## WORK SMARTER

THE WORKSTATION

NIKLAS SKRÆDDERGAARD

MA4-ID7 June 2021

**KASPER PRECHT MØLLE** 

**PRODUCT REPORT** 

#### Title page

Report type: Product report MSc04 Industrial Design S2021 Aalborg university

Master Thesis in Industrial Design ma4-id7 - The Workstation

Project period: 01.02.2021 to 03.06.2021

Main supervisor: Nis Ovesen Technical supervisor: Jørgen Kepler

#### Abstract

As COVID-19 hit and company offices shut down, the use of home offices increased rapidly. The increase in home offices showed many of the beneficial aspects of working from home and many are known moving towards implementing home offices as a regular part of the workweek. But COVID-19 showed that not everyone has room for a professional setup, which led to the development of The Workstation. This solution allows for everyone to work from home, with a professional setup. The portable workstation ensures a focused workspace and the possibility to stand while working. The Workstation, allows for all peripherals to be stored alongside the product, keeping the work setup compact and organized. The product is compact, convenient to use, and can easily be removed after a day's work, creating a clear shift between home- and work mode for the user.

#### Contents

Title page2
Abstract
Introduction4
The change in scene7
Recommended by physiotherapist
User journey10
Product Explanation
Hidden in plain sight
Closed dimensions
Colour options19
Construction
Your needs, your solution
Market size
Development Budget
Illustration list



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The sudden increase in home offices has shown many benefits, but also revealed the drawback for the employees who live in smaller homes and are forced to work at the dining table.



TopDanmark and Codan have experienced a rise of 18 to 35% in reported occupational injuries



9 out of 10 physiotherapists reports an increase in patients due to bad work positions



63% uses a kitchen, living-, or bedroom as a home office and 42% use an ordinary chair for work



81% wants to keep working from home at least once a month, only 36% did this before COVID-19

#### Introduction

Home offices used to be something only used regularly by a few. This however changed with the COVID-19 pandemic, where many experienced the benefits of working remotely.

But not everyone had access to the same quality of equipment, as some were forced to work from e.g., the living room, which does not provide the ideal surroundings for a professional setup.

Through the eyes of employers and employees alike the use of home offices has been a success and something which should be implemented permanently. Therefore, a solution is needed to create the required work setup for those who do not have the space required.

#### **The Workstation**

This solution is thereby introduced, which complies with the Danish legislations regarding home office use. The workstation ensures that the 63% who do not have access to a dedicated office, gets the professional-, scene changing-, focus creating- and easy to changesetup.

This eases the ability of working from home, and removes the back pain experienced by many laptop users.

Using the workstation creates an ease of mind for the employers and gives the employee a healthy work posture.



#### The change in scene

The employees forced to use their living rooms as a home office, experiences a variety of difficulties. Some works using only a laptop, resulting in a very unhealthy work position, and violating work legislation. Others use large monitors, creating setups that cannot be moved at the end of the workday.

This have blurred the boundary between being at work and at home.

#### As easy to use as a laptop

Simple and temporary work setup where the employee places the workstation on any dining table, and thereby creating an office.

#### The professional setup

As good as being at the regular office, with the integrated standing desk functionality and a 27" monitor setup. This ensures an authorised work environment.

## Recommended by physiotherapist

Most people sits on a chair with a bent spine, resulting in the weight of the head, straining shoulder muscles and potentially lead to injuries. When standing, the body is centered, relieving shoulder and neck muscles.

Kristian Milver Nielsen Physiotherapists, Vejle municipality



## Needed by the customer

The employee holds the responsibility, to ensure the employee's home office upholds work regulations

They are usually interested in the employee's health, and would want to minimize preventable injuries.

Working from home increases the effectiveness of employees and lower company expenses.

#### **Desired by the user**



The employee needs a professional and temporary setup, which can be used either in the kitchen-, bed- or living room.

They have experienced pain in their bodies, and wishes for an improved and healthier work posture.

Working from home have loosened the employee's work restraint and increased their spare time.



#### **User journey**

The Workstation is carried to the dining table.

When placed, the laptop is connected via a USB-C cable, and the workstation is powered on.

When seated, the side-panels are opened up, and you are now ready to work.

Whenever you feel like standing up, pull the handle and have the workstation lift the monitor to a standing height, with the use of a gas piston. Deploy the platform, and enjoy working with an improved posture.









height you need.

WORK SI

Height adjustable monitor stand Ensuring an ergonomically correct work position

# Fabric cover

home A professional product belonging in a private

# them Storing the devices you need, where you need Peripheral storage pockets



**Extendable work platform** Creating a platform for your standing needs, whenver you want. Side panels Creating a focusd work mode, in the seated position.

**Compatible with up to 27" monitor** With the VESA-compatible mounting system, you can use your own monitor.

#### Hidden in plain sight

The Workstation is designed to fit into your decoration and the aesthetic of any home.

The size of the workstation when folded, is slim enough to fit next to a comfortable chair for you to lay your phone or put a cup on top while reading a book.

It can also, be placed next to your bed, where it with its fabric fit right in.





#### **Closed dimensions**





#### **Colour options**

With a range of different colours, The Workstation should always fit your style. The high quality fabric resembles a couch, but is stiff enough to act as a table.



#### Back





#### Construction

The workstation is made with a metal core. It's sides are covered with plastic with high quality fabric on the outside, to create the feeling of 'home'. The wooden platform is enforced with steel beams to minimize deflection, and steel feet are added to keep the balance.

#### The Workstation fits to you

Fits within the recommended workspace and upholds the recommendations by the Danish work authorities.



#### Your needs, your solution

The Workstation is bought without a monitor, keyboard and mouse. Besides these products, it will be possible to buy add-on elements to mount on the inside of the magnettic panel. Add-ons could be notepads, webcam lights or fans to cool you down on a hot day.

The electronic add-ons, are battery powered, to remove cable cluster and limitations in movement. If it was USB-powered, sidepanels and height adjustments would be challenging to cable-manage.













A fan for the warmer days

Work light

Notes to remind yourself

Speakers for entertainment

Webcam mount





Sales price: 3500 DKK excl. VAT



#### Have your equipment within reach

On the left side panel an integrated storage solution is added. This peripheral storage system provides pockets for keeping essentials nearby and contains computer peripherals when the workstation is stored. The peripheral storage system is mounted with strong magnets, which allows for changing and customizing the layout to your personal needs.

#### Market size

As a result of the extensive use of home offices during the COVID-19 pandemic have employees seen the many benefits of working from home. Therefore, a large rise is seen in the number of employees who want to work from home after COVID-19 compared to before.

The workstation is targeted at the private sector of the B2B market in Denmark. During March 2020 460.000 employees within the private sector work from home, of those estimations show that 81% are interested in continuing to work from home at least once a month after COVID-19. Corresponding to 372.600 employees either starting to and continuing to use a home office regularly.

Of those 169.011 employees do not have access to a home office, corresponding to 45.36% of employees work from home in the private sector.

The project will follow a 7-step execution plan, centered around the Lean Start-Up business model.



99 office workers response when asked about their home office use **AFTER** COVID-19, compared to their situations **BEFORE** COVID-19. The white arrow highlights, that the home office is on the rise.



#### **Development Budget**

Cost estimations shows that an investment of 375.000 dkk is needed for developing and launching the workstation, covering step 1 and 2 of the execution plan.

Tool Cost	
Injectionmolding tool, 2 pcs.	80.000 DKK
Extrusion tool	40.000 DKK
(Total tool investment)	120.000 DKK
Webpage	20.000 DKK
Consultant development	40.000 DKK
Prototypes	20.000 DKK
Marketing	100.000 DKK
Salary	-
Sub Total	300.000 DKK
Unforeseen costs	25%
Total development cost	375.000 DKK

Sales price excl. VAT	3.500 DKK
Sales profit margin	55%
Sales price	2.258 DKK
Sales coverage	1.242 DKK
Manufacturing profit margin	25%
Manufacturing coverage	456 DKK
Cost price	1.802 DKK
Total profit margin	94%
Total coverage	1.698 DKK

**(5**)

Collaboration with sales channels, entering leasing market

Through sales enter the public sector

6

Widen market scope to neighbouring European markets

#### **Illustration list**

Page 2. Woman: 2021. Woman working from home. [image] Available at: <https://www.investopedia.com/terms/h/home-office.asp> [Accessed 1 June 2021].

Page 8. Physiotherapist: 2021. Kristian Milver. [image] Available at: <a href="https://www.linkedin.com/in/fysioterapeut-kristian-milver-nielsen/">https://www.linkedin.com/in/fysioterapeut-kristian-milver-nielsen/</a> [Accessed 1 June 2021].

### STUDENT REPORT

### AALBORG UNIVERSITY



TECHNICAL DRAWING FOLDER

#### Title page

### **Report type: Technical Drawing Folder** MSc04 Industrial Design S2021 Aalborg university

Master Thesis in Industrial Design ma4-id7 - The Workstation

Project period: 01.02.2021 to 03.06.2021

Main supervisor: Nis Ovesen Technical supervisor: Jørgen Kepler

#### Table of content

Drawing nr. 1 - Isometric View, Entire product Drawing nr. 2 - Exploded View, Entire product Drawing nr. 3 - Exploded View, Scissor mechanism Drawing nr. 4 - Assembly Drawing, Scissor mechanism Drawing nr. 5 - Work Drawing, Scissor Lever Drawing nr. 6 - Work Drawing, Scissor Bracket Drawing nr. 7 - Work Drawing, Top Box



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	7	Monitor S	tand	Steel S235	5	1	
	8	VESA Mo	ount	Steel S235	5	1	
	9	9 Monitor Stand Top		ABS Plastic		1	
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# THE WORKSTATION

NIKLAS SKRÆDDERGAARD

MA4-ID7 June 2021

KASPER PRECHT MØLLER

PROCESS REPORT

# 0.1. Title page

**Report type: Product report** MSc04 Industrial Design S2021 Aalborg university

Master Thesis in Industrial Design ma4-id7 - The Workstation

Project period: 01.02.2021 to 03.06.2021

Main supervisor: Nis Ovesen Technical supervisor: Jørgen Kepler





Kag P. Moller



Niklas Skræddergaard

Niklas Shroddergaard

#### 0.2. The team

The team consists of two members, Kasper Precht Møller and Niklas Skræddergaard. They are studying at Industrial Design, Aalborg.

Entering this project, the team knew that their competencies complement each other. Kasper's main drive about product development lies in the area of research, business development, and production considerations. Niklas' main drive consists of CAD construction and technical aspects of product realization. Each had great understandability of usercentered design.

The team has different focus areas and are 'experts' in different areas, however through close team-working, they both have participated in all studies and exercises and thereby creating a high-performance team.

#### 0.3. Abstract

The use of home offices used to be something that belonged to only the few. This changed as an effect of the COVID-19 pandemic, where many employees were forced to work from home. As a result, both companies and employees have experienced many benefits from home offices and many are therefore pushing toward implementing home offices as a regular part of a workweek. While many companies move towards increasing home office use, they are also challenged by work legislations, as the companies are left with the responsibility for ensuring healthy work positions at the home offices. This is especially challenging for the many employees living in smaller homes, with no access to a dedicated office, where employees instead are, as an example, forced to work from at the dining table using a regular chair. This master thesis

investigates the experience, trends, and challenges concerning the use of home offices, to develop a product that ensures that the employees working from the dining table have access to a healthy and attractive work setup, while the employers are ensured that their employees uphold work legislation.

The result of the development project, is a workstation that users can use in combination with their existing furniture, to create a temporary office and a change in scene, to uphold work legislation and psychologically create a distance between 'home mode' and 'work mode'. The product is developed alongside a user panel to ensure that the product fits into their work routines and storage possibilities of a smaller home.

# 0.4. Reading guide

This proces report presents the work, which have been executed throughout the project.

The report has been split into 5 phases, with each phase representing the chronological structure of the development project. Every topic have been described through worksheets, which have been re-arranged into the headlines seen in the table of contents. With each transition between phases, a recap is described next to a description of the next phase.

It is advised to read the product report, technical drawings and proces report in this given order. The proces report is linked to an appendix, of which will be referenced when additional information is needed.

This is a box, which marks a significant insight.

# Table of content

Title page	
The team	
Abstract	
Reading guide	Ρ
Course of the project / phases 5	
Introduction	
Problem Statement 6	
Phase 1	
Explorative ideation: "How to be together without	
being together"8	
First ideation	
Concept Direction Development	
User Interviews	
Data research: Home Office problem size 14	
A physiotherapist describes the problem of sitting . 14	
PESTEL	
Questionnaire	
Phase 2	Ρ
User Categorization	
Ideation on the 'home office'	
The B2B choice	
B2B direction impact	
Competitor analysis	
User Panel	
User Specification	
Psychologic Impact of Working from Home 30	
Home Office Ergonomics	
Cardboard Mockups	
Buyer Interviews	
Design Brief	
Phase 3	
Business Case	
User Meassurements	
The dining room	
Danish Working Environment Authorities 40	
Peripheral Analysis	
Connecting the laptop	
Choosing a monitor	
Product installment	

Stakeholder Analysis	43
User interactions	44
Requirement specification	45
Phase 4	48
Detailing the concept	49
Combine Design	53
Folded- design aesthetic	57
Gas piston functionality	58
Height adjustment specification	59
Standing work platform	61
Working from home Deloitte	62
Saphe Mockup test	63
Physiotherapist interview	64
Market size	65
Business plan	66
Execution plan	67
Maximum cost price	68
Phase 5	71
Phase 5   ••••••••••••••••••••••••••••••••••••	<b>71</b> 72
Phase 5	<b>71</b> 72 73
Phase 5	<b>71</b> 72 73 74
Phase 5	<b>71</b> 72 73 74 76
Phase 5	<b>71</b> 7273747678
Phase 5       Technical Calculations         Technical Calculations       Technical Calculations         Choosing a gas spring       Technical Calculations         Electronic components and cable management       Technical Calculations         Storing peripherals       Technical Calculations         Component development       Technical Calculations         Materails and production considerations       Technical Calculations	<b>71</b> 727374767879
Phase 5       Technical Calculations         Technical Calculations       Technical Calculations         Choosing a gas spring       Technical Calculations         Electronic components and cable management       Technical Calculations         Storing peripherals       Technical Calculations         Component development       Technical Calculations         Materails and production considerations       Technical Calculations         Weight analysis       Technical Calculations	<b>71</b> 72 73 74 76 78 79 86
Phase 5       Technical Calculations         Technical Calculations       Technical Calculations         Choosing a gas spring       Technical Calculations         Electronic components and cable management       Technical Calculations         Storing peripherals       Technical Calculations         Component development       Technical Calculations         Weight analysis       Technical Calculations	<b>71</b> 72 73 74 76 78 79 86 87
Phase 5       Technical Calculations         Technical Calculations       Choosing a gas spring         Choosing a gas spring       Choosing a gas spring         Electronic components and cable management       Choosing peripherals         Storing peripherals       Choosing         Component development       Choosing         Materails and production considerations       Choosing         Weight analysis       Choosing         Production cost       Choosing	<b>71</b> 72 73 74 76 78 79 86 87 88
Phase 5       Technical Calculations         Technical Calculations          Choosing a gas spring          Electronic components and cable management          Storing peripherals          Component development          Materails and production considerations          Weight analysis          Production cost          Development cost & break even	<ul> <li>71</li> <li>72</li> <li>73</li> <li>74</li> <li>76</li> <li>78</li> <li>79</li> <li>86</li> <li>87</li> <li>88</li> <li>89</li> </ul>
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Phase 5	<b>71</b> 72 73 74 76 78 79 86 87 88 89 90 93 94 95 96
Phase 5	<ul> <li>71</li> <li>72</li> <li>73</li> <li>74</li> <li>76</li> <li>78</li> <li>79</li> <li>86</li> <li>87</li> <li>88</li> <li>89</li> <li>90</li> <li>93</li> <li>94</li> <li>95</li> <li>96</li> <li>98</li> </ul>

# 0.5. Course of the project / phases



# 0.6. Introduction

The use of home offices and the concept of working remotely used to be something that belonged to only the few and never the norm for regular office workers. This however changed as an effect of the COVID-19 pandemic where many offices shut down completely and employees were forced to work from home by their governments. This change proved a great challenge to the companies, which have not previously used home offices regularly.

Society is now reopening, and employees are moving back into offices, meeting colleagues, and returning to their former work routine. But, several months of working from home have shown employers that the use of home offices both increases work efficiency and saves resources. Employees on the other hand have experienced that the use of home offices enables them to save time otherwise spent commuting and enhance their influence on their work assignments, enabling them to schedule work to better suit their private life. A large portion of employers, managers and employees, therefore works towards implementing home offices as a regular part of the work routine, enabling everyone to work both at home and the regular office during a workweek.

While some have had a healthy and professional home office setup working in a room dedicated to being an office with professional equipment, many have been forced to work from either the kitchen or living room, using a dining table and -chair as the basis for their home office. The increased use of home offices has caused a spike in occupational hazards which have been reported to insurance companies. Physiotherapists also experience a growing number of patients suffering from work injuries related to work positions. This shows that while a home office provides many advantages, they are at the same time responsible for several drawbacks.

When an employee is working from home on a regular basis, it is the company for whom they work for that is required by law, to ensure that the employee has access to equipment that provides a healthy work position. Furthermore, the company is left with the responsibility of ensuring that the home offices used by each of their employees uphold the same legislation which applies to the company's regular office.

Increasing the use of home offices and implementing it as a part of a weekly work routine, creates a huge challenge for employers, as they need to ensure that everybody gets access to the right office equipment suiting their individual living situation, providing both a healthy and authorized work position.

# 0.7. Problem Statement

While the problem can be solved by offering monitors, office chairs or even standing desks for the employees who have access to a room, dedicated as a home office. This is however not a lasting solution for those who are forced to work from rooms such as the kitchen or living room.

Both companies and employees are therefore left with the problem of <u>how to create an ergonomic and</u> <u>temporary work environment for smaller homes, that</u> <u>complies with work legislation, without having a</u> <u>dedicated office?</u>

# Table of content for phase 1

Explorative ideation: "How to be together without being together" 8
First ideation
Concept Direction Development
User Interviews
Data research: Home Office problem size
A physiotherapist describes the problem of sitting
PESTEL
Questionnaire



# Determining the direction of the project

The first phase of the project focuses on determining the direction for the development project. The phase focuses on locating a complex problem scenario. This problem is then unfolded and investigated to get a deeper understanding of the problem, the problem owners and to comprehend the scope of the problem and thereby verify if it is an increasing issue.

# 1.1. Explorative ideation: "How to be together without being together"

The project first steps, were related to the COVID-19 pandemic, where many people suddenly were found lonely and without much access to their friends and family. Therefore a brainstorm were performed concerning the question: '*how can we be together, without actually being together?*'.

This lead to a brainstorm, with four different directions: 'Home Office', 'Elderly', 'Conversation Speaker' and 'Integrated Audio'.

#### **Home Office**

The home office related to how co-workers communicates throughout the day either through meetings but also having a social connection to coworkers.

#### Elderly

To create something for the elderly, the team brainstormed on making technology accessible -

even for those with limited understanding of smart products.

#### **Conversation speaker**

Experience with talking with multiple people at once has been lacking, which is why an idea for conference speakers targeted at families was introduced.

#### **Integrated Audio**

While not following the question directly, the integrated audio focused on a better sounding entertainment system, could be added to a home without adding visible speakers.

Underneath, the brainstorm can be found as a mindmap, at Ill. 1.1.



Ill. 1.1. Mindmap of the first ideation brainstorm.

# 1.2. First ideation

The first ideation round focused on the team emptying their heads for their initial ideas on how they could solve some of the topics, highlighted within the mind map.



These ideas focus on the social aspect aswell as decorating the office. There's a social speaker, a webcam + light and a monitor mount with inbuilt camera and speaker unit for online meetings.



The elderly direction were based on some people having a smartphone, with limited use, due to lacking understanding of the interactions. Here, the idea were to make a dock, which simplifies this interaction.



The conversation speaker focus on good quality conversations between two groups, possibly also between one person and a larger group (possibly the rest of the family).

Between a group to one person, the device would pick up directional sound, for the receiving end to decode more intuitively.



The hidden audio, were based on an idea, where it could be possible to integrate speakers into existing furniture, could improve the sound stage in even the smallest homes.

The goal for the excerise were to determine, if a solution direction could be defined. The result was four directions, which can be seen underneath.

# 1.3. Concept Direction Development

All four of the directions were found interesting, but needed more ideation, to specify a clearer concept direction. Therefore a structered ideation process was initiated, split into three steps:

- Mindmap/brainstorm the four directions in more detail
- Sketch on previous ideas, but include somtehing form the mindmaps.
- Get feedback from users, based on the product directions made within this step

The goal of the ideation, is not to define specific concepts, but getting an idea of what the users would like in their home. While sketching, the team built upon each other's drawings and were inspired by the mindmap.

For the additional mindmaps, see the appendix at page 9.

The red boxes have been added in hindsight, as a tracker for what the team got inspired by, and to show the road to where the product proposal ended.



Ill. 1.2. Mindmap of the 'home office' direction.

It was quickly discovered, that the most inspiration were relating to the home office direction. Concepts were developed for the three other directions aswell (which can be found in the appendix at page 9).

When combining the best from the home office concepts, three directions could be underlined:

- Improving online meetings
- Quickly setting up the right equipment / eliminating clutter
- Social relations are missing

A presentation of the three directions and the related sketches can be seen below:



#### Improving online meetings

The online meetings have been observed to be improveable. This is by these concepts done by integrating a high quality webcam with lights on top of a monitor, which in turn can light up either the workspace, or the user's face. Furthermore, the concepts covered integrating different technologies, in the strive to simplify and improve the work environment at home.



# Quickly setting up the right equipment / clutter removal

This direction focus on integrating the storage of the monitor for a workspace, either within furniture or underneath the dining table, with a special clamp system to hide the monitor when it is not needed. The third concept works with integrated storage and making an overview of the work process, while also adding a modular system with a cork-surface allowing the user to add speakers, clocks etc.



# Social relations are missing

Throughout the COVID-19 pandemic, and the home office use which followed, the relations to the co-workers were lacking. This concept attempts to remove the barrier between co-workers, by implementing a social aspect to the home-office.

**Idea Selection** 

When looking at the four directions, the team became aware of a low innovation height, which concerned the 'elderly', 'hidden audio' and 'conversation speaker' directions. These topics were simply not problem based. The home office however, responded to problems discovered during the pandemic. A need to verify the problem and concept direction emerged. Therefore a data collection should be initiated, where concepts could be discussed with potential problem owners.

The home office direction, revolved around four directions, as seen on the mindmap (at page 10): Meetings, social, clean environment, work environment.



Ill. 1.3. Conversation speaker allowin employees to speak wit eachthe in chat-rooms.



Social device, providing Ill. 1.4. visuals to other co-workers with vacncies and video reachable at a glanse.



