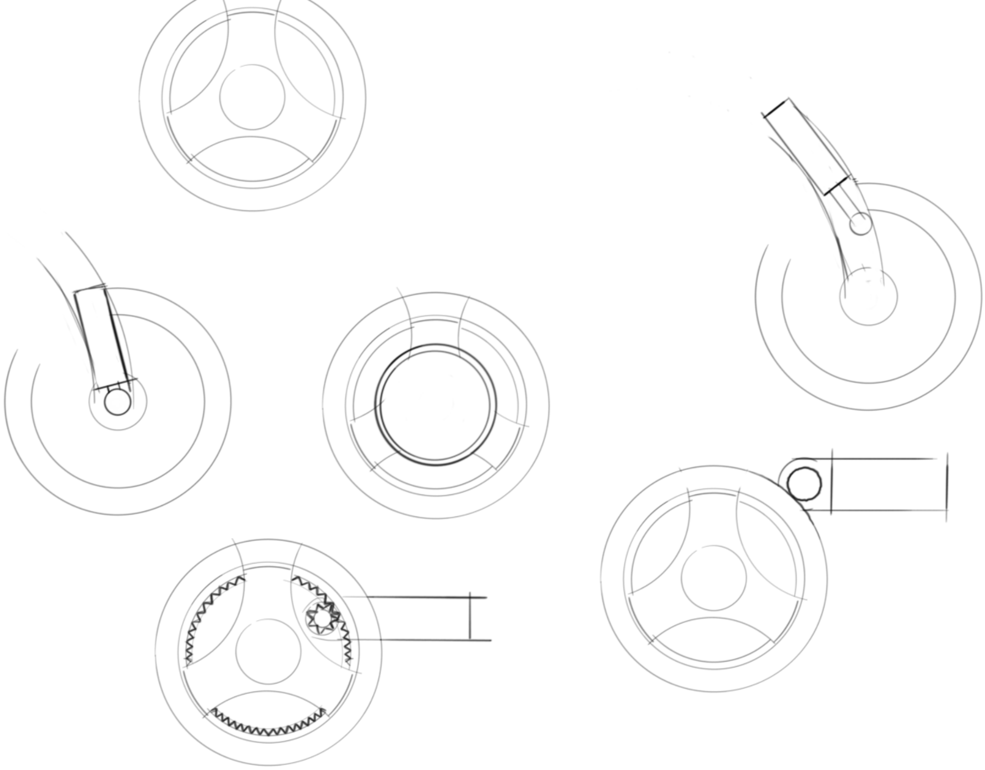
C.1.1 IDEAS & SKETCHES

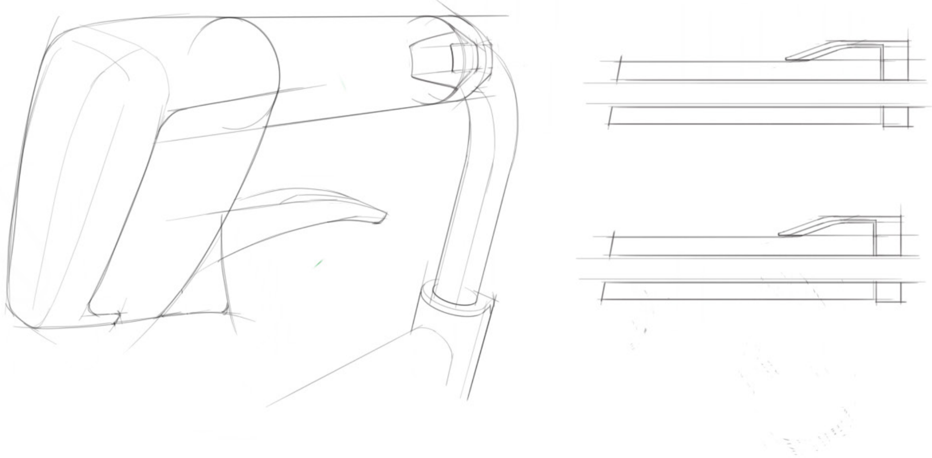


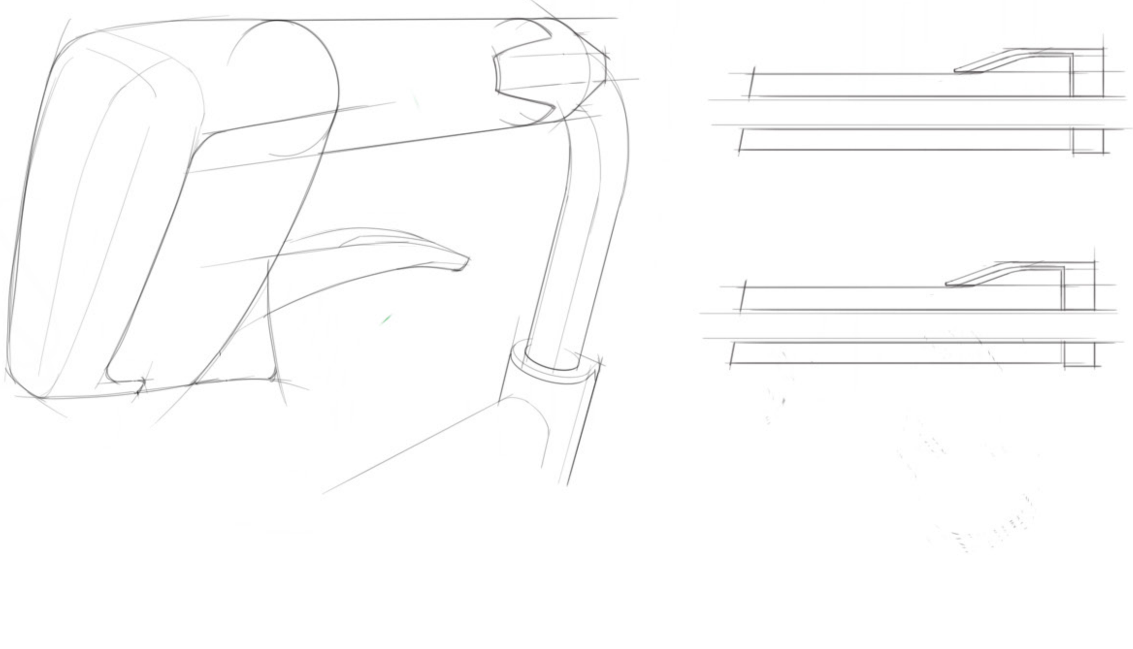


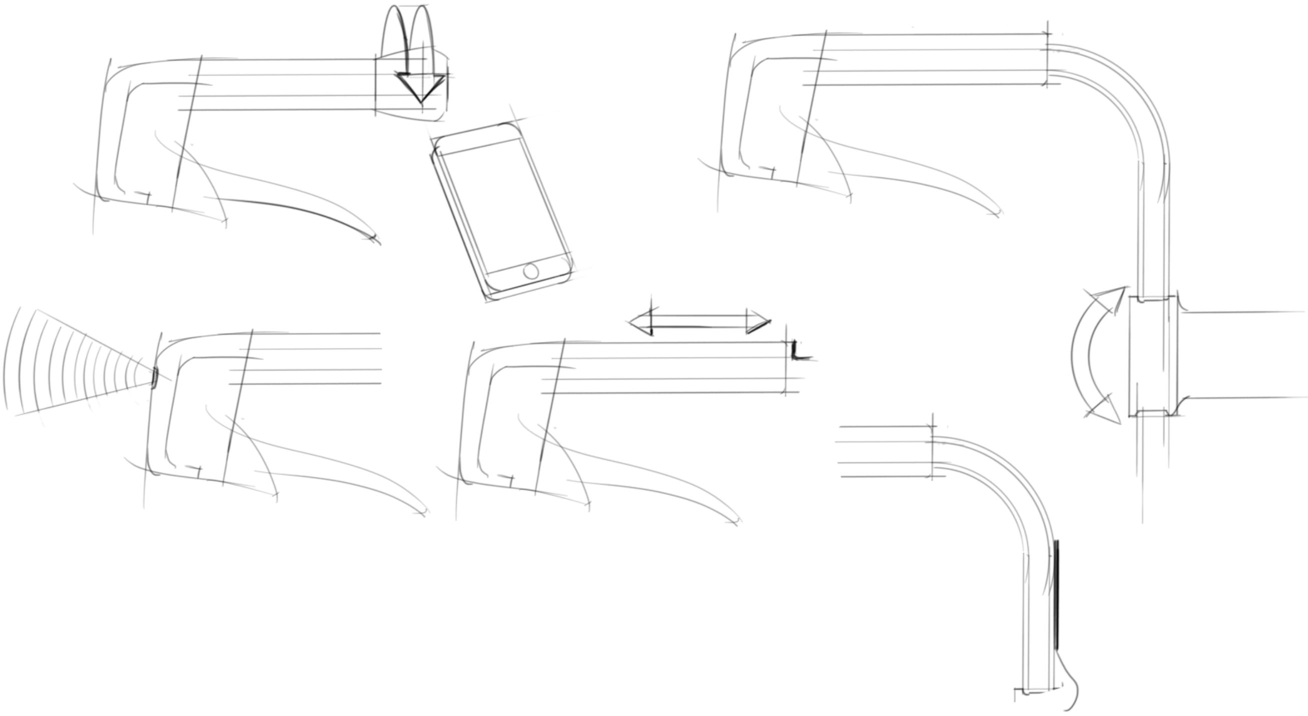

BEUGELFLES
SLIDING
DE/ATTACH

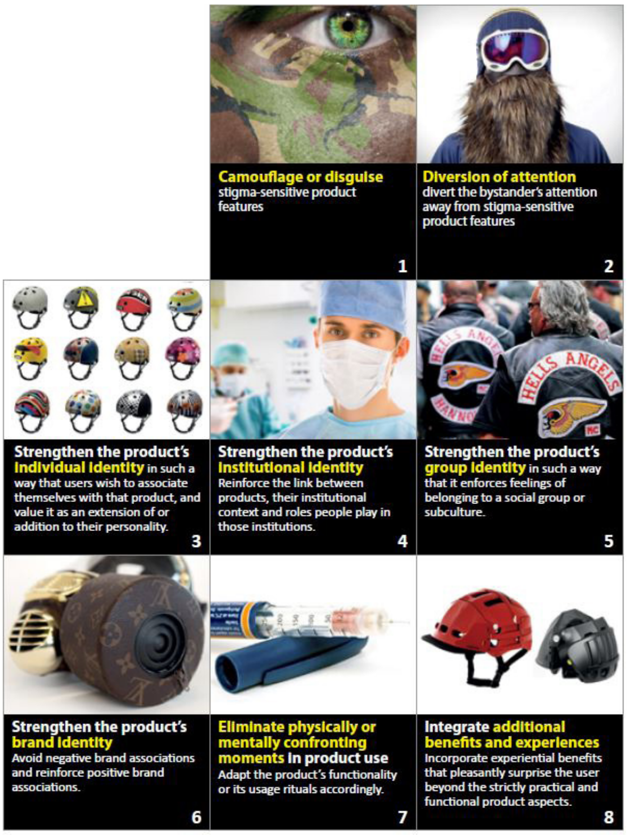

PUSH BUTTON



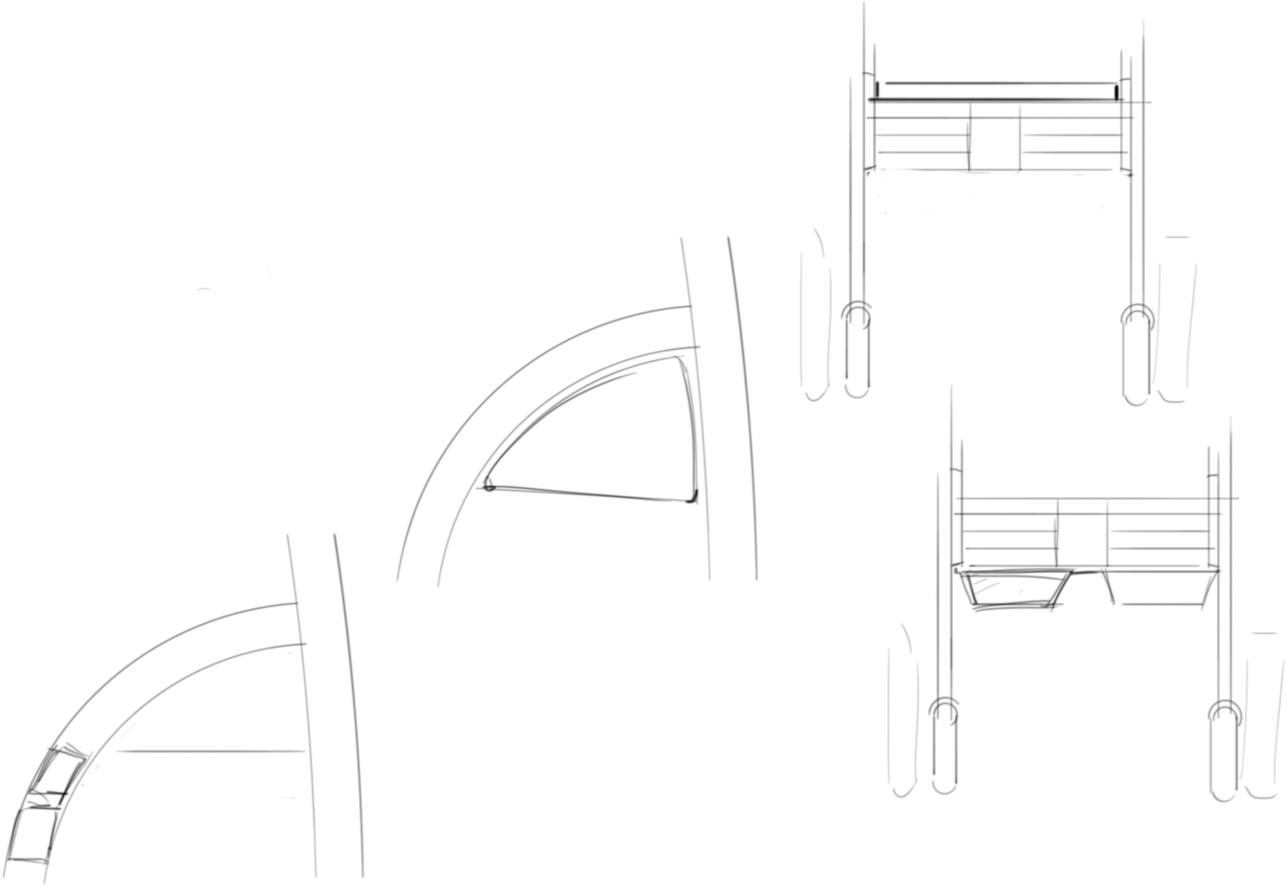


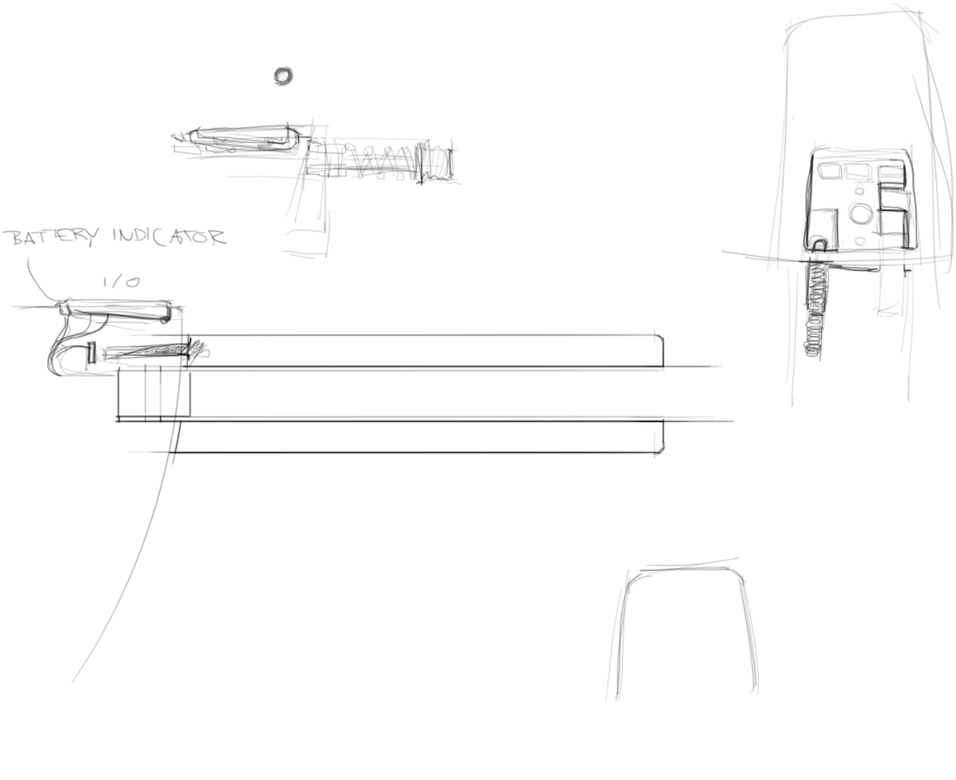


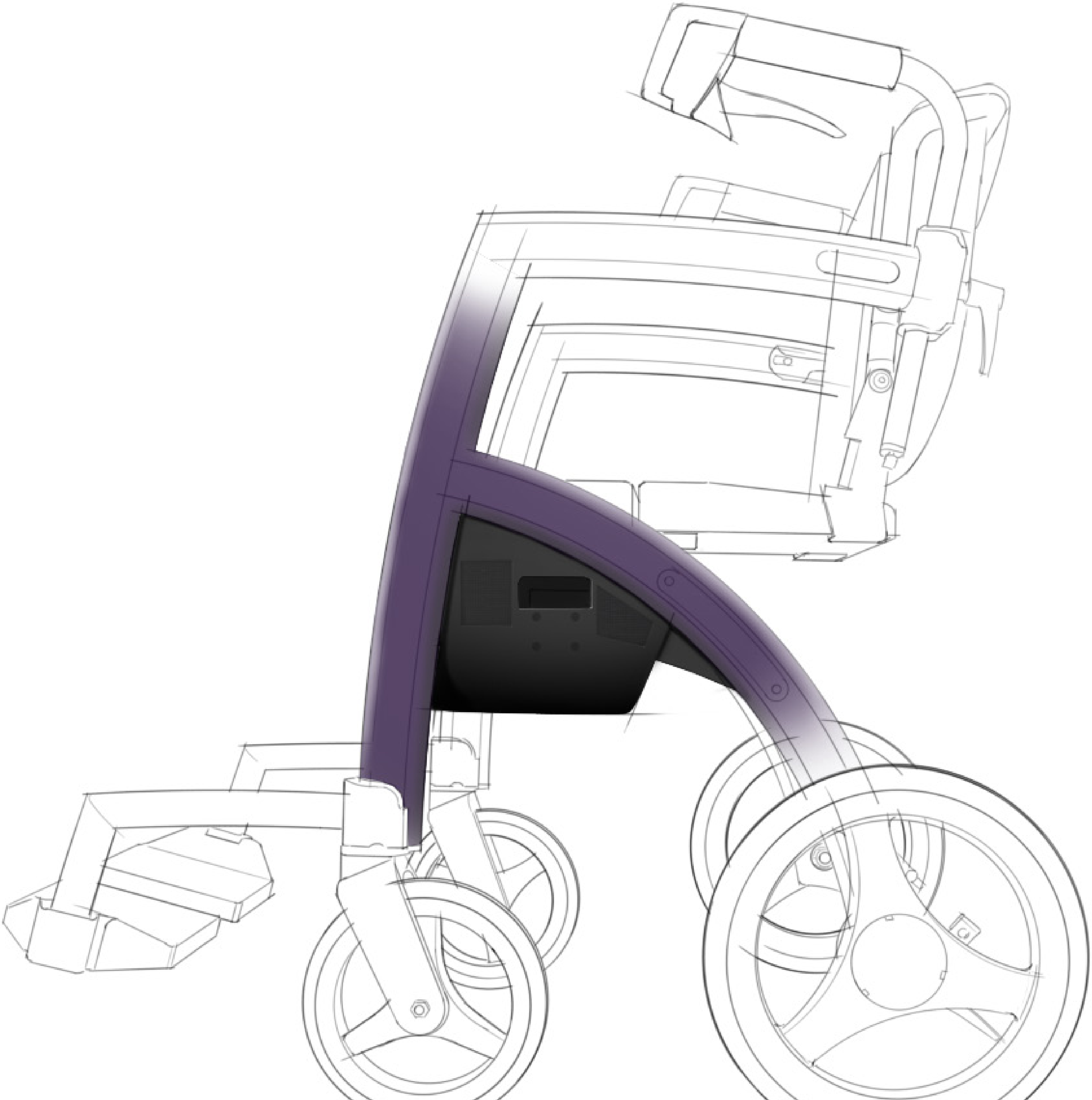


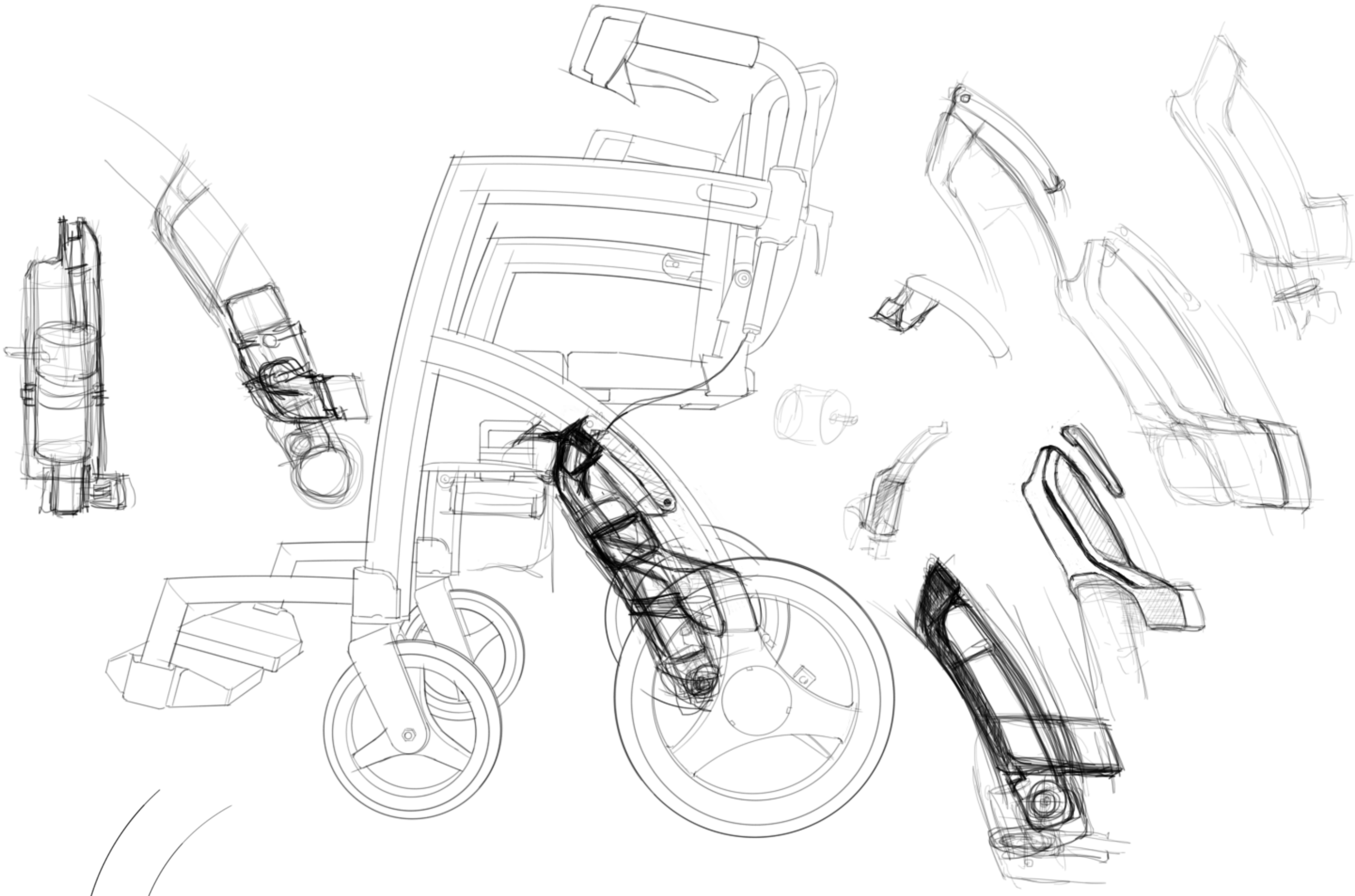

Camouflage or disguise stigma-sensitive product features 1
Diversion of attention divert the bystander's attention away from stigma-sensitive product features 2
Strengthen the product's individual identity in such a way that users wish to associate themselves with that product, and value it as an extension of or addition to their personality. 3
Strengthen the product's institutional identity Reinforce the link between products, their institutional context and roles people play in those institutions. 4
