SAVONIA

THESIS - **BACHELOR'S DEGREE PROGRAMME**
TECHNOLOGY, COMMUNICATION AND TRANSPORT

SEAT SUSPENSION AND TILTING MECHANISM

Product Design and Development

CASE COMPANY: JUNTTAN OY

Author/s: Florian Höchstetter

SAVONIA UNIVERSITY OF APPLIED SCIENCES	THESIS Abstract

Field of Study Technology, Communication and Transport			
Degree Programme Degree Programme in Mechanical Engineering			
Author(s) Florian Höchstetter			
Title of Thesis Seat Suspension and Tilting Mechanism			
Date	2 November 2020	Pages/Appendices	37/0
Supervisor(s) Mikko Nissinen (Savonia) Jarkko Vainikainen (Junttan Oy)			
Client Organisation /Partners Savonia University of Applied Sciences			

Abstract

The aim of this project was to evaluate the current situation, to create concepts for a driver's seat – suspension – tilting combination, which is safe to handle but still has good manufacturability at a reasonable price.

Constant dialog with the supervisors and a field related specialist, as well as designing using a 3D designing tool (SolidWorks 2019) were the methods used to achieve the set goal and to conclude the project.

The project concludes in a design concept for a seat suspension, combined with a re-worked tilting mechanism. This process of product development and design work concealed many challenges. To be successful, a combination of knowledge, education and access to fitting tools were needed as well as motivation, foresight, and calmness. Sometimes all the first named attributes of a successful combination to face the challenges seemed to lack, so calmness turned out to be one of the most important factors during the process.

Keywords

CONTENTS

1 INTRODUCTION

1.1 General

A week contains 168 hours of which we should spend around 52,5 hours (National Sleep Foundation 2015) sleeping. From the left over 115,5 waking hours driver´s seat operators spend up to 50% or more at work. These facts underline the importance of work safety and health protection.

Junttan Oy (Case company), one of the leading piling/drilling rig manufacturers worldwide (PileBuck Magazine, 2018) is permanently improving their products, to fulfil the vision of “Enabling success”. To enable success of the customer, the health of the customer´s work-force it is a big field of interest. An operator of a Junttan Oy - piling or drilling rig must sit up to 10 hours a day in the driver´s seat, permanently handling huge masses at high accuracy. For not to interrupt the operator´s focus, and to avoid the risk of health damage, a certain level of comfort (Chapter 1.2) in the driver´s cab is needed.

This thesis consists of two main parts, a theoretical introduction into product design and development, and a practical concept development for Junttan Oy.

1.2 Background of the study

Junttan Oy produces large piling rigs for driving steel or concrete piles in the ground, to re-inforce and support the existing conditions. Furthermore, the case company produces for the ground drilling business, using the same machines, but with a different tool.

Picture 1 – A piling rig is driving a pile into the soil (Junttan Oy, product archive)

In this chapter the piling process is described. The accruing challenges are more distinctive in this field than in the drilling process. Still, the results of this work can be applied to both work fields.

Like a carpenter uses a hammer to drive a nail into a wooden plank, piling companies are using Junttan rigs to drive huge, special designed concrete- or steel piles into the soil or ground. Depending on given conditions, different challenges appear. The denser the ground, the more force is needed, the harder the hammer needs to punch, the more concussion plagues machine and user.

To achieve the daily work goal, the operator sits in a wheelhouse, controlling the processes. The new pile gets picked up and, guided by a rope and inserted into the hammer´s housing. In order to accomplish this, the operator must lean forward and look upwards up to 25 meters, which represents a challenge for neck and muscles. To facilitate this operation, the driver’s seat should offer the possibility of tilting backwards to allow the operator to look straight and upwards at the same time (see Figure 1).

Field of view

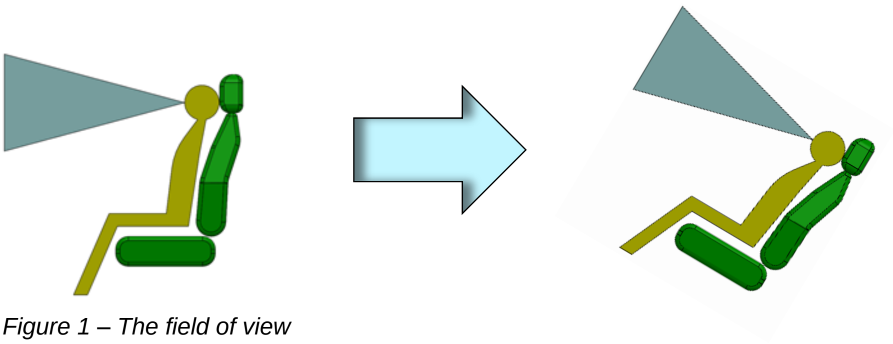


Figure 1 – The field of view

During the actual piling process recurring hits performed by the hammer on the pile are shaking the ground as well as the wheelhouse and the operator. A sufficient suspension is recommended, to protect health and well-being.

1.3 Goal

The aim of this project was to evaluate the current situation, to create concepts for a driver’s seat – suspension – tilting combination, which is safe to handle but still has good manufacturability at a reasonable price.

1.4 Abbreviations

Abbreviation	Meaning
CRM	Customer Relationship Management
QFD	Quality Function Deployment
FEM	Finite Element Method
CAD	Computer Aided Design

Figure 2 - Abbreviations

2 MENTAL WORK PREPARATION – PREPARE YOUR MIND FOR WORK

2.1 “Mind the product” – Mind yourself

In field literature many good thoughts and ideas can be found, they are very helpful to educate and improve ourselves. But before going deeper into theory, another very important part of (work-) life in general is **mindset**. Victor Antonio Gonzáles teaches in an online sales training course (Gonzáles, 2013) that according to his opinion 70% of creating a successful sales process is mindset. Even though Victor Antonio is speaking about sales, this theory can be applied in most other fields, too. An open mind, the will to constantly improve and the consciousness of what we are doing and its effect to ourselves, the environment and to people are key factors to success, likewise **education** and **knowledge**.

On the “Mind the product” conference 2017 in San Francisco Dave Wascha pointed out that “Product Management is a mindset”. The understanding of what really is your job is part of the base of product design and management.

In work life in general people sometimes ask themselves, why am I doing that (their job)? Often the answer is for money or safety. These are reasonable, personal interests but for building up mindset the answer continues. Like in many other work fields also in product design someone must understand that his or her work offers positive things and feelings to people and community. Product designers are solving customers problems and adding value to their lives. This is a fundamental principle to understand in creating mindset (Gonzáles, 2013).

Especially in product design a third factor represents great importance. **Possibilities**, which mean not only to know what is possible, also what is not. Regardless of good education and great mindset, there are most likely always borders and limits, that are to deal with, like money/budget or the availability of resources. It is quite challenging when not even impossible to build a hydropower station in the desert. Wascha called this “Don’t be a visionary”. He said that Elon Musk is a visionary, building self-driving cars and space shuttles, but the rest of us are not!

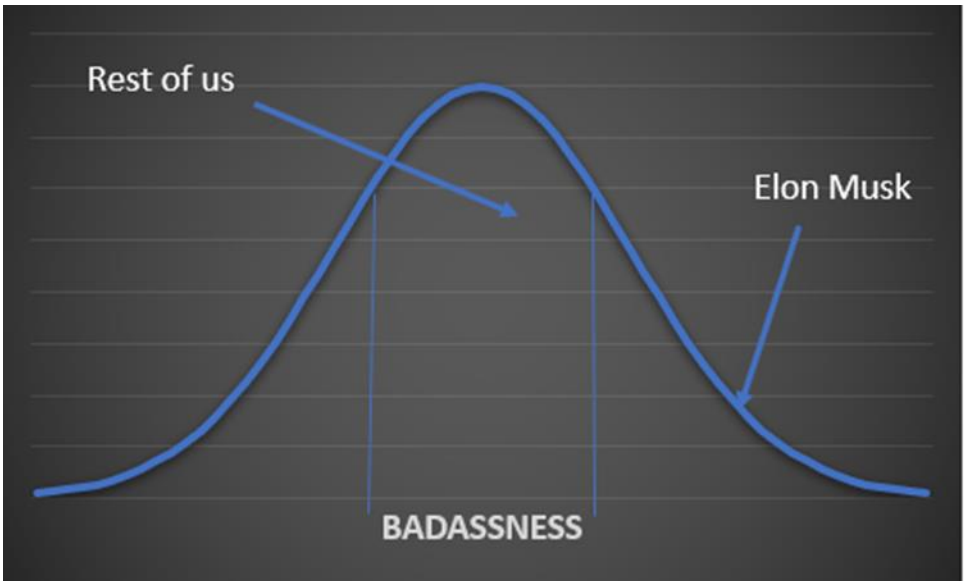


Figure 2 – Dave Wascha´s "Badassness"-Graph, used 2017 at the "Mind the product" conference in San Francisco

In this graph Wascha combines factors like strong will, genius minds, general potential and a touch of craziness the noun badassness, which delivers his message in a clear way. Understand your position, possibilities and resources!

3 PRODUCT DESIGN AND DESIGNING

3.1 What is design?

Apples C.E.O. Steve Job said, “It´s not just what it looks like and feels like. Design is how it works” (Walker 2003, The New York Times Magazine).