Ill. 1.5. Workstation packed away into existing furniture - in this instance, a dining table for space optimizing.



Ill. 1.6. Smart monitor mount, with integrated speaker systems, mute buttons and camera. This, to remove clutter on the desk.

Here, employees could enter a chat room, where if someone else also felt like a break, could join the same room. By mimicking the coffee break with a colleague, the user is no longer required to disturb someone, to have social interactions.

All themes were to be discussed with potential problem owners, to verify the project direction.

Concepts were picked as a representative from each topic, to be presented and discussed with users, to find needs and wishes.

The selected concepts to present to users are:

# 1.4. User Interviews

The concept directions found in connection to the 'home office' theme in 1.3, were to be presented for potential users to determine if the concepts would add value. To do this a semi-structured interview is used to both discuss each subject and to learn about their experiences at a home office.

The interview guides can be found at the appendix at page 19.

# The informants

Due to COVID-19, and the informants working from home, the team reached out to their network, to find users who had the necessary experience to answer questions. Here, co-workers, parents and friends were asked about their thoughts on the topics previously mentioned. The informants were:

- Anna Marie Møller, 53, Private Banker.
- Kamilla Jepsen, 26, Project Engineer.
- Kristian Sleting, 31, Product Manager.
- Anne Jensen, 28, Product Designer.
- John Frydkjær, 55, low voltage engineer.

The interviews were conducted through an online meeting, where sketches were presented along side an interviewguide.

#### Sum-Up of the interviews

None of the informants had never worked at home before COVID-19, however they all wanted to spend more of their time at home afterwards – possibly a couple of days a week. Currently, the interviews indicated a lack of social connections to colleagues, however, most believe the home office to be a focus area, that allows for undisturbed work. As the pandemic has worn off, the lacking social interactions will naturally be fixed.

All interview informants had online meetings from their home offices using a variety of platforms and devices, each person used speakers/headphones for these meetings and while some would prefer better sound/conversation they did not consider a meeting speaker device to be a better solution than what they

#### currently used.

It is important for all the informants to have a clean looking and clutter free workspace when working from a home office. Furthermore, it was important for the informants that their home office was sealed off at the end of the day by closing the door to the office or by removing the equipment converting the office back into a home again. This was something all informants had a desire to do, but not all had the possibility to achieve this at the end of the workday. Several of the informants were especially interested in the foldable table solution, indicating a need for a quick and easy solution that integrates the office space into the home, while allowing the two situations to be completely different.

Based on the informants combined desire to improve/ change their home office setup it is decided to change the direction of the project from '*being together, without being together*' focusing on communication, to improving the situation experienced at the home office with a focus upon '*facilitating a professional office setup which ensures a quick change in scenes, between work and home mode*'.

#### Next step

Continuing from this point forward, it is necessary to determine if the needs and wishes from the five informants can be applied to other people using a home office and to investigate the market situation; who are the competing products in the category? And is the market potential in- or decreasing? Finally the target group should be specified, as the interviews showed the four informants were very different when comparing job positions, work assignments and home office setups etc.

It is decided to change the direction of the project from '*being together, without being together*', to improving the situation experienced at the home office with a focus upon '*facilitating a professional office setup which ensures a quick change in scenes, between work and home mode*'.

# 1.5. Data research: Home Office problem size

In "1.4. User Interviews" on page 13, the project direction was changed to focus upon how to facilitate a professional office setup which ensures a quick change in scenes, between work and home mode. To further explore the 'home office' theme a research process is initiated, where the theme is explored using Infomedia

The research process highlighted five main topics which kept recurring in most publications:

- Home offices are on a rise
- Employees lacks a change of scenes
- Home offices do not support healthy work ergonomics
- Employees miss the social contact at the office
- Online meetings is a permanent supplement for some meetings

to access published news and magazine articles. As a result of the COVID-19 pandemic many have been forced to work from a home office, which have generated an enhanced focus on the area from medias and experts. For a description of the topics, see the appendix at page 11.

A quote from TopDanmark outlines, that they see an increase in damages related to the home office:

"The insurance companies TopDanmark and Codan have experienced a rise of 18% to 35% in occupational injuries related to shoulders, neck, and lower back cause by home office use." (Pröschold, 2021)

#### Sum-up

The research process confirmed the previous assumptions and findings that the use of home offices is not only a temporary solution to the COVID-19 pandemic, but both company owners and employees works towards making it a permanent addition to the professional work routine alongside online meetings. However, the use of home offices would function as a mixture between working from home and at the offices, to ensure the social contact and teamwork between colleagues. While employees are interested in continuing to have the option of working from home, this could have a negative impact on the employee's wellbeing, as home offices lacks boundaries between home and work mode. Furthermore, it is found that home office use have resulted in a rise in occupational injuries due to unhealthy work postures.

# 1.6. A physiotherapist describes the problem of sitting

To widen the understanding of why home office use can lead to unhealthy work positions a physiotherapist is contacted and asked to elaborate on the issues of ensuring a healthy work position in relation to working at a home office:

"Most people who sits in a chair ends up having an unhealthy position. They crunch over, resulting in a bent spine and a head leaning forward. This position applies stress to neck and shoulder muscles, as these muscles must carry the heavy weight of the skull. This work position would over time lead to occupational injuries. When this unhealthy work position is changed to a standing position these issues are removed, as a person working in a standing position have a straight back and have the skull aligned with the center axis of the spine and body. Working in a standing position, ensures that the shoulders and neck do not have to carry the weight of the skull as it instead balances on the shoulders.

When you work in a standing position you have a tendency to move a bit around, shifting your weight from one leg to another, these small movements ensure the all muscles shares the burden of supporting your body. However, sitting down in a crunched position risk isolating muscles that then are over burdened, leading to both small and severe injuries." (Nielsen, 2021)

Physiotherapist, Kristian Milver Nielsen.

# 1.7. PESTEL

To understand the external forces which has an impact on the home office product market, a PESTEL analysis is used. This trend analysis is used to get an overview of which trends/movements from the macro environment that can have an effect on the success of the product, both in a positive and negative way. (Jobber and Ellis-Chadwick, 2016)

#### Political

Both labor unions and larger companies are pushing for increasing the use of home offices after the COVID-19 pandemic. This have resulted in an ongoing change to company politics and labor union contracts, which both pushes for increased use of home offices in the future. (Brandsen, 2020) (Kehlet, 2020)

#### Economic

The company owners stand to save resources by increasing the amount of work from home offices. Some companies plans on reducing office area, estimating that not all employees is going to be at the office at the same time, thereby saving costs on office rent. (Malmgreen, 2020) (Kristensen, 2020)

# S

# Social

The COVID-19 pandemic and lockdown have forced many to work at home, which have proved that it is possible for most to work from home for several days. As a result of this, workers are having an increased interest in gain the possibility to continue to have the flexibility of working from home after the COVID-19 lockdown. (Boddum, 2020)

# Technology

The COVID-19 lockdown has showed that while it is not suitable for everyone to work from home every day of the week, it is for many both possible to work from home several times a month (or week), without impacting work quality or efficiency due to the current state of technology.

# Environmental

An increase in use of home offices have a potential of decreasing the environmental impact of personal transportation, as the natural resources used for commuting is saved. (Østergaard, 2020)

#### Legal

Current work legislation in Denmark state that if a person work from home one day a week or for two hours each day, the employer are responsible for ensuring that the home office complies to current work legislation. (Hjemmearbejde -Arbejdstilsynet, 2021) However, employer organizations are pushing for loosening the legislation demands for working at the home office. They strive to lower the employer's responsibility for ensuring a work environment in accordance with current work legislations and increasing the amount of workhours which can be conducted at home before it is classified as a home office. (Kehlet, 2020)

# Conclusion

The analysis shows that several macro trends push towards an increase in the use of home offices compared to before the COVID-19 lockdown. Both employers and labor unions are interested in increasing the possibility for implementing home office use on a regular basis. An increase in home office use could have a positive impact on the home office equipment market, as this could lead to an increase in sales. However, pressure is put on politicians to loosen the requirements for home offices, which could impact if employers are required to provide equipment to improve the work environment at the home offices. If this happens it could have a negative impact on B2B sales in the home office equipment market, as employers would not be required in the same degree to provide equipment.

# 1.8. Questionnaire

So far the data collection indicates that the 'home office' is trending. This is however based on experts and articles, and not the users themselves. To recieve these insights, a questionnaire was made (see the appendix at page 12).

The questionaire was published on LinkedIn and Social Media, with 99 respondents. With this many respondents, it is believed to be valid insights.

One of the important insights from the questionnaire, were the development in how often the respondents worked and wants to work from home in the future, held up against how the setup is at 63% of the respondents, being seated within their living room or bedroom.

66% of the respondents believe, that they have difficulties changing from the "I'm now at home" to "now I'm at work" in their head, when going from the sofa to the dining table and vice versa. The need of a dedicated space for work, is therefore required.

Only 12% has access to a standing desk, while 66% wishes for it at home. This could mean, that it's either

too expensive to acquire or that it won't fit their current living situation.

It was additionally found that a lot of the respondents experienced trouble, regarding loneliness. They felt excluded from their colleagues and lacked communication with important relations at work.

When viewing the information on how often they will work from home, most of their time will be at the office, where communication with other people would take place.

This means, that the home office situation, should target the 'focus work' more than it should be the communication aspect.

As part of the questionnaire, the respondents were asked to upload a picture of their home office, which could provide insights for the team on the niche problems experienced or focus on the most important equipment spotted the most times. The analysis of these pictures can be found at "2.1. User Categorization" on page 20.



#### **Problem Finding**

Both employees and employers are moving towards keeping home offices as a permanent addition to the work environment. Working from home is valued on both sides, as all stakeholders find benefits in this option. This however leaves employers reponsible for upholding work regulations, at both the company office but also the home offices. Working from home for more than two hours a day, or a whole day each week, applies the same rules to the home office as if it was a real company location. It is the employer's responsibility, that no occupational injuries is given to the employee, when working from home. This creates a big challenge for the companies, as equipment needs can be very specific and customized to different homes.

Both employers and employees are therefore left with the problem of how to create an ergonomic and healthy home office work environment that complies with work legalization?

Focusing on:

- Ensuring that all employees have access to a setup abiding to work legislation.
- Employees have a healthy work position while working from home



#### **Summary**

Through phase 1, a problem area was found concerning the use of home offices. Many employees have been forced to work from home due to COVID-19. This extensive use of home offices has shown several positive aspects to employees and employers, and shared interest is therefore seen to the will to implement home offices as a permanent addition to the work schedule continuing after COVID-19.

The phase was initiated with the question of 'how can we be together, without being together'. Working with this, led to a focus on the home office and the discovery of problems associated with this topic.

# Table of content for phase 2

User Categorization
Ideation on the 'home office'
The B2B choice
B2B direction impact
Competitor analysis
User Panel
User Specification
Psychologic Impact of Working from Home
Home Office Ergonomics
Cardboard Mockups
Buyer Interviews
Design Brief



#### **Product ideation**

The second phase consists of the initial product ideation, where concepts and ideas are developed in response to the previous problem statement. The statement is then explored and challenged through a data collection process, where interviews are carried out with various problem owners, representing both employers and employees. Furthermore, a competitor analysis was initiated to get a understanding of the market. This is done to define and sharpen the problem statement, the problem owners, the stakeholders, and the requirements presented in a design brief.

# 2.1. User Categorization

Alongside the questionnaire a method of social probing were initiated. At the end of the survey the respondents were asked to upload pictures of their home offices. A total of 40 different home offices were uploaded, these could then be divided into two different categories.

# **Primary/secondary Rooms**

Home offices placed in the primary or secondary room of the home (kitchen, living room or bedroom)



#### **Dedicated Rooms**

Home offices placed in either a room dedicated to being an office or a room sub functioning as an office (storage-, guest- or second living room)



Ill. 2.1. Social probing results with the recieved pictures from different homes. They have here been categorised regarding 'primary rooms' and 'dedicated rooms' Pictures can be seen in the appendix at page 14.

# **Primary/secondary Rooms**

The home offices which are placed in the primary or secondary rooms are all very different. Each picture describes a personal situation where the users have made an office which fits their work routines, personal preferences, and home with the equipment they had at hand or have been provided. While each setup is personal and tailored to specific needs, some general trends/solutions can be deducted from combining the pictures. Based on the pictures four general user groups can be categorized:



# Laptop only

The 'laptop only'-users work from home, solely using their laptop without any connected monitors. From the pictures provided through the social probing method it can be further be deducted that no laptop only users use a separate mouse or keyboard. The laptop only users generally use a dining table as their office desk.

# Monitor on the dining table

The 'monitor on the dining table'-users have placed one or more monitors on their dining tables, which they then use as an office. The setup is a heavy setup, which take up space and is not easily removed after work. The pictures shows that some users move the monitors to the side at the end of the day, to change the table of office desk to dinning table. Some users use a dining chair, however some use an office chair for work.

#### Work desk in primary room

The 'work desk in primary room'-users have placed an office desk in what can be categorized as the primary room. The users have one or more monitors and what can be described as a full office setup. The setup is a temporary setup, very heavy, and invasive in the home, as it is not part of the rooms arrangement and seems like it have been installed due to the COVID-19 lockdown. The office desk can not be moved at the end of the day and is therefore a permanent part of the room. The users have all added office chairs to their work desk and the user can be assumed to have a focus on work position, rather than ensuring that the office can be removed at the end of the day.

#### Work desk in secondary room

The 'work desk in secondary room'-users have an office setup in what can be categorized as the secondary room (e.g. the bedroom). The users have one or more monitors and what can be described as a full office setup. The setup can be both a temporary and permanent setup, as some pictures shows that the work desk is part of the rooms arrangement. Some users use a dining chair, however some use an office chair. The setup have some focus on work positions. Identifies:

- Uses a laptop without separate keyboard or mouse
- Work at the dining table
- Do not use an office chair
- No focus on work positions
- Temporary work setup, work stuff is removed at the end of the day

Identifiers:

- Have placed monitors on the dining table
- Work at the dining table
- Some use an office chair, some do not
- Limited focus on work positions
- Temporary work setup, work stuff is moved to the side at the end of the day

Identifiers:

- Have placed an office desk in the primary room
- Have a professional office setup
- Use an office chair
- Highly focused on work positions
- Permanent work setup, cannot be moved at the end of the day
- Temporary solution for the COVID-19 lockdown

#### Identifiers:

- Have an office desk in the secondary room
- Have a professional office setup
- Some use an office chair, some do not
- Limited focus on work positions
- Permanent work setup, cannot be move at the end of the day
- Can be both be a temporary solution for the COVID-19 lockdown or installed and used before the lockdown

# **Dedicated Rooms**

The home offices are placed in a room dedicated to being an office or a room sub functioning as an office (storage-, guest or second living room) are all very different. Each picture describes a personal situation where the users have made an office which fits their work routines, personal preferences, and home with the equipment they had at hand or have been provided. Based on the pictures the users of the offices can in general be described as:

Professional office setup

While the users can be described as all having access to a professional setup, the offices are still personal and tailored to specific needs. The general trends can be described as:

#### Worktable types

- The small workdesk, which is part of a room with another function
- The large work desk which is part of the dedicated office

#### Chair types:

- The ordinary kind, which is also used at dining tables (rare)
- Office chairs with adjustable height and back (common)

#### Monitors:

Nearly everyone has at least one extra monitor, used together with the laptop, with some having two or three monitors. A few even uses a 90 degree rotated monitor.



Ill. 2.2. A professional work setup, within a dedicated room

Ill. 2.3. A professional work setup, within a guest room

#### Sum-up:

When comparing the two categories it is clearly seen that the 'Professional office setup'-users have a home office placed in either a room dedicated to being an office or a room sub functioning as an office (storage-, guest- or second living room). This type of office, is comparable to what can be expected at the company location where most users have one or more monitors, a wide work desk, and an office chair.

Compared to having an office placed in the primary or secondary room of the home (kitchen, living room or bedroom), this is only seen in the user groups 'work desk in secondary room' or 'work desk in primary room'. The users 'work desk in secondary room' have a setup which is part of the home's arrangement, why these are not considered.

The remaining users: 'work desk in primary room', 'monitor on dining table', and 'laptop only', does all have a temporary setup installed because of the COVID-19 lockdown. The users 'Laptop only' have a low focus on work position, but the possibility to remove their office setup at the end of the day. The opposite is the case for the 'work desk in primary room' and the 'monitor on dining table'-users, where it is only partially possible to move their office equipment.

This result in three user groups, which have very different setups and priorities, as the users either focus on:

- 1. Light setup: Easy to move/remove work equipment, not focusing on work positions, or
- 2. Heavy setup: Ensuring a good work position, while being a permanent setup

Either group have not found a perfect solution as the 'Laptop only'-users have compromised on ensuring a healthy work position, while 'desk in primary room'users have compromised on not completely altering the homes' arrangement after work hours.

The project scope is narrowed down to the 'primary room'-users, which needs a flexible, removeable and healthy work position, which includes a monitor setup.

# 2.2. Ideation on the 'home office'

In "2.1. User Categorization" on page 20, the users were defined as 'people working in the primary room'. An ideation process was therefore initiated to develop a concept combining the pros experienced by each sub user group into one concept. The ideation revolved

The ideation proces was split into three steps, based on the book 'Kreativ problemløsning og praktisk idéudvikling' by Ole Striim (Striim, 2006). A more detailed development process can be viewed in the appendix at page 15.

# Step 1

The sketches were based on three topics, each representing a different concept direction:

- Replacement furniture
- Pop Up/add-on
- Permanent but hidden

Examples of these sketches are seen to the right (Ill. 2.4-Ill. 2.6)

# Step 2

To expand on the concepts, a circle technique. Here, the sketches was focused more towards the three usergroups, laptop only, monitor on dining table and desk in primary room.

# Step 3

During step three, the ideas was compared and different directions were selected and drawn digitally, for better comparison between the concepts.

#### around the problem description:

"A solution which facilitate a professional office setup and healthy work positions as seen in the heavy setup in combination with the possibility of removing the home office easily as seen in the light setup."

The steps were:

- 1. Idea Creation (with simple skethces)
- 2. Combining and evolving on sketches
- 3. Idea selection with digital marker drawings



#### Idea selection

During the idea selection phase, it was decided not to continue with the 'permanent but hidden' concepts, as they were products which depended too much on the users homes and decoration preferences. Keeping in mind, that the users are people with lack in space, it was important for the product to be very small and take up as little space as possible, without replacing existing furniture. The concepts which were selected, should be presented for a user panel, to determine a product direction. The three concepts chosen, were: smart mount, dining table desk, and office to go.



Ill. 2.7. Smart mount

#### Smart mount

The smart mount is an add on product which is selected to represent a way of integrating a product which is as easy to use as a laptop, while providing the benefits of using a monitor.



Ill. 2.8. Smart mount use scenario



Ill. 2.9. dining table desk

#### Dining table desk

The dining table desk is a replacement furniture product. The desk replaces the dining desk in either the living room or kitchen and contains an entire office setup and a standing desk functionality.



Ill. 2.10. dining table desk use scenario



Ill. 2.11. Office to-go

# Office to-go

The office to-go solution is a pop up product which is a transportable home office which can be placed on any table. The product is representing the common ground between the 'dining table desk' and 'smart mount'. It is a temporary solution that both supports standing desk functionality and can be removed quickly.



Ill. 2.12. Office to-go use scenario

# 2.3. The B2B choice

To decide whether to sell a product in a B2B direction or B2C, the impact of both is listed for the team to make a better choice.

When viewing the B2C business strategy, the user is the same person as the buyer. This means, that the motivation to buy something should solely rely on the user having a need to spend money on a solution.

When viewing the B2B direction however, the user and buyer are two different people. There are at the same time a push/need applied to the buyer (in this situation

# 2.4. B2B direction impact

#### Buyer or user focus?

The users of the product are employees, who either wants to or are forced to work from home. The users will have many inputs, needs, and wishes concerning the product as they are interested in having a solution that fits their workflow.

However, for a B2B product, it is not necessarily the users themselves who buy or decide to acquire a solution. Instead, the employer would have a say concerning the solution, determining if a product is needed considering the benefits provided against the cost. the company) to provide the user with the correct equipment. This is due to the Danish authorities demanding proper work setups for the employee. By going in the B2B direction, there are therefore a bigger motivation on buying a product which solves all these legislations in one go, compared to the B2C buyer only relying on his own motivation and money.

It is determined to move forward in a B2B direction, as this is viewed as the stronger business case, which also is supported by the findings in the PESTEL analysis.

As the product is to be sold in the B2B market is it necessary to design a product, which is attractive to both users and the decision-makers. These stakeholders could in some cases have different whishes or even conflicting opinions. It would then be necessary to compare and decide in which scenario one opinion is more important than another. However, selling the product in the B2B market is it necessary to ensure that the product withholds all requirements stated by the Danish Working Environment Authorities, as the product would be used in a professional context.

#### Laws and regulation

If an employee work from home more than two hours a day or one day a week are their personal home offices classified as a professional office, and therefore must comply with the same work legislation as a regular company office. When the home offices are covered by the legislation set by the Danish Working Environment Authorities (DWMA) it is the employees' responsibility to ensure that the home office upholds all requirements stated in work legislation. (Arbejdspladsens indretning og inventar Atvejledning A. 1.15, 2008)

**Requirement:** 

The product must uphold work regulations, as it is a professional product.

# 2.5. Competitor analysis

To get an understanding of the market and competition is a competitor analysis is initiated, to verify if the need for a product is a solution problem, sourcing- or a cost problem.

The competitor analysis can be seen in the appendix at page 17. The result of the competitor analysis is the realization that the home office equipment market is a highly red ocean market, with many differentiated competitors competing on both cost and functionality. Therefore, to get a clearer understanding of the market is a strategy canvas was made, where the performance of the competitors is compared through parameters matching the need of the user, the competitors included in the canvas additionally had to comply with work legislation. Through the strategy canvas analysis can it be deducted that while home office equipment is a red ocean market, a blue pond due emerge when looking for 'temporary solutions that comply with work legislation'.

This is seen as no competitor offers a product that provides: a flexible work position, monitor setup, and ensuring a big change of scenas between work and home mode. This verifies the product direction, as the need of the users is a missing solution problem.



*Ill. 2.13. Strategy canvas with some competitors removed, due to not living up to requirements.* 

# **Target model**

Through the strategy canvas it was found that there existed no direct competitors. The rest of the competitors was therefore compared to the proposed product direction through a target model (see III. 2.14), to determine which competitors are the secondary or tertiary competitors.

# Conclusion

Both the strategy canvas and the target models highlight that there are no direct competitors to the proposed product direction. The market for home office products that converts primary rooms into temporary home offices complying with work legislation is a niche market and a blue ocean that no competitors have penetrated yet.





# 2.6. User Panel

To further probe the problem and document requirements, a user panel is created with people who are within reach. The user panel, reflects the answers given in the questionnaire at page 16. An interview were held with Amalie Philipps, Kathrine Nottelmann, Benedicte Ravn and Thor Møller, who each have their own profession and living situation. Common for all of them, is the lack of a dedicated office space.



