ad10-id13

# PROCESS REPORT

Process Report
Group 13, 10th semester
Architecture & Design
Aalborg University
AD10-ID13, 2008

Aalborg University 2008
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Group 13

Title: Compact Cleaning Cart
Project period: 4th February - 4th June 2008
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# PREFACE

This report documents the process of an industrial design project on a cleaning cart made at Aalborg University, Architecture and Design, 10th semester.

The group would like to thank the cleaning assistants who have let us observe and interview them. This has been of great use and created the whole base for this project. Special thanks are addressed Lisbeth Sørensen, for taking part in discussions and concept evaluations and showing great interest in the project.

The group is also grateful for cooprating with head of department in IDA Aalborg, Thomas Saaby and customer manager at ISS in Aalborg, Laila Holst and for helping with their expertise in the business. Also the safety council at ISS must be thanked for taking time to discuss relevant issues regarding safety and work environments.

# SUMMARY

It is established that there is a hole in the market for cleaning carts; cleaning carts that can be stored in limited spaces are not available. Many companies would prefer cleaning with a cleaning cart rather than cleaning with buckets, as cleaning by using buckets is unhealthy for the cleaning personnel and not as efficient as using a cart. However some deselect the cleaning cart due to the storage size. Therefore, a cleaning cart which could fulfill their needs for storage would be a good alternative. At the same time the cleaning cart developed focused on the work procedures of the cleaning personnel making it both healthy and efficient in use.

With development of a cleaning cart as a case, market research, user observation, and active prototyping has been of great use in the project. The case involves 8 different viewpoints around the cart and by investigating these, their different interests are clarified. The interests are valued in regard to each other and translated to criteria which are used to hold the decisions made throughout the development process up against. A wide range of different cleaning situations are observed and the data is processed by using the methods of AEIOU and ELITO. Throughout the project prototyping has been an important tool to validate the different principles and concepts developed.

# READING INSTRUCTIONS

The documentation of the project consists of two reports. A process report (this report) describing the research and development of the compact cleaning cart. The product report presents the solution. The recommended reading sequence is first product report, then process report.

The process report is divided into 5 phases: Program, Analysis, Concept development, Detailing and Evaluation. Each phase is started by presenting the purpose of the phase and ending with an evaluation of it.

All sources are referred to using the Harvard method. A literature list can be found in the end of this report, gathering information on the sources used.

Illustrations are numbered and listed in the illustration list, containing their source.

Appendices contain supplying information on chosen subjects. They are numbered and placed in the back of this report.

# CONTENTS

# PHASE1: PROGRAM

## PURPOSE

The goal of the program is to define the problem that this project aims to solve be a planning tool that the group can use throughout the process. It clarifies the basics of the project by explaining the problem area and presenting the problem formulation. Also it holds an overview of the different approaches which will be taken in the project.

## PROCESS GOALS

The project has been initiated by mapping what competences should have special attention in the project. In this project, the group seeks to demonstrate and improve skills within the following areas:

### User centred design

Understanding work procedures of a complex use situation through observations and interviews and analysis of collected data.

### Active prototyping

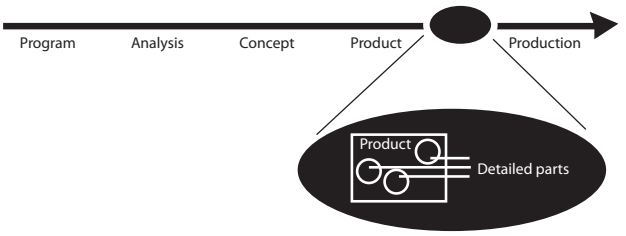
Use prototypes as an active part in the development process to explore and communicate solutions.

### Market research

Systematically gathering, recording and analyzing data and information about customers, competitors and the market so the product developed relates to its context.

## PROJECT GOALS

The goal of this project is not only to demonstrate the competences learned during the education, but also to learn more. The project is therefore planned in order to strengthen the core abilities which the group members will seek to work with in the future. Therefore the Compact Cleaning Cart functions as a case to obtain the process goals described above. To reach the process goals, the case must fulfil certain project goals. This being that the case must focus on an area which has a range of actors involved, but mainly where the end user's interaction around the product is of a certain complexity. At the same time the product should be of a size where it is possible to work in 1:1 models in order to be able to involve prototyping on a high level. The project will be taken to a state where drawings for production and assembly will be made on exemplary level, see ill 1.




Ill. 1 | Level of detail

# SUBJECT DETERMINATION

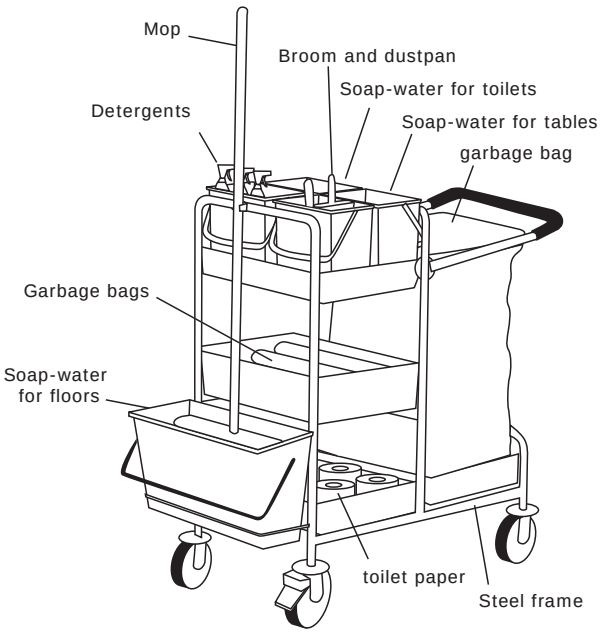
After deciding what competences should be in focus, the group started brainstorming on subjects that fulfilled the competences. Among others, the cleaning cart was suggested and quickly attained the group's interest. This was due to the extensive use situations the cart is part of, which seemed obvious to explore in regard to user centred design. In advance, the subject of professional cleaning was very unfamiliar to the group and was therefore decided to arrange a meeting with some cleaning personnel. After having met the cleaning personnel at Aalborg Airport, it became clear to the group that the cleaning cart contained great potential to fulfil the groups expectations as a case. The group was met with cleaning personnel, showing great interest and accommodation to the group which gave a positive impression and revealed that it would be possible to arrange further collaboration with the cleaning personnel for interviews, observations and likely, see ill. 2.

Ill. 2 | Cleaning cart in use

# CLEANING CARTS

Cleaning carts are used by cleaning assistants at companies or institutions that requires frequently cleaning. Basically, a cleaning cart serves to store and transport cleaning equipment and is therefore a highly appreciated aid for cleaning assistants as it eases their work load, both regarding efficiency and work conditions. Efficiency is both related to the time used on an assignment and the result of the cleaning. The cart makes it possible for the cleaning assistant to bring many kinds of cleaning equipment with them for different cleaning assignments such as tables, windows or bathrooms. In that way time is saved running back and forth getting the equipment. By always having the correct equipment near you, the different assignments can be done faster and with better result. At the same time the cart improves the work conditions as it eliminates a lot of unhealthy lifting e.g. heavy buckets filled with water, see comparison of cleaning by using cart versus cleaning by using buckets in app 2. Cleaning carts are available in many shapes and

sizes and often the customer can configure it to suit his wishes. A cleaning cart typically consists of a steel frame on wheels that can turn in all directions. On the fram, several holders are mounted for detergents, buckets, trays, mops, garbage sacks etc., see ill. 3.

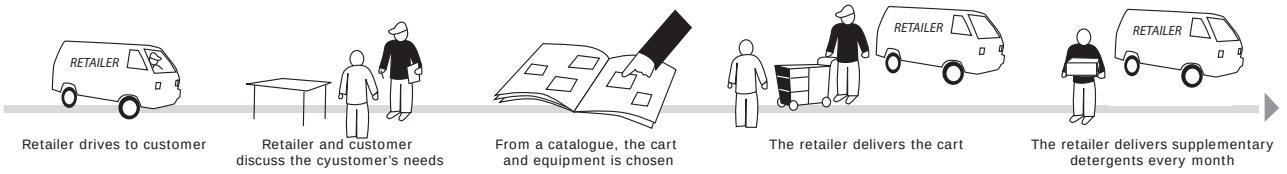



Ill. 3 | A typical cleaning cart

# SALES SITUATION

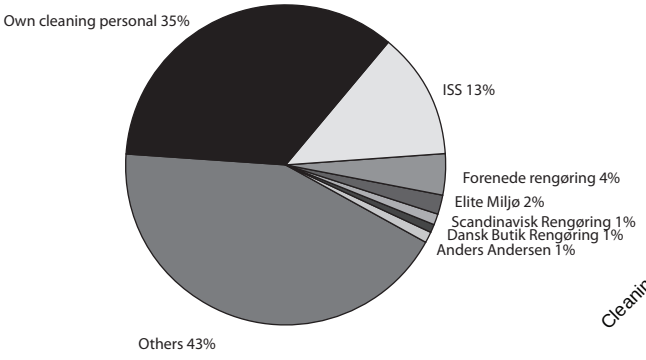
There are two types of retailers selling carts, see ill 4. In general, smaller retailers sell to smaller companies, whereas larger retailers sell to larger companies and service providers like IDA Service. Cleaning carts are rarely sold alone, as there commonly there lies a good deal in the contract of ongoing sale of detergents and cloths, see ill. 4. However, some smaller companies buy their detergents and cloth in super markets and are therefore not in contact with the retailers. Depending on the retailer, the focus is either on universal cleaning carts that are a bit cheaper but have few adjustment possibilities, or on carts that can be configured after the specific wishes of the buyer.

The cleaning service provider's are usually loyal to using the same retailer as supplier for all their cleaning equipment. The brands and types of equipment and cleaning carts available is therefore limited by the retailer. The service providers are very conscious of choosing carts with many adjustment possibilities so it can suit the person using it in order for the best ergonomically work positions. A typical small retailer sells around 50 carts a year, whereas the larger retailers sell around 500 a year.

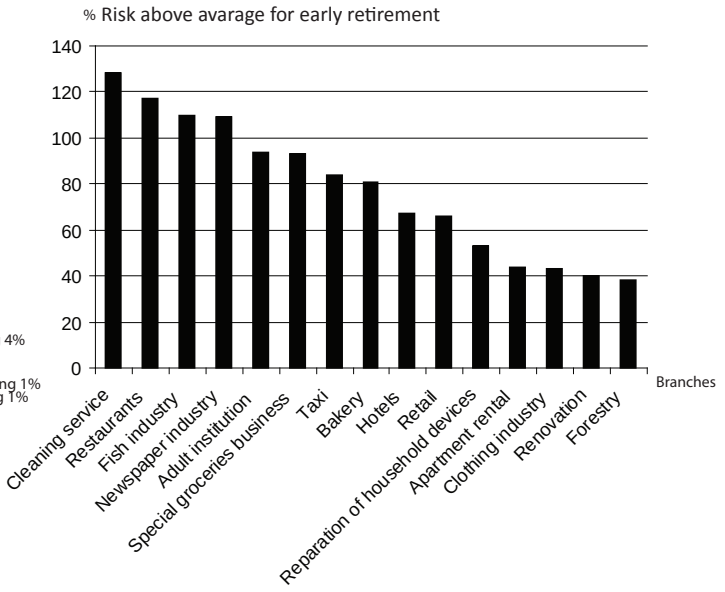



Ill. 4 | Most retailers drive to their customers and sell the carts thorugh catalogues

# PROBLEM AREA




Ill. 5 | Market shares




Ill. 6 | Risk above average for early retirement within different branches

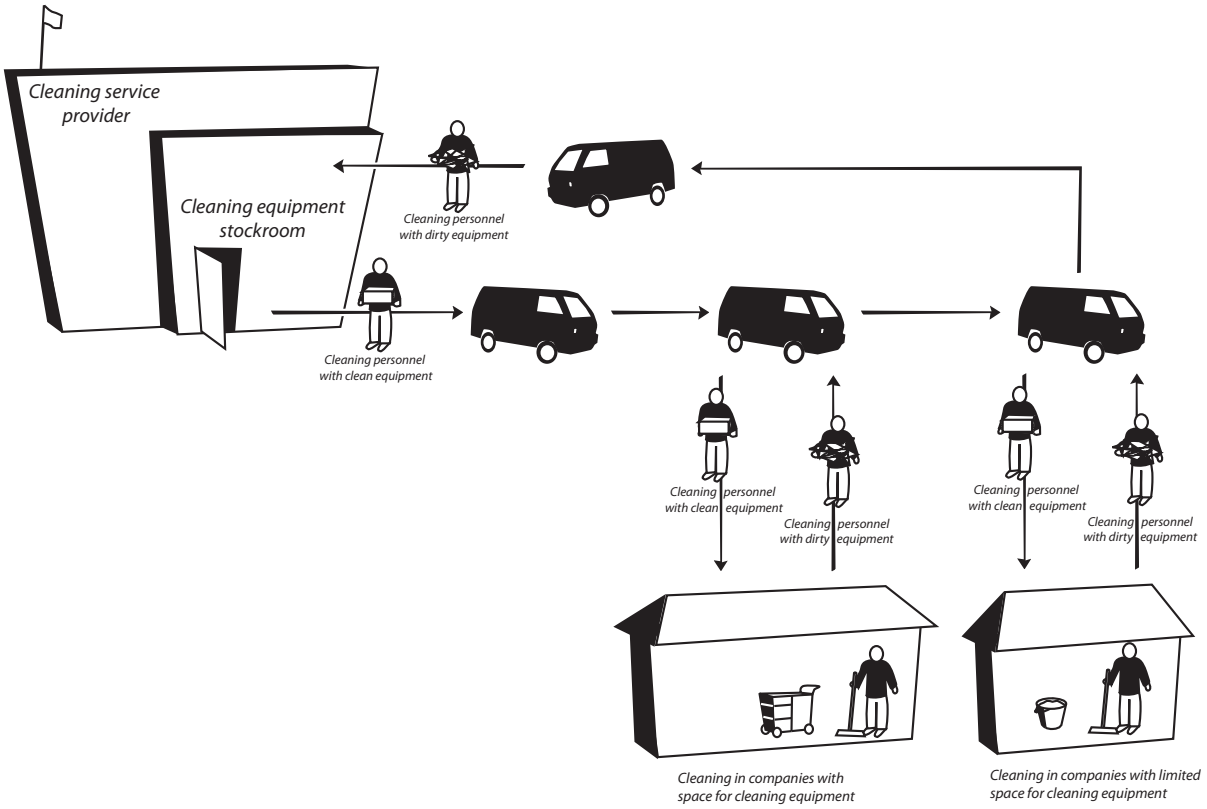
Both large and small companies have needs for cleaning. Most companies employ cleaning assistants to do the job, either they employ one directly or through a cleaning service provider such as ISS Facility Service A/S, see ill. 5 for market shares. According to customer relations manager at ISS in Aalborg, Laila Holst, some companies, mostly smaller companies, that order cleaning has only limited space for storing cleaning equipment and no space for storing a typical cleaning cart.