To understand the complete meaning of design, the separation of the two fields, Industrial design and mechanical engineering, helps. Often understood as one and the same, when it comes to product design, industrial designers are specifically trained to develop products, while mechanical engineers are specialized in making things work.

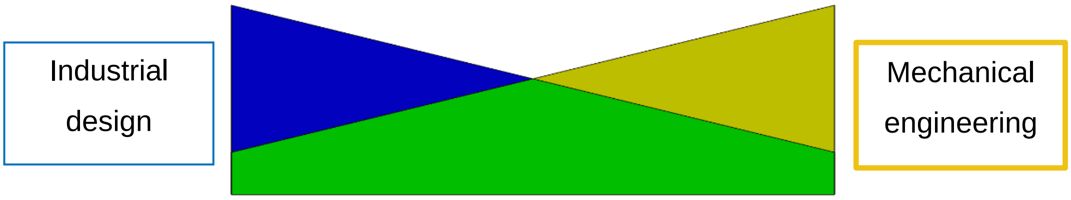


Figure 3 – Comparison Industrial design – mechanical engineering (Jimmy Design, 2019)

People working in both fields empathize with the customer, put themselves into their shoes and try to see the world from their perspective. In industrial design, the focus is more about appearance, and how to make living and handling easier whereas a mechanical engineer ensures the function and the safety of a product. Figure 4 shows how both fields interact. A common shared base (green) and separate main fields (blue and yellow).
In theory, the best possible prerequisites for a product design project are given, if an industrial designer and a mechanical engineer are working together responsively, to find the best compromise of a design´s features, that (still) satisfy the customer. (Jimmy Design, 2019)

Let it be understood, the meaning of design varies in many fields. Manufacturing industry has different requirements than e.g. the piece production of a goldsmith. Still, the thought of design as a collaboration between different designing aspects (design´s requirements), under consideration of the depending customer, describe “design” very well.

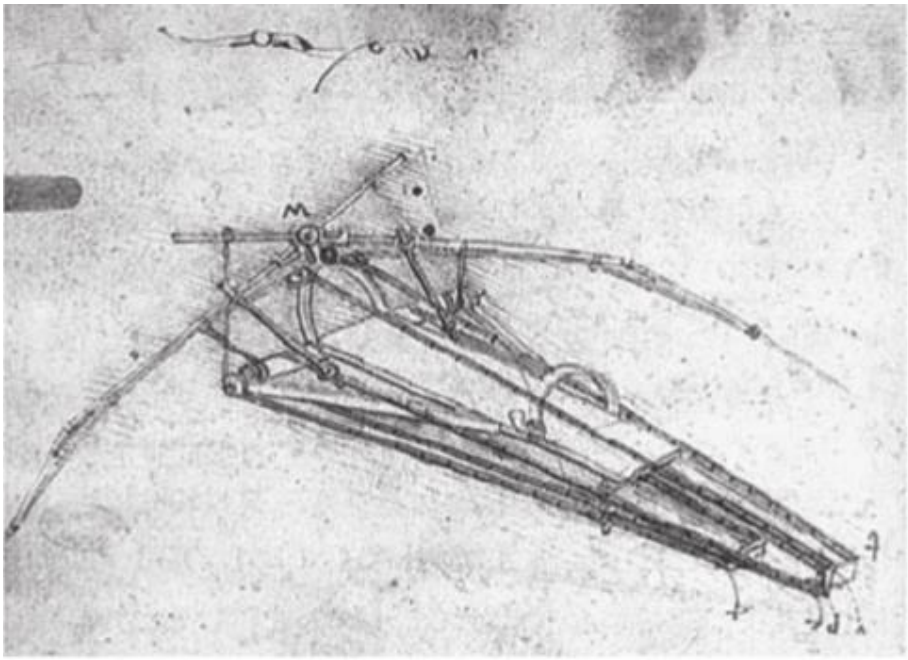
As a result, LUT School of Energy Systems (Lappeenranta, Campus Lahti / Finland) offers since beginning of August 2020 a “Master´s Program in Industrial Design Engineering”, to combine mechanical engineering and industrial design.

3.2 About designing

3.2.1 Historical evolution of modern designing

(Based on Anil Mital, Desai, Subramanian, Aashi Mital, “Product Development: A Structured Approach to Design and Manufacture”, 2008)

Also, the first sketches of designs are going back around 5000 years, in ancient times there was basically no designing phase in the emergence of a new “product”. People in the stone-age made shoes by using leather from the last hunt and some grass-ropes, no drawing was needed.



Picture 2 – Leonardo da Vinci´s flying machine, 1488

With the growth of an industrial society, designing gained more and more importance. Many factors pushed this evolution. On one side people realized, that mistakes and failures can be avoided, if a sufficient amount of time in designing is invested. Additionally, a first design on paper can safe time (and money), compared to a prototype, created only by memory and imagination. Another point is the possibility of standardization and replication. These factors among others built the way from no design via sketching and later ink drawing to the first computer aided designs and now modern 3D modelling.

Picture 3 – Drafting boards in a designing department (Paolo Monti, 1963)

3.2.2 Models in 3D

In modern 3D modelling the designer uses sketches to extrude and process bodies, which can later form whole digital assemblies. The use of simulating a product arrangement or assembly comes with great benefit. Since everything is for the first only digital, no unnecessary material waste appears. A flattened 2-dimensional “drawing” corresponds with cutting machines like laser or plasma cutter as well as a 3D model with a highly complex 5-axis lathe or mill. An interference detection shows possible collisions between parts. The final appearance can be influenced much better, since a 3D model visualizes the proportions of an object like they are. Motions can be simulated. In addition, supporting software offers analysis of material strength (FEM analysis) and how a body react to environmental influences.

By transforming these models into technical drawings, the production process can be determined. Information about welding technologies, bending definitions or surface treatments tells how the part must be handled.

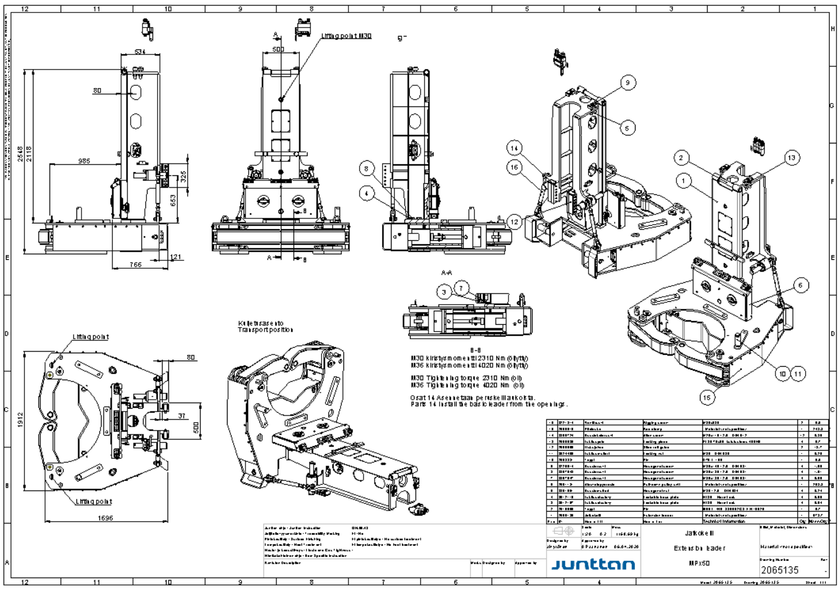


Figure 5 – Modern drawing created with a CAD program (Junttan´s PDM system)

3.2.3 Conscious designing / modelling

Opposite to designing for personal projects, designing for a company contains a big difference. In a private project only the owner must deal with created designs and drawings while during working in a company many other people are involved. The obvious part is represented by the workforce, working accordingly to given drawings and instructions, as well as other postpositive positions. It is part of a designer's responsibility, to offer these positions the best possible material, to fulfil their job. Additionally, there is another, maybe no so obvious field of responsibility. A designer must have the presence of consciousness, that his or her 3D model probably won't stay like it is. Due to revisions, up-dates or re-designs, the original structure changes or is modified. The designer always needs to be aware of that. Not only for easing someone's own work, sometimes this process is performed by another person.

Consciousness in sketching. A reasonable arrangement of origin, planes and parts helps not only during the part designing process. Further it eases the assembling- and adjusting/revising processes. The use of linear- or circular patterns can be helpful, it can as well make revising more difficult. Foresight is needed, and the thoughts of "what if I have to change the design in the future?". It is also advisable to avoid chain dimensioning. Dimensioning from a fixed edge of a body is in many cases the better way, to make adjusting and changing easier. "Anticipate potential requirements to minimize redesign efforts" (SolidWorks Introduction guide, page 24)

Fully defined parts and assemblies. To lower the risk of unexpected surprises, a part or an assembly should always be "fully defined". That means, all necessary dimensions and relations are given, the product got only one possible shape or arrangement. A 3D modelling program tells the designer about the defining status. This should not be ignored. It can on one side give information if something is still missing, if something needs to be adjusted or defined better, on the other side it is important for a possible FEM analysis. Underdefined assemblies or parts can lead to wrong results, the consequences can be imagined. "You should fully define sketches to maintain your design intent" (SolidWorks Introduction guide, page 28)

The use of an interference detection. A modern 3D modelling program offers the possibility of an interference check or a collision detection in assemblies. This process tells the designer, if all parts are well arranged, and do not have any colliding edges. During designing, small interferences are not always visible on first sight, but at the end people in the production line will realize the mistake. It is an often forgotten, but an even more important step to avoid unnecessary additional work or material waste. "To ensure that the assembly functions correctly, you can use assembly tools such as CollisionDetection. CollisionDetection lets you find collisions with other components when moving or rotating a component" (SolidWorks Introduction guide, page 33). The same applies to the interference check.