Name	Amalie Philips	Kathrine Nottelmann	Benedicte Ravn	Thor Møller		
Age	26 years	24 years	26 years	35 years		
Job title	Project Engineer Job consultant		Project Engineer	Student / volunteering	dent /Senior advicerunteering(DFØ)	
Home size	3 rooms	2 rooms	2 rooms	3 rooms		
People at home	2 persons	Alone	2 persons	2 persons		
Picture of the home 'office'						

The interview guide and a detailed user panel description can be found in the appendix at page 20. When describing their future work situation, all respondents is interested in continuing to work from home between 1-3 days each week. The user panel representatives live in small homes and find it beneficial to get a product which could facilitates a proper work environment in the easiest way possible. When working, not all uses a separate keyboard or

"I do not use my dining table, due to the clutter, unless we have guests visiting" (Phillips, 2021)

"It is cumbersome to go from one monitor to another, and setting it up" (Phillips, 2021)

"I 4/5 days a week, clean my dining table from work related stuff" (Nottelmann, 2021)

"I've tried moving my stuff away from the dining table every day, but it is a hassle" (Nottelmann, 2021)

monitor, but all would prefer it. They all currently use their dining table as the base for the home office, but as the equipment is tiresome to set up, they end up keeping their work equipment in the living room for several days, sometimes only removing it during weekends or if guests come over. This has a negative impact on the user panel, as they find it hard to keep a boarder between work and home mode.

"It is extremely important for me, that a solution is very convenient - just finding the right cable to use for a monitor, can be a struggle" (Ravn, 2021)

"I am not good at dividing work and non-work stuff. I am bad at making these boundaries for myself and everything therefore blends together" (Møller, 2021)

"Every friday at 18:00, I am demanded to clean my office equipment away from the dining table" (Møller, 2021)

# 2.7. User Specification

From the user interviews, the following description covers the target group:

- People who have a desk job that can be done remotely.
- People that work at home from a few times a month to several times a week.
- People who do not have a dedicated office space at home and therefore works in the primary or secondary room.

This implies that the product should target everyone who is short on space or do not prioritize to have a dedicated home office and who are able to work from home. Through the COVID-19 lockdown it can be observed that most who have a desk job can conduct their work at home in varying degrees. But the broad variety of the task and job description depending on the different users have a high impact on requirements and demands for a temporary home office setup. This is seen as the needs for a programmer who prefer a monitor in portrait mode is very different from e.g., a salesperson who mainly are on the road and therefore only works a few hours at home at a time. Therefore, to further specify the user group, the user panel is used as a reference for a detailed user description.

The four representatives each have a desk job that can be done remotely, with the use of one monitor used in landscape mode. The users held varying job positions, however while their assignments were different, the setups at their regular office are quite similar as neither of them held a position that required them to use special equipment or devices in connection to their work routines. All users was relying on a regular mouse and keyboard and some a headset.

All users worked from their dining or living rooms, as they either did not have an extra room that could be used as a dedicated home-office or did not prioritize to use their spare room as such. The representatives in the user panels were all interested in continuing to work from home 1-3 times a week, depending on tasks and work situations. Updated user description:

- Have a desk job that can be performed remotely
- Temporarily uses the dining-, kitchen, or living room as a home office instead of having room for a dedicated office space
- Use one monitor, in landscape mode
- Have work tasks that solely requires the use of a regular mouse, keyboard and a headset
- Wants to work from home varying from a few times a month to several times a week

This updated user description fits a wide verity of job positions, which could be described as the general office users. This could include the positions held in the user panel:

- Project engineer
- Job consultant
- Senior advisor
- Volunteer work

While also fitting job positions such as:

- Accountants/bookkeepers
- Managers
- Administrative positions
- Technical support
- Sales
- Etc.

The user description covers the general office worker, not the extreme users which use specialized tools or devices in combination with their home setup, this could be a requirement for several monitors or monitors which is used when rotated (portrait mode). The many types of job titles who can work from home using a general setup, is supported by an analysis from 'Danish Industry *(DI)*' that based on numbers from 'Statistics Denmark' estimates that nearly a third of those who work in the private sector could work from home and conduct some or several aspects of their position remotely. (Breinstrup, 2020)

The user specification has been updated to further define the user, which is the general office woker, using a general office setup.. From the users, it was found that the change between work- and home mode were fuzzy. Based on this, a research was initiated, to understand expert's view on the topic.

"We can benefit from making a plan that clearly delineates the hours that we work and clearly defines our physical surroundings as much as possible," explains Larissa Golloub, LCSW-R. "For example, upon completing work for the day, is there some way to cover or put the workspace out of view, such as putting up a room divider, throwing a big sheet or beautiful throw over the work space, or moving flowers in a vase to the space?" (Page, 2021)

According to Ingvild Sagberg, Ph.d. in organizational psychology, those working from home get an enhanced feeling of flexibility and the pososbility to strucute the workday to fit the personal needs. However, it also leaves ones in the borderland between always being at work and at home. While working at home frees one from the time spend commuting, it removes the 'change of scene' between the office and the home. The added flexibility is beneficial for many, but the biggest challenge is to find a balance between work and home. (Sagberg, 2021)

Sandi Mann and Lynn Holdsworth explains, that the commute from home to work has traditionally allowed the transition between roles to occur. Although many teleworkers attempt to develops partial and temporal boundaries between work and home life, such as creating a room only used for work, working at home does blur the distinction between roles, not only for the teleworker but also for the family. (...) In telework, there is a potential increase in work-family role conflict which could be attributed to the lack of boundaries separating the two roles. (Mann and Holdsworth, 2003)

While working from home provides possibilities, such as the flexibility to structure a day more dynamically and time saved on commuting, there are also drawbacks to working at a home office. It can be hard to experience the change in scene which commuting provides, if ones home do not have a dedicated office space. Due to there not being any clear line between work and home, the boundaries are getting blurred as to when the employee should be working or not, which is normally defined by being at the office.

An ideal home office product should therefore clearly mark a change between work mode and home mode, to help define the boundaries of the work life and create a change in scene.

**Requirement**: Must create a visible change between work- and home mode, reestablishing the boundaries dividing work and spare time.

# 2.9. Home Office Ergonomics

Working from home without a proper desk, office chair or proper equipment does not provide optimal work positions. However, several steps can be taken to improve the work position. By looking into several home office recommendations, a series of steps is found which should be implemented to ensure a good work position.

The recommendations from three different sources (Work environment consultant at HK, Physiotherapist, the Danish Working Environment Authority) can be found in the appendix at page 22.

# Requirements

The following requirements must either be supported or not hindered by the product:

- The work area should be big enough to ensure that the external keyboard and mouse can be moved around to change work position.
- The work area must have an area that gives support for the writs and lower for arms.
- An external monitor must be used, the external monitor should be placed 50-70 cm from the eyes of the user.
- The height of the monitor should be adjustable, the top of the monitor should be at eye level or a bit lower, both in a sitting or standing work position.
- The solution must support two different major work positions. (like standing, sitting at desk or other)

# 2.10. Cardboard Mockups

The project has focused on understanding the users. Based on this information, a cardboard mockup process was initiated aiming to create a concept, which is to be placed on top of a dining table. The models focused on the dining table, as this is seen as something everyone has in their homes. The focus were to implement a quick setup which is easy for everyone to use, that upholds work legislations, and adds the possibility of standing.

Drawings were made (Ill. 2.15) before the cardboard models, to ideate on the construction before building.

The models were made to approve the concept direction in the project and to test product dimensions. Renders were added on top of the cardboard models, to visualize the concept.



# Model 1

The concept builds on the initial 'office to go'idea (at page 24), where the ability of storing a workstation in a brief case like product were sketched. The plates can fold on top of each other, and thereby protect the monitor in transport. The wings were implemented to create an effective focus space.



# Model 2

Second concept builds on model 1, but focuses on removing the added work height in front of the monitor. This were to clean the work space up, but introduced more visual access to the surroundings, thereby lessening the focus space. Having the briefcase shape, allows for easy transport and/or storage.









# Model 3

Re-introducing the wings confirmed a better focus. A motorized lift system is used, with a heavy foot. This were to create a more stable concept. Model 3 also allowed for a free table when seated, making the use of keyboard and mouse unhindered.



#### **Brief usertest**

A quick test was initiated, where a user stated the importance of the wings on each side. This part of the product helped her focus much better.

The concept must therefore include the side panels.

#### Sum-up of important insights:

- Wings on side of the product is very important.
- Space in front of you is needed, which creates a comfortable placement for keyboard and mouse.
- Width of workable surface should be 80 cm.
- Cannot take up too much space on top of the dining table.



- Should feel stable, both visually and while leaning on it.
- It is not a good thing to lift the whole product in its full weight, to adjust the height of the work surface.
- Non-appropriate work positions should be avoided.

# P/V-table of mockups

Through an evaluation table (see III. 2.16), it was found that concept 3 was the most promising, based on requirements from previous research.

Evaluation Table of Mockups in Cardboard from 'Worksheet PH2-019 - Mockups in cardboard'					
Requirement PH2-019	Concept 1	Concept 2	Concept 3		
The product has wings The space in front of the user is adequate for keyboard and m The width of the standing workable desk space is wide enoug The product doesn't take up too much space on the dining tab When raising the product, an appropriate position is used The product 'feels' stable	<ul><li>✓</li><li>✓</li><li>✓</li></ul>	~	** ***		
PH2-017					
The work area when standing, allows for wrists to rest An external monitor can be height adjusted The solution allows for a sitting and standing work position	* * *	* * *	*		
PH2-016					
The setup of the product is convenient and quick The solution allows for storage of the work equipment			**		
Sum	6	4	9		

# 2.10.1. Chosen direction - Concept 3

Through the ideation process and the cardboard development, the selected direction was the concept described as model 3, also called the "the workstation".

The workstation builds upon the idea of combining the functional of both model 1 and model 2 into one product:

- When the users are working in a sitting work position, there are no extra plate added onto the table top as seen with model 1. Instead, the users can use the entire dining table as a work surface.
- When working the users experienced a closed and focused work mode due to the added side panels .
- The product can be adjusted to a standing work position by altering the height of the center pole of the product.
- When working in a standing work position, a foldable tabletop can be deployed from the foot of the workstation, creating a raised tabletop matching the height of the monitor.
- At the end of the workday the workstation can easily be collapsed and stored in the users' home, containing all related work peripherals.




Ill. 2.17. Screenshot of both Inger-Marie Sørensen and Freddy Sørensen during th einterview at Saphe A/S

To understand the perspective of the buyers (managers, company owners and employers), a meeting was arranged with the HR at Saphe A/S, but when we started, Inger-Marie Sørensen had also brought the CEO of the company, Freddy Sørensen. The meeting aimed towards clarifying some of the decision processes when buying products for the employees as a company, but the concepts were also discussed. Underneath, a sum-up of all the insights are listed, with the interview incl. interview guide can be found in the appendix at page 23.

## Sum-Up of important Data:

The buyer interview with Saphe highlighted several important aspects for the project:

- Saphe believes that several of their employees will continue to work from home around two days a week.
- Saphe as a buyer is interested in this type of product. They are concerned regarding both their employees work environment and will avoid breaking the Danish Working Environment Authority.
- Saphe have bought 27-inch monitors for several of the employees during the COVID-19 pandemic, to improve their home office setup.
- Saphe would buy this solution for their employees and cover the entire cost of the product.

- The product should be placed at home with the employee, not moved to and from the office.
- The product should fit a 27-inch monitor.
- A sales price of 2500 DKK incl taxes is an attractive sales price, this cost covers a basis unit excluding a monitor.
- The work setup at Saphe's office has a cost price of 20.000 DKK per employee, this covers one standing desk, a chair and a 34-inch monitor.
- Saphe recommends making a concept, which is simple, and then allowing customers to buy add-ons, as this will strengthen the company.

(Sørensen and Sørensen, 2021)

## 2.12. Design Brief

Based on the requirements found through the user panel, ergonomic recommendations regarding a healthy work position, the psychological aspects of working from home, and buyer interview. From these requirements a design brief can be formed to specify the product direction based on ideation, data collection and market research. This design brief should function as a stepping stone and reference for further ideation and product development.

## **Problem explanation:**

Through the COVID-19 pandemic and lockdown have both employers and employees been forced to work remotely and from home, this have both showed that it is possible for many to work as efficiently from home as at the office. Furthermore, it has been generally recognized that working from home adds flexibility the employee's daily life, by saving time otherwise spend on commuting etc.

Many employers have discovered that by letting the employees working from home, they can save cost on reducing office space (lower rent). It is therefore believed that after the current COVID-19 restrictions have been lifted, home office use will continue as a permanent addition to the job description when working at an office.

When employers and employees continue to work from home this will become a problem for those who do not have a dedicated home office, but instead works from the dining table in a living room or kitchen. Establishing a home office is both expensive and space consuming, but as work legislation applies to home office as well as regular offices are employers forced to ensure that the employees using a home office more than one day a week, or two hours a day, have accesses to a workstation that complies with current work regulations. This home office should not be a permeant installation, as a survey shows that those using a home office in their kitchen/living room/bedroom can have boundary problems and experience that work, and home mode starts overlapping. This is not experienced in the same degree if those working from home have a room which is a dedicated office.

The product is to be used in a private setting (the employee's homes) but should provide a professional setup.

## Problem statement:

How to facilitate a home office experience in a living room, that complies with current work regulations and are a temporary installment which can be setup/removed as part of the workday?

#### Users

- Have a desk job that can be performed remotely
- Temporarily uses the dining-, kitchen, or living room as a home office instead of having room with a dedicated office space and -solutions
- Use one monitor, in landscape mode
- Have work tasks that solely requires the use of a regular mouse, keyboard and a headsets or headphones
- Wants to work from home varying from a few times a month to several times a week

#### Costumers

- Private companies which have employees working remotely and needs to ensure that their home office setup complies with work regulations.
- Companies who want to offer their employees a convenient home office solution

#### Market

- The solutions is a B2B product that should be sold to companies, which can then provide their employees with the solution.
- The product could have a target sales price of 2.000 DKK excl tax.

### **Product requirement summary**

The solutions must comply with the requirement specifications that represents requirements from work regulations, experts, users, and buyers. The seven main requirements related to the product are the following:

#### User Panel:

- The solution must not be a permanent installation in the home
- The solution should be convenient to use and it should be set up or removed in less than a minute

### Employer:

- The solution should ensure that the home office setup complies with current work regulations
- The product should be placed at home with the employee, not moved to and from the office

### Psychologic Impact:

• Crete a visible change between work and home mode, to create a change in scene which ensures the boundaries of work

#### Ergonomics:

- The solution must support two different major work positions. (like standing, sitting at desk or other)
- An external monitor must be used. The external monitor should be placed 50-70 cm from the eyes of the user and the height of the monitor should be adjustable, the top of the monitor should be at eye level or a bit lower.



#### **Summary**

Through phase 2 the users, the problem, and the solution space were specified using product ideation and interview with a user panel and a potential customer. A competitor analysis was conducted, discovering a gap in the market when regards to temporary home office solutions which are convenient to use and upholds work legislation. The findings and specifications were summarized in a design brief, which is to function as the platform for further product development.

## Table of content for phase 3

Business Case
User Meassurements
The dining room
Danish Working Environment Authorities
Peripheral Analysis
Connecting the laptop
Choosing a monitor
Product installment
Stakeholder Analysis
User interactions
Requirement specification
Updated Requirement specification



#### The third phase focus on clarifying and specifying the product requirements. This is to define the technical solution space for further product development. The product is affected by a lot of regulations, which is why the following phase aims to understand the use barriers. The solution space touches other products and environments, of which plays a role in the concept proposal.

The outcome of this phase, should be a detailed requirement specification, concerning laws and work legislation, office peripherals, use scenarios, and the business case.

## 3.1. Business Case

The B2B market is known for having a high price point concerning furniture and other products. This is seen as the company Saphe A/S have spent 16.000 DKK incl VAT for an office chair and a standing desk for each of their employees (PH2-019), at the company location. This price point however stands in contrast to Saphe's estimations of what they conceived as an attractive product sales price. Saphe have purchased 34-inch monitors at a cost of 4000 DKK to all employees at the office, but if employees have been lacking equipment at home, they have been offered a 27-inch monitor which cost 1700 DKK.

This highlights that while Saphe is interested in ensuring a healthy work environment at the home office, both to improve the workday for their employees and to prevent breaking work regulations, they are not interested in spending the same amount of resources on employee's home offices as their regular offices.

#### Sales channels

The product can be sold through either retailers or by selling through the companie's web shop (what the team calls NK Office Solutions). These two sales channels would resolve in very different business cases.

It is decided that when launching the product, it would be beneficial for the company to focus on selling the product through their own website. This would enable the company to have a larger estimated cost price. However, this would also require the company to run sales themselves, support a web shop and to contact potential customers to penetrate an emerging market.

### Web shop

The product should be sold on the web shop as a base unit and it should therefore be considered to offer add-ons or improvements which could be selected in the web shop to specialize the product to different use scenarios. This could be add-on or upgrades like an online meetings upgrade, work lights or phone charger support. Selling add-ons or product upgrades to customize the setup would further raise the income through increased sales.

The product is sold without a monitor or other devices such as a keyboard or mouse. It would however improve the buying situation if all necessary equipment could be purchased from the same web shop. This would both ensure the user that all equipment would fit the work station and ease the buying situation as a complete work setup could be acquired from the same site.

However, as new electronic products are introduced often, the profit margin is low, and competition high, where it would be a risk to have a stock of different monitors, keyboards etc. It should therefore be considered if a partnership agreements could be made with a web shop focusing on electronics and if it would be possible to sell/source their equipment through the NK Office Solutions web shop.

## Conclusion

The workstation is to be sold as a base unit through the startup NK office solutions own webshop. The workstation is bought without a monitor or other computer peripherals, instead, this should be offered through the webshop as well, as a bundle solution, alongside possible workstation add-ons. The sales price of the workstation has yet to be determined, this should be done through further customer research.

The workstation is sold through NK Office Solutions' own webshop.

#### 3.2. User Meassurements

To accommodate the requirement of the workstation supporting both a sitting and a standing work position, is an investigation initiated to user height which has to be supported by the workstation.

According to the Danish Working Environment Authorities, office equipment are required to fit 90% of the adult European population. This means that those belonging to either the tallest or lowest 5% of the adult population is not required to fit the general work equipment, instead employers should offer specialized solutions to ensure a healthy work position for the remaining 10%. (Arbejdspladsens indretning og inventar Atvejledning A. 1.15, 2008)

Adjustments fitting the 90% requires a worktable to fit the following measurements:

- A worktable should fit the person using it •
- The lowest table height when sitting at a table should be 60 cm from the floor to tabletop, this height should be adjustable up to 90 cm (see Ill. 3.1)
- When using a standing desk the height from the floor to table top should be adjustable from 96 cm to 122 cm, this height matches the elbow height for a relaxed work position.



111 3 1 The recommended minimum and maximum heights for work tables

#### **Requirement:**

Should support a standing work height varying from 96-122 cm. Must enable a height increase of 50 cm from the tabletop.

#### 3.3. The dining room

To accommodate the requirement of the workstation being used in combination with a dining table, an investigation is initiated to understand the dimension of the furniture and product used alongside the dining table.

The illustrations below highlight the findings of the research, the full research description can be seen in appendix at page 28.

#### Wish:

In a seated position, the workstation should strive to be no taller than 55 cm, due to the lamp height of smaller lamps.



## 3.4. Danish Working Environment Authorities

The workstation is sold as a B2B product and must therefore comply with work legislation ("2.4. B2B direction impact" on page 25). An information research process is therefore initiated to identify all requirements which apply to the workstation. This is done by going through the 'Workplace decor and fixtures' by the DWMA (Arbejdspladsens indretning og inventar Atvejledning A. 1.15, 2008).

Several of the requirements mentioned in legislation have already by described throughout the development process e.g., in "3.2. User Meassurements" on page 39 Of the requirements which have not been described yet, the most important is *"The working area of the arms is important for the load on the back, neck, shoulders and arms. The work must preferably take place in the normal working area and only to a limited extent in the maximum working area" see Ill. 3.2 (Arbejdspladsens indretning og inventar Atvejledning A. 1.15, 2008)*  The requirements which have not previously been described are:

- Space for resting and supporting the hands and forearm should be available.
- The tabletop should not be reflective.
- Individual adaptation for work positions and movement should be possible.
- Mouse and keyboard should be separated from the display.
- Do not use space underneath the table for storage, as this limits the movement.
- If multiple people use the table, individual height adjustment should be possible.
- The normal and maximum table workspace should be a minimum of 41 x 60 cm.



Ill. 3.2. The work regulation guidelines for normal and maximum work area.

**Requirement:** The product must uphold work regulations, as described by the DWMA. The workstation is to be used with office peripherals (equipment to interact with the computer). Therefore a research is made, to understand the physical requirements given from the equipment, of which should be supported by the workstation.

## Keyboard

For a description of the keyboard sizes, see appendix at page 26.

When looking at different kinds of keyboards, it is found, that there are different form factors and different technologies involved.

The keyboard form factors are:

- Full size
- TKL (ten key less / 80%)
- 75%
- 60%
- Split Keyboards
- Ergonomic Keyboards

When viewing the office environment, the full-size keyboard is often found. Using the smaller variants, could result in work frustrations due to lack of the number keys on the right, which effectuates use of programs such as Excel. Accomodating a full size keyboard, ensures compatibility with the smaller types.

The split and ergonomic keyboard form factors, could however demand extra space – the split, due to the placement of the two parts, being in shoulder width, and the ergonomic one could be bigger, due to the form factor, requiring extra space in the middle.

When comparing different styles of keyboards (office vs. gamer equipment), a size guide is found.

By looking at the maximum sizes of the keyboards, the widest of the keyboards are of the gaming models. And while the typical office size is not as deep as the gaming ones, there are some who wants to use a palm rest. The deepest keyboard addition, is the wrist rest mouse (Contour RM-RED Plus, see III. 3.3). This style of mouse is often used for office work, which is why the maximum sizes of the keyboards found through this analysis must be supported by the product.



Ill. 3.3. Contour RM-RED Plus

#### Mouse

The mice for computers are of a design, being roughly a hand size. A couple of different styles exists, which can be described as:

- Travel mouse (of a smaller size)
- Office mouse (often a bit bigger)
- Ergonomic mouse (vertical)
- Ergonomic mouse (trackball)
- Gaming

However, as the mice are not too different in size, the more interesting research could be to look up the surface area, of which people use their mouse on.

By viewing the trackpads, an area estimation can be found. To find the most common areas for mouse trackpads, the popular SteelSeries brand's trackpad choices is compared:



Ill. 3.4. Trackpad size comparison

Through personal experience and tests, the sweet spot is found to be the medium sized trackpad.

