Titlepage

Theme: Master thesis

Title: Ugo

Project period: September 2nd - January 20th, 2009

Project group: AD10-ID5

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Synopsis

This project focuses on the development of a new type of aid for children with Cerebral Palsy. The development is based on the user's needs in everyday life, and aims to develop a different aid that meets these needs. The project is made in collaboration with the producer of handicap aids, Meyland-Smith.

Abstract

This master thesis revolves around the development of an aid for children with the handicap Cerebral Palsy. The children are usually born with the condition, which limits the child's control of its muscles. They therefore have special needs regarding support and correcting of the body and to move around. The project is made in collaboration with the company Meyland-Smith, producer of aids for people with extended requirements. The project solution is based on extensive research within the context of the users, market and the company's possibilities. The aid is developed to meet the company's requirements about production as well as their possibilities on the competitive market. The product, Ugo, gives the child freedom to move around and to develop as an independent person. It aims to facilitate the movements that children with CP are not able to do on their own. The saddle seat on the aid gives the child a correct posture and enables the child to walk, even when he/she is unable to sustain balance. Ugo has an integrated motor to help the child change heights while seated, from the height of a kitchen bench to a comfortable walking height and to floor height, where the child is able to play or exit and enter the chair without assistance.

Prefase

This project is written by group 5, 4th semester of the M.Sc. Eng. Industrial Design education at the institute of Architecture & Design at Aalborg University. The offset of the project originates from a research project on Aalborg University called "Sitting and functional skills", where a subproject for developing a wheelchair was getting started. The theme of this master thesis derives from the wheelchair project. The aim of the master thesis is to demonstrate the project group's ability to work through a design process from problem definition through context- and user research, concept and product development, to a final product. This will be done through, for the project group, an unknown context; handicapped children with the prognosis Cerebral Palsy. The goal of the project is to develop a physical product for children to move around in everyday situations.

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Reading guidance

The project is documented in two reports; a process report and a product report. The purpose of the process report is to describe the underlying work that has been done throughout the semester. Ranging from the initial research and definition of focus areas to the development and detailing of the final product. The process report is structured in phases according to the progress of the project:

- Phase 1 Initial Research
- Phase 2 Research
- Phase 3 Concept Development
- Phase 4 Product Development
- Phase 5 Product Detailing
- Phase 6 Discussion

The product report describes the final product and how it is intended to be used. The product report is directed primarily to the company Meyland-Smith and secondly to the end users, whereas the process report is addressed to supervisors and censor.

The sources are noted in reference to the Havard method *[Author, Year]*. References to appendixes are noted *[App. #]*. Illustrations are noted as: *Ill. #.#* and this is only included in the illustration list if they are not produced by the project group. Reference list, appendixes and illustration list can be found in the back of the report.

Motivation

The project's overall vision is to make the life of handicapped children better, by developing a product that meets some of the needs that children and the surrounding people -being parents and caregivers- have in their everyday life.

The goal for the project is to demonstrate the project group's competences achieved during the education at Architecture & Design. Furthermore the project group wants to show the ability to work with user research, idea generation, concept and product development and product detailing.

Besides fulfilling the semesters' curriculum, the project group wants to show the ability to work with an unknown context and to understand the users in that specific context, exploiting the position as an outsider of the context to generate new concepts and product solutions. It is also a goal to show abilities in going in detail with a product, maturing it until production, including making valid decisions about materials, production methods and cost price, as well as making a physical product in collaboration with a company.

PHASE 1
Initial Research

This phase describes the overall project which this master thesis is a part of, as well as the initial research, where the basic knowledge about handicapped children with cerebral palsy is established. The goal is to get a common understanding of the context and its different actors in order to find specific problem areas.

Cerebral Palsy

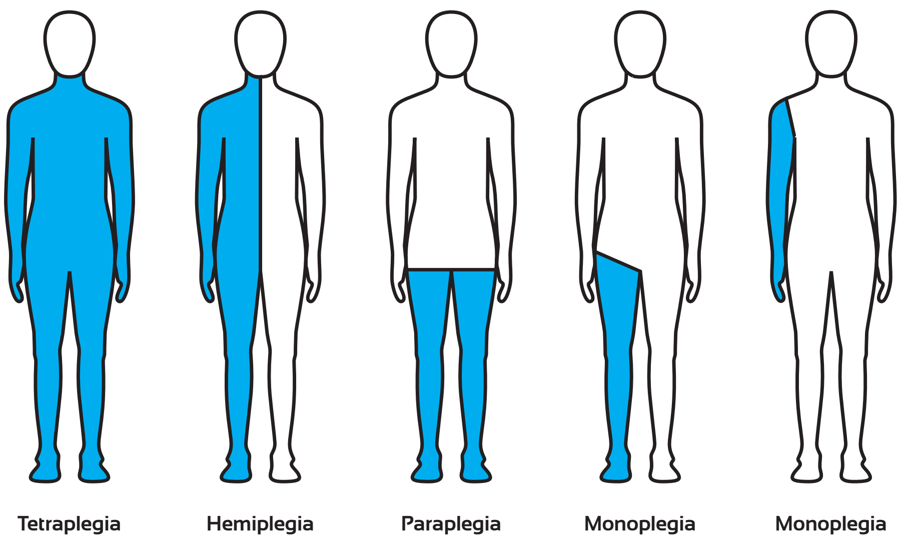
Cerebral palsy is a neurological disorder caused by brain damage which affects the muscle movement and coordination. In 9 out of 10 cases CP appears when the brain is developing during the pregnancy. In 1 out of 10 cases CP occurs during or right after the birth. *[Spastikerforeningen, 2009]*

Studies imply four main reasons for CP to occur *[Spastikerforeningen, 2009]*:

- Damage to the white matter of the brain
- Abnormal development of the brain
- Bleeding in the brain
- Brain damage caused by lack of oxygen in the brain *[NINDS, 2009]*

Cerebral Palsy can be divided into 3 main categories *[Spastikerforeningen, 2009]*:

- Spastic Cerebral Palsy appears as muscle stiffness. The muscles are in a constant contracted mode, where the strongest muscles, the bending ones, are dominant. Spastic Cerebral Palsy is the most common type which covers 75% of people with CP.
- Dyskinetic Cerebral Palsy form 10-15% of people with CP. It is a condition where the person's muscle tensions are affected by emotional influences, which is why the muscles overreact to stimuli.
- Only 5-7% is affected by Ataxic Cerebral Palsy. It affects balance and depth perception, which result in poor coordination.
  [Sundhedsguiden, 2009]



Ill. 1.1Types of Cerebral Palsy

Cerebral Palsy can affect the body differently. As shown on Fig. 1.1 the condition can either affect the entire body or segments of the body. The tetraplegia is the most common, where as hemiplegia and monoplegia are rare.

The degree of CP is varying, from the mildest form that hardly can be seen to the strongest affected with severe movements in the muscles. It is usually the strongest muscles which contain the spastic movement, therefore bending and tension are most powerful. This gives the characteristic body posture where most of the body's joints are bended.

Additional disorders

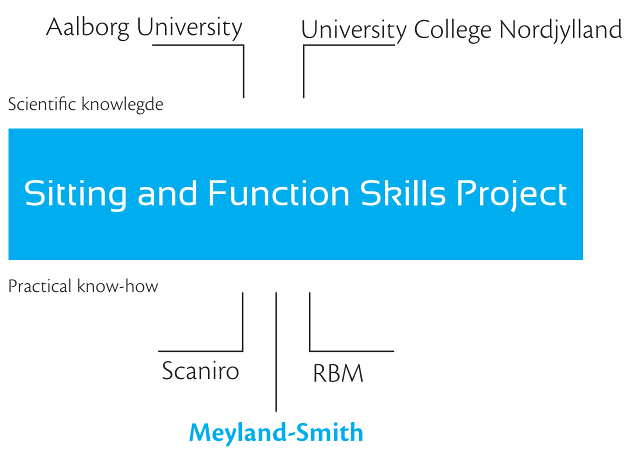
Most children with CP are also developing cramps and epilepsy, but also problems with sight, hearing, talking and eating occurs as well as ADHD (Attention-Deficit Hyperactivity Disorder), besides problems with walking and keeping the balance at the same time.

"Sitting and functional skills"-project

The master thesis is part of an interdisciplinary project, started by Aalborg University. The purpose is to create knowledge about mechanisms and conditions affecting the body of people with extended requirements to their wheelchair. The project aims to generate knowledge which can be used to develop products for users with various needs. From wheelchairs for people with severe handicap, to office chairs for people with more normal needs. The offset of the "sitting and functional skills"-project is spasticity, meaning it revolves around people having Cerebral Palsy (CP).

The project is in collaboration between Aalborg University, University College Nordjylland and the companies Scaniro, RMB and Meyland-Smith. An overview of the stakeholders can

Ill. 1.2: Partners Network



be found in Appendix 1. As shown on Ill. 1.2 the companies receive knowledge from the "sitting and functional skills"-project, meanwhile the Universities have the possibility to apply their knowledge to products, in order to get more publicity and practical knowledge.

A sub-project

The project this master thesis is directly connected to is based on an experiment that investigates how neck and shoulder muscles, attention and perception in people with CP are affected by light movements caused by an "active" pillow in a sitting position. The goal is to explore if movements in the seat can affect the motor skills of children with Cerebral Palsy. The initial idea with the master thesis was to implement the "moving seat" technology into a wheelchair for children with Cerebral Palsy. Since the experiment was not finished and no final conclusions were made, it was still uncertain if the experiments actually would have a positive outcome. Pictures from this experiment can be found in Appendix 2.

Redefining the approach

The primary stakeholders in the project are Aalborg University and Meyland Smith. Since the results from the experiment, which the master thesis should be based on, were not finished it was decided to approach the master thesis from the company's point of view instead. In that way the master thesis could still contribute the sitting and functional skills"-project, by giving insight to the needs of the company and users.

Meyland-Smith

The director of Meyland-Smith, Torsten Langsted, is the coordinator of this part of the project. At the first meeting he presented the company's ideas for a new product. Their entire concept description can be seen in Appendix 3. The list below shows the primary demands Meyland-Smith wants to implement in the new wheelchair.

The target groups are:

- Children with Cerebral Palsy
- Children with psychomotor dysfunctions
- Premature children
- Children with muscular dystrophy

Contexts:

- Home
- Institutions
- Transport situations: regular car, bus, special van.
- Inside and outside
- Summer and winter

The wheelchair should fit the user also when he/she grows.

Interviews

The first step to understand the context of the project was to establish contact with the users. The first meeting was held with the ergo-therapist Anne Mette Støvring, teacher at University College Nordjylland. She has many years of experience working with children with CP. It was a discussion about the children's physical and everyday practical needs.

The second meeting was at a kindergarten, specialised in observing and handling children with CP. The observation part is important in order to determine the extent of the handicap. This meeting consisted of an interview with one of the ergo-therapists. In the interview a typical working day was described. The interview also broached the problems with the parent's first encounter with the handicapped world. It was also possible to make a general observation of the children's way of moving around and interact with both the other children and the personnel at the kindergarten. The project group was also introduced to the different aids, which were available at the kindergarten. It gave a good impression of the actual look and usage of the products as well as the challenges the people face when it comes to the products available on the market today.

The third meeting was on a school where both handicapped and non-handicapped children are attending. It was an interview with the two therapists in charge; an ergo-therapist and a physiotherapist. It was a discussion about what considerations they were making when they had to decide what type of aids the child needs to have, and what measures they need to take into consideration in order to make the aids work as good as possible.

It was not allowed to take pictures of the children at the institutions the project group visited, therefore the opposite picture montage is a mix of own pictures of aids, with pictures of CP children found in the internet.

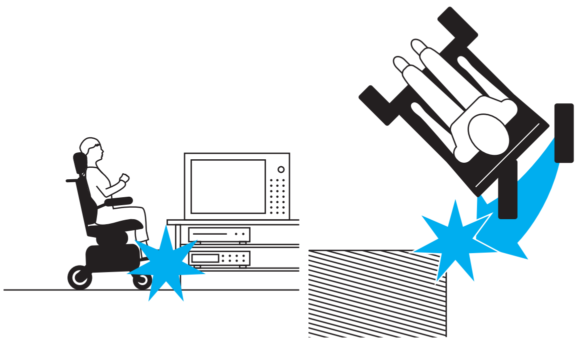
A sum-up of the interviews and meetings can be found in Appendix 3

Ill. 1.3: Products CP children use in their every day life

Scenarios

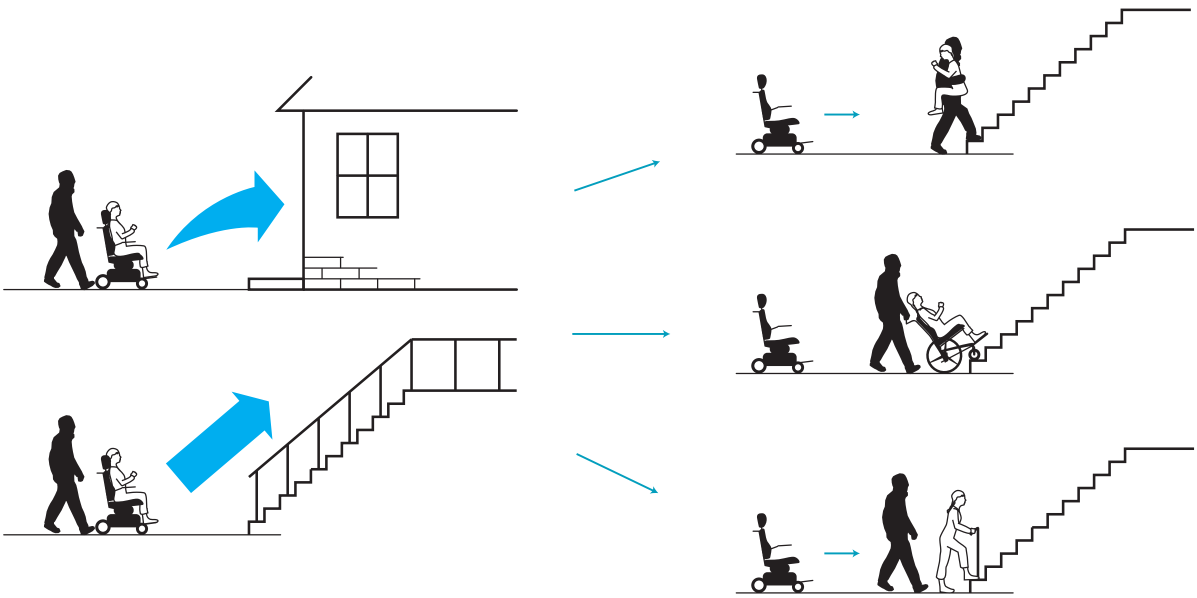
The scenarios were made to pinpoint the problem areas found during the initial research and especially during the user interviews. The scenarios also gave a basis for the discussion on the importance of the different problems.

Ill. 1.4: Scenario 1



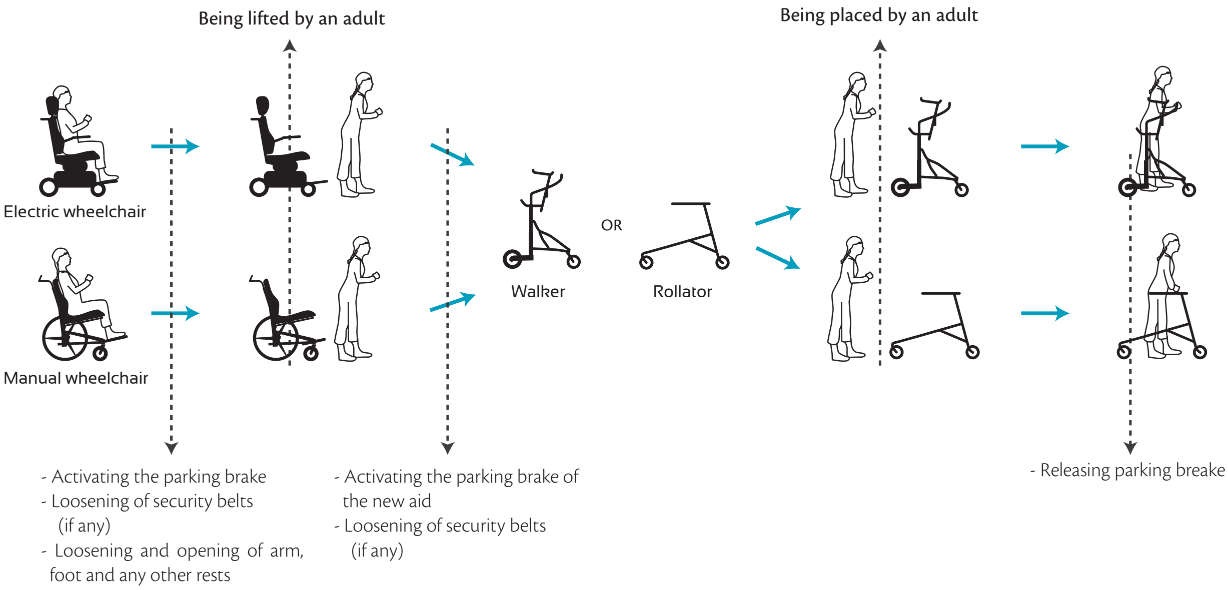
The electric wheelchair is convenient for the child that needs to keep up with more mobile friends, when playing. But indoors the wheelchair is often very hard against the interior; the turning radius combined with the weight (over 130 kg) and power of the wheelchair, are the main factors responsible for the damage caused in the home by the electric wheelchair.

Ill. 1.5: Scenario 2



When the child has to enter areas that are not optimised for wheelchairs, the electrical wheelchair is very inconvenient. E.g. when vistiting family or friends, the child has to use the manual wheelchair, which is liftable. when moving on stairs, the child is carried by a parent and afterwards the wheelchair can be carried up or down the stairs.

Ill. 1.6: Scenario 3



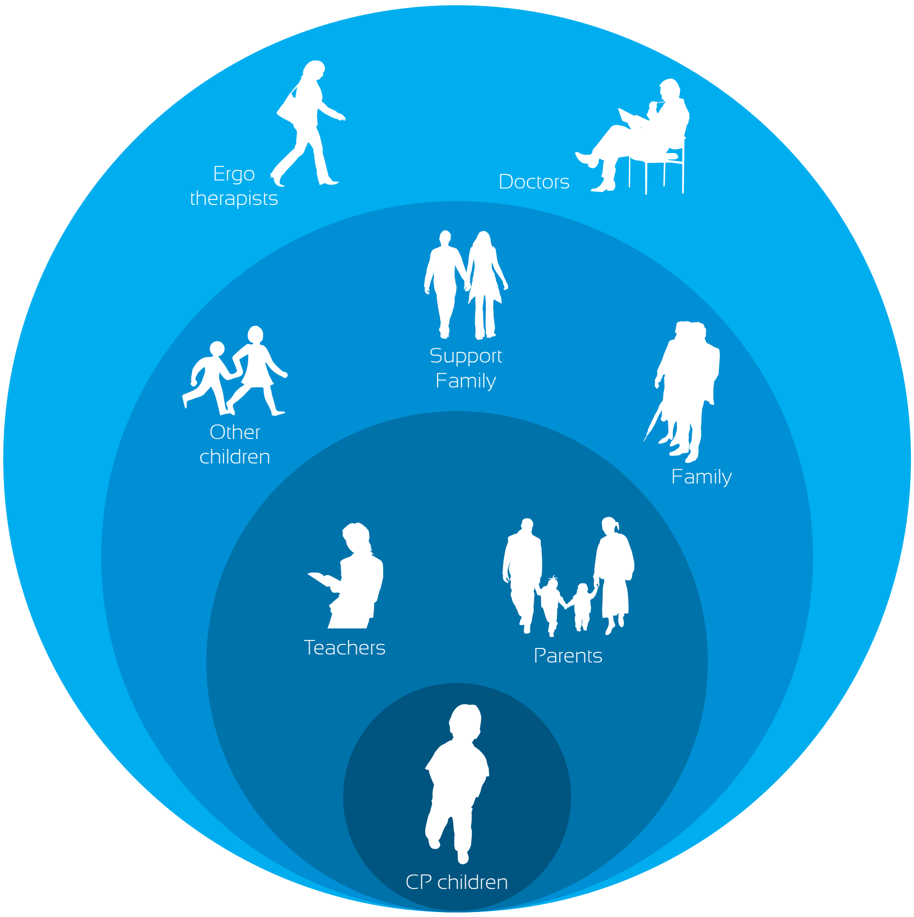
The child is making a lot of changes between aids during the day. This is demanding for both the child and the adults, who have to carry the child.

Users

The people around the children create a whole environment; it is here that the children will develop physical as well as social skills with help of the aids.

The children can have a life very close to a normal one; having friends, attending classes and sports. But it is necessary to have special attention to their needs and wishes, in order to facilitate the best possible context –aids included- suitable for the activities. The following scheme shows the users around the aids.

Ill. 1.7: User Environment



Close Related Users

CP children. For this project it was decided to focus the user group on children between 3 – 6 years old, this is the user group that had been observed at the moment. At this age the children begin to use aids, dealing with a lot of them.

The parents. They are also close users to the wheelchair, they are the ones who will adjust, clean and control it.

Caregivers. Children can attend to either a regular or a special school, therefore teachers may be seen as a regular teacher or a teacher focused on this type of children. Their role is mainly taking care of the children, sometimes also controlling the wheelchair and taking the children from one playing area to another or even feeding them.

Indirectly Related Users

Other children. The children need to participate and interact in a safe way with the other children around.

*Family (*Grandparents and non-first-degree relatives). They are close to the children though may not be there on a regular basis.

Support Family. Some families help by having these children for some hours at their home, thereby giving some rest or free time to the natural family.

Occasional Related Users

Doctors. The children have the right to be frequently checked by the hospital until they are 18 years old. The frequency of these dates is always the same, and is established by the doctors and parents.

Production Users

Assembly / Construction people. They are in charge of all the production of the wheelchair.

Storage. While being transported as well as sold.

Sales / Aalborg Kommune.

GMFCS

The Gross Motor Function Classification System (GMFCS) is a five-level classification that differentiates children with cerebral palsy based on the child's current gross motor abilities, based on their ability to move in relation to sitting, walking and wheeled mobility. The distinctions between the levels are made upon the need for assistive technology and wheeled mobility. The GMFCS contains 5 age bands; under 2 years, 2-4 years, 4-6 years, 6-12 years and 12-18 years *[App. 5]*.

Since the children observed so far were small children between 3 – 6 years old, it was decided to study these levels of the GMFCS in order to get a better understanding. Their handicap was around the level 4, which is defined as follows.

Level 4, for 2-4 years

Children sit on the floor when placed, but are unable to maintain alignment and balance without use of their hands for support. Children frequently require adaptive equipment for sitting and standing. Self-mobility for short distances (within a room) is achieved through rolling, creeping on stomach, or crawling on hands and knees without reciprocal leg movement.

Level 4, for 4-6 years is defined:

Children sit on a chair but need adaptive seating for trunk control and to maximize hand function. Children move in and out of chair with assistance from an adult or a stable surface to push or pull up on with their arms. Children may at best walk short distances with a walker and adult supervision but have difficulty turning and maintaining balance on uneven surfaces. Children are transported in the community. Children may achieve self-mobility using a powered wheelchair.

Problem description

The following description is a sum-up of the knowledge achieved during the three meetings. It is made to provide a general understanding of the use of aids in a typical day for the children with CP and the people surrounding them.

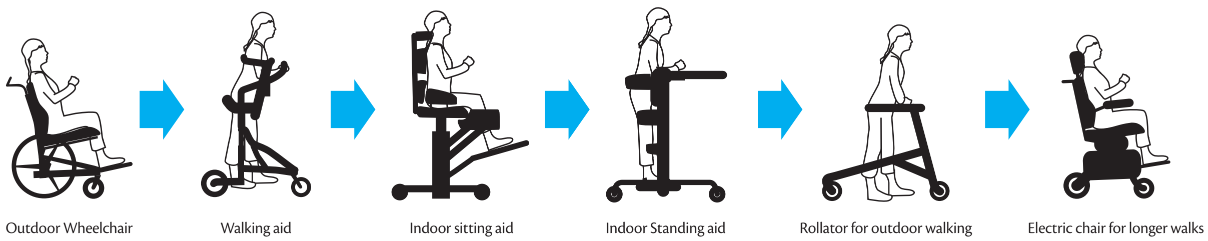
A regular day around the Cerebral Palsy aids begins with the transportation from home to the kindergarten or school.

This could be either by bus, a special van or even walking when the distance is close. Special vans are adapted for fixing the wheelchair, keeping the child safely seated on the aid while being transported. It could be either a manual or an electric wheelchair. Most manual wheelchairs are not approved for transport; hence an extra car-seat is needed. When the distance to walk is short enough, the children can use an electric wheelchair, or they are pushed in a manual wheelchair, depending on their level of handicap.

Once they are delivered to the kindergarten or school, the children are changed from their own wheelchair to either a walking device or left free to move around on the floor. During the day, depending on their activities –e.g. playing, eating and working- the children may use several different devices, from walking aids to rollators and standing aids. When the children are going to the toilet they need to use a rollator in order to make the transfer from the aid to the toilet.

They have to use a standing aid for a fixed period of time every day as a therapy for keeping their growth in control and in a posture as normal as possible.

Ill. 1.8: Some of the aids used during the day



These devices are for personal use, meaning that two children may not share any of the devices unless indicated by a therapist. Children like to customize their devices with stickers, hanging toys, etc.

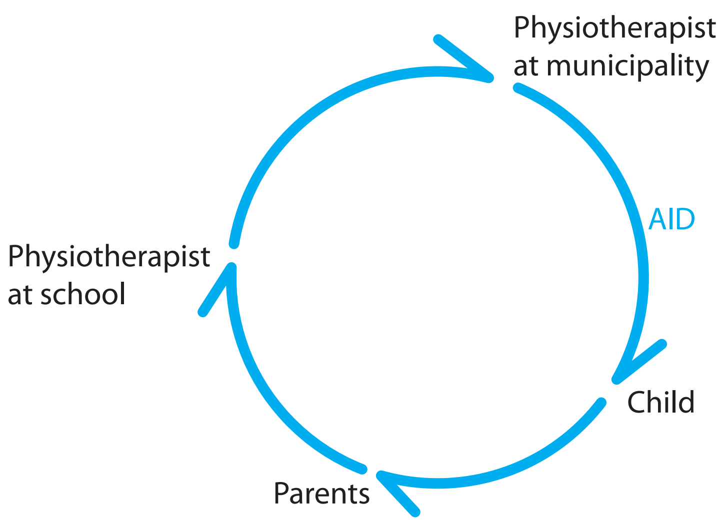
The main reason for these devices being personal is that they are adjusted to fit every child. These adjustments include the overall height, position or angle of legs, arms, back, sides and head support. Many of the devices have an extra piece for more cushioning made by the therapists or teachers themselves. Additional steps are also roughly made to enable the child to help when he or she is moved from one aid to another. Most of the adjustments are done by the therapists, teachers or parents, but some of these adjustments are more complicated, so they have to be made by the manufacturers' staff.

Some activities require a change on the position of a major part of the device, for example by tilting the back and seat, lowering the child to the ground or moving him/her upwards. These adjustments are temporary and made by the adults.

When the children are going to eat or use a school table, they can either get the height of their device adjusted or use a special working chair which may allow them to stand or be seated at a higher level.

The therapists working on the institution are deciding the configuration of the aid for each child, in collaboration with the parents and the therapists in the municipality. It is not rare to combine the seat from one manufacturer and the wheelbase from another.

Ill. 1.9: Users deciding when buying aids for the child



Focus areas

The project group has extracted key problems from the initial research for further development. These include the everyday dealing with many aids around the handicapped child, as well as psychological, social and working aspects for the child, parents and caregivers.

A product for the everyday

The project group have chosen to work with the everyday situations. Therefore the focus is on the kindergarten, school and the home of children as well as the transport situation between those two places. In addition, possible ways to solve problems in the perimeter of those situations will also be considered, such as problems when visiting not-handicap-improved houses, moving on stairs and over obstacles.

Many products

Around the age between 3 and 6 is where the child is beginning to use aids to move around. Earlier the child has lived without using handicap aids like wheelchairs and walkers, being dependent on the parents and caregivers. But when the child starts to attend to an observation kindergarten, the testing to find suitable aids starts. Thus it is the parent's first encounter with handicap aids. This is often an overwhelming experience for many parents, who feel their child suddenly gets a stigma as handicapped. The number of aids enhances this experience.

The appearance of most of the products enhances the stigma of being handicapped; when the child is placed in an aid, like a wheelchair, the child tend to look more handicapped. The aids are often constructed of bended steel pipes, which give a complex appearance. In addition, some aids have many complex adjustments.

Change from one device to another

Having many devices present in the kindergarten is also problematic for the employees. Firstly, they often have a space problem, but more importantly the many products used during the day leads to frequent and heavy lifting when children need to be moved from one aid to another.

Difficult to adjust

The user research showed examples on confusing semantics as well as knobs and screws that were hard to adjust or needed special tools to be adjusted.

Social interaction

The aids often interfered with the social interaction, either between the child and the parents or caregivers, or between the child and other children.

Demand specification version 1.0

Demands

The product must:

- Reduce the amount of aids needed during the day
- Be suited for indoors and outdoors use as well as in transport situations
- Fit children between 3 and 6 years, with CP on level 4 on the GMFCS
- Look less like a handicap-aid, the child should be the centre of attention
- Be easy to manoeuvre for the parents and caregivers
- Be easy to adjust for the parents and caregivers
- State clearly what and how the aid is adjusted and manoeuvred

Wishes

The product should:

- Enable the social interaction between the child and parents, caregivers and other children
- Have low weight
- Have low price
- Be possible to move/ carry the child and the aid on stairs.

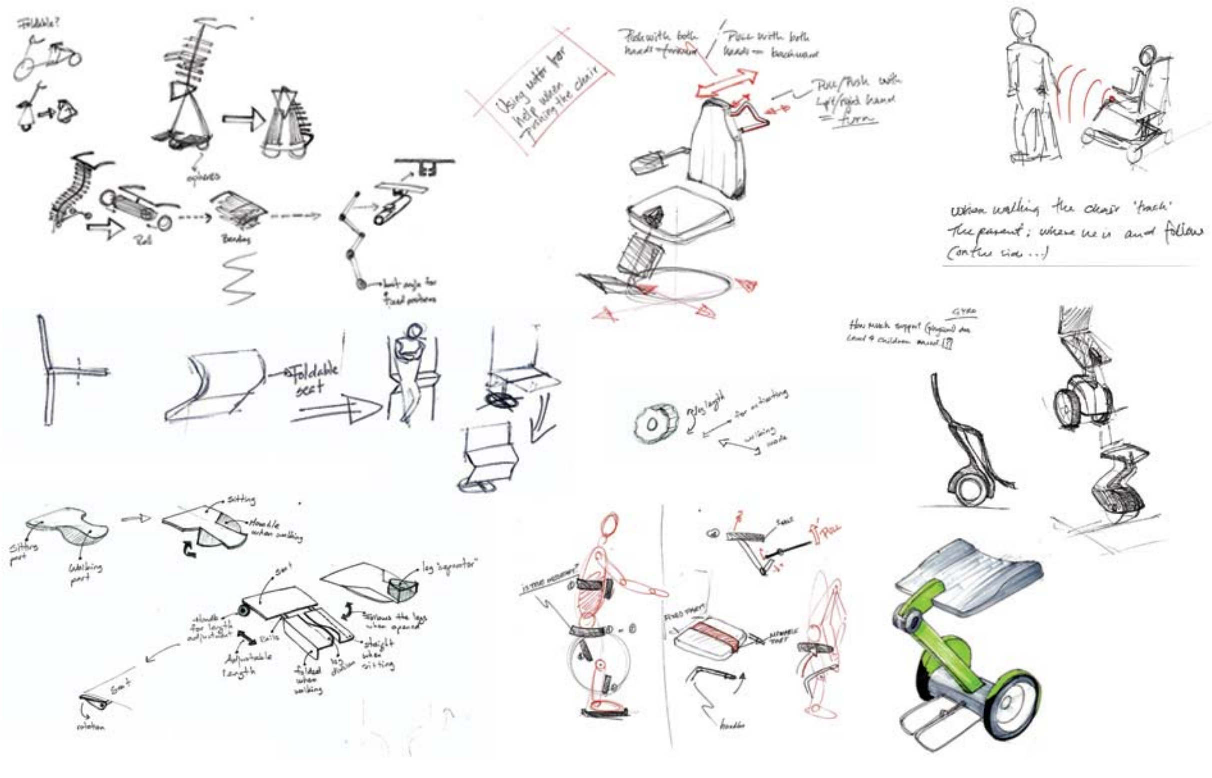
Initial sketching

The initial sketching was a way to start up the considerations about possible directions for the product development, a very rough consideration about a direction for the further research.