3.3 Requirement of design

(Based on Pye, 1989)

1. Correct embody of the arrangement
2. Geometrical relation between all components and the object
3. Strength
4. Access
5. Costs
6. Appearance

"Design is the process of satisfying these requirements". During designing, these requirements are in constant conflict. Everything must fit together, must be strong enough to withstand environmental influences and fulfil safeness and lifecycle expectations, the product must be cheap in cost and production, and last but not least, its appearance must be satisfying. It is up to the designer, in correspondence with the customer, to find the best possible compromise between all included factors. This fact makes designing to a “problem-solving activity” and, because of the influence and importance of appearance, an “art”. (Mital, Mital, Desai, Subramanian, 2008)

3.4 Properties of the product

Similar to a product´s requirement it is essential in designing to know and to understand a product´s properties, which can be divided into design, internal, external and systematic properties. The design tells about a product´s structure and form, about its tolerances and its surface, about the used materials and manufacturing methods. Internal properties are strength, corrosion resistance, durability and manufacturing properties. External properties representing ergonomic and aesthetic as well as economic and function. Other contributing factors are budget, and naturally law conformance. As systematic properties can be seen a product`s space requirement, its durability, weight/mass and maintenance ability, its surface quality, color and appearance, the storage space needed, its quality, costs and price, the appearing waste and its recyclability, its general function and reliability. (Mital, Mital, Desai, Subramanian, 2008 – adapted from Hubka and Eder, 1988)

4 PRODUCT DESIGN / DEVELOPMENT

4.1 Strategy

For every (repeating) process it is advisable to create an approach system, its own strategy. Nevertheless, everyone should figure out the best way of solving challenges on his/her own, field literature gives good frames for this process. Ulrich and Eppinger describe a "Mission-Statement-Development-Plan" in their book "Product design and development".

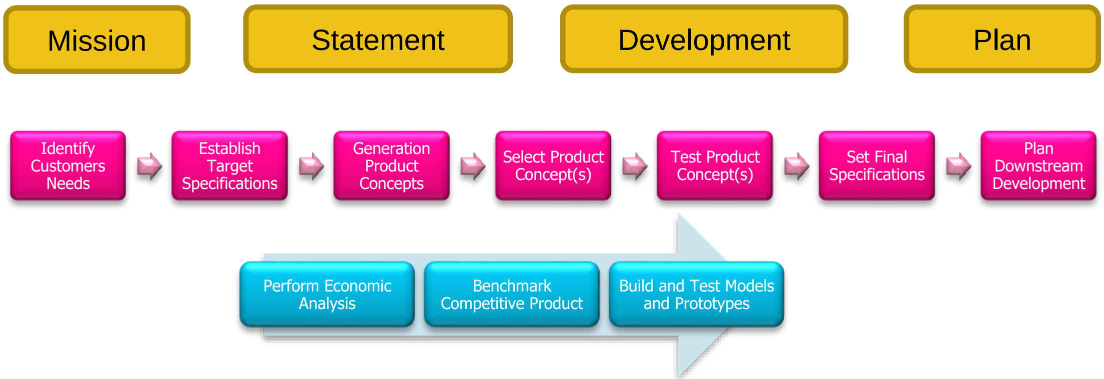


Figure 6 – Mission - Statement – Development – Plan (Ulrich and Eppinger, 2011)

This plan describes a special conceptualized strategy throughout a whole product development process. 7 steps from the identification of customer needs to a sustainable plan of development, permanently supported by economic analysis, comparison with competitive products and constantly testing the models and prototypes. This strategy leads to a reasonable, well designed final product. The following chapters offer a deeper look into the certain steps of the process.

4.2 Identifying customers' needs

4.2.1 Who or what is the customer?

To be able to identify customers' needs it must be defined who or what the customer is. The most common understanding of the concept "customer" is the person that goes to a store and buys something. But being a customer is not only the process of buying for example a new car, also using and maintaining the car, the transferred economic status and many other points more are defining the field. Everyone and every group of people can be, and is somehow a customer, from the single person up to a whole population. Everywhere, where goods or services are used, transferred or exchanged, depending positions can be defined as supplier and customer. Even your co-worker, that receives your work to continue with can be seen as your customer. The knowledge of “who is the customer” is especially important in the field of product design, since all customer-types have separate, specific needs to focus on. That means, they value a products properties different.

4.2.2 Identification of the needs

(based on Sauro, 2015)

An uncountable number of techniques and strategies exist, but before investing time and money in new researches it is to check what knowledge, e.g. a past survey or the support call log, is already existing. “Starting with existing data” should be the first method for identifying customer needs, followed up by stakeholder interviews. These two processes contain huge potential and are completely for free.

If the customer`s process is known, it can be mapped. Jeff Sauro shows a great and successful example. It takes the old-fashioned process of using a taxi and is mapped in the following way..

Figure 7 – Old fashioned way of ordering a cab (Sauro, 2015)

And here is what Uber turned this process into.

Figure 8 – Uber´s way (Sauro, 2015)

Specialized surveys, customer interviews or any related other way of data collection offers information about the customers goals, challenges and problems, which then can be turned into improvements and opportunities. Another potential and legit field of gaining information is customer analysis. Successful competitors may have done things the right way, so why not adopt parts of their doing? Such studies can later be used throughout the whole product development process and additionally in benchmarking and marketing/sales processes and strategies.

4.2.3 Identification of the needs, a different approach

Clayton Christensen, a Professor at Harvard Business School offered a different approach to identify a customer´s needs. “The customer is the wrong unit of analysis” he said, “ask what the customer is trying to accomplish?” What are the goals? And think about ways that support the customer to achieve these goals. As an example, Christensen described the former situation of a sales- or a serviceperson, that needs to work “out of the car”, their car is there office. Mobile internet connection was not that usual as in 2020 and the car industry had not yet developed a car cockpit, that is designed as a workstation. Since the people in question often spend a lot of their working hours on the road, they were forced to pull over many times to reach an internet hotspot here or there, when a table is needed to fill papers and reports, or when it comes to storing these documents in a proper way. “They stop at a traffic light and the laptop falls over, because there is no docking station” is another description of the situation. Christensen finished this thought with “Just by watching what people are doing, you can imagine the opportunities…”. (Christensen, 2012)

4.2.4 Example of a customer’s value analysis

A survey or analysis of a (potential) customer(s) about key factors of a product´s properties. The customer(s) is (are) asked to value the importance of certain factors on a scale from 0 to 100, where 100 represents the most important field. The following results are gathered.

Properties							
Design		Internal		External		Systematic	
	Value		Value		Value		Value
Structure	10	Strength	25	Ergonomic	25	Weight/Mass	10
Surface quality	10	Durability	25	Aesthetic	80	Maintenance	20
Materials	10	Corrosion resistance	10	Economic	40	Costs	100

Figure 9 – Example of a customer’s value analysis

These results reflect how much the customer(s) values the specific properties and, projected into a chart, the focus areas.

Figure 10 – Results of Figure 9

In this particular case, the priority lies in costs and aesthetics, where quality and durability are not in the main focus. This or these customer(s) want a fancy looking, cheap product and do not care too much about if it lasts or from what it is made of. This knowledge not only tells about where to focus on designing, additionally it gives valuable information about the customer general, which can be used in marketing or CRM.

4.2.5 Customer care

In former days product design and management was about defining the functional requirements of products (Cost, Speed, Power). This is no longer enough, in our times also appealing to emotional and social needs is more and more important. Customers want to be heard and understood, customers want to trust into products they are investing in and trust is less build on pure performance than on the realization that the product management and the product designers know who customers really are, and what are their needs. (Wascha, 2017)

A comparison of older and newer field literature empowers this impression. While older resources like the design requirements according to Pye, 1989 (chapter 3.3) focus only on the technical features and the appearance of a design, modern thoughts always point out the importance of customer care and collaboration also in the design state.

4.3 Establishing target specifications

(based on Ulrich and Eppinger, 2011)

The target´s specifications are factors, that can be affected by designing. In order to establish them it is important to know where to focus on. The use of matrices is a common tool to show the most important points regarding customer´s needs and his/her own possibilities. Such matrices use information, gained by the customers analysis, paired with field related knowledge, potential and experience.

In this stage of the development process the product gets an environment. It is to define, what size, what room the product should occupy, and how it needs to get prepared for that. Properties like strength, surface treatment and other boundaries build the framework in which a designer can move, to transform customers' needs into sketches and models.

Probably the most known and approved approach is the QFD´s house of quality. In a design related variation of this technique the voice of customer is compared with factors that can be controlled by the design.