#### **Requirements:**

- The trackpad area should be of 27 × 32 cm
- The keyboard area should be of atleast: width: 50,5 cm × depth: 35,5 cm

## 3.6. Connecting the laptop

The workstation is required to support a laptop, which is why the connectivity between the computer and e.g. the monitor and peripherals are to be investigated.

Through personal experience and quick online verifications, it was found that the USB-C connection, is an all-round solution for transporting data-, power-, and display signals.

It could be relevant to also support the connectivities shown at Ill. 3.5, however the previously three signals are a must-have-support.



Ill. 3.5. Types of ports

By using a USB-C cable for the essential signals, the cable management becomes easier, as only one cable should go to the workstation with power, and one cable going from the monitor to the laptop. (Sagar, 2021)

## 3.7. Choosing a monitor

when selecting a type of monitor which should be supported be the solution, it would be beneficial to select a monitor that have a built in docking solution, due to the previously determined USB-C connection

When viewing the monitors on the market today, the important thing to investigate, would be weight, dimensions, mounting possibilities and cable routing (specifically how the dimensions should be, to accommodate most monitor types). To make the search smaller, monitors allowing for a USB-C connection will only be considered. The monitors compared are:

24" - ASUS PA24AC	32" - BenQ EW3270U
Dimensions:	Dimensions:
W: 53 cm	W: 69 cm
H: 35 cm	H: 39 cm
D: 6 cm	D: 6.5 cm
Weight: 4.3 kg (no stand)	Weight: 6 kg (no stand)
27" - Dell U2720Q	34" - Samsung LC34H890
Dimensions:	Dimensions:
W: 61 cm	W: 81 cm
H: 36 cm	H: 37 cm
D: 5 cm	D: 12 cm (curved)
Weight: 4.4 kg (no stand)	Weight: 6.3 kg (no stand)

All the monitors have a built-in power transformer and is connected to a power outlet by using a standardized IEC-C13 male socket, to connect to a IEC-C14 female plug, described in the IEC 60320 standard. (What are Power Cords? Which Cord Powers Your Computer? -Blog | SF Cable, 2021)

Based on tests, the 27" model is chosen as the golden standard, as to what screen size/compromises are made with this size. The dimensions of this monitor (with added gaps) should be supported.

All monitors support the mounting standard VESA 100. This standard allows for monitors to be mounted on a third-party monitor stand. (VESA Hole Patterns for TV Wall Mounts, 2019)



Ill. 3.6. A VESA mount dimension (VESA Hole Patterns for TV Wall Mounts, 2019)

#### **Requirements:**

- Monitor dimensions supported should be: 65 × 40 × 7 cm.
- The monitors (and workstation) must support: VESA: 100 × 100.
- Must support USB-C.

## 3.8. Product installment

When a company acquire the product, it is needed to be set up and installed before the employee can start using it. It is considered that product installment should be made by the buyer. Most companies have an employee/caretaker responsible for installing and implementing new equipment at the office. This person could fullfuill the service position and be responsible for e.g. installing new monitors or computers' standing desks, when either new employees are hired, or current equipment is replaced. For larger companies, an employee could be placed in a dedicated caretaker position, while in smaller companies the employee holds this position while still maintaining another position at the company.

The product is bought without a monitor, which therefore should be installed by the caretaker before use. This should be done together with the employee who will use the workstation, to ensure that the product is adjusted to fit the preferred work position of the user. The product is to only be used by one user, not shared by several users, and it is therefore not necessary for the users to adjust the monitor setup

## 3.9. Stakeholder Analysis

Several stakeholders exist for the workstation. On the customer side, three different stakeholders exist: The buyers, the users and the product installment. Each stakeholder have different interests, stated in bulletpoints.



The buyer covers the customers who are the decision-makers behind acquiring the product. These are the ones who decide if a solution is needed, and which criteria a solution is selected upon. It

is not necessarily the decision-makers who conduct the purchases themselves, in larger companies this assignment would typically be handed over to another person. The decision-makers could be employers or managers who have the responsibility for the welfare of their employees and are responsible for the employees upholding work legislation. The buyer has an interest in a solution, as they must ensure that the employees uphold work legislation and that the employees have a work setup that has a positive effect on their work effort and decreases the risk of occupational hazards caused by bad working positions. The buyers are cost focused, why low cost is prefereable ("2.11. Buyer Interviews" on page 34).

Main interest:

- A solution that upholds work legislation
- A solution that offers a healthy and efficient work experience

after successful installment. The product should be easy to use, and simple to set up. The users should therefore connect as few cables as possible when using the workstation. The installment of the product should therefore include mounting all necessary cables, only leaving the user with connecting their laptop to the product and connecting the product to power.

When the caretaker has added the monitor, adjusted it to the users, connecting the necessary cables, and successfully connected the employee's laptop to the workstation, the product is ready to be handed over to the end-user. The product is now installed, and the employee can bring the product home to use as a home office.

### Steps in the installment process

- 1. Receiving and unpack the product.
- 2. Install monitor together with the user, to ensure correct work position.
- 3. Connect cables.
- 4. Connect laptop to the workstation.
- 5. Handover workstation to the user



The workstation is used throughout the work day, by the users, which can both be employees, but also the managers or employers who are the decision-makers behind acquiring the specific solution.

The users are interested in having a solution that is as simple and convenient to use as possible, as the solution should offer the experience of having a professional office setup combined with the ease of working on a laptop. The solution should offer the feeling of being at an office and not working in a living room.

Main interest:

- A solution that is easy and convenient to use
- A solution that offers a healthy work position

In the "3.8. Product installment", it was determined that the users were not the ones who would install and setup the product. This should instead be done by a caretaker or the person at the company who is responsible for setting up the

work desk and computer for new employees. For the person responsible for product installation is the main concern how easy and simple it is to install the solution and adjust it to the end user.

Main interest:

• Simple installation and adjustment process

## 3.10. User interactions

To determine if the proposed workstation concept reduces the amount of steps made by the user, a comparison is made with vs. without the workstation.

The different categories of steps are divided into the currently used number of steps and the new envisioned, future concept number of steps. It will be detailed and will include all steps, of which have the user do anything. For both cases, the equipment is stored within a secondary room (bedroom) and brought into the primary room (living room).

## Setting up the home office

## Current number of steps

- 1. Clear out the dining table to prepare the workspace.
- 2. Go to the bedroom, and grab work bag.
- 3. Open work bag and place computer on table.
- 4. Put bag on the floor.
- 5. Go to bedroom and take monitor.
- 6. Place monitor on table.
- 7. Take HDMI cable, which is already placed in the monitor from last time and connect it to the computer.
- 8. Go back to bedroom and get a mouse with mousepad and keyboard.
- 9. Go to living room and place mousepad and mouse on table.
- 10. Take USB-adapter for keyboard and mouse and plug into the computer.
- 11. Take charger from bag for computer and plug it into the pc and wall.
- 12. Take power cord for monitor and plug it into the wall assuming it is already inserted into the monitor.
- 13. Adjust monitor height when seated.

## Envisioned number of steps

- 1. Clear out the dining table to prepare the workspace.
- 2. Go to the bedroom and grab the workstation.
- 3. Set the workstation on the dining table.
- 4. Unfold the workstation.
- 5. Bring computer from bedroom's work bag.
- 6. Place computer near workstation.
- 7. Plug in USB-C cable to computer from workstation.
- 8. Plug in power cord to the wall, from the workstation.

In addition to this, the added benefits of having the workstation, instead of the alternative of only using a monitor, is the ability to stand up while working, limiting the peripheral vision allowing you to focus and storing everything in one unit.

## Changing to standing work position

When the user needs to stand up and work, the following steps are made (without the workstation, this requires a few creative moves to be allowed in the users home).

# **Current number of steps** (laptop only / *not in compliance with work legislation*)

- 1. Un-plug monitor, keyboard, mouse, charger from computer.
- 2. Locate somewhere in your home, which has the correct standing height.
- 3. Clear furniture from items.
- 4. Place laptop.
- 5. Plug in charger for laptop.
- 6. Work, with a reduced ergonomic posture (neck position)

# **Current number of steps** (if using a monitor / *in compliance with work legislation*)

- 1. Un-plug monitor and charging cable from laptop.
- Locate somewhere in your home, with the correct standing height / find elements in your home to place on top of your dining table (boxes, smaller tables etc.)
- 3. Clear previously mentioned furniture for items.
- 4. Unplug monitor and computer power cord from wall.
- 5. Move monitor to new furniture.
- 6. Bring laptop, and place on top of the new furniture with keyboard and mouse.
- 7. Plug in both computer and monitor to the new wall outlet.
- 8. Continue working.

## Envisioned number of steps

- 1. Stand and push in buttons on each side to adjust the height of the workstation (*Keyboard and mouse will stay on the table.*)
- 2. Grab foldable platform and extend it towards you.
- 3. Move keyboard and mouse to the platform.
- 4. Continue working (*Monitor is already correctly positioned*.)

Comparing the number of steps from the current setup to the envisioned workstation setup it became clear that the workstation lower the user interactions and simplify the process of implementing a home office.

## 3.11. Requirement specification

Through the development project, requirements and wishes have been located which should be considered when developing the product. The requirement and wishes are essential to ensuring that the product will be accepted by both the users and the customers. The requirements and wishes are summarized in the requirement specification table below, which additionally references the origin of the requirement.

Requirement	Source	Also found in:		
Psychology				
Must create a change in scene, to shift between work- and home mode	"2.8. Psychologic Impact of Working from Home" on page 30	"1.8. Questionnaire" on page 16		
User Panel				
The setup of the product should take less than 1 minute	"2.6. User Panel" on page 28			
The solution must not be a permanent installation within the home	"2.6. User Panel" on page 28			
Buyer				
The monitor used, should be 27"	"2.11. Buyer Interviews" on page 34			
The solution should not be moved outside the user's home	"2.11. Buyer Interviews" on page 34			
Peripheral Analysis				
Trackpad area should be $27 \times 32$ cm	"3.5. Peripheral Analysis" on page 41			
Keyboard area should be of atleast: width: 50,5 cm × depth: 35,5 cm	"3.5. Peripheral Analysis" on page 41			
Monitor dimensions supported should be: min. 65 $\times$ 40 $\times$ 7 cm.	"3.7. Choosing a monitor" on page 42			
The monitors and workstation support: VESA: 100 $\times$ 100.	"3.7. Choosing a monitor" on page 42			
The workstation should support USB-C display signal and laptop charging.	"3.7. Choosing a monitor" on page 42			
The workstation should support IEC-C13 and -C14 power plugs.	"3.7. Choosing a monitor" on page 42			

Requirements	Source	Also found in:			
Should create a temporary workspace within the user's home (living room)	"2.3. The B2B choice" on page 25				
Should allow for a standing and sitting work height	"2.3. The B2B choice" on page 25	Ergonomy + User Panel sections			
The Danish Working Environment Authority ( (Arbejdspladsens indretning og inventar Atvejlednin	<b>DWEA)</b> g A. 1.15, 2008)				
Depth of table should allow for placement of a monitor between 50-70 cm from the eyes	DWEA	Ergonomy section			
Space for resting and supporting the hands and forearm should be available	DWEA	Ergonomy section			
The tabletop should not be reflective	DWEA				
Individual adaptation for work positions and movement should be possible	DWEA				
Mouse and keyboard should be separated from the display	DWEA				
Do not use space underneath the table for storage, as this limits the movement	DWEA				
If multiple people use the table, individual height adjustment should be possible	DWEA				
The normal and maximum table workspace should be a minimum of 41 x 60 cm	DWEA				
Ergonomy					
Work area should allow for keyboard and mouse	"2.9. Home Office				
to be moved around, to change work positions	Ergonomics" on page 30				
An external monitor must be used	"2.9. Home Office Ergonomics" on page 30				
The height of a monitor, should be at eye level (or a bit lower), both while sitting and standing	"2.9. Home Office Ergonomics" on page 30				
When the monitor is adjusted to the lowest height setting, the distance from tabletop to monitor bottom should not be higher than 9 cm.	"4.6. Standing work platform" on page 61				
Should support a standing work height varying from 96-122 cm. Must enable a height increase of 50 cm from the table.	"3.2. User Meassurements" on page 39				
Sitting table-top work height should be between 72-75 cm (to fit dining table chairs, of which is between 42-47)	"3.3. The dining room" on page 39				

Wish	Source	Weight (1-5 being best)		
User Panel				
The solution must be very convenient to use	"2.6. User Panel" on page 28	5		
All necessary work equipment could be transported within the same unit	"2.6. User Panel" on page 28	3		
The solution should be rewarding for the user, and remove the overwhelming feeling of packing/un- packing	"2.6. User Panel" on page 28	2		
General				
Appeal to living room context	"2.6. User Panel" on page 28	3		
The equipment should feel 'nice' and like 'quality'	"1.8. Questionnaire" on page 16	2		
When seated, the solution should strive not to be taller than 55 cm, due to lamp height	"3.3. The dining room" on page 39	4		



The result of phase 3 is a detailed requirement specification, outlining the solution space for the product regarding use, work position, work legislation, and computer peripherals.

## Table of content for phase 4

Detailing the concept
Combine Design
Folded- design aesthetic
Gas piston functionality
Height adjustment specification
Standing work platform
Working from home Deloitte
Saphe Mockup test
Physiotherapist interview
Market size
Business plan
Execution plan
Maximum cost price



#### **Concept Specification**

The next phase focuses on bringing the workstation concept from the idea stage, to a construction and specification stage. This is done by detailing the concept selected at phase 2, and ensure the product upholds all requirements specificed at the end of phase 3. Tests are made with users, customers and experts, to create the best possible solution. The business aspect of the prorject is also considered.

## 4.1. Detailing the concept

At "2.10.1. Chosen direction - Concept 3" on page 33, concept number 3 was determined as being the best proposal. To further develop and detail the concept, a technical development process is initiated. The development process focuses on detailing the key critical functions needed to ensure and comply with the requirement specifications, especially the ability of standing up while working.

## 4.1.1. Height adjustment mechanism

An online search were initiated, to find inspiration for height adjustment mechanisms. The search showed three relevant types of mechanisms:

- Linear actuator
- Scissor construction
- Rotating thread pole

Based on these directions, an ideation were made on lifting mechanisms. See Ill. 4.1-Ill. 4.3. Based on this ideation, three concepts were proposed.

## **Concept 1** – *Thread poles on each side*

The workstation consist of two parts, one which is placed on the table, another which is mounted to threaded poles with a bracket on each side. When rotating the poles with a DC motor, a platform is lifted, ensuring a standing work position. See III. 4.3 for a CAD model of the mechanism.

Pro	Con
• The mechanism is relatively simple to implement	<ul> <li>Requires double layer of materials for the moving and standing part of the product</li> <li>The two points of support is not ideal for leaning on top of the product.</li> <li>Height is predetermined and can not be smaller than the necessary adjustable height.</li> </ul>

## Concept 2 – Center pole

The proposal builds on the idea of only using one actuation point. The working platform is mounted to a center pole, which will make the product simple to construct. However, the support is narrow and does not automatically create a well balancing construction (see relating mechanism at Ill. 4.5.)

Pro	Con
• The mechanism is relatively simple to	• Narrow support for weight
implement	
• Could be a telescope	
solution, which could	
lower overall packaged	
height.	
Clean looking	

The three critical functions for further development are:

- 1. How can the user change from a seating to a standing work position?
- 2. How can the user establish a work platform when working in a standing position?
- 3. How to ensure product stability, when working in the standing position?



Ill. 4.1. Linear actuator with pole Ill. 4.2. Scissor construction



Ill. 4.3. Rotating pole thread powered by DC motor



Ill. 4.4. Rotating pole thread powered by DC motor (CAD)



Ill. 4.5. (CO-Z Motorized TV Mount, 2021)

## Concept 3 – Scissor lift

The scissor lift is based on a collapsible movement where the height can be adjusted based on the movement of a scissor mechanism. The height is adjusted by regulating the angle of the beams in the construction, this can be done with the use of an actuator, gas piston, or motor.

The support for the construction is placed on four bearings, placed at the end of each scissor beam.

	Pro	Con	
•	Very stable feeling Short movement for tall transportation (horizontal movement is minimal compared to the lateral gain) Possibility of manual motion (supported by gas springs) and automatic height	<ul> <li>Could be a heavy solution</li> <li>Industrial looking</li> <li>Fingers can be cut</li> </ul>	
•	Solution is always folded as much as possible, when mobile. No unnecessary height or width is added.		

## Lift mechanism selection

Based on the three proposals, the scissor mechanism is estimated to be the most optimal solution due to the pros that:

## Scissor lift – Height adjustment

The height adjustment system of the scissor lift is regulated by changing the angle of the scissor construction. This can be done with the use of a gas piston, actuator or electric motor connected to a threaded rod or similar.

The height should be adjustable from a seated position to a standing position, which requires a height change of 50 cm ("User Meassurements" on page 39). To calculate the horizontal travel length necessary a SolidWorks assembly of the scissor lift is used, which results in the horizontal length change is defined as 210 mm.

To compare the three mechanisms; Gas piston, Linear actuator, and DC motor, a pros and cons list is used.



Ill. 4.6. Scissor mechanism with linear actuator

- The support area for the contraction is shared by four points and not one or two points like in the other proposals
- The total collapsible height can be much lower than the potential height gained when raised.
- The solution is based on a simple construction

#### Gas piston

Pro	Con
<ul> <li>Simple mechanism</li> <li>Does not rely on electricity for adjustment</li> <li>Standard component</li> <li>Light weight compared to a motor</li> <li>Cheap solution</li> </ul>	<ul> <li>Height change relays on the user lifting the product</li> <li>Height change is not as smooth as seen with an actuator or motor</li> </ul>

#### Linear actuator

	Pro		Con
•	Simple mechanism	•	Needs electricity for
•	Standard com-ponent		height adjustment
•	change	•	pis-ton
•	Height change relays on the user pushing a	•	Expensive solu-tion
	button		

## DC motor with threads

Pro	Con
<ul> <li>Smooth height change</li> <li>Height change relies on the user pushing a button</li> </ul>	<ul> <li>Customized mechanism</li> <li>Solution requires several components</li> <li>Needs electricity for height adjustment</li> <li>Heavy compared gas piston</li> </ul>

Based on the pros and cons tables it is decided to move forward with a gas piston, as this component is believed to be both the simplest mechanism to install, the cheapest component, and since the user can regulate the height of the workstation without connecting it to electricity.

#### The weight applied to the product

The added weight to the product, of which the mechanism is supposed to uphold (not necessarily move) is tested by having one of the team members, lean on top of a display cabinet.

From this, it is found that a very hard push on top of the scale, applies a maximum of 20 kg. With regular resting, 5-10 kg is applied.



Ill. 4.7. Kasper leans on top of the cabinet

## 4.1.2. Making a platform

The research's goal is to determine a mechanism for extending a platform while standing. To do so, the outer parameters must be determined of which:

- *The platform size* should be: 70x50 cm (based on the peripheral analysis)
- The *weight at the edge* of the platform should support: 20 kg. (based on the test above)
- The storage area for the *mechanism can be no deeper than*: 15 cm
- With the *height to be maxed at*: 10 cm. (dimensions are chosen based on cardboard mockups at page 31)

It was quickly determined to use a sliding mechanism such as a telescopic drawer system. Online research showed the construction of the rails, which acted as inspiration for a mechanism concept. At Ill. 4.8, a heavy duty rail system supporting 200 kg is showed. The research highlighted that several manufacturers produce custom heavy duty rails. Based on these dimensions, it is determined that the component can be bought pre-fabricated by a sub-supplier, while still fitting the specified product dimensions. (Coustom-Heavy Duty Sliding Rail, 2021)



A visualization is made in CAD (III. 4.9), which is created based on the picture from before. The mechanism is estimated to withstand the weight limit and extends from a base of 140 cm to 560 cm which is a 400% extension. The platform itself, consists of a folding platform. This platform is hinged together, and defines a smooth surface (III. 4.10)



Ill. 4.9. Proposed slider mechanism



Ill. 4.10. Platform plates on slider Phase 4 - 51

## 4.1.3. How to make it balance

This research aims at creating a mechanism, which is useful to make the product balance. This is required, due to the overhang of the platform in its raised state.

At first, a sketching session was initiated based on initial ideas for a mechanism as a concept. Here the team had 6 overall categories of balancingmechanisms shown at Ill. 4.11.

Common for all of the ideas, were to create a balancing platform (or extending the bottom plate) towards the user when standing, as this creates a more stable solution.

The solution chosen, is the bottom left one, as this is the most userfriendly design based on the interactions by the user. It also integrates nicely into the existing scissor box, making a more flush design.

The mechanism is afterwards made in solidworks (see Ill. 4.12).



Ill. 4.11. Balancing mechanisms



Ill. 4.12. The balancing mechanism in its current state made in SolidWorks.

#### The workstation concept consists of:

- A scissor lift mechanism
- A gas piston to help lift the working platform
- Rail system with a foldable platform
- A balancing mechanism in the front

#### Requirement

Should support 20 kg. on work platform

## 4.2. Combine Design

Until now the design has been divided into subcomponents or systems based on function and each system have then been solved individually. An attempt were made to combine the different components, but it became clear that the functions did not integrate well with each other and with the overall dimensions and shape of the design. As the product is an integrated

The iterative process contained redesign of the side panels, lifting mechanism, the extendable platform of concept 3 at page 32 and is tested by creating a cardboard model.

#### Side panels

An ideation process was initiated where the different functions and the design is reconsidered. This was done through an ideation process where different components are combined to redesign the structure. These combinations are then sketched on a whiteboard, where the team could discuss, evaluate, and tweak the construction (see III. 4.13 to III. 4.15). The result of this process was a decision to move the side panels from being part of the monitor mount to become a part of a skeleton/protective case for the

system, it became clear that it was necessary to consider the product composition from a holistic angle, as all functions affect each other. Based on this realisation it was decided that the concept had to return to the drawing board to rethink the construction and composition. This was done with the principle of "one component, two functions".

product where the side panels (also called 'wings') can protect the front of the product when folded. By implementing this design change, the side panels can no longer rise with the monitor when the product is changed to a sanding position. However, as the side panels now are attached to the components placed on the ground, they can be combined with the components ensuring product stability and one foot is therefore added to each side panel. This resolved in the side panels now having the following functions:

- Create a room within a room, a place to focus.
- Protect the monitor when folded.
- Contain the components needed for ensuring product stability when the user is working in a standing position



Ill. 4.13. The workstation when folded

*Ill. 4.14. Niklas is editing the construction on the whiteboard* 

Ill. 4.15. Dimensions of the overall workstation

#### Lifting mechanism and extendable work platform

The lifting mechanism is also redesigned, and it is discussed if the scissor mechanism driven by a gas spring should be dismissed and changed to a motor which ensures that the height can be changed by rotating two threaded rods. However, it is decided to keep the scissor solution, due to the pros found in "4.1.1. Height adjustment mechanism" on page 49':

• Short movement for tall transportation (horizontal movement is minimal compared to the lateral gain)

- Possibility of manual motion (supported by gas springs) and automatic height adjustment
- Solution is always folded as much as possible, when mobile. No unnecessary height or width is added.