The avaiable space can be limited to a closet forcing the cleaning personnel to use alternative cleaning procedures such as using buckets, which requires a lot of lifting from place to place. This increases the risks for work injuries due to unhealthy work positions. Also, a lot of walking back and forth to the closet is necessary and this takes more time.

The working environment for cleaning assistants is something that has been focused on for a long time in Denmark due to the physical tough work. Examinations show that employees within the cleaning business have the highest risk of all for early retirement, see ill 6 (Arbejderbevægelsens Erhvervsråd, 2007).

A product that could make cleaning more healthy and at the same time more efficient in environments with limited space for storing cleaning equipment could therefore be attractive for both cleaning personnel, cleaning service providers and the hosts of the areas cleaned.

Cleaning in these places is not extensive enough to have fulltime employed cleaning assistants working there. This means cleaning assistants cleaning at these places are often driving from place to place, see ill. 7. Having a Compact Cleaning Cart stored these places would be a good alternative to using buckets.




Ill. 7 | Cleaning assistants cleaning in smaller companies are driving from place to place

Larger service providers are really focused on persuading customers to apply some space for a cart, even if it is in a toilet or wardrobe. Therefore it is only a small part of their customers that have no cleaning carts stored. Laila Holst at ISS explains that whenever a cleaning cart somehow can be fitted into the location, it is chosen, no matter how small the cleaning assignment is – this to have the healthiest possible working environment for the cleaning assistant.

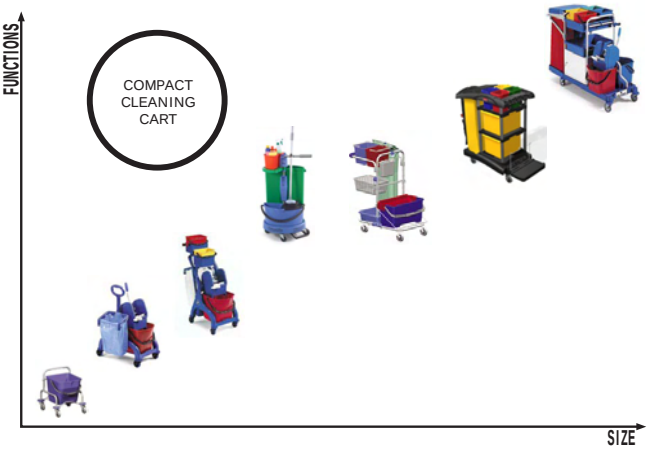
## Sales potential

The total amount of the service providers' customers that have limited or no room for storage of cleaning equipment is approximately 20% resulting in over 9000 places. This number is based on interview with two large service providers. Of these, some have inappropriate interior arrangements, some are cleaned rarely and some are not interested in exchanging their existing equipment. This is estimated to bring the number down to around 3700 possible carts sold to service providers over 10 years in Denmark. If the part of companies with limited or no room for storage is the same as for service providers, around 3900 carts can be sold to companies employing own cleaning personnel over 10 years in Denmark. If the cart was sold on the Scandinavian market an estimated sale on 34000 is expected, see App: 3: sales volume.

## The market for the Compact Cleaning Cart

By categorizing a representative range of cleaning carts by size and functions it is evident to see that these follow each other proportionally, see ill 8.

There are currently no carts that fulfill the needs which Compact Cleaning Cart is intended to fulfill. However, some carts do have elements which can be folded in to make their storage size smaller. Examples of these are shown in ill 9-10. The reduction in size of these examples is limited.

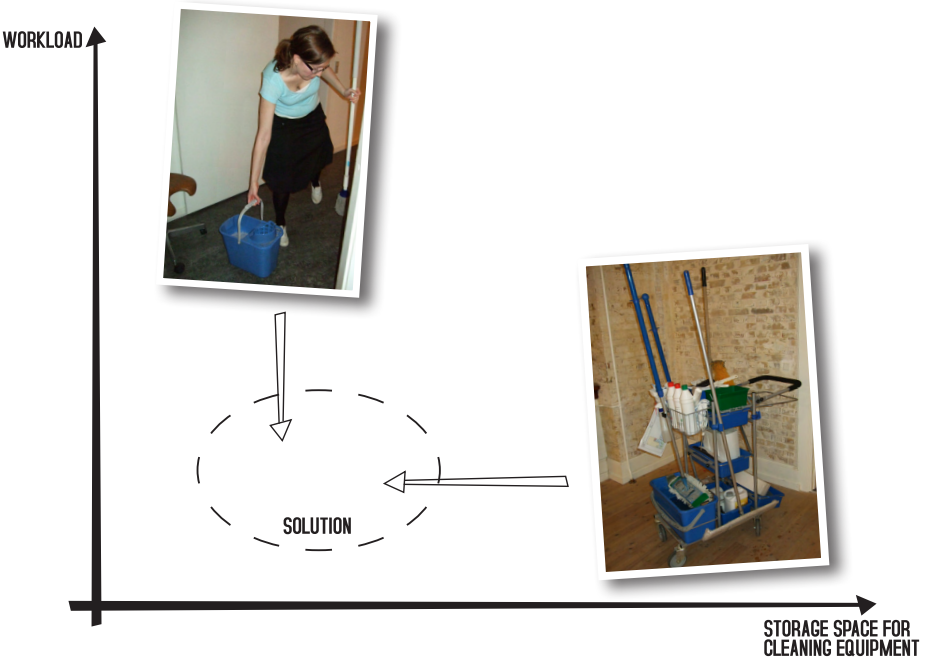



Ill. 8 | Market for the Compact Cleaning Cart

Ill 9. By folding in the handle and holder for the garbage bag, this cart becomes smaller and reduces its size to a square in the ground area.

Ill 10: Again the handle and garbage bag can be folded in but in this case making the cart taller. It folds to 86 cm x 56 cm in ground area.

# PROBLEM FORMULATION




Ill 11: The function of transporting and storing cleaning equipment is taken from the cart while the small storage size is taken from the bucket.

The following assignment has been defined for the project, illustrated on ill 11:

**Designing a cleaning cart that improves cleaning assistants' work procedures in environments with limited storage space for cleaning equipment**

Both the aspects of ergonomics and efficiency are included in the phrase "improves cleaning assistants' work procedures". This improvement is measured in regard to buckets meaning that the Compact Cleaning Cart should give healthier and more efficient work procedures than the existing cleaning method with buckets. As this project then strives to make the cart both healthy and efficient, some compromises must be made as these two aspects not always are compatible. In some cases, a healthy work procedure, after the book, takes more time and is by that, less efficient. An example is that you should fill large buckets with water from smaller ones instead of lifting the large bucket and fill that directly. Therefore the question on health versus efficiency is put in the following phases.

- Fulfilment of recomondations from "clean lines for the working environment" by the Danish Working Environment Authority
- More healthy than cleaning by using buckets
- More efficient than cleaning by using buckets

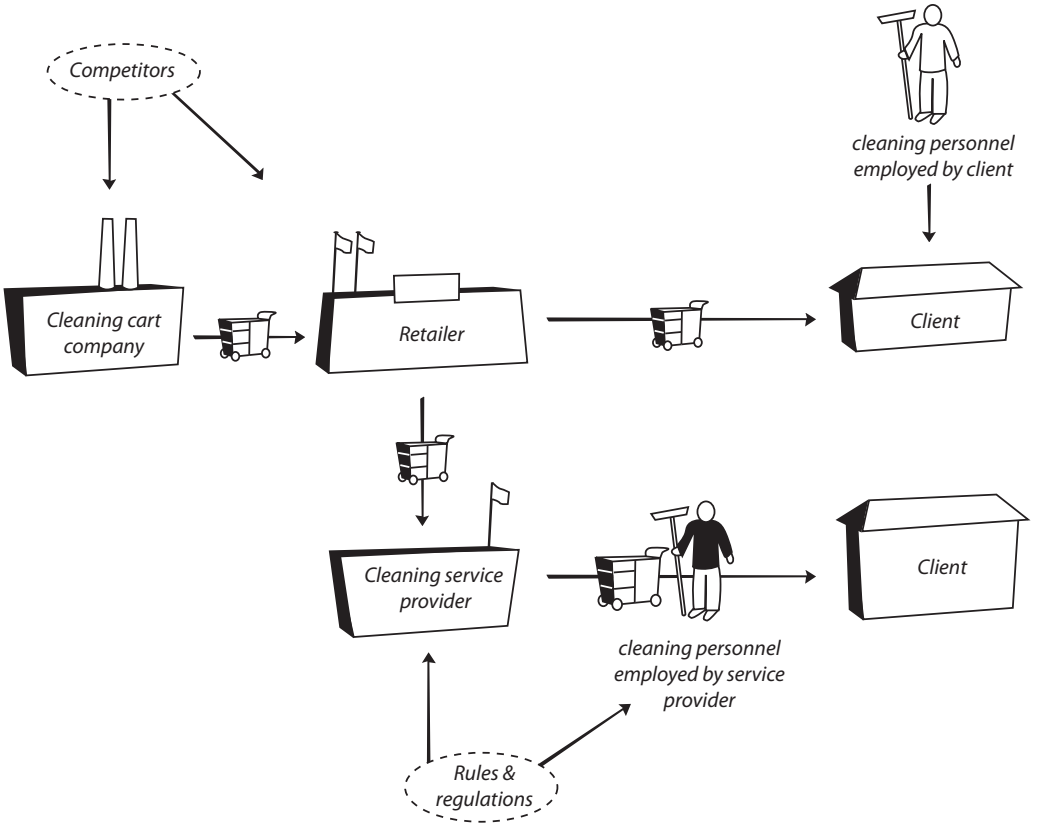
## Delimitation

This project will not:

- Make precise price calculations but only estimations.
- Considerations on environmental concerns.
- Involve observation in other countries than Denmark.
- Locate specific production companies.
- Involve work areas with special demands like hospital and hotel cleaning services

# INVOLVED ACTORS

When designing a cleaning cart it is important to take into consideration all the actors which are in contact with the cart. Illustration 12 shows how the cart moves between the actors. The next page contains a scheme holding a description of each actor's role, their area of interest and a reference to an appendix where more information can be gained.