Weight factor

Voice of customer	Controlled factors	Material A	Material B	Open mechanism	Covered mechanism	100 KW Power	200 KW Power
Low cost price	3	+				+	
Low maintenance costs	3		+	*			
Safeness	5				+		
Function A	1	*	*	*	*	*	*
Function B	3		*	*	*		*
Function C	5		+	*	*		+
Quality	3		*		*		
"made in"	5	+					
		85	115	60	110	35	70

+ = 10

* = 5

Importance factor

Figure 11 – Design related House of Quality

The results in Figure 11 show, that according to the highest "importance factor", using material B in a covered mechanism with a 200 KW engine would most likely satisfy the customers.

4.4 Generation of product concepts

Now that all limitations are evaluated, demands are specified and preparations are concluded, the active design work can start. The aim of this stage is to present different solutions, to fulfill customers´ needs and wishes. At this phase concepts don't have to be completely elaborated. It is more about brainstorming, gathering ideas and thoughts, as many as possible. A product´s concept at this stage is an "Approximate description of the technology, working principles, and form of the product or service" as well as a "concise description of how the product or service will satisfy the customer's needs" (Prof. T. Lee, 2012)

To visualize these thoughts, modern designing utilizes 3D CAD software. The use of software offers great support in designing, it revolutionized the whole field.

Depending on the scale of a product, the first prototypes are constructed in this stage. Normally less in daily routine work, but in project working. While revisions of existing products, services or processes are in the responsibility of the designer, concepts for new developments, projects or competitive bidding can request tactile demonstration models, which needs approvement from higher levels like the department leader, production manager or even the CEO. It depends again on who is the "customer".

4.5 Selecting product concept(s)

(based on Ulrich and Eppinger, 2011)

The goal of concept selection is not to select the best concept, it is to develop the best concept. Evaluation processes and techniques supporting the decision-maker. The following strategic selection process consist of two main steps, concept screening and concept scoring.

4.5.1 Concept screening

In concept screening all concept ideas are re-evaluated critically, for feasibility. The goal of this step is to reduce the number of different concepts, or concept parts. Depending on the product it can either be seen as one concept, or as a building set, where partly independent components form the product.

Concept Screening

	Design Concepts							
	Concept A	Concept B	Concept C	Concept D	Concept E	Concept F	Concept G	Concept H
Quality Set	Quality	Quality	Quality	Quality	Quality	Quality	Quality	Quality
Capacity Value	Capacity	Capacity	Capacity	Capacity	Capacity	Capacity	Capacity	Capacity
Economy Set	Economy	Economy	Economy	Economy	Economy	Economy	Economy	Economy
Appearance	Appearance	Appearance	Appearance	Appearance	Appearance	Appearance	Appearance	Appearance
Continuation?	No	Yes	No	No	No	Revise	No	Revise

Figure 12 – Concept screening

It is important to understand, in this phase it is not about selecting the best solution, it is about developing it. In Figure 12 eight different concepts are compared. Green reflects good performance, red stands for bad performance and white is average. The evaluation criteria are for example given by the research done in customer analysis or the product specification evaluation. In this example one concept shows three green values, two others each have two. After consideration of possible feature exchanges, or combinations of different concepts, a set of probably new concepts remains.

4.5.2 Concept scoring

A concept scoring table (Pugh Chart) is a common tool to compare concepts and criteria´s in depth.

PUGH CHART EVALUATION

				Design concepts		
	Concept Selection Matrix	Weight	Standard	Concept 1	Concept 2	Concept 3
Quality	Quality criteria 1	3	S	+	S	-
	Quality criteria 2	2	S	++	S	-
	Quality criteria 3	1	S	S	+	--
Capacity	Capacity	2	S	+	S	++
Economy	Economical criteria 1	2	S	-	+	S
	Economical criteria 2	2	S	S	+	-
	Economical criteria 3	3	S	--	+	S
Appearance	Apperance	1	S	++	S	-
	Score			3	4	-4
	Score weighted			3	8	-6

Figure 13 – Pugh chart evaluation

In the example three concepts (1-3) are formed from the former 8 (A-H) and compared with a set standard. This standard can either be one of the remaining concepts, that is in the opinion of the operator the most average solution, or an imaginary “Standard-concept”. The concepts are rated as follows.

Symbol	Value
++	2 (much better than standard)
+	1 (better than standard)
S	0 (as standard)
-	-1 (worse than standard)
--	-2 (much worse than standard)

Figure 14 – Value explanation

After the score is calculated, the results are multiplied with a weight-factor. This factor can also be taken from former steps, like for example a house of quality. The highest “weighted score” represents most likely the best concept for the evaluated areas.

4.6 Testing product concept(s)

(based on Ulrich and Eppinger, 2011)

In this stage a prototype is built and compared to information and specifications gathered beforehand. It is about finding answers, does the product fulfil functions and needs, is it feasible and does it satisfy the customer. Performance tests and lifetime estimations/calculations are used to prepare for a presentation of the concept. A presentation leads to acceptance, rejection or acceptance under modification. If a concept is accepted, the final designing work, followed by production can start. In case of rejection, the project/design is determined, but most often this phase tells about how to continue, what is still needed to get the product ready for production.

The concept testing process is chronologically segmented in several steps. It starts with a definition of the test´s purpose, followed by choosing a survey population and format. It must be clear how to communicate the concept and how to measure the response. After these steps the results are interpreted and reflected.

4.7 Setting final specifications

Information gathered from tests and feedback from the customer leads to a set of final specifications, that describes how the product will look like, and what is able to perform. According to these "specs", as specifications are shortly called, the final product will be produced. It is important that all included positions have got the same level of information before this step is concluded.

4.8 Planning downstream development

After finishing the first run, the sequences can be formed to a circle, for continuous quality control and improvement.

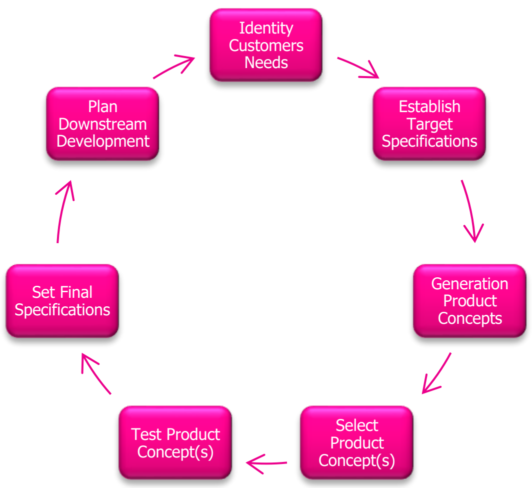


Figure 15 – Product development circle (Ulrich, Eppinger, 2011)

Also, this phase is postpositive to the actual designing and producing, it is nevertheless important. The potential of a product, regarding perspectives like specialization or future aims and goals should be defined. It is advisable to control, and as the circumstances require to adjust a product's life cycle estimation. In order to increase the profit-possibility of a product, improvement- or further development processes must start early enough. The goal is to erase, or at least minimize the "decline" phase of a product´s life cycle.

4.8.1 Life cycle of a product

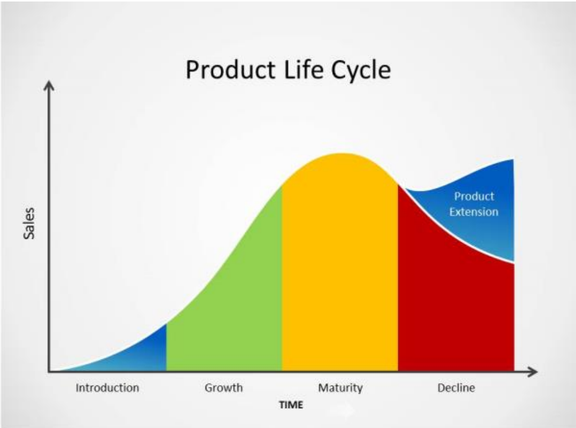


Figure 16 - Product life cycle (Jeff Bodenstab & Stefan de Kok, 2015)

After the maturity phase a product extension (e.g. an updated product, modernized with new features) tries to cancel out the decline phase and to replace it with the next growth- and maturity phase. This consciousness shows the importance of downstream planning since the development precedes the life cycle curve. To keep up constant sales, the product extension must be ready right after the maturity phase, which means its development must start even earlier. Companies like Apple or Sony are exactly aware of this fact and present the new iPhone or PlayStation at the strategic best point in time, as long as the development is ready.

5 THE SEAT PROJECT

5.1 Today’s situation – Status quo

Today, the driver`s seats of Junttan rigs are equipped with suspension, offered by the supplier. This arrangement can absorb occurring concussions from the hammering process, but it is not possible to tilt the seat backwards, to allow a better view for the operator. Tilting backwards is not possible because there is no space left between seat and backwall, which is in this case a big control cabinet. These wheelhouses are filled up with technic, switches and levers, monitors and other supporting equipment. Everything needs to be installed and stored safely, which does not leave enough room for a suspended **and** tilt able seat.