Strengthen the product's group identity in such a way that it enforces feelings of belonging to a social group or subculture. 5
Strengthen the product's brand identity Avoid negative brand associations and reinforce positive brand associations. 6
Eliminate physically or mentally confronting moments in product use Adapt the product's functionality or its usage rituals accordingly. 7
Integrate additional benefits and experiences Incorporate experiential benefits that pleasantly surprise the user beyond the strictly practical and functional product aspects. 8

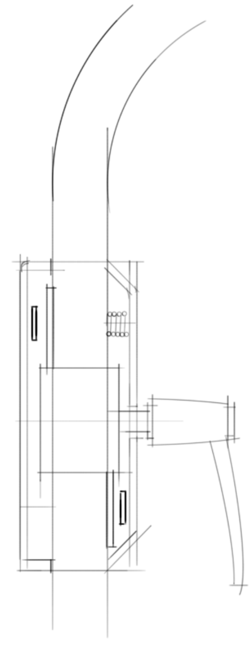

Manage the frequency and intensity of product use Adapt the product so users can limit the frequency or intensity of product use and reduce social tension and exposure. 9
Focus on the ultimate product goal By exclusively addressing this ultimate goal, the product could become obsolete in all other situations. 10
Reshape product meaning through advances in technology Applying new technology can make a product smaller, more performing, cheaper to buy and own, etc. 11
Reshape product meaning through advances in material technology Applying new technology can make a product lighter, more ecological, etc. 12
Reflects on meaningful interaction with other products Strive for a semantic cooperation between complementary products / mimic the typology of a product that is accepted. 13
Endow the product user with extra abilities Instead of adding disabilities, try to increase the user's abilities above those of 'abled' users. Extra ability can also be suggested. 14
Boost the user's social skills Make the user rise above the reactions of others by making him or her visually or verbally more assertive. 15
Campaigns or interventions that educate or change public views Also consider interventions in public space to promote interaction or appropriate behavior 16
Increase positive social visibility / product endorsement Increase the social 'visibility' of a product / product endorsement by influential political, sports or media figures 17