Ill 12 | The actors in contact with the cleaning cart

| **Competitors**, see app. 4 | |
|---|---|
| Role | The existing cleaning carts set the standard for the market and have great influence on whether the cart can be sold or not. |
| Area of interest | • Creating a product which can compete with the already existing cleaning carts. |

| **Production company**, see app. 11 | |
|---|---|
| Role | The production company's viewpoint is involved to make sure that the cart developed will be attractive to produce. The viewpoint is not limited to one specific production company. |
| Area of interest | • having a profitable, flexible and sustainable production |

| **Retailer** , see app. 9 | |
|---|---|
| Role | The retailer is the contact between the buyers of cleaning equipment and the producers. There are two main types of retailers. The first is the retailers using salesmen who drives around to big customers with a catalougue and sells the product that way. The second retailers are the ones selling the product through a physical shop. |
| Area of interest | • sales potential and integration in the current sales procedure<br>• reaching new buyer segments to increase sales |

| **Service provider**, see app. 6 | |
|---|---|
| Role | The cleaning assignment is for many companies a secondary activity. By using a cleaning service provider they can focus entirely on their core business. At the same time the cleaning assignment becomes the main assignments for the service providers and therefore they can have a larger focus on working environment. |
| Area of interest | • Creating a durable cart that secures quick, safe and high quality cleaning. |

| **Service provider's client**, see app. 7 | |
|---|---|
| Role | The clients are the ones hosting the areas where the service provider cleans. They have influence on the environments where the cart should function and can be anything from a small dentist to a law firm. |
| Area of interest | • Having a cart which fits into their environment. |

| **Smaller companies hiring own cleaning personnel** , see app. 8 | |
|---|---|
| Role | Service providers are not the only buyer of the cart. Companies hiring their own cleaning personnel represent a little over a third of the market and are thereby a big purchaser of the cart. At the same time they host the area where there is to be cleaning and thereby have influence on this. |
| Area of interest | • Low expenses connected to the cart and the personnel using it<br>• Having a cart which fits into their environment. |

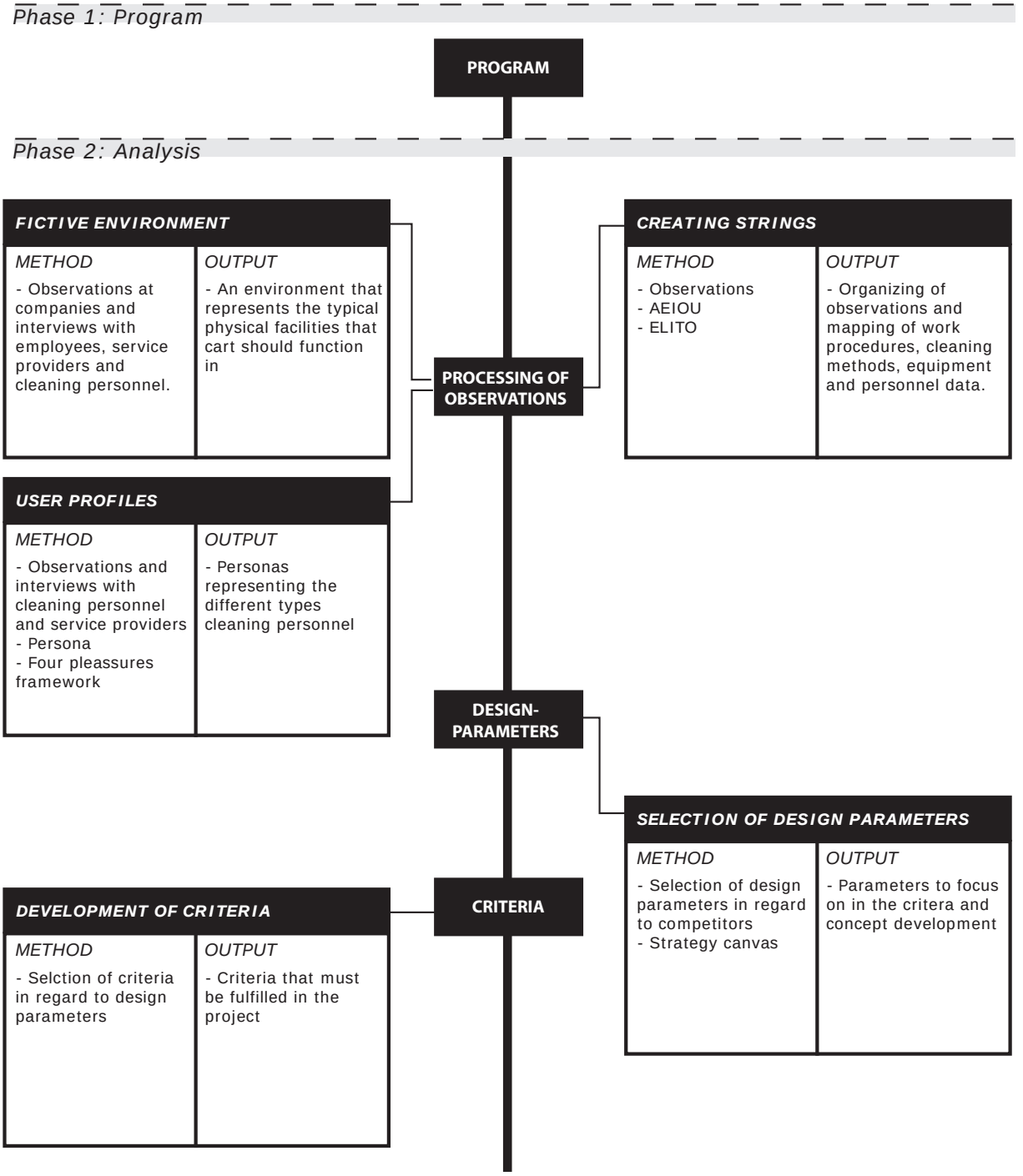
| **Cleaning personnel** , see app. 10 | |
|---|---|
| Role | The cleaning personnel are the actual users of the carts. They possess a large sum of experience both conscious and unconscious. |
| Area of interest | • The everyday use of the cart both concerning functionality and how the cart effect the way they feel about their job. |

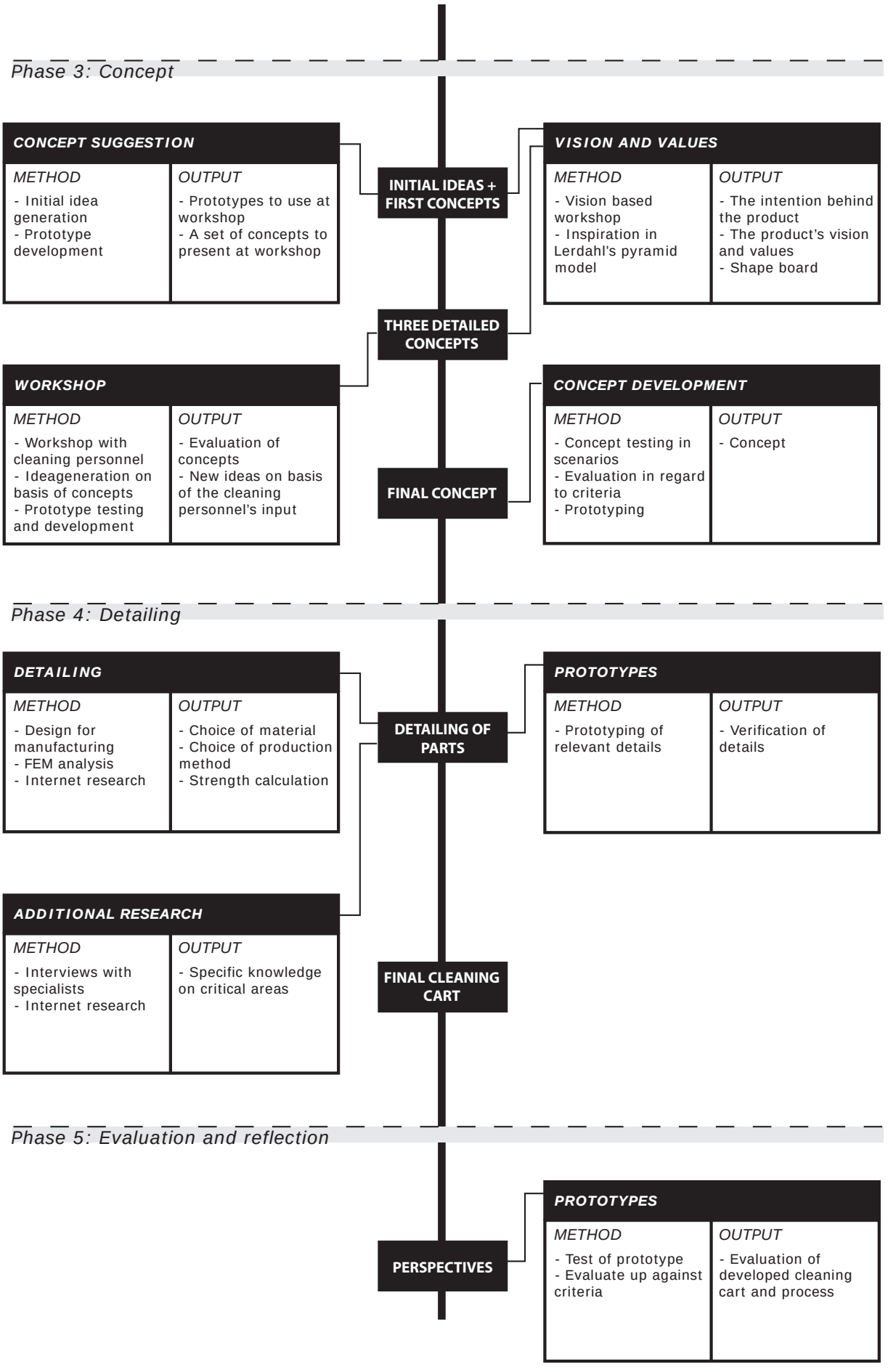
| **Danish Working Environment Authority**, see app. 5 | |
|---|---|
| Role | Provides guidelines for healthy work procedures around the cleaning cart. |
| Area of interest | • Fulfilling regulations regarding cleaning within health and work environments<br>• Obtaining healthy work positions and procedure. |

# APPROACH

In illustration 13 an overview can be gained on how the different actors will be investigated and used in the project. The illustration also shows the how the other phases will be handled.

Ill 13 | Approach





# REFLECTION, PHASE 1

Initial investigations have shown a product potential within the market of cleaning carts: a compact cleaning cart. This subject has been found appropriate to work with in order to fulfill the group's expectation as a subject concerning learning goals. A quick visit at some cleaning personnel made the subject more tangible and has helped understanding the subject. The main issues to work with have been found, and have created the base for the further work. The subject has a complex use situation and several actors need to be investigated in the analysis. A plan has been made for this approach, which has been very useful in later process.

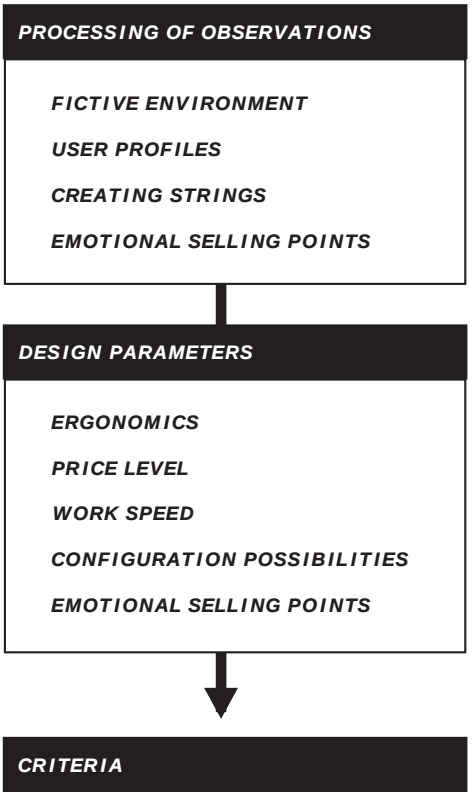
# PHASE2: ANALYSIS

## PURPOSE

The goal of this phase is to gather information on relevant aspects and viewpoints, and to create a set of specific criteria for the Compact Cleaning Cart that the further development can take point of departure in. The criteria are presented in the end of this phase and will function as a short and precise document to measure the result of the project against.

## APPROACH

To be aware of who has what interests, all the actors have been investigated and a list of interests has been developed for each. Having that many actors with several interests in regard to the cleaning cart means that not all actors can have their needs fully met and therefore compromises must be made. Therefore, these interests and needs are processed again and related each other in order gain a set of criteria which can be used as base for the following phases. In this process, a set of design parameters has been used to rule and evaluate the interests' role in the development of the final product, see ill. 14. Each chapter in this phase will have a description of how and what data is collected and then how this data is processed. After that, the design parameters will be set up and the actors' interests within each of them will be evaluated against each other.