As the side panels now ensures the stability when the user working in a standing position, it is found that the monitor is placed inside a box with no bottom plate. However, the bottom part of the scissor lift can be combined with the side panels and backplate to ensure the stability needed in the product. Previously the goal was to construct the scissor mechanism as foldable as possible. Through the iterative ideation process it is however found that it could be beneficial to integrate the foldable platform solution proposed in "4.1.2. Making a platform" on page 51' into the scissor solution. The foldable platform is space consuming in height, as it built on a sliding drawer principle. The space used for the system is however restricted to the side, where the drawer inspired rails should be placed. This leaves an empty area between the rails, to utilize this unused space. It is decided to combine the scissor mechanism with the platform rails. The drawer inspired rails are attached at the top platform of the scissor solution, and the grooves for the scissor mechanism should be placed between the rails.

#### Cardboard mockup - first round

To evaluate the redesign proposal and to investigate if the design is feasible it is decided to build the workstation as a carboard model using the proposed measurements. The workstation must fit a 27" monitor and have a height lower than 55 cm due to lamps ("3.3. The dining room" on page 39) and be able to lift the monitor up to 50 cm from a sitting position ("3.2. User Meassurements" on page 39). A mock-up is therefore built which when folded have the dimensions of W80cm × H54cm × D15cm.



Ill. 4.16. The proces of building the carboard mockup



Ill. 4.17. Test within a dining table surface area

The cardboard model is tested on a marked area representing the standard width of a dinner table (Ill. 4.17), which at IKEA varies between 75 and 95 cm., the majority of which have a width of 80 cm. (Spiseborde, 2021).

In some use cases, the users would have a lamp hanging from the ceiling over the dining table, which could resolve in the workstation needing to be placed at the end of the table to ensure that a standing

#### Cardboard mock-up - second round

The updated mock-up was used for testing the design and size of the product. It is found that by shirking the width of the product to 70 cm the visual look of the product became lighter, and it did not look as heavy when placed on a dining table as before.

Shrinking the product changed the width of the extended platform from 80 to 70cm limited the work area, however the size still upheld the work legislation recommendations. ("3.4. Danish Working

position is possible without hitting the lamp when standing. Therefore, as the product must be useable on most dinner tables, it is necessary to adjust the design to fit a 75 cm wide table. It is therefore decided to shrink the width of the product with 10 cm, resolving in a product which when folded have the dimensions of W70cm x H54cm x L15cm.

This redesign was once again built as a carboard mockup to test and verify the design

Environment Authorities" on page 40) During the test of working in a sitting work position were the supportive legs extended. The distance between these legs is 70 cm, identical to the width of the work platform. However, the test showed that while 70 cm seemed fine when standing it felt limiting the working in a sitting position. From this realization it was decided that the legs ensuring stability should not be folded out before changing the workstation to the standing work position. Having the legs folded in when sitting would not affect the stability of the product, as the added stability ensured by the legs is not needed in

#### the sitting work position.

This created a risk that the users could forget to deploy the stability legs before changing to a standing work position and thereby risk tilting the product. To avoid this risk is it decided that the activation handle for the scissor mechanism should be placed behind the supportive legs, thereby forcing the user to deploy the stability legs before activating the gas spring.



Ill. 4.19. The view of the workstation when standing.

#### Cardboard mockup - foldable platform

Ill. 4.18.

Further test with the mockup highlighted issues with the planned method for applying the foldable platform. In "4.1.2. Making a platform" on page 51 it was considered that the platform consisted of an extendible rail and a foldable platform made from plates which were placed on top of the scissor mechanism. However, when trying to extend the foldable platform it was found that the platform would hit the monitor, which is not acceptable.

Mounting the display

to the monitor pole.

During the mockup session that team was not able to solve this problem, as the thickness of the platform nor the placement of the monitor had been determined, it was therefore decided to reconsider the folding principal of the platform when detailing the design in CAD.



Ill. 4.20. The platform is in storage mode.



*Ill. 4.21. When lifting the platform, the edge will hit the monitor above it.* 



Ill. 4.22. Showing the handle on the side and lid on top.

#### Cardbord mockup – lid and handle

Through the mockup design process was a lid added to the mockup to be able to close of the top of the product when folded. Sides are added to this lid which covers the side panels function as the protective front when folded. The lid ensured that the mockup stayed closed when folded and transported, this solution was a very simple solution, and it should be investigated if this should be the function which should be used to close the product when the product is detailed. Along with the lid were handles added to the product as well. Like the lid, the handles were added as a way of showing the users the interaction areas, without deciding if the handles should be added to the final design.

## 4.2.1. User test with mockups

The cardboard mockup was tested on nearby users at Aalborg University, through interviews. This was used to get an initial feedback on the product and thereby determining the credibility of the concept.

The semi-transcribed interviews can be found in the appendix at page 30. The findings of the interview is presented on this page.

#### Andreas



Ill. 4.23. Andreas testing the product in a seated position



Ill. 4.24. Andreas testing the product in a standing position



Frederik

Ill. 4.25. Frederik testing the moveability of the product



Ill. 4.26. Frederik testing the product in a standing position

By conducting the tests, it was possible to determine what works and what does not work about the product. Here, some positive feedback and concerns are listed:

#### **Positive:**

- The feeling when sitting at the workstation is nice, very focused and allows for a good work position.
- The laptop is not needed with this kind of monitor.
- Space for keyboard and mouse is fine, and the platform allows for stuff to be stored (phone, cup etc.)
- Individual step-less height adjustment is great.

#### Neutral:

- The product is both big but manageable.
- The allowed weight would be around 10 kg.
- Straps as a handle is fine, but a firmer grip is preferred.
- The product is pushed across the floor, possibly damaging either/or.

#### **Concerns:**

- The lid mechanism is silly and should be refined.
- The monitor should be able to tilt, and possibly also positioned on the fly up and down.
- The product weight should preferably not exceed 15 kg, including equipment.

The cardboard mockup and design process combined with user tests showed that the product fitted the use context and the needs of potential users. The updated design ensured stability while incorporating the mechanical functions. Through the user test, an additional requirement was discovered for the workstation.

#### **Requirements:**

- The monitor should be able to tilt
- A firm grip is needed to carry the workstation

#### Wish:

• Combined weight should be below 15 kg.

#### Maria



Ill. 4.27. Maria testing the product in a seated position



Ill. 4.28. Maria testing the moveability of the product

## 4.3. Folded - design aesthetic

When folding the workstation, it is shaped as a rectangular box. This box needs to be stored in the users' homes and only be used on occasions, as the users wants to work remotely between a few days a week and a few days a month. As the users have limited space, it is a possibility that the product will end up being visible when stored and should therefore blend in with the existing decoration.

Parallels can be drawn to existing elements, when looking at the workstation in it's folded down state, such as: suitcases, bags, benches or even radiator hiders.

Bags have certain design elements around it, which is difficult to describe, but can be elements such as handles, straps and zippers etc. While these elements should in some way also be integrated into the product, another aesthetic direction emerges when viewing the product in it's 'non-used' state (when being stationary on the ground). Therefore, arguments could be made about the product resembling more of a furniture in it's stationary form, than the bag aesthetic when moved. The user panel were asked to take pictures and mark the placement of the box when stored. This helped explaining the context, of which the product should be placed in. A styleboard is made from elements on these pictures. To fit the most interiors, the most common elements is chosen for the sum-up in the end. This is seen at Ill. 4.29 below.

The styleboard is processed, by taking elements from the pictures, and gather them into a styleboard, comparing materials, colours and the likes. These three contexts, thereby end up in three styleboards, of which is gathered into one in the end. Here, it is found that light wooden surfaces with matt white surfaces are to be integrated into the design, however elements of colorful fabric should also be added.



Phase 4 - 57

It is required to understand the gas piston mechanism, since this is the chosen lifting mechanism. Gas pistons are therefore research regarding the use and functionality, to ensure the right component is selected for the workstation.

A gas piston, also known and referred to as gas springs or gas dampers, is commonly filled with a pressurized nitrogen gas and/or oil in a sealed airtight cylinder. The pressurized gas enables the gas spring to store energy, which can be released at a later point.

Two different types of gas springs exist:

- Compression gas springs (positive pressure inside the cylinder / pushes)
- Traction gas springs (negative pressure inside the cylinder / pulls)

For a more complete explanation of the two types of springs, see the appendix at page 34.

**Incorporating a gas spring into the workstation** The gas spring needed for the workstation is a lockable gas spring, to ensure that the user can lock the height of the workstation when it have been adjusted to match their preferences. Including this type of gas spring, results in the need of adding a handle or button which when activated should open the valve in the gas spring to adjust the pressure in the spring by moving the piston rod.

Implementing a gas spring into the design, the user should only apply a small force in an upwards direction, to lift the weight of the workstation when changing from sitting to standing, as the gas spring could lift the workstation to the standing position. When changing from a standing to sitting position, the user should apply a small force downwards on the platform, which in combination with the weight of the monitor and platform itself should collapse the scissor construction and increase the gas spring tension. This can be achieved if the selected gas spring is designed to be in equilibrium with the forces caused by the scissor levers. Both a traction and a compression gas spring could be used for the scissor mechanism.

To select which lockable gas spring that should be used for the workstation the scissor mechanism has to be designed in detail to determine the following gas spring specifications:

- **Compression or traction gas spring?** Based on the design of the scissor mechanism it should be determined if there are mechanic reasons to select either a compression or a traction gas spring or if this should be done based on cost.
- **Gas spring length** The travel length of the piston rod needs to correspond to horizontal travel distance of the scissor mechanism when changing from standing to sitting position.
- **Gas spring force** The force of the gas spring depends both on the scissor mechanism design and the weight of the workstation's platform, monitor, and scissor construction itself. When these factors are known a technical analysis can be made to determine the levers load acting on the gas spring.



Ill. 4.30. (Technical information about gas springs - Lesjöfors, 2021)

## 4.5. Height adjustment specification

During "4.4. Gas piston functionality" it was found that the workstation could use either the compression or a traction gas spring to ensure the height adjustment. But to determine the specific gas spring, it was necessary to detail the design of the scissor mechanism and revise the proposed design, based on "4.1.1. Height adjustment mechanism" on page 49. The requirements for scissor mechanism design are:

- The construction must be stable when the workstation is used in a standing position.
- The mechanism should take up minimal space when collapsed.

## **Ideation process**

To determine a suitable mechanical design, a research process was initiated where different scissor lift designs were compared and their construction analyzed, to understand if there are general design rules which applies to height adjusting scissor mechanisms. The research process additionally gathered inspiration from a variety of different design.

The products which worked as inspiration varied from ironing boards to heavy duty lifts, and to competing home office products (III. 4.31 - III. 4.34).





Ill. 4.31. (Manuelt løftebord, 350 kg, 1200x800x450 mm | AJ Produkter, 2021)

Ill. 4.32. (Choosing an Ironing Board - Sew4Home, 2021)





Ill. 4.33. (Standing Desk - X-Elite Pro Height, 2021)

Ill. 4.34. (Scissor lift for wheel alignment, 2021)

Based on the research, three general design rules can be assumed:

- 1. A stable scissor mechanism requires four levers consisting of two scissor pairs.
- 2. The four leavers should be fixed with a pin, creating a bearing, in one side and movable with a roller or sliding bearing in the other.
  - All levers must be fixed in the same end of the product.
  - The rollers/sliding bearings must be fixated to ensure that movement is confined to one axis.
- 3. A scissor pair should be connected with a pin through the levers.
  - The pin can additionally connect the two scissor pairs (all four levers).
  - The connection of a scissor pair does not have to go through the center of gravity of the levers, resulting in an asymmetric scissor pair design.

An iterative design process is initiated where various mechanical design proposal is developed based on the design rules. The designs are then evaluated though a collaborative sketching process, where ideas are combined and detailed, while others get discarded. The ideation process followed three steps:

- 1. Ideating and proposing different scissor mechanisms designs and layouts.
- 2. Discuss the layouts and design, either discarding or expanded concept discussion functionality and construction in relation to height adjustment, the extendable work platform, and size efficiency.
- 3. Evaluate mechanical design proposals, to determine final design direction and layout.

Through the third step of the ideation process five different design details were found to be essential for creating a design upholding the requirements, these five details are:

## Findings

- 1. The product should use a traction gas spring (III. 4.36) instead of a compression gas spring (III. 4.35), as this would result in a simpler construction.
- 2. The levers should be made from beams and have rollers placed inside the beams, instead of rollers mounted to the side of the beams (Ill. 4.38). This should be implemented to minimize the width of the product.
  - This proposed design requires a cutout to be made to the beams, to ensure that the scissor is foldable.
- 3. The rails supporting the rollers should be made from a metal sheet and contains two grooves which ensures the rollers movement is restricted to one axis.
- 4. The levers should leave room on each side to accommodate for the platform rails.
- 5. A handle should be added to the middle part of the of the scissor box.

The design details are then combined into one design, using CAD to ensure correct dimensions (Ill. 4.37). The new design direction ensures that the mechanism is slimmer than previously proposed design, to make the product more compact. The gas spring which should be used is a traction gas spring, this gas spring is mounted so that is it expanded when the scissor mechanism is folded down and compressed when the user is working in a standing position. The scissor mechanism moves using rollers, and have rails which confine the lever movement to one axis.

#### **Requirements:**

• A traction gas spring should be used



Ill. 4.36. Traction (pull) gas spring construction



Ill. 4.35. Compression (push) gas spring construction





In the cardboard mockup test it was found the that the previous idea for the foldable tabletop did not fit the current design, as the tabletop would hit the monitor when being deployed. Therefore, a research processes was made into how a foldable tabletop could be combined with the design.

An ideation process was initiated where a solution such as jalousie systems were tried to be incorporated alongside a sliding platform system. See appendix at page 35. However, these concepts did either not fit the concept or were too mechanically complicated. An additional ideation process was therefore made with the focus on how to create a simplistic and functional platform system, see appendix at page 36. The result of this process is a concept consisting of a foldable tabletop, with four boards that is connected by hinges. The tabletop fits the gap beneath the monitor when stored, and when deployed the user take out the platform, unfolds it and deploy it on the heavy duty rails ("4.1.2. Making a platform" on page 51)

#### Boards

The boards used for the platform each measures H0,7 x W69 x D11cm which makes them vulnerable to deflection caused by a user leaning on a platform. In 4.1.2 at page 51 it is found that the platform should be able to withstand a load of 20 kg, as this corresponds to the weight of large man leaning on the product. The platform must not deflect severely when leaned upon, however a small deflection of the boards would warn the users that they could be leaning too heavily upon the product.

A deflection of 3 mm is therefore allowed when applying a load of 20 kg, as this is deemed as a deflection which would warn the users while not making the product look too fragile.

To determine the material for the platform, an FEM analysis is used as a tool to calculate the deflection of the platform. The analysis is made on wooden boards. The boards are placed on top of rails, which acts as support. For the FEM analysis a simple setup is therefore used, where one board is exposed to the 20 kg load.



09011111

Ill. 4.39. A load of 20 kg is applied to an ordinary beam construction

The analysis showed that if two steel beams of  $20 \times 4 \text{ mm}$  is added to the boards the deflection is limited to 3 mm, which is accepted.

#### Veneer

Manufacturing the plates for the foldable tabletop in MDF would not match the aesthetics direction described in the style board. It is therefore necessary to use a light wood veneer, like beech, to cover top, bottom and the sides of plates, to ensure a visual identity matching the direction described in "4.3. Folded - design aesthetic" on page 57.

#### Hinges

The hinges used for the foldable platform is double pin hinges, as these ensures that the platform would have a completely flat surface when unfolded, thereby ensuring that the users can work freely without hitting bumps with the computer mouse, as normal hinges could result in (see III. 4.40).



Ill. 4.40. Types of hinges applied to the construction



The further build on the customers view on the product is an interview arranged with Deloitte. Deloitte is a company with many employees are they both an important potential costumer and representative for the costumer group.

It is therefore relevant to investigated if Deloitte have bought home office equipment, how they have bought it and their view on the proposed product.

Until now, the development process has focused on the users and their requirements, wishes, observations, and the remarks and wishes from the potential costumer Saphe, who represent the smaller companyies. To understand the perspective of a costumer from a larger organization, an interview is planned with the company Deloitte. Through this interview a representitive from Deloitte is interviewed to understand the company view on working from home and the proposed product to investigate the buyer's requirements and wishes. The interview is a semi structured interview where the informant is asked about what have been done at Deloitte regarding home office use and then presented to the cardboard mockups for feedback. It was conducted through an online Teams meeting. The interview is semi transcribed, to note the most important information and remarks. See appendix at page 39.

## Findings:

Through the interview it was found that Deloitte plans to permanently implement working from home as a regular part of their employee's daily life. They do not plan to order their employees to work from home every day, but they will urge their employees to work from home a few days a week. Deloitte plans to do this as they have received positive feedback from their employees regarding working remotely. Working at home increases efficiency and lowers cost. Deloitte had a plan to move away from the current offices in Copenhagen, as they did not have room for all 2000 employees. Due to the COVID-19 pandemic, they realized that if working remotely is integrated as part of the work culture, they would be able to stay in their current office and not have to move to new facilities.

As Deloitte currently have employees working from home, they have initiated a service where they lease a home office setup for the employees who needs the equipment. The cost for each setup is a 100 DKK, which is paid monthly on a 5-year leasing agreement.

#### The setup includes:

- 1x Monitor, with built-in docking station
- Keyboard
- Mouse
- Webcam
- Office chair, optional

Deloitte are currently leasing this setup on behalf of 1700 employees, however while all



Ill. 4.41. Jacob Bangsted, Director of Procurement

of these have selected the monitor many have decided not to include the chair as they do not have room for it.

"Our home office pack includes full monitor setup and a chair, but many choose not to take the chair as the have small Copenhagen apartments and cannot fit a big ugly chair into their home" – Jacob Bangsted, Director of Procurement (Bangsted, 2021)

Deloitte are positive toward the suggested product direction, which they think solves the problem for those who do not have the room for a dedicated office space or an office chair. They see the product as something which could be offered alongside their current work setups, and the employees should then select the product which fit into their use situation.

"I see that this fit into the product range, as a sublimit which could be offered to our employees" – Jacob Bangsted, Director of Procurement (Bangsted, 2021)

Deloitte are currently paying a total of 6000 DKK for their home office setups, but dose not have set maximum cost for the products which they lease for their employees. For Deloitte the cost have to reflect the value or gain from the product.

"If you made a product that could limit occupational injuries and ensured a better work position, then we are willing to cover a cost matching the value gained from that. We are not locked to 100 DKK/month/5 year" – Jacob Bangsted, Director of Procurement (Bangsted, 2021)

Through the interview it was found that Deloitte is interested in the solution, as it offers a functionality which is not matched by their current home office setup.

Deloitte did not have specific costs for the home office, but believed in that cost for the product should match the value offered in a healthier work position and upheld legislation.

## 4.8. Saphe Mockup test

A mockup had previously been made of cardboard, which was tested with users from co-teams at the university. Based on the insights through this test was it decided to conduct a test with office workers as well. Therefore, the potential customer Saphe was contacted to conduct tests with their employees.

The cardboard model was not enough when testing with users at the University, as it was too flimsy. The team then went into the wood workshop and constructed a modular platform, with 4 variable height adjustments. This was to make the users more comfortable in actually trying the platform when in its raised position.

From this, three interviews were held at their local office, each taking 25 minutes, due to extra comments along the way. The test setup was placed at Saphe' office, where the team made a base with all the mockup-components on one side of the room (III. 4.42), with the test subjects placed in the other (III. 4.43). The interviews were structured around an interview guide, and the informants was videorecorded for the team to semi-transcribe afterwards.



Ill. 4.42. The upgraded cardboard model with wood platform



Ill. 4.43. The test setup for the users to try

The informants were:

## **Anne Nold Jensen**



Industrial Designer

"The solution is quite smart, as everything is compact and all of it is placed at the same place. For a studio apartment, this makes very much sense, as it does not take up much space."

## Klaus Dahl Kristensen



Product Team Leader "I think it's a great idea. I can easily see the use of such a product"

"The depth of the platform, is quite nice, as I don't think I would ever stand right against the edge - thereby not hitting my knee against the tabletop."

## Niels Jørgen Kofod



Hardware Engineering

"Depending on the process of adjusting the height, it is very nice to be able to stand up at home. It should however be so intuitive, that your thought process is not broken, and the action should be within seconds. "

They were each asked to answer what type of scenario they have at home, and what setup they currently own. All of them had a dedicated office space of which only they spent time in. They therefore are not in the direct target group; however, they are all working from home 3 days a week and could identify with other people who might gain something from the proposed solution.

For their full insights, please see appendix at page 40.

The product renderings shown to both Saphe and the physiotherapist looks like the following.







Ill. 4.44. The product in it's closed position

Ill. 4.45. The product in it's open and seated position

Ill. 4.46. The product in standing position

## 4.9. Physiotherapist interview

The development and design process of the workstation have built upon the recommendations and legislation described by the Danish Working Environment Authority and guides for improving the home office published by experts. To validate the design and consider if changes should be made to the concept to improve work ergonomics a physiotherapist is interviewed.

The interview conducted is a semi structured expert interview where the informant first is presented with the product and the use case, then asked general questions about work positions and finally asked about his thoughts and remarks concerning the product. The interview is conducted using Microsoft Teams, recorded and semi transcribed, to note information and remarks stated by the physiotherapist.

## Physiotherapist

Kristian Milver Nielsen Physiotherapists, Vejle municipality

#### **Findings:**

• "Using the product ensures a much healthier setup than what most currently use or even have access to at home."

- "Being able to adjust the angle of the monitor is important, as it can help relieve stress caused to the neck and upper shoulders."
- "Support for the lower arms and even elbows are vital to a healthy work position. When forearms are resting comfortably on a tabletop, both the shoulders and the neck are relaxed too."
- "This setup ensures that those who do not have an office, can get a healthy and correct work position."
- "Heavy lifts are something which can cause injuries, and it is therefore important that the users do not end up injuring themselves when carrying or moving something heavy. However, it is only two times a day that the product is moved and therefore not a repeating action and thereby not as critical."
- "Lifting light loads under 5 kg in a stressed arm does not hurt anyone."
- "People don't know how to adjust furniture or equipment to fit their own body posture, the best solution is a solution that somebody adjust to fit the user and the users should then be kept from messing with those settings themselves."



Ill. 4.47. Screenshot of the informant from Teams (Kristian Milver Nielsen, right)





Workstation – Sitting work mode

Workstation – Standing work mode

*Ill. 4.48. A presentation were held, to let the physiotherapist learn about the product* 

## 4.10. Market size

The workstation has been designed in accordance with Danish work legislation. Large portions of the work legislation is decided in EU, and therefore applicable to all members of the European Union. Each nation have the possibility to conduct local adjustments to the legislation. (EU-direktiver om arbejdsmiljø - Arbejdsmiljø - EU-OSHA, 2021)

It is therefore decided to focus on the Danish market at product launch, with the possibility to widening to a broader European market after proof of product. When widening to neighboring countries it is important both to examine local legislation to determine if product adjustments is needed and to consider local trends to determine if some countries are shifting more towards implementing home offices than others.