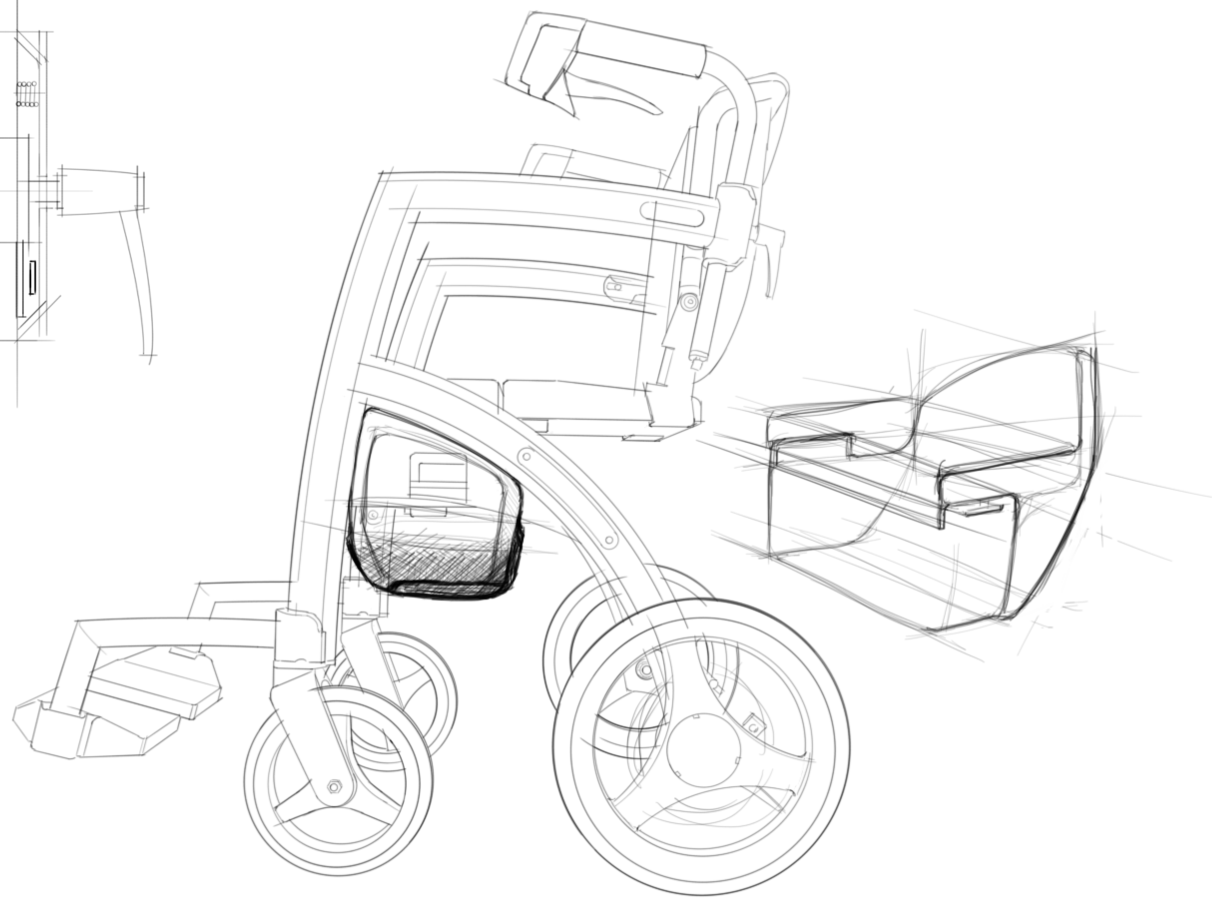


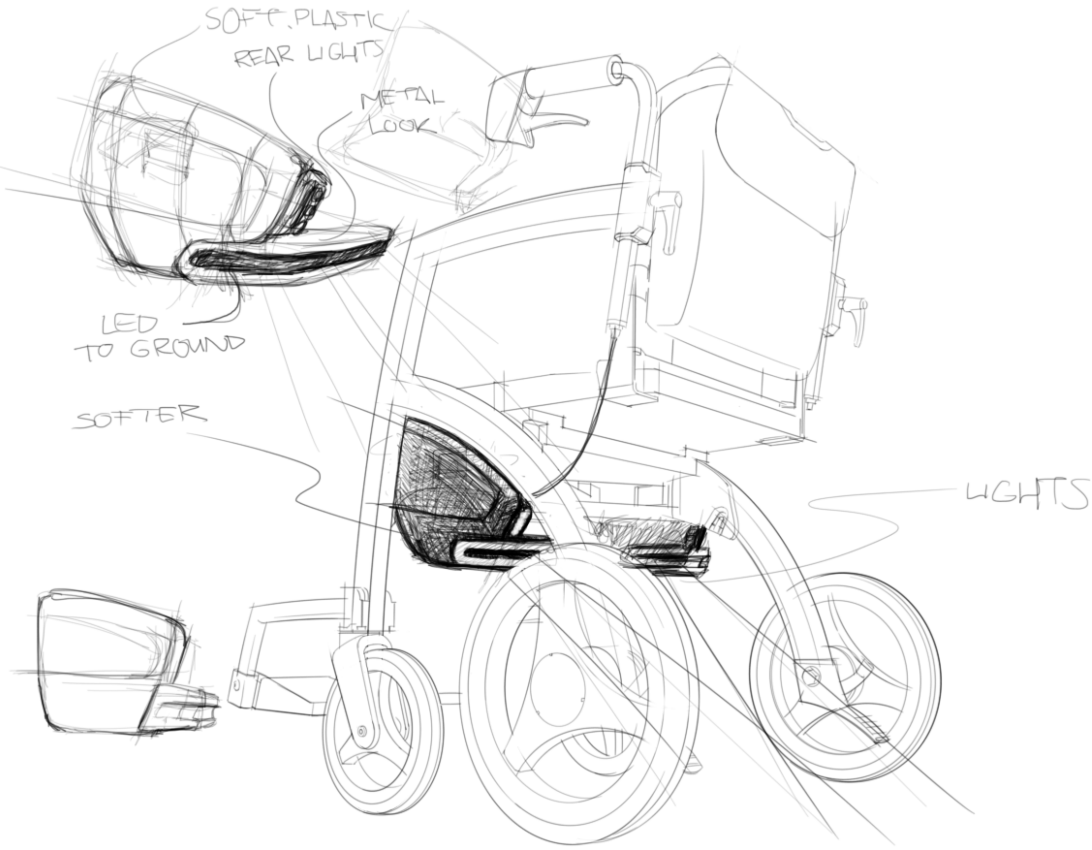

BATTERY INDICATOR
I/O

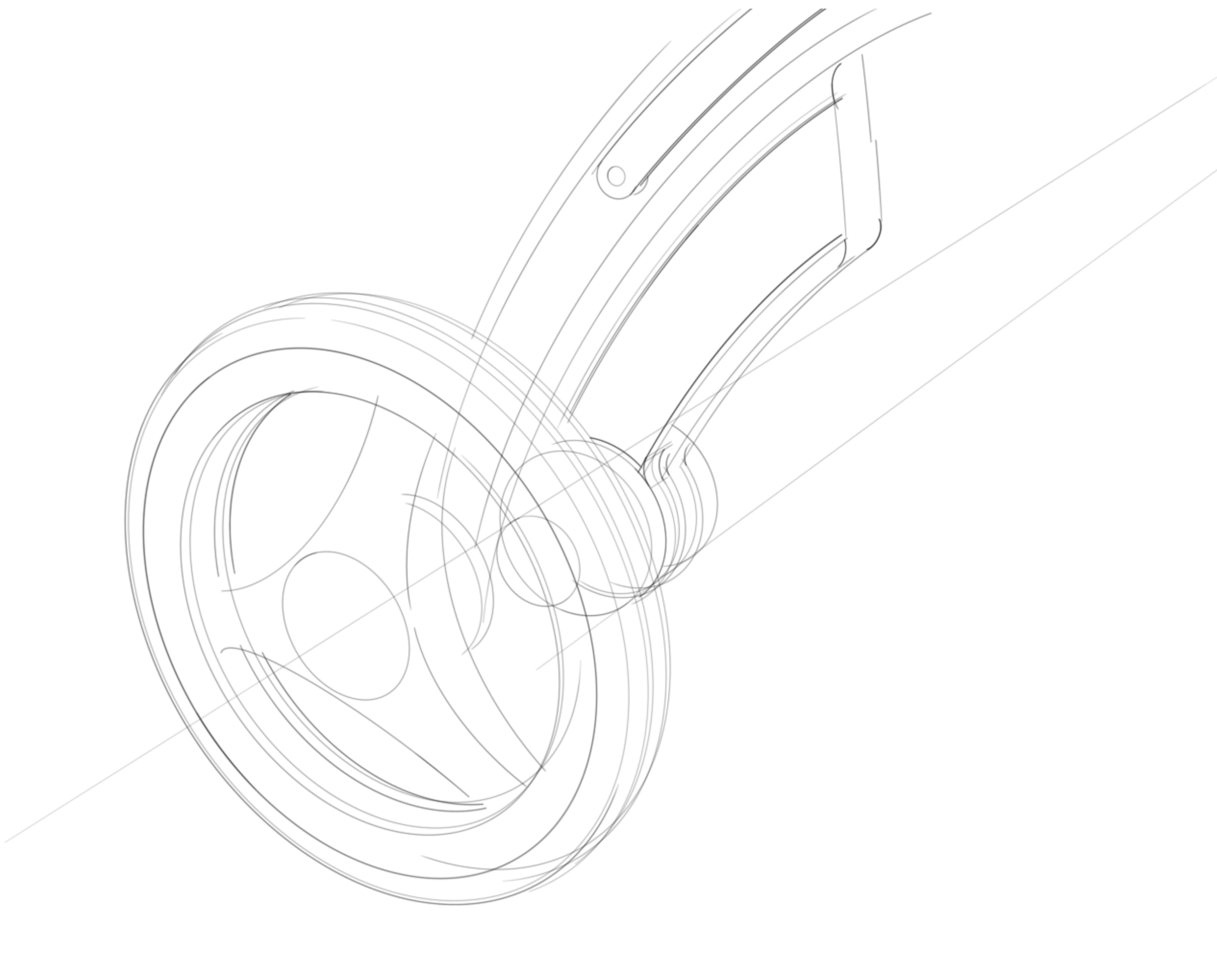


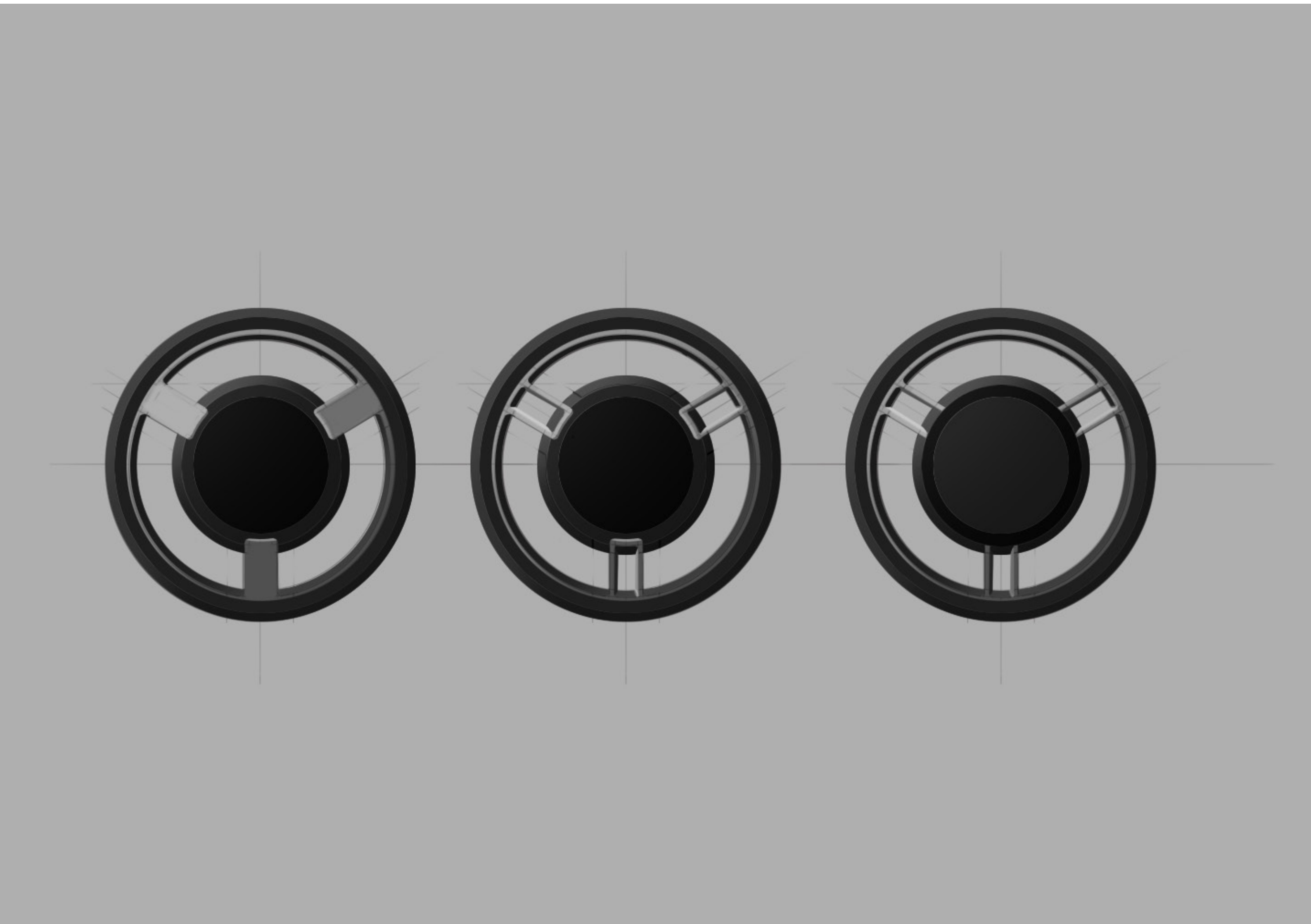


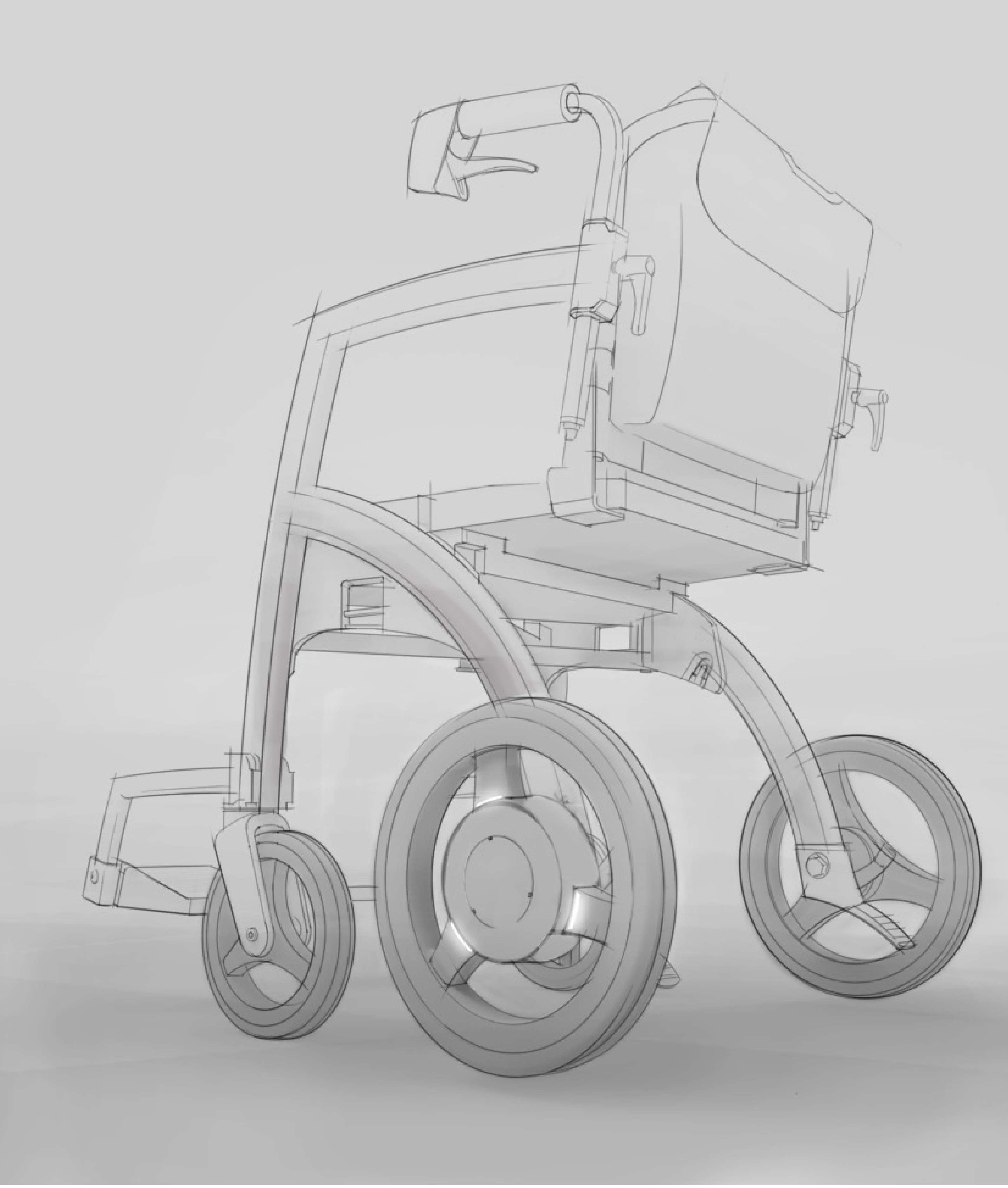





SOFT PLASTIC
REAR LIGHTS
METAL
LOOK
LED
TO GROUND
SOFTER
LIGHTS





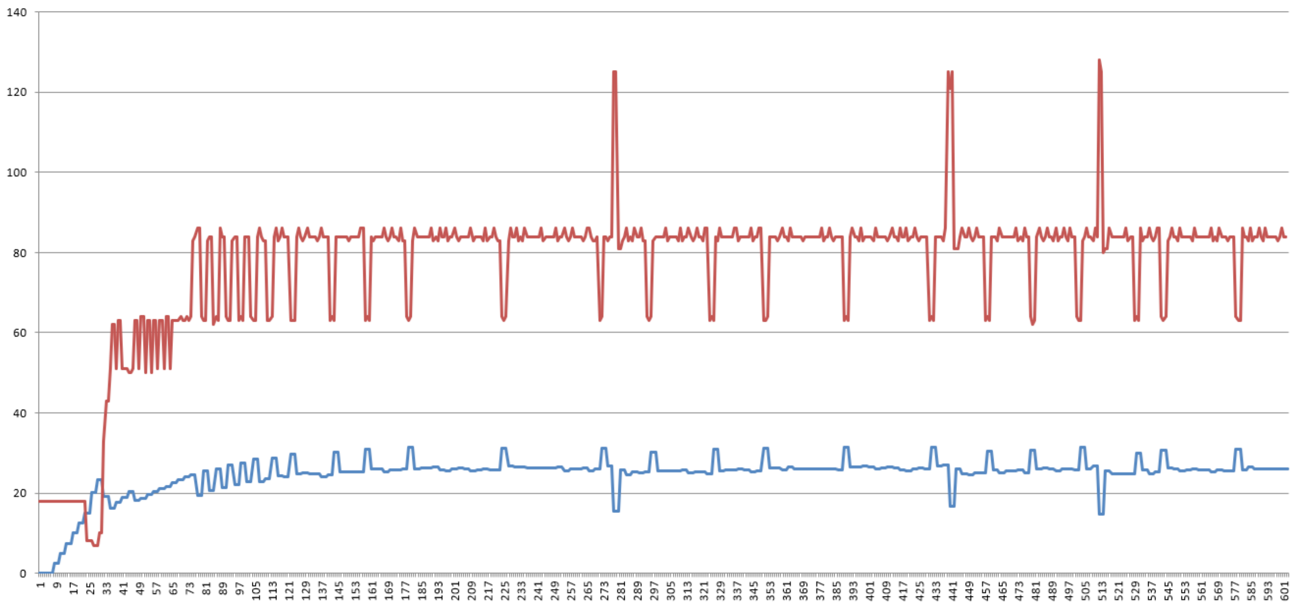


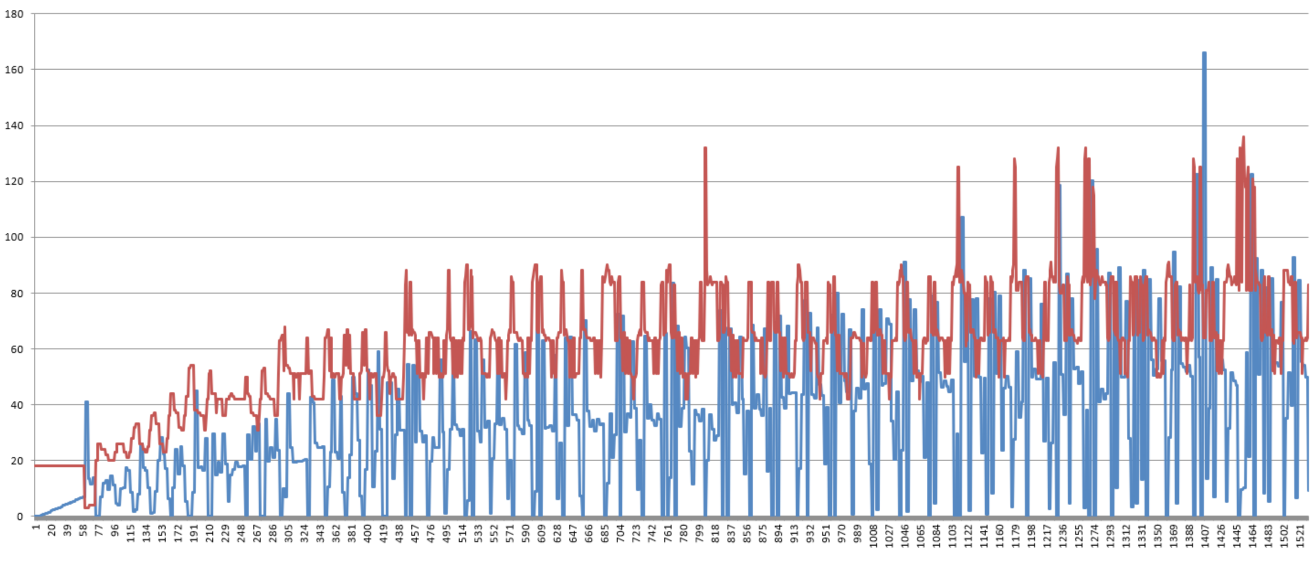
C.2.3 TEST DATA

Motor controller

Below the test data for the motor control system are shown. The graph above shows a PI controlled motor. The red line in this graph is the detected motor speed (measured in RPM). The blue line is the control input (measured as a PWM value). This PI controller worked well enough to go to a specific speed, and therefor could be used in the tests for the prototype.

The graph below shows the best optimised system that uses a PID controller. This system is far less stable that its PI controlled equivalent.