Ill 14 | Approach

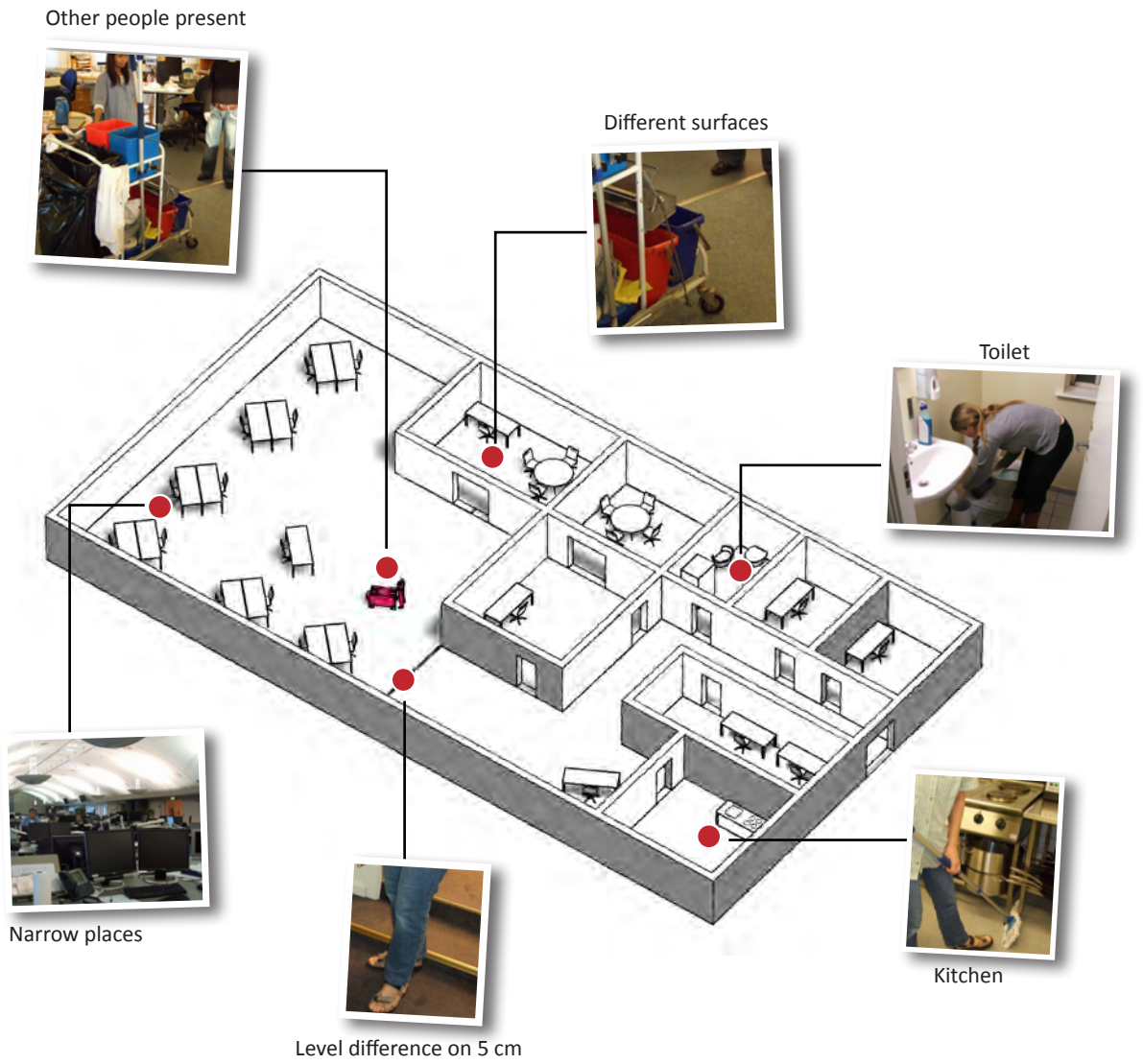
# PROCESSING OF OBSERVATIONS

Several observations have been made of cleaning personnel, both employed by service providers and directly by companies, see examples in ill. 15. Also, cleaning has been observed in different types of companies. These have been strategically chosen to cover a wide range of user types and environments, app 15. Regarding the environments, much information has been very clear and direct, such as how much space there was available for storage at the location and how high the steps are. This type of data is gathered in a fictive environment describing the context the cart should function in, presented in the next chapter, “Fictibe environment”. Most other data gained in the observations has needed to be processed or interpreted. This was done through the methods AEIOU and ELITO, which have been used to organize the data and to clarify what the interests of the users are. This process is described in the chapter, “Creating strings”. From the observation data, personas have also been made to gather information on user profiles. These are presented in the chapter “Personas”.

Ill 15 | Example of observations. Left: Ann is studying and cleaning at a dentist on the side. Center: Maria is foreigner employed at IDA-Cleaning and among other places, cleaning at a school. Right: Lisbeth is employed fulltime at Jyske Bank’s as cleaning assistant.

# FICTIVE ENVIRONMENT

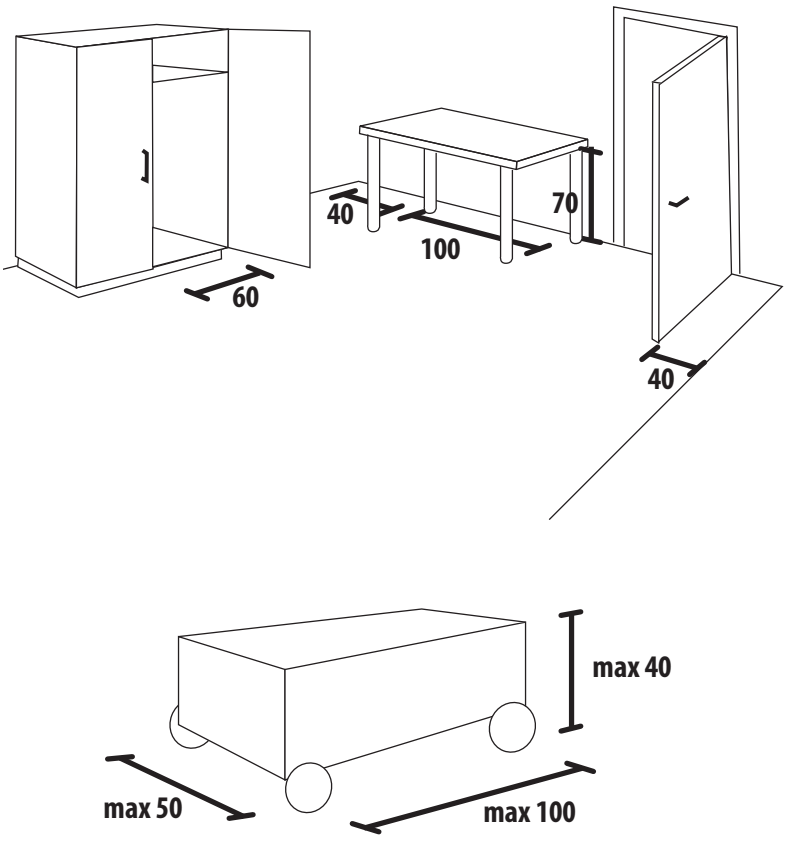
The companies with limited space for storage are often smaller companies of 2-20 employees and with a size of 50-200 m2. Through the observations it is also possible to create a fictive environment that the cart should function in. Even though the observed environments are different there still is a set of common physical limitations that the Compact Cleaning Cart needs to relate to. By creating one physical setting that represents all the observed environments, see ill 16, it becomes easier to relate to when designing, than if all the observed environments had to be taken into consideration each time a decision should be made.




Ill 16 | The fictive environment where the cart should function

Based on observations at clients it was concluded that if the cart both had possibility to be stored lying down and standing vertical it would have a large range of different storage possibilities. Ill 17 holds photos of possible storage places taken at clients. From this, the cart was limited to the measurements shown on illustration 18.

Ill 17 | Example of possible storage place




ill. 18 | The maximum measurements of the cart

# CREATING STRINGS

## AEIOU

The AEIOU framework was used to get an overview of the observations and to secure that the observations covered the problem area. Observations were noted on post-its supported with a relevant picture. Then these were put up on a board and divided into the categories of AEIOU:

**Activities**: What are the modes people work in and the specific activities and processes people go through?

**Environments**: What is the character and function of the space overall, and of individuals' spaces or shared spaces?

**Interactions**: What is the nature of routine and special interactions between people, between people and objects in their environment, and across distances?

**Objects**: What are the objects and devices people have in their environments and how do they relate to their activities?

**Users**: Who's there? What are their roles and relationships? What are their values and prejudices?

(Keeley, 2000)

The placement of the observations in the AEIOU framework was discussed by the group to secure the right placement in the framework, see ill. 19.

## ELITO

ELITO is a method for processing gathered observations from the analysis, creating a coherency from the observations directly to criteria. The first step was to put the judgment, values and criteria on post-its onto the observations from the AEIOU structure, see ill. 20. A discussion about the judgment of the observations started since this was the hardest one to put on the board.

**Observation**: An observable fact described in concrete terms. A question or paraphrase from secondary research. May include description of objects, people, environment, interactions, activities, conversations or states of being.

**Judgment**: An opinion about the observation. Expresses a point of view and probably a reference to a human value of some form

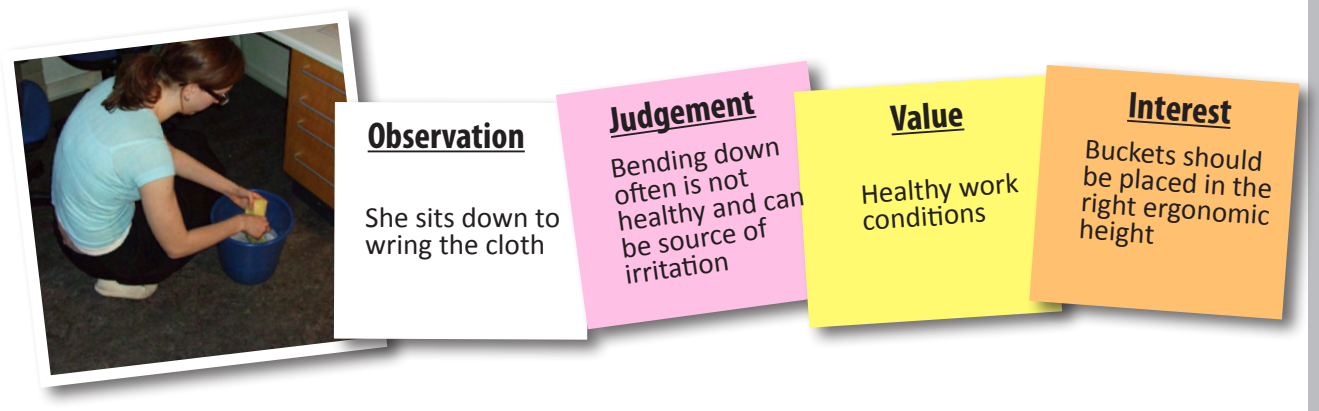
**Value**: Description of a basic human value.

**Interests**: Description of an approach or idea. The discussion can be any length but should outline salient feature (what it does) and properties (what it is).

The four subjects of ELITO are being put in horizontally order, creating a string. The string refers to the coherency from the observation to the criteria and concept made. An example of the strings is shown in ill. 21 - the rest can be found in appendix 16.

ill. 19 | The board is put up with observations after the AEIOU framework. The AEIOU framework divides the board in 5 colums. Post-its with different colours are put up, representing the 4 ELITO subjects.

ill. 20 | The observations are re-organized, having the ELITO strings horizontally.




ill. 21 | Example of a string developed from the ELITO framework

# USER PROFILES

## Purpose and approach

Based on the strings and the observation data in general, much data has been gathered about the cleaning personnel. It is important to have a solid understanding of the cleaning personnel as these are the ones using the cart. The report, “arbejdsmiljø og helbred hos rengørings assistenter i Århus amt 2004”, describe the cleaning personnel as shown in ill 22.

ill. 22 | Information on the average cleaning personnel

- *Average age: 52*
- *Only 6% has more than 10 years of education*
- *30 % has another native language than Danish*
- *More than 50% has a BMI (Body mass index) above 25. A person BMI should be below 25*

This is basic facts which are useful but they do not tell about the cleaning personnel’s preferences or personalities. Therefore three personas has been made on basis of user observations (see app 13) and knowledge gained from extern investigations made about cleaning personnel and published in “Arbejdsmiljø og helbred hos rengøringsassistenter i Århus amt”. Thereby three profiles are gained which cover the large group of cleaning personnel’s interests and in that way it is possible to design directly for these three and still end up with a product that is targeted a large user group.

# MARIA

Age: 34
Employed at: ISS Facility Service
Years of experience: 4 years
Work hours: 5:00-12:30 at Aalborg Airport, 5 days a week

Physio-pleasures:
- She is not very tall and needs equipment that takes this into consideration
- Like firm routines

Socio-pleasures:
- Enjoys contact with colleagues
- Enjoys working alone

Psycho-pleasures:
- She does not feel comfortable speaking Danish
- Afraid to do something wrong
- She does not have big demands to the gear that she uses, and are often satisfied with less than needed.

Ideo-pleasures:
- Prioritize both her job but also raising and spending time with her children.

ill. 23 | Persona: Maria

# PERNILLE

Age: 28
Employed at: An institution for elderly people
Work hours and places: 3:00-4:00 at institution
Years of experience: 6 years

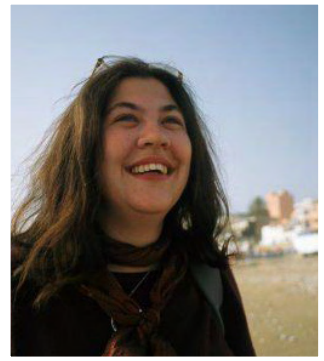
Physio-pleasures:
- Uses the tools that are present. Do not have high demands for the cleaning equipment
- Often uses the tools in an unhealthy way

Socio-pleasures:
- Like helping others. It gives her a feeling of appreciation

Psycho-pleasures:
- Do no see cleaning as the most important assignment, but understand the necessity of it.
- She does not care about ergonomics
- Her knowledge about cleaning is limited
- She is interested in the result of her work, because it has influence on others.

Ideo-pleasures:
- Believes that we all have a responsibility towards each other.

ill. 24 | Persona: Pernille



# MONA

Age: 52
Employed at: IDA Service
Years of experience: 29 years
Work hours: 5:00-8:15 at an institution, 5 days a week
14:30-18:00 at an office, 5 days a week
17:00-19:00 at a production company, 2 days a week

Physio-pleasures:
- Considers the cart as her own.
- Does things the way she finds most efficient and not what the rules says.
- Due to problems with right shoulder she would like equipment that spares it.

