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Utvikling av nytt voggekonsept

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Produktutvikling og produksjon
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Norges teknisk-naturvitenskapelige universitet
Institutt for produktutvikling og materialer

NORGES TEKNISK-
NATURVITENSKAPELIGE UNIVERSITET
INSTITUTT FOR PRODUKTUTVIKLING
OG MATERIALER

MASTEROPPGAVE VÅR 2012
FOR
STUD.TECHN. JOHANNE ESKERUD HOVI

UTVIKLING AV NYTT VOGGEKONSEPT
Development of new cradle concept

I forbindelse med forskningsprosjektet LPD ble det utviklet og patentert en voggemekanisme (VAPA) som er patentert i Europa og USA. VAPA har alt bevisst store funksjonelle, miljømessige og produksjonsmessige fordeler men det har enda ikke vært utviklet en industrialiserbar krybbe som har utnyttet potensialet.

Masteroppgaven har derfor som hovedmål å designe ett konsept som gir best mulig kundeverdi og samtidig størst mulig verdiskapning for potensiell produsent. Viktige deloppgaver blir derfor:

1. Utarbeid forretningsideer basert på alternative kundegrupper og markedssegmenter (institusjon eller privatkunder)
2. Utarbeid en kravspesifikasjon basert på valgt forretningside
3. Skissere alternative voggekonsepter basert på kravspesifikasjon
4. Evaluere, velge og designe i 3D den valgte konseptløsningen

I den grad tiden tillater det:

5. Bygge en enkel prototyp for funksjonstesting
6. Analysere og optimalisere valgt konseptløsning mht kravspesifikasjonen (design, materiale, stivhet, funksjon, produksjon, resirkulering og transport)

Før kandidaten går i gang med forsøkene, skal han/hun sette opp en oversiktlig forsøksplan som inneholder alle opplysninger om forsøksmetodikk og forsøksbetingelser. Planen skal foreligge til godkjenning innen tre uker etter utlevering av oppgaven.

Besvarelsen skal ha med signert oppgavetekst, og redigeres mest mulig som en forskningsrapport med et sammendrag på norsk og engelsk, konklusjon, litteraturliste,

innholdsfortegnelse, etc. Ved utarbeidelse av teksten skal kandidaten legge vekt på å gjøre teksten oversiktlig og velskrevet. Med henblikk på lesning av besvarelsen er det viktig at de nødvendige henvisninger for korresponderende steder i tekst, tabeller og figurer anføres på begge steder. Ved bedømmelse legges det stor vekt på at resultater er grundig bearbeidet, at de oppstilles tabellarisk og/eller grafisk på en oversiktlig måte og diskuteres utførlig.

Senest 3 uker etter oppgavestart skal et A3 ark som illustrerer arbeidet leveres inn. En mal for dette arket finnes på instituttets hjemmeside under menyen masteroppgave (http://www.ntnu.no/ipm/masteroppgave). Arket skal også oppdateres en uke før innlevering av masteroppgaven.

Besvarelsen skal leveres i elektronisk format via DAIM, NTNUs system for Digital arkivering og innlevering av masteroppgaver.

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PREFACE

This report contains the results from my master thesis written for the Department of Engineering Design and Materials at NTNU the spring of 2012. The time period was 21 weeks, from February 9th to July 5th.

First I would like to thank my supervisor Terje Rølvåg for his guidance, support and help during the whole semester. I would also like to thank all members of the reference group for contributing with great ideas, Oluf Tonning for all computer help, Bebito for providing me with useful information, my friends that have had a baby for sharing their experience and my mother for proofreading the assignment.

The course TPD4175 Introduction to Product design was in taken parallel with writing my master thesis.

PURPOSE OF THE THESIS

Following the Lean Product Development (LPD) project, a tilting mechanism (VAPA) was developed and patented by Terje Rølvåg at Department of Engineering Design and Materials (IPM), NTNU (See Appendix C). VAPA has proven to have functional, environmental and production related advantages. The purpose of this master thesis is to design an industrial feasible cradle concept that exploits this mechanism. The concept should maximize the customer value as well as provide great value for a potential producer. As agreed with the supervisor focus has been on aesthetical and functional design without looking into detailing and dimensioning. However, a simple design has been emphasized to facilitate production and transportation.

SUMMARY

In this project a baby's cradle has been designed. The cradle is based on a tilting mechanism developed by Terje Rølvåg at the Department of Engineering Design and Materials at the Norwegian University of Science and Technology. The goal of the project was to design an aesthetic and functional cradle adapted to the tilting mechanism. The mechanism should help to calm the child by rocking at an optimal frequency.

A simple segment analysis was performed. Different user groups and business ideas were discussed before a chosen concept was pursued. Furthermore, a literature search was conducted to support previous studies that suggested a frequency of 1-1.5 Hz as the optimal rocking frequency for babies.

Based on the selected concept, customer requirements and interests were identified in order to create an adequate specification. Different solutions are presented before one of the designs were taken further and modeled in NX. Different safety standards were reviewed to ensure the optimum quality of the final product. The final design was based on current safety standards for cradles and findings from the user analysis.

The project resulted in four different design ideas. It will be up to the supervisor or to pursue one of these designs.

SAMMENDRAG

I dette prosjektet er en barnevugge blitt designet. Vuggen tar utgangspunkt i en vippemekanisme utviklet av Terje Rølvåg ved Institutt for Produktutvikling og Materialer på NTNU. Målet med prosjektet har vært å utforme en estetisk og funksjonell vugge tilpasset vippemekanismen. Mekanismen skal bidra til å roe barnet ved hjelp av vugging ved optimal frekvens.

Det ble uført en enkel segmentanalyse hvor ulike brukergrupper og forretningsideer ble drøftet før et utvalgt konsept ble videreført. Dessuten ble det foretatt et litteratursøk for å underbygge tidligere undersøkelser som antydet en frekvens på 1-1,5 Hz som optimal vuggefrekvens for babyer.

Basert på det valgte konseptet ble kundekrav og -interesser identifisert for å kunne lage en adekvat kravspesifikasjon. Forskjellige løsninger er presentert før ett av designene ble tatt videre og modellert i NX.

Forskjellige sikkerhetsstandarder ble gjennomgått for å sikre optimal kvalitet på sluttproduktet. Det endelige designet er basert på gjeldende sikkerhetsstandarder for vugger samt funn fra brukeranalysen.

Prosjektet resulterte i fire ulike designforslag. Det vil være opp til veileder eventuelt å føre et av disse designene videre.

CONTENTS

DEFINITIONS

Abbreviations, terms and other definitions used in this thesis are explained in table 1.

VAPA	Virtual Adjustable Pivot Axis
VAPAV	Virtual Adjustable Pivot Axis Vogge
Cradle	A small bed for infants furnished with rockers
Crib	A bed for babies or young children
Cot	A small bed placed on a frame (number 1 in figure 1)
Stringers	The VAPA frame that supports the cot (number 2 in figure 1)
Carry cot	A light cot with handles that may work as a pram body
URS	User Requirement Specification
PRS	Product Requirement Specification
Carer or caregiver	The person that looks after the baby. This may be a parent, babysitter, nurse, foster parent etc.

Table 1 Abbreviations

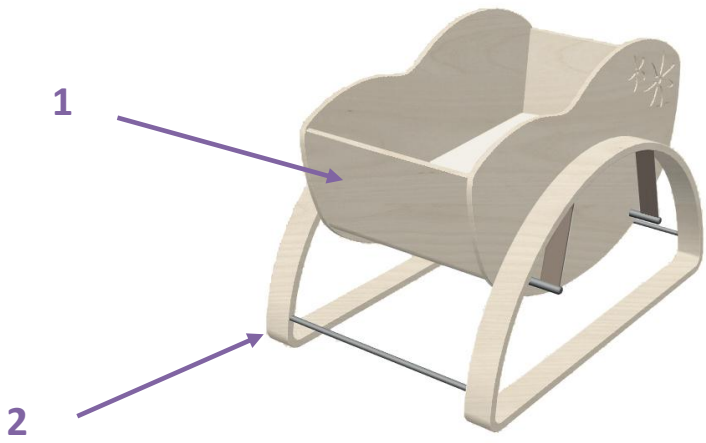


Figure 1 Abbreviations, cradle

REFERENCE GROUP

A reference group was created to help generating ideas for concept and design. The group was formed together with Lise Abrahamsen Kratter (Graduate student, Engineering Design and Materials, NTNU) who writes her master thesis about how the VAPA mechanism can be utilized in a chair. The group consisted of Terje Rølvåg (Supervisor, concept initiator and Professor, Department of Engineering Design and Materials), Knut Einar Aasland (Associate Professor, Department of Engineering Design and Materials, NTNU), Trond Are Øritsland (Associate Professor, Department of Product Design, NTNU), Mats Herding Solberg (Graduate student, Industrial Design, NTNU), Hege Berg Bache (Graduate student, Engineering Design and Materials, NTNU), and Morten A Christoffersen (Graduate student, NTNU School of Entrepreneurship).

BACKGROUND

VAPAV (Virtual Adjustable Pivot Axis Vogge)

VAPA is an invention developed by Professor Terje Rølvåg. One or two flexible 2D structures enable tilting rotation about a virtual pivot point or axis. The location of the pivot point or axis is given by the geometry of the structure and may be located outside it. In this thesis these structures are referred to as stringers.

Figure 2 VAPAV mechanism

It has been found research that indicates that combined longitudinal and vertical oscillations with 2-3 cm amplitudes, in the frequency range of 1-1.5 Hz make young children fall asleep (See Appendix C).

The VAPA mechanism can facilitate the desired motion. It can be integrated in a cradle and utilize its benefits to sooth infants and help them sleep. Traditional cradles have only one roll degree of freedom and the roll axis is located below the cradle, normally to give a sideways translation. This motion may actually cause nausea rather than make the child tired.

Figure 3 Traditional cradle

An actuator located beneath the cradle can control the amplitude.

The VAPA mechanism may also help older children or adults if integrated in a larger bed.

CHAPTER1: CONCEPTS

1.1 MARKET SEGMENT ANALYSIS

In order to create a successful product, the wants and needs of the end customers must be identified. Various market segments and customer groups will lay down different requirements for the product. In this chapter, several concepts are considered and evaluated for a variety of customer groups.

The market segments and customer groups were established through a brainstorming together with the reference group. Two main segments for a VAPA bed are private customers and institutions. Institutions can be divided into both public and private.

Table 2 to 4 show different customer groups within the two segments. Main user refers to the person that is intended to sleep in the bed. Secondary user refers to the person that mainly operates the bed, i.e. cleans or rocks it.

1	**PRIVATE**		
section	Customer group	Main user	Secondary user
1.1	**Home**		
		Infants	Parents
		Infants with colic	Parents
		Children	Parents
		Insomnia patients and adults with sleeping disorders	The patient

Table 2 Segment analysis: Private

2 INSTITUTIONS – *PUBLIC*

Section	Customer group	Main user	Secondary user
2.1	**Kindergarten**		
		Infants and/or young children	Kindergarten staff
2.2	**Hospital**		
		Infants	Nurses
2.3	**Nursing home**		
		Adult Insomnia patients	Nurses
2.4	**Foster care**		
		Abstinence children	Foster carers
2.5	**Technical aids center**		
			Nurses

Table 3 Segment analysis: Public institutions

3	**INSTITUTIONS – *PRIVATE***		
Section	Customer group	Main user	Secondary user
3.1	**Kindergarten**		
		Infants and/or young children	Kindergarten staff
3.2	**Nursing home**		
		Adult Insomnia patients	Nurses

Table 4 Segment analysis: Private institutions

1.1.1 INFANTS

There is a well-known fact that getting young children to sleep can be a strenuous affair, especially if the little one has colic.