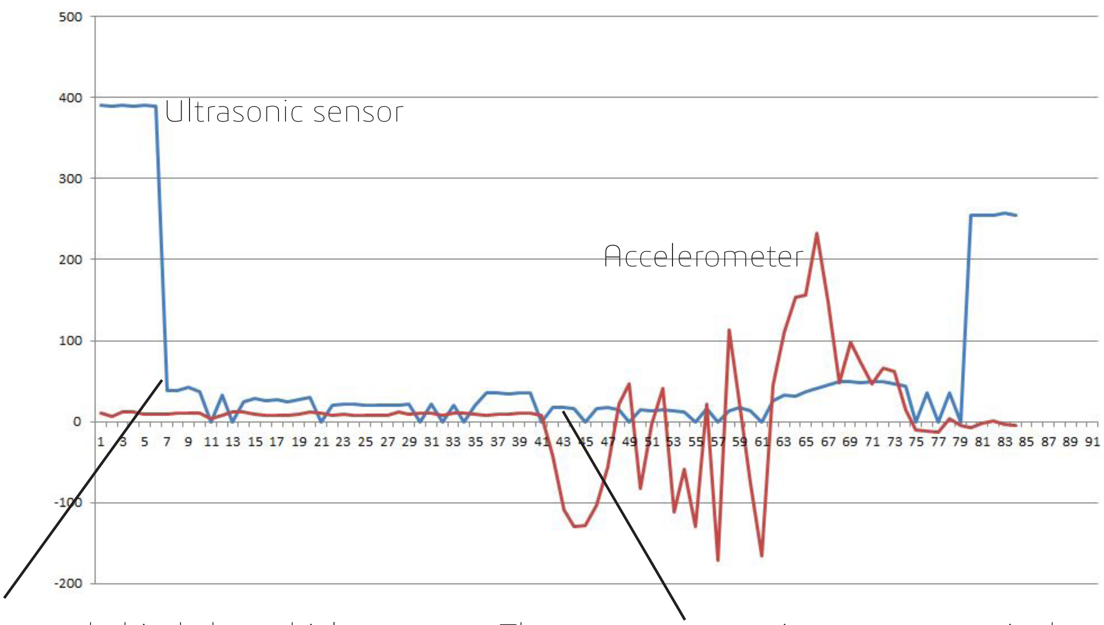




Human machine interface

Graphs that show the effectiveness of the human machine interface technologies are shown below. These are rated to how well they are able to detect the intentions of the user.

The graph above shows the results of a test with an ultrasonic distance sensor (blue line shows the distance between the sensor mounted to the Rollz motion and a person) and an accelerometer (red line). It was tried to determine whether an proximity sensor could detect the intentions of the users. When the user started moving and stopping (as can be seen in the accelerometer data) , the position of the user changes a bit. But the ultrasonic sensor could not detect this variance in position of the user. The ultrasonic sensor could not detect the intentions of the user.