The first exercise was to empty the head of ideas – big and small – which were piling up in the minds of the group members during the initial research. So a good way to be able to come up with new ideas was to get the existing ones down on paper first.

The sketching was a continuous process, going back and forth between sketching on details trying to create a synthesis from them.

Ill. 1.10: First sketches



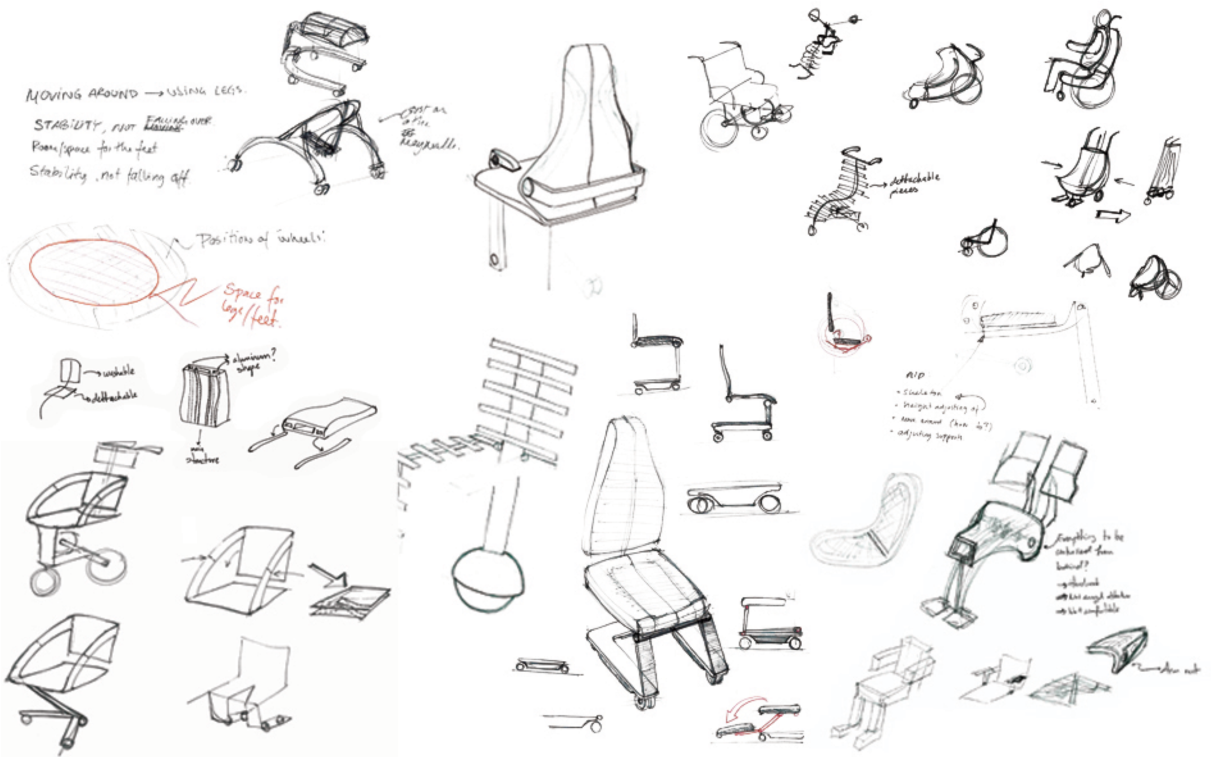
A following sketching round started out from the focus areas and the demand specification. The focus areas were elaborated and categorised with mindmaps, in order to find specific problems to sketch feasible ideas from. The offset was to sketch on one problem at the time, trying to get as many ideas as possible; quantity rather than quality. This was controlled by setting time limits on the sketching rounds.

The best ideas were selected for further detailing and investigation.

Later the proposals were gathered in different configurations, looking for more general ideas or concepts, which could solve some of the demands.

Ill. 1.12 shows some of the initial sketches which were further detailed.

Ill. 1.11: Second round of sketches



The process was going back and forth between generating new details, creating synthesis from them and comparing them against the focus areas and demand specification.

The many iterations did not lead to a well defined way to direct the project. The main reason for this was that the idea generation and idea proposals could not be detailed very much, due to lack of knowledge; when an idea was further detailed, it generated more questions than solutions and at some point the project group was not able to give a sufficient answer.

Consequentially, the project group decided to acquire more knowledge in order to generate ideas and be able to analyse the level of the quality of the ideas better.

Conclusion

At this point, the potential was seen to create an entirely new product, better suited to meet the user needs in the everyday context. The alternative being to redesign one of the many existing products. It was therefore considered more important to pursue this potential new product than to reach a higher level of detail that a re-design would allow. This was a decision made on the basis of the time limit.

Reflection

The project group chose to have a wide approach to the possible solution space. The decision was made on the basis of the user investigations, which demonstrated holes in the usability provided by the existing product available for the users. A much narrower project approach could have been chosen, which would have made the research phases more focused, but it would have been at the expense of the potential innovation of products dedicated to the users needs.

The process during this phase was a difficult compromise between getting a wide foundation of knowledge, and at the same time gaining a deep enough knowledge to make qualified decisions about the importance of the different subjects. Even though the process is described as linear, it consisted of many iterations, going from researching to understand the user needs better, to generating and testing ideas and possible ways to go with the project. The sketching turned out to be an excellent way to scan for possible directions the project could go in, and to get an overall understanding of the feasibility of a certain direction. The sketching process was a good way to provoke questions about directions, in order to test them and to test the basis of knowledge the project group was having at a given time. This contributed to look at the directions for the project from different angles and ultimately it also helped to make the decision of working with a new product, at the expense of achieving a greater level of detail. Hence the research is, in the following phase, broadened in order to find which user needs are relevant for the further product development.

PHASE 2
Research

The research focuses on target users, market and the company Meyland-Smith as well as production and technologies used in the context. The goal of this phase is to gain a deeper knowledge of the context and the problem areas in order to specify focus areas and to make a sufficient demand specification to continue with the concept development. The following phase is describing the more in-depth research, in order to get a better understanding of all the aspects of the project.

Company Profile

Meyland Smith

Ill. 2.1: Meyland-Smith logo

Background

Meyland-Smith A/S was established in 1901. The company started producing stoves, but soon they got a contract to produce all mobile material for the newly build Gentofte Hospital. Today their biggest competences are within the development and production of walking aids for handicapped people. Along with walking aids, they also create products for other means in the handicap sector.

Sales and Product Portfolio

They only sell their products through sales agents located in the area, in order to establish direct contact to the buyers of the products.

Meyland-Smith's product portfolio is made from products of their own and products done by other companies, in these cases Meyland-Smith works only as a distributor. This is the complete list of products they have:

- *Walking aids:* Meywalk mk2, Meywalk 2000, Miniwalk, Henry, MeylandDiscover and Push Cart.
- *Indoor sitting:* System Beta.
- *Mattress system:* Sleeping Star.
- *Pushchairs:* Swifty, Jazz Easys, EASyS TWIST.
- *Tandem bikes:* Meybike, Wavebreaker.
- *Carlift.*
- *Protection helmet:* Toppen.

Sales

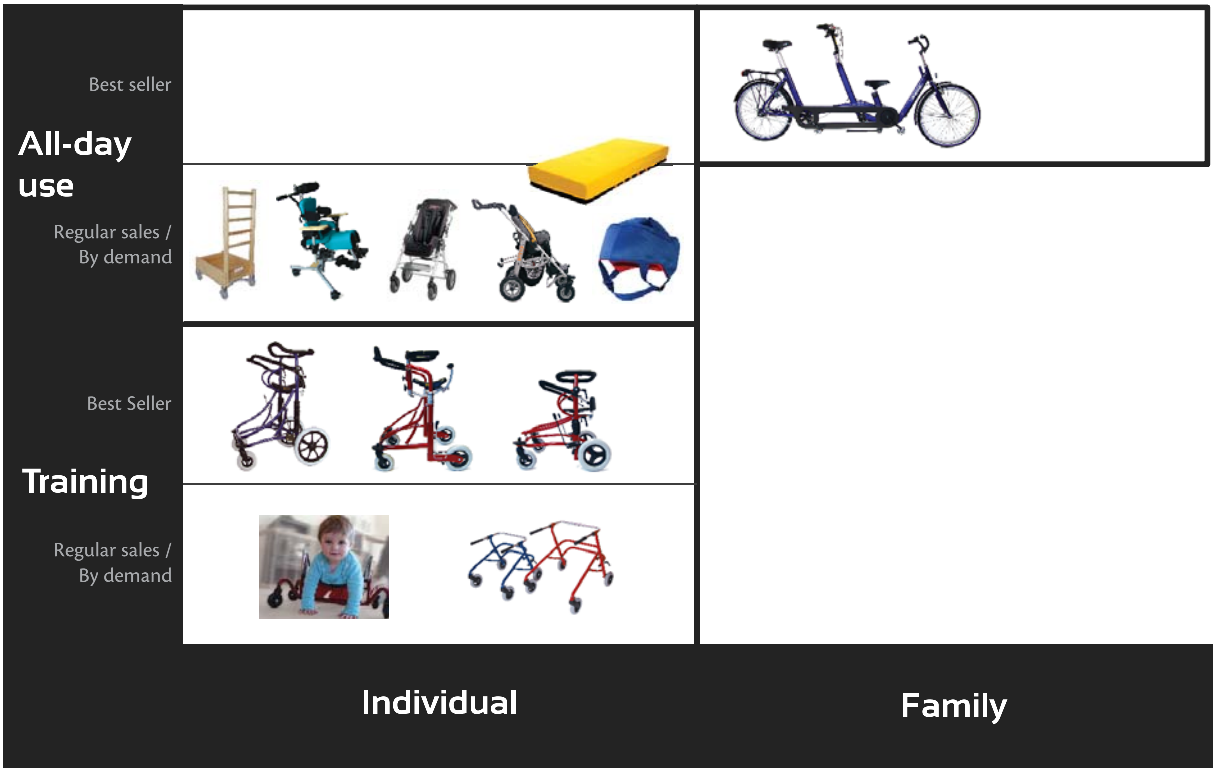
Meyland-Smith is selling to 25 countries; most of Europe, Japan, Taiwan, New Zealand, Australia, Saudi Arabia, Canada and USA. They only sell their products through sales agents located in the area, in order to establish direct contact to the buyers of the products.

Values

The words used to describe Meyland-Smith's values are derived from overall strategy. They are described below:

- *Closeness*

"We provide the best possible service to the users of our products. We strive to maintain a close relation to our customers and the users of our products so they know that they can always contact us for help and advice."



Ill. 2.2: Meyland-Smith Product Portfolio

- *Knowledge*

"Since the foundation of the company in 1901 we have established a large amount of knowledge based on experience. This serves as a basis for the development of new products. We want to extend and develop this basis through our communication with the users of our products and the collaboration with a range of relevant educational institutions."

- *Functional Design*

"The quality of our products is essential. We develop products in close contact with the current users of our products. This way it is ensured that we offer products that fulfil actual needs for future users."

Production

The company can process most metals. They normally use steel pipes for constructing the aids.

Some of the in-house processes are started to be moved to subcontractors. Some parts are completely processed when they enter the company, already cut, bended, welded and painted. Others are semi-processed and need some work before being painted and moved to the assembly line.

During the interview with CEO of Meyland-Smith, Torsten Langsted, he explained his visions for the company. The aim is to outsource most of the processes which demand expensive machinery to subcontractors, so only the development and assembly will be in-house. In this way, the knowledge will stay inside the company and at the same time provide more flexibility in terms of production, materials and detailing of the products.

Cannibalism

Meyland-Smith's main focus is on their walking aids, the Meywalk. It has been updated several times, thus it is available in different editions. Even though the newest edition has improvements, it is likely that the new product will steal buyers from the old product. The productions costs may increase with two similar products offered for the exact same target group The same possible problem is also present in their second most popular product group; the tandem bikes.

Existing Market

The following is an extended list of the most common devices available for CP children, based on the closest competitors to Meyland-Smith *[App. 6]*.

1. Sitting aids
    - Indoor chair
2. Walking aids
    - Walker
    - Rollator
3. Standing
    - Standers
    - Prone-standers
4. "Driving" moving aids
    - Manual wheelchair
    - Electric wheelchair
    - Push chair
5. Transport aids
    - Car chair
    - Lift system for car
    - Locking system for car
    - Indoor lifting system
6. Toilet and bath
    - Bating chair
    - Bathtub lifts
    - Toilet chair
7. Accessories
    - Head Support
    - Side Supports
    - Vest and Belts

The transport, toilet and bath aids and accessories will not be considered for this project, for they belong to different categories of use which is not of the interest of this project.

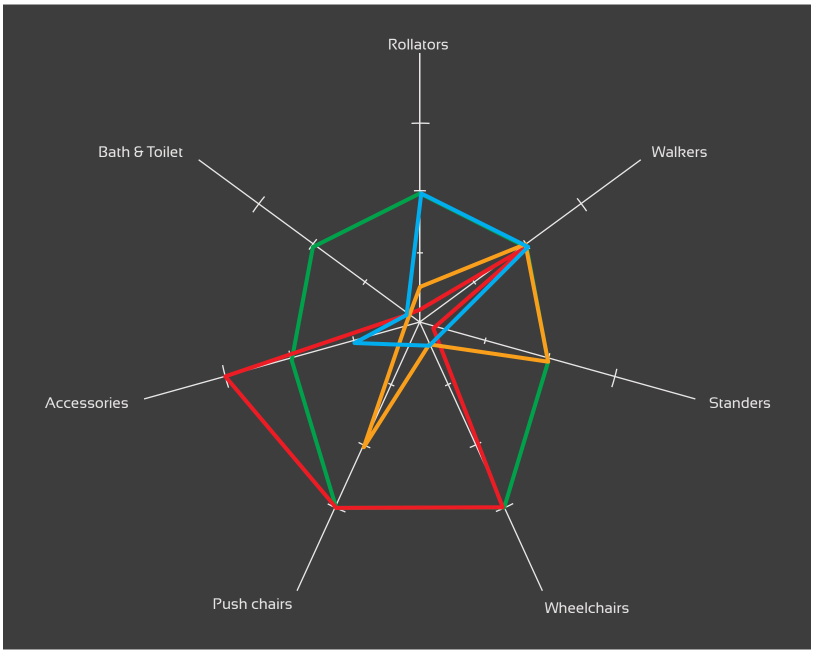
Ill. 2.3: Examples of products for CP

The market to study is based on seating, standing, walking and driving aids from the different competitors closely related to Meyland-Smith. This market covers the needs that are the focus of this project.

Products can be divided into "active" or "still". Active means an aid where the user is actually allowed to use his/her body, for instance a rollator or a walker; whereas still means an aid where the user is mostly sitting, for instance a electric wheelchair or a pushchair.

The following diagram shows the market coverage by the different competitors. The diagram is done from a functional and technical point of view.

Ill. 2.4: Existing Market



People with cerebral palsy, who are using aids to move around have at least two different kinds in order to overcome everyday tasks. A user who has an electric wheelchair normally has a manual one as well. The electric one is used in the regular actions during the day. If the user is to do something besides the regular actions, he is often forced to use the manual chair. This could be climbing stairs, entering an airplane or just enter a home which is not fitted for an electric wheelchair.

The existing products are very specific; they are focused on solving only one situation at the time. This fact limits their use to only one situation per device, which then creates the need for having several devices. Some examples are the standing aid, which children have to use for a couple of hours each day to correct the bone structure, and the electric wheelchair, which improves considerably the child's mobility outdoors but has a very limited use indoors due to it being very oversized as well as harmful to the furniture, walls, etc.

Having the child as their only focus, the main areas of specialization for these devices are adjustability and ergonomics, for manual wheelchairs, and mobility for electric wheelchairs. This leaves the adults –who are actually adjusting the aids- aside, making it difficult for them to interact with the devices.

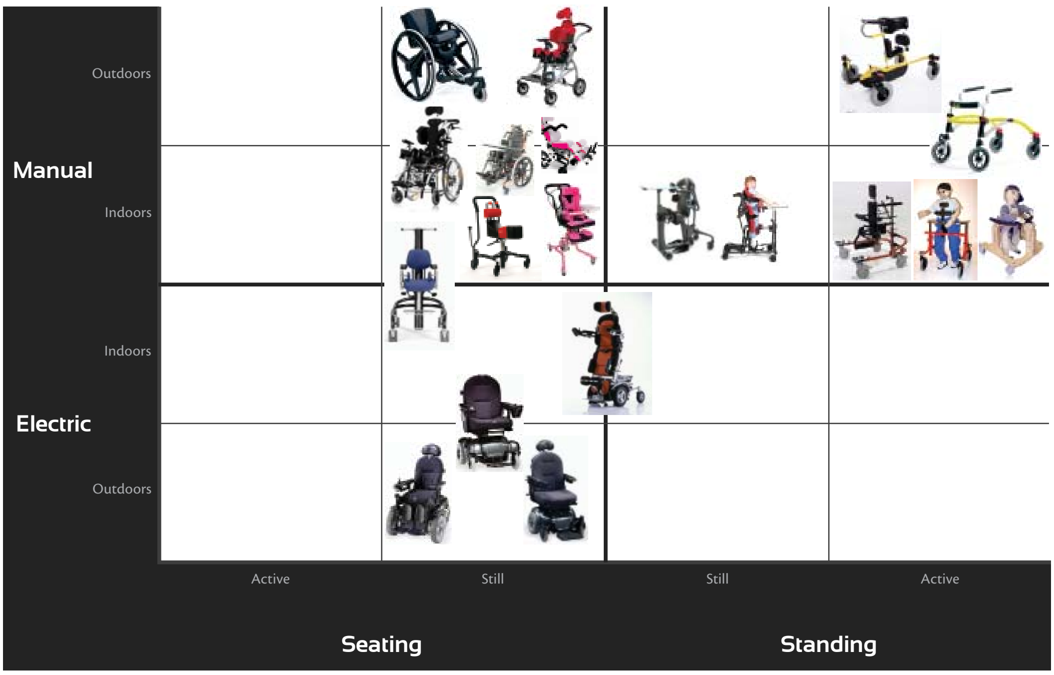
In accordance to the areas of specialization, the main point of view for developing these aids seems to be the technical details. In general, factors such as aesthetics or usability is poorly considered, with a few exceptions.

Market position and possibilities

Today Meyland-Smith is extremely focused on the walking aids. If they choose to broaden the focus, the possibilities of cannibalism will, of course, be significantly reduced.

The existing products are very different and they cover several situations and areas in the life of a CP child. Ill. 2.5 shows products for moving around actively.

Ill. 2.5: Product Coverage map

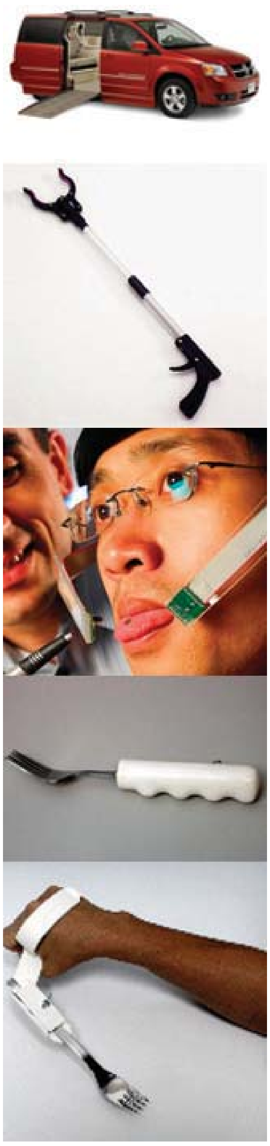


This project will focus on using a different approach to the existing products, by observing to the actual needs of the users around these aids and the several situations in a common day. By acquiring a different point of view, which may involve more actively the people who have more contact with these aids, it may be possible to create a more innovative solution, which brings the possibility of creating a minor blue ocean within the market segment of aids for children with Cerebral Palsy.

This solution could also involve the use of technology that may make the manipulation of the aid easier.

Technology

Ill. 2.6: Technology examples



Technology can be big; an automated lift for a van or for the bathroom, or small; a Velcro-attached grip for a fork or a pen. It can be new age, as interactive voice-activated software for speech therapy. It can be high tech; a computer screen operated by eye movement- or low tech, a specially designed door handle for people with muscular dystrophy.

Technology can be a substitute, such as an alternative augmentative communication device that provides vocal output for a child who cannot communicate with his voice. This means that a child who cannot speak can push a button and communicate with other people.

Existing technologies

Technology is a key to levelling the playing field for individuals with disabilities. An individual may use assistive technology to travel, communicate with others, engage in recreational and social activities, learn, work, control the immediate environment, and increase his or her independence in daily living skills.

Positioning equipment helps put a child in the correct posture to improve eating, drinking and digesting. It can also help him sit or stand to enjoy family, friends and learning. Daily living skills are enhanced by Velcro closures on clothing, long-handled combs, or automated feeding devices such as those activated by chin movements.

Education aids include adaptable keyboards, computer software programs, automatic page turners, and adapted pencil grips to enable children to participate in classroom activities.

Wheelchairs, scooters and hand controls on automobiles enhance mobility. Adapted car seats and wheelchair restraints augment transportation safety. At work sites, special computers, ramps and telephone headsets mean fewer barriers to employment.

For fun and games, there are special wheelchairs for organized sports and tricycles and bicycles for children who use wheelchairs. Adaptive switches can help a child play with toys and games. Easels are also adaptive for young artists in wheelchairs and slanders. Exercise machines for people who use wheelchairs can provide a great workout for the upper and lower body, as well as arms and legs. Acquiring assistive technology does not just happen once in a lifetime. The type of device needed may change depending on a child's age, newly acquired skills and physical challenges.

To get a broader perspective on the possible solution space, a scan was made of existing and future technologies, which is applicable to aids for children with Cerebral Palsy and to mobility impaired people in general. This observation was used as inspiration for new possibilities and tendencies in the area of human movement and rehabilitation.

Conclusion

Considering the availability of the existing technology, it can be divided into two main categories:

1. Practical: electric wheelchairs, actuators, different motors and engines.
2. Conceptual: Exoskeletons, robots and Gyro. This last one is getting more available every day.

For this project, the choice of technology will be very much limited by the price/cost. Considering the following aspects:

- It has to be accessible
- Easy to understand when using
- Low cost
- Easy to manoeuvre and control by the child and adults around

Ill. 2.7: Technology examples

Production

In order to get an approach to the materials and processes used in this type of devices it was decided to study the most common and yet demanding aids, the wheelchairs *[Spinlife, 2009]*.

The majority of manual wheelchairs are made of either aluminium or steel.

High-end, meaning ultra light or sport wheelchairs are typically being constructed of exotic materials such as high performance aluminium, titanium and advanced composites. The choice of one material over another depends on the material's strengths and weaknesses and how the chair will be used.

The business of manual wheelchairs is very much affected by the aerospace industry. They adopt many of the different materials and manufacturing processes. This happens because the two industries deal with similar issues, such as strength vs. weight, cost and reliability. This can be seen in the progression from steel alloys to aluminium, titanium and more recently advanced composite materials.

Material Type

Steel is typically used in wheelchair frames. It is inexpensive, easy to work, readily available and versatile. However, it has a low strength-to-weight ratio relative to other materials. This material is used in standard wheelchairs.

The Chromium-molybdenum alloy steel (AISI 4130) is widely used because of its strength, its ability to be easily welded and ease in fabrication. It can be treated for higher strength and to resist abrasion. It is used in the frames of ultra light wheelchairs.

Aluminium is also used in manual wheelchairs. The aircraft grade aluminium is an inexpensive and versatile structural aluminium alloy that offers good mechanical properties and corrosion resistance. It can be welded using most common methods. Most aluminium wheelchairs are made of this alloy, especially ultra light wheelchairs and sports wheelchairs.

An increasing number of high-end wheelchairs, such as ultra light and those for sports, are made of titanium. Titanium is the most exotic and therefore the most expensive metal used in manual wheelchair production. Titanium is used because of its availability, appearance, corrosion resistance and high strength-to-weight ratio. Nevertheless, it is a very demanding material, since it requires highly skilled personnel and machinery to be treated in order to avoid failures and weaknesses in the final product.

Advanced composites also have been making the transition to wheelchair design from aerospace and industrial applications. Composites are carbon fibre, fibreglass, and Kevlar. Composites can also be moulded into complex shapes, which opens a multitude of possibilities for wheelchair design. Moulding, specifically for curved pieces, allows the design of wheelchairs with fewer joints. This is important since the majority of frame failures occur at joints (bolted or welded). Also, complex shapes provide the greatest benefit to individuals who use a wheelchair because:

- dampening (reduction of vibrations felt by the individual) characteristics of the material can be most effectively utilized
- wheelchairs can be made with less material and fewer joints and therefore be less conspicuous
- wheelchairs can better conform to the features of the body, providing a more comfortable fit

On the other hand, the ability to produce complex shapes can be considered a downside of composites; these shapes can be demanding and thus not cost effective. However, new technologies in the production of composite components and frames are being introduced which should reduce the manufacturing costs. Composites are mainly used in racing wheelchairs.

Function

The different types of material are used depending on the desired functionality of the wheelchair.

Mild steel is often used for depot or standard wheelchairs, where the cost of materials and production is the primary consideration. A depot or standard wheelchair is meant for temporary use by more than one person, typically in an institutional setting, and is often attendant-propelled. Therefore, the weight of the wheelchair, long-term comfort, manoeuvrability and durability on rough terrain are not a major concern.

For a lightweight or ultra light wheelchair intended for individual use as a long-term independent mobility aid, its comfort, durability and manoeuvrability are primary concerns. Therefore, some types of steel, aluminium, titanium and advanced composite materials are employed in the manufacture of the frame and components.

Materials like aluminium, titanium, or composite may allow for a less noticeable wheelchair, so the individual is seen before the wheelchair in a social setting. An inconspicuous wheelchair also means a lighter wheelchair, allowing for easier propulsion and manoeuvrability. Reduction in weight may also lead to a reduction in secondary injuries such as repetitive stress injuries. These injuries may be a result of wheelchair propulsion or lifting the wheelchair during car/van transfers.

Though cost may not be a primary concern to the individual, it automatically becomes one as soon as a third-party payer gets involved. Obtaining a lighter, more durable and consequently more expensive wheelchair with exotic materials may be justified by it having a more durable and economic life cycle and in the costs incurred while treating a repetitive stress injury. Therefore, the selection of the material used in manual wheelchairs is a function of the durability, aesthetics, function, ride comfort and cost of the wheelchair, as well as the wheelchair purchaser.

A more detailed description of material types and their advantages and disadvantages can be found in Appendix 7.

Conclusion

The choice of material depends very much on the final use of the aid. It is important to consider the weight as wells as the strength, depending on the activities the aid is thought to do.

Besides, it is important to take into consideration the possibilities of failure that come from welding and joints, it could be to prefer to avoid them as much as possible or have them in places that may not jeopardize the overall strength of the aid structure.

Interviews

Two interviews were conducted in order to gain a deeper understanding of the way the products were used and to determine possible similarities in the activities performed by each of the aids used in the everyday life of the children and their surroundings. Video recordings of the two interviews can be found in the attached CD at the back of this report.

Meeting with a family

The interview was carried out at the home of the family. They live in a house which has been modified to handle wheelchairs and other aids needed. The family consists of the parents, the handicapped child -a 7 year old boy-, two older sisters and a six years younger brother. The boy is tetraplegic and is not able to carry his own weight on his legs or keeping his balance. He has great difficulties communicating verbally, though the parents understood most of his sentences.

The meeting started out with an introduction to the different aids they have and a demonstration of their use, followed by a semi structured interview, revolving around their experiences with the products and how they used them. The interview also consisted of showing three maps to the parents. These maps were used to define the importance parents associate with specific values of the aids: product appearance, ownership and functionality. The maps show a cross with opposite words aiming at creating a discussion with the parents in order to find the level of importance they associate with those words. The maps in full size can be found in Appendix 4.

This child has many different aids; the preferred one for inside use is a chair with adjustable height which has many adjustment features for an optimal sitting comfort. He uses the chair when he is watching TV, playing videogames, reading and when he is eating. He also has a manual wheelchair, for situations where weight is an issue. It could be when they are visiting family members and it is possible that he needs to be lifted in order to enter the house. A newly received electrical wheelchair; he has had it for three months and was proudly showing off his skills in it. It was used both outside and inside, because it gives more freedom to do things. And finally he had a walking aid from Meyland-Smith; the MeyWalk. It was used as a training device that was to be used a predetermined amount of time every day. Besides the regular aids he also used a thick mattress when he was lying on the floor. The house was equipped with lifting systems in the boy's room and in the bathroom.

Meeting at Vestermarksskolen in Aars.

The meeting was held with the physiotherapist Rikke Veddum. She is working as the only physiotherapist at the school; hence she is responsible for the children's physical wellbeing and for the selection and alters of the aids for the children.

The first part of the meeting was an introduction to all the aids, followed by an interview with the physiotherapist. The introduction to the aids helped the project group to understand details and technical solutions of the existing aids available on the market, as well as understanding how the school is working when seeking to provide the children with the best product solutions.

The interview was started during the introduction to the aids, where it was discussed what challenges they face in everyday life, with the children and the aids. Later the maps also used at the interview with the family, were introduced. It led to a good discussion about her own attitude towards the products and their appearance, ownership and functionality.

Two important issues were noticed from the interviews, these made an influence on the project group for changing the definition of User Group. These are explained below.

Social context

The child's development is the main concern of the adults (parents, caregivers and experts). And how to give the child the best possibility to develop is an ongoing discussion between the adults who take part in the child's life. Both the child's physical and the social development are taken into consideration.

Often, when the child is getting older, the social aspects are rated higher than the physical. The electrical wheelchair is an example of this. When the child reaches an age where non-handicapped friends move around more independently, it gets more important for the handicapped child to be able to keep up with the friends. This is at the expense of maintaining the physical development. Therefore, the electrical wheelchair is often chosen over manual wheelchairs.

Another aspect of the social development of the children is their possibility to express their feelings and moods. It is difficult to do, being locked in a wheelchair, unable to move around at will. The normal reaction to a situation that is unpleasant is to react by moving away or through body language. It is much more demanding if the child is forced to try to express it verbally, instead.