Cradles have been used for centuries to comfort infants and help them fall asleep, but they do not offer an optimal motion. Today the traditional cradles are used as furniture or heritage rather than a crib for babies. They are also often large and heavy, and not particularly portable or space saving. A cradle that can rock babies to sleep in an instant and calm those with colic would be a blessing to most parents.

The concept may, with minor adjustments, also be used in kindergartens, hospitals or be offered by technical aids centers.

Figure 4 The VAPA mechanism integrated in an infant's crib

1.1.2 CHILDREN

Many children have trouble sleeping and struggle to calm down before bed time [1]. This can be an affliction for parents that often want some quiet alone time at the end of the day.

The VAPA mechanism could be integrated in a children's bed to make bedtime easier for both parents and the child. Today's solution for severe sleeping problems among children is medication, which often involves adverse reactions.

Figure 5 The VAPA mechanism integrated in a children's bed

1.1.3 ADULTS

Poor sleep routines are a common problem in society today [2]. Early rising, work, stress, caffeine and late night activities such as TV-watching are all factors that impact our sleep adversely. As much as 12 percent of the American population may suffer from chronic insomnia. Insomnia is the condition where patients have difficulties falling asleep or staying asleep during the night. It is often a symptom of stress, anxiety, physical disorders and other underlying factors. Insomnia is often treated with medications, but this does not work well on a long-term basis. People with chronic sleep disorders may benefit from a VAPA bed.

The bed can also help people with poor sleep routines to calm down and fall asleep faster at night. The bed may be used in private homes or in nursing homes, as elderly often has trouble sleeping.

Figure 6 The VAPA mechanism integrated in an adult bed

1.2 CUSTOMER REQUIREMENTS

Private customers and institutions will have dissimilar requirements for a cradle. Table 5 shows various customer requirements and discusses their importance for both segments. This is based on assumptions and discussions with the reference group.

The cradle requirements are assumed to be the same for both public and private institutions.

Requirements	**Segments**	
	Home	Institution - *Public and private*
Durability	Would most likely be used for only one or two children. Reuse may occur as the cradle can be inherited, resold or donated. Still, durability is not the most important factor.	Must be able to withstand reuse. The cradle will be used by a number of children and several operators for an extended period of time. Thus the quality of the cradle must behave accordingly.
Cost	Cost is rarely the decisive factor when buying an efficient aid for your screaming baby, but still the cradle should be affordable to most parents.	Cost should be competitive with alternative solutions for the institution market.
Documentation	The product must have a good reputation and be recommended by other parents.	The product must have documentation of its functionality.
Design	To be competitive, It is important that the cradle is aesthetic and follows trends in the market.	As the functionality of the cradle will be the main factor, this segment does not have the same demands to aesthetics.

Requirements	**Segments**	
	Home	Institution - *Public and private*
Cleaning	The cradle will mainly be used by one individual and thorough cleaning will not be needed on a regular basis. It must however be easy to maintain a hygienic environment for the baby.	As the cradle will be used frequently and by several individuals, it must be easy to clean.
User friendliness	It is important that the cradle is easy to use, as baby sitters, grandparents and other new users may have to operate the cradle from time to time.	It is very important that the cradle is easy to use, as many different people may operate it.
Safety	Safety for both operator and user is very important. The cradle will have to fulfill national and international standards in this area.	Safety for both operator and user is very important. The cradle will have to fulfill national and international standards in this area.
Assembly	The cradle may be delivered unassembled.	The cradle should have the opportunity to be delivered assembled or with an installer, as hospitals or kindergartens may buy many at a time.
Storage	As future siblings may inherit the cradle, it is practical if it is foldable or easy to store in another way.	The cradle must be easy to store and should be foldable.

Table 5 Segment requirements

1.3 CHOICE OF CONCEPT

After consultation with concept originator, it was decided to proceed with the cradle concept intended for infants. It will be focused on a cradle designed for private households in this thesis. However, with small adjustments the cradle may be easy to produce for institutions such as hospitals and kindergartens as well.

CHAPTER2: REQUIREMENTS ANALYSIS

2.1 USER ANALYSIS

To establish the user requirements a children's equipment store[1] was visited to have a close look at cradles and other baby products available. The personnel were also asked about their experience on what customers emphasized in the design of a cradle. Furthermore a mother of young children[2] was interviewed on the topic.

It became apparent that the traditional, handcrafted cradle design is not to prefer among today's generation of parents. They want a modern version that can stand in the living room without interfering with the other interior. It should also be less massive than the original cradle, and more elegant. The cradle should have clean lines and soft and round edges – just like a baby.

White is currently the most popular color, since it goes with other baby gear that often has colors[3]. Light woods, such as birch and beech are also in style. Flowers, stars, rabbits and other décor are popular on baby furnishings, but must not be exaggerated.

It turned out additional accessories and extra features, such as adjustable rest angle and more rocking options, was an incentive to buy a cradle. It would be convenient if the cradle were pretty tall, or at least as tall as their bed. Most important, it must be safe and stable, and not able to turn over. It would be useful if it was foldable and/or easy to store, but not an essential factor.

[1] Bebito, Trondheim

[2] Melissa Mørch Kerrison, Asker

[3] Mainly pink and blue.

Further, It became apparent that many newborns find comfort in confined spaces, and that parents often need to use blankets and pillows to create a "inside the womb" feeling for their youngest one.

2.2 EXISTING SOLUTIONS

In order to assess strengths and weaknesses of corresponding products in the existing market, a competitor analysis can be conducted. The analysis may also help generating ideas for concepts, positioning features and design. Table 6 shows a number of cradles or devices that claim to comfort babies and have a positive effect on their sleep. All products have received numerous praises and positive reviews in social forums. Especially the baby hammocks are popular amongst Scandinavian parents due to both function and design.

Each product is analyzed briefly with regard to design, function and convenience.

Product	**Features**
Leander 	Leander is a single point suspended cradle and can be put in subtle movements by either a parent or the child itself. The producers claim the swaying motion provides security to the child and stimulation of its senses. The Leander design is elegant and modern, and a major incentive for parents to buy this relatively expensive cradle[4] The cradle can be attached to the roof or a tripod. This forms a large structure which is difficult to move around. An advantage is that it cannot tip over by siblings, pets or others.

[4] According to discussions in social media

Product	Features
Byssanlull 	Byssanlull is suspended from two hooks in the ceiling, providing the cradle a soft and steady longitudinal motion. The producers claims it has a calming effect on children with colic and makes babies fall asleep faster than in a conventional cradle. Byssanlull has been featured in an interior design TV show and seem to be popular amongst parents due to its modern design. Like Leander, Byssanlull's design makes it impossible to tip over, providing security for the baby. However the suspension makes it difficult to move from room to room.
Dream-Mover 	DreamMover rocks the baby back and forth while making a soothing sound. The manufacturer claims it calms children with colic and helps them sleep. The device is portable, which is an advantage. DreamMover works well for daytime sleeping, but will not substitute a bed or a cradle intended for nighttime sleep. It works with most strollers, carry cots, car seats or just a mat, but does not come out as a part of a complete children's cradle. The sound may also be intrusive for parents during nighttime.
Emmaljunga Edge Duo stroller 	The bag in this stroller has a curved base that lets parents rock their baby when the bag is placed on the floor. This is a flexible solution, but not an alternative for nighttime sleep.

Baby hammocks 	Baby hammocks have become popular during the past few years and are an adequate alternative to the conventional cradle. The Miyo hammock has many of the same features as Leander. The hammock claims to help children sleep better and relive colic symptoms. The Miyo hammock looks exotic and combines old techniques with modern designs. Miyo, as most other baby hammocks, can be suspended from the roof or from a hammock stand. Hammock stands are portable, but often large and space consuming.
So-Ro 	So-Ro rocks longitudinal, but does not offer an optimal motion since the roll axis is located below the cradle. The sleeping pad is tilted 3 degrees to allow efficient air supply around the baby's head. The cradle has received the award "Merket for God Design 2010" from Norsk Designråd.
Baby cradle swings 	Baby cradle swings rock back and forth at various speeds, and sometimes side to side as well. This helps calming the baby during the day or before bedtime. The swings often offer various sensory features such as sounds, music, lights and toy bars to keep the child entertained. Some swings allow more sitting angles. The swings are normally foldable which makes them easy to store. It should be emphasized that the cradle swings are purposed for daytime use only.

Table 6 Competitor analysis

2.2.1 CONCLUSION

The suspended cradles have an advantage since they cannot tip over. Dream Mover and Emmaljunga Duo Edge Stroller are flexible solutions that allow parents to rock their baby without removing them from the stroller. Baby cradle swings provide accessories and various soothing features such as sound or light systems. They also offer different rocking speeds and sitting angles. So-Ro has a tilted base that allows efficient air supply for the baby.

To make the cradle a successful product some of these positioning features could be adopted. A modern design should be assigned to the cradle to add further customer value. The cradle could be easy to move around to have an advantage against the suspended cradles.

Some of the products in the analysis are easier to store than others. Some kind of folding mechanism would be an advantage, but as conventional cradles are usually not foldable this is not an obligation. Most consumers would not require such for their cradle.

2.3 USER REQUIREMENT SPESIFICATION

The User Requirement Specification (URS) convert discoveries from the user- and competitor analysis into requirements. The URS will be used later in the project when generating concepts and final design of the cradle. The criteria are rated as “shall” or “should” and refers to whether the conditions are mandatory or just an advantage.

User Requirement Specification

Section	Description	Shall	Should
1	**Use**		
1.1	Rock the baby into sleep without providing any discomfort	√	
1.2	Accommodate infants	√	
1.3	Appear safe and stable	√	
1.4	Easy and comfortable to operate	√	
1.5	Easy to store		√
1.6	Additional features		√
1.7	Additional accessories		√
2	**Design**		
2.1	Elegant and “soft” design that bear a resemblance to babies	√	
2.2	Fit into the modern home	√	
2.3	Complement other popular baby gear on the market		√
2.4	Decoration and/or color options		√

Table 7 URS

CHAPTER 3: MOTION

3.1 BACKGROUND

Many parents have experienced that different motion patterns can be comforting to a baby, help it sleep, and even relieve colic pains. When parents are rocking their baby, or even driving a car to calm the baby, there is a response pattern that can be controlled by the parent. In a cradle where the child could be left unattended, it is important that the motion pattern is calming or reliving and not the opposite.

According to Rølvåg (see Appendix C), former research on VAPAV indicates that a frequency of 1-1.5 Hz make kids fall asleep. It has not been possible to find scientific surveys that confirm a relieving frequency for infants with colic, but it could be presumed that a frequency of 1-1,5 Hz could have a calming effect also on some colic babies.

This project has consequently reviewed research on the human body's reaction to different motion frequencies.

3.2 MOTION AND THE HUMAN BODY [3]

The Vestibular system is located in each ear of the human body and is the main sensory receptor related to motion and body orientation. It contributes to balance and spatial orientation and comprises of two components; The Semicircular Canals provide information about body movement and the Vestibular Sacs provide information about body posture in relation to the vertical. The Semicircular canals are only sensitive to acceleration or deceleration. Body movement at a constant rate does not stimulate these canals.