The user steps behind the vehicle, this is clearly detected

The user starts moving, movement is detected by the accelerometer. The proximity sensor does not clearly show a difference in measurements

C.3.1 CONCEPT 1

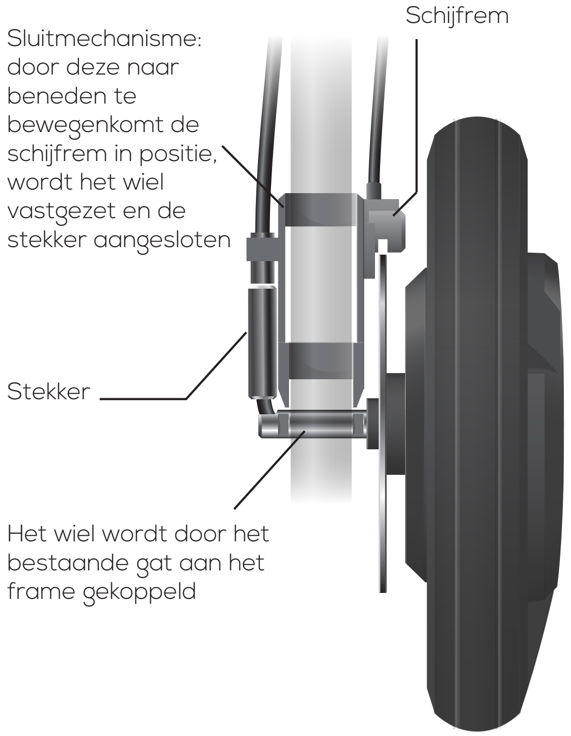
Afleiding

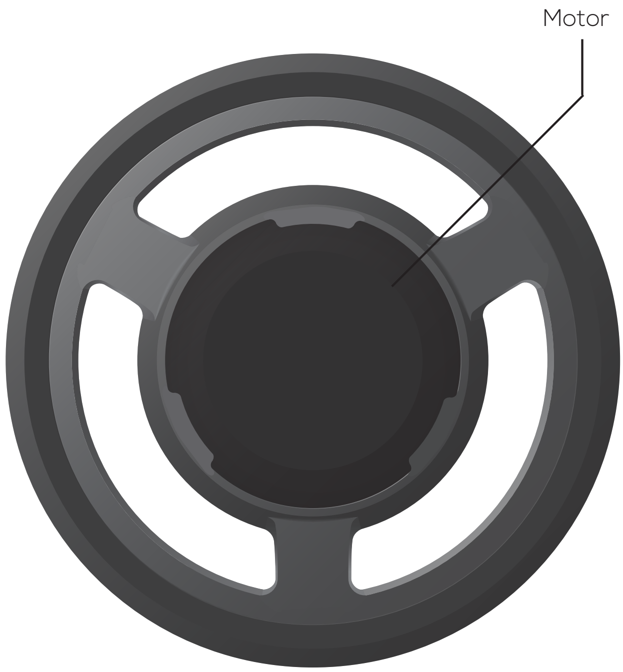
Gebaseerd op de oplossingen als in het fysieke prototype.
Deze oplossingen zijn gekozen om een ongemotoriseerde Rollz Motion snel en eenvoudig om te kunnen bouwen.
Deze eigenschappen zijn ook gewenst in het daadwerkelijke product

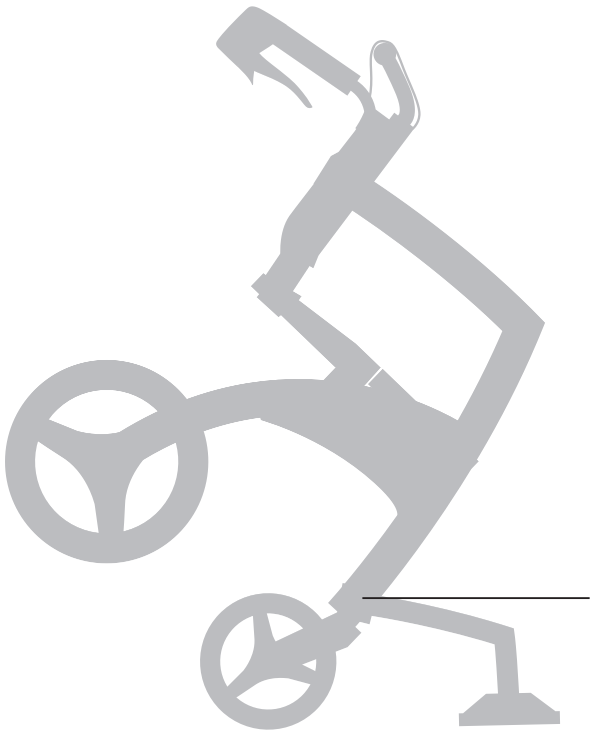
PCB en (uitneembare) accu's weggewerkt in een 'buidel' onder het inklapmechanisme

afneembaar **HUB motor wiel**: het model weegt meer dan 20kg. Die wielen zijn bijna 7kg tezamen. Door ze afneembaar te maken verbetert de transporteerbaarheid.

Vanwege het hoge gewicht van het model is er gekeken naar oplossingen om dit te verlagen. Vooral omdat uit het onderzoek bleek dat het gewicht iets is waar gebruikers tijdens het aankoopproces veel naar kijken. Voor dit concept is een oplossing gevonden door het wiel met motor erin afneembaar te maken.







Om het plaatsen en loskoppelen van de wielen makkelijker te maken is extra stabiliteit nodig. Om deze stabiliteit te creëren dienen de voetsteunen te worden aangepast zodat de Rollz Motion hierop kan steunen.

Dit heeft als bijkomend voordeel dat de gebruikers niet tot de grond hoeven te bukken als ze de wielen willen aan of afkoppelen.

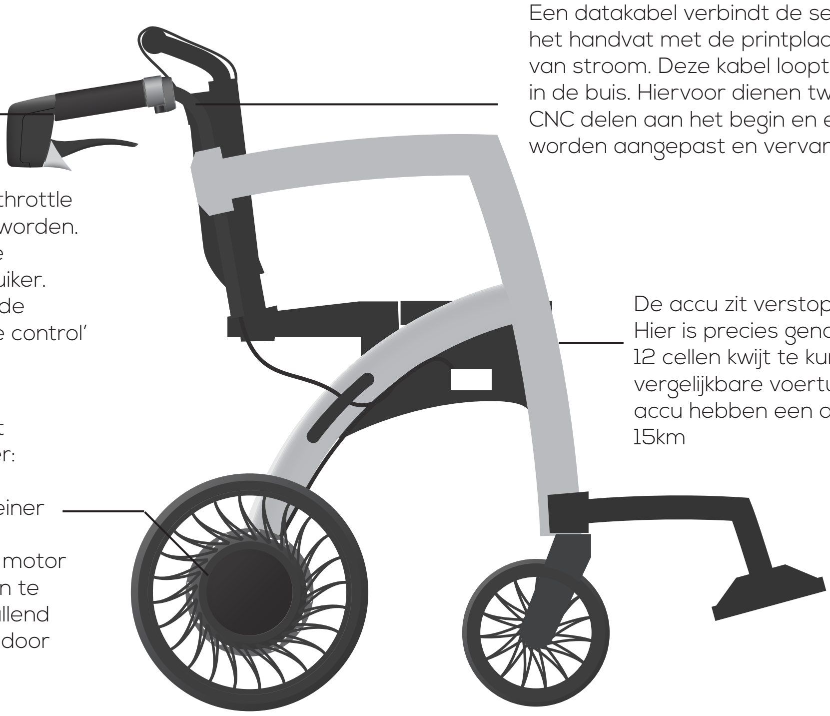
C.3.2 CONCEPT 2

Lichtgewicht

Waar concept 1 het totale tilgewicht omlaag bracht door componenten opdeelbaar te maken, verlaagt dit concept het gewicht door de componenten zelf te verlichten

Een datakabel verbindt de sensoren en LEDs in het handvat met de printplaat en voorziet deze van stroom. Deze kabel loopt naast de remkabel in de buis. Hiervoor dienen twee aluminium CNC delen aan het begin en eind van de buis te worden aangepast en vervangen.

Met behulp van één thumb throttle kunnen de wielen bestuurd worden. Een IR sensor detecteert de aanwezigheid van een gebruiker. Deze componenten bieden de mogelijkheid voor een 'cruise control' functie.



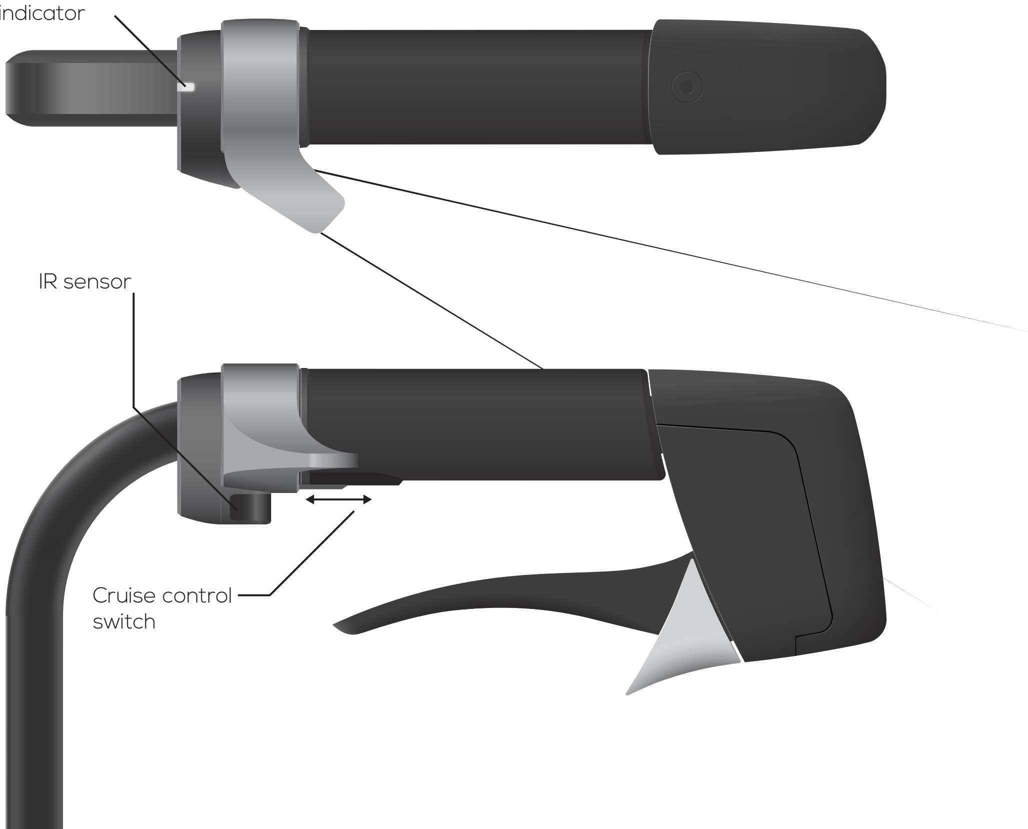
De accu zit verstopt onder de zitting. Hier is precies genoeg ruimte om 12 cellen kwijt te kunnen. Andere vergelijkbare voertuigen met zo'n accu hebben een actieradius tot 15km

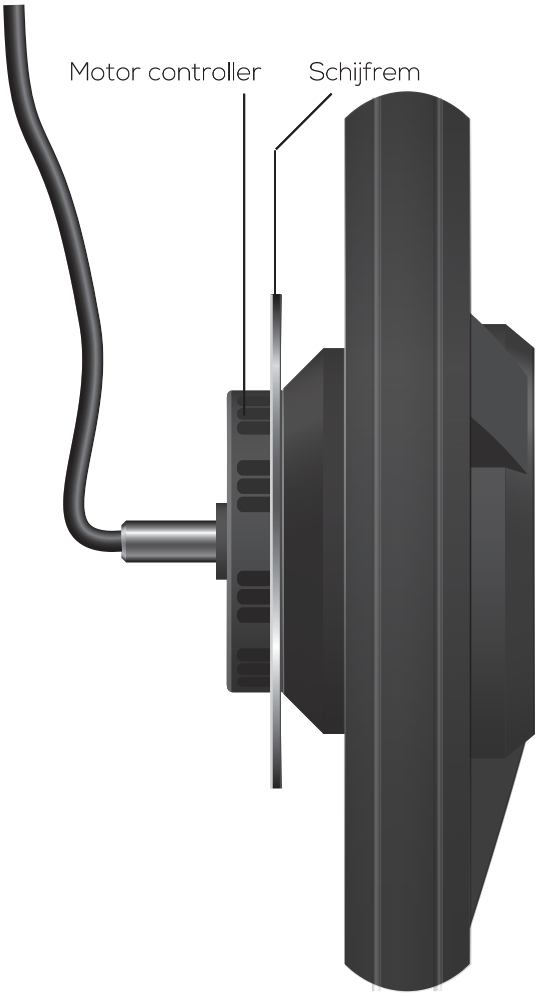
Geared HUB motor wiel met ingebouwde motor controller: motoren met een tandwiel reductie mechanisme zijn kleiner en lichter dan HUB motoren zonder tandwielen. Door de motor controllers ook aan de wielen te bevestigen zijn deze onopvallend weggewerkt. Het wiel wordt door deze keuzes breder.