Grounding

This is also a relevant subject when it comes to handicapped children's development. It is derived from psychology and was introduced by Alexander Lowen. Here, the term "grounding" refers to a somatic level, meaning achieving a sense of having one's feet on the ground and of being on one's lower body ***[Lowen Foundation, 2009]***. In practise, grounding is used by the physiotherapists to give the handicapped children an understanding of solid ground. This is important when the child is spending much time in a wheelchair or other aids with footplates.

Grounding helps children to become more aware of their own body and position. Lately it has an effect on the development of their own identity and individuality by being able to see their limits and understand that they are an independent being.

This approach to the child's mental and physical development is based on the idea that too much protection is a disservice to the child. When the child is too shielded from the real world, the child is not able to learn from mistakes, which is a normal way for children to develop *[App. 4]*.

User group version 2

Change user approach

During the initial research, it was decided to focus on the age group between 2 and 6. The decision was based on the interviews made at the time. Furthermore the project group found the issues around the parents' first encounter with the many different aids interesting.

The possible hole in the market -manual wheelchairs for small children-, further user investigations and the introduction to the Gross Motor Function Classification System (GMFCS) caused the focus to change.

The revised user approach was changed based on both a strategic and a practical approach. The strategic approach is based on the idea of having a space centred solution instead of one based on the level of handicap. This focus allows the company to evolve the product, both to other levels of handicap and to other ages.

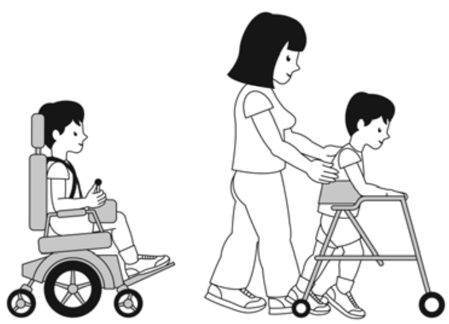
The practical approach to changing the user group was based on the interviews and meetings with the users. It was found more relevant to work with a user group that is more closely attached to the aid, which the group between 2 and 6 years old is not, they are starting, to some degree to use some aids, but are still more dependent on their parents than on the aids. The 6-12 years is an interesting group, when it comes to becoming more independent.

Updated user definition:

The primary users are children between 6 and 12 years old. They are levelled 4 on the GMFCS scale. The children have only a limited amount of mental handicap. Meaning they have a good level of cognitive understanding.

The level is defined as follows.

Ill. 2.8 GMFCS Level 4 for children from 6 - 12 years old



GMFCS Level IV

Children use methods of mobility that require physical assistance or powered mobility in most settings. They may walk for short distances at home with physical assistance or use powered mobility or a body support walker when positioned. At school, outdoors and in the community children are transported in a manual wheelchair or use powered mobility.

Personas

The following characters are made-up from the knowledge archived during the user research. Information from both the interviews and from the observations made during the visit at the family and at the different institutions was used to create the three personas.

The personas were used as a part of the process in understanding the user group better. It was a way to be able to relate to the users, and to give a basis for discussion about the differences and similarities the children have. The personas were therefore made to reflect the diversity the children have, being boys and girls, and in different ages with different interests and needs.

Later it was used in workshops for inspiration on the overall visual appearance during the concept development phase.

Ill. 2.9: Personas

Thomas

He is 6 years old and is hemiplegic. He has a younger brother (3 years old). Thomas likes cars and likes to play with his collection of toy cars along with his father. He knows most of the names of the cars he sees when they family is driving around. His favourite character is Lightning McQueen from the cartoon Cars. He has posters on his room and stickers on his manual wheelchair with the character.

He likes to lay on the floor, because that is where it is most easy to play with his cars. Sometimes he likes to take his remote controlled car outside in front of the house. He needs help to hold the remote and needs a good sitting posture in order to concentrate on controlling the remote.

Peter

Peter is 8 years old and is tetraplegic. He has a 4 year older brother. He likes videogames about strategy and adventure. His favourite game is Sims, because he can play alone or sometimes with his brother.

He also likes sports, especially handball and basketball. He follows the Danish league in handball and cheers for FCK. He enjoys playing basketball with his brother or his parents, but he never plays alone. When they are playing, he is sitting in his manual wheelchair and using his legs to move around, thus he can use both hands to control the ball.

Helle

Helle is 10 years old and has paraplegia.

She has two siblings; a younger brother and an older sister. She likes horses. She is riding two times a week. Her parents are taking her every time, but she prefers to be left alone, so she has more time to concentrate on the horses, her friends and the instructors. Helle has two friends in the school class, who are also interested in horses. They like to visit the homepage Wendy, where they can read about horses and share experiences and pictures.

She also likes to be outside, in the garden and go to the woods nearby the house with her parents.

The following figure was created as a way to get an understanding of the redefined user group. It represents examples of what children in those ages find interesting.

Social network becomes more evident, compared to younger children. They start to develop their personal identity.

The youngest children in the group start being very aware of products and brand names, and about what they like and dislike; if the right product is a Barbie, Build-A-Bear or Star Wars.

The older part of the group is different from the younger. Being tweens, between 8 and 12, they are transitioning from childhood -no longer being interested in toys- and aspiring to being a teenager - buying music, makeup, etc.- More information about this study can be found in Appendix 8.

Ill. 2.10: Children's Identity Diagram

Market Opportunities

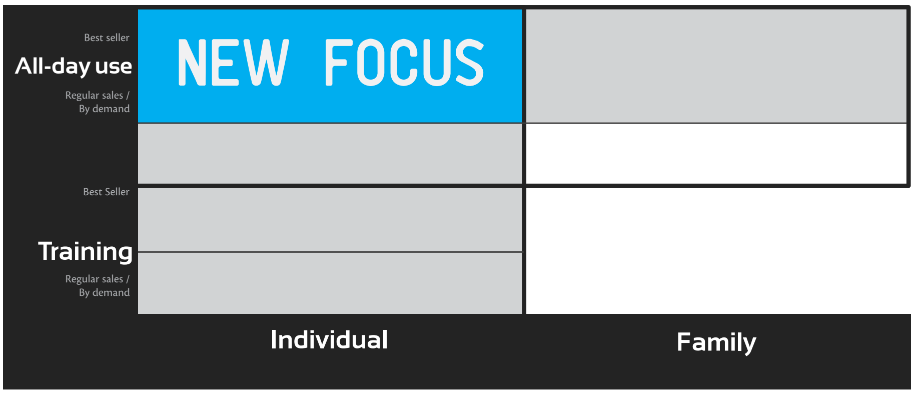
Based on the company and competitors research, it was possible to find some keypoints that could be used as a guideline for the project.

Meyland Smith

The Company has a good reputation and is very much focused in selling abroad, not only in Denmark. Even though their most popular products are walkers, they do not see themselves as producers of training devices. Their major income is the Meywalk in its two different versions, followed by the foldable tandem bike and lastly the wholesale of products belonging to other producers.

In order to increase the presence and strength of the company it is necessary to get a new focus that could differentiate them from their competitors. This new focus should also avoid the common belief that Meyland-Smith is a company that developes training devices.

A possibility for a new focus could be found in the practical use of the aids, meaning everyday use, since this point of view is not very much considered by the competitors, becoming then a possibility for Blue Ocean as well. It also avoids the idea of a training device by focusing on a complete opposite, the everyday use.



Ill. 2.11: New Focus for Meyland-Smith

Competitors

The existing products made by the closest competitors to Meyland-Smith are very specific, meaning that they are focused in solving properly only one need at the time.

The main areas of specialization are adjustability and ergonomics –for manual wheelchairs- and mobility –for electric wheelchairs-.

There are also a series of accessories in these areas, probably aimed at creating loyalty to the brand or holding on to the customer.

The main point of view, according to the way products are developed, seems to be on technical details, not really considering the human interaction with the products.

Focus Areas

The research done in this phase was a continuation of the one done in the initial research phase. Therefore the focus areas were continuously adjusted and readapted to fit the newest information. The following focus areas are therefore based on the previous versions presenting the further development done on them.

The project will be focused in the human aspect of the aid, meaning the interaction and perception the users get from it, including the social context. It was observed that the needs regarding this area are not entirely fulfilled by the existing products; therefore it means a good opportunity for developing a significant improvement, as well as a Blue Ocean for Meyland-Smith, as a part of the new focus suggested for the company.

The focus of the project can be observed in four main areas, which will be considered as the guiding points, each one of them gathering a series of values or features considered to be the most common or important. All these are derived from analysing the information previously presented, especially from the User Research. The areas are:

Visual Appearance

- Robust: the aid should have a strong appearance, in order to withstand the movements and everyday use of the child
- Playful: the main focus is on the child, the aid should express that it is the child's aid.
- Seeing the child not the aid. The children are looking more handicapped than they are in many aids, this can be avoided by making the child the centre of attention instead of the aid.
- Safe: the aid should look like it cannot break or have malfunctions, since it is a main concern of the adults.

Adjustments

- Semantics, meaning the understanding of how the controls work
- Mechanical Movement, knowing beforehand the consequences of a handle/lever movement

Functions

- Helping, not limiting: the aid should be a tool for moving more freely, feeling more confident; not setting unnecessary limits for the body to move or act. Thus the child gets more freedom to move and interact with other children or people around.
- Different Postures, such as walking, standing or stretching.
- Comfort

- Reliability: the aid should not cause any damage in case of a breakdown or a malfunction, the technology (if any) should have a safety break/lock. Besides the aid should be possible to operate when the technology is not working
- Safety for child: the child should be protected from falling.
- Safe Home: the aid should be friendly to the furniture, avoiding breaking or causing them severe damage.

Mobility

Meaning the manoeuvrability for:

- Adults: when pushing the aid.
- Child

Demand Specification 2.0

Users

The focus of this project is on both the children and the adults around them, the child being the most important.

The child is between 6 and 12 years old, medium handicapped -placed on level 4 of the GMFCS scale- and with none or little mental handicap.

The adults are the parents and the personnel at the institution where the child is on a daily basis. The adults are divided into two groups; parents and care givers are in the group who has everyday contact with the aid and the child, but with a low level of expertise. The expert group has less contact with the child and the aid, but have a higher level of knowledge about the child's physical needs.

The caregivers and the experts are not always clearly divided in reality. Some experts -being physiotherapists or occupational therapists- are in close and everyday contact with the children; hence they will be present in both groups. On the other hand the normal caregiver and the parents build up a lot of knowhow, which give them the possibility to make some expert decisions.

Context

The aid is aimed at making every day easier, therefore the focus is the home –inside and the close surroundings, meaning the pavement and garden. At the institution it is indoor- and outdoor areas.

Indoors needs:

- Move over 50 mm height steps
- Get through 750 mm doorways
- Manoeuvre through a course (Avoiding furniture, people or pets)
- Not destroying the house when crashing into stuff. Be friendly to furniture and interior

Outdoors needs:

- Move on level ground
- Move on grass
- Move on slightly uneven terrain (stone floors)

Social context

The aid should help the child to feel more confident and to interact more naturally with the people around, by being more able to communicate through movements or body language.

It should also be inconspicuous, making the child the centre of attention.

Tasks

The project aims at making "the most preferred aid of the day".

The adults should be able to operate the aid from a comfortable position, and be able to lock the wheels of the aid.

The aid should enhance the skills of the child, in order to make him/her move and communicate more freely.

Adjustments

We will consider the physical ergonomic functions of the adjustments on the aid, as well as the cognitive understanding for the different ways to operate the adjustments.

Responsive aid, flexible supports for every part of the body

- Consider that the child may have sudden and uncontrolled movements that should be supported or contra rested.
- Easy to get in and out of the aid when changing to or from another aid

Configuration of the aid, in order to support the child's body

- Create an aid which is more adapted to the body, divided in pieces that could conform accordingly to the human body

Clear Semantics for the Adjustments

Clear understanding of the functioning/movements

Visual appearance

Keywords for the visual appearance of the aid, achieved from the user research:

Freedom of movement

- Flexibility to move your body, responsive aid
- Freedom to move around freely
- Playful; give the child the possibility to play as he/she wants to.

Less physical barriers between adults and children

Personalisation

- Allowing to hang/have personal stuff on the aid e.g. toys
- Order different colours

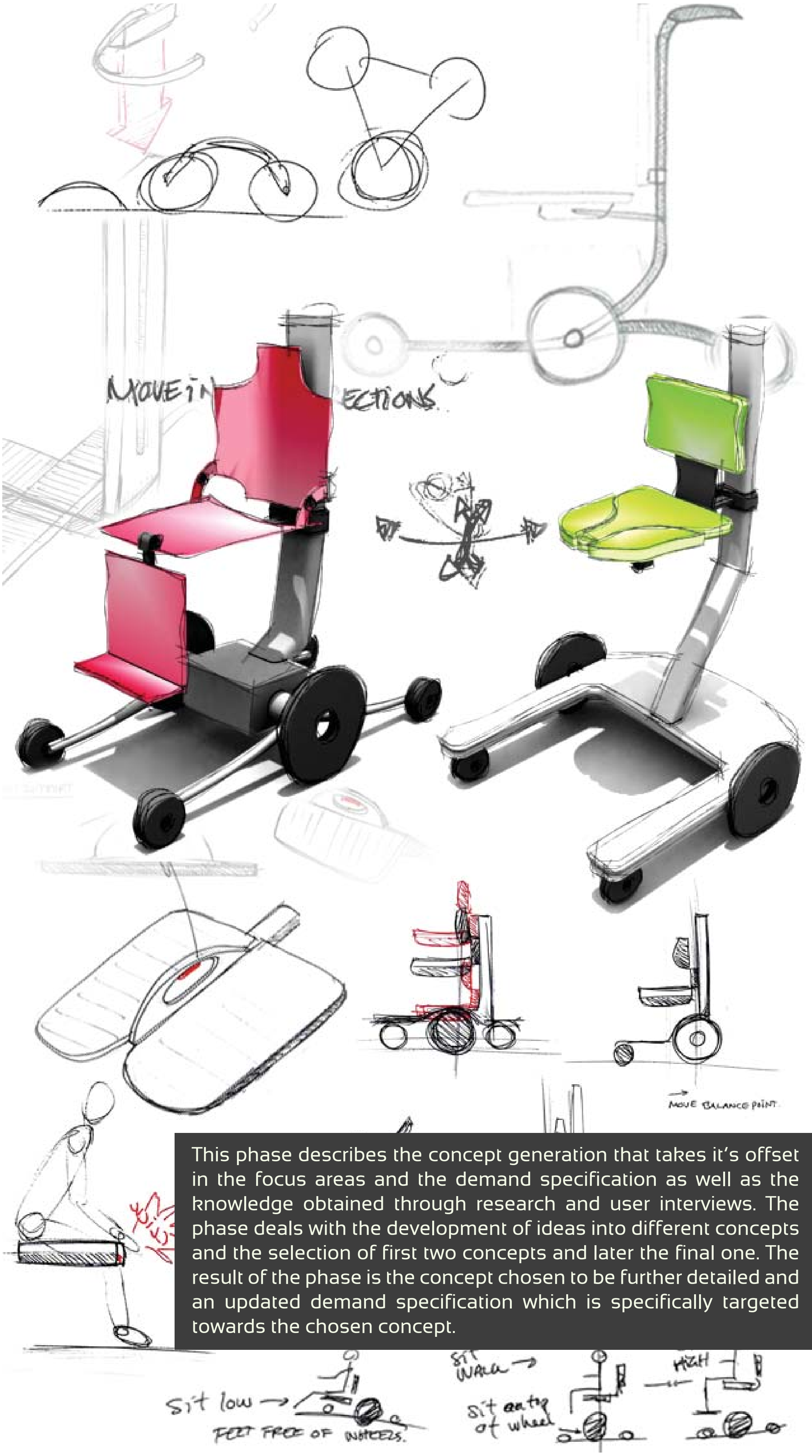
Safety

The aid should be easy for the child to operate, hence the possibility for the child to do anything wrong or to harm itself should be limited.

- The chair should be stable in all positions and on a 15° slope
- The wheels should be lockable
- The chair should not be able to overturn, either backwards nor to the sides.

Problem Statement

How can a new aid for children with Cerebral Palsy improve everyday use, by helping the adults that operate the aid to understand, relate and manipulate it and at the same time give the child more freedom to move around?



PHASE 3
Concept Development

This phase describes the concept generation that takes it's offset in the focus areas and the demand specification as well as the knowledge obtained through research and user interviews. The phase deals with the development of ideas into different concepts and the selection of first two concepts and later the final one. The result of the phase is the concept chosen to be further detailed and an updated demand specification which is specifically targeted towards the chosen concept.

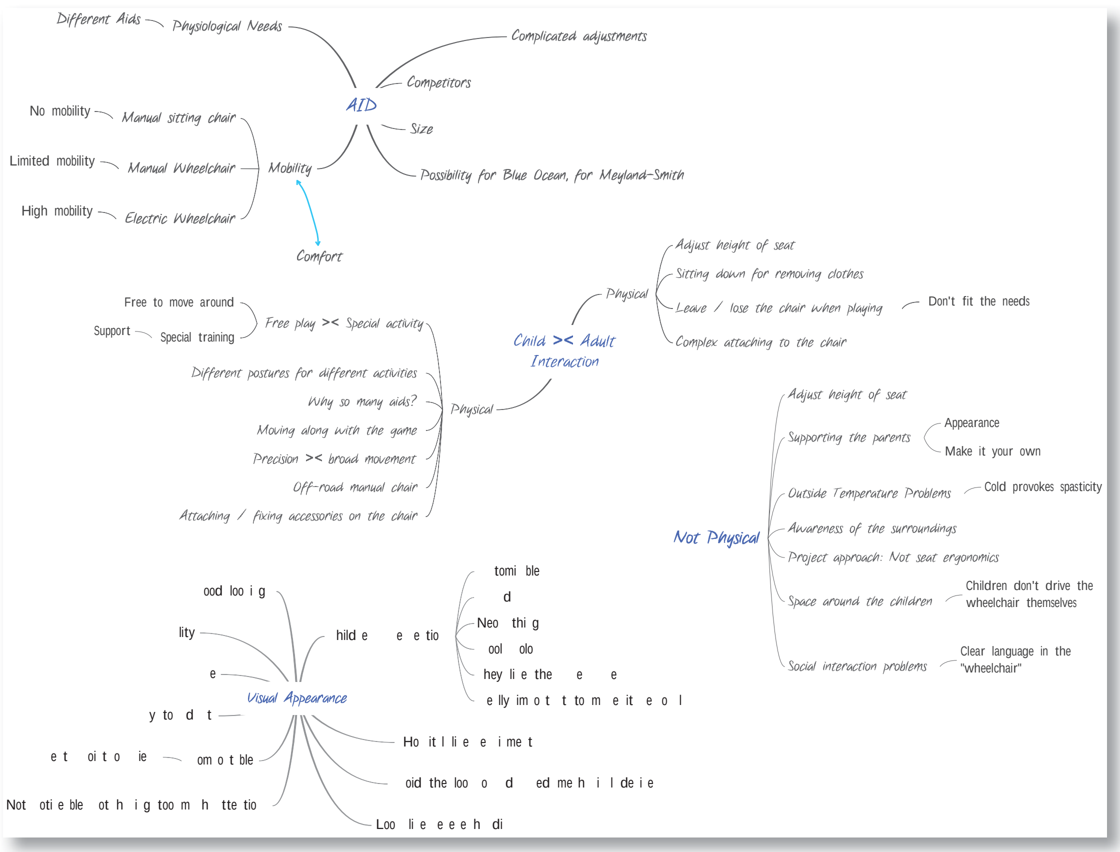
Concept generation and selection

After the further research and the refined demand specification it was possible to sketch more focused on different concepts. At this stage, the NCD model was used as an overall guiding tool, to give an overview of the several factors of the project by making the project group aware of where in the model the problems were attacked from. This method helped to have consensus in the project group of where and how to approach the development. It also worked as a reminder of the other parts that were being worked on at the specific time. The NCD model can be seen in Appendix 9.

Later, and once the Focus Areas were redefined, they were used as a basis for creating several mindmaps on the different areas, some of them were "mobility", "child - adult interaction", "visual appearance" and "different postures".

The aim of these mindmaps was to create several keywords that later would be used as inspiration for quick sketching rounds, the selected words that were chosen to be used were: *movement, standing, sitting – walking and interaction*.

Ill. 3.1: Starting mindmaps for Concept Development



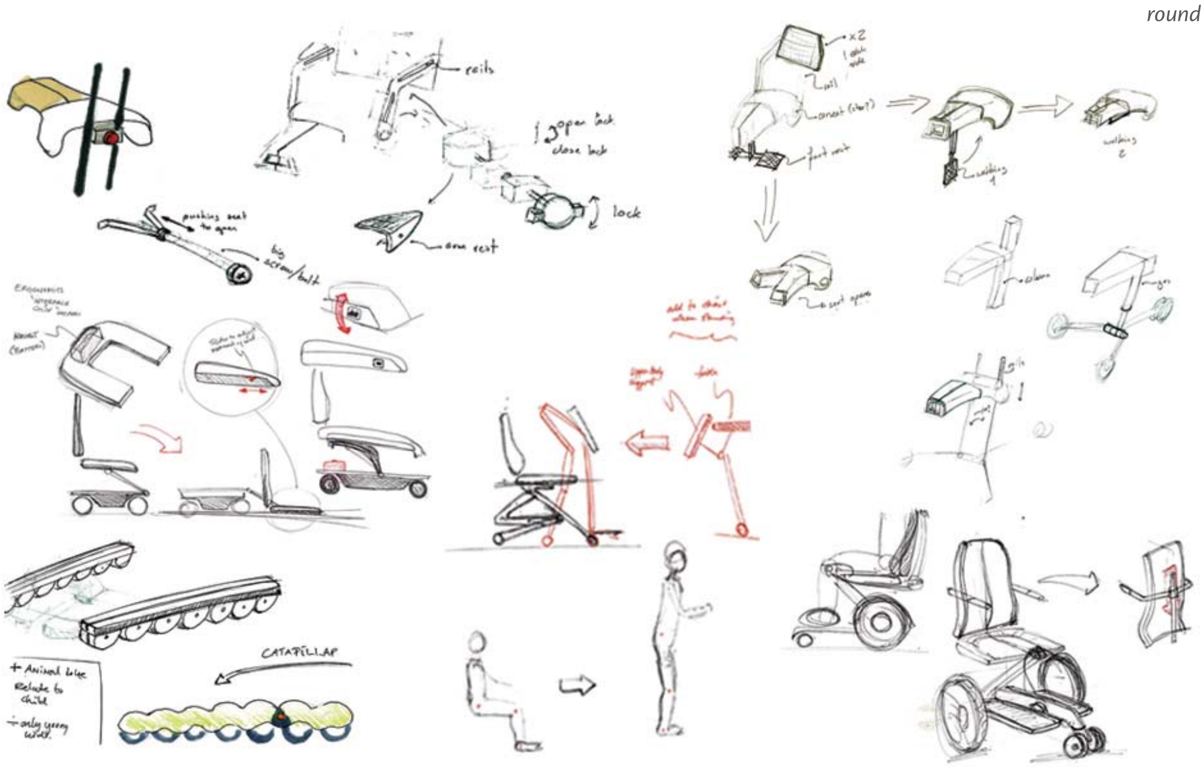
The first group of quick sketching rounds took “Movement” and “Standing” as themes, then “Sitting – Walking”. The keyword “Movement” should be understood as the ability to go from a place to another as well as the possibility for changing the height at which the child is sitting.

A second sketching group was done on the sub-elements the product should contain, meaning specific parts for the adjustments, e.g. the seat, wheel base or supports. At this moment no evaluation was done yet, all the ideas were used only as inspiration for creating more and finding specific solutions on functional principles.

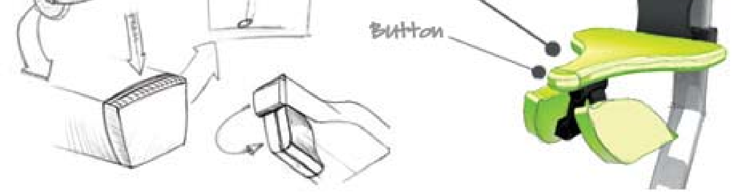
Later, these two groups of sketches were combined, internally presented and explained, and then used as inspiration for a final sketching round, trying also to get ideas for mechanical principles, particularly on manoeuvring and getting up/down.

By confronting the resulting ideas with the keywords from the mindmaps it was decided to choose two concepts; one was based on “sitting-walking” and another one based on “changing postures”. These were roughly tested by making two simple functional models. These models and the two concepts were showed at a status seminar, where the other 10th semester students and supervisors were present.

Ill. 3.2: Second Sketching round



Ill. 3.3: Functional Models



Ill. 3.4: Concept 1 "Sit-walk"

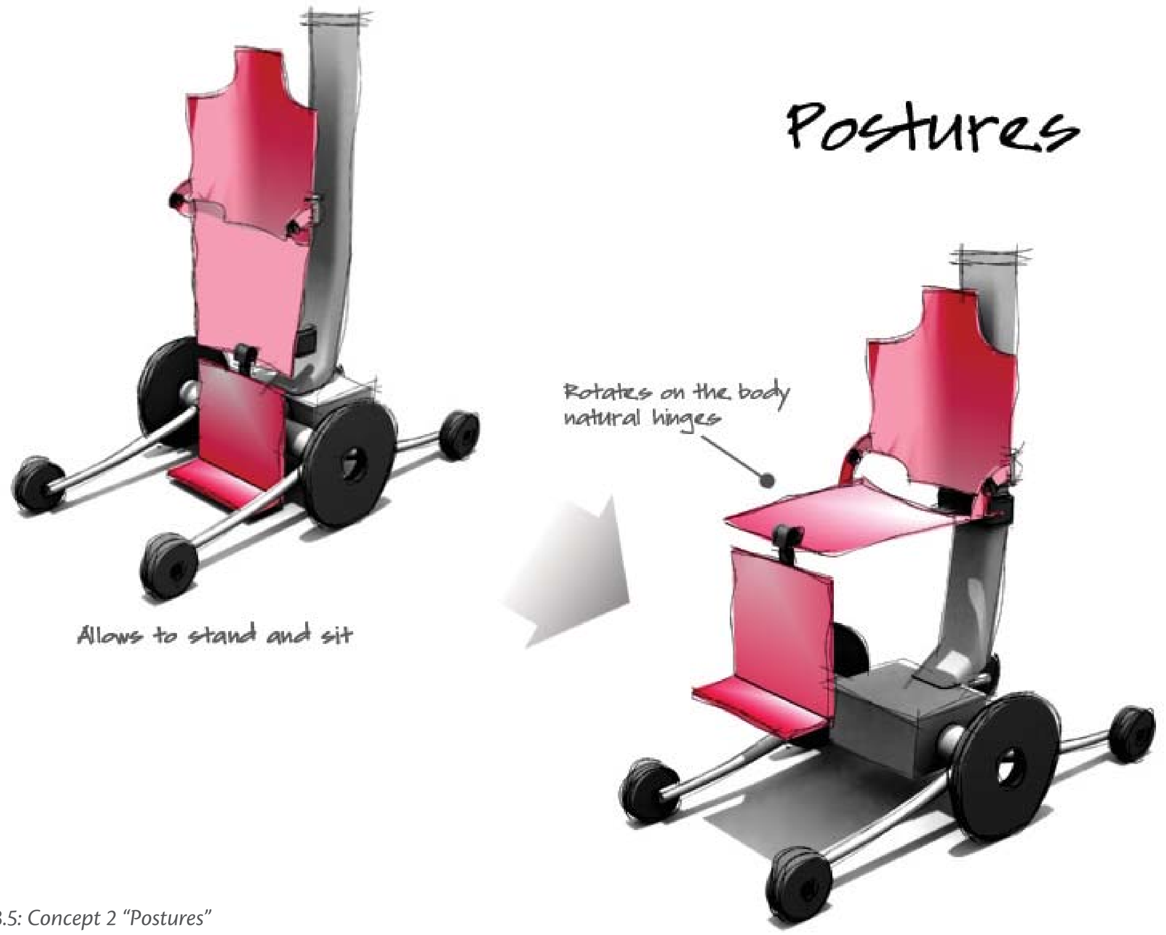
Concept Presentation

"*Sit-walk*" allows the child to walk while being sat by changing the shape of the seat. The seat has two movable parts mostly covering the front, by pressing a button located at the front and centre of the seat these two parts rotate downwards giving more space for the legs to move. The back part of the seat remains wide in order to maintain the balance of the child when walking, it is necessary to help the child maintaining the balance when walking, because CP children have problems combining motor functions and balance.

This concept also allows changing the height, the seat can be moved up and down, and therefore be used in different situations for instance playing at a ground level or eating at a regular table.

The main values behind this concept are:

- to be the child's own aid
- to provide more freedom to move around
- safety, the aid will support the child, preventing him/her from falling from the aid



Ill. 3.5: Concept 2 "Postures"

"*Postures*" allows the child to sit and stand up with the same aid, in order to help relaxing the muscles by changing their posture. This concept has the joints placed at the same height and angle the child body's joint, following then the natural movement, which ensures a constant fastening and support for the whole body.

This concept needs an engine or motor to move around and to lift the child as well, it has a joystick from where the child or the parents can control the aid.

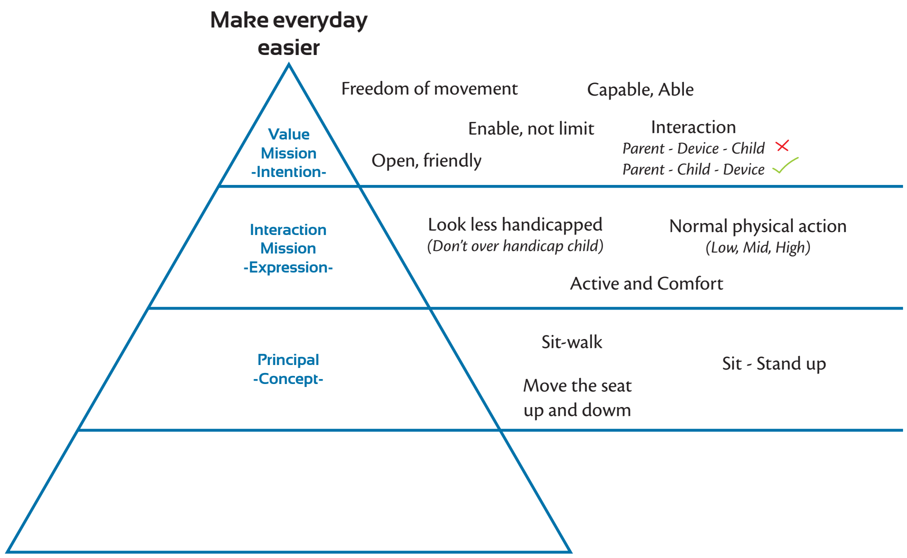
The main values behind this concept are:

- a better interaction with the people around
- to give the possibility to relax and move with the same aid

Concept Selection

Using Lehrdal's Pyramid as inspiration, the keywords from the focus areas were rearranged in order to provide criteria to analyze these two concepts and then be able to select the final one. The two concepts were then placed in the second level of the Pyramid -"Principal"- while the keywords were placed in the third and fourth levels –"Contextual and "Spiritual". The following task was to confront the functionality, represented by the concepts, against the needs and requirements of the users and from other players (Meyland-Smith vs. competitors), represented by the keywords. The new focus intended for the company was also added as part of the criteria.

This method helped to understand and get an approach of finding common factors for very different users, in order to give a more appropriate yet broad solution.



Ill. 3.6: Lerdahl's Pyramid

According to these criteria, the "Postures" concept was very focused on one specific situation, therefore having a narrow range of use; the main function was to help the child to stand up, this action is much related to ergonomics and is well solved by the ergo-standing aids, besides it could be easily taken for a training aid, which was against the new focus for the company proposed in the Research Phase.