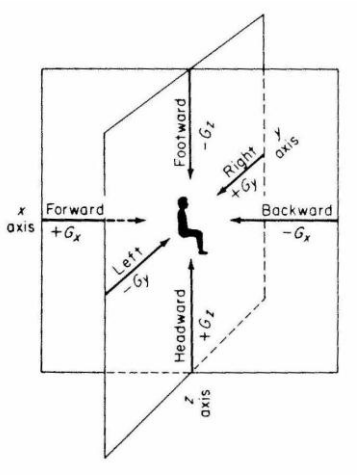


Figure 7 'Illustration of three directions of linear acceleration. The direction of displacement of the heart and other organs is opposite to that of the motion of the body.' [3]

Vibration may be sinusoidal (a single sine wave of some particular frequency or combinations of sine waves of different frequencies) or random (irregular and unpredictable waves). Random vibration is the most common type of vibration encountered in the real world. Along with type, vibration is described in terms of direction (e.g. forward-backward, left-right, headward-footward) (see figure 7), frequency (Hertz) and intensity (e.g. amplitude, displacement, velocity).

The level of comfort experienced by a test subject exposed to vibration cannot be measured or observed, it has to be reported by that person. A challenge for both researchers and designers is that individuals perceive whole-body vibration differently.

When transmitted to the body, vibration can be attenuated or amplified as a result of body posture, muscle tension, seat cushioning and other factors.

Different body parts and organs have different resonance frequencies. At whole-body vibration people complain about pains in chest and abdomen at 4-

10 Hz, backaches at 8-12 Hz while headaches, eyestrain and irritations in the intestines and bladder occur at 10-20 Hz. Vibrations at 3.5-6 Hz seem to have an alerting effect on subjects doing boring tasks as one tenses the trunk muscles to attenuate the amplitude of shoulder vibration (see figure 8). Outside this range one can attenuate the shoulder vibration more by relaxing the trunk muscles. This may be a good way to fall asleep!

Low frequency oscillations (oscillations below 1 Hz) cause nausea and "motion sickness". Figure 9 show that vibrations between 0.15 and 0.25 Hz, or 9-15 cycles per minute, cause most people to throw up. The study was conducted by exposing more than 500 subjects to vertical sinusoidal vibrations of various combinations of acceleration and frequencies below 1 Hz for 2 hours.

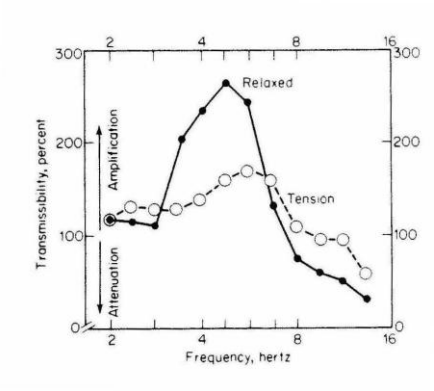


Figure 8 'The effect of tensed and relaxed trunk muscles on the amplitude of vertical vibration of the shoulders of a seated man.' [3]

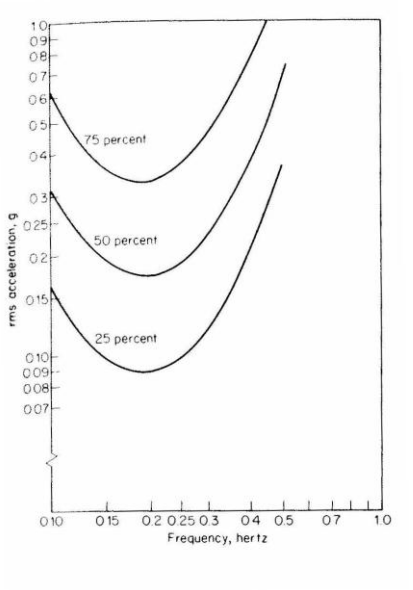


Figure 9 'Equal motion sickness contours, based on percentage of emesis within 2 h for 500 male subjects exposed to vertical sinusoidal motion.' [3]

3.3 MOTION AND CHILDREN

There are few studies on infants and whole-body vibration, although a study from University of Western Ontario in 1973 shows that children at the age of two months fell asleep the fastest when exposed to frequencies of 1.5 Hz and amplitude of three inches (See Appendix C). The study was conducted on 64 children, and they were exposed to the oscillations for 15 minutes.

Most other research on the topic is conducted with adult test subjects. However, it can be assumed that frequencies that are considered unpleasant by adults also are unpleasant for young children. Hence, it is important that the frequencies in a children's cradle can be monitored thoroughly as frequencies below 1 Hz may cause nausea and frequencies above 2 Hz may be harmful.

CHAPTER 4: SAFETY REQUIREMENTS

4.1 CRADLE SAFETY

Cribs and cradles should be secure places for parents to leave their baby unattended. However, a consistently high number of injuries associated with cribs, cradles and bassinets are observed over the past two decades in the US[5] [4]. The most common injury was falling. Most of these incidents were associated with cribs, which often has a drop side latch that may fall down or may be left down unintentionally. The percentage of fall related incidents increased with age. To prevent such incidents it is important that cradles are not used for babies older than the age of 6 months, which is when they usually begin to pull themselves up.

A general cause of fatal incidents was being wedged between the mattress and the side of the crib, or being trapped facing down in the bedding, causing suffocation. Suffocation may also occur if babies fall from the crib side causing their clothes to get caught around any protruding parts.

Proper design and manufacturing combined with correct setup and use are essential to prevent injuries and deaths. The cradle should be designed with particular emphasis to prevent falls and entrapments.

[5] An estimated average of 9561 children younger than 2 years of age were injured every year

4.2 SAFETY REGULATIONS

The crib should be designed in accordance with existing safety standards. This will protect children from unreasonable risks of injury as well as improve product quality, build consumer confidence and facilitate market trade and access.

The VAPA mechanism is patented in Europe and The United States, and focus will be on the standards applicable for these markets.

This report takes account of two prevailing standards: ASTM F2194-10 Standard Consumer Safety Specification for Bassinets and Cradles provided by ASTM International [5] (Applicable for the US) and BS EN 1130-1:1997 Furniture - Cribs and cradles for domestic use [6] provided by British Standards Institution (Applicable for Europe). Where the two standards contradict, the most conservative requirement will be emphasized. Safety standards for Bassinets and cradles: Notice of Proposed Rulemaking provided by the Consumer Product Safety Commission (CPSC) [7] will also be used as a guide. If the cradle should also be sold to institutions, additional requirements may apply.

The standards apply for cradles designed for infants that are not able to sit, kneel or pull themselves up (usually at the age of 0 to 6 month).

The most relevant regulations for the design of this cradle are described below

Access zone 1 refers to the space around the cradle which an infant can access. Access zone 2 refers to the space not covered by access zone 1.

4.2.1 CONSTRUCTION

The internal bed base must not exceed 900 mm and the height of sides and ends of the crib should be at least 275 mm. A distance of at least 25 mm must exist between the crib-body and any frame. There must be no protruding parts in access zone 1. Protruding parts, small components and exposed edges in access zone 2 must be chamfered or have radii of minimum 2 mm and be free of sharp edges. Wood parts shall be smooth and free of splinters. Open-ended tubes are not permitted. Any holes or slots with a diameter greater than 5 mm in access zone 1 must not exceed 10 mm in depth.

4.2.2 SLEEPING PAD

The cradle must be sold complete with sleeping pad. F2194-10 emphasize that the filling thickness of this mattress must not be greater than 2.5 mm. The pad must not leave a gap between the perimeter of the pad and the perimeter of the crib that is greater than 13 mm when placed in the middle of the cradle.

4.2.3 REST AND SWING ANGLE

There are currently no maximum US or European requirements for swing or rest angle for cradles. However, the CPSC recommends a maximum 20 degrees rock/swing angle[6] and a maximum mattress angle of 5 degrees[7] [7].

The CPSC also emphasize the importance of a level crib (when not swinging or rocking) to facilitate a safe sleeping environment. Even when the infant is being laid at the edge or in the corner of the sleeping surface, the surface must not tilt. According to [7] a non-level sleeping surface can cause the infant to roll to a corner and get trapped or even suffocate.

4.2.4 MATERIALS

Wood-based materials and materials of vegetable origin shall be free from decay and insect attack. Metal within access zone 1 must be protected against corrosion.

In addition it is important that the cradle is tested properly in accordance with EN 1130-2:1996 [8] and test methods covered in F2194-10.

Table 8 summarizes the most important requirements and recommendations.

[6] based on the Canadian standard for cribs and cradles, SOR 86-962

[7] based on conclusions from the Australian study "The Danger of Freely Rocking Cradles" and the Australian/New Zeeland standard for cribs and cradles, AS/NZS 4385:1996

Section	Requirements
1	**Mandatory**
1.01	Side heights must be at least 275 mm
1.02	The internal bed base must not exceed 900 mm
1.03	A distance of at least 25 mm between cot and frame
1.04	No protruding parts in access zone 1
1.05	All sharp edges must be chamfered or have a radii of minimum 2 mm
1.06	No open-ended tubes
1.07	No holes or slots in access zone 1 greater than 10 mm in depth if the diameter exceeds 5 mm.
1.08	Pad thickness must not exceed 2.5 mm
1.10	Pad must not leave a gap that is greater than 13 mm in the cot
1.11	The cot must stay level when tested in accordance with EN 1130-2:1996 and F2194-10
1.12	Materials of vegetable origin shall be free from decay and insect attack
1.13	Metal within access zone 1 must be protected against corrosion
2	**Recommendations**
2.01	Maximum 20 degrees rock/swing angle
2.02	Maximum mattress angle of 5 degrees

Table 8 Safety requirements

4.3 PRODUCT REQUIREMENT SPESIFICATION

The Product Requirement Specification (PRS) contains quantifiable and measurable goals and requirements to determine limitations in the design process. It is based on safety requirements and observations from the URS.

Criteria from the safety requirements and criteria that are essential to place the product at the desired place in the market are primarily listed as “shall”s. Positioning requirements that are not crucial, but may increase the customer value are listed as “should”s.

The Product Requirement Specification is used in later stages of the project, for instance in the concept evaluation stage.

Product Requirement Specification

Section	Description	Shall	Should
1	**Functional requirements**		
1.1	Accommodate a baby up to 9 kg[8]	√	
1.2	Accommodate infants at the age of 0-6 months		
1.3	Be able to rock at the desired frequency	√	
1.4	Provide a sleep environment for the baby	√	
1.4	Provide a 3 degree rest angle to offer sufficient air supply to the baby[9]		√

[8] The weight of an infant test dummy presented in EN 1130-2:1996 [8]

[9] [10] show the importance of sufficient air supply around the baby’s head

2	**Operational requirements**		
2.1	Offer a convenient height for caregiver to rock or pick up/lay down the baby		√
3	**Safety requirements**		
3.1	Satisfy requirements defined in **F2194-10** and **EN 1130-1:1996**[10]	√	
4	**Appearance requirements**		
4.1	Curved edges	√	
4.2	Simple shapes	√	
4.3	Neutral colors		√
4.4	Decoration		√
5	**Environmental requirements**		
5.1	Sustainable materials		√
5.2	Non-hazardous materials	√	
5.3	Easy to flat pack		√
6	**Production requirements**		
6.1	Consist of few parts		√

Table 9 PRS

[10] See table 8

CHAPTER 5: STRUCTURE AND DESIGN

5.1 EXISTING DESIGN

A prototype of the cradle has previously been built at the Department of Engineering Design and Materials for testing. Any other designing of the cradle has not been conducted at this moment.