Therefore, the company is planning to re-design the whole wheelhouse. A first prototype, with more space inside, is located at the company’s premises and used as a simulator. In this simulator the seat is tiltable. This tilting mechanism fulfills the need of keeping the position of the operator´s knees stable. This is important because the operator must control gas and brake pedals with his feet. The problem is this system is not suspended. Using the supplier’s suspension is not possible because it would raise the seats level too much, the average operator could not reach the pedals anymore. Additionally, the existing tilting mechanism is open. An unexperienced operator faces the danger of squeezing his or her fingers, due to incautious handling. A third problem point is the manufacturability and the resulting costs.

5.2 Work preparation

Like described in chapter 1.3 the goal is to support the case company Junttan Oy by creating concepts for a tiltable and suspended driver´s seat. The goals of this development project are to higher the comfort and safety for the operator and to improve the manufacturability of the seat suspension, if possible, at lower costs.

Permanent access to the simulator room as well as all needed tools for digital concept creation and practical testing are granted.

5.3 Customer´s needs

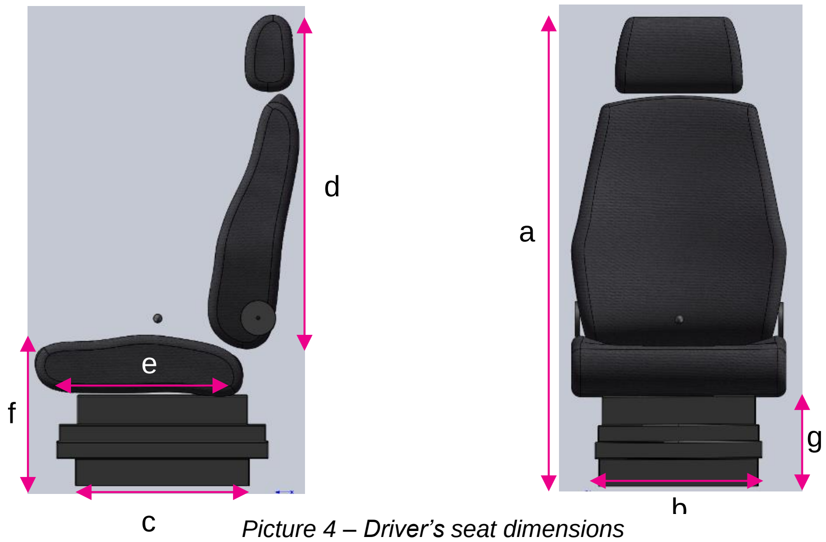
In this case the research resulted in three different “customers”. On one side it is the company, that buys a new piling rig. The main fields of interest for these companies are price and sustainability. On the other side there are the direct users, the operators. Their main field of interest is comfort and safety. Also, the operator needs the possibility to always reach the gas- and brake pedals, which are located on the floor in front of him or her. The third party is the producing company. The product should be cheap and easy to assemble and with good manufacturability.

5.4 Target specifications

Max. Forces acting:

- User 150 kg → ~ 1500 N
- Chair 45 kg → ~ 450 N

Seat dimensions, including the supplier's suspension:



Picture 4 – Driver's seat dimensions

Position	Dimension [mm]
a	1200
b	400
c	400
d	800
e	450
f	600
g	320-400

Figure 17 – Driver´s seat dimensions

Type of load/strain: repeating hits with a frequency of maximum 2 hits / second

The important factors which set the frame of this project are:

- a constant distance between the operator's knee and the gas / brake pedal
- a tilt angle of 30° should be achieved (see chapter 1.2 - figure 1)
- a sufficient suspension / shock absorbing system is needed

5.5 Concept generation Suspension / Tilting

5.5.1 Concept A

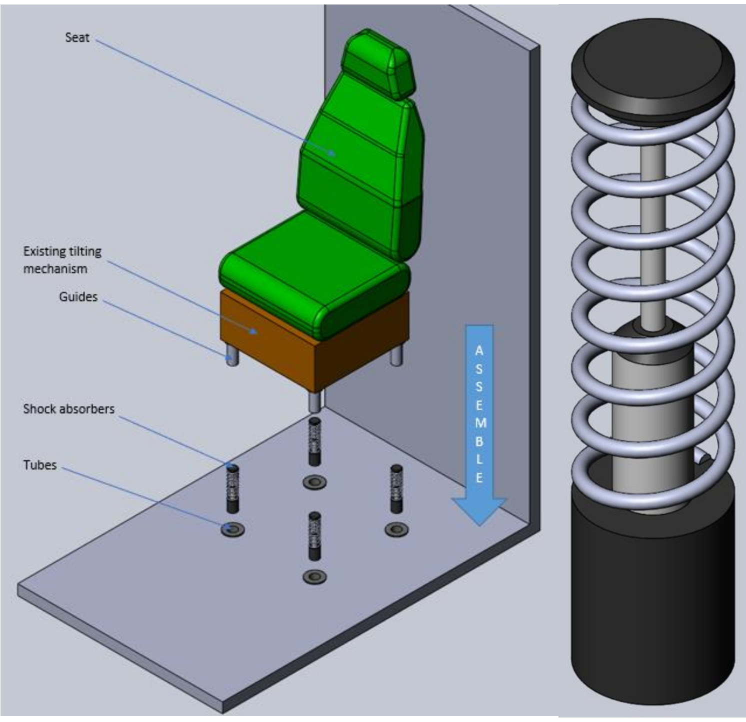


Figure 18 - Concept A, seat on shock absorbers

This concept uses shock absorbers below the existing tilting mechanism. The absorbers are located between 4 guides and accordingly 4 tubes.

For an easy and real cheap solution, shock absorbing or reducing rubber bumpers can be mounted between the existing tilting mechanism and the seat. This system has a down-side, since the shock absorbers would make the whole tilting mechanism unstable and more difficult, if not impossible to control.

5.5.2 Concept B

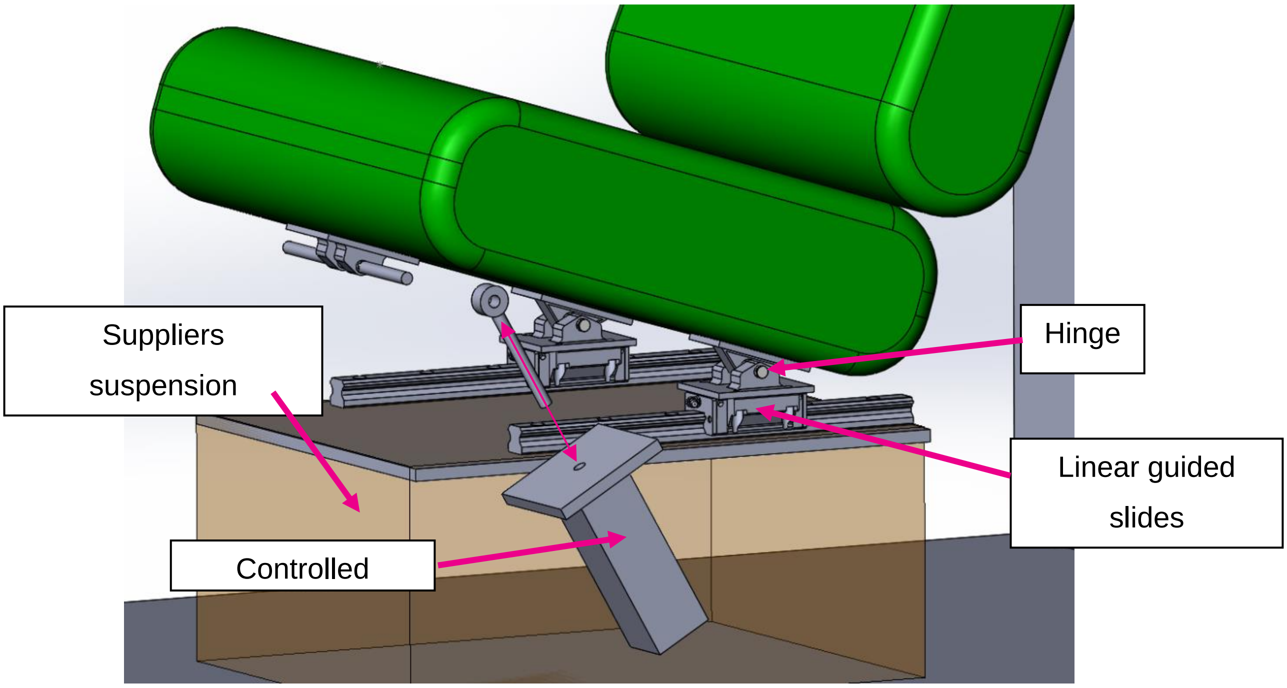


Figure 19 – Concept B, hinge on slides

This concept uses strong hinges in between the seat and the supplier's regular suspension, mounted on a slide. The possibility of removing the seat from the suspension is given.