Dit concept maakt gebruik van een thumb throttle met een extra infrarood sensor in het handvat. Deze sensor detecteert de aanwezigheid van een gebruiker achter de Rollz Motion. Hierdoor is het mogelijk om een 'cruise control' functie te bieden.

Zo'n thumb throttle is ook te vinden in andere duwondersteuningen voor rolstoelen. Als de gebruiker deze naar beneden draait met zijn/haar duim wordt gas gegeven.

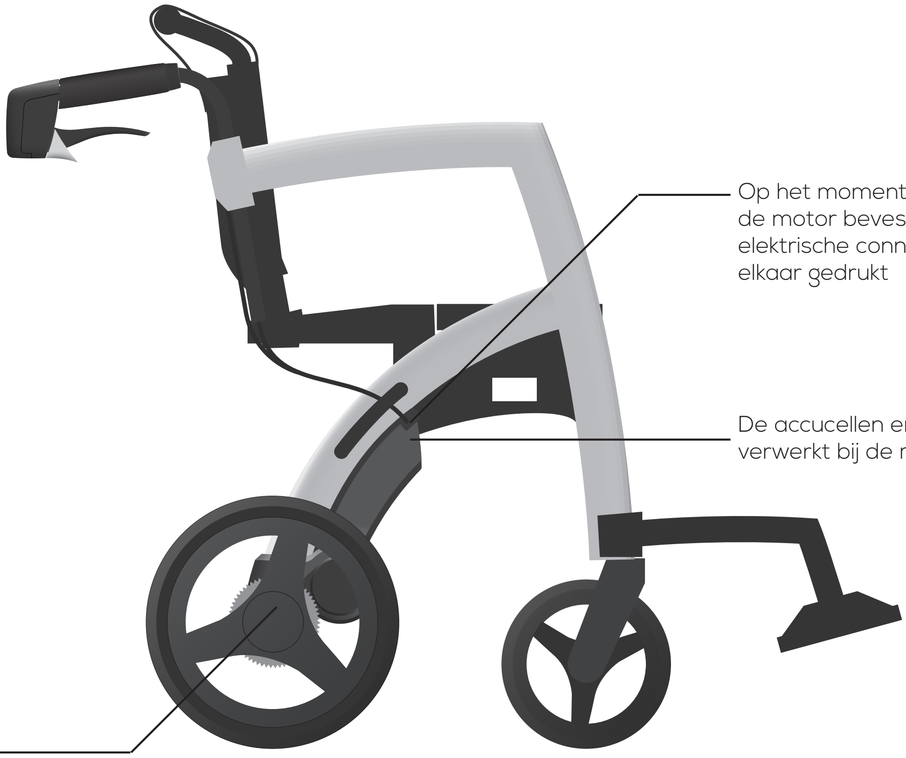
De vorm van deze hendel is zowat identiek aan de vorm van de rem van de Rollz Flex, een shopping rollator van Rollz.

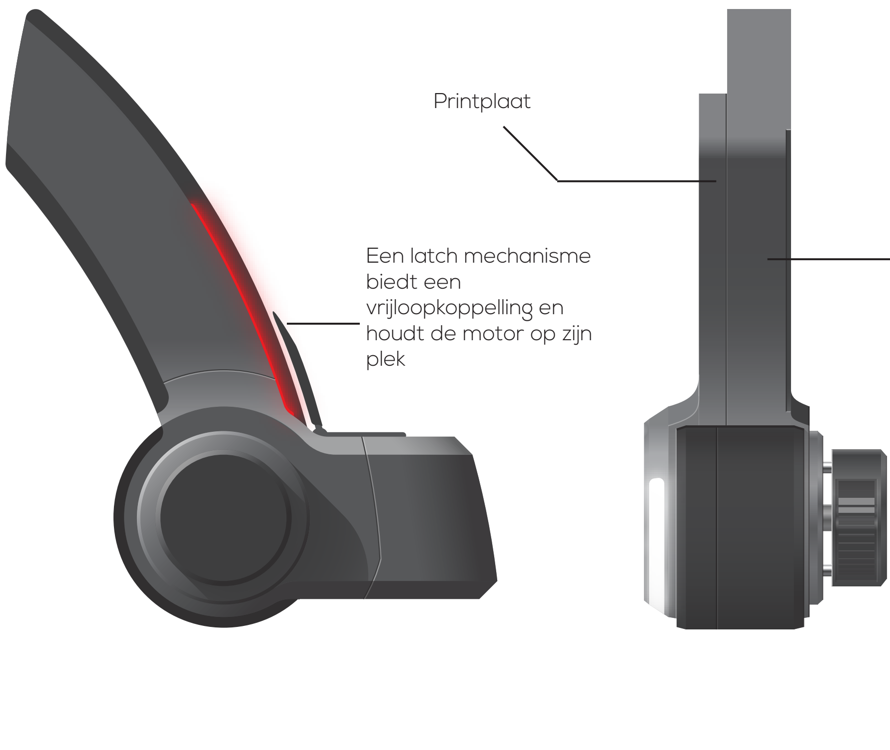



Motor controller
Schijfrem

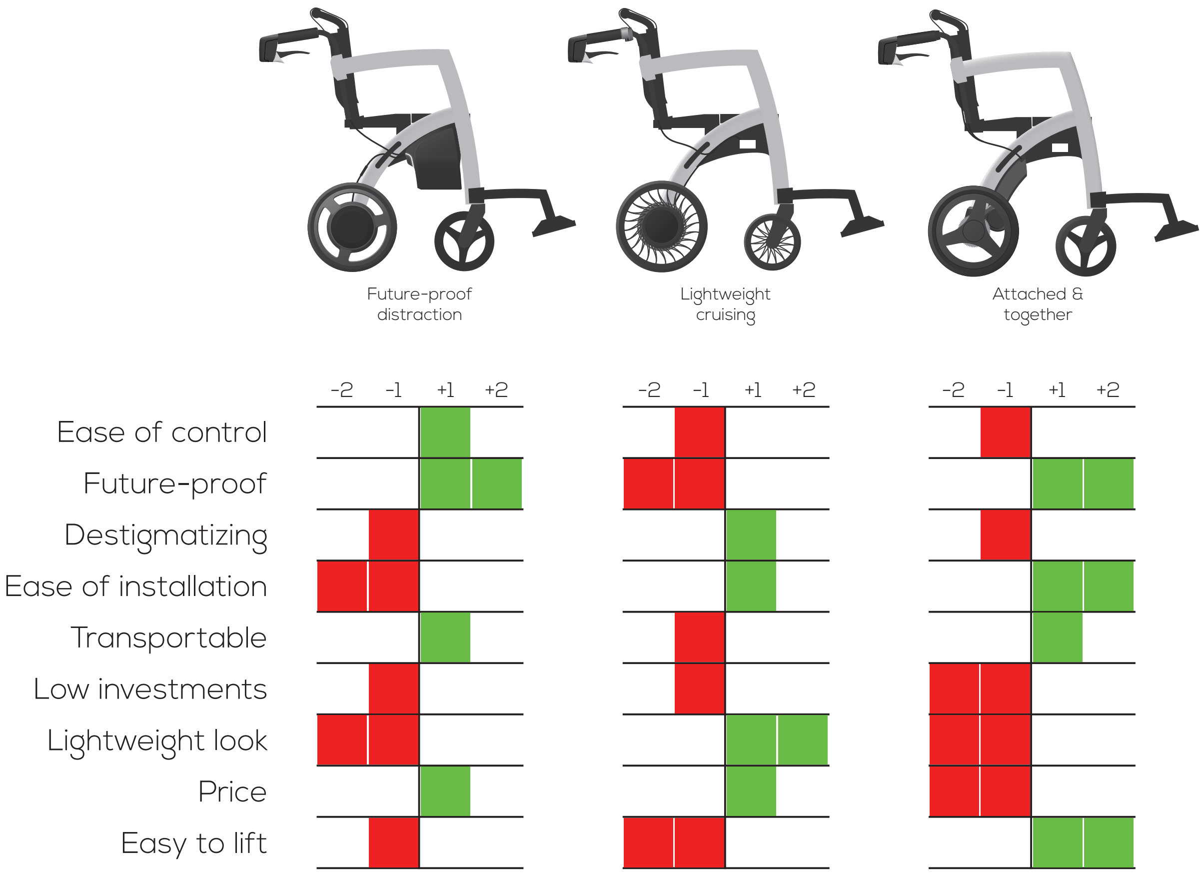
C.3.3 CONCEPT 3

Bestuurbaar van zowel achter als naast de Rollz Motion. Dit verkleint de hiërarchische verhoudingen tussen degene die duwt en degene die zit en maakt het communiceren makkelijker.