Figure 10 Existing prototype of the cradle

5.2 ANALOGIES

When generating sub-functions for a concept, analogies can be helpful. Products with different applications might have similar solutions or mechanisms and a wide range of products should be considered. Analogies for the design and for the tilting mechanism were used as inspiration.

Figure 11 Design analogies

Figure 12 Tilting mechanism analogies

5.3 STRINGERS

It has previously been considered to make VAPA stringers by milling molded polyamide or POM boards for use in chairs [9]. The method could be used to produce the tilting part of the stringers, but this would be costly and also interfere with the design specifications. A more affordable and elegant solution could be to use straps to enable the desired rocking motion.

Figure 13 VAPA chair stringers made from Polyamide [9]

In this thesis the stringers are thought to be made with leather straps, after discussions with the supervisor.

Stringer material	Pros	Cons
Leather	Organic, modern, aesthetic, durable, affordable, easy to assemble	May smell. Allergies to chromium, adhesives and preservatives in the leather may in worst case occur, but the allergy develops at the site of contact between the skin and leather, and is not airborne.
Plastic	Durable, sanitary, discrete look	Expensive to produce, may require more advanced assembly than straps. Might be perceived less attractive by some customers.

Table 10 Stringer evaluation

5.4 DESIGN BRAINSTORMING

The second brainstorming with the reference group was held at April 20th. Participants were Trond Are, Mats, Lise and Hege. The members were asked to produce design- and principle-sketches of both cradle and chair. After 40 minutes there was a brief pause where everyone presented and discussed their ideas. Then the group conducted a new set of 40 minutes sketching.

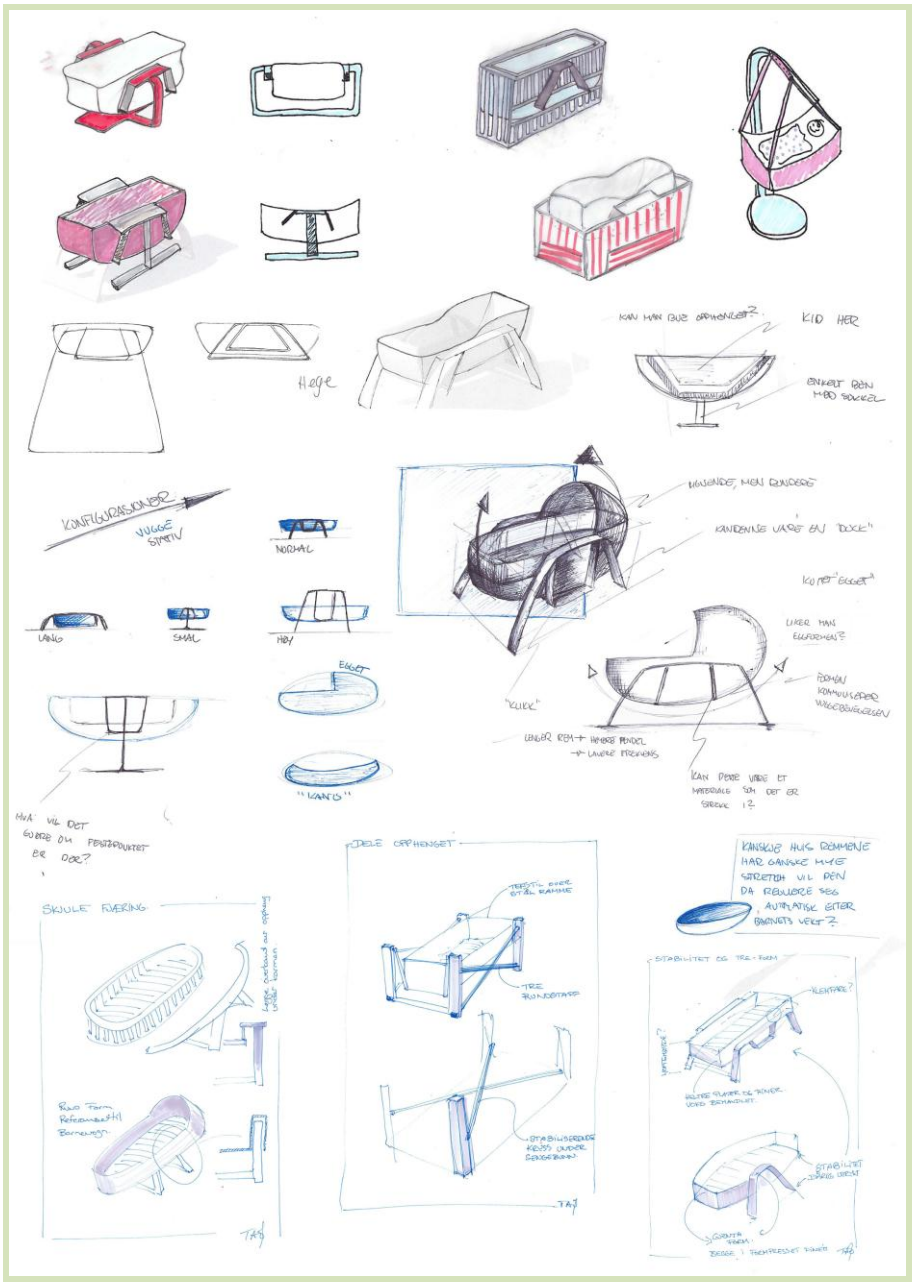


Figure 14 Sketches from the second brainstorming with the reference group

5.5 SKETCHES FROM SOON DESIGN

The design company Soon Design was hired by concept initiator to assist in the cradle design. Most of the sketches interpret the VAPA mechanism incorrectly and some sketches are too edgy and contradict with the design requirements from the PRS. The drafts may still be used as inspiration during the design process.

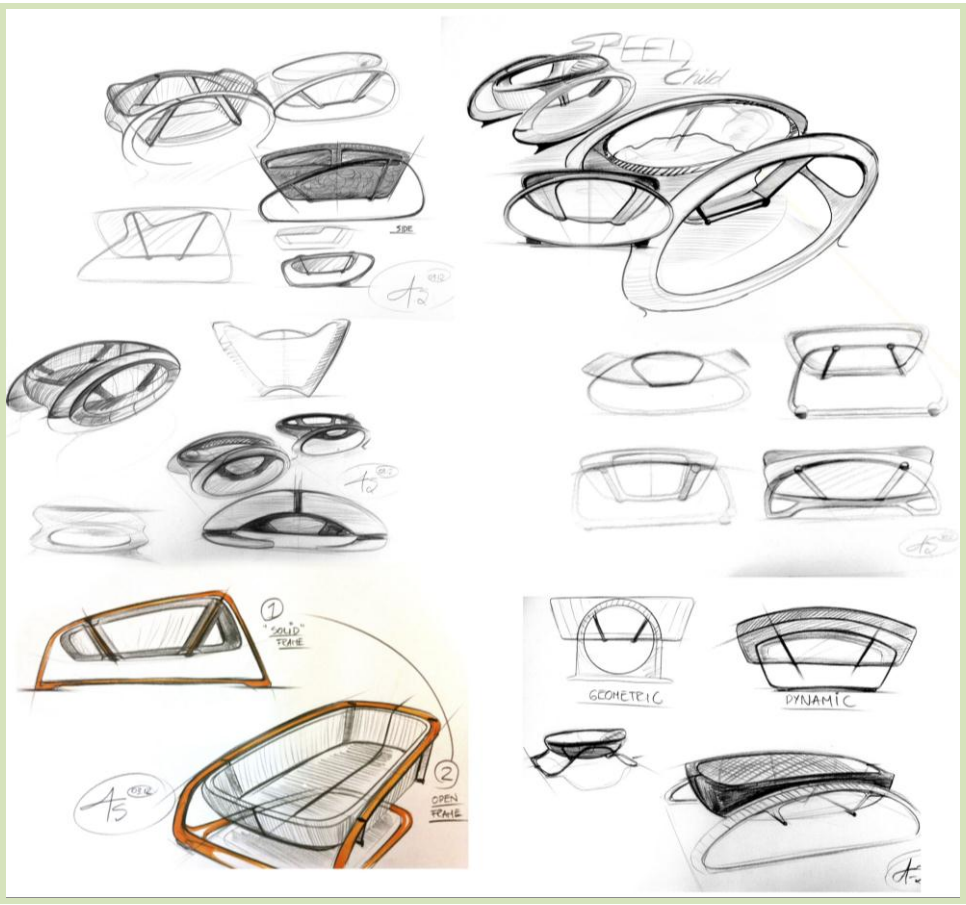


Figure 15 Sketches provided by Soon Design

5.6 CONCEPTS

Different ideas for a VAPA cradle were drafted after the second brainstorming with the reference group. The competitor analysis and sketches from Soon Design were used as additional inspiration. The concepts were evaluated based on safety, appearance and feasibility (see table 11). Concept 4 was announced the winner, and will be basis for the further design process.

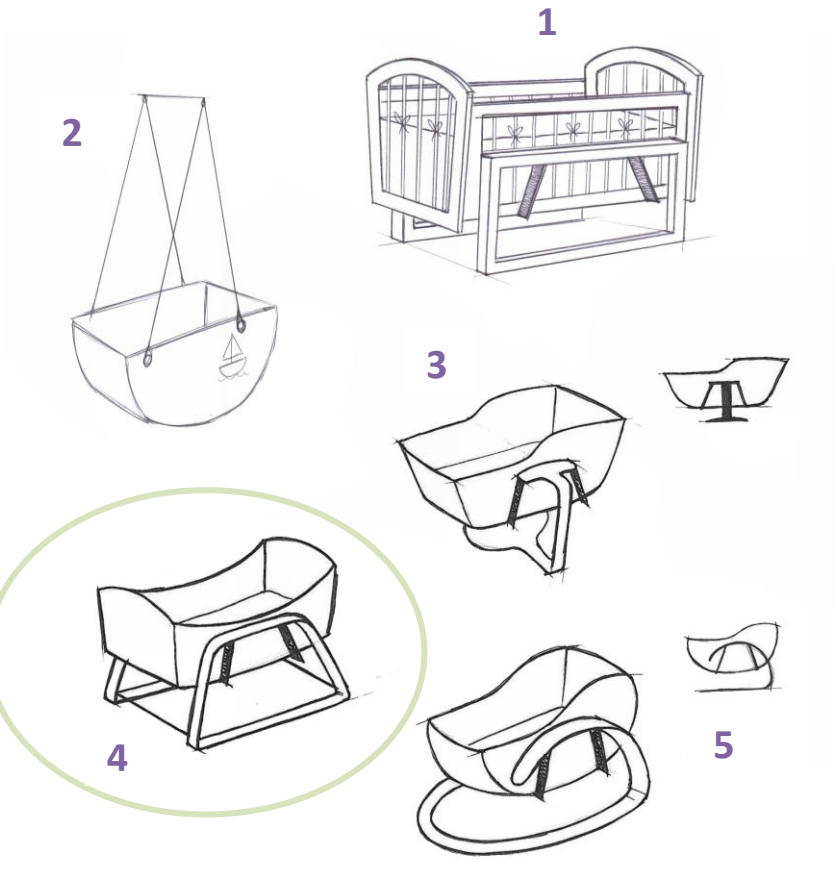


Figure 16 Preliminary concepts. Concept 4 will be basis for further work

Concept	Description	Pros	Cons
1	A classic crib in combination with the VAPA mechanism. A bumper pad prevents the baby from getting arms or legs trapped between the rails.	Rails give an open impression and enables easy insight to the baby.	Bumper pads have been criticized for being a suffocation hazard for young children [4]. Rails makes the assembly process complex.
2	The cradle is suspended above the baby: From the roof or from a rack. The cradle may be made of fabric which makes it easy to store and flat pack.	Few parts. The simple design can give benefits related to cost, production and transportation. The cradle cannot tip over by pets or siblings.	The suspension makes the system difficult to move from room to room. Controlled movement at the desired frequency may be a challenge.
3	The Stringers are minimized in relation to the current solution.	Reduces the size of the system and makes it more elegant.	May be difficult to make the system strong and stable.
4	The stringers are similar to the current solution, but the cot is lifted up from the floor.	A stable construction ensures the safety of the child.	No particular.
5	The stringers are made more organic than the current solution.	Reduces the size of the system and makes it more elegant.	The stringers appear unstable. The system may collapse if the older brother decides to sit on it…