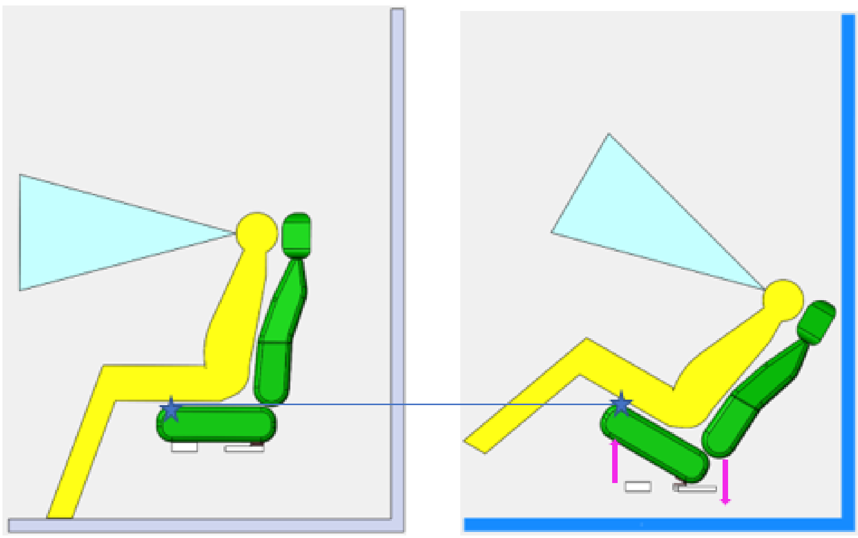


Figure 20 – Concept B, turning point

Controlled by a cylinder, the front of the seat can be lifted, while the supplier´s suspension moves downwards. That keeps the position of the seat´s front constant.

5.5.3 Concept C

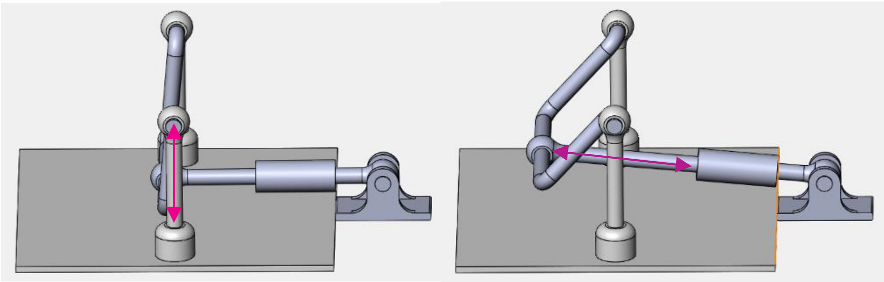


Figure 21 – Concept C, the swing

In this concept the seat is mounted on a swing. The two side cylinders are suspending the whole mechanism, which is controlled by a third cylinder from the back.

5.5.4 Concept D

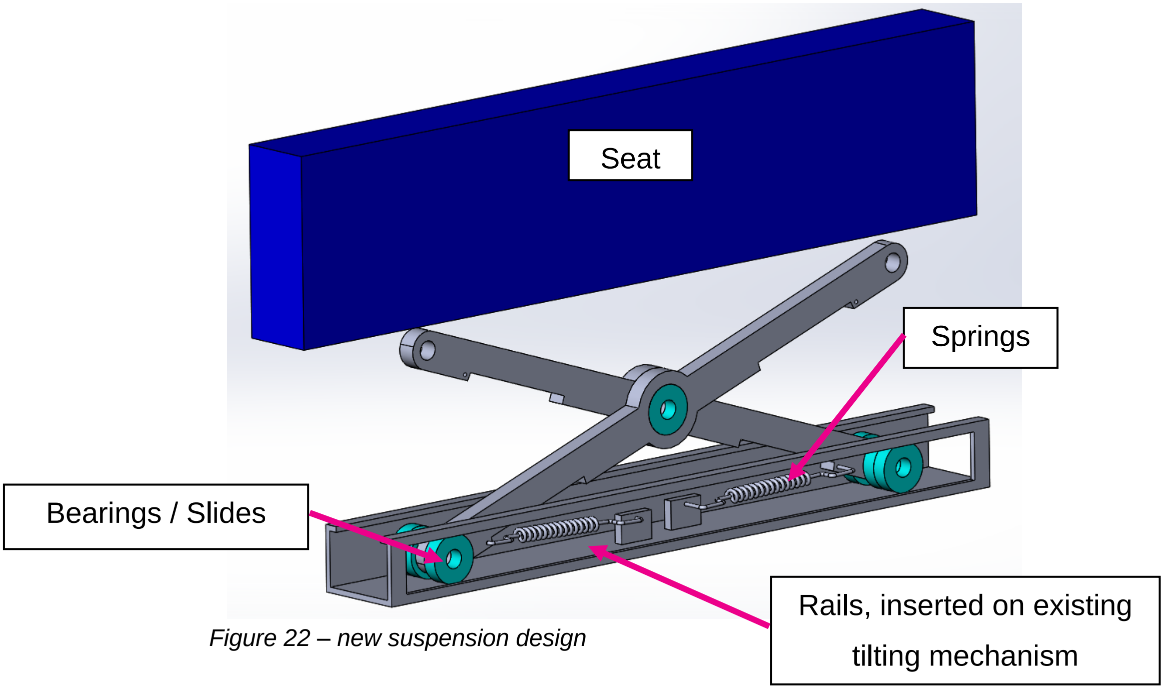


Figure 22 – new suspension design

In this concept the existing tilting mechanism is used. Rails (one on each side) are mounted in which a scissor mechanism with springs can suspend the seat. When the operator sits down, the applied force will push the seat downward. This causes the springs to stretch. The springs now create a force working against the applied force. These two forces will balance at some point in a new equilibrium. Every change of one of the forces will cause this process to repeat and so create a suspension for the seat.

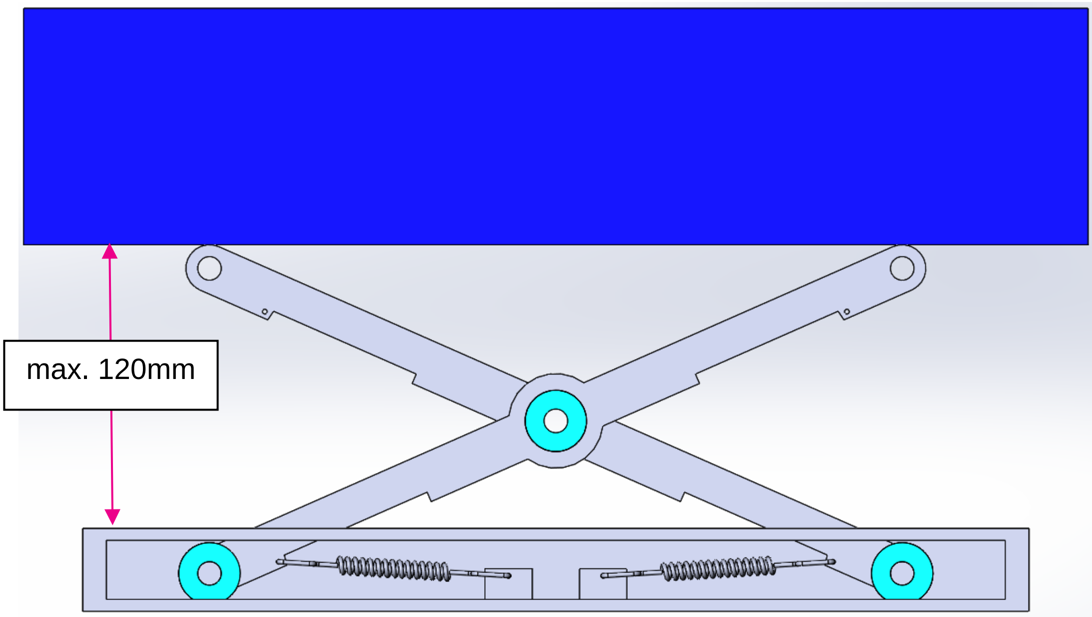


Figure 23 – suspension design max

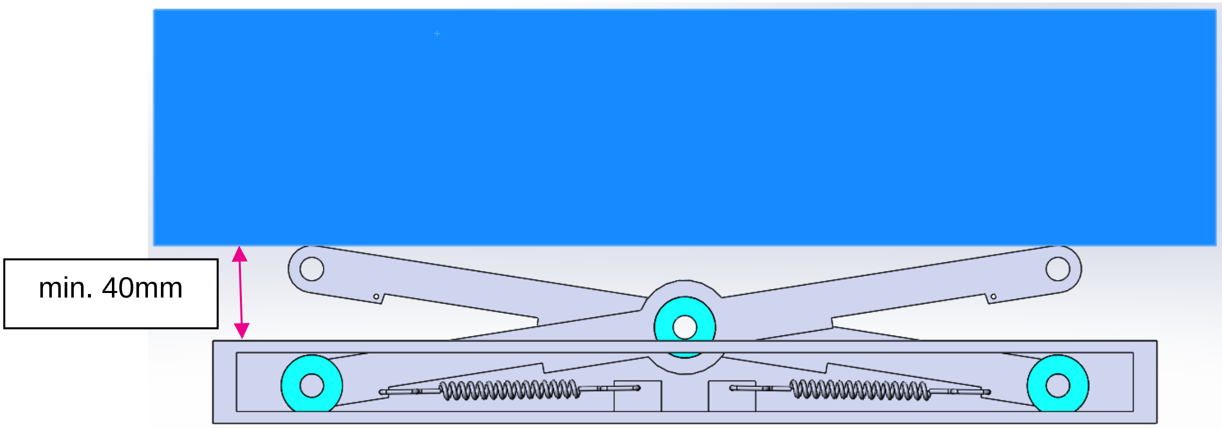


Figure 24 – suspension design min

The idea is to include the rails in the tilting mechanism design, to conserve the height of the rails. This would offer up to 8cm suspension and raise the chair level only by 12cm.