#### Market size – Denmark

The B2B market regarding professional home office products in Denmark can generally be divided into two broad categories:

- The private sector
- The public sector

While both sectors have been forced to work remotely during the COVID-19 pandemic, and the public sector are the sector who have worked from home the longest (Jørgensen, 2021), it is decided to focus on launching the product within the private sector and use the private sector in Denmark as a spearhead market for the product. During product development, the companies Saphe and Deloitte have both shown interest in the product. Selling products to the private sector requires a simpler process than larger acquisitions within the public sector, as the private sector is not forced to acquire products through cumbersome processes.

The branch organization Danish Industry estimates that after the pandemic 160.000 employees would work from home on any given day within the private sector. (90.000 flere vil arbejde hjemme efter coronakrisen - DI, 2021) But as most employees would prefer to both have the possibility of working from home and at the office, during the work week, the total numbers of employees who would have the possibility of working from home during a month, are higher than the estimated 160.000 employees.

During March 2020 and the first COVID-19 lockdown, 460.000 employees within the private sector were forced to work from home. (Arbejdsgivere forventer fordobling af hjemmearbejde efter corona, 2021)

Research during project, showed that 81% of the employees who have worked from home, is interested in continuing to work from home ("1.8. Questionnaire" on page 16).

Based on this, a potential market size can be estimated.

The estimation shows that in Denmark, within the private sector, the potential market size is 169.011 users (see III. 4.49). However, it is not realistic to sell to 100% of the potential customers, a more realistic scenario would be to sell to 5-10% of the potential customers. But as the private sector in Denmark is to work as a spearhead market, before the product is altered to enter a broader European market, it is considered an attractive market and market size.

Statement	Info	Source
Employees in the private sector working from home during march 2020	460.000 Employees	(Arbejdsgivere forventer fordobling af hjemmearbejde efter corona, 2021)
Percentage of employees interested in working from home more than one day a month after the COVID-19 pandemic	81%	"1.8. Questionnaire" on page 16
Number of employees interested in continuing to work from home	372.600 Employees	Estimation
Percentage of employees currently using their primary or secondary room as a temporary home office	63%	"1.8. Questionnaire" on page 16
Number of employees who would work from home in the kitchen, bedroom, or living room	234.738 Employees	Estimation
Percentage of employees working from home, using one monitor	72%	"1.8. Questionnaire" on page 16
<b>Potential market size:</b> Covers the number of employees within the private sector, who would work from home more than one day a moth, establishing a temporary home office setup in either in the kitchen, bedroom, or living room and using just one monitor	169.011 Employees	Estimation

Ill. 4.49. Table of researched numbers

## 4.11. Business plan

When entering the spearhead market: 'The private sector in Denmark' it is necessary to determine which business case approach should be applied, as the two potential customer interviews through the development process have different business requirements:

**Saphe:** Interested in a product which they can acquire through a one time payment. Saphe want to own and control the workstation.

**Deloitte:** Interested in a product which they can acquire through leasing. Deloitte are not interested in being furniture owners and would therefor lease the product.

As NK Office Solutions is a startup who are trying to penetrate a new market with a new type of product, it would be beneficial to focus on selling the product, not leasing the product, to faster get the resources needed to cover investment cost. But when the product has been proven through sales, it should be considered to enter the leasing market, in collaboration with a business partner to access large customers such as Deloitte or to widen the costumer focus to also cover the public sector.

## Lean Start-Up method

NK Office Solution is a start-up company, a business strategy is therefore needed which matches the experience at NK Office Solutions. This could be achieved by applying the Lean Start-Up method. (Blank, 2013) The Lean Start-Up method promotes developing the product alongside the costumer, issuing an agile development process where the product is updated based on customer needs and pivots can be made to the design based on insights and learning experiences caused by failures.

When applying the Lean Start-Up method, it is necessary to be able to alter the product and design through an iterative proces. It would therefore be beneficial to have manufacturing locally in Denmark, to ensure that the design can be adjusted, and functions evolve incrementally. Saphe have previously shown interest into the product and stated that the product would be highly relevant to some of their employees. It would therefore be optimal to approach Saphe as a potential first costumer, who can acquire the product and have it developed together with the end users. When widening the customer base from Saphe to including other companies, it should be sold through NK Office Solutions own website. Implementing a web-shop would result in more work as NK Office Solutions both have to manage development and the sales channel. But, cutting out established sales channels could leave to higher profits and ensure the close contact needed between developers and customers, to ensure successful costumer development and thus applying the Lean Start-Up method.

#### Lean Traditional Summer Development Bet out of the office and test hypotheses Business Plan Implementation-driven Customer Development Bet out of the office and test hypotheses Product Management Prepare offering for market following a linear, step-by-step plan Dig Development Build the product iteratively and Incrementally Agile or Watefall Development Build the product iteratively of fully specify the product before building it Organization Customer and Agile Development Teams Hire for learning, nimbleness, and speed Departments by Function Hire for experience and ability to execute Financial Reporting Customer acuisition cost, lifetime customer value, churn, viralness Accounting Increment, balance sheet, cash flow statement, balance sheet, cash flow statement, balance sheet, cash flow statement Failure Exception Fix by firing executives Rapid Operates on good-enough data Measured Operates on complete data

Ill. 4.50. Lean vs. traditional start-up method

## 4.12. Execution plan

When the product is sold to a wider customer base, and no longer co-developed alongside the costumers, new manufacturers/suppliers could be contacted, to find manufacturers who can produce and deliver the product in large number, focusing on cost, rather than agile development. NK Office Solution would then break with the principles of the Lean Start-Up method, and start shifting toward a classic costumer and supplier relationship, focusing on cost, and ramping up production. As a stable costumer base is ensured through NK Office Solutions own sales channels, it should be considered how to target a wider part of the market. This could be done by entering the leasing market, approaching large customers such as Deloitte. ("4.7. Working from home Deloitte" on page 62)

Deloitte have stated that they want to acquire all their home office equipment through the same platform. The workstation is only relevant to a portion of the Deloitte employees and should be offered alongside solutions matching other users' requirements and wishes, such as products fitting a dedicated home office instead of a temporary home office. Instead of NK Office Solution having to widen their product portfolio to include red ocean products e.g., office chairs, NK Office Solutions could sell the product through a sales channel, e.g., kontormøbler.dk, who already offers leasing solutions to their customers. The workstation could therefore be included in such a leasing solution.

This would lead to a business setup, where the costumer has two different approaches to acquire the product:

- Buying: The workstation can be bought using NK Office Solutions own web-shop
- Leased: The workstation can be leased using established sales channels, e.g. kontormøbler.dk

When NK office solution has successfully penetrated the spear head market, it should be considered how to widen the costumer scope by altering the product to match work legislation in other European countries or, through the leasing sales channels, try to enter tender agreements to sell the product to the public sector.

#### Seven-step execution plan

Following the business case and execution plan, this would lead to a seven-step plan:

- 1. Find local suppliers to manufacture the product to first costumer, focusing on agile product development.
- 2. Launch product in collaboration with a costumer, developing and finalizing the product together with users.
- 3. Launch product through own website, increasing sales.
- 4. Locate manufacturers to produce the product, focusing on cost.
- 5. Contact established leasing sales channel, to offer the workstation to customers through leasing.
- 6. Work towards offering the product to the public sector.
- 7. Investigate neighboring European countries work legislation, to widen the market to a broader European scope.

To ensure a viable business case it is necessary to conduct a maximum cost price estimation to deduct the cost price limit when compared to the estimated sales price.

In the worksheet "4.11. Business plan" on page 66, two different sales channels were outlined:

- Sales though own web shop
- Leasing through business partners

In the execution plan it is described how the first business step is to sell the product through NK Office Solutions' own website and later on move into the leasing business with a collaboration with an established B2B furniture leasing company e.g. Kontormøbler.dk. Therefore, the maximum cost is estimated on the assumption that 'NK Office Solutions' exclusively sell through their own web shop.

### Estimated sales price

'NK Office Solution' is a startup that offers a product that is highly differentiated from competitors and strive to create a blue ocean in an otherwise red ocean market. NK Office Solutions would therefore presumably experience heavy economic costs entering a new market as a new player. However, as the product have no direct competitors 'NK Office Solutions' are not forced to attract costumers through low sales prices and can instead focus on setting a sales price based on the user's needs, of which is solved by acquiring the workstation.

#### Customers

#### Saphe

Through an interview with the HR manager and owner of Saphe A/S, it was found that they were interested in the workstation. ("2.11. Buyer Interviews" on page 34) During the interview, potential sales prices were discussed with Saphe, who stated that they would find a sales price of 2000 DKK excl. vat as a very attractive sales price. The sales price of 2000 DKK was for what could be described as a "monitor stand", as the price did not cover a height adjustment feature, which they believed should be sold additionally as a product upgrade.

#### Deloitte

In an interview with the procurement manager at Deloitte it was found that Deloitte is currently paying a total of 6000 DKK for their home office setups, through a leasing agreement during 5 years. ("4.7. Working from home Deloitte" on page 62) This cost covered a total setup of monitor, chair and docking station, however Deloitte did not have a maximum cost for the products which they lease for their employees. For Deloitte, the cost has to reflect the value or gain from the product. 68 - Phase 4 "If you made a product that could limit occupational injuries and ensured a better work position, then we are willing to cover a cost matching the value gained from that. We are not locked to 100 DKK/month/5 year" – Jacob Bangsted, Director of Procurement (Bangsted, 2021)

Deloitte believed that the product would fit well into their leasing portfolio, as it covered a need which they currently did not have a solution to.

#### Competitors

Through the strategy canvas and target model two competitors are outlined as being those closest to offer the same solution as NK Office Solution. These competitors are:



Ill. 4.51. Varidesk Pro Plus 48 Sales price: 485 euro  $\approx$  3600 DKK excl vat

Ill. 4.52. Victor DC400 High Rise Sales price: 600 USD  $\approx$  3650 DKK excl vat

#### Sales price

From the interview with Saphe and Deloitte it is found, that both companies are interested in the solution, and that they are willing to spend more than 2000 DKK to equip their employees with the product. The closest competitors which offer comparable products have a cost price above 3600 DKK excl vat. It is therefore decided to set the sales price just below the competitors at 3500 DKK excl vat. This sales price is higher than the attractive sales price indication offered by Saphe, but as their estimation of 2000 DKK would be without a built-in standing work option it is believed that a sales price of 3500 DKK is a realistic estimation.

#### Estimated cost price

The maximum cost price estimation is calculated using the target cost calculation method presented by Ulrich and Eppinger. (Ulrich and Eppinger, ch. 6, 2012) The methodology presented by Ulrich and Eppinger is applied as it provides a simplified guide to calculate cost, while considering the gross margin for each party in the sales process.

The data for the cost estimation is based on the approximate percentage coverage for manufacturers, wholesalers, distributors, sales representatives, and retailers provided by Ulrich and Eppinger. The guide does not account for product owners also acting as sales channel, disrupting the traditional sales proces, as NK Office Solution execution plan describes. It is therefore decided to divide NK Office Solution into two parts, ensuring a coverage margin both during production and during sales.

The coverage margin is not known for manufacturers producing B2B office equipment or furniture, however according to Ulrich and Eppinger, industrial equipment have a gross margin varying between 20-45%, and its therefore chosen to use 32,5% for the estimation.

The coverage margin is also not known for retailers of B2B office equipment or furniture product, however according to Ulrich and Eppinger, industrial specialty retailers, which is considered the field closets to B2B home office solutions, have a gross margin varying from 40-70%, and its therefore chosen to use 55% for the estimation.

#### Conclusion

Based on the interviews with potential customers and a competitor analysis with the two closest competitors, a sales price is set to: 3500 DKK excl vat. Using the target cost calculation method by Ulrich and Eppinger a maximum cost is estimated based on the sales price, to 1698 DKK. Producing the workstation at a cost of 1698 DKK and selling it at 3500 DKK ensures NK Office Solutions a total coverage of 1794 DKK, corresponding to a profit margin of 106%. These earnings should then be used to cover investment during development and product launch and cover the cost of running a web shop and conducting product sales.

Target costprice		
Estimated sales price incl VAT	4375 DKK	
VAT	25%	
Sales price excl. VAT	3500 DKK	
Sales coverage	1242 DKK	
Retailer profit margin	55%	
Sales price	2258 DKK	
Manufactoring covorage	551,85 DKK	
Profit margin	33%	
Maximum costprice	1698 DKK	
NK Office Soltuions total coverage	1794 DKK	
NK Office Soltuions total profit margin	106%	

Ill. 4.53. Maximum cost price calculation

The workstation should be sold for 3500 DKK excl. VAT.

Maximum production cost should aim to be below 1700 DKK.

Sale of product should go through own webshop.

Estimated market size is: 169.011 users.
#### **Problem Specification**

Concept tests at development during phase 4 have shown a general interest in the proposed solution by both the users and the customers. The product has been presented both physically and digitally and through this, the concept and problem space were specified, to cover a problem statement of **how to create an ergonomic and temporary work environment that complies with work legalization, without having a dedicated office?** 

# PHASE 4

#### **Summary**

Through phase 4 the concept was developed and conceptualized in detail, focusing on defining the height adjusting construction, including considerations regarding the gas spring and foldable platform. The concept was made as a mockup for user tests and to verify the proposed solution. Test and interviews showed that both potential users and customers showed interest in the product solution and a physiotherapist verified the proposed product as improving the users' work environment at the home office.

## Table of content for phase 5

Technical Calculations
Choosing a gas spring
Electronic components and cable management
Storing peripherals
Component development
Materails and production considerations
Weight analysis
Tipping point
Production cost
Development cost & break even



#### **Technical specifications**

The fifth phase focus on detailing and specifying the concept developed through phase 4. The phase revolves around the product's critical components and functions, to render the concept trustworthy. Through the phase, technical calculations are made regarding the product to select a gas spring. The components are detailed in CAD software, and materials and production techniques are suggested. Based on the proposed materials, production cost and an investment budget for the project are estimated.

Finally, the proposed concept is compared with the requirement specification to verify the proposed solution.

## 5.1. Technical Calculations

The product is through simulations tested to support the load of the product combined with the 20 kg applied weight from the user. Calculations are made regarding what the force of the spring should be, and an FEM simulation is made regarding whether or not the workstation scissor elements can withstand the force.

At first, the gas spring force is determined. The system is seen at Ill. 5.1.



Ill. 5.1. The calculated scissor system

The calculations for both the spring and FEM can be found at the appendix at page 44.

The outer angles of the system are determined to be:

$$\Theta_{\max} := 53 : \Theta_{\min} := 3.5 :$$

Where the forces in the system are calculated as:



The FEM system, is with a roller on one of the support legs, a fixed support on the right and a roller on the back of the platform. On top, the product weight and the user's applied weight is added.



Ill. 5.2. Deformation in the system in (Theta) 30 degrees



Ill. 5.3. Stresses in the system in (Theta) 30 degrees

In the outer positions, the forces and deformation is found to be:



At the bottom, the stresses max out at 312 MPa and displacement at 1,3 mm.



At the top, the stresses max out at 274 MPa and displacements are at 2,4 mm.

## 5.2. Choosing a gas spring

For the gas spring, it is determined that the maximum force required (with the person lifting 3 kg themselves) should be of 650N. The gas spring should be lockable, to ensure that the user can fix the product at a fitting work height when changing to a standing work positions (just like an office chair).

The gas spring is a contraction mechanism, of which is highligted in the table at Ill. 5.5. This gas spring, applies a pull force ranging from 150N-1000N, which upholds the requirement given in the calculations of the gas spring forces at "5.1. Technical Calculations" on page 72.

The spring can be viewed in Ill. 5.4.



Ill. 5.4. A lockable gas spring (Locking Gas Springs, 2021)

Manufacturing specs								
Туре	Cylinder Ø	Piston rod Ø	Stroke (mm)	Extender length	F1(N)			
Lock	22	10	12-250	150-650	150N- 1000N			
	28	10	12-250	150-650	150N- 1000N			
	28	10	12-250	150-650	200N- 1200N			

Ill. 5.5. Component specifications for Ill. 5.4

## **Envisioned** interaction

However, the exact interaction mechanism for this spring is not the prefered method. The interaction needed for the workstation, should be some-what similar to a bike break mechanism, of which the following product was found to do (III. 5.6).

This height adjustable work table, specifies that it uses a gas spring as the locking and lift mechanism, and the close-up of the product handle clarifies that the spring is released through the use of a cable.

Thereby, it can be concluded that the team is able to create the desired interaction, while fitting the physical dimensions of the specified gas spring.



Ill. 5.6. (Height adjustable desk MAHTUVA M 68x40 | SELKA, 2021)

## 5.3. Electronic components and cable management

To determine the cable routing inside the workstation an analysis were made to determine the necessary electronic components.

The users should experience the workstation as a 'plug and play' solution, where they only have to connect their laptop to the workstation using a USB-C cable and the workstation to the power outlet using a power cord. ("3.10. User interactions" on page 44) The monitor which is used together with the workstation is defined in worksheet "3.5. Peripheral Analysis" on page 41 as:

- 27-inch monitor
- Monitor with a standard VESA mount
- Monitor with build in docking functionality
- Connected to power through a IEC-C13 socket connecting to an IEC-C14 plug

Having a monitor with built-in docking stations ensures that the monitor can:

• Power and charge a laptop through a USB-C connection

- Receive image and audio, though the USB-C connection
- Have USB-A inputs, for connecting peripherals such as mouse, keyboard, etc.

To enable the 'plug and play' feeling of the product, the user interaction should when setting up the workstation, be limited to connecting the workstation to power and connect their laptop to the workstation through USB-C.

The USB-C and power cable would need to be connected to the monitor, but to ease the user experience it is investigated if a female USB-C plug and IEC-C14 plug can be added to the backside of the product, which then is connected to the monitor during installation, through wires running internally in the workstation. This would ensure an easy and convenient setup for the users, who only needs to connect two cables at the back of the product before being ready to work.

## **Monitor power**

The monitor is required to be connected to power for the workstation to function, as the monitor both is the display and have a built-in docking station connected to peripherals, while also powering the laptop. The monitor is powered by the user connecting an IEC-C13 socket to an IEC-C14 plug at the back of the product. The C14 plug should be connected with a cable that runs internally from the bottom of the workstation to the monitor and connects to the monitors C14 plug with a C13 socket.



Ill. 5.7. C13(male)-C14(female) powercable

## **Cable routing**

During setup the users connects a C13 plug to the C14 socket, a cable then needs to be wired from the socket to the monitor. This can be achieved by a power cable running inside one of the hollow legs used for the

scissor construction, similar to how a brake cable on a bike is hidden inside the bike frame or how power cables are run through a lamp. In both cases a plastic bushing is used in metal cut-outs, to soften sharp edges and avoid damages caused to the cable. Using a technique similar to this, would ensure a connection between the power plug and socket when the user is working both sitting and standing, and the user easily being able to power the product by connecting a power cord to the workstation.

The power cable can then be wired through the monitor mount, to ensure a connection between the C13 plug in the workstation and the monitors' C14 plug.

In both cases a plastic bushing is used in the end of the metal, to soften sharp edges and avoid damages caused to the cable. Using a technique similar to this would ensure a connection between the power plug and socket when the user is working both sitting and





Ill. 5.8. Plastic/rubber grommet/bushing

Ill. 5.9. Internal cable routing on a bike

standing, and the user easily can power the product by connecting a power cord to the product.

The power cable can then be wired though the monitor mount, to ensure a connection between the C14 plug in the workstation and the monitors C14 plug.

## Laptop power and image signal

The laptop needs to be connected to the monitor through a USB-C cable, to both ensure that the laptop will receive power and provide the image signal for the monitor. To ensure the USB-C connection between laptop and the monitors' dock, the same technique can be used as for the power cord.

A USB-C female connector can be placed on the back of the product, and a USB-C cable can be wired alongside the power cord from the bottom of the workstation, through the metal leg used for the scissor mechanism, the monitor mount, and connect the female USB-C input in monitor's dock.

#### Installment

The internal wiring would be needed to be built into the product when received by the user, leaving a C13 and USB-C male socket hanging out from the monitor mount. During installation by the caretaker, the two sockets are connected to the monitor, when the height is adjusted to fit the users.

> When the caretaker receives the workstation, both a USB-C and a power plug have been run through the scissor legs and monitor mount, prepared for a simple monitor installation.

> When in use, the user should connect to cables to the back of the product to a USB-C female socket is placed, alongside a female powerplug IEC-14.

When the workstation is not in use the users need to store the peripherals inside the workstation, to ease the work routine during setup ("3.10. User interactions" on page 44).

The peripherals which is required to be stored inside the workstation is:

- Computer mouse
- Keyboard

As well as

- USB-C male to USB-C male
- C13 to power outlet

Initially, the intention was to store the keyboard and mouse on top of the scissor mechanism, beneath the monitor. However, this is not possible when the monitor is positioned in the lowest setting and the foldable work platform is placed on top of the scissor mechanism. This leaves a gap of 7mm. It is therefore necessary to find a new storing solution for the peripherals.

The dimensions for the main office peripherals were outlined during "3.5. Peripheral Analysis" on page 41 as:





Ill. 5.10. Logitech MX Master 3 D:12,5 × W:8,4 × H:5,1 cm

*Ill. 5.11. Logitech K740 D19,5 × W45,5 × H1 cm* 

The mouse was the largest regular office mouse found through the peripherals research, but as some keyboards were either a bit higher or deeper, it was decided to enlarge the keyboard pocket size to: D22 × W47 × H3 cm.

# Concept – magnetic pouches for peripherals

To ideate on a new storing solution was a sketching process initiated where different concepts were discussed and evaluated using a whiteboard as the center for the ideation process. The result of this process was a concept where a steel plate is added to the side panel and magnetic pouches was included with the product. The users can the add these pouches to the inside of the side panels and arrange the pouches to fit their needs.

The pouches can be used for storing a keyboard, mouse, cables etc. + addons could be included such as a part for storing pencils or post-it notes, which were noted by users during interviews as something they would like to include. ("4.8. Saphe Mockup test" on page 63)

With some of the older electronic products, it was not recommended to use magnets near e.g. monitors, as the magnetic field could damage the display. But the technology currently used in monitors and electronic components, are not affected by magnets. (Norman, 2021)

It is proposed that a minimum of three separate pouches is included in two different sizes:

- 1x Keyboard pouch: D30 × W220 × H470 mm
- 2x mouse or cable pouch: D:55 × W:84 × H: 125 mm

Furthermore, a magnetic pencil and Post-it manager could be added as an extra add-on, which can be bourght at a later point, thereby generating an extra sale. Other sales could be a magnettically mounted webcam light or a fan to cool you down, during hot days.