Table 11 Concept evaluation

5.7 DEVELOPMENT OF CONCEPT 4

A variety of sketches were made based on the chosen concept. Figure 17 shows different systems of combined cots and stringers. Note that design 6 should only be considered with regard to the cot design. Figure 18 shows a variety of different cots and stringers based on the chosen concept.

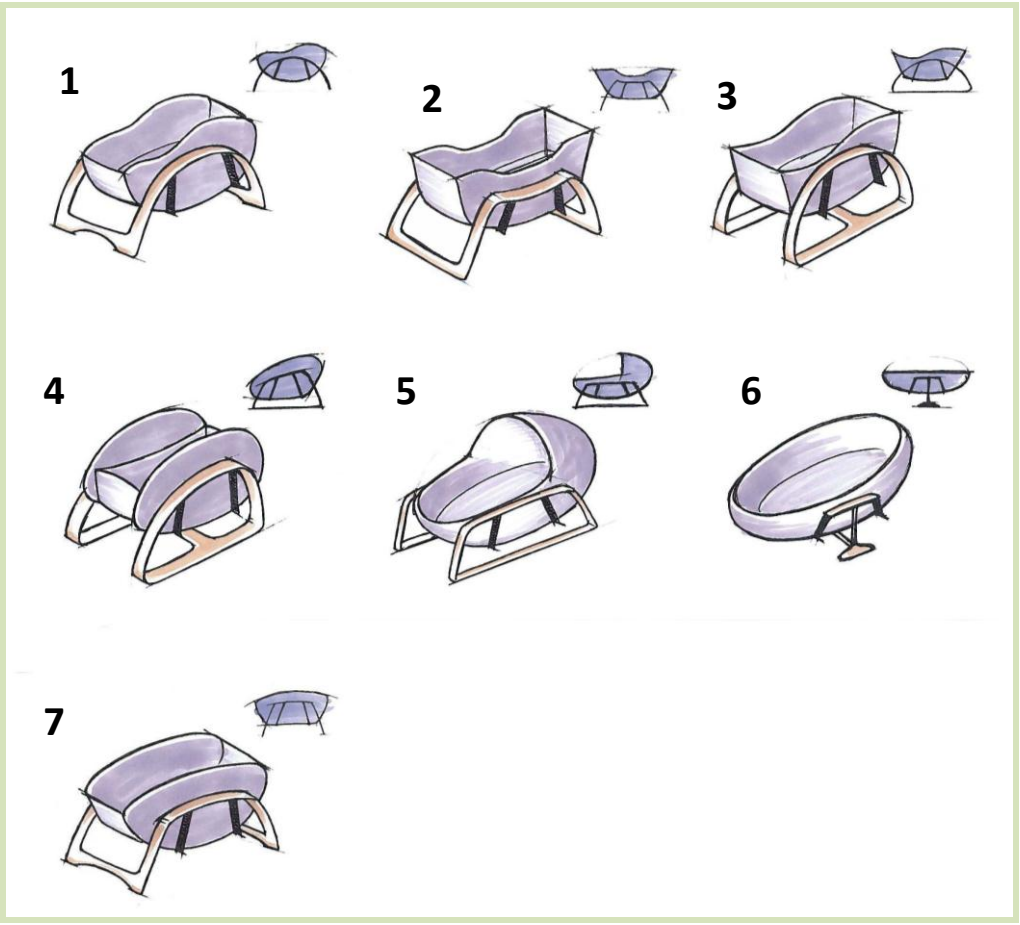


Figure 17 Design ideas based on concept 4

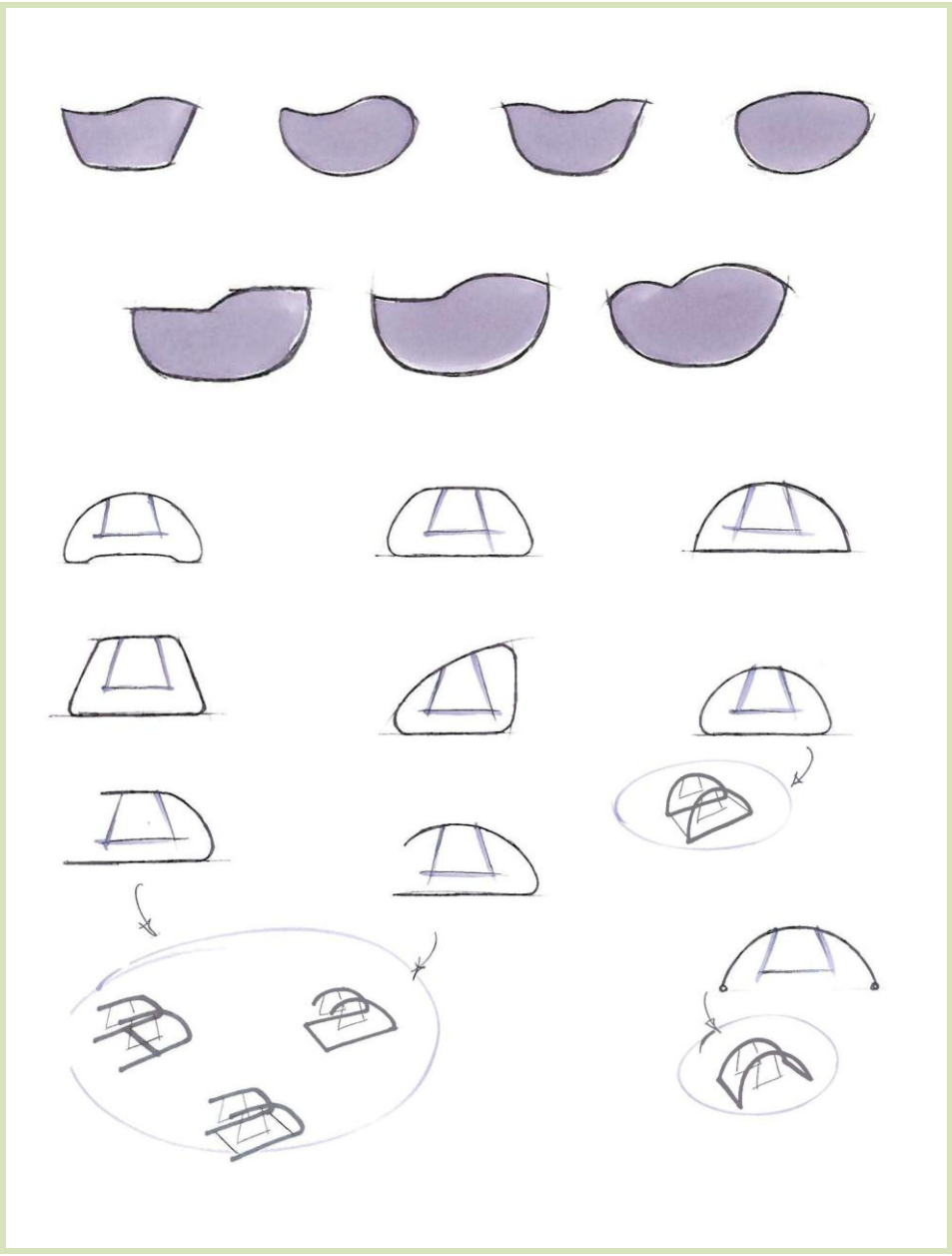


Figure 18 Assorted cot and stringer shapes

5.7.1 EVALUATION OF DESIGNS

The evaluation was conducted together with supervisor Terje Rølvaag, reference group member Lise Abrahamsen Kratter and Melissa Mørch Kerrison who are familiar with similar products, as she has a son at the age of 12 month. Requirements from the PRS were used as guidance. The cradles were criticized due to aesthetics, functionality and safety. The evaluation is summarized in table 12.

Design	Cot	Stringers
1	Clean lines and organic design. Gives associations to a traditional pram.	Clean lines, classic design. Looks stable. Will be easy to produce.
2	Old-fashioned cradle design.	Stringers should better adopt the shape of the cot.
3	Wave shaped version of the traditional cradle. Edges are too sharp.	Organic shape. Looks stable and may be easy to produce and flat pack.
4	Organic shape that resembles an egg.	The stringers should not be asymmetric.
5	Traditional carry cot combined with an organic egg shape. Modern, but too massive design.	Stringers are narrower than the other designs. They look stable but the height may be too short.
6	Open solution gives good insight to the little one. The oval shape may make the cradle too wide.	Will probably be unstable.
7	The shape may be designed slightly different to make the cot more subtle	The stringers do not match the cot.

Table 12 Design evaluations

5.8 FURTHER DESIGN DEVELOPMENT

It was decided to work further with organic shapes and shapes inspired by traditional cradles and prams. When designing the stringers it was emphasized that they should be stable and easy to produce and assembly. It was also considered to make the stringers taller to make it more convenient for carer to pick up/lay down the child.