On the other hand, the "Sit-walk" concept was focused on a specific movement which could be used in different situations, such as playing at a ground level, eating at a kitchen table or working at a regular table; it was more coherent with the values intended for the aid regarding independence and a more human look and interaction, and could easily become an aid to be used on a regular basis, which is coincident with the new focus for the company stated in the research phase.

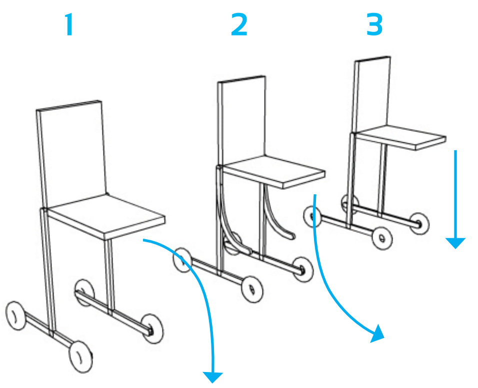
Therefore it was decided to choose the "Sit-Walk" concept for further development.

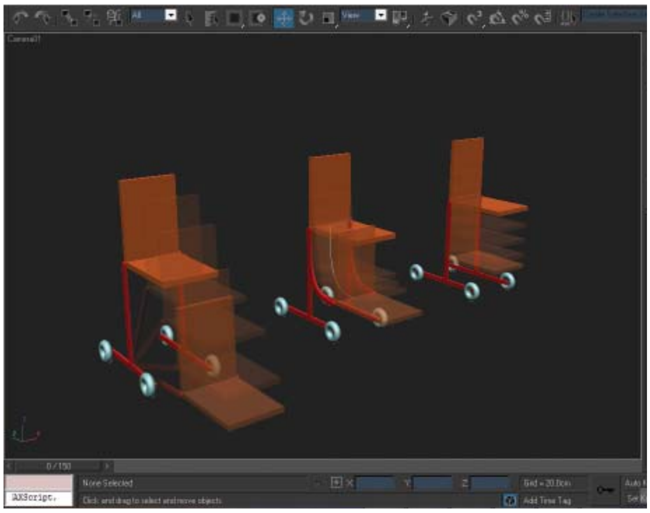
Concept definition

This part of the phase consisted of testing the seat, finding an appropriate trajectory for its movement and then defining the overall configuration of the aid.

This stage started with the trajectory for the seat. Based on the Lehrdal's Pyramid values, several proposals for movements were evaluated. This was done through computer animations.

Ill. 3.7: Movement Animation





The selected trajectory was curve "downwards – front" (number two), since it was a smooth movement that could also resemble an arm "delivering" the child to the ground, being then a more human and natural movement which is in accordance with the values set. The animation of the three proposals can be found in the attached CD at the back of this report.

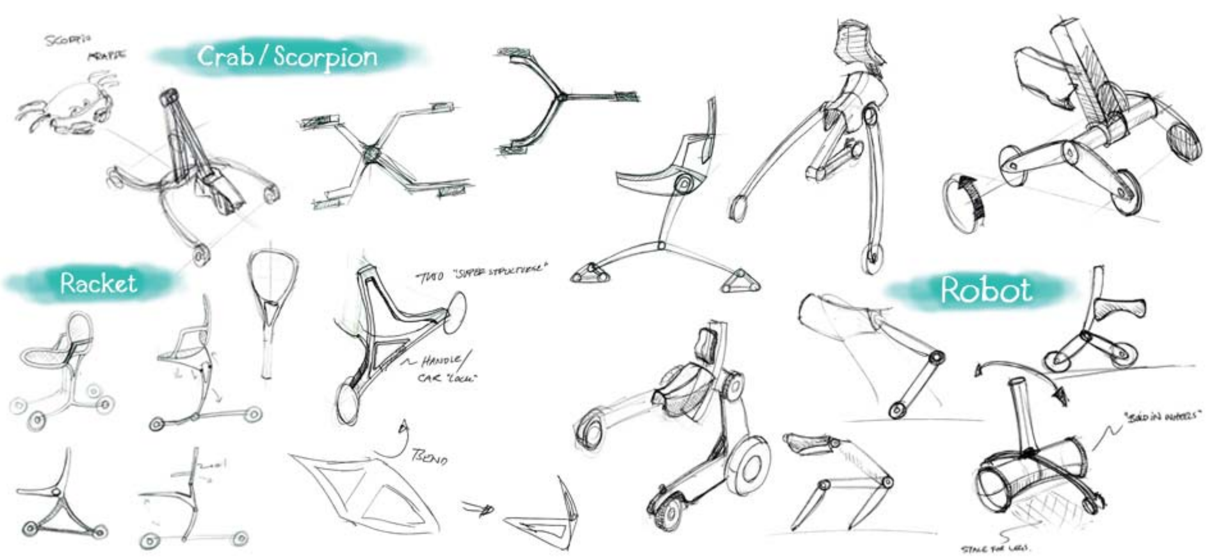
At this point it was possible to carry out a quick workshop on defining the overall shape configuration. This workshop consisted of three iterations of sketching rounds based on forced relationships between two keywords. These keywords were represented with pictures used as inspiration. The values were still based on Lehrdal's Pyramid and selected from the knowledge about the children's identity from the research phase, whereas the words are the result of quick mindmaps on every value.

The keywords and pictures for the first round were:

- Sport (racket)
- Robot
- Scorpion – Crab
- Friendly – Welcome

The first iteration was with "robot" as theme. This was decided because of the qualities to express mechanical movement in an interesting and "cool" way. The second theme was "racket" where the sport and the advanced materials were the main triggers. The first two sketching rounds were first worked separately and then in the third round they were combined.

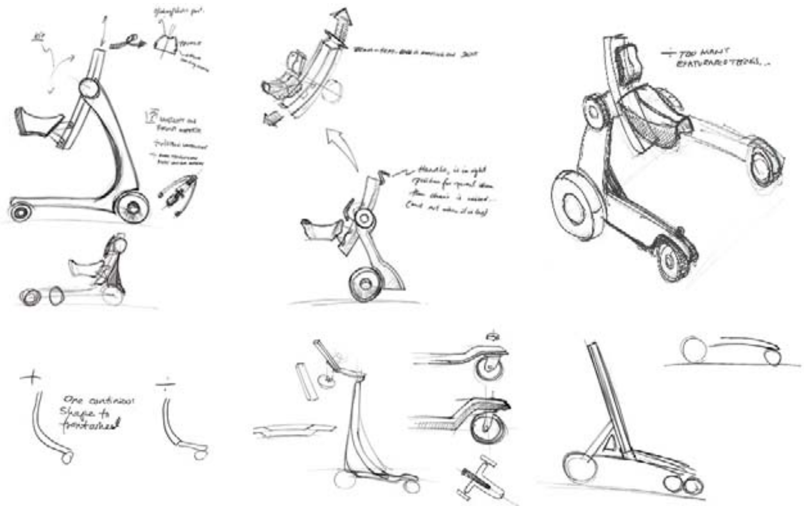
Ill. 3.8: Workshop sketches



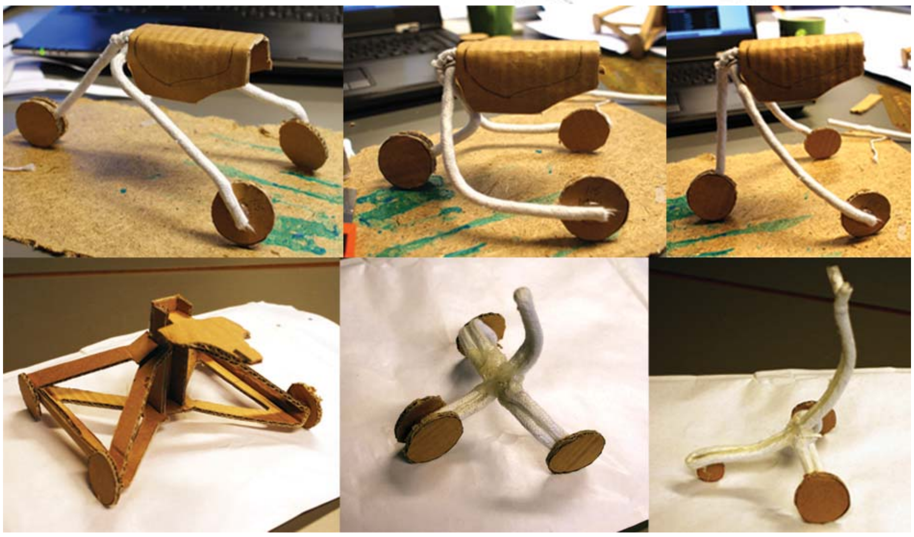
The keywords “Robot” and “Friendly – Welcome” were the main focus for a second iteration, due to them being coherent with most of the values; one of the main reasons for selecting them was that the aid should not be the centre of attention, but the child.

A following and final sketching round was carried out at this point, based on the following keywords: robot, manga - cartoon and sport. A pin-up session was made to evaluate the quality of the outcome from the workshop. The workshop ended by making quick scale models of some shapes which were kept as a guideline for a final decision later.

Ill. 3.9: Workshop sketches



Ill. 3.10: Workshop models

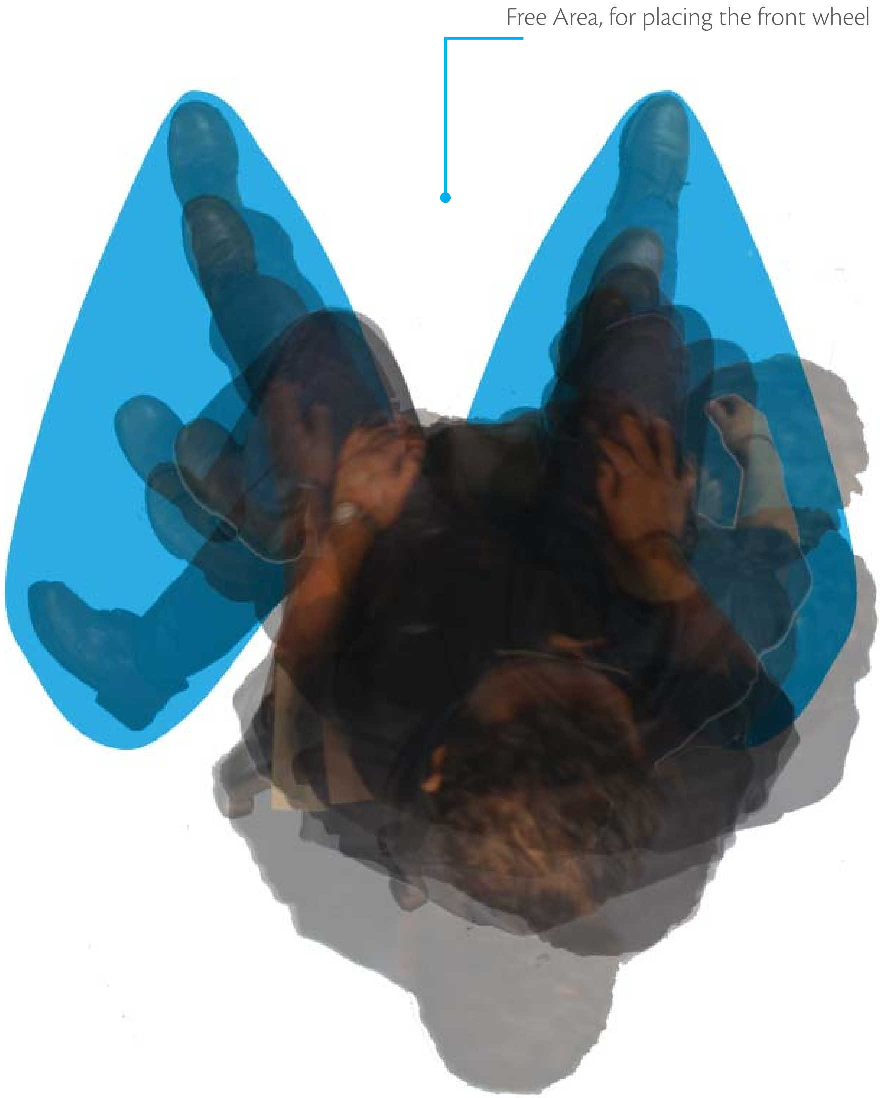


The next step was to test the seat. Being its main feature to allow the child to walk while being seated, it should provide comfort and room enough for the legs to move. It was thought then that the movable parts may cause some unpleasant or surprising feeling by suddenly disappearing when preparing to walk. It might also be complicated for some children to reach and activate the button to rotate them; therefore it was decided to remove these movable parts, having instead only one single element that could be used both for walking and sitting. A mock-up model was done in order to test it and find out the appropriate measurements.

Ill. 3.11: Seat model

The saddle seat has advantages, compared to normal seats. It forces the child to sit in an ergonomic correct way, also allowing the movement for the legs and at the same time it fixes the body, so it does not slide back or forth. The saddle seat is used in different solutions for office chairs, for accommodating an active and ergonomic sitting position.

When testing the seat it was observed that the area used by the feet when walking is only located to the sides of the user. This fact worked as an additional criterion evaluating the shapes previously made. The final configuration was the back wheels placed at the sides and the frontal wheel placed at the centre.



Ill. 3.12: Testing the seat, pictures from top view

The next step was to define an overall size as well as the maximum and minimum heights the seat could be moved to.

It is important to mention that this type of product is generally tested, usually by a government department before being sold. It is therefore considered to meet the selected Standards dictated by the department, in this case the ***Hjælpemiddel Institut (HMI)***. Since it was not possible to get the Danish Standard applicable to handicap devices for children the project group decided to take a basis on the one for Rollators [***DN/EN 11199 2:2005***], due to its availability and similarity of use for both devices.

According to this Standard, the maximum sizes of the whole device should be:

- 70 cm in length
- 60 cm in width
- 100 cm in height

These were then the measurements considered being the limit for this project.

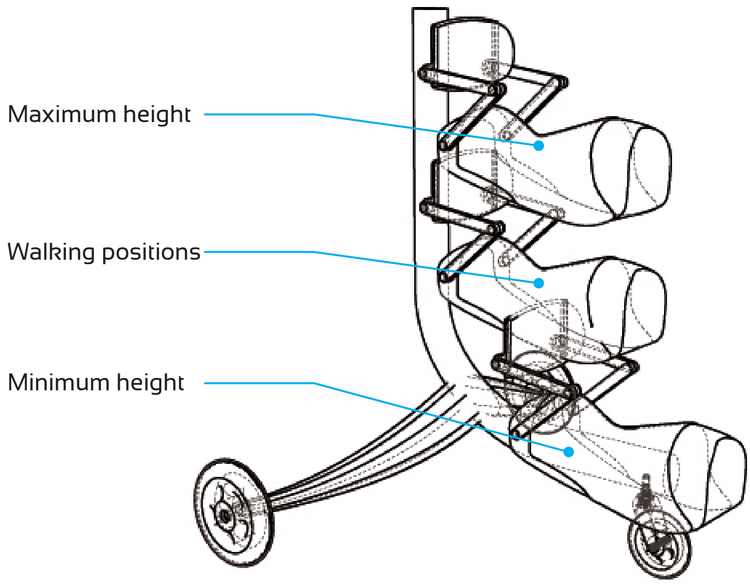
Based on the information obtained in an interview with a physiotherapist [***App. 4***], it was decided to consider that, when the seat is in its lowest position, the knee should be bent making the calf go under the seat, the sole of the feet facing backwards. Since the main reason for having this lowest position of the seat is for the child to be able to play at a ground level, it was decided then to have a distance limit based on the lenght of the thigh (25.7 cm) and reach range (45 cm) of a 50 percentile 6 years old child, due to being the smallest user, being then 25 cm distance from the ground to the top of the seat [***Tilley, 2002]***.

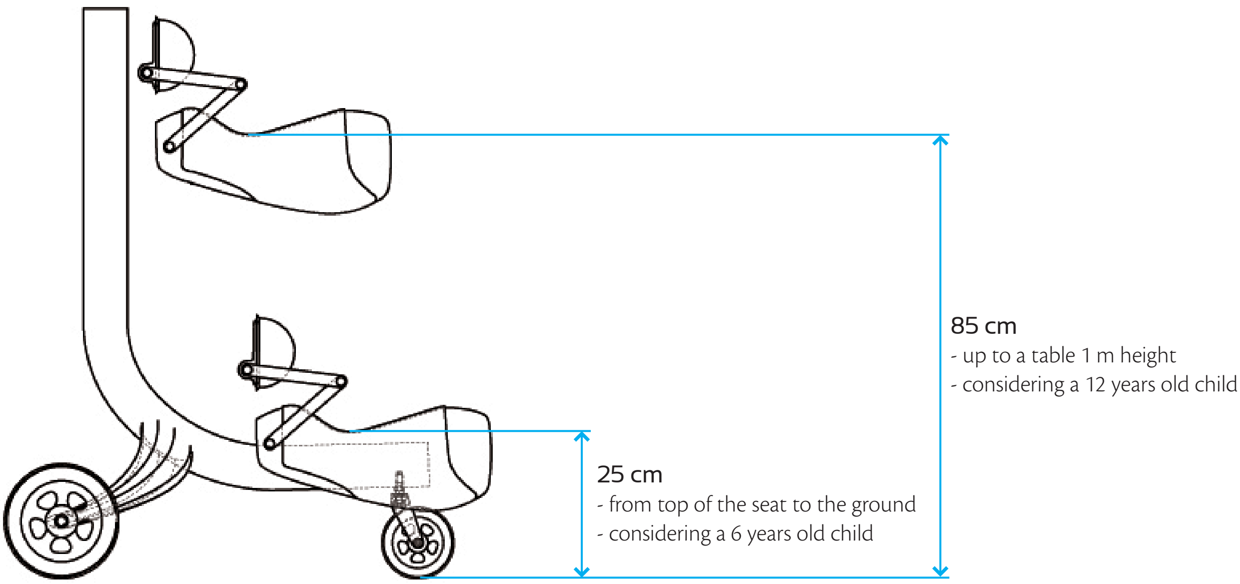
The maximum height was given considering a kitchen table, which is up to 1 m [***Tilley, 2002***]. The size used this time was the leg width of a 50 percentile 12 years old child (10 cm) plus 5 cm of tolerance, therefore the highest position of the seat is 85 cm, measured from the ground to the top of the seat.

The backrest and side supports were also developed in collaboration with the physiotherapist. The back support is placed only at the lumbar height for "reminding" the body to keep a correct position. The side supports prevent the child from falling off the saddle seat, sideways.

All these considerations gave the opportunity to get a final configuration for the aid, which is shown here.

Ill. 3.13: Final shape and different heights





Demand Specification 3.0

Users

The focus of this project is on both the child and the adults around the child.

The child is between 6 and 12 years old, medium handicapped -placed on level 4 of the GMFCS scale- and with none or little mental handicap.

The adults are the parents and the personnel at the institution where the child is on a daily basis. The adults are divided into two groups; parents and care givers are in the group who has everyday contact with the aid and the child, but with a low level of expertise. The expert group have less contact with the child and the aid, but have a higher level of knowledge about the child's physical needs.

The caregivers and the experts are not always clearly divided in reality. Some experts, being physiotherapists or occupational therapists, are in close and everyday contact with the children; hence they will be present in both groups. On the other hand the normal caregiver and the parents build up a lot of knowhow, which give them the possibility to make some expert decisions.

Therefore it is important to make it clear, through the semantics, which adjustments are on expert level and which are not.

Context

The aid is aimed at making every day easier, therefore the focus is the home –inside and the close surroundings, meaning the pavement and garden. At the institution it is indoors and outdoors areas. Make "the most preferred aid of the day".

Indoors needs:

- Move over 50 mm steps
- Get pass through 750 mm doorways
- Manoeuvre through a course (Avoiding furniture, people or pets)
- Not destroying the house when crashing into stuff. Be friendly to other furniture.

Outdoors needs:

- Move on level ground
- Move on grass
- Move on uneven terrain (stone floors)

Social context

The aid should help the child to feel more confident and to interact more naturally with the people around, by being more able to communicate through movements or body language.

It should also be inconspicuous, making the child the centre of attention.

Tasks

The project aims at making "the most preferred aid of the day"

The aid should help or allow the child to:

- Sit
- Walk
- Get to different heights

  Close to the floor ***maximum distance to the floor from the top of the seat:*** *25 cm*

  Enables the child to move in and out of the chair with no help

  Normal table *55 cm from floor to seat top*

  Up to kitchen table – *81.5 cm, where 101.5 cm table height -20 cm to seat top*
- Get support when sitting
- Get support when walking

The adults should be able to operate the aid from a comfortable position, and be able to lock the wheels of the aid.

The aid should enhance the skills of the child, in order to make the child move and communicate more freely.

Adjustments

The physical functions to be considered, as well as the cognitive understanding for the different ways to operate the adjustments, are:

Responsive aid, flexible supports for every part of the body

- Consider that the child may have sudden and uncontrolled movements that should be supported or contra rested.
- Easy to get in and out of the aid when changing to or from another aid

Configuration of the aid, in order to support the child's body

- Create an aid which is more adapted to the body, divided in pieces that could conform accordingly to the human body

Hierarchy of the physical adjustments according to frequency of use (short and long term, expert, parents or child –use)

Short term

- General height of the aid

- Remove extra accessories (Footplate, body harness, table)

Long term

- Side supports; angle, width, height
- Lumbar support; angle, width, height
- Seat support; angle

Experts

- The long term adjustments
- These are adjustments that need expert knowledge about the child's physical and social needs
- In some short term adjustments the experts also have a saying in how and when the support should be used.

Parents and caregiver

- All short term adjustments

Child

- Changing the general height of the aid
- Children with high mobility can move out of the chair to the floor and back

Visual appearance

Keywords for the visual appearance of the aid, achieved from the user research:

Freedom of movement

- Flexibility to move your body
- Freedom to move around freely
- Playful; give the child the possibility to play as he/she wants to.

Clear Semantics for the Adjustments

Clear understanding of the functioning/movements

Less physical barriers between adults and children

Keywords for the look: Sport, robot and manga. See the Appendix 10 for details.

- To make the child look active, dynamic and young
- I can do things
- I am active
- I am young and playful
- I am not stupid / slow / scary

Personalisation

- Allowing to hang/have personal stuff on the aid e.g. toys
- Order different colours

Functionality

Safety

The aid should be easy for the child to operate, hence the possibility for the child to do anything wrong or to harm itself should be limited.

- The wheels should not be in the way of the feet, when walking
- The downwards movement of the seat should help the child to kneel (the calf should go backwards and under the thigh)
- The chair should not move to the side when the seat is in the lowest position (to make on / off movement easier)
- No possible pinching when seat is moving, for the child
- The chair should be stable in all positions and on 15 degrees slope
- The wheels (2) should be lockable
- The chair should not be able to overturn, either backwards, nor to the sides.

Reflection

This process was (and always is) very messy. Therefore, different methods for keeping the overview were used. In the beginning the NCD model was freely used to locate where in the process we were working. It was also used to work around the problems.

Lehrdal's pyramid was used later in the process to create consensus between the abstractions levels.

It would have been very time consuming to make the expression iterations if they should have been done to the fullest; instead it was decided to use the iterations as exercises to determine which form-expressions would work. The fact that the group only hold two members made it possible to make the session short, because the sketches were being described very detailed, throughout the process.

PHASE 4

Product Development

This phase deals with the further development of the concept, from being ideas about how the problem areas should be solved to a realisable product. The phase will focus on combining the functionality of the aid, production cost and reliability and strength into the final product. Some of the essential features of the aid will be detailed further in the ensuing phase.

Profile Development

The process in implementing the conceptual ideas into a final product has been very iterative, where especially the considerations around reliability and simplicity have been important factors. Including the fact that the production number is low compared to similar products like bikes and regular pushchairs, hence the production costs should be low as well.

When the overall shape and trajectory were defined, the next step was to find the profile section and a rail combination that could allow the chosen movement of the seat while keeping it always horizontal.

Several shapes were developed and later analysed with a criteria based on the following considerations:

- Expression, visual appearance
- Weight, overall weight of the aid
- Weight distribution, placement of the child's gravity point along the trajectory
- Simplicity, few moving parts
- Production price
- Feasibility
- Strength, overall strength and durability of the structure

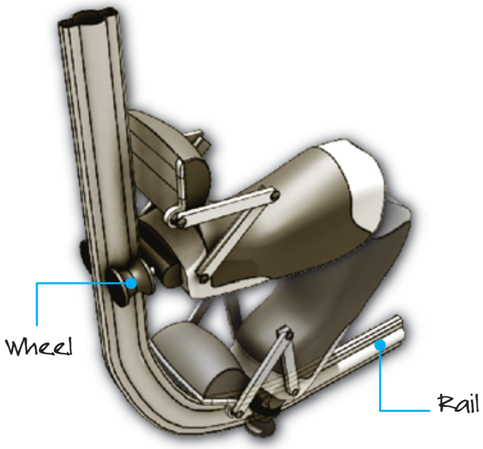
Production and strength of the structure were considered to be the most important, since the aid would be under sudden, and sometimes big, stresses due to the spasms of the children. The production was considered important for it is a major influence on the overall strength of the profile.

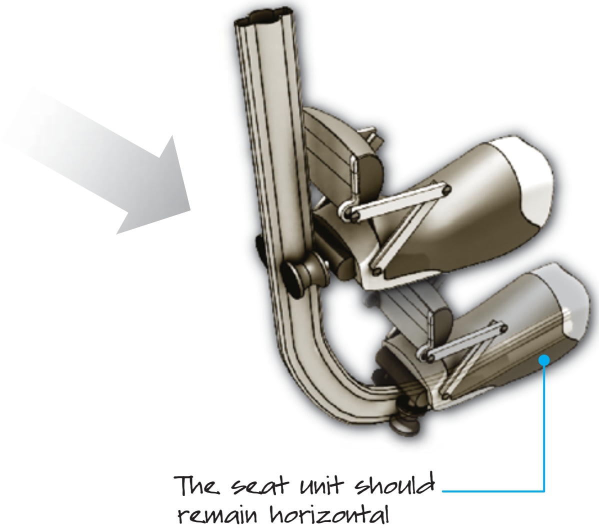
The following pages show the analysis done to the different shapes ending with selecting one to be further detailed.

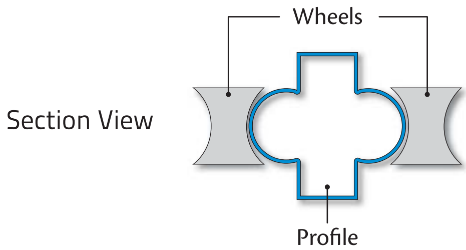
Shape 1

A rail with two wheels running on each side of the profile.

The wheels keep the seat unit always perpendicular to the profile, therefore it is needed to have a mechanism to keep the seat unit always horizontal.





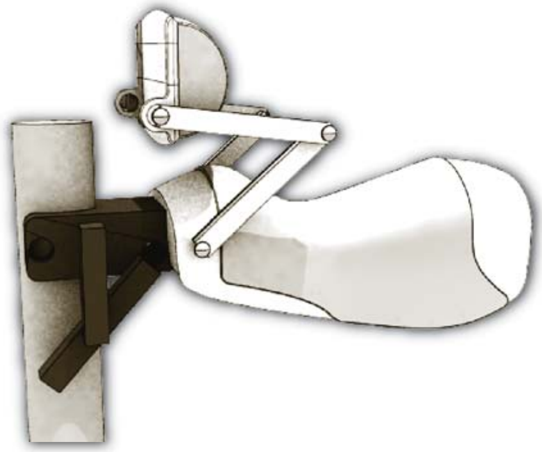


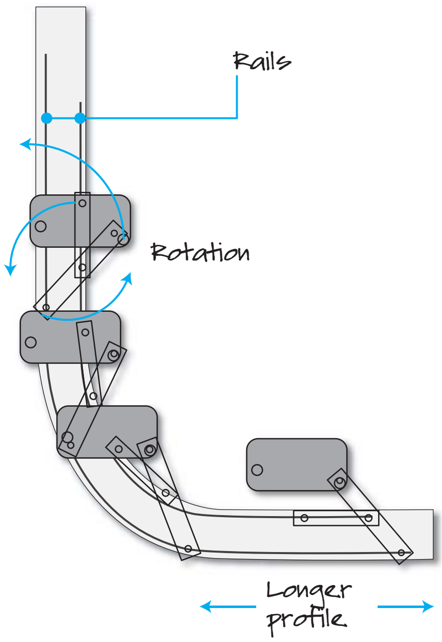
Shape 2

A variation of parallelogram to keep the seat unit horizontal.

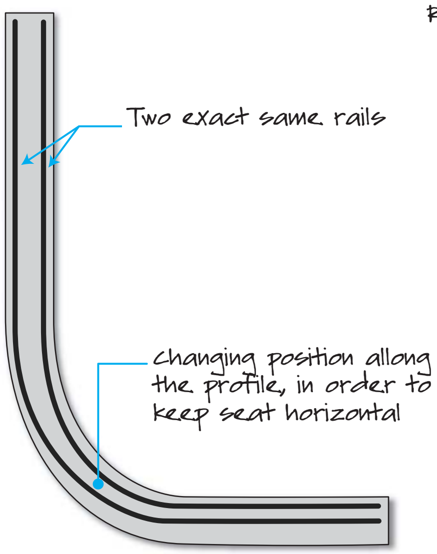
This proposal needed a longer profile in order to get to the lowest position, which was then out of the total length limit for the chair set to 70 cm.

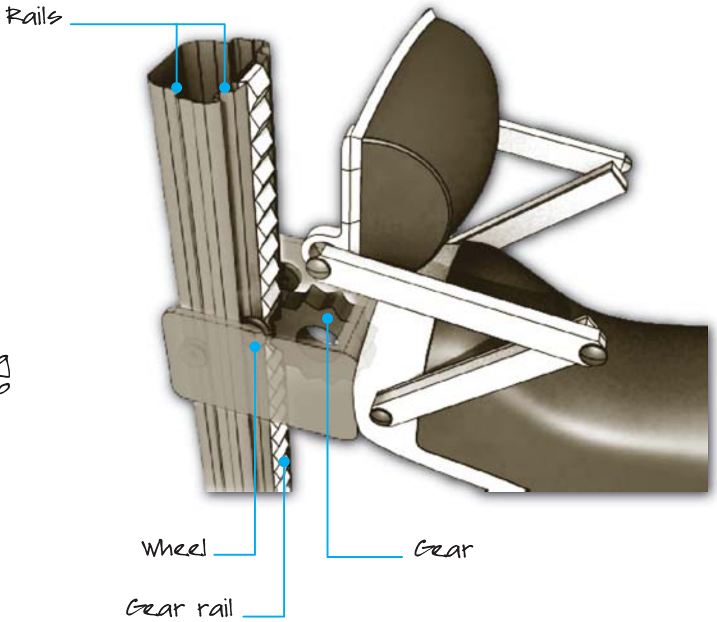
In some parts of the radius, the mechanism was also locking itself.