Socio-pleasures:
- Misses having colleagues

Psycho-pleasures:
- Has an ability to come to terms with the conditions as they are. She accepts rules from the service provider and that she is overweight.
- Believes she is good at what she does.
- Likes the flexibility of the job. It gives her freedom to plan things the way she want.
- She believes that she is cleaning in the best way, and her routines are difficult to change that she uses, and are often satisfied with less than needed.

Ideo-pleasures:
- Prioritize both her job but also raising and spending time with her children.

ill. 25 | Persona: Mona

# EMOTIONAL SELLING POINTS

There are more to a cleaning cart than just the physical features. There is also the feeling that makes the buyer buy the product and makes the user feel that it is a good cart in the use situation. When the cart is perceived as a good cart of the buyer and user, it will be easier to sell it, which is in the interests of the production company and the retailer.

It is not given that the cleaning personnel are present in the sales situation and the buyer will often be the employer of the cleaning personnel. This employer has interests in getting the best cart for the cleaning personnel in order to get the job done best possible. Therefore the buyer will try to put himself in the cleaning personnel's place. For this reason the emotional selling points that the cart should give are based on the end user and not the buyer. Lerdahl's pyramid model has been used as inspiration to link the expression of the cleaning cart to values that the end users seek.

From the ELITO framework based on the user observations, different values have been defined that the users seek in their work and their activities, see app 16. After several iterations using mindmaps the values were grouped as showed on ill 26, which gives an idea of what the overall values. Each group where labelled with a group value, which where further defined with metaphorical phrase in order to make their meaning more evident.

To be able to express the values in the cleaning cart, three new words were found, describing the expression that would make the values to be felt. The new words were defined through a shapeboard with pictures which each represent a part of the three values. Again, this was an iterative process that has circled several times. See the final shapeboard on next page, ill. 27.

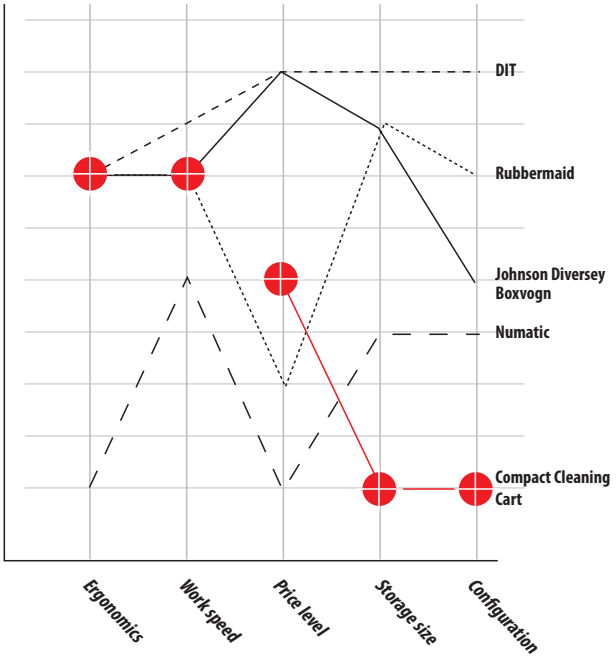

ill. 26 | Grouping of values found in the ELITO framework


ill. 27 | Shapeboard from the 3 values

# DESIGN PARAMETERS

The program describes a hole in the market that the Compact Cleaning Cart should fill by being able to be stored on limited space. In that way the Compact Cleaning Cart separates it self from the other carts on the market, but still it will be compared to other existing carts by actors with interests in the cart. Therefore the Compact Cleaning Cart needs to take a stand on the parameters the existing carts are competing on and also new parameters where the Compact Cleaning Cart could get an advantage over others.

The parameters on illustration 28 are found with inspiration in a Vita Riis design analysis of four existing carts, see app 4, and the different actors' interests. Competing cleaning cart providers' scores are estimated from knowlegde gained from interviews, observations and from the internet. Following is a short description of why each of the parameters is chosen to be the one to prioritize the different actors' interest against. The design parameters' settings at the end of this phase should be seen as a point of departure for the concept development and not as a locked up setting which cannot be changed. Even though this report has been structured as a linier process, the actual process consists of much iteration on different levels where the parameters has been used as a design tool.




ill. 28 | Design parameters

Ergonomics

From the interviews with service providers and cleaning personnel it is very clear that ergonomics is something they prioritize high. Also the meeting at the biggest Danish producer of carts, DIT International A/S, confirmed that they integrate ergonomics when developing new parts for their carts. Ergonomics is therefore a parameter that this analysis will describe further to make it clear how the interests of the actors in contact with the cart should be prioritized.

Work speed

Buying the cart is a one time expense and what really costs money is the salary for the cleaning personnel using the cart. However, the work speed is influenced by different interests e.g. compromises in regard to the cleaning personnel's wellbeing and the cleaning result. Therefore the weighing of this parameter is important.

Price level

The price for the existing cleaning carts varies a lot. Price often follow the value of the product and in that way this parameter compromises how many of the actors' wished can be fulfilled in regard to how much the buyer are willing to pay for the cart.

Storage

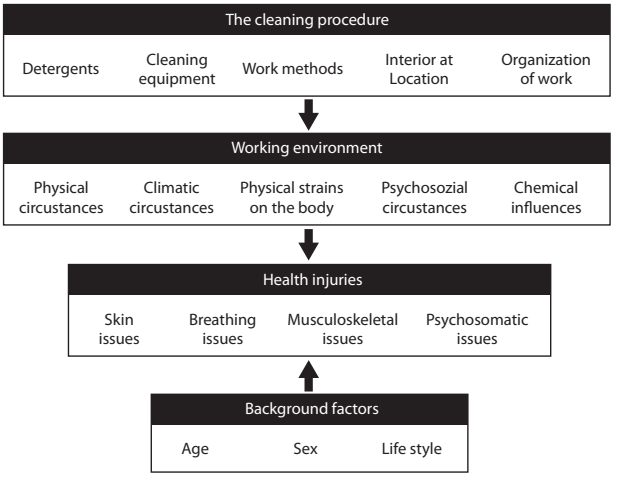
Creating a cart which should be stored in limited spaces means that several other aspects must be designed in regard to this. As the storage aspect is a part of the foundation of the Compact Cleaning Cart, this parameter cannot be compromised but must fulfill the storage demands set in fictive environment, page 24. This parameter will therefore not be further treated in the analysis phase.

Configuration possibilities

Many of the carts can be configured in several ways, which provides certain flexibility, but at the same time complicates the carts. Through the different actors' interest it is necessary to decide on a level of configuration.

# ERGONOMICS

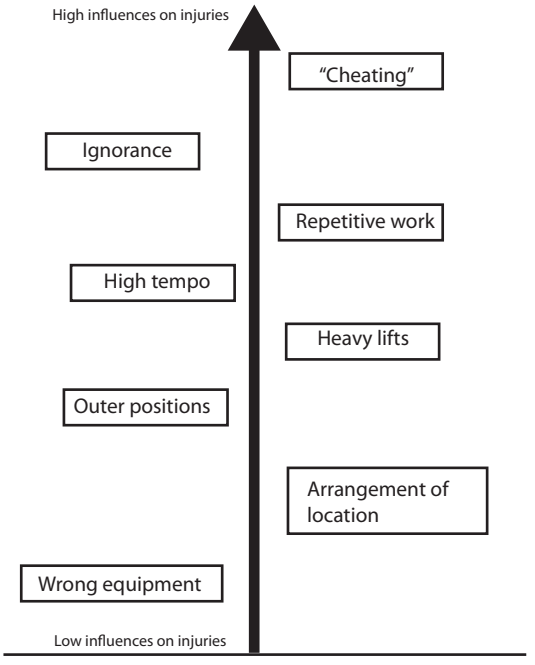
Cleaning is in general considered as a branch with a high level of work injuries. Taking precautions when designing the Compact Cleaning Cart could help bring the level of work injuries down which is both in the interest of the users as it is their welfare and their employees as it will bring down the number days lost through illness. Many precautions are already formulated by health and work environment departments as it is their interest to have a healthy population, see app 5 for rules and regulations.




Ill. 29 | Factors that influence the health of cleaning assistants (Arbejdsmiljøfondet, 1993)

On the face of it all actors seems to have matching interests in keeping the cleaning personnel healthy. However, examinations show that employees within the cleaning business have the highest risk for early retirement of all (Arbejderbevægelsens erhversråd, 2007). To figure out why this is, the factors influencing the health of cleaning assistants are presented in ill. 29. The figure shows that injuries are difficult to evaluate as they depend on many factors. Not only are the equipment and work methods relevant, but also the organization of them; in what order and frequency they are done, breaks between routines and likely.

To figure out the concrete causes that produce injuries within cleaning, the safety council at ISS has been interviewed. Here a prioritized list of causes was set up, see ill 30. However, the different causes are highly interrelated which means that often it is a combination of causes that leads to an injury.




Ill 30. The causes of injuries listed prioritized, with the most influential first, on the background of a meeting with the safety council at ISS. A further explanation of the causes can be read in appendix 5.

## Weighting of parameter

The causes for injuries show how the ergonomic design parameter is related to the other parameters set up. This means that if the ergonomic parameter is set as one of the main parameters, the rest of the parameters will be downgraded. There is therefore a balance between basing the cart on healthy work procedures without it complicating the routines for the personnel and tempting them to sidestep the healthy procedures to make it easier. Also the service providers and clients

are not interested in having healthy procedures taking up too much time. The Danish Working Environment Authority has sent out a folder regarding cleaning carts that presents a standard for the level of ergonomics, which is expected from service providers (Arbejdstilsynet, 2008). The level of this has been evaluated to be suitable to follow for the Compact Cleaning Cart.

# PRICE LEVEL

Since the price has influence on the value of the cart it is not only the buyer who has interest in regard to the price but also the users of the product. The production company therefore has the interest of putting as much value into the product without raising the cost price. This could e.g. be done by optimizing the production by using easier assembly or using same components more places in the construction.

The Compact Cleaning Cart both aims at service providers and companies hiring own cleaning personnel. For the service providers, a long lifetime is an important parameter when selecting a cleaning cart. The service providers expect a lifetime of the cleaning at 10 years, which the current carts can offer.This differs from those companies that are hiring own personnel, that mainly is looking at the price of the product and the work condition it offers.

By having an idea of the price the Compact Cleaning Cart can be sold for, it is also possible to estimate the maximum cost price.

## Weighting of parameter

From interviews with service providers and clients and screening of competing products' sales prices, an expected sales price has been set at 4000,- DKr. This sales price is set on basis of that the smaller companies will be a big part of the costumers of the Compact Cleaning Cart. Smaller companies do not have cleaning as the main priority in their company and it is therefore limited the price that they will pay for the extra ergonomics that the Compact Cleaning Cart will provide in comparison to using a bucket when cleaning. The cost price has been converted to the producer's maximum production price, see the scheme in ill 31. The earnings of retailers and producers are estimations and expenses for transport are not included.

| | |
|---|---|
| **Consumer price incl vat*** | 4000 DKr |
| vat | 25 % |
| Consumer price excl vat | 3000 DKr |
| Retailer gross earning | 30 % |
| Retailers purchase price | 2100 |
| Producers gross earning | 30 % |
| **Producers maksimum production price** | **1470 Dkr** |

Ill. 31 | Calculation of maximum production price.

# WORK SPEED

The faster the cleaning can be done the cheaper it is and this is in the interest of the service provider and the client. However, none of them is interested in the speed reducing the results of the cleaning. The cleaning personnel have an interest in getting the job done quickly without having to rush. This implies that the work flow and use situation around the cart is structured in a way so the cart helps the cleaning personnel e.g. by having the most used tools nearest.

This means that everybody is interested in having a good work flow around the cart providing a high work speed. Based on the observations a scenario of the different situations happening during cleaning is set up, see app 12. In this scenario there is some situations where improvement is needed.

## Weighting of parameter

Even though the situations above are improved, the Compact Cleaning Cart is adding another time consuming situation; it has to be packed away for storage. Even though if this situation is made easy and quick for the cleaning personnel and maybe only takes less than half a minute taken from a 4 hour work day, it will be deterioration in comparison to a cart which should not be packed away for storage. Therefore this is presented as a top parameter.

# CONFIGURATION POSSIBILITIES

## Intro

This chapter is divided in three areas: the cleaning method/methods the cart should be designed for, what degree of configuration it should fulfil and what content it should be able to hold.

## Configuration possibilities regarding cleaning method/methods

There are different interests in regard to whether the cart should be configured for only one method or more methods. Having only one method secures that the cleaning personnel uses the most ergonomic and fastest method and this is in the interests of user, client and service provider. At the same time it is not as demanding in the sales situation as the costumer does not have to choose between different configurations, which are in the interest of the retailer. It is also in the interest of the production company as fewer configurations gives a lower cost price. It will most likely be simpler and the structure does not have to be compromised in the same degree as with more configurations. On the other hand a cart compatible with more methods means that buyers can use their preferred method, which could give a larger buyer group in the interest of the retailer. The buyer can also change between cleaning methods without exchanging the cart.