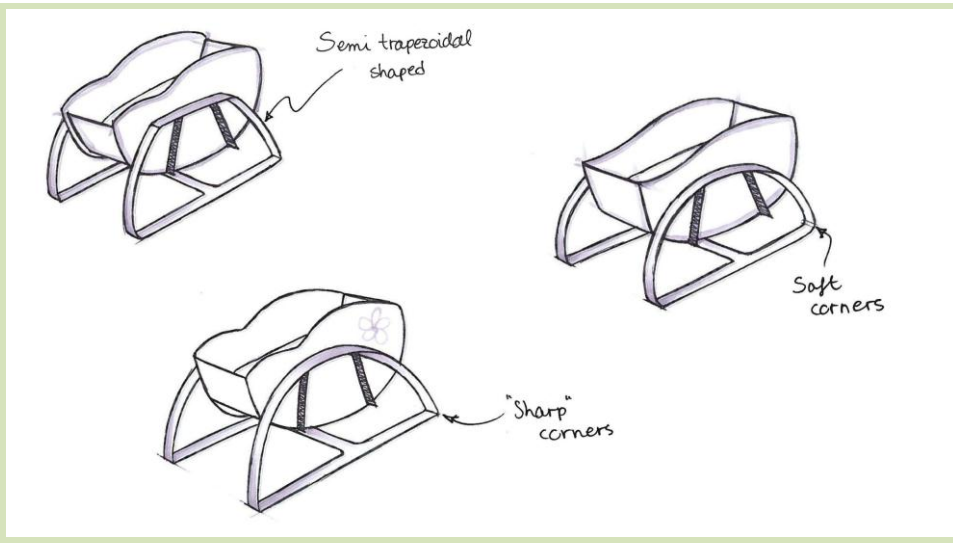


Figure 19 Design ideas

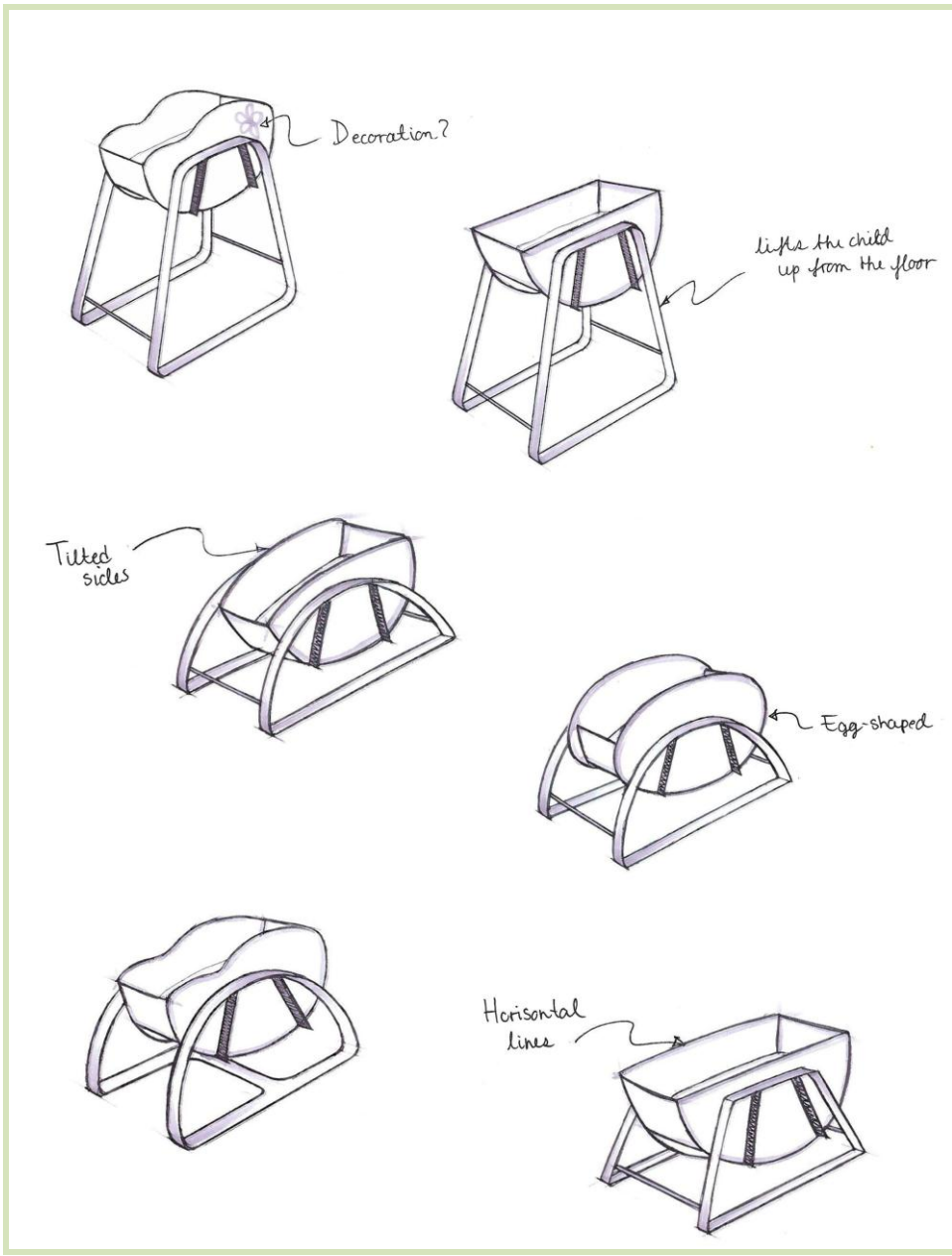


Figure 20 Design ideas

CHAPTER 6: FINAL DESIGN

6.1 SHAPE AND APPEARANCE

The final design has clean lines and curved edges. Additional character can be added in terms of color and décor. The cradle consists of few parts and should be easy to assemble. A total of four different cots were created after analyzing two different shapes in NX. Figure 21 display sketches of the two main shapes.

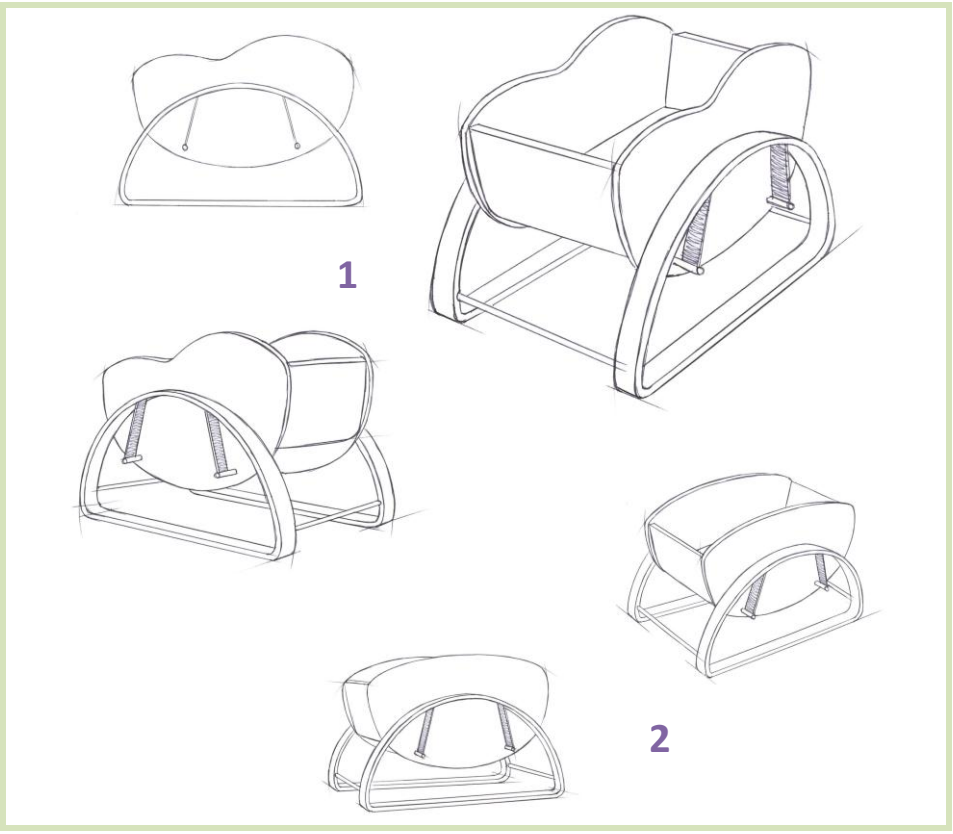


Figure 21 Final design

6.1.1 DESIGN 1

The sides of the cot are curved to make it cute and baby-like. The shape was originally inspired by traditional prams as they in the last few years have become iconic.

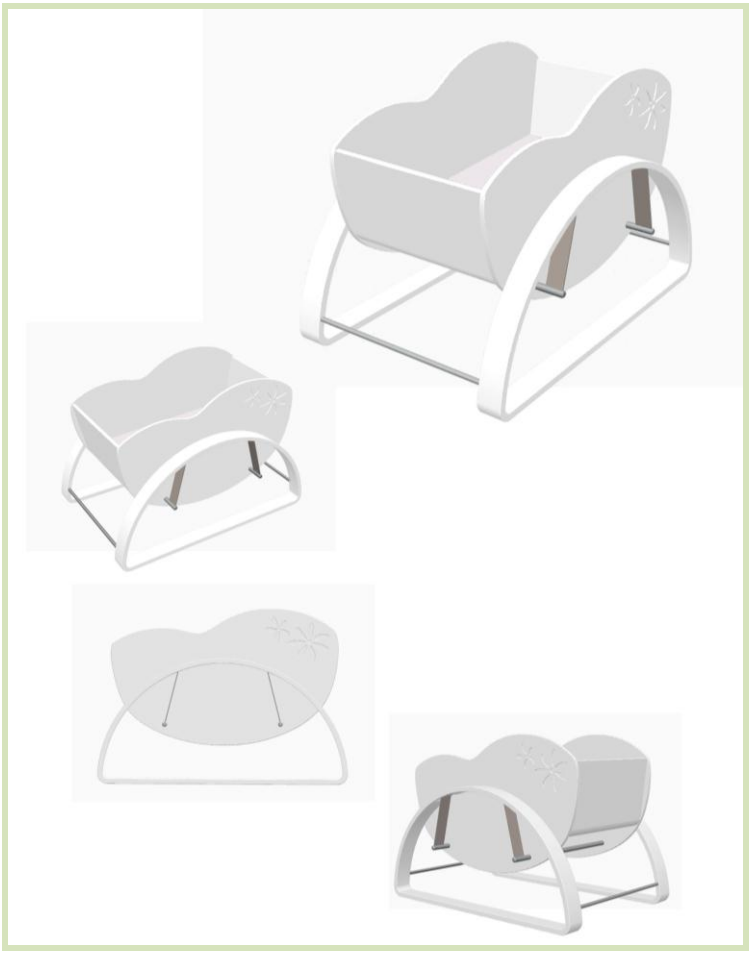


Figure 22 Final design 1

6.1.2 DESIGN 2

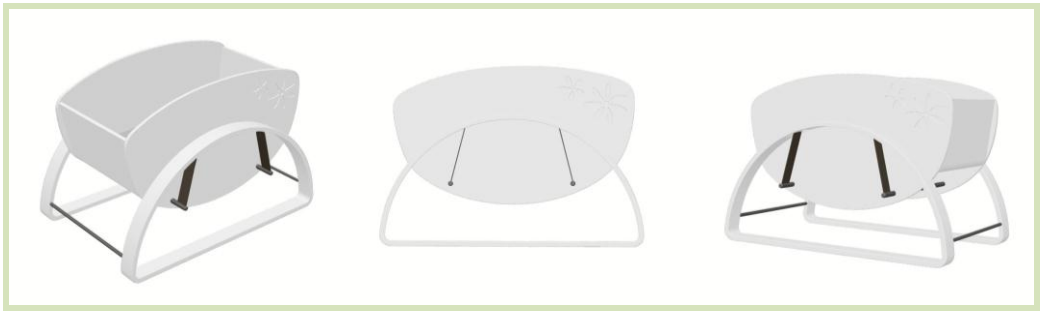
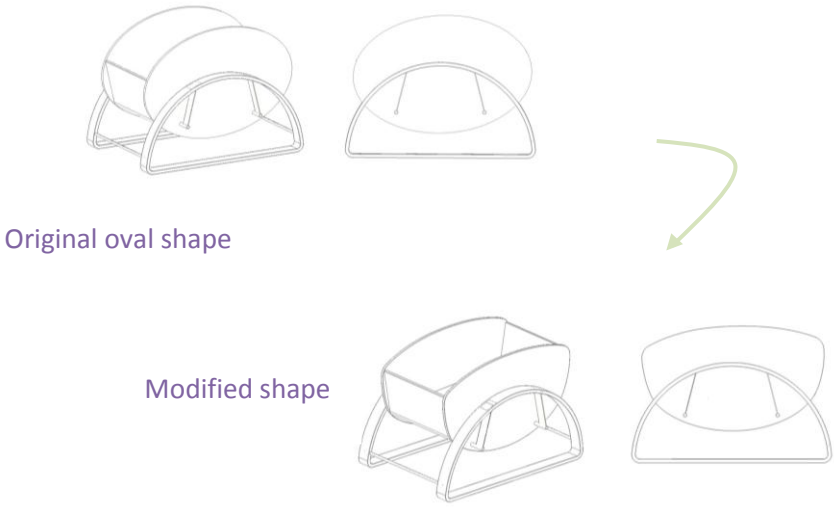


Figure 23 Final design 2

Concept initiator was initially found of the egg shaped sides. When modeling the cradle in NX it was discovered that the oval shape would make the appearance of the cradle massive. The oval shape was modified to make the design look less heavy and to provide more insight to the baby.