The pouches should be attached to the side panels, by using a magnettic back on the fabric pouches. At Ill. 5.12, the dimensions of these pouches are shown.



Ill. 5.12. Dimensions of pouches on the workstation sidepanels - see appendix at page 48 for a bigger version of this illustration.

# **Changing workstation dimensions**

Adding pouches for storing the peripherals requires an alteration of the dimensions of the workstation. In the current design the depth of the workstation is 150 mm, which leaves a gap of 42 mm between the inner side of the side panel and the monitor (Ill. 5.13). As the pouch fitting the computer mouse needs to have a depth of 55 mm, the mouse can not be stored in the current position, without the users risking damaging their monitors due to the height of their PC mouse.

A requirement is therefore added to the design to ensure that a PC mouse can be safely stored in the workstation without harming the monitor.

The depth of the workstation is therefore extended with 20mm, widening the product from 150 to 170 mm as total depth (III. 5.14), thereby increasing the distance between the side panel to the monitor from 42 mm to 62 mm, which enables a pouch depth of 55 mm and leaves 7 mm as a safety gap between the PC mouse and monitor.



#### Requirement

The distance between the side panels and monitor must be no less than 60 mm.

## Concept inspiration and design pivot

An online research process is initiated to investigate if a similar magnetic system exists for the pouches and if the peripherals storage solution is something that can be acquired as a standard solution or something which NK Office Solution should produce and manufacturer themselves.

The research process showed that 'Locker Pockets' and magnetic add-ons to metal lockers are a widespread phenomenon in USA for upgrading school lockers.

Based on the finding it is decided to change the proposed concept of using several different pouches and instead make one large piece with a large minimalistic bag and pockets included in the design. Instead of having open pockets as seen in the 'locker pockets' at Pottery Barn (Ill. 5.15), zippers should be added to the pockets to ensure that the peripherals are kept safe.

Changing the proposed concept to a design which is one large magnetic patch, with several pockets, removes the customizability of the concept, as the users cannot place the pouches as they deem best. Instead, one pocket system is included with the product, and the other is an add-on to generate extra sale revenue (see III. 5.12).

- Left side panel pocket, a pocket system covering the whole left panel and adds an additional pocket than previously suggested.
- Right side panel pocket, a pocket for storing pencils and managing post-it's for note taking. The pocket only covers the lower part of the right panel, leaving room for hanging notes or other magnetic addons.

As the locker pockets is a type of product which can be bought from several American webstores, it should be investigated if a supplier can be found who already have experience with locker pockets. Through this supplier, locker pockets should be bought which is customized to fit the workstations side panels and requirements.



Ill. 5.15. Magnettic locker decorations and storage pouches (Pottery Barn, 2021)

To determine the design and production technique for the components, a development process were initiated where production techniques are specificed for the main parts concidering production methods and materials. The key components are designed in detail, considering assembly. Below an exploded overview of the workstation is shown, with headlines describing the 15 parts of the workstation (Ill. 5.16).



Ill. 5.16. Exploded overview of the workstation

## 5.6. Materails and production considerations

## 1. Cabinet - see appendix at page 49

The cabinet function as the backbone of the workstation, protecting the monitor and ensuring product stability.

During manufacturing, the cabinet is made as two separate parts:

- The backplate
- The bottom and side plates

It is decided to manufacturer the two parts using an S235 steel sheet, as this S235 is a universal type of steel, which is used for a variety of products with low requirements regarding corrosion protection and a focus on cost. The two parts should be cut from a regular 2mm sheet, one part should be bent into a U shape. The two parts should then be welded together, creating a rigid cabinet construction.

After welding the parts, it would be necessary to post-process the cabinet to clean up the welding. Afterward, the cabinet should have a powder coating to ensure a nice surface, and to protect it from corrosion.



Ill. 5.17. Cabinet

#### Material: 2 mm steel S235 sheet

#### Production method:

- 1. Cut
- 2. Bent
- 3. Welded
- 4. Powder coated

## 2. Scissor levers - see appendix at page 49

The scissor levers are the components that ensure that the movement of the gas spring is transferred to a vertical height adjustment. Furthermore, the USB-C and power cable should be wired internally in the scissor levers, which connects the monitor to the laptop. The workstation consists of a total of four levers, two scissor pairs.

The levers should be manufactured in steel, due to the load applied to the components. The FEM analysis showed that the maximum load applied to the levers was 275 N/mm<sup>2</sup>, exceeding the yield strength of S235 steel previously used. It is therefore decided to use the stronger steel material S355, as this material has a yield strength higher than the maximum load, resolving in a stable construction.

The levers should be acquired as a 16x16x1,5mm profile at lengths of 6 meters. The beams should be cut into the lengths of the scissor levers and have cutouts fitting the construction. Afterward, the levers should have a powder coating to ensure a nice surface, and to protect it from corrosion.





*Material:* 16x16x1,5mm profile S355

## Production method:

- 1. Cut
- 2. Grinded
- 3. Powder coated

## 3. Sidepanels - see appendix at page 51

The side panels both protects the monitor when the workstation is stored, create a focused view when working in a sitting position, and have a magnetic surface to ensure a connection to the peripheral pockets.

The workstation contains two side panels, a left- and a right-side panel. Each panel should be made as a sandwich construction, having a plastic core, and then be covered with the laminate 'Formica Magnetic Folkestone'.

The laminate is made from a combination of steel and plastic, ensuring a durable and magnetic surface. Each sheet has a thickness of 1 mm and should be glued onto a 3,5 mm plastic sheet, using a Polyvinyl Acetate (PVAc) adhesive. (FORMICA, 2012)

The plastic core should be a 3,5 mm PVC foam, which is a rigid closed-cell plastic foam often used in sandwich constructions to ensure lightweight panels. (Closed Cell PVC Foam Core Material; 3mm, 5mm, 10mm, 25mm - Easy Composites, 2021)



Ill. 5.20. Sidepanel

#### Material:

- 1. Formica magnetic laminate
- 2. Closed chell PVC Foam

#### **Production method:**

- 1. Cut material sheets
- 2. Glue sandwich construction

#### 4. Handles - see appendix at page 52

The handles are connected to each side of the cabinet and work as the handles which are used by the users to move the workstation. The handles consist of a right and a left handle part.

Due to the complex geometry of the part, it is proposed to manufacture the handles using ABS plastic and injection molding.

ABS was selected through a systematic material selection process, due to a relatively low-cost price, rigid properties, and simple surface treatment before after processes such as e.g., gluing.

The two handles are similar in design, but not identical and would therefore require different molds. In collaboration with the supplier it should be considered if the parts could be manufactured using one aluminum mold, with two different inserts and thereby lower tool cost.



Ill. 5.21. Handles Material: ABS plastic

**Production method:** 1. Injection molding

## 5. Fabric covers - see appendix at page 54

The fabric covers are used to hide the screwheads and other visible components used for connecting the handles to the cabinet. The covers are additionally covered in fabric to match the decoration of the users' homes when stored.

The fabric covers are manufactured using the same material and production techniques as the handles, ABS, and injection molding. The fabric covers have been designed to be identical, and therefore allows for production using just one tool. Using ABS plastic allows for snap fittings to be added to the design, enabling the parts to snap around the handles and then be fastened using a strong solvent-based glue.

Fabric is added to the components after injection molding, the fabric is glued to the outer shell of the plastic components and wrapped around to be fastened on the inside of the component.



The supportive beams function as sliding rails ensuring a connection between the scissor mechanism and the cabinet. The supportive beams should be manufactured using a polyamide (nylon) rod, which ensures low friction in connection with S235 steel, as polyamide is often used as a sliding bearing due to its mechanical properties.

The parts are manufactured by acquiring polyamide sheets, cutting them into lengths, and milling a groove in beams to ensure an edge that fits together with the top box.



Ill. 5.22. Fabric covers

#### Material:

- 1. ABS plastic
- 2. Fabric

#### **Production method:**

- 1. Injection molding
- 2. Gluing



Ill. 5.23. Supportive beam

*Material: Polyamide sheets* 

#### **Production method:**

- 1. Cutting
- 2. Milling

## 7. Foldable tabletop - see appendix at page 55

The construction and manufacturing process of the foldable tabletop has been described through "4.6. Standing work platform" on page 61. It is proposed to manufacture the tabletop using 4x Veneer covered MDF boards with steel support and double pin hinges.

The boards have been designed through technical analysis, simulating the maximum load which could be applied to the board. Through the design process, it was found that each board could be manufactured using an MDF board with a thickness of 7 mm with two 20x4mm steel beams added to reduce deflection. The boards should be covered in veneer to match the style board.



Ill. 5.24. Foldable tabletop

*Material:* Steel enforced MDF boards with veneer

#### **Production method:**

- 1. Cutting
- 2. Milling
- 3. Glueing

The backplate ensures a flush surface between the handles and that the back of the product blends into the user's homes when stored.

The backplate is manufactured using the same manufacturing technique and materials as the side panels:

- Rigid plastic core
- Laminate sheet

As the backplate is mounted to the back of the cabinet it is only necessary to use one laminate sheet and not two as with the side panels. The laminate should match the Formica magnetic Folkstone laminate used for the side panels. However, it is not necessary to have the magnetic effect on the back, as it is seen on the side panels. The laminate can therefore be changed to regular Folkstone colored décor from Formica.



Ill. 5.25. Backplate

#### Material:

- 1. Formica decor laminate
- 2. Closed chell PVC Foam

#### Production method:

- 1. Cut material sheets
- 2. Glue sandwich construction

## 9. Supportive legs - see appendix at page 56

The supportive legs ensure product stability when the workstation is used in a standing position. The supportive legs have a thickness of 4 mm and can therefore be cut from a metal sheet and the edges rounded. As the legs have to withstand the stress from supporting the workstation when a heavy load acts on the foldable tabletop, it is decided to use the stronger S355 steel material used for the legs, rather than the S235 steel material used for the cabinet.



Ill. 5.26. Supportive leg

Material: 4 mm steel 355 sheet

#### Production method:

- 1. Cut
- 2. Grinded
- 3. Powder coated

## 10. Scissor mechanism - see appendix at page 57

The scissor mechanism connected with the levers is what ensures that the workstation can be used both standing and sitting. The scissor mechanism consists of several parts:

- Top box, acting as a cover hiding the leever and gas spring
- Gas spring mount
- Rails which guide the scissor levers and holds the rollers/bearings
- Hinges, connected to the scissor levers

The part should be manufactured using the same materials and production techniques as proposed for the cabinet. Cutting the part from a 2mm S235 steel sheet, bending the parts, and assemble them through welding. After welding the parts, it would be necessary to post-process the parts to clean up the welding and the part should have a powder coating to ensure a nice surface, and to protect it from corrosion.



Ill. 5.29. Scissor mechanism

Material: 2 mm steel 235 sheet

#### Production method:

- 1. Cut
- 2. Bent
- 3. Welded
- 4. Powder coated

## 11. VESA mount - see appendix at page 57

The VESA mount connects the monitor to the monitor stand and ensures that the monitor height can be adjusted to fit the end-user. The VESA mount consist of two parts:

- The VESA mount, connected to the monitor.
- The stand mount, connected to the monitor stand.

The parts should be manufactured using the same material and production techniques as the cabinet: 2mm S235 steel sheets, which are cut, welded and powder coated for corrosion protection.



Ill. 5.27. VESA mount bracket Material: 2 mm steel 235 sheet

#### Production method:

- 1. Cut
- 2. Welded
- 3. Powder coated

## **12. Monitor stand** - see appendix at page 58

The monitor stand connects the monitor to the scissor mechanism. As with the cabinet and VESA mount, the monitor stand can be made from sheet metal, using the same material and production techniques; 2mm S235 steel sheets, which are cut, bent, welded, and powder coated for corrosion protection.

Material: 2 mm steel 235 sheet

#### Production method:

1. Cut



3. Powder coated



Ill. 5.28. Monitor stand

## 13. Lid - see appendix at page 58

The lid is the workstations top cover and protects the product when folded. To match the user's home decoration, the lid is covered with a fabric matching that of the fabric cover. The lid should therefore be manufactured using the same material and production techniques, ABS and injection molding.

Fabric is added to the components after injection molding, the fabric is glued to the outer shell of the plastic components and wrapped around to be fastened on the inside of the component.



Ill. 5.31. Lid construction

#### Material:

- 1. ABS plastic
- 2. Fabric

#### **Production method:**

- 1. Injection molding
- 2. Gluing

## 14. Peripheral pockets - see appendix at page 59

The peripheral pockets are the storage system with pockets for storing peripherals such as the computer mouse, keyboard, and cables. The pocket is attached to the left side panel, through a magnetic connection. In "5.4. Storing peripherals" on page 76 the storage system was discussed and it was decided to contact potential manufacturers and order custom-designed pockets based on the existing magnetic locker pocket products, instead of 'NK Office solutions' are the manufactures of the pockets themselves.



Ill. 5.30. Peripheral pockets

## 15. Platform rails - see appendix at page 59

The platform rails are the extended rails which creates support for the foldable tabletop when the product is used in a standing position. In "4.1.2. Making a platform" on page 51 the rails were discussed, and it was decided to contact potential manufacturers and order custom-designed rails based on the existing heavy-duty rails, instead of 'NK Office solutions' are the manufactures of the rails themselves.



## Sidehandles combined with hinges

A key consideration for the workstation is the connection between the side handles made of plastic, the steel side panels and the hinges holding the side panels. These parts have to be designed to ensure a secure and stable connection between the components.

Therefore, teeth are added to the backplate's sides, creating a mounting point for the side handles (green). This solution can not be used for the front, as it has no backplate. This proved problematic, as the hinges for the side panels could not easily be added. An attempt was therefore made to combine the two functionalities.

This is done by letting the hinge be mounted with the side handles in with the same kind of 'tooth' as the backplate. The hinge must be specially made, in the shape of a Z-hinge, as this allows for the wings to open up fully in 240 degrees.

The 'taps' on the right side of the hinge, makes sure that the hinge is not pulled through the side panel, once firmly mounted into the green side handles.



Ill. 5.33. Sidehandles with side panel and wing hinge

# Fabric covers on the side

Due to the previously mentioned mounting system for the hinges, exposed bolts will be visible on each side of the workstation, due to the manufacturing procedure. Therefore, the design is altered to include a premium fabric cover, this is an extra part which through injection molding have snap fits which clicks into the bolt holes. Thereby, the workstation becomes more holistic and sleek, with the larger surfaces covered in laminate, and the edges covered in fabric hiding visible screws.

## Side panels

The side panels are another key component of the workstation. A peripheral add-on system have been proposed which is mounted with magnets to the inside of the side panels. As the peripheral pockets require a magnettic surface, a steel sheet is added to the wings in a sandwich construction alongside a plastic sheet and a laminated front and back.

However, it was realized that the sandwich construction would heavily increase the weight of the side panels, therefore research was made into a substitute solution. While investigating types of laminates, magnetic laminate sheets were discovered. The sheets are 1 mm thick, consisting of a mixture of metal and plastics, which would both lighten and simplify the sandwich construction.





Using the magnettic laminate sheets still requires a plastic core, this could be made from a rigid closed cell foam, further adding to the weight reduction of the side panels.

## 5.7. Weight analysis

As the components and materials are fully defined, it is possible to create a weight analysis of the workstation. This is done by using the volume of the parts in SolidWorks, multiplied with the density of the specified materials and amount of parts.

When viewing the SUM of the weight, it is discovered, that the workstation is too heavy, as the total weight (without smaller components as nuts and bolts), exceeds 30 kgs (Ill. 5.34). By talking with the user group, it was found that a maximum of 15 kg is wished for.

An attempt were made, to lower the weight by changing some materials, primarily changing steel to aluminum, marked by yellow (Ill. 5.35). In some cases, a change were made to the geometry. However, this is still not enough, as the weight still exceeds 20 kg.

When viewing the danish authorities regulations, the 24 kg could be accepted through legislations, as it is acceptable to carry less than 30 kg in a under-arm distance from the body.



Ill. 5.36. Danish legislation regarding allowable lifts (Løft, træk og skub - Arbejdstilsynet, 2021)

By allowing the 23,2 kg, due to requirement by the DWEA, the weight is within the acceptable limit in an under-arm length from the body. However, this will not be pleasing to the users and other manufacturing techniques should be investigated to further reduce the weight of the workstation. The weight issue is primarily caused by using steel, it could be that changing most of the steel parts to plastics could lower the weight while ensuring a rigid product.

This could possibly be achieved by rotation molding the cabinet and handles as one part, which beforehand should have been redesigned to ensure a rigid construction. The visible metal parts (not including the levers) could be changed to aluminum, ensuring a similar visual look and lighter weight.

Part	Material	Mass (g/cm^3)	Component name	Volume (mm^3)	Amount	Weight (kg)
Peripheral pocket						
	Fabric	0,917	Peripheral pocket	2841545	1	2,61
Cabinet						10,53
	Steel	7,8	Side plate (2mm)	169620	2	2,65
			Bottom plate (2mm)	234600	1	1,83
			Back plate (2mm)	759000	1	5,92
	Plastic foam	0,1	Back plate plastic	1302493,5	1	0,13
Scissor construction						1,19
	Steel	7,8	Scissor lever	30015	4	0.94
			Scissor slider	7362	4	0.23
			Scissor bracket	552	4	0.02
	Nylon	1.15	Roller	459	4	0.002
Fabric covers	,	-/				-,
	Fabric	0.917	Click fabric covers	272572	2	0.50
Side handles		-,				-,
	Plastic (ABS)	1.05	Side handle	762322	2	1.60
Monitor stand		2,00		,01011	-	2.25
inomitor stand	Stool	7.8	Vesa bracket	56027	1	0.44
	Steel	7,0	Monitor polo	220664	1	1.80
	Diactic (ABC)	1.05	Top plastic covor	230004	1	1,80
	Flastic (Ab3)	1,05	Niddle plastic cover	4433	1	0,003
114			windle plastic grummet	093	1	0,001
Lia	Directio (ADC)	1.05	Lid construction	400111	1	0,52
	PidSUC (ADS)	1,05	Click febrie sever	400111	1	0,51
Cido non ele	Fabric	0,917	Click Tabric Cover	12701	1	0,01
side pariels	Direction Concerns	0.4	to state of state seconds			1,05
	Magnettia laminata	0,1	Inside of side pariers	600250	2	0,12
	iviagnettic laminate	1,35	Inside cover of panels	1/1500	2	0,46
	Laminate	1,35	Outside cover of panels	1/1500	2	0,46
Tabletop						4,36
	MDF	0,7	labletop	396500	4	1,11
	Steel	7,8	Support rods inside	52000	8	3,24
Supportive legs						
	Steel	7,8	Supportive legs	49684	2	0,78
Platform rails						
	Steel	7,8	5 part sliders	69400	2	1,08
Guiding lines on back						
	Nylon	1,15	Sliders on the back	57527	2	0,13
	Aluminium	2,7	Aluminium guide	1211	2	0,007
Top box						
	Steel	7,8	Box capsulating scissor	271274	1	2,12
Monitor						
			Bought product		1	5,00
Hinges						
	Steel	7,8	Bought product	6442	10	0,00
Gas spring						
			Bought product		1	2,00

Ill. 5.34. Weight analysis first draft (35,7 kg)

Part	Material	Mass (g/c	n Component name	Volume (m A	mount	Weight (kg)
Periphera	pocket					
	Fabric	0.4	Peripheral pocket	2841545	1	1.14
Cabinet			• F • • F • • •			3,73
	Aluminium	2.7	Side plate (2mm)	169620	2	0.92
		,	Bottom plate (2mm)	234600	1	0,63
			Back plate (2mm)	759000	1	2.05
	Plastic foam	0.1	Back plate plastic	1302494	1	0.13
Scissor co	nstruction	-,-				1.19
	Steel	7.8	Scissor lever	30015	4	0.94
		.,=	Scissor bracket	552	4	0.02
	Aluminium	2.7	Scissor slider	7362	4	0.23
	Nylon	1.15	Roller	459	4	0.002
Fabric cov	ers	1,15	- Tonei	155		0,002
	Fabric	0 917	Click fabric covers	272572	2	0.50
Side hand	les	0,517		272372	-	0,00
e.ac nana	Plastic (ABS)	1.05	Side handle	762322	2	1.60
Monitor st	tand	2,00		702022	-	0.78
	Aluminium	2.7	Vesa bracket	56927	1	0.15
		_/.	Monitor nole	230664	1	0.62
	Plastic (ABS)	1.05	Top plastic cover	4433	1	0.005
	1 10500 (7105)	1,00	Middle plastic grummet	693	1	0.001
Lid			inidate plastic grannier	055	-	0.11
2.0	Plastic foam	0.2	Lid construction	488111	1	0.10
	Fabric	0.917	Click fabric cover	12701	1	0.01
Side nane	s	0,517		12701	-	1.05
once parte	Plastic foam	0.1	Inside of side panels	600250	2	0.12
	Magnettic laminate	1 35	Inside cover of nanels	171500	2	0.46
	Laminate	1 35	Outside cover of panels	171500	2	0.46
Tableton	Lannace	1,00	outside tover of puncts	1/1500	2	2 00
rabictop	Plastic foam	0.2	Tableton	396500	Δ	0.32
	Aluminium	27	Support rods inside	78000	8	1.68
Supportiv	elegs	-,,	Support rous inside	70000	0	1,00
oupportio	Steel	7.8	Supportive legs	49684	2	0.78
Platform r	ails	7,0	Supportive regs	15001	-	0,70
	Steel	7.8	5 part sliders	69400	2	1.08
Guiding lir	nes on back	7,0	5 part shaces	05100	-	2,00
	Nylon	1 15	Sliders on the back	57527	2	0.13
	Aluminium	2.7	Aluminium guide	1211	2	0.007
Top box		_,.				-,
	Steel	7.8	Box capsulating scissor	271274	1	2.12
Monitor		.,=				_,
			Bought product		1	5.00
Hinges					-	2,00
	Steel	7.8	Bought product	6442	10	0.00
Gas spring	/	,,0		0.1.2		0,00
200 00.008			Bought product		1	2 00
Total weig	ht (kg)*				-	23.20
. Star weig						20,20

\* This is without smaller components such as nuts and bolts

Ill. 5.35. Weight analysis second draft (23,2 kg)

## 5.8. Tipping point

In order to test if the workstation tips over when the work platform is deployed, is the scenario simulated where the load from the user leaning on the platform is added. An analysis of the reactions is calculated using a simplified system, by simplifying the system to a beam, with simple supports, the following system is created (III. 5.37)



restart: W1 := 200[[N]]: W2 := 100[[N]]: L1 := 50[[cm]]: L2 := 17[[cm]]:

$$\begin{split} F_{xl} &\rightarrow = C_x = 0 \\ F_{yl} \uparrow = B_y + C_y - W2 - Wl = 0 \\ M_B & \curvearrowleft = Wl \cdot Ll - W2 \cdot \frac{L2}{2} + C_y \cdot L2 = 0 \end{split}$$

Due to the  $C_y$  being a negative number, the system would be unstable and thereby tip over when 20 kg is applied.