Ill 32 | Cup method: A cup of soap-water is splashed on the floor and dry mops are used to wipe off.

Ill 33 | Drip system method: Mops are put in water and afterwards put on the driptray for the extra water to drip off before usage. Afterwards, a dry mop is used to wipe off.

Ill 34 | Mop press method: The mop is put in a bucket of water and afterwards press through a moppress. Afterwards, a dry mop is used to wipe off.

Ill 35 | Moisturizing. Clean mops are being put in a bucket and water is scattered over them to moisturize them. Afterwards, a dry mop is used to wipe off.

| | Small storage size on cart | 25% | Ergo-nomic | 20% | Speed | 15% | Under-stand-able first time | 10% | Work before and after | 10% | Cleaning result | 20% | Result |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cup method | 4 | 1 | 4 | 0.8 | 4 | 0.6 | 1 | 0.1 | 4 | 0.4 | 3 | 0.6 | 3.5 |
| Drip system method | 3 | 0.75 | 3 | 0.6 | 2 | 0.3 | 3 | 0.3 | 3 | 0.3 | 2 | 0.4 | 2.65 |
| Mop press method | 1 | 0.25 | 1 | 0.2 | 3 | 0.45 | 4 | 0.4 | 3 | 0.3 | 2 | 0.4 | 2.0 |
| Moisturizing | 5 | 1.25 | 5 | 1 | 4 | 0.6 | 1 | 0.1 | 2 | 0.2 | 5 | 1 | **4.35** |

Ill. 36 | Comparison of cleaning methods in score scheme (after Ulrich and Eppinger, 2003)

To find the best suited cleaning method/ methods a comparison of the different methods has been made, see ill 36. The comparison is based on different parameters which are in the interest of the different actors such as how ergonomic a method is to use and the speed the cleaning assistant can clean with by using the method. The methods compared are presented in ill. 32-35.

From the scheme the moisturizing method has been found the most suited from the parameters set up. The method scores a high score on ergomics, as it does not bring much water/weight around. Regarding storage, this also eliminates a bucket as you in the other methods have one bucket for water and one for mops. The mops are always clean and ready to use, meaning the work speed can be high and the result as well. On the downside, more mops are generally used as you change for each time the mop gets dry which means more laundry. The method is considered not very self-explanatory, as there is nothing on beforehand that reveals how to use the mops and buckets for this method.

As supplement for this method, a method for cleaning interior and toilets with cloths has been found with similar advantages. It is called “spray-on-cloth” and as for the mops, you avoid bringing a full bucket with soap-water around. Instead you bring spray bottles that you spray on the new cloths, see ill. 37.

## Weighting of parameter

If the cleaning cart should consist of more than one method the complexity of the cleaning cart increases and the demands to the cleaning cart and the retailers will be higher. However, it is a conservative market and the cleaning personnel have each their viewpoints on which method is the best based on the experiences they got and what they are use to. The Ulrich and Eppinger scheme showed that the moisturizing method were the most suitable cleaning method for the Compact Cleaning Cart. In addition, a meeting with ISS Facility Service made it clear that it is this method they in the future want their cart configured to. As ISS Facility Service is a large customer of the Compact Cleaning Cart, this is a reasonable method to aim for. This however means that the cart only will be configured to this one method, setting the design parameter of “low configuration” high. As it is a method some cleaning assistants are not familiar with it can eliminate some of them as buyers. On the other hand this is seen as the most common method in the future due to the large advantages of the reduced workload and therefore in time it will be accepted by the conventional cleaning personnel. Hopefully, ISS Facility Service will help make this method the most common in the near future.

Ill 37 | Spray-on-cloth: The cloth are sprayed with soap-water

## Cleaning equipment on the Compact Cleaning Cart

It is in everybody's interest that the cart carries the needed equipment. Not only the users are interested the correct equipment for the different tasks in order to perform the cleaning tasks efficient and healthy, this is the service providers also as it gives the users better working conditions. The retailers are also interested in selling a cart that fits to their users, but they are not interested in the troubles connected with configuring it. From the production companies point of view is should be kept as simple as possible.

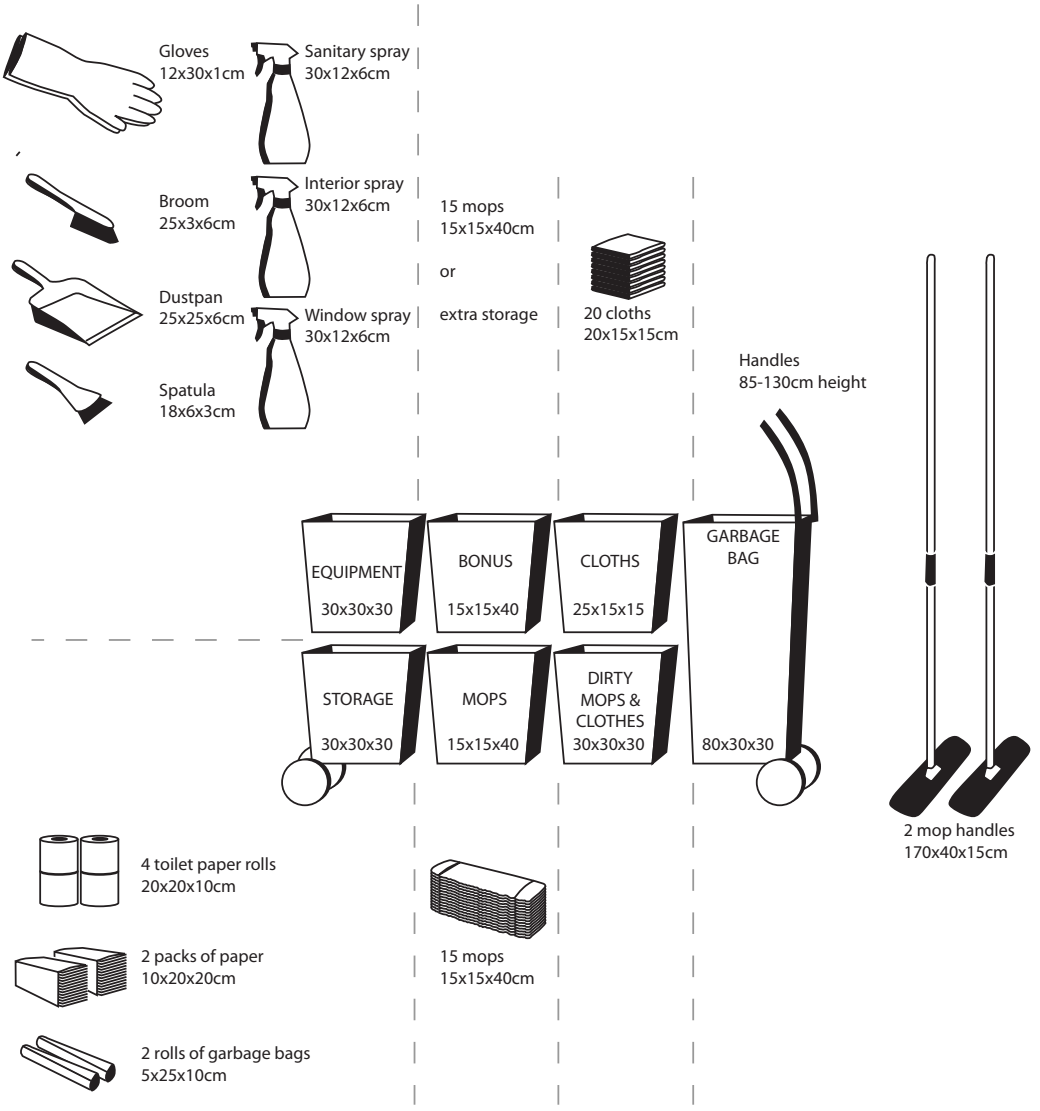
To figure out what cleaning equipment the cart should hold it is necessary to decide what types of cleaning assignments it should fulfill. Given is, that the environment has a toilet and also that it has floors which needs to be washed. If there is no floor much of the reason for using a cart is lost as it would not transport much equipment.

The illustration, ill. 38, shows what the buckets necessary for cleaning the in the fictive environment, established ealier. In order to avoid locking up any concrete shaping of the buckets they are thought of as relatively 6 liter and 22 liter buckets/areas.


Ill 38 | Bucket that should be on the Compact Cleaning Cart

## Weighting of parameter

Given that the assignments the cart needs to fulfil are so similar, the individual configuration wishes in regard to the assignments can be seen as superfluous if the cart is made so it takes the physical needs of the user into consideration. The necessary configuration in regard to equipment on carts is basically limited to whether you wash one or two types of floor surfaces and how much storage space is needed. The solution has therefore been to have a solution aimed for one floor wash as the basis, but added a large bonus bucket, giving the possibility for another floor wash or having an extra storage room. For some, this bucket will be superfluous, but in most cases it will come in handy. Having decided on the cleaning method and the cleaning assignments the cart should be designed in regard to, the following list of items can be set up ill. 39.




Ill 39 | Example on equipment neccessary to clean the fictive environment.

# CRITERIA

## PURPOSE

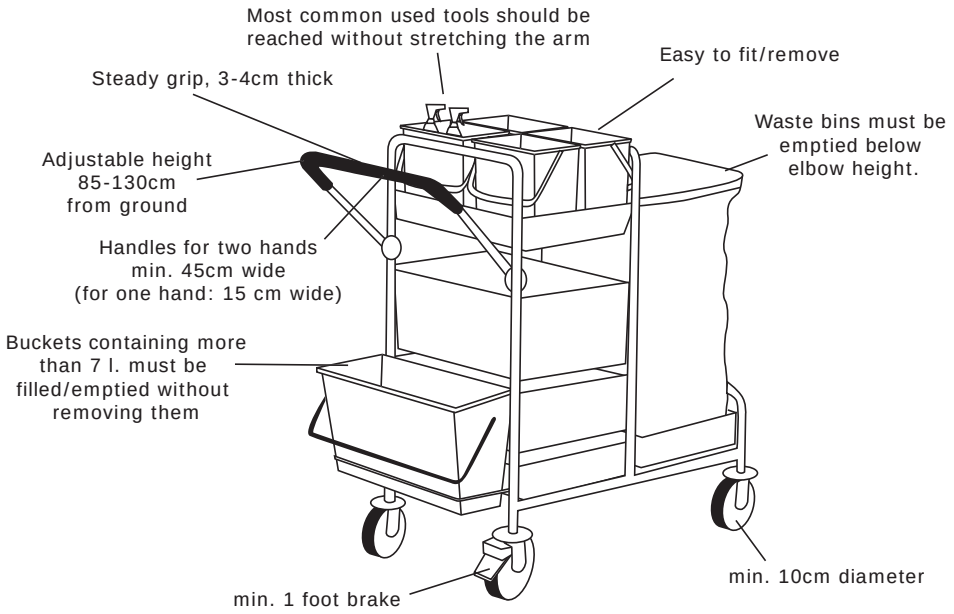
The purpose of this chapter is to structure the gathered information in order to give the group a common understanding before entering the concept development phase. In that way the group all the time has a document to compare the quality of their results to.

The structure has been made in respect to the design parameters: ergonomics, work speed, price, storage size, configuration. These are followed by emotional selling points. To be able to track down the criteria's origin they are marked with the initials of the concerning viewpoint/viewpoints:

Competing carts = CC
Ergonomics = ER
Service providers = SP
Clients = CL
Companies hiring own personnel = CH
Retailers = RE
Users (Cleaning personnel) = US
Producer of cart = PR

# ERGONOMICS

***The cart must reduce unhealthy work positions compared to existing cleaning carts, including body twists, unstable work positions, large physical efforts and repetitive procedures. Loads that needs to be handled should be designed so its' weight, shape, balance, surface and placement do not lead to unhealthy conditions. (ER)***




Ill 40 | Buckets neccessary

***The cart should be designed so it does not involve safety risks for the user or others during preparation, maintenance or use, including securing correct use of the cart, safe manoeuvring and avoiding physical shaping that could cause injury. (ER)***

- Equipment should be placed securely on the cart and not be able to fall off. (ER)
- The fully loaded cart must not limit the view for the user. (ER)
- With the cart should follow necessary instructions about use, maintenance, transport, preparation and if necessary safety precautions. (ER)

# WORK SPEED

***The cart must help and encourage the user to carry out the assignments in the most efficient and ergonomic way including preparation, cleaning and storing away the cart. (CL, CH, US, SP, ER)***

***Cleaning***

- The cart must be organized so it is logical how it should be used and thereby maintain order, e.g. by having colour coding for different contents. (CL, CH, US-)
- The cart should be easy to move and turn, e.g. by having handles on more sides. (US)
- The cart should be accessible from more sides. (US)
- The cart should be designed so it allows variation in the work procedures. (ER, US, SP)

***Preparation/Finalizing***

- The cart must be easy to assemble at customer by having few, obvious joints and well illustrated assembly manual (SP, CH, US)
- The cart must be easy to prepare for use and pack up for storage including refilling equipment and emptying for dirty mops and garbage and cleaning the cart. (US, SP, CH)