6.1.3 DESIGN 3

Figure 24 Final design 3

This is another variant of the oval shape, where the top has been cut off to get easy access to the baby. The cradle has been given four legs by modifying the stringers, to create a different look.

6.1.4 DESIGN 4

Figure 25 Final design 4

The shape of the sides are similar to the first design, but the corrugated shape of the cot has been toned down and the overall shape is more organic.

6.2 SIZE AND STRUCTURE

To ensure adequate air supply for the child, the sleeping pad is tilted so that the head is 3 degrees higher than the feet at rest position (see figure 29). This will for instance be an advantage if the baby has coryza. [10] mentions the importance of sufficient oxygen supply to the baby in order to prevent Sudden Infant Death Syndrom (SIDS).

The cradle has inner dimensions of 430x780 mm and the front and back walls are 275 mm tall. The height of the cradle is approximately 700 mm, but varies between the different designs. The length of the cradle is 900 mm. The sleeping pad thickness is 25 mm. The stringers are placed at a distance of 25 mm from the cot

Metal rods are chamfered and all edges are blended and have a radius of 2 mm.

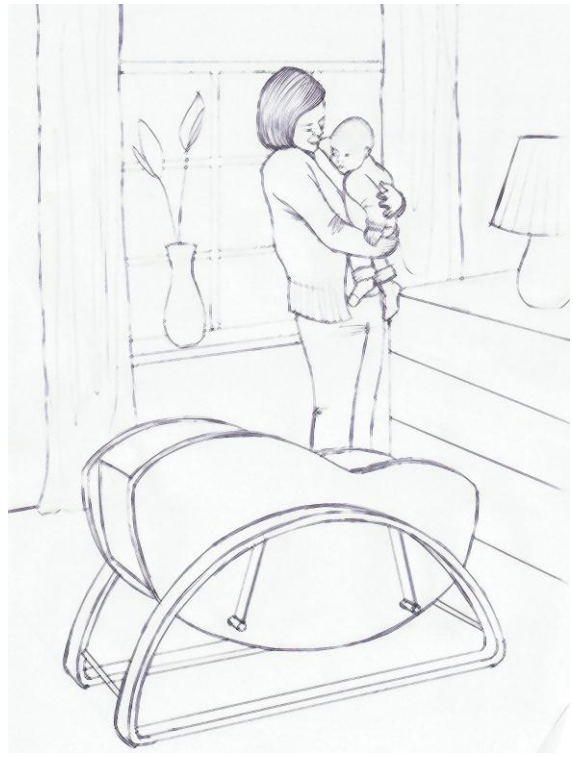


Figure 26 Approximate size of the cradle in relation to humans

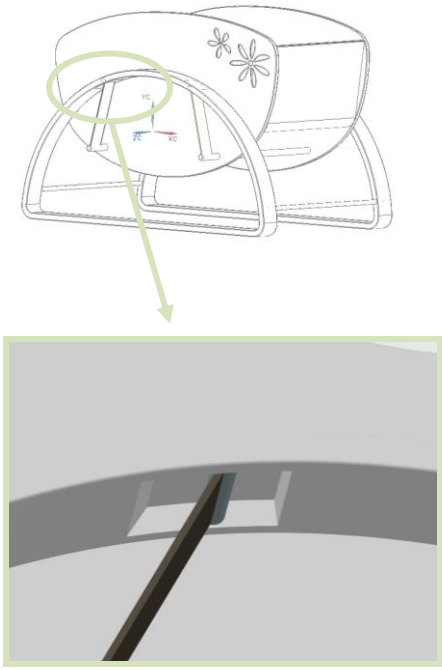


Figure 27 Belt suspension

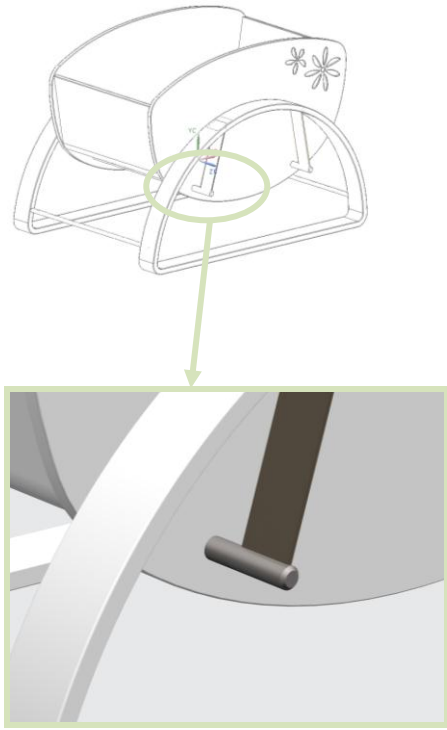


Figure 28 Edges are blended and rods are chamfered

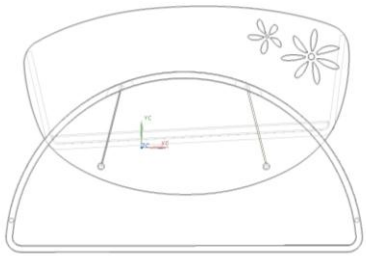


Figure 29 Wireframe model of the cradle. The sleeping pad is tilted 3 degrees at rest position

6.3 INTERIOR EXAMPLES

Figure 30 and 31 show the designs in different surroundings. The cradle may be used in the bedroom at nighttime or in the living room during the day. The simple design lets the cradle blend in with a variety of interior styles.

Figure 30 Interior example 1

Figure 31 Interior example 2

6.4 COLOR OPTIONS

The cradle may come in different woods, colors or patterns, as shown in figure 32. The color proposals displayed are based on findings in the user analysis. Colors such as light woods, white, beige, brown and grey tones are easy to combine with other colors, and are currently in fashion. Vivid colored patterns are fun and fits well with a children's bedroom.

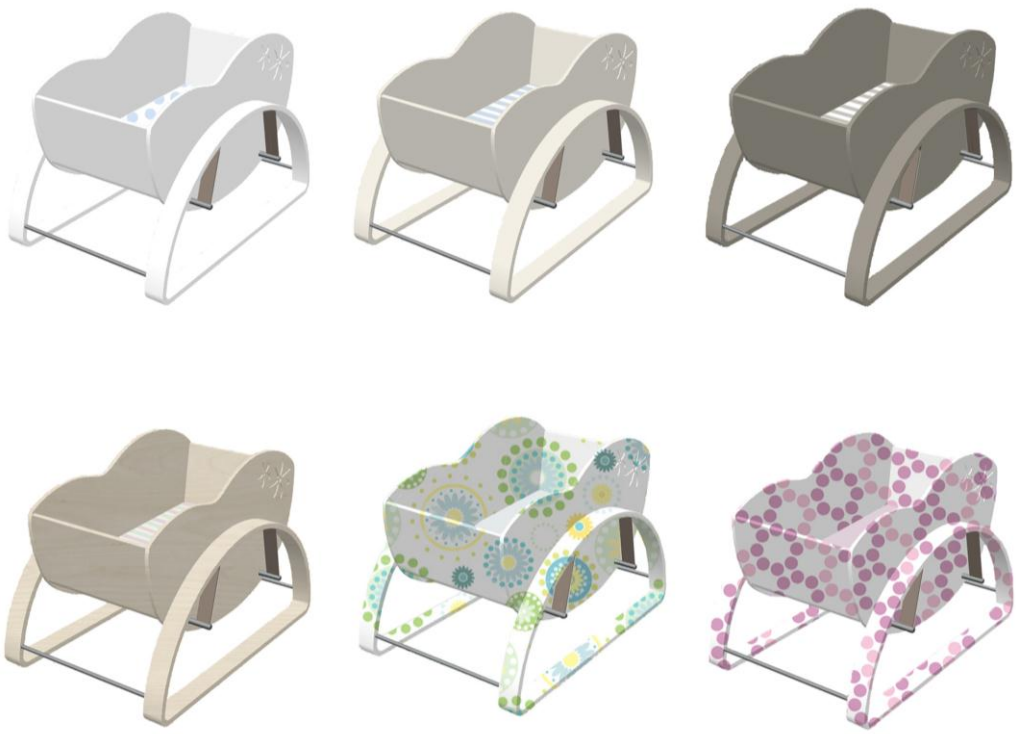


Figure 32 The cradle displayed in white, cream, taupe, birch veneer, green pattern [11] and pink pattern [12]

6.5 DÉCOR

Figure 33 Décor options

A décor may be added to one or both sides of the cradle as shown in figure 34. Plexiglass openings may be added to get an open look and enable more insight to the baby. This also allows the baby to pay more attention to its surroundings. A proposal is shown in figure 34.

Figure 34 Cradle with plexiglass

6.6 MATERIAL PROPOSALS

Material properties have not been analyzed in this thesis, but due to design aspects the cot is proposed to be made of plywood covered with laminate or birch veneer. Plywood is a strong material that can be shaped easily for the suggested design. The stringers could be produced in laminated wood. Birch is a wood that have long traditions in Scandinavian furniture, and can give the cradle an association to Scandinavian design. Beech is an alternative that will give the same associations. Based on table 10 it has been chosen to use leather for the straps.

These materials are all from renewable sources and can be recycled or as a minimum be used for energy recovery.

A children's furniture company named Green Lullaby makes all their products out of cardboard. This may be a fun idea to attract environmentally conscious customers.

Sustainable and natural materials such as organic cotton and bamboo are diligently used among many of the most popular cribs and cradles on the market. However a sales person at the baby gear store Bebito claims that this is an expiring trend amongst parents today, and that it is more important that the material looks good.

6.7 EXTRA FEATURES

6.7.1 LOUDSPEAKER AND SCREEN

Concept initiator has already played with the idea to add a loudspeaker and a screen to the cradle, to simulate any environment.

There are a variety of popular baby soothing apps available for iPhone or Android simulating everything from lullabies and the sound of rain and waterfalls to a mother's heartbeat and white noise such as hair dryers and vacuum cleaners[11]. One app also lets parents record their own voice[12]. If a docking station for iPhone or Android is added, caregiver can simply download the sound or video that work best for their child. This provides more options than if the system only has a number of prerecorded effects.