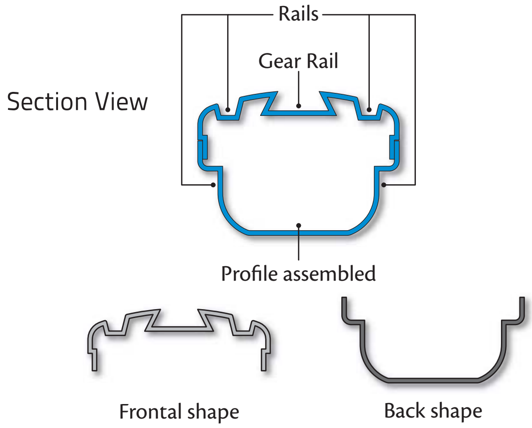




Ill. 4.1: Profle Development





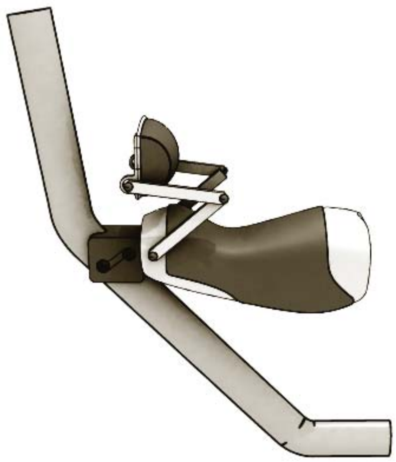


Shape 3

Two exact same rails on each side of the profile, thus maintaining the position of the seat.

Since the two rails need to have exactly the same radius, their position on the profile changes all along, making it then impossible to extrude.

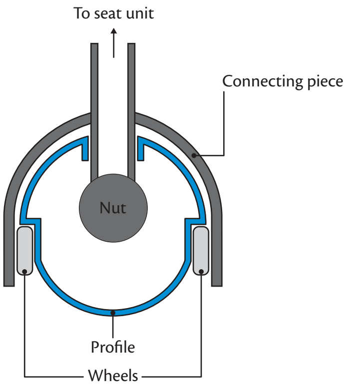
This proposal needed to be produced in two different pieces, which leads to wielding or gluing, and then bending. The piece has a high degree of complexity in production and may not have the required strength.



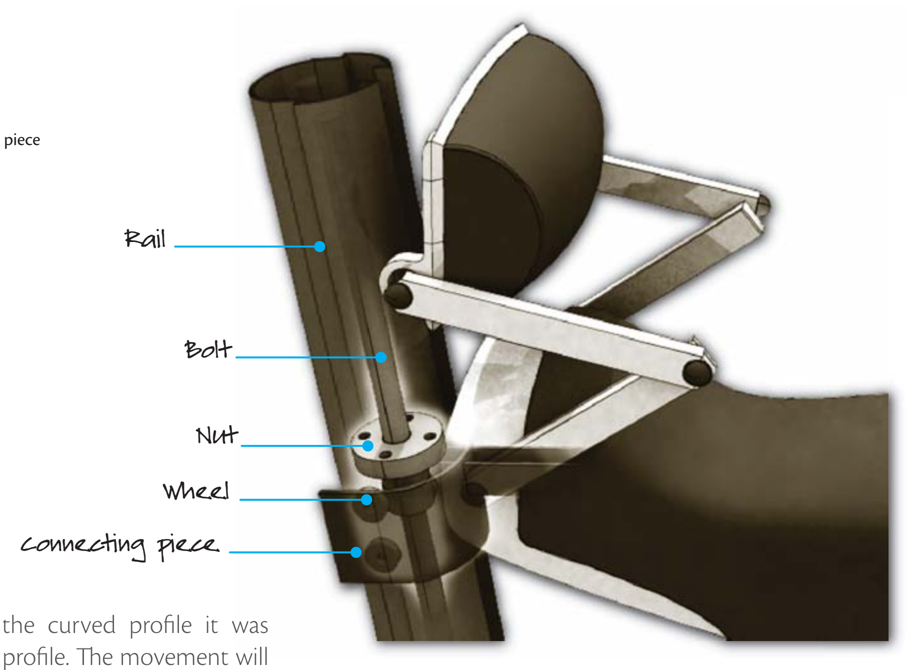
- Variation on Shape 3

Yet not possible to have the profile in one single piece, the rails may become straighter as the radiuses used on the bending of the profile are smaller, but still changing slightly their position along the profile.

Ill. 4.2: Profle Development



Section View



Shape 4

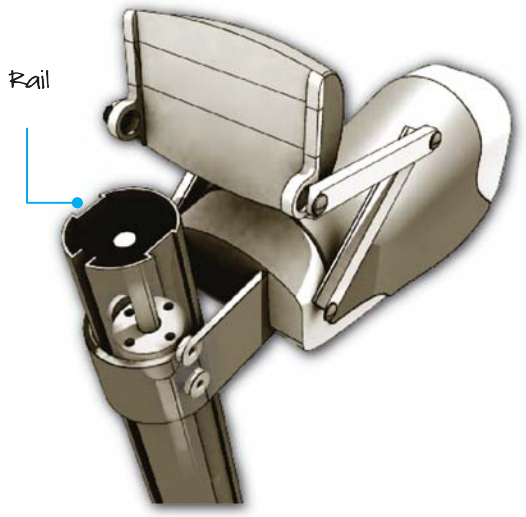
Due to the complexities of the curved profile it was decided then to use a straight profile. The movement will be then given by a bolt running inside the profile.

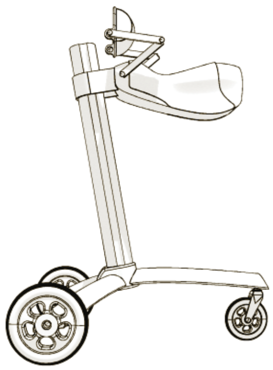
This proposal has a rail on each side and an opening at the front that allows connecting the seat unit directly to the bolt.

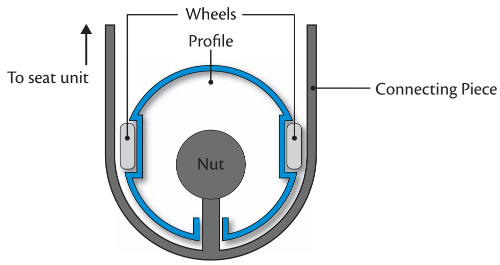
Final Shape

A variation on Shape 4.

The piece connecting the seat unit to the bolt was made in several pieces. In order to increase its strength it was decided to reduce the number of pieces by combining them. This generated a new shape for the profile, which allows a better connection and also reduces the opening distance, increasing the profile's strength. The opening is now at the back and due to its angle it is more difficult to get something inside that could block it.







Ill. 4.3: Profle Development

	Importance	Shape 1 - Cilinder wheels	Shape 2 - Parallelogram	Shape 3 - Assembled profile	Variation on Shape 3 - 3 sided profile	Shape 4 - Straight rail, frontal openning	Variaton on Shape 4 - Straight rail, back openning
Expression	3	2	1	3	3	2	2
Weight	4	2	2	3	3	4	4
Weight distribution	3	5	5	5	5	4	4
Simplicity (few moving parts)	2	2	1	3	3	4	5
Production price	4	4	4	2	2	4	4
Feasibility	5	5	5	3	3	5	5
Strenght	5	3	3	1	1	5	5
		89	84	72	72	108	110

Ill. 4.4: Profle Evaluation

Even though the preferred trajectory was a curve downwards and to the front, the production of this profile was very complex, since the rails for keeping the seat horizontal had the same radius they were changing their position all along the profile, which made them not suitable for a simple extrusion.

It was preferred to have one single piece, meaning one extruded piece, in order to ensure the strength of the structure. If it was produced in two different pieces, these would have to be bent and later welded or glued, which would have led to deformation and a bigger possibility of failure areas.

Besides, having an extruded piece which needs to be bent afterwards means more steps in production and an increase in the cost since it would require specialized machinery and templates. See Appendix 11 for the suggested production steps.

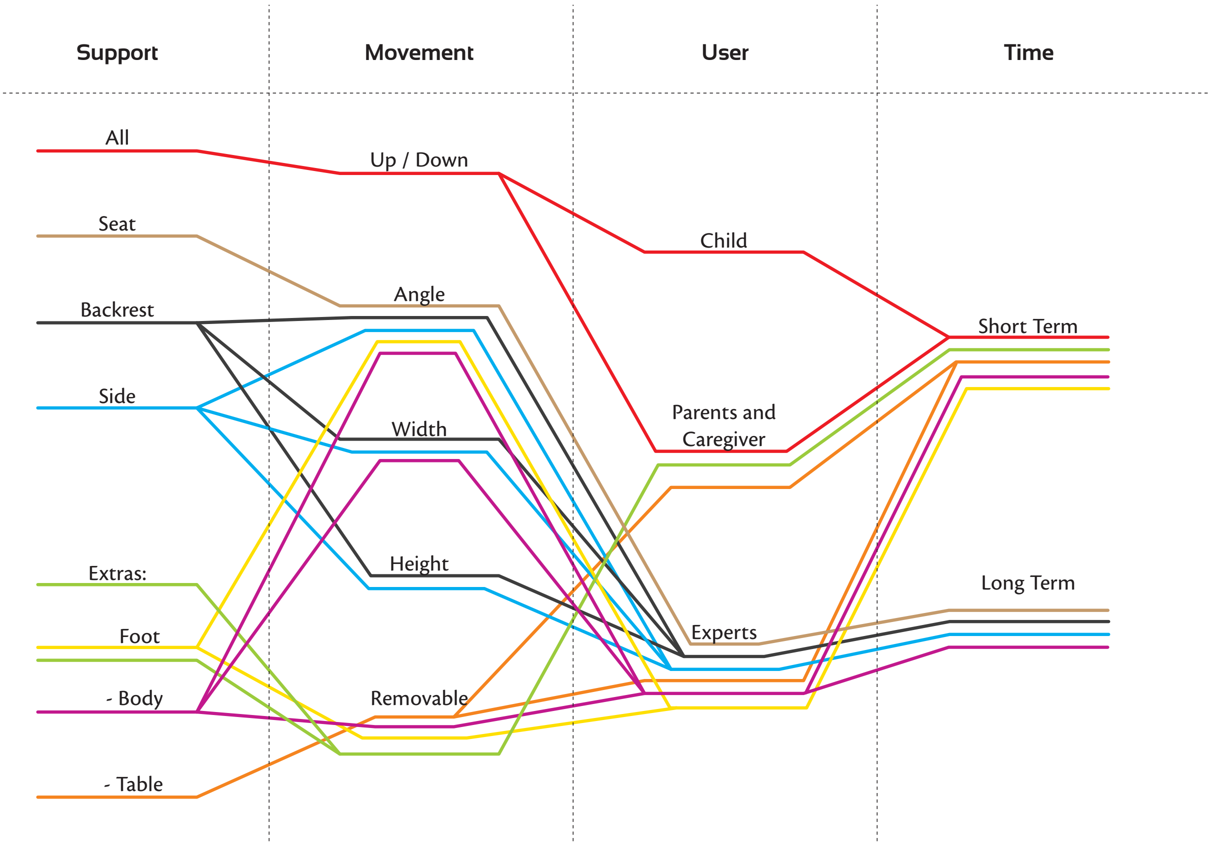
For these reasons it was decided to use a straight profile instead.

Adjustments

The adjustments were categorised according to the frequency of use and the level of expertise required these considerations were also based on the information given by the interviews with experts.

The following step was to define the adjustments for the aid. These were categorised according to the frequency of use and the level of expertise required, these considerations were also based on the information given by the interviews with the physiotherapists.

Ill. 4.5: Adjustments Table



At this point in the process, it was possible to have a quick evaluation on the overall proposal with the help of a physiotherapist who had been interviewed in the research phase of the project. According to the expert, it is to prefer no arm or foot rests on the aid, due to the need and importance of the children to learn the concept of grounding, previously mentioned in this report. These elements can be a part of the accessories to the aid, depending on the level of handicap and the needs of the child and the other users of the aid.

Following these recommendations the arm and foot rests were considered to be secondary and thus not that relevant for this project.

The following is a list of all the available adjustments in this aid:

- angle of the seat
- angle of the backrest
- side support
- moving the seat upwards and downwards

The adjustable angle of the seat gives the expert the possibility to optimise the posture based on the individual needs of the specific child. As described earlier, the saddle seat enables the child to sit in a more upright position by its own force. Even children with great difficulties in sitting without fixation, get a self-containing sitting position in a saddle seat *[App. 4]*.

The backrest and side support was also developed in collaboration with the physiotherapist. The back support is for "reminding" the body to keep positioned correctly by supporting the lumbar area of the back. The side supports is to prevent the child from falling sideways off the saddle seat. Since some of the children have epilepsy as an additional disorder, they need extra support in these cases. The side support is placed at the hip's rotational point, giving the best ergonomic fit for the child.

Height adjustment

For changing the height from the seat to the floor, it was decided to use an electric motor; to give the child as high a level of self-determination as possible. This movement should be controlled by both the child and by the adults. The first proposals were revolving around a joystick placed in the front of the child on the seat.

Ill. 4.6: Joystick models

The front of the seat was elevated to prevent the child's private sphere to be crossed, when e.g. the parent is adjusting the height of the chair. Different suggestions for the configuration of the joystick were tried out, but it was not possible to meet all the different user's needs. E.g. some children with CP have the arms bended, with both hands in front of the torso; they would not be able to reach the joystick on the seat. Furthermore, the elevated front of the seat interferes when the child is leaving or climbing back on the chair.

Therefore the chosen solution was a wireless remote control. The remote could be placed wherever it was possible for the child to operate it from, according to the level of handicap and abilities.

Remote control

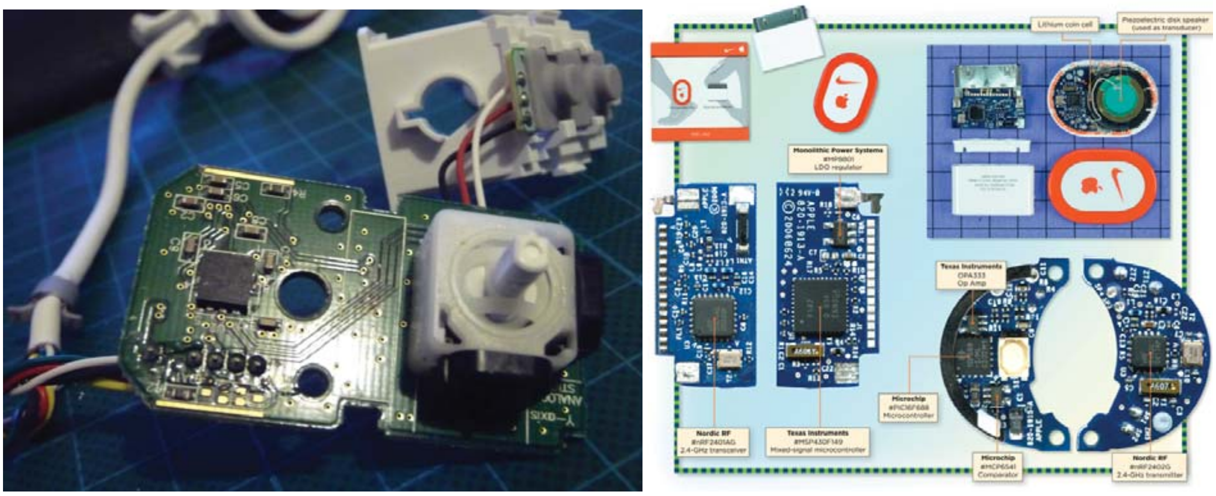
The outline of the remote control is based on following demands, a further development of the remote control will be needed before the final aid can be produced, however the remote control will only be processed on a conceptual level.

Demands for the remote control

- Wireless control
- Synchronise one remote to one aid; only one aid should react to the remote
- Should be possible to control for child, parents and caregivers
- And should therefore be attachable to the seat, the aluminium profile and to the child itself
- Only the adults should be able to elevate the seat higher than the child's standing height
- The child's standing height should be easily configurable
- The semantics of the remote control should clearly state what is up and down, so no mistakes are made when the adults are placing the remote control where the child is using it.
- Easy to change batteries

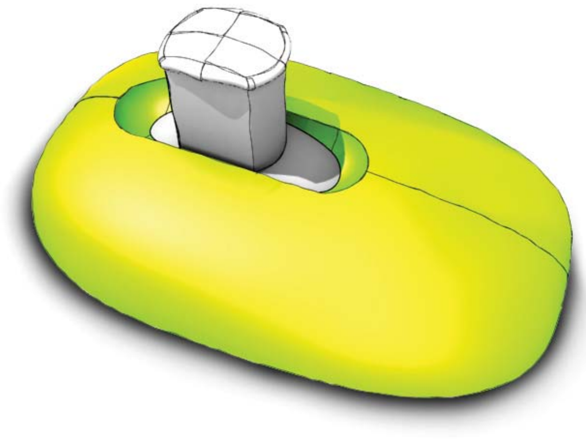
In order to get an overview of the proportions of the remote control, a scan of existing components with related functions was done to estimate the size of the components. The proportions were found by searching for circuit boards and pictures on the internet as well as measuring components with transmitters and antennas, battery and the joystick to control the movement.

Ill. 4.7: Wii Nun-chunck and iPod Nike components

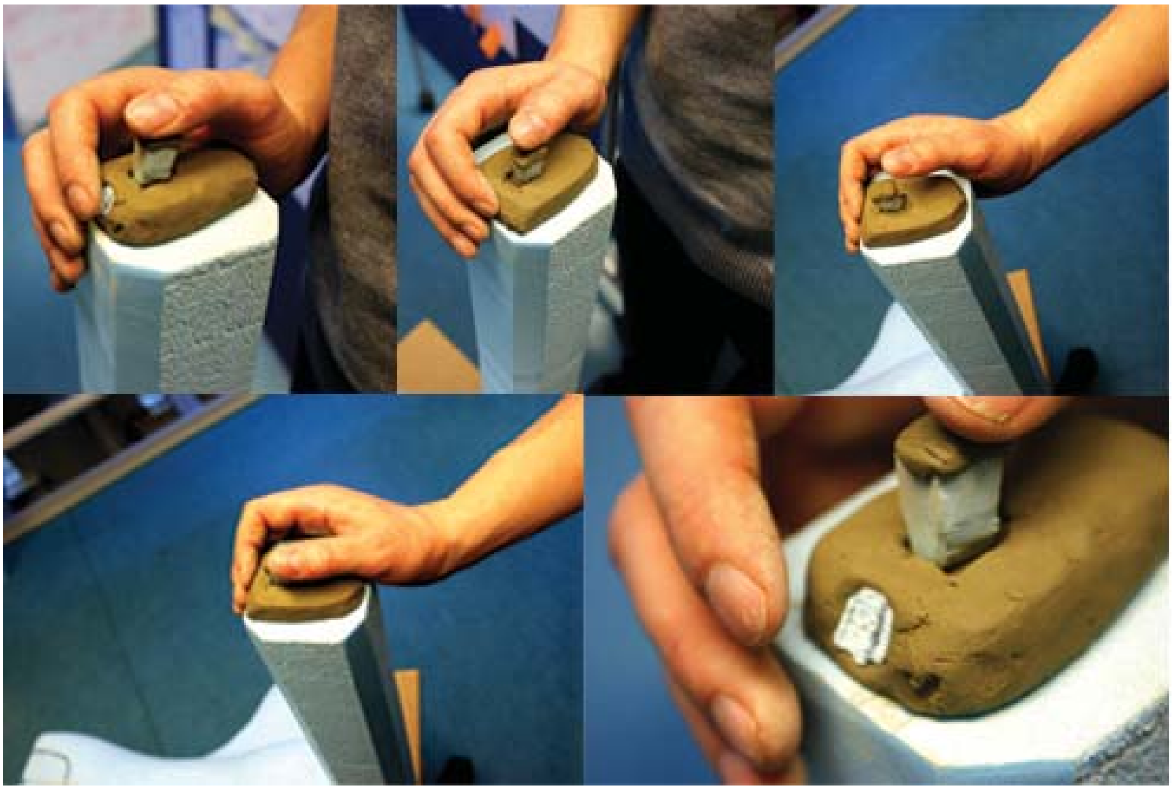


The functionality of the remote control should be very simple; a joystick for up/down movement. A second functionality was a build in safety mechanism to prevent the child to elevate the seat higher than the feet can reach the ground. This feature should only be possible for the parents to operate, so the child only gets lifted from the ground after the footrest is installed.

Ill. 4.8: Remote Control



A quick way to determine the size of the remote was to make different mock-up models in clay and test them according to adult hand-size and the places on the chair where it could be mounted. Preventing the joystick from going missing, the intention is to have it mounted on the chair, either where the child can reach it or within the reach of the adults. The adults' reach-area would be in the top of the profile close to the handlebar. The child's is where ever the specific child is capable of operating the joystick from; being strapped on the thigh or upper body, or mounted on the seat.



Ill. 4.9: Remote Control mounted on profile

Most of the electric wheelchairs have a wired control for driving them. Since these aids are used roughly it is very common that the wires get broken making the wheelchair useless for a time. For this project the possibility of having a wireless control for the up/down movement of the seat was studied.

The solution of the remote control will be solved on a conceptual level, in order to outline the fundamental ideas and functions of this part of the product solution.

The movement should be possible to limit by the parents. It is the parents who will set the maximum and minimum position the child can go. These limits can always be changed by the parents.

The remote will have use a Velcro patch in order to make it possible to be attached anywhere on the child, depending on his skills for controlling it. It works with a joystick moving only on one axis, making it simple for the child to manipulate it.

It also has a small button, which is controlled only by the parents when setting the movement limits.

Handlebars and grips

Considering the interaction and understanding of the adjustments, a quick study was done on the shape of the handlebars and grips. The measurements were based on the book "The Measurement of Man and Woman" ***[Tilley, 2002]***. Afterwards, the possibility of using them as an aesthetic element was considered.

The words "Manga – cartoon", derived from the workshop during the Concept Development phase, were used here again, aiming at making these handlebars and grips more playful and slightly exaggerated in their size and at the same time make it easy for the parents and therapists.

Ill. 4.10: Grip tests

Handlebar

The aid is mainly made for the child to be able to move around on its own, but in some cases the parents or caregivers also need to manoeuvre the aid. For this reason the aid is equipped with a handlebar, which is placed at the top end of the aluminium profile. The criteria for the development was the ergonomics for the adults; it should be comfortable to grip the handle and it should be possible to use it with one or two hands, from behind the aid and from the side, for better contact to the child. The handle should be small in order to emphasise that the handle is a secondary way to move the aid around (compared to the child moving around itself).

Different shapes were tested to find an appropriate shape and size of the handle.

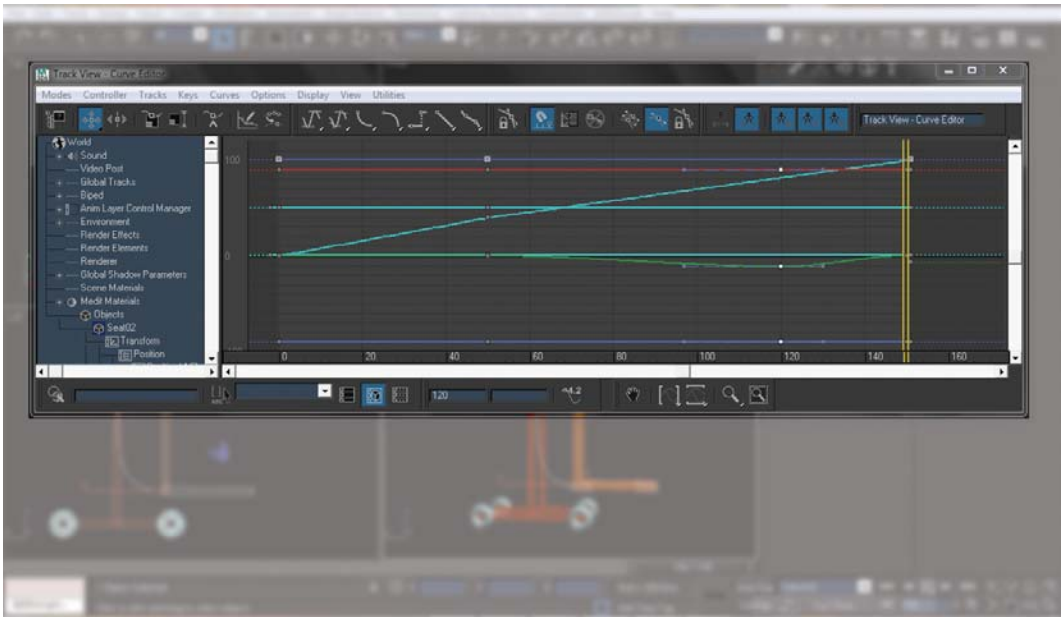
Ill. 4.11: Handlebat tests and final shape

The final shape of the handle leaves enough place for both hands. The flattened midsection of the handle gives a good support for the hand when manoeuvring the aid with one hand. The handle can be angled, so it can be folded down alongside the profile, when it is not used.

Motor and battery

As mentioned earlier, the height adjustment of the seat is powered by a motor, in order to meet the needs of the child. The motor should be able to move the seat from the top position to the lowest position, from 85 cm to 25 cm above ground in 5 seconds. The speed is based on animations made in the concept development phase. To give a smooth movement on the straight profile, which the seat is running on, the acceleration and deceleration was defined in 3D MAX. It was important that the movement was not too slow, leaving the child impatient on the seat, or too fast that it looked dangerous.

It was necessary to calculate a motor needed for the up/down movement. This was done through the following formula *[Variadores de velocidad, 2009]*:



Ill. 4.12: Speed curves test in 3dsmax

Considering a weight of 50 kg from where:

- Child = 45 kg
- Seat mountings = 2 kg
- Seat unit = 3 kg

TOTAL = 50 kg

A maximum distance of 60 cm and a time of 5s

The tension force is calculated by:

$$F = 9.8\frac{m}{s^2} \text{ x } 50\ kg = 490\ Newtons$$

The work is calculated by:

$$W = 490\ N \times 0{,}60\ m = 294\ Joules$$

The power is calculated by:

$$P = \frac{294\ J}{5s^2} = 58{,}8\ Watts$$

Shown in HP:

$$1\ HP = 746\ Watts$$

$$HP = 58{,}8\ Watts \left| \frac{1\ HP}{746\ Watts} \right| = 0{,}07\ HP$$

Battery size

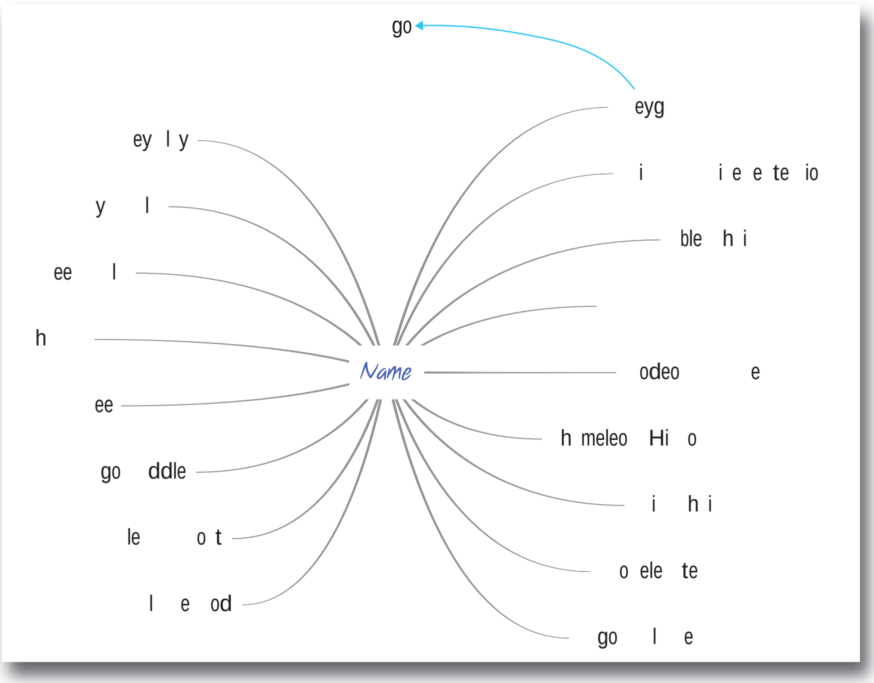
The battery size is estimated to be similar to modern power tools, used by professional handymen. The voltage is high enough to "feed" the motor. The typical battery type is a lithium ion battery, which is getting cheaper and more applicable. Hence, the prices are also falling, and the batteries are therefore more suitable for the low-production aids.

In order to lower the weight of the aid, it is possible to have two batteries with a smaller size each, and a charger. In that way, if the battery runs empty, it can be swapped with the one in the charger. This is also a way to ensure that the aid always have the sufficient power available.

Ill. 4.13: Batteries for drilling machines

Name

A quick brainstorm was done in order to find a name that could express the main idea behind this proposal, the freedom of movement and possibility of giving independence to the child.



Ill. 4.14: Brainstorm for the name

The selected name was Ugo. Taking inspiration on the english pronoun "you" and the verb "to go", intended to sound like an invitation for the child to move on his/her own and to do or explore more things. In this regard, the name is aimed towards the user.

Ill. 4.15: Name for the project

Ugo

Reflection

The main purpose of this phase was to develop the concept to a realisable product. the primary focus was therefore make the movement of the seat in a manner that consider the needs defined in the project.

The profile, where the seat should move along, was subject to time consuming iterations, going back and forth between different solutions. The quality of the solutions were discussed through parameters like the complexity of the production processes, the level of complexity needed to make the motor work through the entire movement and the stability of the final structure. This part of the process demanded much research in order to be able to solve the technical aspects of the different solutions. The final decision was made by a quantitative evaluation of the different solutions. This was a way to make an objective choice, based on the importance of the relevant aspects from the demand specification. It was also a necessary way to make the necessary decisions without clinging on to a favourite solution.

The other parts of the product were processed to a degree where it could support the overall concept of the aid, and others were decided not to be essential for the understanding. Quickly made mock-up models helped determine the shapes of the touch point of the aid. And was a good tool for testing the ergonomics and the proportions' relation to the aid. E.g. the handlebar, placed on the top of the profile was proportioned to fit the hands of an adult and at the same time not be a too dominant part on the aid.

PHASE 5
Product Detailing

This phase describes the detailing of the product. The phase outlines all components and their respective properties. Furthermore, the wheelbase of the aid will be subject to a strength analysis, determining the material type and wall thickness.

Final Proposal

Ill. 5.1: Final Proposal

Once the proposal was defined, the subsequent steps were to further detail aspects such as production, overall functionality and final measurements.

The detailing phase started with the production considerations, being the choice of material and possible processes.