# PRICE

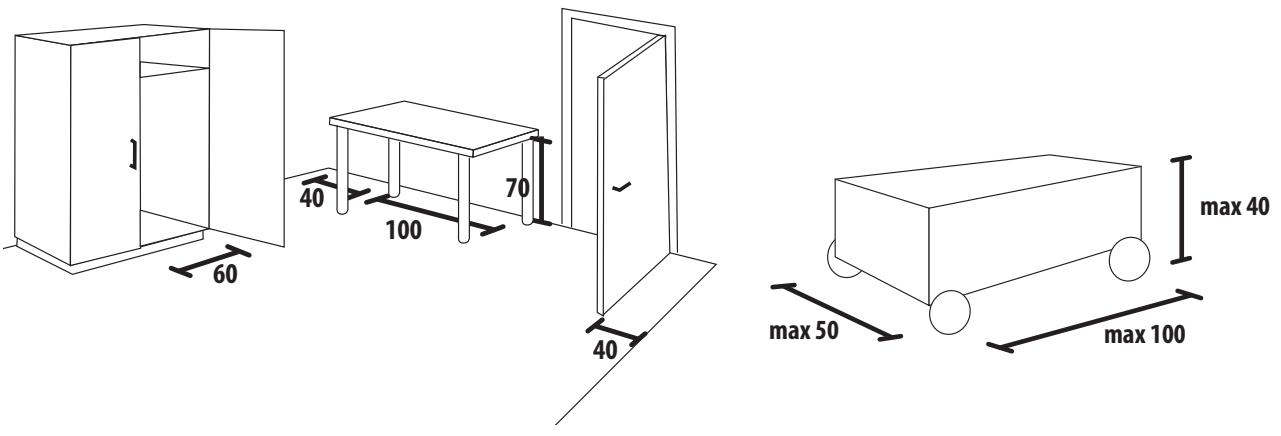
***The cart's components and production methods must be designed to be durable and designed for low cost production and assembly, e.g. by using few components, standardized components, symmetrical parts and obvious joints. (PR, CH, SP, RE)***

- Production methods are suitable in regard to the numbers of expected products (PR)
- Sales price is not higher than 3999, - Dkr. (CH, SP, PR, RE)
- The cart must be manufactured to handle the use situations and to stand a lifetime of 10 years, including choice of material, labels and surface coatings. (CH, SP, ER)

# STORAGE SIZE

***The cart must fit in an environment with limited space for storage and be able to overcome obstacles in the environment. (CC, US, CH, CL, ER)***

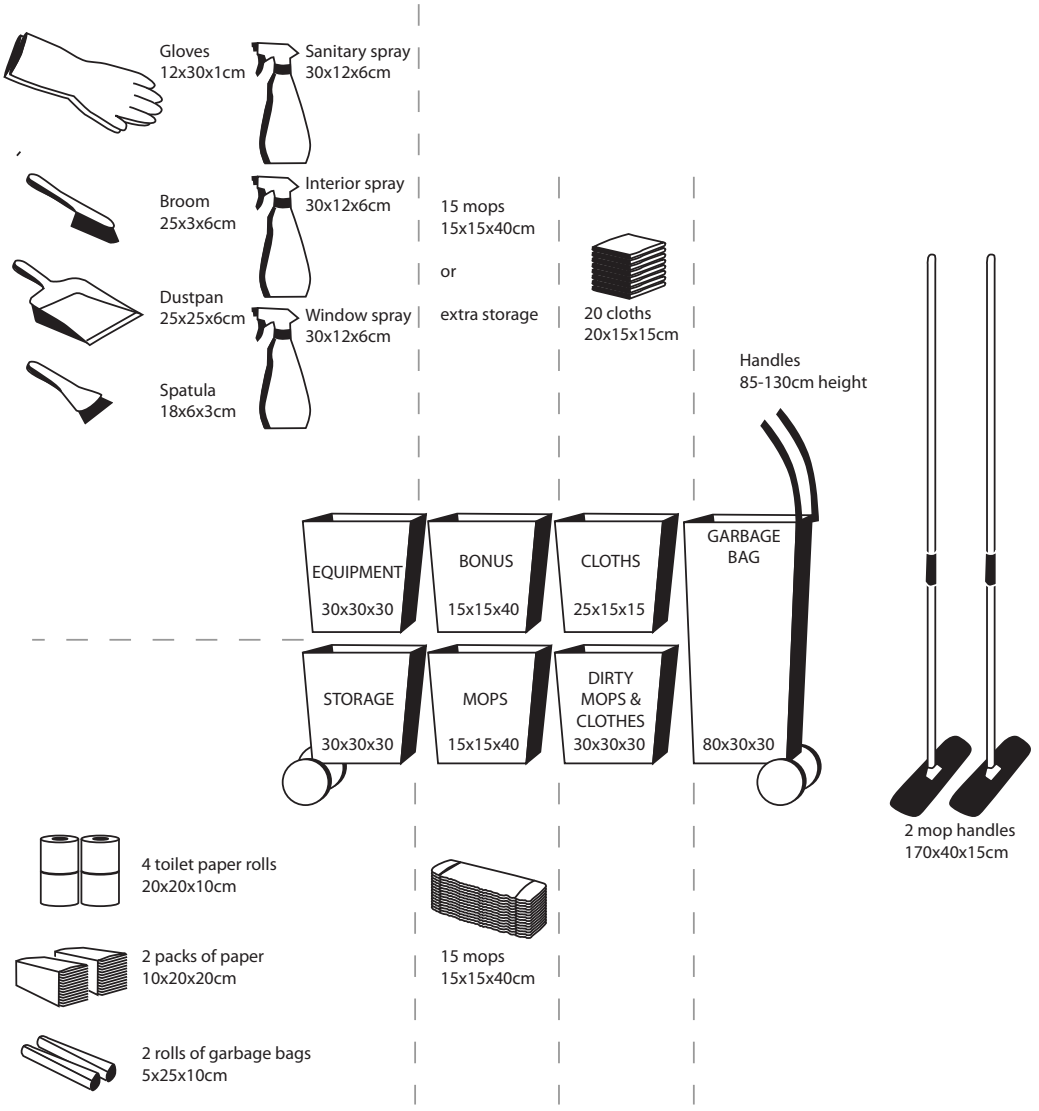
- The cart must not measure more than 55cmx30cmx100cm in order to fit into the environment described on illustration xx (above). (CC, CH, US)
- The cart must be able to pass a level difference on 10 cm. (CC, CL, US)
- The cart must be easy to manoeuvre and able to come around on narrow places. (US)
- Wheels must be chosen in accordance to the floor/surface. (ER, US-)




ill. 41 | The maximum measurements of the cart.

# CONFIGURATION

***The cart should be able to store and transport the needed equipment to carry out the cleaning assignments, using moisturized mops and the "spray-on-cloth"-method (US-U, SP)***




Ill 42 | Example on equipment neccessary to clean the fictive environment.

# EMOTIONAL SELLING POINTS

***The cart should express Quickness, Serious and Comprehensibility as shown in the shapeboard:***


Ill 43 | Shapeboard

# REFLECTION, PHASE 2

Throughout the analysis a large amount of data has been collected from all the different actors in contact with the Compact Cleaning Cart. It has been processed and gathered in a set of criteria which is useful in the following phases.The criteria set up in the beginning of the process have not been unchangeable, but refined throughout the project as more and more knowledge were gained. This was done to prevent getting stuck in rules and limitations but instead letting the criteria grow with the project and in that way the criteria became more of a working tool than a set of limitations.

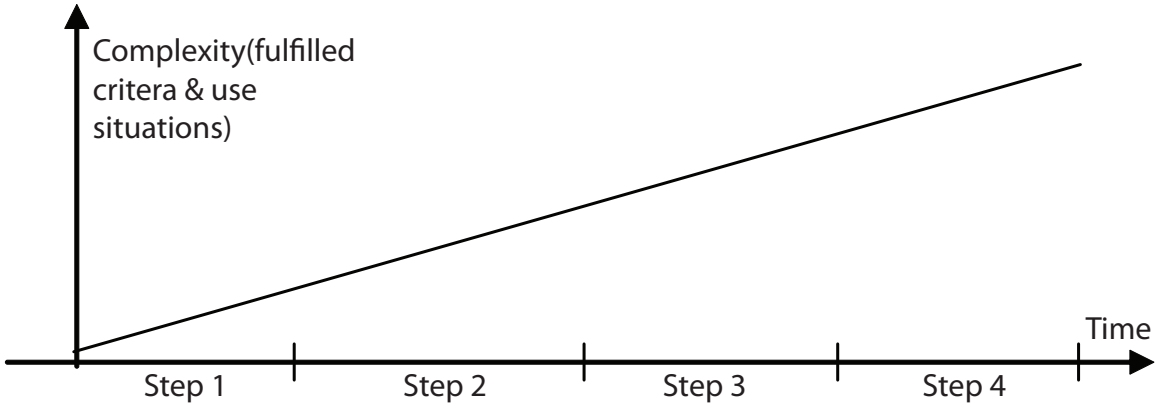
# PHASE3: CONCEPT DEVELOPMENT

## PURPOSE

From the analysis a broad spectra of information has been gathered which sets the ground to build the concept upon. This phase describes how concepts have been developed, evaluated and refined.

## APPROACH

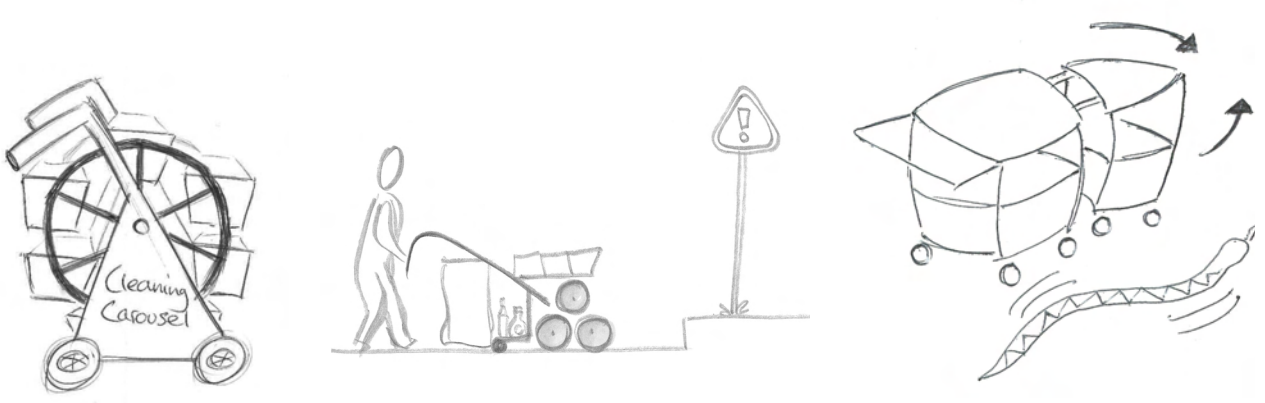
Starting with a free sketching workshop, concepts has taken shape and gradually advanced to fulfill more use situations and criteria, see ill 44.



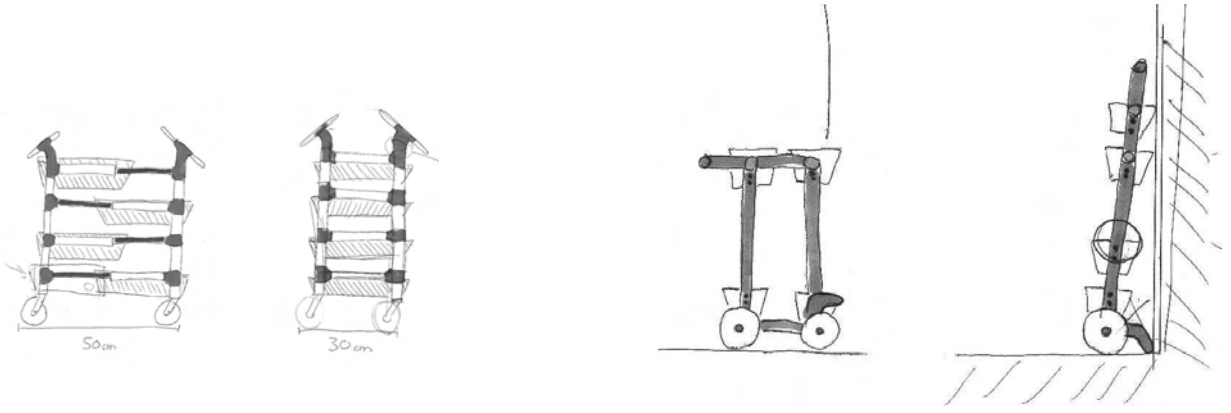

Ill 44 | Phase division

# STEP 1: WORKFLOW AND STORAGE PRINCIPLES

To initiate the concept development phase, a sketching workshop was started with point of departure in two areas: obtaining a small storage size and the cleaning assistant's workflow. This is the two main aspects in the project, as stated in the problem definition. The goal was to initiate this phase with an open mind without being too limited by the many criteria. By that, loose ideas that have been thought of or discussed during the analysis was put on paper and a bunch of new ideas were generated.