IPhone has baby monitoring apps, but parents are advised to use a conventional baby call monitor instead due to safety reasons [13]

6.7.2 ACTUATOR

It was attempted to find an actuator especially designed for rocking cradles. Even though several cradle rocking actuators have been patented during the past 30 years, it seems like none has been commercialized yet.

[11] Baby Soothe, Womb sound, Sleep pillow among others

[12] Voice sleep baby

6.7.3 TOY BAR

A toy bar or baby mobile arm may be added to the cradle to amuse the baby. Toy bars and mobiles are great options if the parents are skeptical of using technology to comfort their baby.

Figure 36 Illustration of toy bar

Figure 35 Illustration of mobile arm

6.7.4 DAY CUSHION FOR NEWBORNS

A day cushion that fits the cradle may be sold separately to provide extra support to newborns, premature and low birth weight babies and keep them snug. Some newborns feel comfortable and secure in confined surroundings after having spent the first 9 months of their life in their mother's womb. Figure 37 shows a versatile cushion[13].

Figure 37 Illustration of cradle cushion

[13] Cuddle-Soft liner from Sunshine Kids

CHAPTER 7: CONCLUSION AND RECOMMENDATIONS FOR FURTHER WORK

The project has taken the cradle concept to a level where design has been decided and additional functionality has been suggested. There are still considerations to be taken with regard to optimization of production, assembly and packing. Material suggestions for the cradle have been made but adequate analyzes will be needed. The cradle must be dimensioned and then tested in accordance with prevailing safety standards.

It is also recommended that the cradle is tested by babies and their parents to confirm the effect of the VAPA mechanism. The original plan was to do so using the existing prototype. However the prototype was sent to Stokke a while ago and has not been available through this semester.

The cradle designed in this project is an integrated solution. However with minor adjustments it may be easy to make it module based. With a proper universal attachment device on the stringers parents can use carrycots or car seats etc. with the VAPA mechanism.

Some sort of folding mechanism may be developed to make the cradle easy to store.

Research was done to find an actuator especially designed for rocking cradles. As this was unsuccessful, a suitable actuator that can control the amplitude properly when rocking the cradle, should be developed.

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12. Anechka, *Pattern circles*, VectorStock.

13. Henriksen, A.B. *Ipaden kan hjelpe ditt barn å sove*. 2011 [cited 2012 01.07]; Available from: http://www.klikk.no/foreldre/helse/article716627.ece.

APPENDIX

APPENDIX A: LIST OF FIGURES

APPENDIX B: LIST OF TABLES

Bakgrunnsinformasjon til VAPA-vugge — Av Eirik Andersen og Cecilie Kjellevold, 09.06.2010

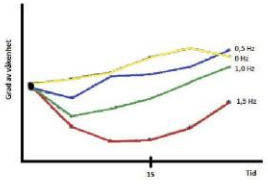
Bevegelsesmønster.

Det er gjort få studier for å finne ut hvilke faktorer som gjør at en vugge er en effektiv metode for å få små barn til å sove. Men det som finnes av forskning innen området peker i samme retning.

Bevegelsesmønsteret til en vugge kan deles inn i tre deler:

1. Frekvens

En forsøk fra University of Western Ontario ble i 1973 gjort for å teste hvilke frekvenser som fikk 64 stk 2mnd. gamle spedbarn raskest i søvn. Målinger av hjerterytme og visuell vurdering av barnets grad av oppmerksomhet viste at barn utsatt for 1,5Hz svingninger raskest falt i søvn. Grafen viser grad av våkenhet. Barna ble utsatt for svingningen i de første 15 minuttene.



Det er lite annen forskning på frekvenser påvirkning på spedbarn. Det mest av slik forskning er utført på voksne testsubjekter. Spesielt innen bilindustrien er dette aktuell forskning. Testene som er utført tilsier at voksne finner frekvense i overkant av 1 Hz behagelige. Man skal derimot ikke ha stor differanse før det virker direkte ubehagelig. Under 0.8Hz gjør testsubjektene kvalme og over 2 kan være skadelig. Ut i fra dette antar vi at svingninger kan ha den samme ubehagelige effekten på småbarn og det er derfor viktig å kunne kontrollere svingefrekvensen i en vugge nøyaktig.

2. Amplitude

Vi har ikke tilgjengelig noen rapporter som har fokusert på denne faktoren, men under forsøkene med ulike frekvenser var amplituden satt til 3" altså beveger vuggen seg +-4cm fra nullpunktet. Ved en frekvens på 1,5Hz, som gir en svingetid på 2/3 sek, høres dette ut til å være i det øvre sjiktet av hva som er behagelig amplitude ved denne hastigheten.

3. Bevegelsesretning.

De siste årene har vugger endret fra å bevege seg fra side til side til å vugge i lengderetningen. Dette skal være bedre for barnet og få det raskere i søvn. Det ville i tillegg vært interessant å vite hva som er det optimale rotasjonspunktet. Plassering av rotasjonssenteret vil også ha en effekt på hva som vil være optimal amplitude på svingningen. Rotasjon om et punkt vil kunne takle større amplitude enn rene lineære bevegelser i horisontalplanet.

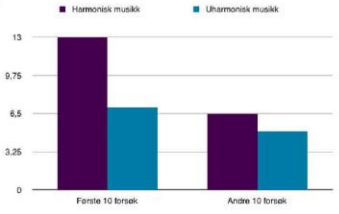
Musikk:

Følelser i stemmen:

Vuggesanger har vært brukt i alle tider for å dysse småbarn i søvn. Hvorfor den beroligende stemmen til far og mor roer ned spedbarn er det viktig å vite hvs man ønsker å erstatte sangen med musikk, og dette har det blitt forsket på. Undersøkelser har vist at en viktig del av vuggesangen er den menneskelige kontakten, barnet oppfatter følelsene i stemmen, men type musikk som synges eller spilles av er også en viktig faktor. Barn reagerer positivt på harmonisk musikk.

Harmonisk og uharmonisk musikk:

Figuren under viser en test hvor spedbarns oppmerksomhet rettet mot musikken som blir avspilt ble målt. Lilla kolonne er tiden barna var oppmerksom på harmonisk musikk, mens den blå kolc ene vise



Klassisk musikk:

Det har også blitt gjort tester på hvilken musikksjanger som er mest effektiv på småbarn og her kommer klassisk musikk godt ut. Klassisk musikk har generellt god påvirkning på hjerneaktiviteten til barn. Flere studier har vist at klassisk musikk gjør barn mer avslappet og gir klare helsefordeler. Rolig gitar musikk er brukt i studiet som er nevnt ovenfor, artister som Eric Clapton har rolig gitarmusikk som virker terapautisk og beroligende på både barn og foreldre. Og i en undersøkelse utført ved Nova Southestern University viste resultatene at tiden det tok for et spedbarn og sovne ble redusert med hele 30% når det ble spilt klassisk gitarmusikk mens barna sov.

Mean Sleep Onset Time (in minutes) During Naptime Music (no music) for Toddlers an Preschoolers		
	Music	No music
Toddlers	16.9	26.0
Preschoolers	30.0	37.9

Produsenter:

1. Stokke - Kjent for skandinavisk design kombinert med god funksjonalitet. VAPA-vugge ser ut til å være et produkt som passe godt inn i deres produktsortiment.
stokke.com/no-no/contact-us.aspx

2. Simo og Brio - Delvis sammenslått i firmaet European Nursery Group AS. Markedsledere i Skanidnavia innen barneutstyr. Har fra før et stort utvalg av vogner og barnesenger.
konsument_no@engbaby.com, info@brio.net

3. Graco og Fisher-Price - Store amerikanske produsenter av barneutstyr med et svært bredt sortiment. Begge har allerede en del ulike motoriserte husker/vugger fra før, men "plast"-faktoren på disse er høy og innovasjonshøyden lav.
fpconaff@Fisher-Price.com

4. Britax) asjonal produsent av sportsvogner, bilseter m.m. Har ikke noen form for barneseng i sortimentet. service.no@britax.com

5. SO-RO - Vugger med norsk design og produksjon, men svært rettet mot design. service.no@britax.com

Title: Virtual Adjustable Pivot Axis Vogge (VAPAV)		Dato: 18/09-2010
Keywords: VAPAV baby cradle	Written by: Terje Rølvåg	Reference: Input to VAPA cradle design

Current situation:

Infant cradles are designed to comply with traditional rules. That means sideways motion (roll), handcrafted designs, traditional wood and no additional features stimulating sleep.

All cradles have one roll degree of freedom. That make no sense since roll motion tend to make babies seasick rather than tired. The roll motion also creates an unwanted sideways baby translation since the roll axis is located below the cradle. Here is one typical design:

Research [1,2,3] indicate that coupled longitudinal and vertical oscillations with 2-3 cm amplitudes, in the frequency range of 1-1.5 Hz, make kids fall asleep. Unfortunately, no existing cradle designs enable this motion.

Solution:

The patented VAPA mechanism concept enables the desired cradle motion. The invention is based on one or two flexible 2D structures. The flexible structure allows two translational and a flexible tilting rotation about a virtual pivot axis (3 degrees of freedom / DOF's).

The tilting stiffness is given by the geometry and thickness of the flexible 2D structure.

The direction of the pivot axis is defined by the two pivot points or the surface normal of the flexible structures. The centre of rotation is given by the geometry and can be outside the volume of the flexible structure itself.

VAPA Benefits:

Cradle motion that makes the baby fall asleep.

•The tilting characteristics are optional, and by locating the pivot axis above the cradle the baby will feel like sleeping in a hammock.

•The tilting characteristics is simply altered by selecting different flexible structures giving the cradle an eigenfrequency in the desired range (1-1.5 Hz).

•The amplitude (2-3 cm) can be controlled by an actuator located under the cradle. The structures also have linear tilting characteristics until self contact occur (can be limited to 3 cm). Then it still allow flexible motion but the stiffness increase.

Other sleep-inducing factors.

• VAPA may include sound and display systems for visual and auditive effects simulating any environment . It is proven that some music, running cars and trains are sleep inducing factors [2]. I would like to add a wide range of movies ...

Scalable design

•VAPA can be designed for both infants, babys, larger kids and adult insomnia patients. The flexible structures can be dimensioned for any load and application

Modular design.

•The VAPA cradle is a platform solution with many optional add-ons adding functionality and comfort. The VAPA cradle can be market as a modular or a high end integrated cradle system as shown below.

The VAPA frame give you the desired longitudinal and vertical cradle motion!

An actuator creates resonance at the right frequency (1-1.5 Hz)

Any bag or custom bould cradle can be used with WAPA.

Add loudspeakers and a monitor to simulate any environment

References:

[1] Hitoshi Kimura, Mami Endo, Michihiko Koseki and Nori Inou, Tokyo Institute of Technology, Dept. of Mechanical and Control Engineering,"Sleep-inducing factors in mechanical environments", Journal of Environment and Engineering, Vol 5, No 2, 2010.
[2] David R Pederson, University of Western Ontario", The soothing effect of rocking as determined by the direction and frequency of movement".
[3] Yvonne Backbill, Georgetown University Medical School, "Continous stimulation reduces arousal level, stability of the effect over time".