Production

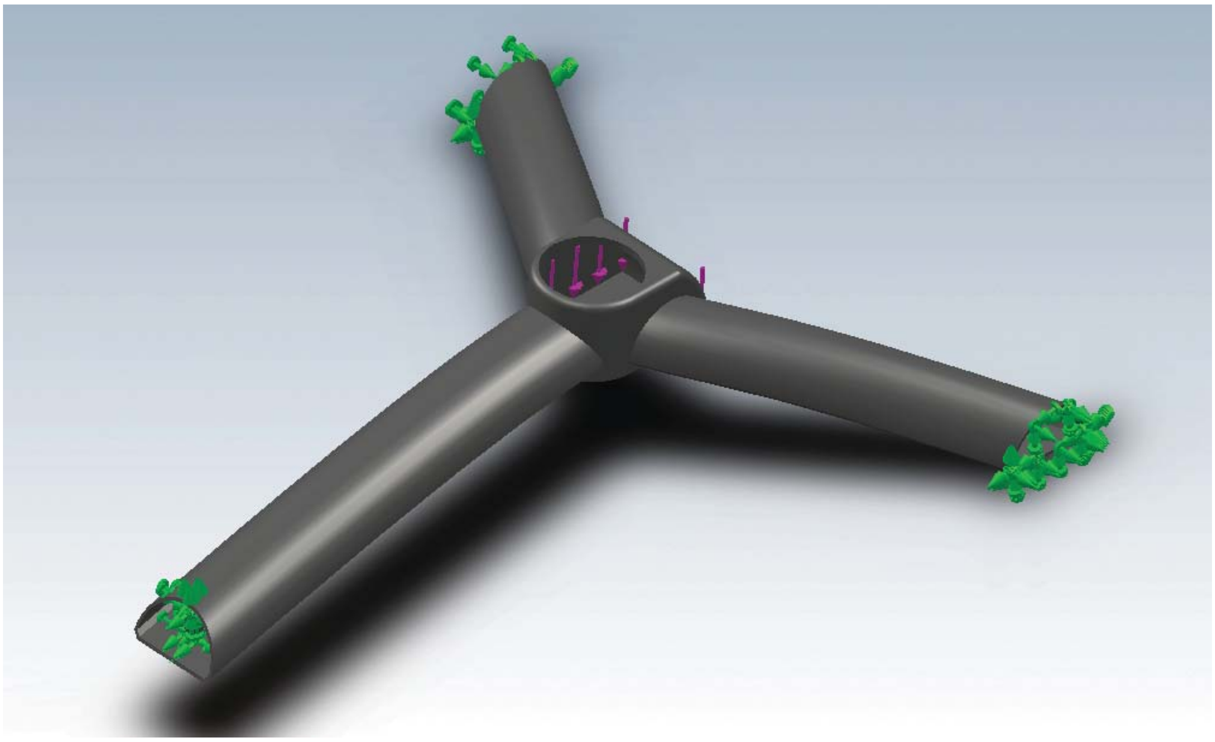
According to the information presented in the research phase, steel and aluminium are the most appropriate materials when the weight is an important issue. Both materials are easy to handle, do not require very specialized skills and the price is not an issue. Aluminium though, offers a lighter weight without compromising strength, and may offer a better appearance as well.

Since this aid is focused in improving the mobility of the child, and considering that it requires a bigger effort for some of them to control their legs, it is important to have an aid as light and strong as possible.

In order to ensure that the aluminium was strong enough, strain, displacement and strength calculations were done to test the material and the structure. The piece selected for study was the wheelbase, since this is the piece under more stresses and with more fixed points.

The main effort comes from the profile; since this is the piece delivering the efforts caused by the child's weight and his/her movements. The wheelbase is only fixed in the wheels, being these important points for efforts. Finally, the wheelbase is made of three pieces which are welded. As mentioned in the research phase, welding may be a point for possible failures; therefore they needed to be tested.

Ill. 5.2: Efforts applied to the Wheelbase



The calculations were done with the following considerations:

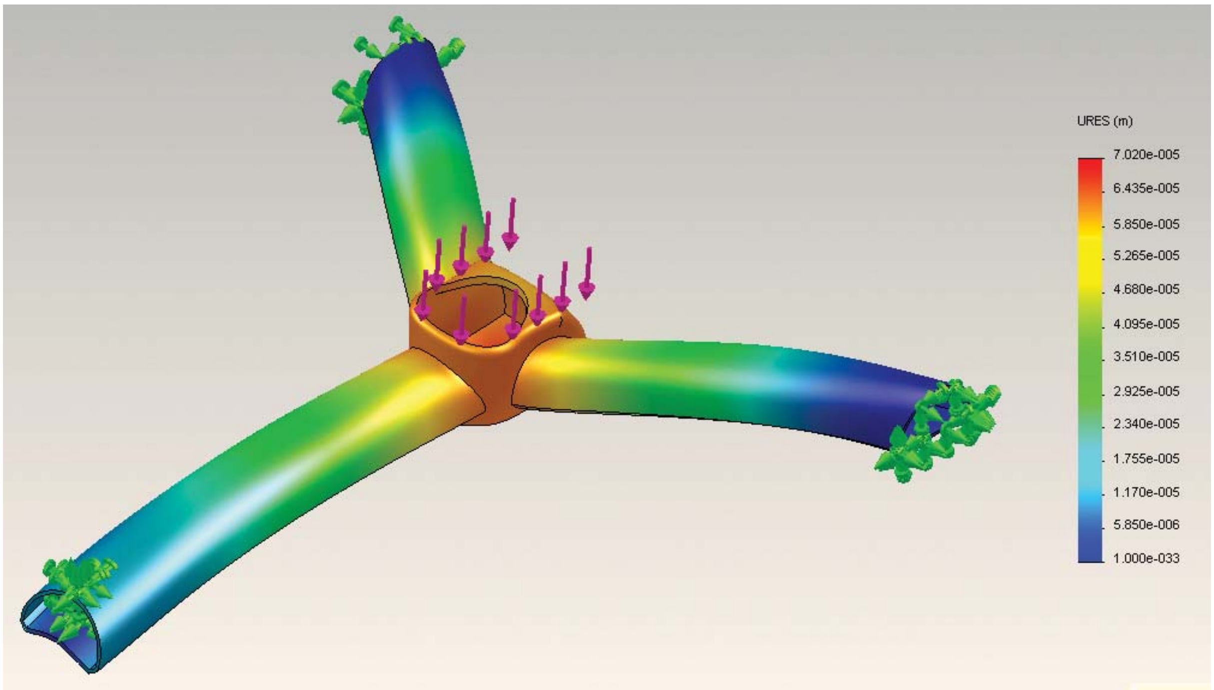
- Weight: 60 kg (10 kg more than the heaviest 12 years old child, including seat weight)
- Material tested: Aluminium 7020

Displacement

Displacement is the result of a change in the configuration of a continuum body. The displacement of a body has two components: a rigid-body displacement and a deformation. A rigid-body displacement consists of a simultaneous translation and rotation of the body without changing its shape or size. Deformation implies the change in shape and/or size of the body from an initial or undeformed configuration to a current or deformed configuration.

If after a displacement of the continuum there is a relative displacement between particles, a deformation has occurred. On the other hand, if after displacement of the continuum the relative displacement between particles in the current configuration is zero i.e. the distance between particles remains unchanged, then there is no deformation and a rigid-body displacement is said to have occurred ***[Wikipedia, 2009]***.

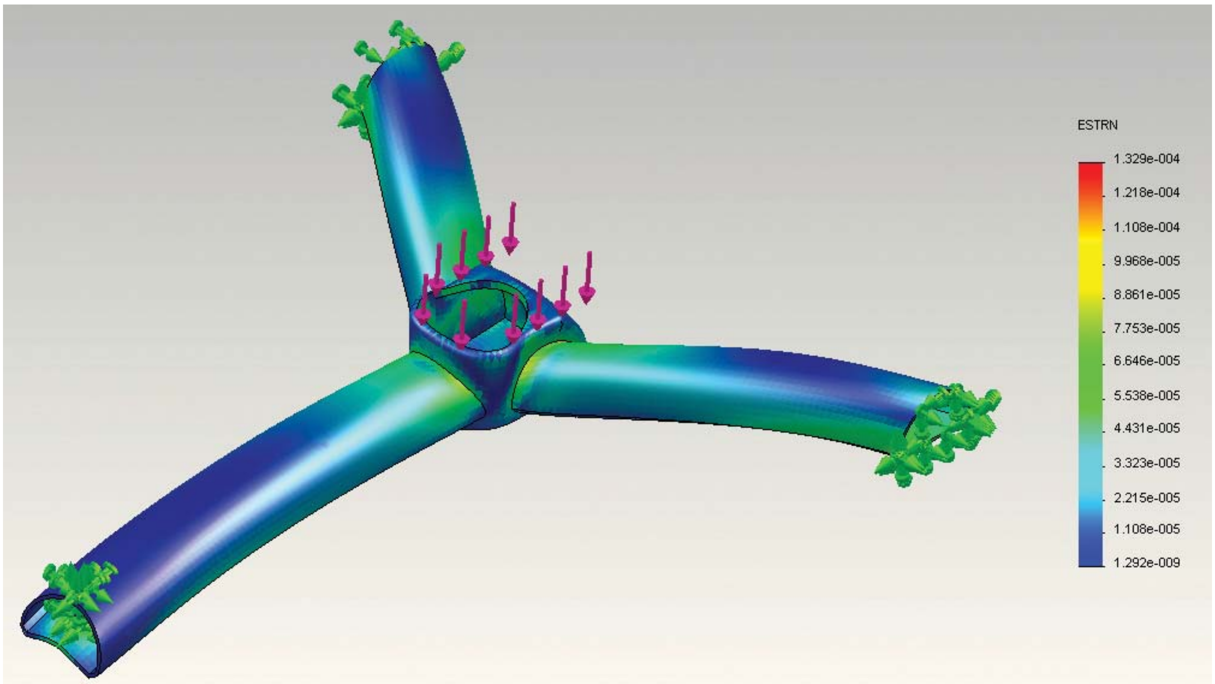
Ill. 5.3: Displacement Calculation



Strain

Strain is the geometrical measure of deformation representing the relative displacement between particles in the material body. It measures how much a given displacement differs locally from a rigid-body displacement. Strain defines the amount of stretch or compression along a material line elements or fibres -normal strain- and the amount of distortion associated with the sliding of plane layers over each other -shear strain- within a deforming body. Strain is a dimensionless quantity, which can be expressed as a decimal fraction, a percentage or in parts-per notation. This could be applied by elongation, shortening, or volume changes, or angular distortion *[Wikipedia, 2009]*.

Ill. 5.4: Strain Calculation

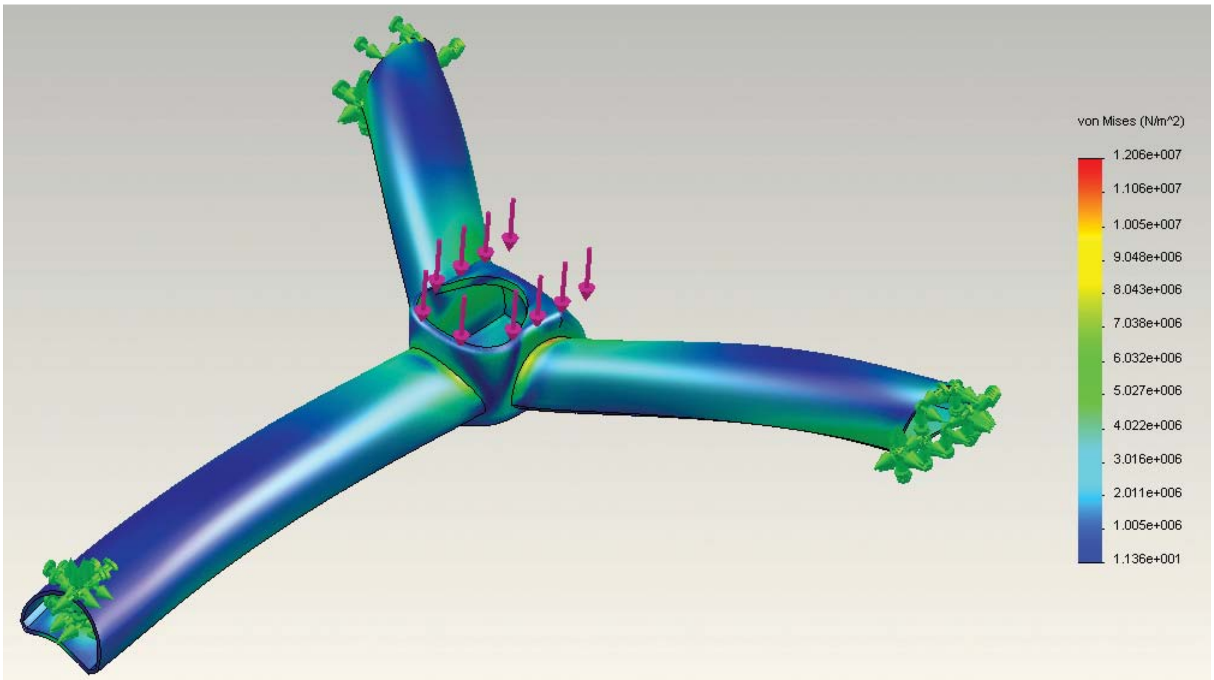


As expected, the stress test shows that most affected area of the wheelbase is the centre, where the profile is received. As the figure shows, the strength of the material is enough to withstand the forces applied.

Consequently, the deformation of the wheelbase is insignificant, implying the choice of material and shapes to be strong enough to withstand the movements and weight of the child.

Therefore it is possible to make this structure in Aluminium 7020.

Ill. 5.5: Stress Calculation



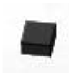
One of the main considerations for defining the shape of the pieces was to avoid welding as much as possible, these areas may become a failure point later. This also affected the material chosen as well as their assembly.

Ill. 5.6 shows the pieces of the final proposal, followed by illustrations on their assembly, while the ensuing table shows the material chosen for each part. These choices were based on the information gathered in the research phase regarding the materials as well as considering the facilities and demands from the company concerning production. Other materials, regarding plastics for instance, are qualified guesses based on the project group's own experience as well as on materials being used for other aids, such as wheelchairs or rollators.

Ill. 5.6: Pieces of the aid

Item	Pieces		Parts	Material	Process
1	1		**Profile Tap**	Polypropilene	Injection moulding
2	1		**Seat unit joint**	Aluminium (6 mm plate)	Laser Cutting Bending Welding Anodized
3	1		**Backrest support**	Aluminium (6mm plate)	Laser Cutting Anodized
4	1		**Backrest**	Fibre - reinforced plastic	Injection moulding
5	1		**Backrest foam**	Polyurethane foam Cotton Fabric cover	Cutting Sewing
6	1		**Seat foam**	Polyurethane foam	Cutting Sewing
7	1		**Seat**	Fibre - reinforced plastic	Injection moulding
8	2		**Side support**	Polyurethane foam	Cutting Sewing
9	2		**Back wheels**	Commercial Parts	
10	1		**Motor**	Commercial Part	

Ill. 5.7: Table of pieces

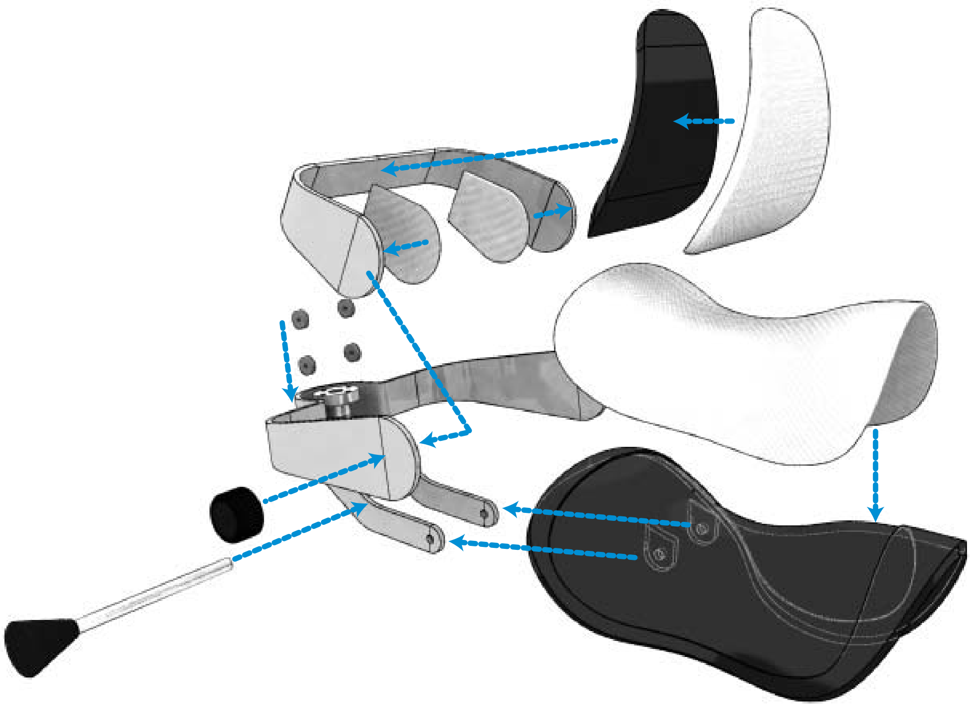
Item	Pieces		Parts	Material	Process
11	1		**Wheelbase**	Aluminium (6mm plate, for central box) (2.4 mm sheet, for profile)	Laser Cutting Bending Welding Anodized
12	1		**Front wheel**	Commercial Part	
13	1		**Battery**	Commercial Part	
14	1		**Bolt**	Commercial Part	
15	1		**Profile**	Aluminium (2.4 mm wall thickness)	Extruded Anodized
16	1		**Angle-seat grip**	Commercial Part	Injection moulding
17	1		**Angle-backrest grip**	Commercial Part	Injection moulding
18	4		**Stabilizing wheels**	Commercial Part	
19	1		**Handlebar**	Polypropylene	Injection moulding

Ill. 5.8: Table of pieces

Assembly

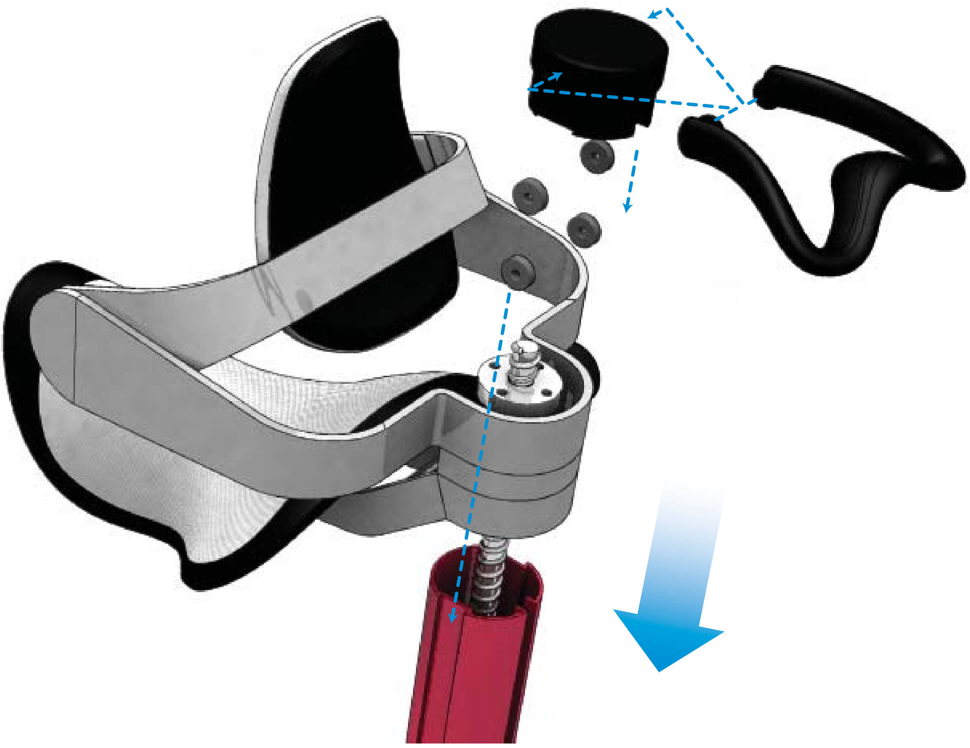
The following illustrations show the general assembly of the Ugo, starting with the seat unit, the lower part of the aid and ending in the connection of both parts.

Ill. 5.9: Seat unit assembly



Ill. 5.10: Lower part assembly

Ill. 5.11: Final assembly



Functionality

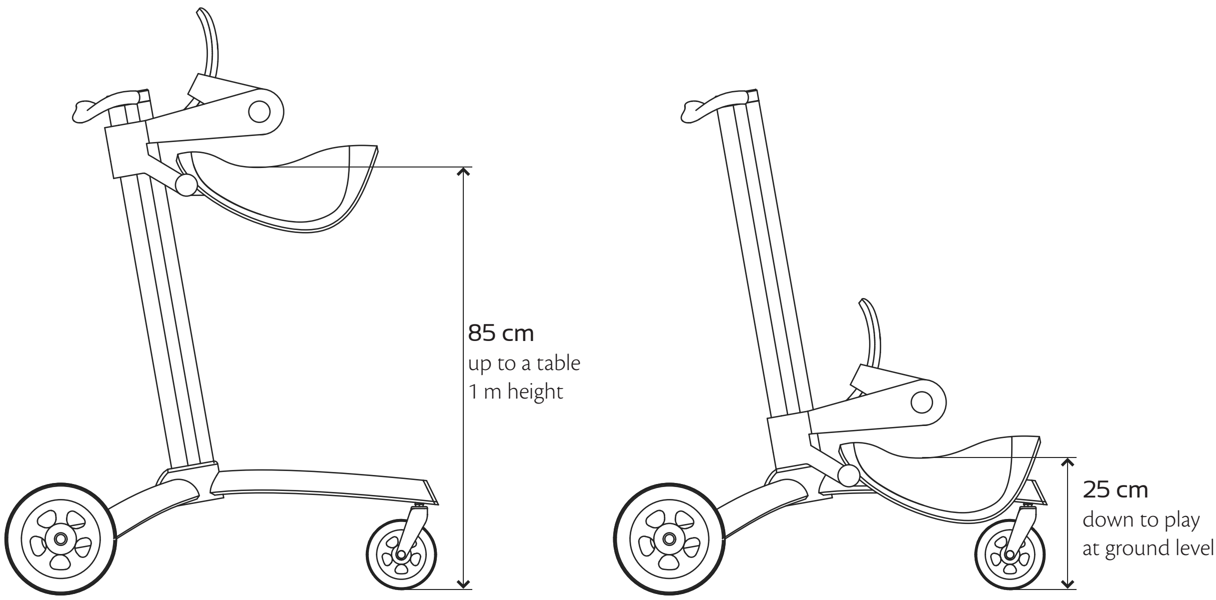
The main purpose of the Ugo is to provide the child with more mobility, either being of help when walking, playing or when a change of height is required.

Illustration 5.12 shows the maximum and minimum heights reached by the Ugo.

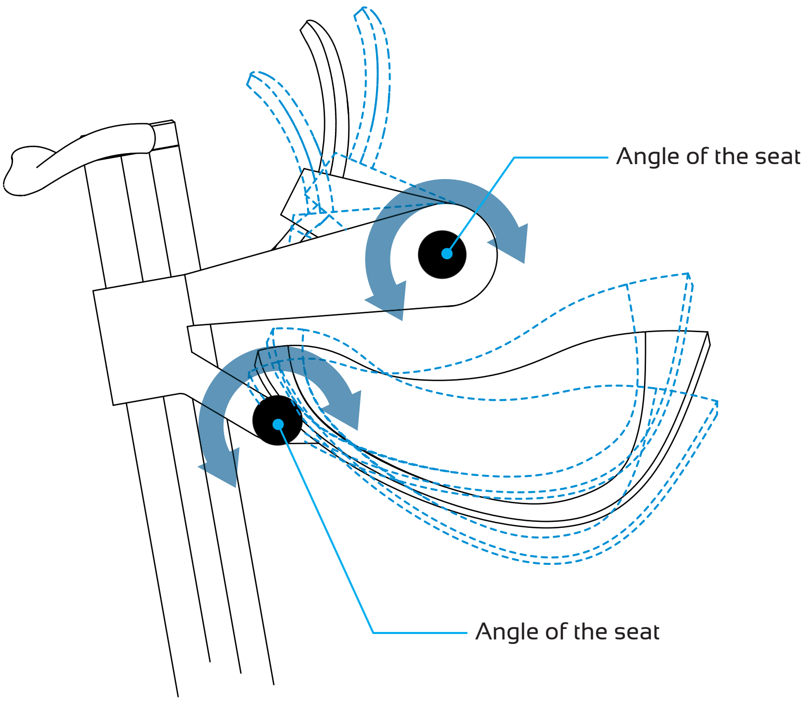
The adjustments were only detailed to explain the mobility and their place on the aid, as well as the shape and sizes. No mechanism was further detailed in this regard.

The adjustments and their function are shown in the illustration 5.13.