L2/2



$$L3 := 7.5 \llbracket \operatorname{cm} \rrbracket : L4 := 53 \llbracket \operatorname{cm} \rrbracket :$$
  
$$F_{x2} \to F_x = 0$$

$$\begin{split} F_{y2}\uparrow &= F_y + E_y - W2 - W1 = 0\\ M_E & \backsim &= W1 \cdot L3 - W2 \cdot \left(L4 - \frac{L2}{2}\right) + F_y \cdot L4 = 0 \end{split}$$

$$W1 \cdot L3 - W2 \cdot \left(L4 - \frac{L2}{2}\right) + F_y \cdot L4 = 0 \xrightarrow{\text{isolate for F} y} F_y = 55,66 \text{ [[N]]}$$
$$F_y + E_y - W2 - W1 = 0 \xrightarrow{\text{isolate for E} y} E_y = 244,34 \text{ [[N]]}$$

With the supportive legs applied, the system becomes postive, hence the system being stable and not tipping over. In fact, the system would allow for 1424 N, before becoming unstable.

If the product were weighed down to 10 kg (instead of W2=24kg), the allowable weight would be 593 N. The cost price for the workstation can be estimated based on the known materials and manufacturing technique for each component. In analysis "4.13. Maximum cost price" on page 68, a maximum production cost was estimated based on the target sales price. It should therefore be investigated if the cost price can be upheld for the product. Furthermore, is the investment cost and development budget calculated to estimate breakeven.

# **Material cost**

The component material cost has been estimated by using prices from danish web shops (e.g. staalxperten.dk) in combination with overseas material cost sourced though Alibaba. NK Office Solutions' execution plan outlines that the workstation initially should be manufactured using local (Danish or European) suppliers, to ensure a swift and iterative development process alongside the costumer, following the vision of the Lean Start-Up business case. For this reason most material costs have been found through danish web shops, as the product preferably would be manufactured in Denmark initially.

However, when NK Office Solutions have proved the business case and gotten positive feedback from customers, should the supplier be changed to manufacturers which can focus on low cost and scalability. It is therefore assumed that product production would be moved to either Asia or eastern Europe due to favorable production costs.

## **Cost price**

The total component cost for the workstation accumulate to 1287,12 DKK (see Ill. 5.39), which includes a general estimation regarding the cost for electronic parts and hinges/screws. The assembly and manufacturing cost is estimated to be 40% of the cost price, corresponding to 514,87 DKK, which includes both the worktime for the metal working producing the product and the cost for e.g. paint and corrosion protection. According to the labors union Dansk Metal is the average hourly pay for a metal worker 200 DKK/hour, and an assembly cost of 515 DKK is therefore deemed realistic. However, the total cost for the product accumulates to 1802,04 DKK, thereby exceeding the maximum cost price of 1698 DKK by 104,04 DKK. It should therefore in collaboration with the potential manufacturer be investigated if the cost price can

be lowered with 104,04 DKK. However as this can not be confirmed, the exceeding cost price should be deducted from NK Office Solutions total coverage of 1794 DKK, leaving NK office solutions with a total coverage of 1.689,96 DKK and a profit margin of 94% per sold product.

	Cost price -	Workstati	on				
ltem	Material	Material cost	sc. pr. material	Cost i	Psc. Ti	otal	Source
Peripheral pockets							
Left panel pocket	N/A	N/A	N/A	30,00	1	30,00	Estimation
Right panel pocket	N/A	N/A	N/A	30,00	1	30,00	Estimation
Cabinet							
Backplate	2mm sheet - steel \$235 - 1000x2000mm	508	4	127,00	1	127,00	A: staalxperten.dk
Bottom + Side plates	2mm sheet - steel \$235 - 1000x2000mm	508	5	101,60	1	101,60	A: staalxperten.dk
Scissor levers							
Scissor levers	20x20x1,50 mm beam - steel S235 - 6005mm	309	10	30,90	4	123,60	B: staalxperten.dk
Supportive legs	American start parts 1000-000-00	1000.0	163	10.37		20.52	Costantine all
supportive legs	4000 5000 5000 5555 125002500000	1003,2	102	10,27	2	20,55	c. staatipertentuk
Sidepanels							
Plastic sheet	Closed Cell PVC 3mm, EasyCell 75 - 1080x1020mm	119,85	8	14,98	2	29,96	D: easycomposites.co.uk
Laminate sheet	Formica magnetic laminate Folkestone - 3050x1220 mm	400	12	33,33	4	133,33	Estimation
Platform Rails							
Platform Rails	OEM custom full extension heavy duty rails	N/A	N/A	6,00	2	12,00	E: alibaba.com
Scissor mechanism							
Top box	1,5mm sheet - steel S235 - 1000x2000mm	439,2	9	48,80	1	48,80	F: staalxperten.dk
Gas spring	OEM custom Gas spring	N/A	N/A	22,00	1	22,00	G: alibaba.com
Rails	1.5mm sheet - steel \$235 - 1000x2000mm	439.2	200	2.20	4	8.78	F: staalxperten.dk
						., .	
Supportive beams							
Supportive beams	10 mm sheet - Nylon - 1000x2000mm	560	160	3,50	2	7,00	H: sanistaal.com
Foldable tabletop							
MDF	7 mm MDF - 1220x2440mm board	92	33	2.79	4	11.15	I: alibaba.com
Steel beam	8 mm beam - steel \$235 - 50x6000mm	431.2	16	26.95	8	215.60	J: staalxperten.dk
Veneer	Beech Veneer 0.3mm - 1000x1000mm	27	12	2,25	8	18,00	K: alibaba.com
Backplate							
Plastic sheet	Extruded plastic sheet 4 mm - 2100x2000mm	409,6	6	68,27	1	68,27	L: plastdk.dk
Laminate	Formica laminate Folkestone - 3050x1220 mm	100	4	25,00	1	25,00	Estimation
Handle							
Handler	Injection molded APS	15	1	15.00	2	20.00	Entimation
	injection monaca Add	15	-	13,00	-	30,00	Composition (1997)
Fabric cover							
Inner part	Injection molded ABS	10	1	10,00	2	20,00	Estimation
Fabric	BERN Furniture Fabric - 1550x1000 mm	214,4	18	11,91	2	23,82	M: tm-materialer.dk
VESA mount							
VESA mount	1,5mm sheet - steel S235 - 1000x2000mm	439,2	60	7,32	1	7,32	F: staalxperten.dk
Monitor Stand							
Monitor Stand	1,5mm sheet - steel S235 - 1000x2000mm	439.2	20	21,96	1	21,96	F: staalxperten.dk
Lid							
Inner part	Injection molded ABS	25	1	25,00	1	25,00	Estimation
Fabric	BERN PURILLUIE PADRIC - 1550X1000 IIIII	2.14,4	10	21,44	1	21,44	WI. UNHINACENAIEL.OK
Elecronic parts							
Electonics parts	N/A	N/A	N/A	70,00	1	70,00	Estimation
Hinges and screws							
Hinges and screws	N/A	N/A	N/A	35.00	1	35.00	Estimation
-							
Sub total						1287,17	DKK
Assemble and manufacturing cost					40%	514,87	DKK
Total						1802,04	DKK

Ill. 5.39. Cost price table. See appendix at page 60.

## 5.10. Development cost & break even

A development budget for NK Office Solutions is estimated based on the needed tools investment and other required investment before product launch. The needed investment for producing the product is estimated to 14000 DKK, which includes three tools for plastic manufacturing components and website development (see ).

Startup Investments - NK Office Soltuions						
item	Psc. Price		Total	Source		
Plastic molds						
Injectionmolding 1+1 tool, Handle	1	50000	50.000,00	Estimation		
Injectionmolding tool, Handle cover	1	30000	30.000,00	Estimation		
Extrusion tool, Lid	1	40000	40.000,00	Estimation		
Webpage	1	20000	20.000,00	Estimate		
Total			140.000,00			

Ill. 5.40. Startup investments

To launch the product, further 235.000 DKK are needed to cover prototypes, product tests, consultancy and marketing needed before product launch. During the development period are two employees working at NK Office Solution, however they do this without getting as the work is seen as an investment into the company.

Development Budget - Workstaion						
Item	Psc.	Price	Total			
Startup Investments	1	140.000,00	140.000,00			
Consultant development	1	40000	40.000,00			
(Low voltage engineer, Physiotherapist etc.)						
Prototypes	5	4000	20.000,00			
Marketing	1	100000	100.000,00			
Salary	2	0	0,00			
Sub total			300.000,00			
Unforeseen costs		25%	75.000,00			
Total			375.000,00			

Ill. 5.41. Development budget

## Breakeven

If NK Office solution used their total coverage to pay back on the investment needed for the project, could this be achieved after 221 workstations have been sold, corresponding to 0,13% of the market estimation.

However, this would never be the case for NK Office Solution as the earnings would have to cover several other expenses such as:

- Rent for offices and storage capacity.
- Employee salary.
- Marketing.
- Cost needed for securing new customers.
- Maintenance of sales channels.
- Administrative work following owning a company.

Launching a new type of product as a startup in an established market would take time and sales would be expected to be rise slowly during the launch period. As NK Office Solution get a name and reputation as a quality brand is it expected that the sales number would increase rapidly, compared to the launch period.

Furthermore, depending on how the needed investment have been ensured could NK Office Solutions have to pay interests of the loans or an investor would need an increased return compared to the funding to make it an attractive business case.

# 3.12. Updated Requirement specification

At the end of phase 3, a requirement specification was summarized. During the continued development process further requirements and whished were defined as part of detailing the product. All requirements have been combined into one requirement specification sheet and the proposed product solution is compared against the requirement specification to determine the critical aspects of the product during further research.

Requirement	Source	In compliance
Psychology		
Must create a change in scene, to shift between work- and home mode	"2.8. Psychologic Impact of Working from Home" on page 30	$\checkmark$
User Panel		
The setup of the product should take less than 1 minute	"2.6. User Panel" on page 28	?
The solution must not be a permanent installation within the home	"2.6. User Panel" on page 28	$\checkmark$
Buyer		
The monitor used, should be 27"	"2.11. Buyer Interviews" on page 34	$\checkmark$
The solution should not be moved outside the user's home	"2.11. Buyer Interviews" on page 34	$\checkmark$
Peripheral Analysis	• •	
Trackpad area should be $27 \times 32$ cm	"3.5. Peripheral Analysis" on page 41	$\checkmark$
Keyboard area should be of atleast: width: $50,5 \text{ cm} \times \text{depth}$ : $35,5 \text{ cm}$	"3.5. Peripheral Analysis" on page 41	$\checkmark$
Monitor dimensions supported should be: min. $65 \times 40 \times 7$ cm.	"3.7. Choosing a monitor" on page 42	$\checkmark$
The monitors and workstation support: VESA: $100 \times 100$ .	"3.7. Choosing a monitor" on page 42	$\checkmark$
The workstation should support USB-C display signal and laptop charging.	"3.7. Choosing a monitor" on page 42	$\checkmark$
The workstation should support IEC-C13 and -C14 power plugs.	"3.7. Choosing a monitor" on page 42	$\checkmark$

Requirements	Source	In compliance:
Should create a temporary workspace within the user's	"2.3. The B2B choice" on	$\checkmark$
home (living room)	page 25	
Should allow for a standing and sitting work height	"2.3. The B2B choice" on page 25	$\checkmark$
The Danish Working Environment Authority (DWE	<b>N</b>	
(Arbejdspladsens indretning og inventar Atvejledning A. 1	.15, 2008)	
Depth of table should allow for placement of a monitor	DWEA	
between 50-70 cm from the eyes		¥
Space for resting and supporting the hands and forearm should be available	DWEA	$\checkmark$
The tabletop should not be reflective	DWEA	
Individual adaptation for work positions and movement should be possible	DWEA	$\checkmark$
Mouse and keyboard should be separated from the display	DWEA	$\checkmark$
Do not use space underneath the table for storage, as this limits the movement	DWEA	$\checkmark$
If multiple people use the table, individual height adjustment should be possible	DWEA	$\checkmark$
The normal and maximum table workspace should be a minimum of $41 \ge 60$ cm	DWEA	$\checkmark$
Ergonomy		
Work area should allow for keyboard and mouse to be	"2.9. Home Office	$\checkmark$
moved around, to change work positions	Ergonomics" on page 30	
An external monitor must be used	Ergonomics" on page 30	$\checkmark$
The height of a monitor, should be at eye level (or a bit	"2.9. Home Office	
lower), both while sitting and standing	Ergonomics" on page 30	·
When the monitor is adjusted to the lowest height setting, the distance from tabletop to monitor bottom should not be higher than 9 cm.	"4.6. Standing work platform" on page 61	$\checkmark$
Should support a standing work height varying from 96- 122 cm. Must enable a height increase of 50 cm from the table.	"3.2. User Meassurements" on page 39	$\checkmark$
Sitting table-top work height should be between 72-75 cm (to fit dining table chairs, of which is between 42-47)	"3.3. The dining room" on page 39	?
Product Detailing		
Must support an applied weight of 20 kg, on the work platform.	"4.1. Detailing the concept" on page 49	$\checkmark$
The monitor should be able to tilt	"4.2.1. User test with mockups" on page 56	$\checkmark$
A firm grip is needed to carry the workstation	"4.2.1. User test with mockups" on page 56	$\checkmark$
A traction gas spring should be used	"4.5. Height adjustment specification" on page 59	$\checkmark$
The distance between inside of sidepanels and monitor,	"5.4. Storing peripherals"	$\checkmark$
must be no less than 60 mm.	on page 76	

Wish	Source	Weight (1-5 being best)	In compliance
User Panel			
The solution must be very convenient to use	"2.6. User Panel" on page 28	5	$\checkmark$
All necessary work equipment could be transported within the same unit	"2.6. User Panel" on page 28	3	$\checkmark$
The solution should be rewarding for the user, and remove the overwhelming feeling of packing/un-packing	"2.6. User Panel" on page 28	2	?
General			
Appeal to living room context	"2.6. User Panel" on page 28	3	?
The equipment should feel 'nice' and like 'quality'	"1.8. Questionnaire" on page 16	2	?
When seated, the solution should strive not to be taller than 55 cm, due to lamp height	"3.3. The dining room" on page 39	4	$\checkmark$
Product Detailing			
Combined weight should be below 15 kg.	"4.2.1. User test with mockups" on page 56	5	×



Through phase 5 it is concluded that the workstation is stable and not prone to tipping when in use. The components were designed to withstand the load of the product and to avoid deflection. At the end of phase 5 it was discovered that the product was too heavy and in violation of the requirements specified through the project, but within the allowed area specified by work legislation. Continuing the project, a critical area of research is investigating how to lower the weight of the product. The workstation was compared against and upheld the remaining requirement specified for the project. If NK Office solution were to continue the development process and launch the workstation, several parts of the product would have to be further developed and detailed.

As an effect of COVID-19, access to the user panel has been limited, and it has therefore not been possible to observe nor test the product together with the users. Continuing with the project it is vital to contact, and possibly widen, the user panel, to initiate prototype testing. Through these tests, office employees should incorporate the workstation and test its functionality during workdays at their home offices. This should be done to get insight from the users regarding their experiences, to determine if the product covers their needs, and test if the design or functionality matches the users' needs and expectations.

The product is still at a conceptual state. NK Office Solutions are therefore in an open process and in a position where the concept can pivot to change direction based on potential findings. The tests should focus on the currently unanswerable parts of the requirement specification, to verify or change the product so that it: Appeals to living room context, that the workstation feels 'nice' and like 'quality' and the users can go from home to work mode in less than a minute with the workstation.

While testing and interacting with users, one of the focus areas would be a weight test. During the conclusion of the development process, it was discovered the workstation did not comply with the user's wish concerning the combined weight of the workstation being below 15 kg. This wish was derived from the cardboard mockup user tests. It would therefore be necessary to test and interview the users to verify the requirement and specifying the maximum product weight.

Based on the updated requirement, it would be necessary to change product construction and design to achieve a lighter product weight. This could initially be done by NK Office Solution, applying the methods used in the weight analysis and continue matching different materials and product constructions, to compare weight results. However, it would be necessary to contact experts, as it could be pososible for NK Office Solution to optimize the product by changing production techniques or changing materials to previously un-considered materials e.g., manufacturing the cabinet and side panels using a composite material like fiberglass.

The current cost price for the product is based on a combination of Danish and Overseas suppliers. NK Office Solution do not plan on manufacturing the product themselves, as this would require NK Office Solution to establish an assembly and possibly production facilities. Instead, the execution plan describes that the company should locate a local OEM manufacturer, who could be responsible for manufacturing and assembling the product. It is suggested to locate a manufacturer from Denmark; however, this could turn out to be expensive, compared to manufacturing the parts in eastern Europe. It should therefore be investigated if a manufacturer could be located in Europe, which could ensure the needed agile production facilities and fast shipping. The cost price for the product should be determined in collaboration with the OEM manufacturer.

Lastly, the project needs an investment of 375.000 DKK to launch the product, therefor after verifying the product solution and solving the weight issue, it would be necessary to ensure the needed investment. If the investment cannot be secured, production can not be initiated, and NK Office Solution would not be able to continue. However, as analysis shows that the home office market is a growing market, and as no competitor has entered the niche market of temporary home office equipment targeting smaller homes yet, it is believed that the product would be profitable and that a source of investment can be located. The result of the development project is 'the Workstation', a product designed to enhance the experience of working from home without having access to a room dedicated to being a home office. The workstation is designed as a response to the growing trend of integrating the use of home offices as a permanent addition to the workweek.

The workstation is bought by employers through NK Office Solutions' webshop and handed over to the employees, ensuring the users an improved work position when working from e.g. the dining table. When in use, the workstation creates a dedicated workspace, marking a clear visual transition for the users between being at work or relaxing at home, all while using the same room. When an employer equips their employees with the workstation, they are left with the knowledge that their employees have access to a work setup improving their work ergonomics and ensures that their employees comply with work legislation.

The workstation is designed with a focus on the employees, the use situations, and work legislation. It is designed to fit a 27" monitor, as this is commonly offered by a company, to the home office. The product has a built-in height adjustment system, which enables users to convert their dining table into a standing desk, facilitating a healthy work position.

When the users work in a seated position, the side panels function as blinders creating a focused and dedicated work environment. The workstation contains a peripheral storage system, attached to the side panels, storing the computer peripherals where they are needed.

The biggest barrier hindering a successful product launch is the weight of the product. During development, the product was designed using steel to ensure a rigid structure and a stable foundation. A weight analysis showed a product weight of 35 kg., which could be reduced to 23kg if several steel parts were changed to aluminum. This, however, still violates the specified requirement wish describing a maximum product weight of 15 kg. Therefore, if development is continued, it should be considered how the reduce the weight of the product by changing parts of the construction and materials.

The product is aimed at the B2B office furniture market, which is a red ocean market. However, a market analysis showed that while the general office furniture market is a red ocean market, is the niche market 'temporary home office equipment' a blue pond in a red ocean. Within this area, no direct competitors are offering a similar product nor functionality.

The workstation is to be launched by NK office solutions, as the first product by a startup company. The product is sold through the company's website avoiding established sales channels, to increase coverage while ensuring a low sales price. The workstation has a sales price of 3.500 DKK excl VAT and a cost price of 1.802 DKK.

An investment of 375.000 DKK is needed to launch the product, which covers tool costs, further product development, and pre-launch marketing.

The workstations solve the issues and concerns carried by both employers and employees regarding implementing home offices as a permanent addition to the company offices. But, for the workstation to succeed in the market, it is necessary to further develop the product with a focus on weight reduction and thereby improving the user experience for the employees.

## 6.3. Reflection

The initial steppingstone for the project was the realization, that many benefitted from working from home. This is backed up by a movement pushing towards implementing remote working as a permanent addition to the workweek. Several of the users interested in keeping the possibility of working from home, however experienced drawbacks. The problem and issues which was the focus of the project were during the project's beginning experienced by most office workers in Denmark, as an effect of the extensive use of home offices due to COVID-19.

This has several positive implications on the project, as it was possible to get in contact with a wide variety of users. Therefore, when unfolding the problem, the team experienced many different interests and views on the project direction, as every office worker had personal experience and considerations regarding the pros and cons of working from home. Initially, it seemed like all users experienced the same problems and that there were no general difference in the experience of the people working from a kitchen using a laptop, to the people having implemented a professional and permanent office set up in a spare room. This let to view that the problem seemed universal and resolved in the problem being very fuzzy as the team had problems defining the solution space for the project.

This was worsened by the fact that the team behind the development project themselves worked remotely doing most parts of the development project. This made the development team personally invested in the solution as it felt like a product was needed every day. Due to that problem, the project led to a biased and fuzzy development process during the beginning of the proces, where the scope of the project was too broad. During this period the user panel in some regards were left in the background and the team themselves moved forward, based on their assumptions and considerations founded in their personal experience.

This however was corrected during the ideation process, when it became clear that there existed no "one solution fits all". As the team unfolded the problem it was realized that while many experienced and shared the same problems, the cause behind these problems was highly differentiated and even contradicting at periods. Based on this realization the team was able to better specify the user group and increase the dependency on the user panel. This helped to define a clearer definition of the problem owners and the user panel enabled the team to take a step

away from the problem, considering it from a holistic approach, instead of a personal angle. Throughout most of the project, the team was not allowed to work at the university and therefore could not interact with other teams, limiting the daily interactions and knowledge sharing which otherwise is the norm. To workaround this drawback, a weekly reference group meeting was scheduled with two other project teams. At each meeting, the teams presented what they had worked on during the week, what they had learned, and each team then gave feedback to each other. This activity proved very helpful especially during the beginning of the project, as it was found that while the teams focused on highly differentiated subjects, the same struggles were experienced in the across the teams.

This is an experience, of which the team highly valued, and something which will be considered during future development projects after graduation. This interaction with fresh eyes, helped clear some thoughts and steer the project based on extra feedback.

The restraint of not being able to access the workshops at the university worked as a barrier for the team delaying the point of when prototype building was started. Due to this, the team relied heavily on cardboard mockups during the development, and at times the team wanted to use more advanced prototyping to test product functionality, for example to build the scissor mechanism, but this was not possible. However, the extensive use of cardboard models also worked as an advantage, as the speed at which models could be built, tested, and adjusted resulted in very agile development and user test process.

The same restricted access which was experienced with access to the workshop was experienced with access to the user panel, and it was not possible to test mockups with the user panel. It was therefore necessary to rely on the user panel for feedback and insights through digital platforms and test the product using other users.

Generally, the team is satisfied with the result of the project and the problem were very relevant. It was an evolving subject during product development, which added a motivation factor to the development project. Several products were noticed entering the market during the project, but non focusing on the same problem angle or user group as the team did.

## 6.4. Reference list

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