5.6 Concept selection

During an interview with the supervisor and a field related specialist the concepts were presented. The concepts A, B and D were shown on paper and as digital assemblies, Concept C via an animated video. Feedback was gathered and new thoughts implemented in the concepts. After further development the concept generation phase can be set on hold, and a comparison could start.

5.6.1 Concept screening

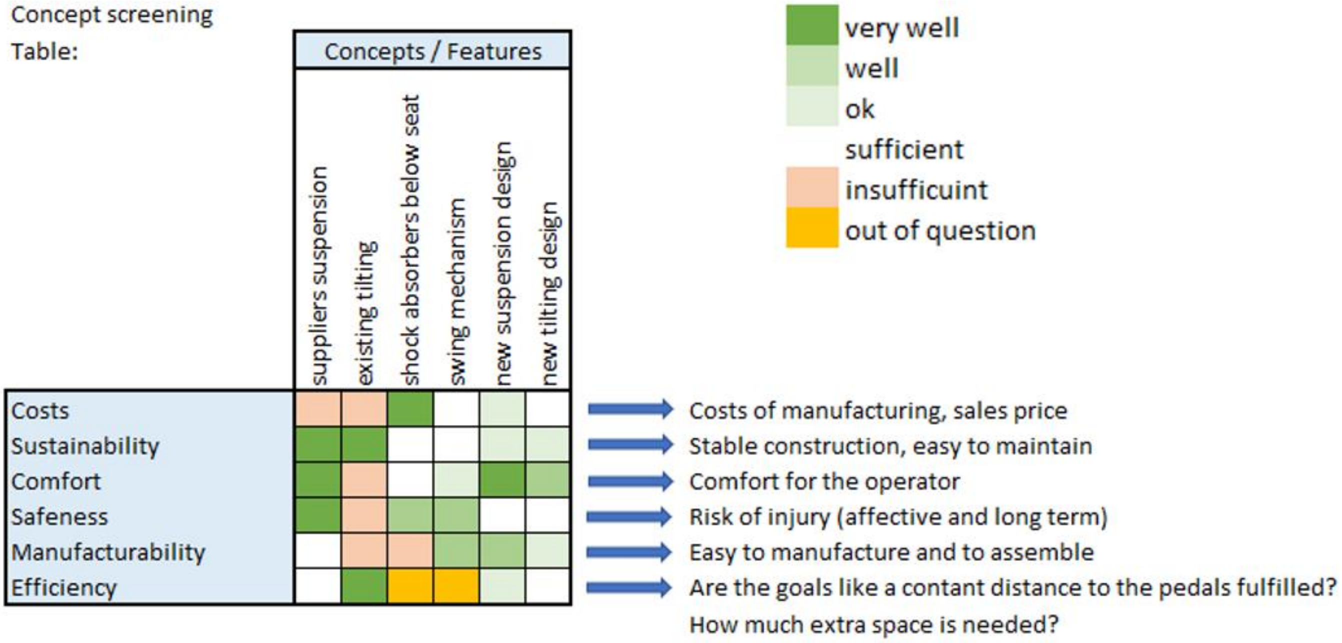


Figure 25 – Concept screening

The concepts / features were evaluated by their performance in costs, sustainability, comfort, safety, manufacturability, and efficiency.

The supplier's suspension offers great comfort, is safe and its sustainability is great. But it is rather expensive, needs a lot of space and an additional tilting mechanism is needed. The existing tilting mechanism performs great in the field of efficiency, but is expensive, unsuspended, and not safe to use. Concepts A and C (shock absorbers, swing mechanism) don't give any useful information. It is not what the company is looking for, and not even features from the concepts are valuable. A new suspension design as well as a new tilting design would offer high comfort at lower price if they are implemented.

After comparing, analyzing, and discussing the ideas, the following information was gained. The existing tilting mechanism fulfils many needs and is stable and controllable. It is in its actual shape too expensive, so a design rework is needed, to improve manufacturability and reduce the costs. This mechanism is to be combined with a new, customized suspension system. Additionally, an accordion shaped rubber sleeve is needed, to cover all the moving parts and to protect the operator.

The combination of the supplier's seat suspension and a new designed tilting mechanism offers potential but further development work is needed.

5.6.2 Concept scoring

Concept scoring Table:

		Concepts	
	Weight	Suppliers suspension & new tilting design	Existing tilting & new designed suspension
Suspension	3	++	0
Tilting	3	0	++
Safeness	2	e	e
Stability	2	2	2
Pedal distance	2	0	++
Costs	1	-	0
Score		3	6
Score weighted		9	14

++	=	2
+	=	1
0	=	0
-	=	-1
--	=	-2
e	=	the concepts are equal, no evaluation

Figure 26 – Concept scoring

In the concept scoring process, the two created concepts were compared. The score and weighted score are in favor of the second concept. The focus of the upcoming designing work will be on creating a new, customized suspension, that works placed on the existing tilting mechanism. The existing tilting mechanism will receive a re-work, in order to lower its costs and to raise the manufacturability. Since during the process of developing the final concepts it turned out many times that safeness needs in some way an improvement, the whole design including tilting and suspension will get a rubber sleeve. This sleeve works in two ways, it protects both, the operator from injury and the mechanisms from dirt.

5.6.3 The final concept

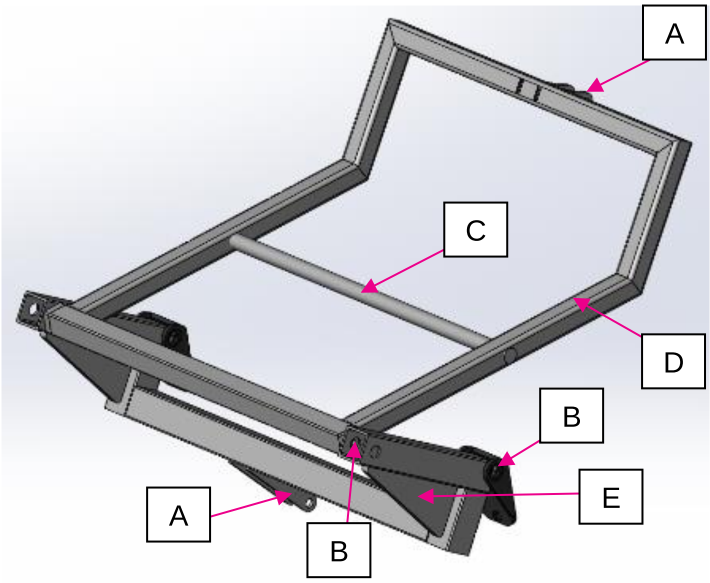


Figure 27 – The frame of the tilting mechanism

The original tilting mechanism is confidential. Figure 27 shows the result of the re-work. The design uses a squared tube frame [D], formed from one piece. During the process of cutting the tube at length, grooves at a certain angle are cut as well. This makes it easy for the worker to bend and weld the frame (Figure 28). Further, the frame is reinforced by a round bar [C], simply pushed through pre-cut holes and welded in place. This round bar is additionally used in the suspension design, for holding the springs. The lower part of the product is again formed from squared tubes and two strong gusset plates [E]. The cylinder attachments [A] are placed into pre-cut slots and welded (Figure 29). These are the spots where cylinders, controlled by electric motors are acting. Their correct interaction is responsible for keeping the operators knee position constant, while tilting back- or forwards. Two joints [B] located on each side of the construction allow the upper and lower parts to pivot while the cylinders are moving.