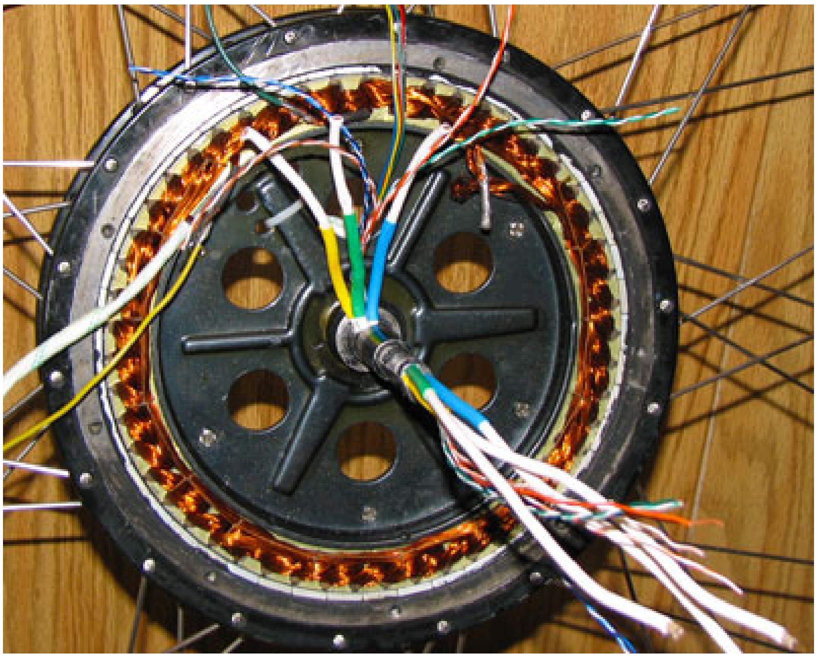


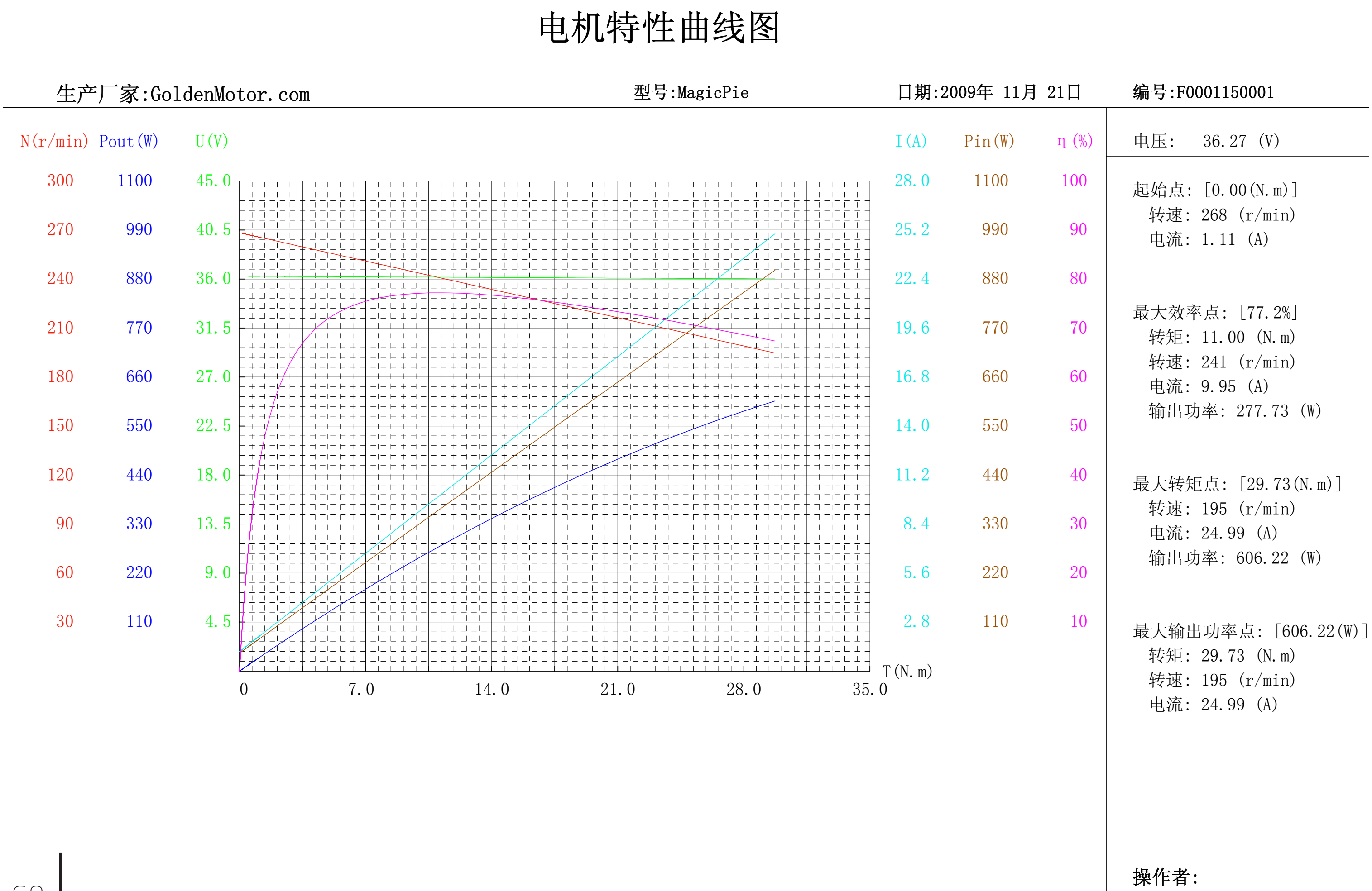
C.3.5 HARRIS PROFILE



D.1.2 MOTOR COMPARISON

Here a motor that is comparable to the motor in the motor package is presented. The size of the stator and rotor are almost exactly the same, as well as the provided the voltage. In the graph below is shown that the speed and torque that this motor can deliver will be sufficient for the situation of the Rollz Motion as well.





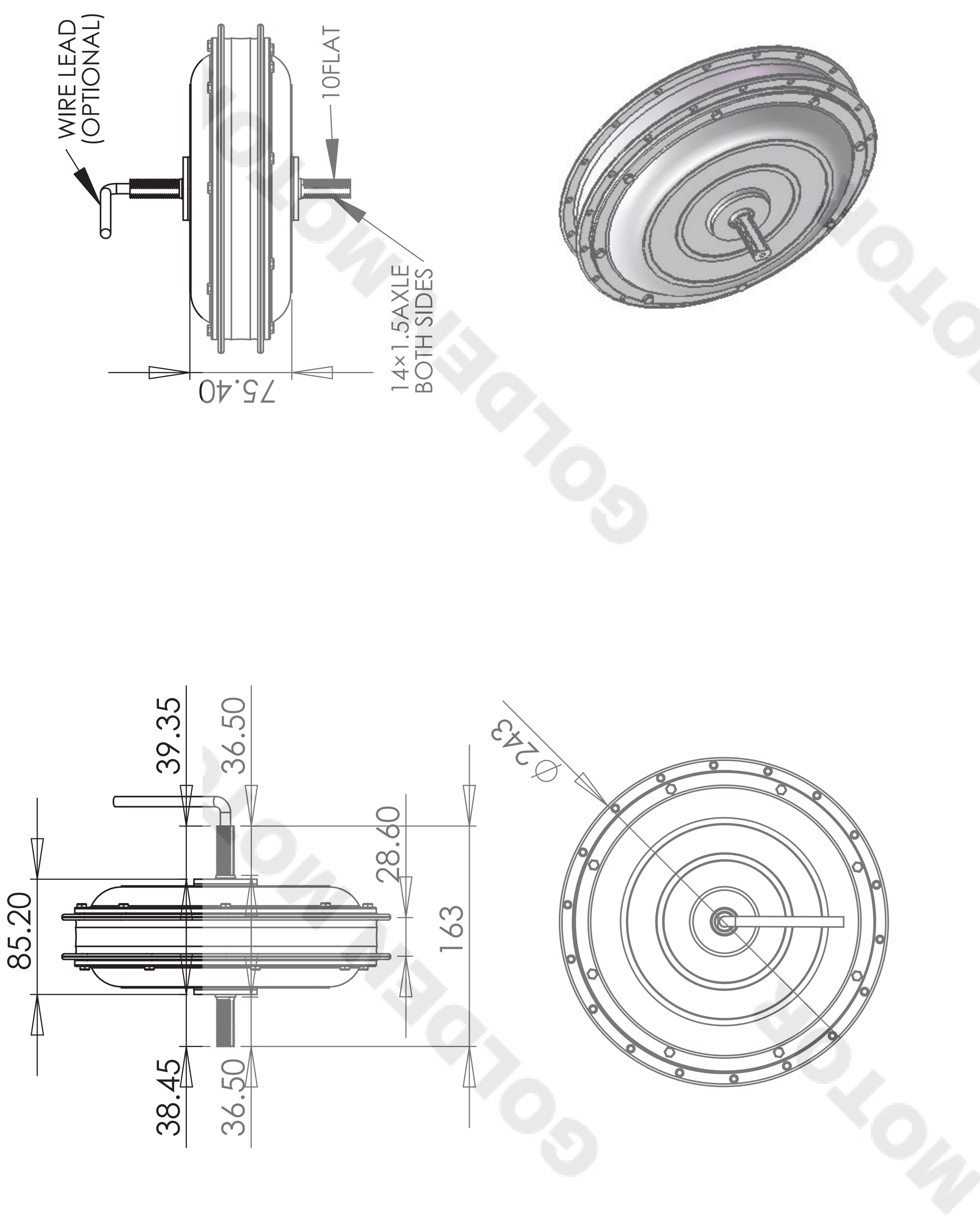


Image courtesy of goldenmotor.com

D.1.3 USER TEST

Introduction
After the research phase, the concept has been developed without too much influence by the users. To still validate how the system is being used and whether the users understand and like the human machine interface of the concept is tested here.

Method
The prototype was switched on first while it was standing still in an open space. A researcher would then instruct the user about the system and about the way that the system could be powered (by pushing the handles forwards and backwards). After this brief explanation the participants were being instructed to start pushing it around. A researcher constantly walked next to the vehicle to stop it in case something would happen.

If the participant failed to move the Rollz Motion around the researcher would instruct the participant the correct way to start powering the vehicle again. If the participant failed again the second time the researcher started walking the Rollz Motion by himself to provide give an example on how to control the vehicle.

Afterwards a semi structured interview was held to find the views about the controls by the participants.

For safety reasons only vital people that do not posess a rollator or wheelchair have been selected to participate in the test.

Result
Participant 1: Bo, 45 years
The prototype was installed inside at the office where the participant works. He got scared when the system started moving immediately.

After getting instructed not to focus on the walking motion he walked for a brief moment but stopped again after one meter.

Participant 2: Ben, 64 years old (see figure)
This test took place outside. He got scared a bit when the vehicle started moving.

After a while this participant liked the movement of the prototyped, mentioned that it felt natural and walked with it without problems.

Participant 4: Ella, 54 years old (see figure)
This participant saw her husband (Ben) walk with the prototype. Without any instruction she started controlling the system by herself.

She liked the controls of the system and she mentioned to like the intuitivity of the system and liked that she did not constantly have to push a button.

Participant 5: Max, 18 years old
This test started inside the house of the participant. The participant wanted to start walking immediately. The sudden acceleration surprised him and he stopped the vehicle again.
He asked to continue the test outside where he would have more space. Once the prototype was set up again to be tested, this participant started walking immediately again, using the system as intended.

On his own initiative he asked his little sister (approximately 50 kg) to take place in the prototype and to push her around. Apparently he had enough confidence in the system to make a relative sit inside it. He pushed her around both with additional motor force and without the additional force to compare both situatios

Conclusion
These tests showed that users need some time to start trusting the electric Rollz Motion. The first encounter generally was not positive. Users wait for the vehicle to

start moving. As a result the users responded too late when the vehicle got powered. This made the prototype drive away a bit which scared the users. Although, safety was maintained and the vehicle speed quickly decreased again the first experience was generally negative.

The results improved a lot after the users got instructed to just start walking with the Rollz Motion. Still some moments of fear could be distinguished, but these faded away after some minutes. Almost all users were able to use the system as intended.

Eventually, after getting more acquainted with the system, most users became enthusiastic,and found the movement natural.