Ill. 5.12: Maximum and minimum heights



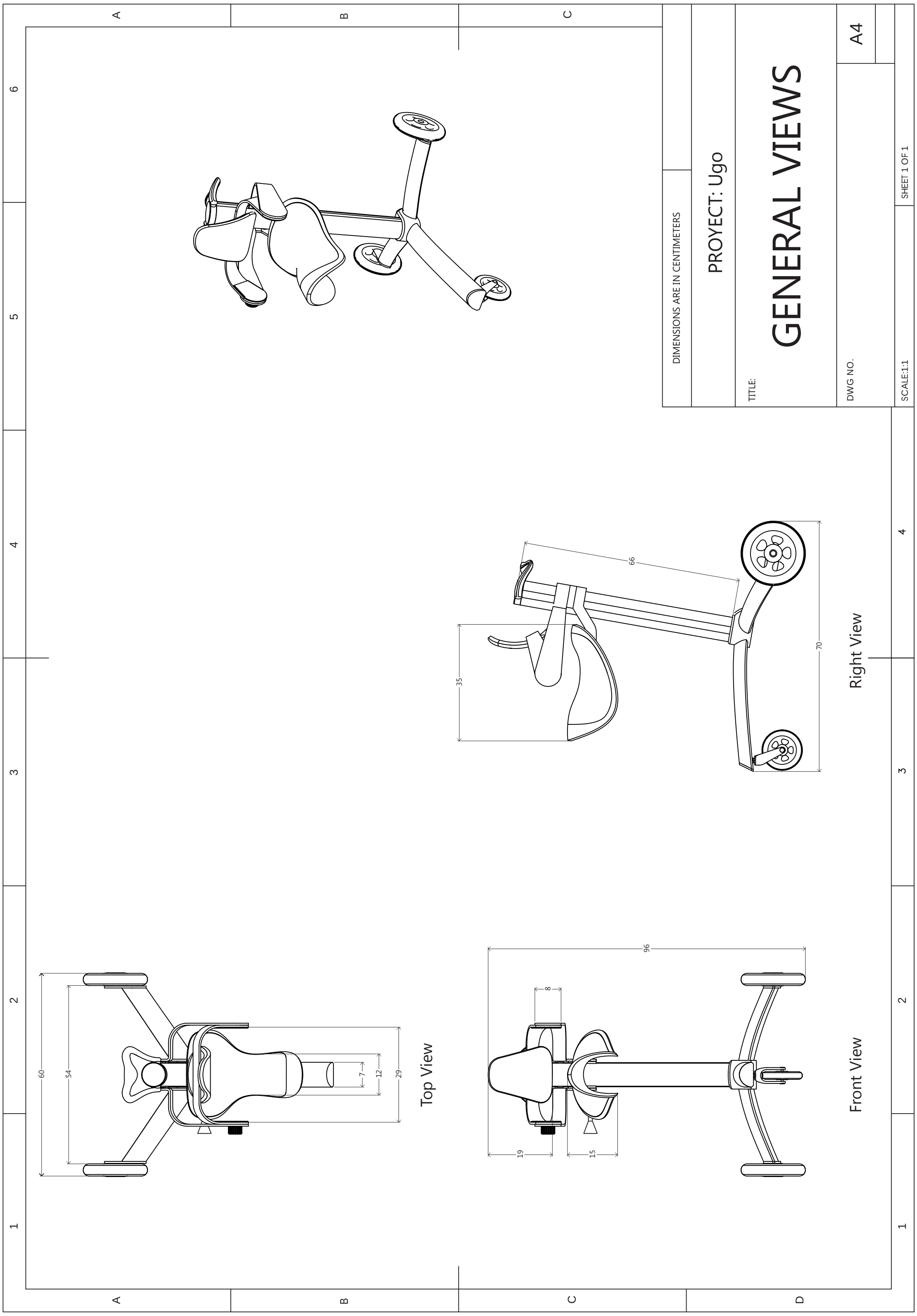
Ill. 5.13: Angle adjustments

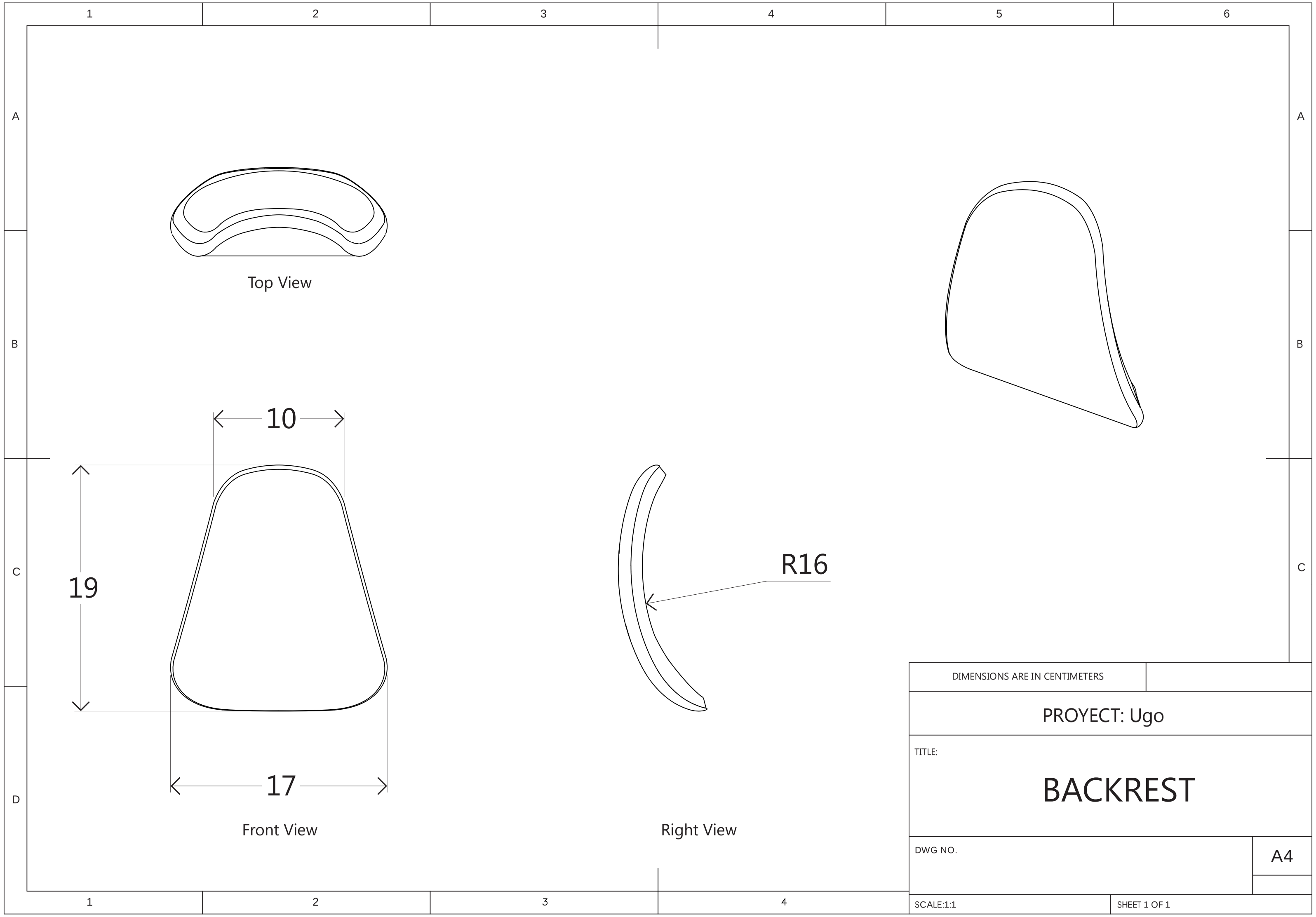


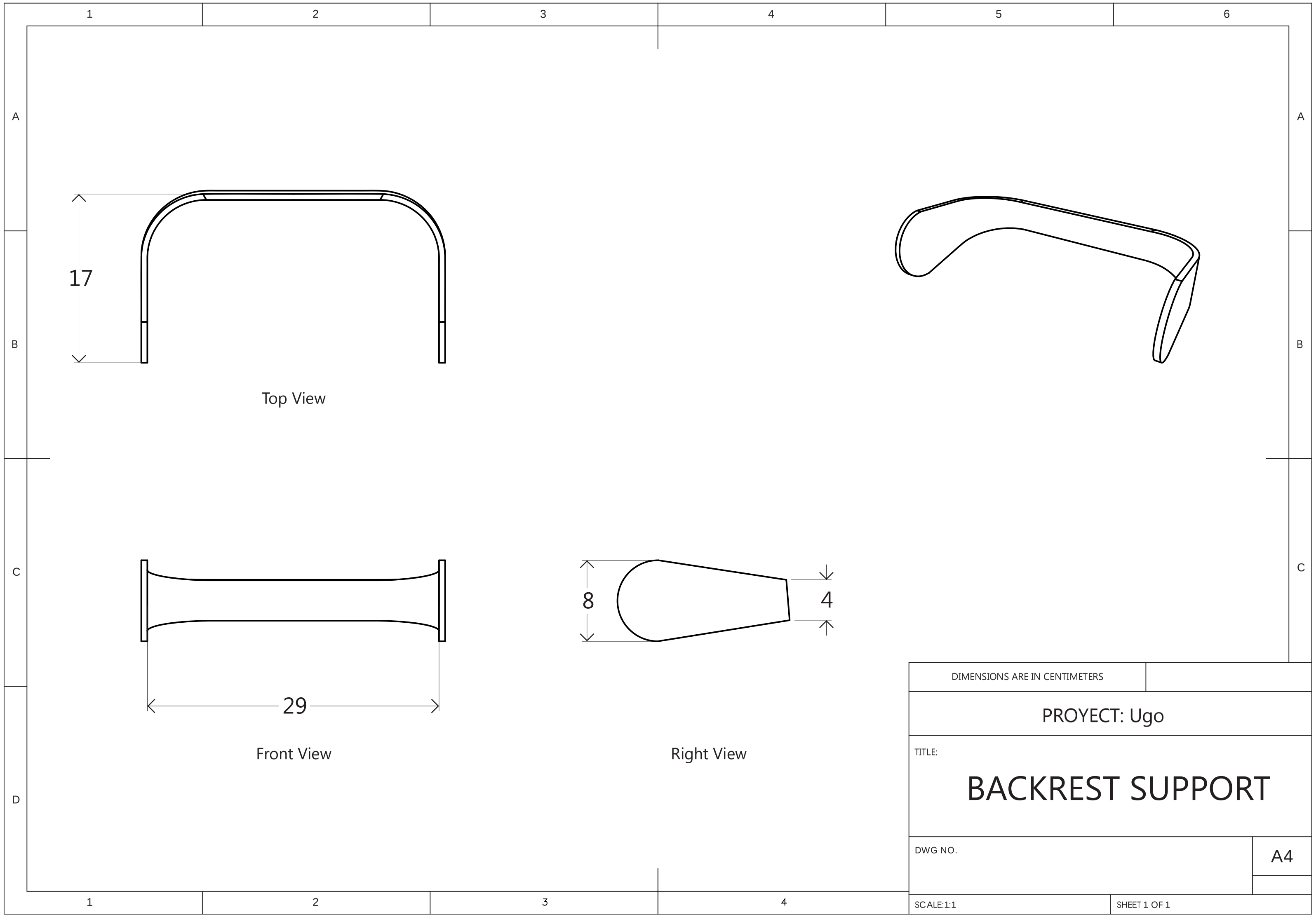
Technical Drawings

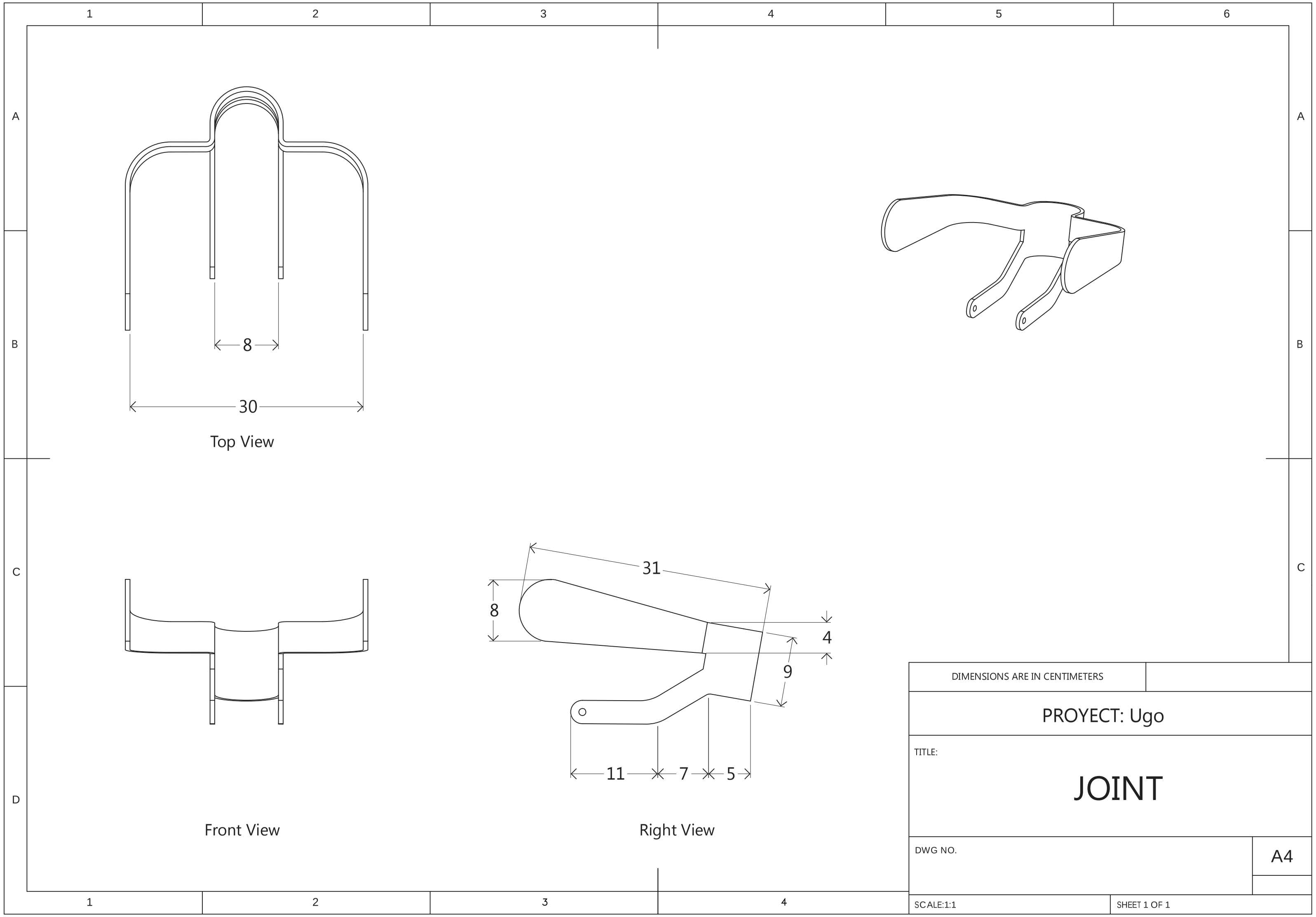
Since children between 6 and 12 years old are still growing at a considerable speed, the range of sizes of the children becomes very broad. Therefore it was decided to make two different sets of seat units –seat, backrest and side supports-, one that can be used by children from 6 - 9 years old and a second one for children from 9 – 12 years old. This division of ages comes from the children having slightly more common sizes in these two groups.

The following are the general measurements for the aid.

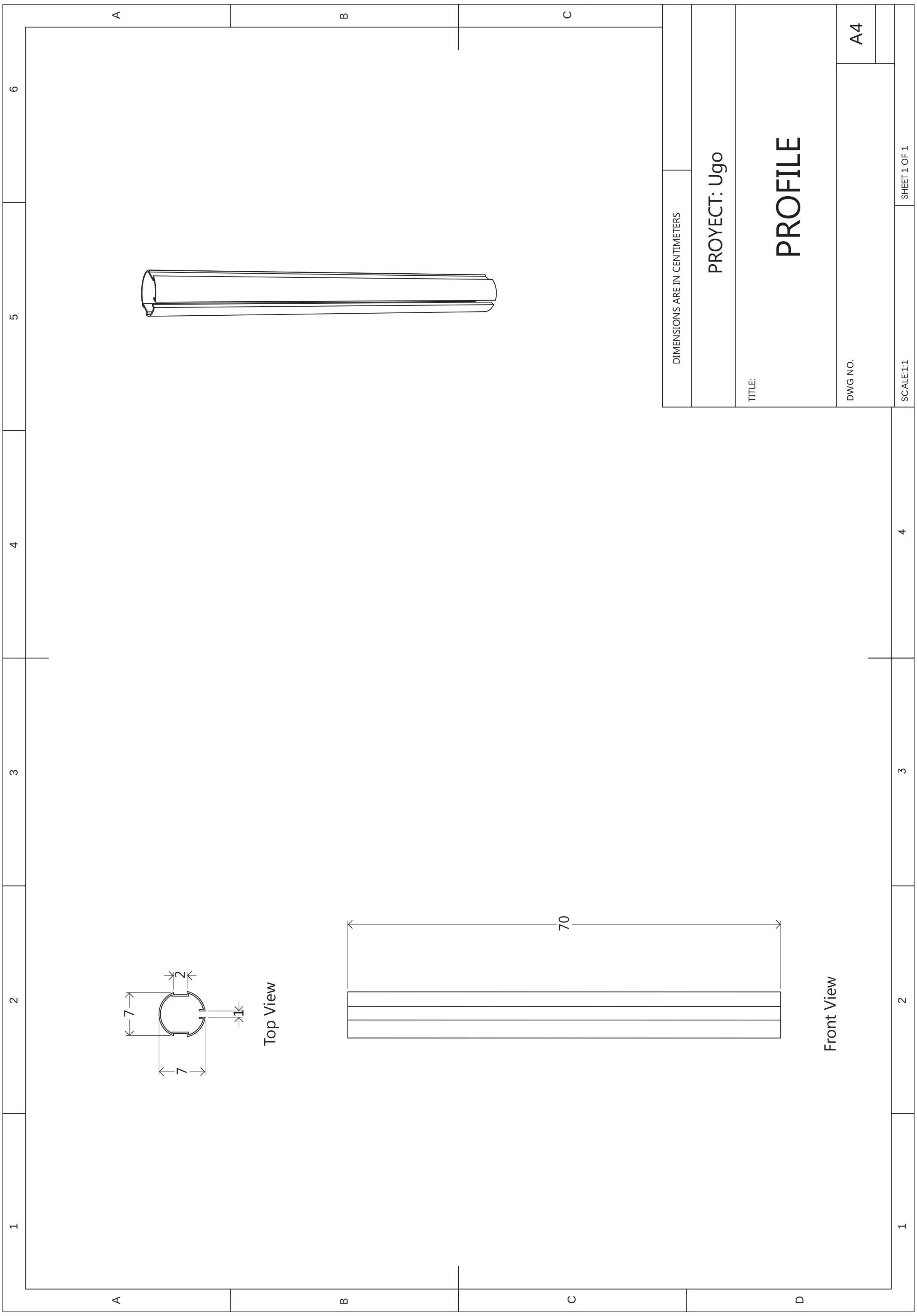

DIMENSIONS ARE IN CENTIMETERS
PROYECT: Ugo
TITLE:
GENERAL VIEWS
DWG NO.
A4
SCALE:1:1
SHEET 1 OF 1
Top View
Front View
Right View
66
35
70
96
8
19
15
60
54
7
12
29
A
B
C
D
1
2
3
4
5
6

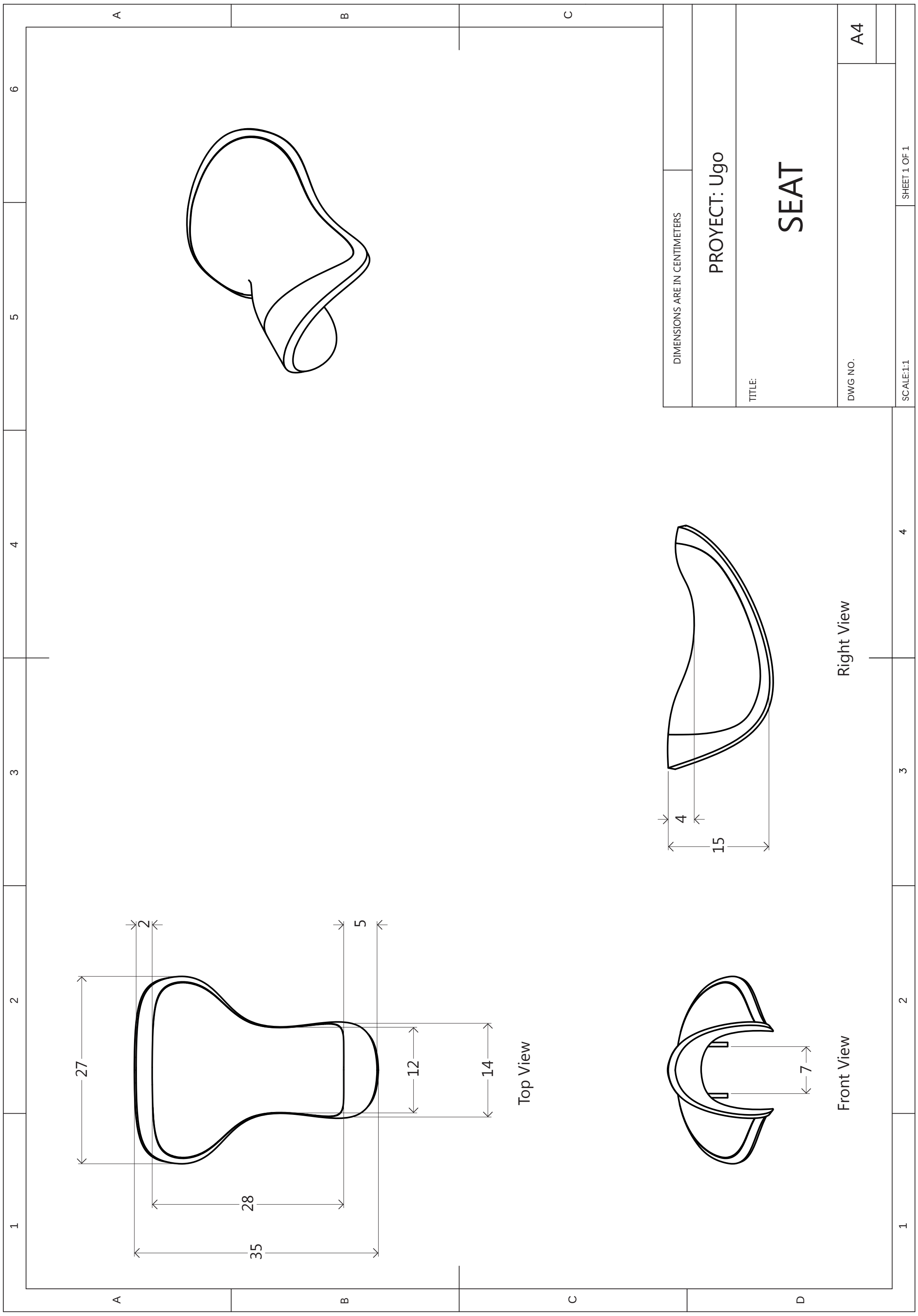

Top View
10
19
17
Front View
R16
Right View
DIMENSIONS ARE IN CENTIMETERS
PROYECT: Ugo
TITLE:
BACKREST
DWG NO.
A4
SCALE:1:1
SHEET 1 OF 1

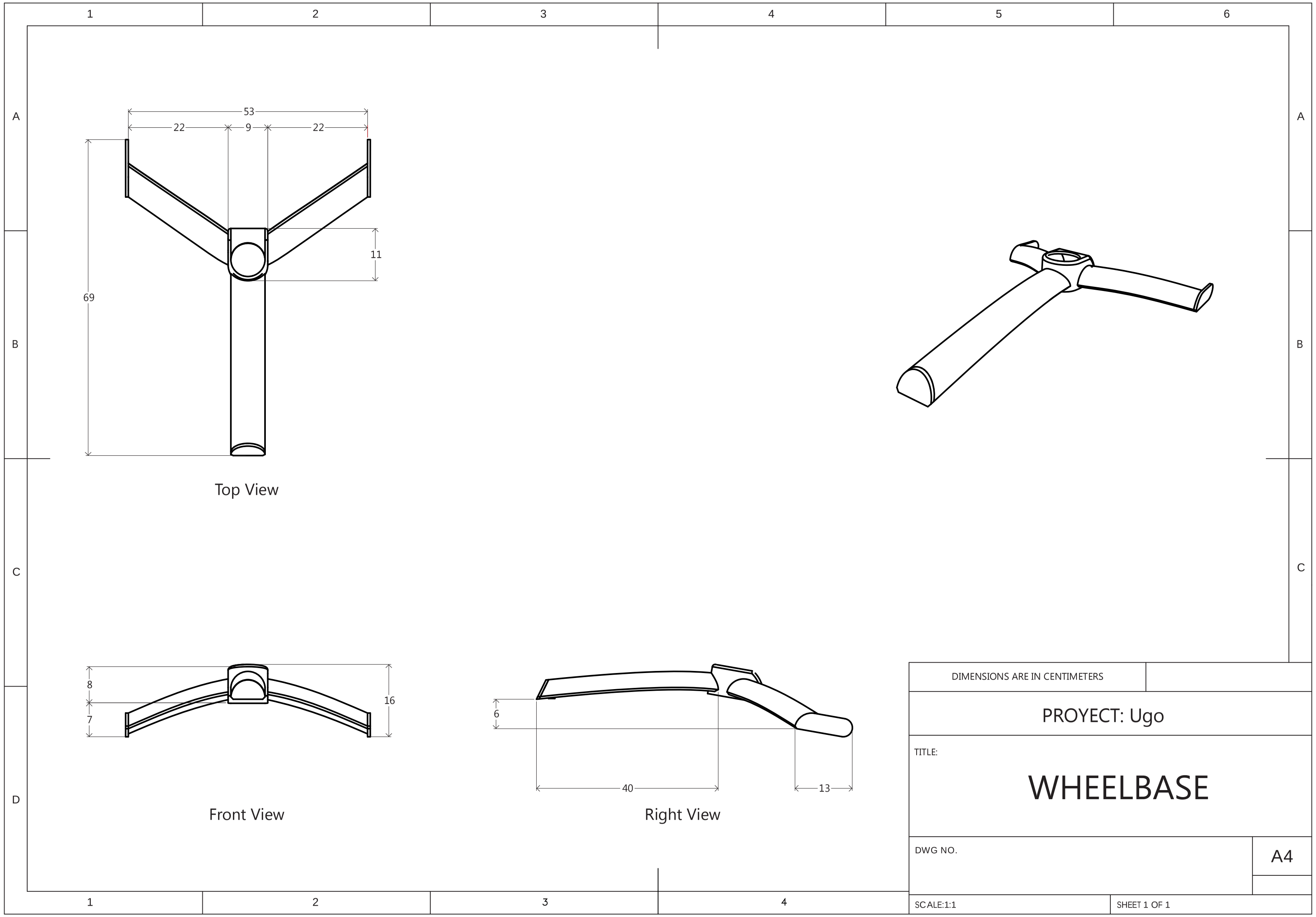

17
Top View
29
Front View
8
4
Right View
DIMENSIONS ARE IN CENTIMETERS
PROYECT: Ugo
TITLE:
BACKREST SUPPORT
DWG NO.
A4
SCALE:1:1
SHEET 1 OF 1



8
30
Top View
Front View
31
8
4
9
11
7
5
Right View
DIMENSIONS ARE IN CENTIMETERS
PROYECT: Ugo
TITLE:
JOINT
DWG NO.
A4
SCALE:1:1
SHEET 1 OF 1


DIMENSIONS ARE IN CENTIMETERS
PROYECT: Ugo
TITLE:
PROFILE
DWG NO.
A4
SCALE:1:1
SHEET 1 OF 1
Top View
Front View
70
7
7
2
1


DIMENSIONS ARE IN CENTIMETERS
PROYECT: Ugo
TITLE:
SEAT
DWG NO.
A4
SCALE:1:1
SHEET 1 OF 1
Top View
27
2
5
28
35
12
14
Right View
4
15
Front View
7



Top View
Front View
Right View
53
22
9
22
11
69
8
7
16
6
40
13
DIMENSIONS ARE IN CENTIMETERS
PROYECT: Ugo
TITLE:
WHEELBASE
DWG NO.
A4
SCALE:1:1
SHEET 1 OF 1

Reflection

In the product development phase it was necessary to prioritise which areas to focus on. It was a difficult process, since many of the areas were started before realising their extent, and some of them were later discarded due to lack of time.

Because of the company looking to outsource the production, it was not completely possible to make a price calculation. The outsourcing of the production makes it very complicated to calculate the production cost. Hence, the level of detailing of the production was limited to developing parts that are suited for low-unit production, without compromising the quality and simplicity of the product.

Another area which was not completely calculated was the stability of the aid. This fact was very much left to meeting the measurements set by the Danish Standard, which led to assume that the stability was not a big issue since all the measurements are within the limits and therefore maintaining already defined safe proportions.

DISCUSSION

This is the discussion of the process and the project solution. The first part is an overall reflection and discussion of the most relevant subjects concerning the entire process. This is followed by a general discussion and reflection of the final product.

Process

Finding the relevant focus

The initial goal of the project was to develop a product, then detailing it to a level where the solution was ready for the first prototype. During the initial research however, it became evident that the project group needed to make a decision; to either follow the predetermined goal or to adjust the objective in order to better meet the user needs instead. The results from the user research suggested that a possibility to develop an aid that was not already defined in an existing product category, could offer the users new possibilities. This was beneficial for both the users and the company. Ultimately, the choice was between changing the goal or end up with a product with a weaker argumentation. The still undefined concept needed a broader research foundation, because it was not settled within a specific product category. Because of this, the research phase and the following concept generation phase was prolonged, which meant less time to mature the product.

The decision about aiming for a new product type was made quite early in the process, however the discussion about how "new" it should be was continuing during the research phase. As a means to determine the innovation level of the product solution, aspects such as production, market and technology were used as criteria for evaluation.

The first part consumed a large amount of time; finding an area to work with. Especially to think outside the conventional way of thinking handicap aids. But it was decided that it was more important to have a sound concept rather than a detailed product.

Unknown context

One of the starting points for the project was to show the ability to work with an unknown context and its users. The topic handicapped children turned out to be a very interesting and highly motivating frame for the project. Surprisingly, the user group was quite difficult to get in directly contact with. Even though they (parents and caregivers) seemed interested and open minded towards the idea of the project, they were fairly cautious about agreeing on meetings, and were understandably protective anout the children's well being. Most of the contacts were made through the collaborating company, which turned out to be a slow process as information and agreements had to go through an intermediary. If the contacts had been established first hand, it might have been more fruitful, with a potentially broader representation of both institutions and user families.

The fact that the context was unknown forced the project group to have a completely open-minded approach to the project and the solution space. This meant that it was not possible to make any prejudiced decisions. The subject Cerebral Palsy is extremely complex for outsiders, requiring a lot of research before it was possible to make any sound decisions. The process of retrieving the information took a long time and many resources. If there had been a closer contact to the user group this part of the process could have been shorter and more focused.

Working with a company

The company Meyland-Smith was an important factor in the decision making during the process. The project was aiming to develop a product that was suited for Meyland-Smith. Even though the contact to the company was limited to three meetings and some phone conversations it was a good guiding tool for finding the best arguments in the process. The company's approach was very different from the users, which gave other limits for the product development. This information along with the contact to the users and the supervisor meetings was crucial in order to get well argued discussions on the possible ways to go with the project, which can be hard to get in a group, counting two members.

The visits to the institutions were a good way to get a generic understanding of the users. Because they deal with many children, each with their own personal needs, they have a more general approach to the needs compared to the families, who are specialists in their own child's specific needs. But because of the complexity of the context, it would have been preferred to have a broader spectrum of users to build the knowledge upon.

Product

One of the particular areas the product solves is the social and mental aspects of the user's needs. The ability to move around freely, to act on its own and to make mistakes and learn from it is crucial for the development of the children, according to the research. The question is then if the diversity of the childrens abilities, and therefore their needs, are too big, that only a small part of the users will be able to exploit the aid's potential. A way to give children with a higher level of handicap the possibility to use the aid is with extra added physical supports.

Testing the product

Before the product can be produced it needs to be verified that the product is functioning as intended. Because of the great diversity within the user group, it is important to test the aid with many different children in order to get a realistic picture of the product's usability.

The technical aspects have been evaluated in order to meet both the users and the company's wishes. After the definition of the users needs the primary driver for the material selection and definition of the motor and battery were the company's needs and possibilities. All parts and materials have caused many considerations, where the main concerns were revolving quantity and quality. In the handicap sector, and especially the area for CP, the sales figures are very low, even on a global scale. Secondly, the products are used more roughly than products for normal consumers and need to be solid build. Thirdly, one of the project's goals was to develop a product with amore simple appearance in order to bring more attention to the child, not to the aid. To get to a point where low cost price, high strength and simple visual appearance was integrated in the aid, many iterations were made and demands and wishes was adjusted in order to get all three parameters integrated. The product was simplified throughout the final phases of the process, simplifying both the shape and the production steps. Technologies used were likewise considered and rejected or simplified.

Different product types

The product developed in this project is likely to be an indoor product, because of the width. If it should be stable enough to be an outside product it would be too wide to easily go through doors inside.

The span of the children's age, from 6 to 12 years, is sufficiently large that two different sizes of seats might be needed. This would be a consideration when optimising the ergonomics of the seat.

Product price

The cost price of course needs to be calculated. The aid is made primarily of aluminium, which has a low market price. But the expenses of the processing vary from manufacturer to manufacturer. Whether it is a Danish or a Chinese company, or if the company's production facility is new or old, all influence the final cost. Therefore, considerations regarding the cost price in this project have been focused on considering materials and manufactoring processes and comparing number of parts, start-up and tooling price in order to find a "setup" suited for the company's needs and wishes.

Detailing of product parts

As mentioned earlier, the initial offset of the project was changed after the meetings with the users. This shift in focus led to a bigger research phase than initially anticipated, and also meant that the concept development was prioritised over the detailing and maturation of the product. Therefore, several parts of the product need to be further detailed before the first prototype can be produced.

- The remote control, including the semantics to reduce faulty use and the technical parts such as the wireless components and battery size and capacity.
- The seat, including selecting suitable fabrics and upholstery and optimise the ergonomic sitting quality of the shape of the seat in collaboration with ergo- and physiotherapists.
- Engine and battery should be calculated more exact to ensure the reliability of the product.

APPENDIX

Appendix 1:
"Sitting Position and Function Skills" Project Partners

Meyland-Smith A/S
Producer of manual wheelchairs and other products for disabled children, including children with CP.

RMB A/S
Producer of office chairs. The company is currently moving the production from Jutland to Sweden.

Scaniro A/S
Subsupplier in metal products. Focus on optimising the production through automated machinery.

Scaniro's management have close relations to RMB.

Aalborg University
AAU is managing the research of the technology, which the project is revolving around. Different departments are involved in the project such as ime, hst and the CHAT

Department of Mechanical Engineering (ime)
Department of Health science and Technology (hst)
Centre for human appliances and technology (chat) (anybody Project)

University College Nordjylland
Is providing expert knowledge within the area of spasticity; several ergo therapists are attached to the project.

Appendix 2:
"Sitting Position and Function Skills" Project Experiment

Appendix 3:
Project task from Meyland-Smith

Konceptbeskrivelse – Børnekørestol

Målgruppe:

Målgruppen for en børnekørestol er:

Børn med Cerebral Parese (spasticitet eller slaphed). Disse børn har, naturligvis afhængigt af skadens omfang, store problemer med at kontrollere deres lemmer på grund af spastisk muskelaktivitet, dvs. albuer, hofter og knæled bøjes sammen og håndled og fodled strækkes ufrivilligt.
Afhængigt af hvor hårdt barnet er ramt, kan disse ufrivillige muskelsammentrækninger ramme en arm eller et ben, alene overkroppen, kun højre eller venstre side af kroppen eller hele kroppen. Denne muskelaktivitet er et symptom på en hjerneskade, og der er oprindeligt ingen skade på muskler eller lemmer. De voldsomme spasmer vil dog, hvis de ikke lindres og behandles, på sigt give børnene problemer med muskler og sener.

Børn med psyko-motoriske dysfunktioner, som følge af medfødte eller erhvervede hjerneskader. Denne definition er meget bred og dækker over en forskelligartet gruppe børn, men generelt har de svækket motorisk kontrol i varierende grad.

Premature børn, som er forsinkede i deres udvikling og som derfor ikke har den samme grad af motorisk kontrol som deres 'jævnaldrende'. Dette er naturligvis ikke en lidelse, men blot børn som fra starten udvikler sig med nedsat hastighed og disse børn vil med tiden indhente deres jævnaldrende.

Børn med muskelsvind-lidelser. Muskelsvind er en fællesbetegnelse for en række sygdomme som påvirker samspillet mellem nerver og muskler. Kendetegnende er, at muskelkraften gradvist forsvinder fra de enkelte muskler eller muskelgrupper og disse børn og unge mister derfor gradvist evnen til at holde deres krop oppe mod tyngden. Børn, som lider af muskelsvind, har brug for den ekstra støtte og hjælp samt de udstrakte indstillingsmuligheder for at modvirke de følger som sygdommen kan have fx skævhed i ryg og brystkasse (skoliose).

Fælles for alle disse børn er, at de er motorisk handicappede og har brug for en høj grad af hjælp og støtte. Aldersmæssigt er der ideelt set tale om børn fra ½ til 18 år.

Funktionelle krav:

Stolens overordnede funktion er, gennem positioneringen af barnet, at virke støttende og for CP-børnenes vedkommende reflekshæmmende. Det vil sige, barnet får hjælp til og/eller øget mulighed for at kontrollere sin krop som følge af den støtte, stolen giver.

Stolen skal desuden stimulere barnets muskel-led sans (proprioceptive sans), hvilket kan medvirke til at barnets vågenhed stiger som følge af en øget sanseintegration og arousal.

Som nævnt har disse børn brug for en høj grad af støtte og tilpasning. De umiddelbart vigtigste er dog:

- trinløs højdeindstilling af hele siddeenheden
- trinløs tiltning af hele siddeenheden
- trinløs indstilling af sæde/ryg vinkel
- indstilling af ryggens højde
- indstilling af sædets længde og bredde
- indstilling af fodstøtter i højde og vinkel

Børnene sidder typisk i denne stol hele dagen. Den bruges i skolen, til leg, lektier, spisning, transport... dog med hyppige pauser, hvor børnene tages ud af stolen for at aflaste hoved, ryg og lemmer. Det betyder at der stilles meget høje krav til såvel tilbehør som polstring, som kan skabe en optimal siddekomfort for barnet.

Stolen skal kunne fungere såvel inde som ude, i hjemmet og i institutioner. Den skal kunne spændes fast i bil således at brugeren kan sidde i stolen under transport i handicap bil- og bus (og desuden gerne kunne slås sammen).

Stolen er personlig, men tilpasses til hhv. sommer-, vinter-, ude- og indebeklædning. Der sker derudover naturligvis en tilpasning efterhånden som brugeren vokser.