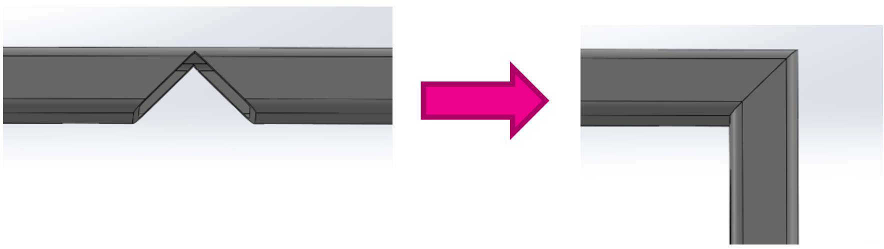


Figure 28 – Squared tube bending

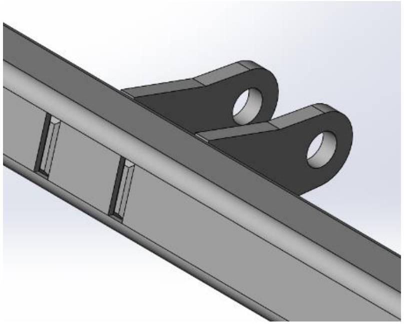


Figure 29 – The cylinder attachment points

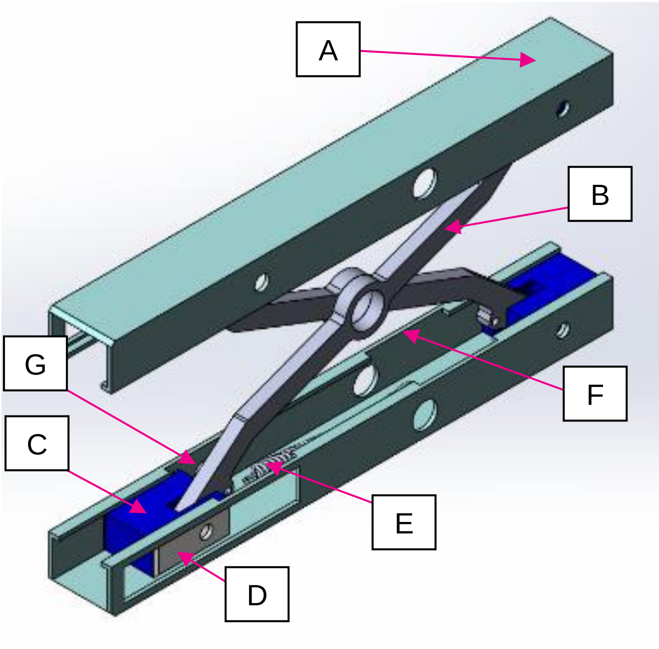


Figure 30 – The suspension concept

Like described in chapter 5.5.4, the suspension is formed by a scissor mechanism [B] and sliders [D] attached to a sliding block [C], placed in modified rectangle tubes [A], where a spring [E] creates the counterforce to the occurring loads. Two of these are to be install between the tilting mechanism and the driver's seat. To assemble the mechanism the sliding blocks with the attached sliders are dropped into the lower rectangular tube, using the little opening at position [F]. The scissors are now placed and secured by pins. The backside pin goes through rectangular tube, sliders, slider block and scissor and is fixed with a retaining ring on each side. The front side pin is a little shorter as the rectangular tube is wide. It only goes through slider block, sliders, and scissor, to enables the sliding block to move. A hole in the middle of the front opening [G] allows the pin to be placed. Since under load the block never reaches this position again, the pin doesn't need any additional securing. After the same steps are done on the top side, the spring can be placed between the front scissor and the round bar of the upper frame. As soon as a load, for example a driver's seat will create a force downwards, the spring will create the counterforce and the system will level itself in a new equilibrium.

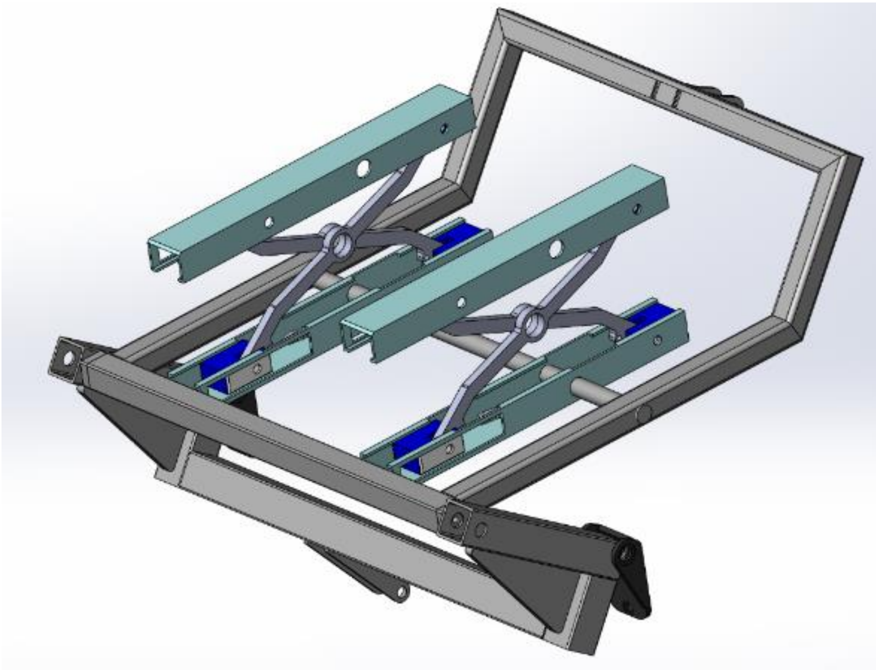


Figure 31 – Suspension in tilting mechanism

The suspension is worked into the tilting mechanism, to safe space. This design now can go into the next phase. The next step will be to produce a prototype, which will show if the theory will work in praxis, and where and how many adjustments need to be done. The last steps to achieve this stage was to create all manufacturing drawings, including a production step order and making material- and surface treatment decisions. The sliders are made from PVC, the solid manufactured parts from S355K2+N and for the tubes S355J2H steel is used. All steel parts will get painted, to be protected from corrosion.

6 CONCLUSION

During the process it became clear that product development processes are filled with compromises. This design and development process aims to improve an existing product, based on a variety of different points of view. As a fact of nature different points of view support different interests, which can be difficult to combine. A 100% solution is nearly impossible in product design and development, it is all about finding the best compromise.

Mistakes were made! Every designing or development process is also a learning process. In this case many hours were spent on how to fit all the needs into the existing driver´s cabin, until it turned out that the company is already planning to re-design this cabin. This mistake was caused by two to three factors. Lack of communication or/and a simple misunderstanding, and tunnel vision by the designer. Focusing so hard on something can steal the ability of seeing the big picture. Plenty of working hours could have been saved if only one step backwards would have been taken at the correct time, to realize, it is not possible to fit all the needs into the given surroundings. Before an analysis of what caused a wrong direction of thinking, walking or in this case designing can be done, the mistake must be realized, and tunnel vision is the worst enemy in that task. It is important from time to time to step a bit away from the actual work and ensure that everything still stays on the right track. This learned lesson again proves the importance of understand the customers' needs and additionally of documentation. A written report or project plan checked and signed by all involved parties would have minimized the danger of misunderstandings.

After overcoming all obstacles and problems, two concepts were created and one of them is ready to enter the prototype phase. Most impressive is the realization of how many factors are surrounding an actual design, especially in working for an industrial company.

REFERENCES

Bodenstab, Jeff & de Kok, Stefan 2015. Forecast Over the Product Lifecycle. Blog by toolsgroup. Published 31.03.2015.
https://www.toolsgroup.com/blog/forecasting-over-the-product-lifecycle/
Accessed 02.11.2020

Christensen, Clayton. Harvard Business School. Identifying customers' needs. Video. YouTube video service, published 23.04.2012.
https://www.youtube.com/watch?v=yVCZ-7xSsCw

Gonzales, Victor Antonio. How to Sell Your Product or Service Series Intro – Online Sales Training Course. Video. YouTube video service, published 15.04.2003
https://www.youtube.com/watch?v=kGnjRC0UckA&list=PLA6As4Un47h_LE-Cvmlu61F_NBzHyT0s6

Jimmy Design, Mechanical Engineering vs. Industrial Design (What is the difference?). Video. YouTube video service, published 12.09.2019.
https://www.youtube.com/watch?v=t9yp2ktfiXc

Lee, Thomas Y. 2012. Naming. PDF file. Published Summer 2012.
https://www.google.de/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEw-ieie6t7_TsAhWJGBQKHa86BrUQFjACegQIAhAC&url=https%3A%2F%2Fwharton.instructure.com%2Fcourses%2F406664%2Ffiles%2F14200119%2Fdownload%3Fwrap%3D1&usg=AOvVaw29HbZWzUQR9vzfjJrmmPND
Design and Development of Web-based Products and Services. Wharton University of Pennsylvania OPIM416X IPD517. Accessed 02.11.2020.

Monti, Paolo 1963. Photography. Ercole Marelli offices

Sauro, Jeff. 2015. Customer Analytics for Dummies. 1st edition. John Wiley & Sons, Inc.

Ulrich, Eppinger. 2011. Product Design and Development. 5th Edition. McGraw-Hill Education

Walker, Rob. 2003. The Guts of a New Machine. The New York Times Magazine 30.11.2003
https://www.nytimes.com/2003/11/30/magazine/the-guts-of-a-new-machine.html

Wascha, Dave. 20 Years of Product Management in 25 Minutes. Video. YouTube video service, published 11.09.2017.
https://www.youtube.com/watch?v=i69U0lvi89c

LUT School of Energy Systems. Lappeenranta / Finland.
https://www.lut.fi/web/en/admissions/masters-studies/msc-in-technology/mechanical-engineering/industrial-design-engineering
Accessed 02.11.2020

Dassault Systemes. SolidWorks Introduction Guide 2015. PDF file.
https://my.solidworks.com/solidworks/guide/SOLIDWORKS_Introduction_EN.pdf
Accessed 02.11.2020

National Sleep Foundation 2015. National Sleep Foundation's sleep time duration recommendations: methodology and results summary. Published 14.01.2015
https://www.sleephealthjournal.org/article/S2352-7218%2815%2900015-7/fulltext
Accessed 02.11.2020

PileBuck Magazine 2018. Top 6 Foundation Drilling Rigs on the Market Today. Published 08.06.2018
https://www.pilebuck.com/foundation/top-6-foundation-drilling-rigs/
Accessed 02.11.2020