Muligheder for samarbejde:

I udviklingen af den beskrevne stol ser Meyland-Smith et potentiale i samarbejde med følgende virksomheder / institutioner:

Sundheds CVU - Ergoterapeutuddannelsen
Bidrage med analyser af stolens målgrupper til uddybning af kravsspec. *(tidlig analysefase)*

Udformning af stolen mht. indstillingsmuligheder og udstrækningen af disse, udformningen af forskellige kropsstøtter og stolen generelt ud fra deres viden om stolens målgrupper. *(input til prototype stadier)*

Deltage i afprøvninger med brugere, hvor de kan bidrage med deres faglige evaluering af givne funktioner. *(vekselvirkning med udvikling af prototyper)*

Anybody technologies
Undersøgelser af ergonomiske kvaliteter i stole. Hvordan støttes mest optimalt når visse muskler / muskelgrupper er sat ud af funktion? (så følgerne af muskelsvind mindskes mest muligt) Hvordan støttes bedst når visse muskler / muskelgrupper agerer meget kraftigt og pludseligt *(såvel helt tidlige som senere prototype stadier)*

Center for sensory-motor interaction - AAU
Undersøgelser af cerebral parese og hjernen... Kan hjernen hos CP børn påvirkes 'af deres siddestilling' (mekanisk, elektrisk eller?) så de ufrivillige muskelsammentrækninger hæmmes? Kan hjernen stimuleres 'af deres siddestilling' (mekanisk, elektrisk eller?) så normale bevægemønstre og motorisk kontrol fremmes? *(helt tidligt undersøgelses stadie samt afprøvning af prototyper)*

Tests af prototypers påvirkning af brugerne - hvilken effekt har de enkelte funktioner mht. kraftpåvirkning/energiforbrug, iltoptag...? *(afsluttende prototype stadier)*

~~RBM Furniture~~ Scanviro
Samarbejde om ergonomisk korrekt udformningen af stolen (med udgangspunkt i deres erfaringer med Anybody)
Samarbejde om at skabe polstring der aflaster brugere med meget svage muskler og betræk som er behageligt, slidstærkt og let at rengøre.

Institut for produktion
Samarbejde om anvendelse af (for Meyland-Smith) 'nye materialer'.

Appendix 4: Interviews

User Interview #1

Kindergarten

New parents are met by many devices

There are many specific or specialized aids

The personnel is not always able to adjust the aids, they need people from the manufacturing company to do it, which takes time

Children have two of the same aid, one at home and one at the kindergarten

The personnel create the aids for the children by mixing features from products by different companies into one "chair"

Most of the adjustments or add-ons are home made

User Interview #2

Mariendal skole

The personnel make add-ons for easier handling of the children, such as steps, so the children can stand during the change of one aid to another

It is important for the children to combine physical and social needs

They get the seat from one company and a "base" or "structure" from another, and so create a new wheelchair. This is a very important point for them, which also makes them feel very proud.

They consider that the existing sitting-to-standing aids are not good, for they pull the clothes when changing the posture of the child, due to the rotation point of the aid being at a different point as the one from the children's body. Therefore the personnel prefer not to use this feature of these products.

Children have a saying when buying; they can see the aid as if buying a bikeUser Interview #3

Family

The parents were having some problems for getting used to technical aids, whereas the child has a very good control of the electric wheelchair

The electric wheelchair destroys the home. Leaves marks and bumps all over the interior.

The sitting comfort is very important; it requires fine tuning given with one special tool that works as a Swiss knife. This also meant that for once they were having the necessary tools for adjusting the aid

The parents consider that, even though it is not a toy, the aid should help the child to play

The child has a little saying in the purchase of an aid. Mainly the colour, not the type of for example wheelchair the child should have

The reliability of the aid is a very important factor

The parents are looking for products that are strong, stable and simple, because the reliability is importan.

User Interview #3

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The reliability of the aid is a very important factor

The parents are looking for products that are strong, stable and simple, because the reliability is important

User Interview #4

Vestermarks skole

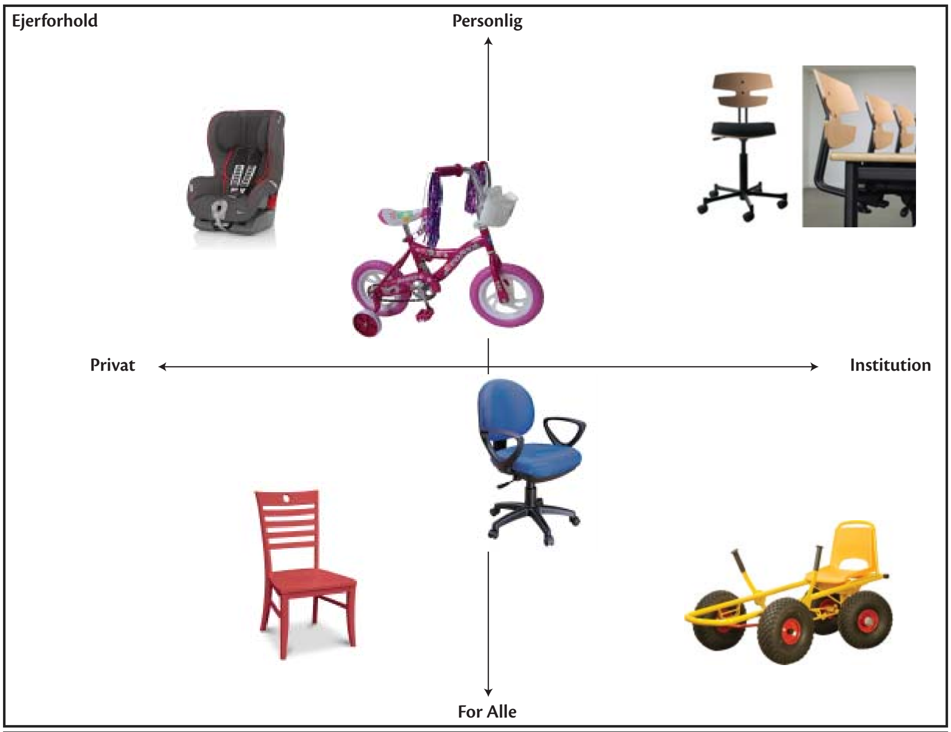
The child needs independent movements to communicate, e.g. moving away when they refuse something

The aid should enable and help, not being a limit

Make the children look and feel safe, not vulnerable

There is a semantics mess, making difficult for the personnel to manipulate and adjust the aids

The aid should always work, be robust cause if it breaks it becomes a limit for the child and thus the child becomes vulnerable. It should as well be simple for there is many people around adjusting it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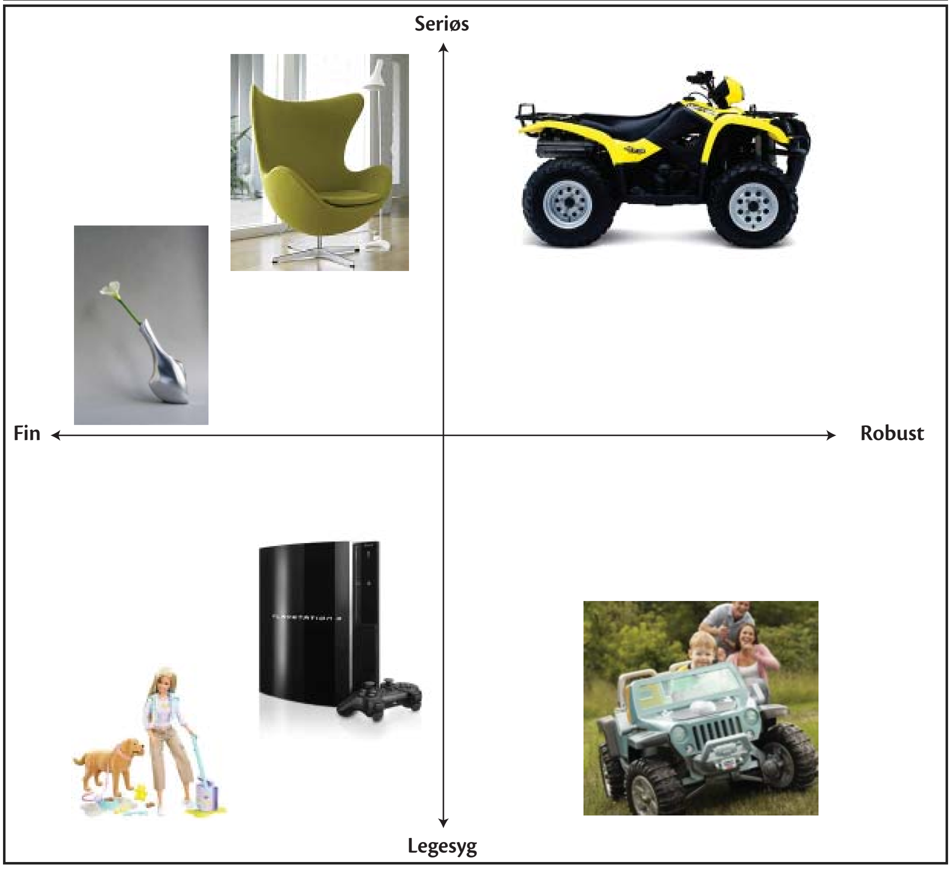
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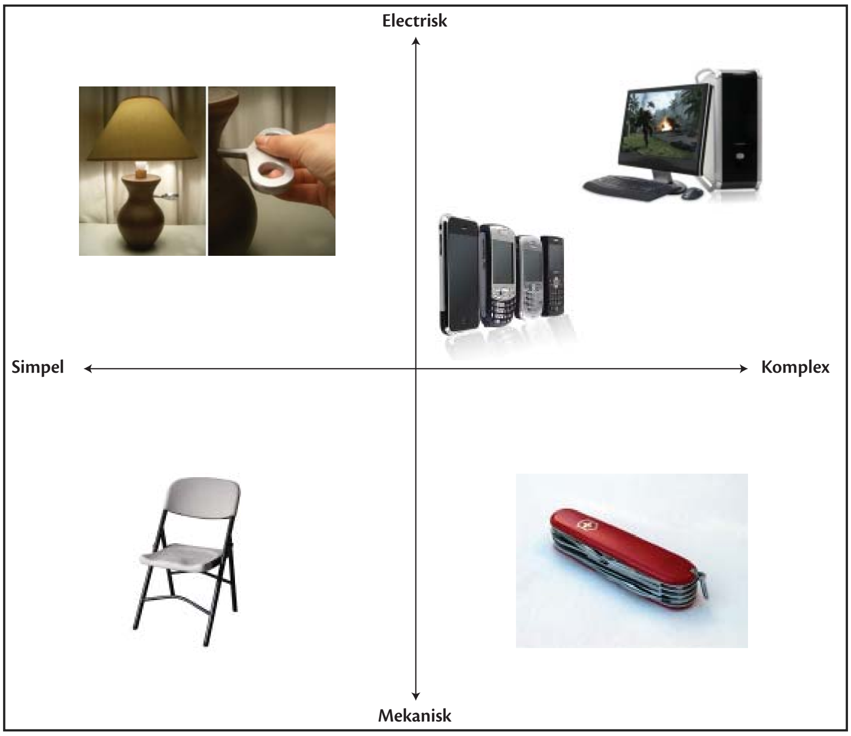
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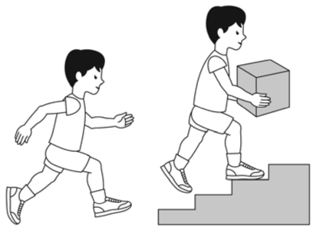
Mekanisk

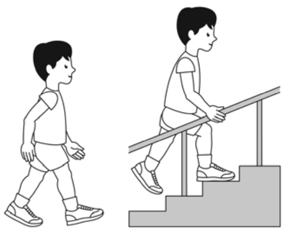
Appendix 5:
GMFCS Table

GMFCS E & R Descriptors and Illustrations for Children between their 6th and 12th birthday



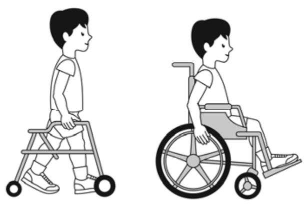
GMFCS Level I

Children walk at home, school, outdoors and in the community. They can climb stairs without the use of a railing. Children perform gross motor skills such as running and jumping, but speed, balance and coordination are limited



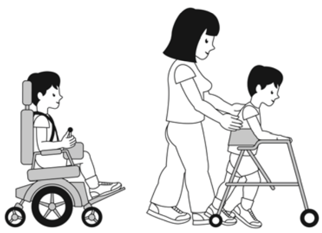
GMFCS Level II

Children walk in most settings and climb stairs holding onto a railing. They may experience difficulty walking long distances and balancing on uneven terrain, inclines, in crowded areas or confined spaces. Children may walk with physical assistance, a hand-held mobility device or used wheeled mobility over long distances. Children have only minimal ability to perform gross motor skills such as running and jumping.



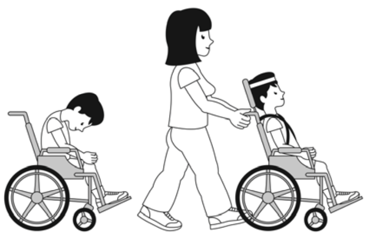
GMFCS Level III

Children walk using a hand-held mobility device in most indoor settings. They may climb stairs holding onto a railing with supervision or assistance. Children use wheeled mobility when traveling long distances and may self-propel for shorter distances.



GMFCS Level IV

Children use methods of mobility that require physical assistance or powered mobility in most settings. They may walk for short distances at home with physical assistance or use powered mobility or a body support walker when positioned. At school, outdoors and in the community children are transported in a manual wheelchair or use powered mobility.



GMFCS Level V

Children are transported in a manual wheelchair in all settings. Children are limited in their ability to maintain antigravity head and trunk postures and control leg and arm movements.

Appendix 6: Competitors

Anatomic Sitt

Sweden.

Products aimed to wheelchair users. Their assortment includes sitting- walking- and standing and toilet and bath aids. Covers the whole Sweden, exports to the Nordic countries, Netherlands, Germany, Cyprus, Japan among others.

Products:

- Atlas Walker

Sitting products

- Zitzi Sharky, Zitzi Delfi, combined with chassis; Octopus, Flipper, Grizzly or Zitzi Wave.

Standing

- EasyStand; training device for moving from seated to standing position.

Chunc

USA / UK.

Posture and Mobility for Young People. They sell to UK, USA, France, Finland, Lithuania, Scandinavia, Spain, Autralia, Kuwait, New Zealand, Saudi Arabia, Aouth Africa.

Products:

Sitting

- Chunc 45. Postural management system.
- Chunc Spica. Post operative mobility
- Chunc Adapt; without the seat. For surrogate seating system.

R82

Denmark.

Producer of technical aids and appliances for disabled children, within the categories: Seating, Standing, Walking, Toilet and bath. Mainly products for milder types of CP. Sells products in more than 30 countries, including Denmark, Norway, Sweden, Czech Republic, France and others.

Products

- Pony, Bronco

Sitting

- Cougar: teenagers and adults.
- x-panda: adjustable seat
- Wombat: indoor seating system

Standing

- Rabbit: adjustable angle.
- Toucan: upright or prone position. Most wheelchairs can fit in between the frame, which make the switch easier.
- Gazelle ps can be adjusted from horizontal position, where the child is laying on the back all the way over standing up, prone or laying on the front.
- Buffalo is roughly the same as Gazelle, but comes in more sizes.

Zitzi Delfi by Anatomic Sitt

Chunc Spica by Chunc

Bronco by R82

JCM seating

Ireland.

Producing products that covers needs 24 hours a day; for seating, standing, rolling, sleeping and for toilet and bath. Present in 16 countries; Australia, Austria, Finland, France, Greece, Ireland, North Ireland, Italy, New Zealand, Norway, Portugal, Spain and Switzerland.

Products:

No walking aids, but in the standing category, they have "Vision", a table with fixtures for legs and back.

Sitting:

- Star x comes in two sizes; 1-4 and 4-8 years. It is a high chair for use in school or at home.
- Triton: the company's most adjustable seating system. It can be fitted on three different frames; Prmo, Custom and Dynamix.
- TX wheelchair chassis is where the Triton seat can be fitted.

Mulholland

Idaho, USA.

Products designed for the development of skills. Sell to UK, Norway, Italy, Portugal, Spain, Australia, New Zealand and Japan.

Products:

- Walkabout and Gait Master

Sitting:

- Acrobat
- GGS (Growth Guidance System): allows air circulation all around the child

Standing:

- Omni, prone stander, rocket, peer level and wheelabout

The Mulholland Standing Systems were designed to provide individuals requiring prone, vertical, or supine standing, precise postural control at the upper trunk, pelvis, knees and ankles. All standers adjust from prone to vertical, offering therapists the opportunity to provide graduated weight bearing, to promote more normal tone distribution and stability, and to facilitate selective extension of the spine. Standers also stimulate head-righting, weight-bearing on the forearms and mid-line hand use. *[from Mulhollandinc.com]*

Leckey

North Ireland.

Manufacture of positioning equipment for children with cerebral palsy, muscular dystropy, spina bifida and other special needs. Range of seating systems, standing frames, bath chairs, toilet seats, walkers, strollers, sleep systems and head support systems. Sold in USA, Canada, Norway, EU and Aisa.

Products:

- Atlas Walker

Sitting:

- Mygo; 4-12 years. Focus on posture in 3 areas: Pelvic, Trunk & Head, Leg & Foot
- Squiggles, 6 months to 4 years. Available in seating, standing and saddle systems

Triton by JCM seating

Omni by Mulholland

Atlas by Leckey

Appendix 7: Wheelchair Materials

In order to get an approach to the materials and processes used in this type of devices it was decided to study the most common and yet demanding aids, the wheelchairs. Being them also a very closely related aid.

The majority of manual wheelchairs are made of either aluminium or steel.

High-end, meaning ultra light or sport wheelchairs are typically being constructed of exotic materials such as high performance aluminium, titanium and advanced composites. The choice of one material over another depends on the material's strengths and weaknesses and how the chair will be used.

The business of manual wheelchairs is very much affected by the aerospace industry. They adopt many of the different materials and manufacturing processes. This happens because the two industries deal with similar issues, such as strength vs. weight, cost and reliability. This can be seen in the progression from steel alloys to aluminium, titanium and more recently advanced composite materials.

Material Type

The types of common alloy steel typically used in manual wheelchairs are:

- Mild steel (AISI 1040 or 1060)
- Chromium-molybdenum alloy steel (AISI 4130)
- Chromium-nickel-molybdenum alloy steel (4340 and 8620)

The mild steel and chromium-nickel-molybdenum alloy steel are typically used in wheelchair frames. They are inexpensive, easy to work, readily available and versatile. However, they have a low strength-to-weight ratio relative to other materials. This material is used in standard wheelchairs.

AISI 4130 is widely used because of its strength, its ability to be easily welded and ease in fabrication. It can be treated for higher strength and to resist abrasion. It is used in the frames of ultra light wheelchairs.

The types of aluminium used in manual wheelchairs are SAE 2024, SAE 6061 and SAE 7075, though SAE 2024 is not used as often as the other two.

SAE 6061 (also known as aircraft grade aluminium) is an inexpensive and versatile structural aluminium alloy that offers good mechanical properties and corrosion resistance. It can be welded using most common methods. Most aluminium wheelchairs are made of this alloy. There are numerous examples of the use of this material in ultra light wheelchairs and sports wheelchairs.

SAE 7075 (also known as high performance aluminium) is one of the highest-strength aluminium alloys, which is ideally suited for high-stress parts. It is not recommended for welded parts.

An increasing number of high-end wheelchairs, such as ultra light and sport, are made of titanium. Titanium is the most exotic and therefore the most expensive metal used in manual wheelchair production. Titanium is used because of its availability, appearance, corrosion resistance and high strength-to-weight ratio. Cost is not the only problem when using titanium. It requires a highly skilled welder to make suitable welds, since titanium can only be welded using special inert gases (TIG welding). It also requires special tools as well as a highly skilled and experienced machinist when manufacturing a wheelchair. If not, the titanium may become worn or flawed, leading to a rapid failure of the material.

Advanced composites also have been making the transition to wheelchair design from aerospace and industrial applications. Composites are carbon fibre, fibreglass, and Kevlar®. Composites come as cloth, tape or yarn and are woven to form special layers that are held together by resin (i.e. often epoxy-based). To achieve greatest strength a minimum amount of epoxy must be used while wetting all of the fibres. To increase the strength and stiffness of structural components, a foam (e.g., Styrofoam, urethane, or PVC) core is used to separate the cloth layers.

Composites also can be moulded into complex shapes, which opens a multitude of possibilities for wheelchair design. Moulding, specifically for curved pieces, allows the design of wheelchairs with fewer joints. This is important since the majority of frame failures occur at joints (bolted or welded). Also, complex shapes provide the greatest benefit to individuals who use a wheelchair because:

- dampening (reduction of vibrations felt by the individual) characteristics of the material can be most effectively utilized
- wheelchairs can be made with less material and therefore be less conspicuous
- wheelchairs can better conform to the features of the body, providing a more comfortable fit

On the other hand, the ability to produce complex shapes can be considered a downside of composites; these shapes may require intensive manual labour, which is not cost effective. However, new technologies in the production of composite components and frames are being introduced which should reduce the manufacturing costs. Composites are currently used in order to reduce the weight of the casters and the rear wheels, while improving the aerodynamics of the rear wheels, which is important for racers.

Function

The different types of material are used depending on the desired functionality of the wheelchair.

Mild steel is often used for depot or standard wheelchairs, where the cost of materials and production is the primary consideration. A depot or standard wheelchair is meant for temporary use by more than one person, typically in an institutional setting, and is often attendant-propelled. Therefore, the weight of the wheelchair, long-term comfort, manoeuvrability and durability on rough terrain are not a major concern.

For a lightweight or ultra light wheelchair intended for individual use as a long-term independent mobility aid, its comfort, durability and manoeuvrability are primary concerns. Therefore, chromium-molybdenum alloy steel, aluminium, titanium and advanced composite materials are employed in the manufacture of the frame and components. Materials which reduce the amount of vibrations and the individual experience (i.e. good dampening properties) composites can be used to improve ride comfort.

Materials with a high strength-to-weight ratio (e.g., aluminium, titanium, or composite) may allow for a less noticeable wheelchair, so the individual is seen before the wheelchair in a social setting. An inconspicuous wheelchair also means a lighter wheelchair, allowing for easier propulsion and manoeuvrability. Reduction in weight may also lead to a reduction in secondary injuries such as repetitive stress injuries. These injuries may be a result of wheelchair propulsion or lifting the wheelchair during car/van transfers.

Though cost may not be a primary concern to the individual, it automatically becomes one as soon as a third-party payer gets involved. Obtaining a lighter, more durable and consequently more expensive wheelchair with exotic materials may be justified by it having a more durable and economic life cycle and in the costs incurred while treating a repetitive stress injury. Therefore, the selection of the material used in manual wheelchairs is a function of the durability, aesthetics, function, ride comfort and cost of the wheelchair, as well as the wheelchair purchaser.

Appendix 8:
Article: "How to market tweens"

How to market to 'tweens'

http://www.microsoft.com/smallbusiness/resources/marketing/market-research/How-to-market-to-tweens.aspx#Howtomarkettotweens

sidst set d. 11. November 2009

Rieva Lesonsky has been one of the nation's foremost experts on entrepreneurship for over 20 years. The former editor of Entrepreneur magazine, Rieva is CEO of SMB Connects, based in Irvine, California, which helps connect corporations, organizations and government agencies with entrepreneurs. To ask her a question, sign up for her free email newsletter or have her speak to your group, go to www.askrieva.com.

Q: As we all know, times are tough. I'm ready to launch a new business. Is there a market that's recession-proof? I've heard that the kids market is still going strong. True?

A: You've heard right. At the moment the kids market is holding up pretty well. Parents don't want to deprive their children, so they're spending less on themselves and their homes, but still splurging on their kids.

There are three distinct segments of the children's market: younger children, tweens and teens. Many smart marketers are targeting the nation's tweens, since there are about 26 million of them and they've become a spending powerhouse. Definitions vary, but generally tweens range from eight or nine to 12 or 13 years of age. Being a tween is not just an age, but an attitude. Experts say that by the time a child reaches 5th grade (most 5th graders are 10- years- old) they're transitioning from childhood (no more toys) and aspiring to being a teenager (buying music and makeup like their teenage counterparts).

Now you may be thinking, how much money can a 10- year- old really spend? Well, a lot. According to Alloy Media + Marketing, a youth marketing company, tweens themselves spend $51 billion annually, while an additional $170 billion is spent on them by parents and other family members.

Girls have long dominated tween spending (young girls are natural viral marketers), so if you're seeking a niche to exploit in the youth market, you might look to tween boys, who spend a lot on fast food, clothes and fun (i.e. skateboarding).

Since we're still in the midst of a new baby boom, the size of this generation alone will have a lasting impact on the marketplace. There will be millions of tween influencers for years and years. Many businesses are going beyond just selling products to this group, but trying to establish a relationship between their brands and tweens as well. The earlier you make inroads into this demographic, the better your chances of building lasting brand loyalty.

What do tweens want? Surveys have shown that tweens are concerned with style, brand names and the latest fashions. In other words, they're status conscious. Tweens are vulnerable to peer pressure and "fitting in" is very important to them. According to a report from Packaged Facts, tween boys are into sports and both boys and girls love to shop. Most have

Internet access. Surprisingly these kids have a global perspective and are increasingly socially conscious. Entrepreneurs targeting this market need to understand that tweens continuously balance their desire for individuality with their need for conformity. And above all, do not treat them like kids.

So how do you reach this lucrative market? Marketing research firm eMarketer reports that as tweens become teens they increasingly turn to online socializing to communicate. They're into instant messaging, texting and joining social networks. Tweens (and teens for that matter) are easily bored, so be sure to change your message often. Try reaching them through their favorite blogs. Check www.technorati.com to find the bloggers with big tween followings.

Perhaps most important, tweens become teens with even more disposable income. Teenage spending is expected to reach nearly $209 billion by 2011.

Appendix 9:
NCD Model

Engine:

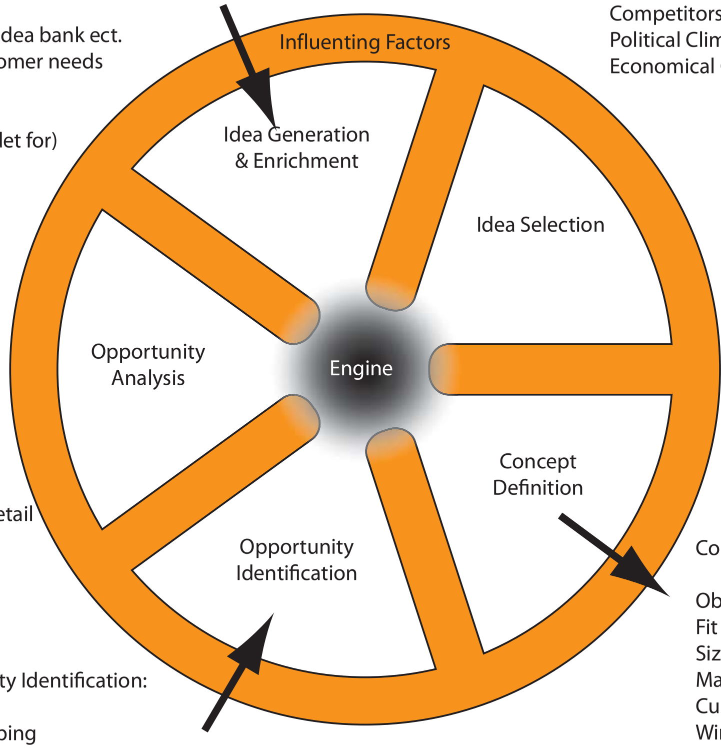
Business Strategy
Business Goals
Company culture
Company Leadership

Influenting Factors:

Organizational capabilities
Distribution channels
Law
Government policy
Customers
Competitors
Political Climate
Economical Climate

Idea Generation & Enrichment:

Birth, development, maturation of idea
Brainstorming, mindmap, brainpool writing, idea bank ect.
Discovering archetype of customer, and customer needs
New technologies
...Ongoing process in company...
(evt bruge dele af Tollestrups workshop i stedet for)



Idea Selection:

Technical success probability
Commercial success probability
Reward
Strategic fit
Strategic leverage (indflydelse)

Opportunity Analysis:

Road mapping, in detail
Technology trend analysis, in detail
Customer trend analysis, in detail
Competitive Intelligence analysis, in detail
Market reseach, in detail
Scenario planning, in detail

Concept Definition:

Objectives
Fit of the concept with strategy
Size of opportunity, e.g. financial
Market needs and benefits
Customer needs and benefits
Win/win for value chain participants
Risk factors
"Showstoppers", e.g. safety

Opportunity Identification:

Road mapping
Technology trend analysis
Customer trend analysis
Competitive Intelligence analysis
Market reseach
Scenario planning

Appendix 10:
Concept Development Workshop Images

Sketch from these inspirations:

Welding Robot

Keywords:
Joints
Mechanical

Sport Bicycle

Keywords:
Light weight
"Sport"
Notice the shape structure;
organic like

"Manga"

Keywords:
Exaturated details
Friendly
"Cute"

Appendix 11:
Suggested Production Processes

	Straight Profile		Curved Profile
Production Structure	- Commercial profile - Cut of profile in final length - Cut rails for seat base - Cut for receiving tube for frontal wheel - Commercial caps for profile	- Extruded piece - Moulding	- Moulding for front part of profile - Extrusion of front part of profile - Cut of profile in final length - Cut back part from metal sheet - Bending metal sheet for back part - Wielding / gluing pieces together - Bending the profile - Cut for receiving tube for frontal wheel - Cutting caps for profile - Cut commercial profile for closing the gear rail
Production Wheels	- Roll metal sheet - Wield metal sheet to make pipes - Cut caps from metal sheet - Drill caps for receiving back wheels - Wield nut to caps - Wield caps to tubes - Cut tube for receiving frontal wheel - Wield frontal tube to structure	- Extruded pieces - Moulding	- Roll metal sheet - Wield metal sheet to make pipes - Cut caps from metal sheet - Drill caps for receiving back wheels - Wield nut to caps - Wield caps to tubes - Cut tube for receiving frontal wheel - Wield frontal tube to structure
Structure Assembly	- Wield structure and back wheel tubes - Anodizing the structure for colour		- Wield structure and back wheel tubes - Mounting central gear rail and caps - Anodizing the structure for colour
Production Seat	- Injection moulded seat and backrest - Cut foam for seat - Cut and sew fabric - Assemble foam and fabric for the seat - Cut foam for backrest - Cut and sew fabric - Assemble foam and fabric for backrest		- Injection moulded seat and backrest - Cut foam for seat - Cut and sew fabric - Assemble foam and fabric for the seat - Cut foam for backrest - Cut and sew fabric - Assemble foam and fabric for backrest
Adjustments Assembly	- Injection moulded handles and side supports - Assembly of pieces together with seat and backrest		- Injection moulded handles and side supports - Assembly of pieces together with seat and backrest
Final Assembly	- Place seat base on long bolt - Place the long bolt inside the structure - Place the motor inside the structure - Attach long bolt to motor - Close the profile with commercial caps - Mount the seat unit on seat base attached to long bolt - Mount back wheels with bolts - Mount front wheel by pressing		- Place the motor under the seat unit - Attach seat unit to profile: gear on central rail, side wheels on own rails - Close the profile with caps - Mount back wheels with bolts - Mount front wheel by pressing
	32 STEPS	**36 STEPS**	**35 STEPS**

Illustrations List

PHASE 1

PHASE 2

PHASE 3

PHASE 4

PHASE 5

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