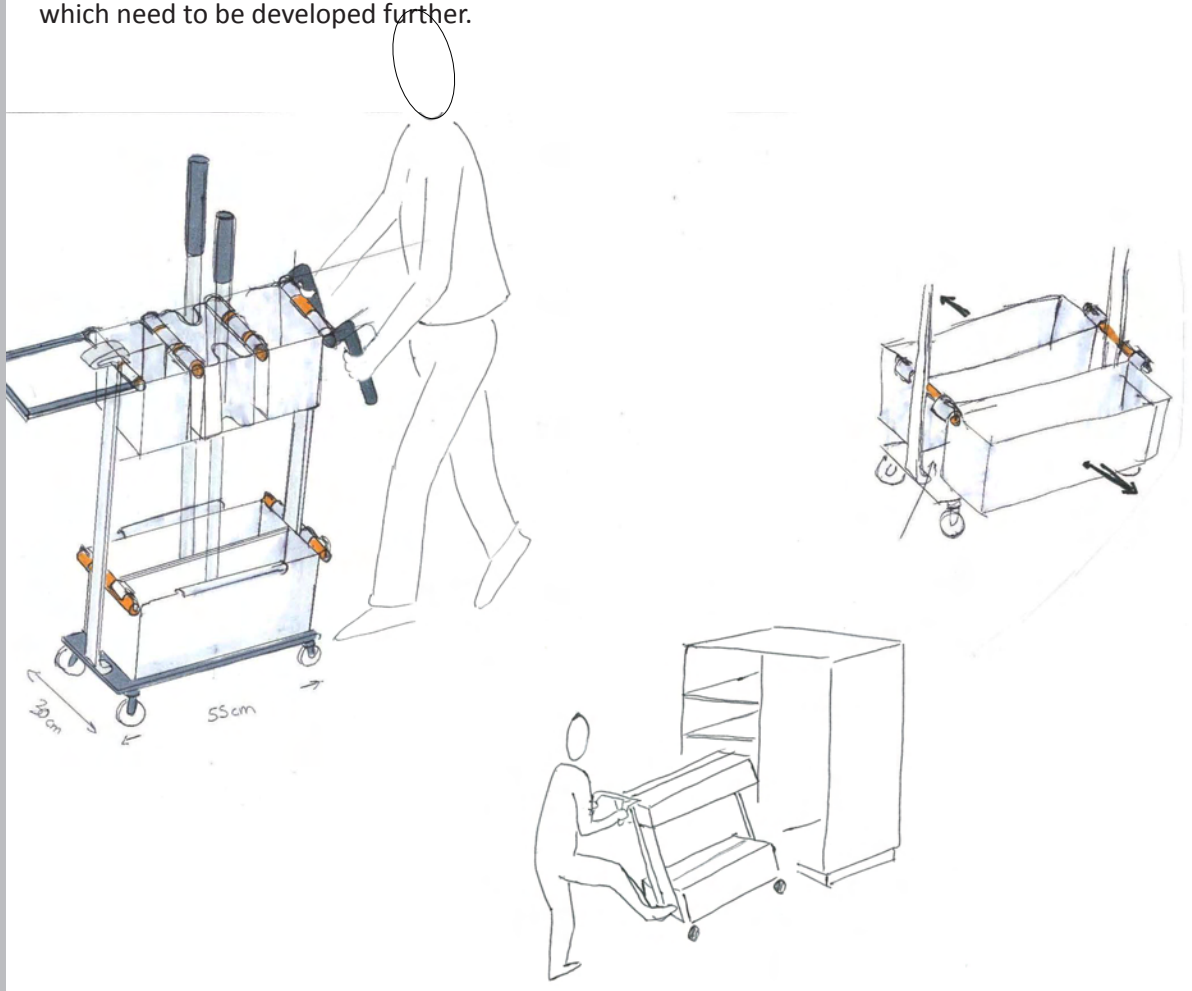

ill. 45 | Ideas on workflow from the initiation of the concept development phase. The first is inspired by a Ferris wheel, allowing the user to rotate the buckets in order to always have the equipment needed in top position. The second sketch shows an example of how to overcome steps. The third sketch is a principle on maneuverability inspired by the movement of snakes.



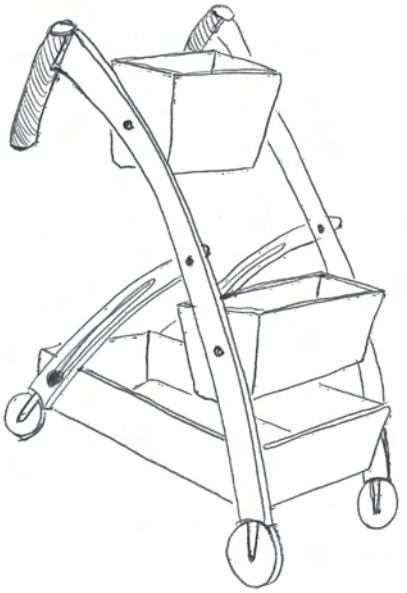

Ill 46: Initiating ideas on obtaining a small storage size. First sketch shows a cart where the buckets slide in between each other like drawers and thereby obtain half the size for storage. In the second principle the cart can be lifted in one side and in that way gaining a tall but slim shape.

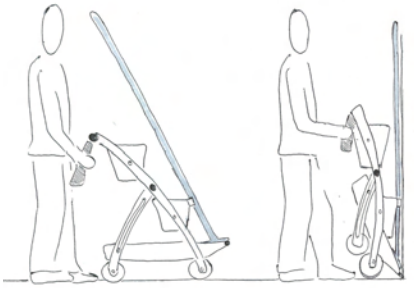
# STEP 2: FROM PRINCIPLES TO CONCEPTS

By time, the principles of the initiating sketches were developed further and put in relation to specific use situations and criteria. Illustration 47-49 presents three of the concepts the initiating principles were gathered in. These have several good aspects, but also aspects which need to be developed further.

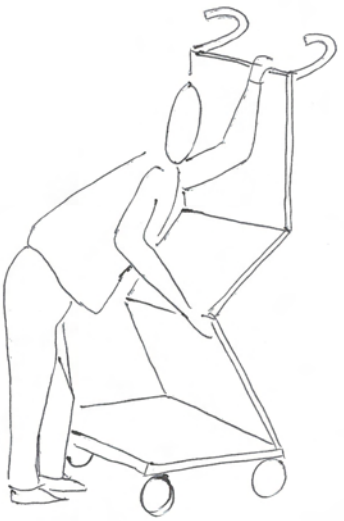



ill. 47 | Box cart: A simple structure that appears closed, fixed and strong. There are few mechanical joints that are moveable and the preparation is quick. However, it does not have room for any refill items like toilet paper. As it is only 30 cm wide it can be perceived unstable.





ill. 48 | Stroller:
Inspired by a stroller, this concept builds on a simple folding principle and allows easy preparation. There is not much storage space on the cart and the placement of the mop would interfere with the cleaning assistant pushing the cart.



ill.49 | Slim: This cart has a very slim structure when folded and appears as a very closed and clean object that can be stored visible for clients/customers. The folding principle is complex and probably not easy.

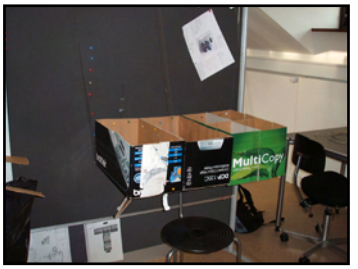
# STEP 3: 3 CONCEPTS

The many different concepts developed in step 2 were in this step narrowed down to three, each representing an important aspect: appreciation (CLEAN), ergonomics (ERGO) and storage (FLEX). They where developed further in regard to their focus areas, the criteria list and linked to specific ELITO-strings. This was done as it was not possible to solve all criteria at the same time this early in the project. Each concept was put into the whole workflow to be able to compare them in all situations. The expression of the cart in regard to the shape board also had a higher priority in this step compared to the previous. In the following, the process up to the three concepts is shown in short.

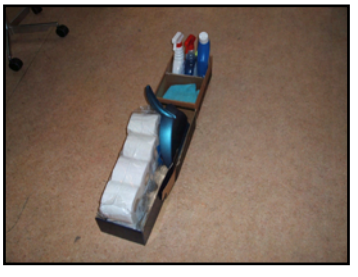
## Development of the three concepts:

Different methods were used when developing the three concepts. LEGO models were built to


Ill 50: Workflow presentation of the three concepts and Lisbeth illustrating how she would use the cleaning carts.

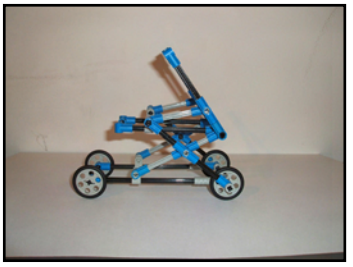


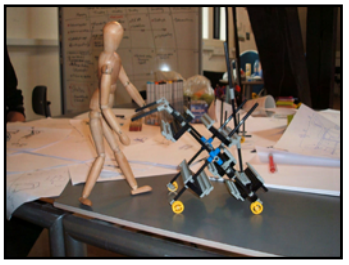
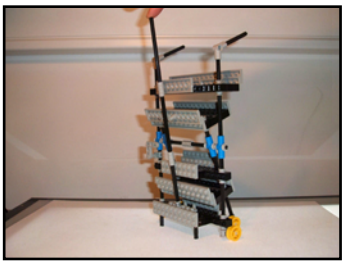

Ill 51: The three concepts presented at the workshop and comments.

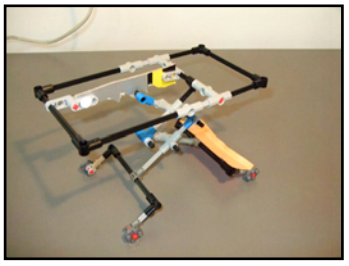


Ill 52: Mockups with cardboard boxes

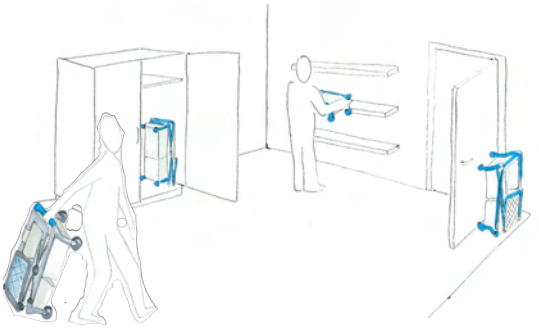
develop and test out the folding principles, see ill 53. To get an idea on sizes and how the carts were to work around mock-ups in cardboard boxes were made. Equipment where put in the boxes to decide if they had the right size, see ill 52. Also a workshop was held with one of the cleaning assistants, who were observed earlier in the project. For this workshop the three concepts were presented at their current state and this was done through the cardboard mockups, the LEGO models and drawings of the work procedure, see ill 50. From the workshop many comments were gained on the different concepts, see ill 51, but also other relevant information were achieved. Afterwards the concepts were developed to a state where it was time for them to be gathered in one. See the presentation of the different concepts on ill 54-56.

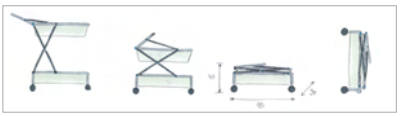





Ill 53: LEGO models built when developing the three concepts

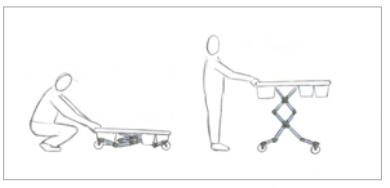


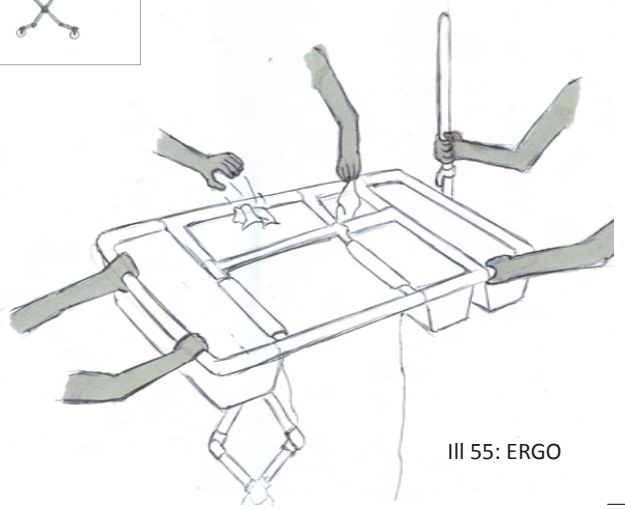


Ill 54: FLEX

## CLEAN

CLEAN has appreciation as focus area. Appreciation is a part of the emotional selling points, which in this concept is expressed through a clean and organized structure. E.g. a department is made for dirty mops which is hidden away inside the structure. Also the structure is much more solid than many of the other concepts and in that way it becomes more of a front, which can be perceived as making the cart more important than if it had a more transparent structure that blends in with the surroundings. When folded it looks almost like furniture and the much closed appearance makes it look important. The downside of this closed structure is that it limits the access to the different tools in the use situation that. This concept could also be limiting the view for small persons and it lacks height adjustment.
CLEAN is made upon the ELITO-strings: K, O, R, V, Y. See app. 16.



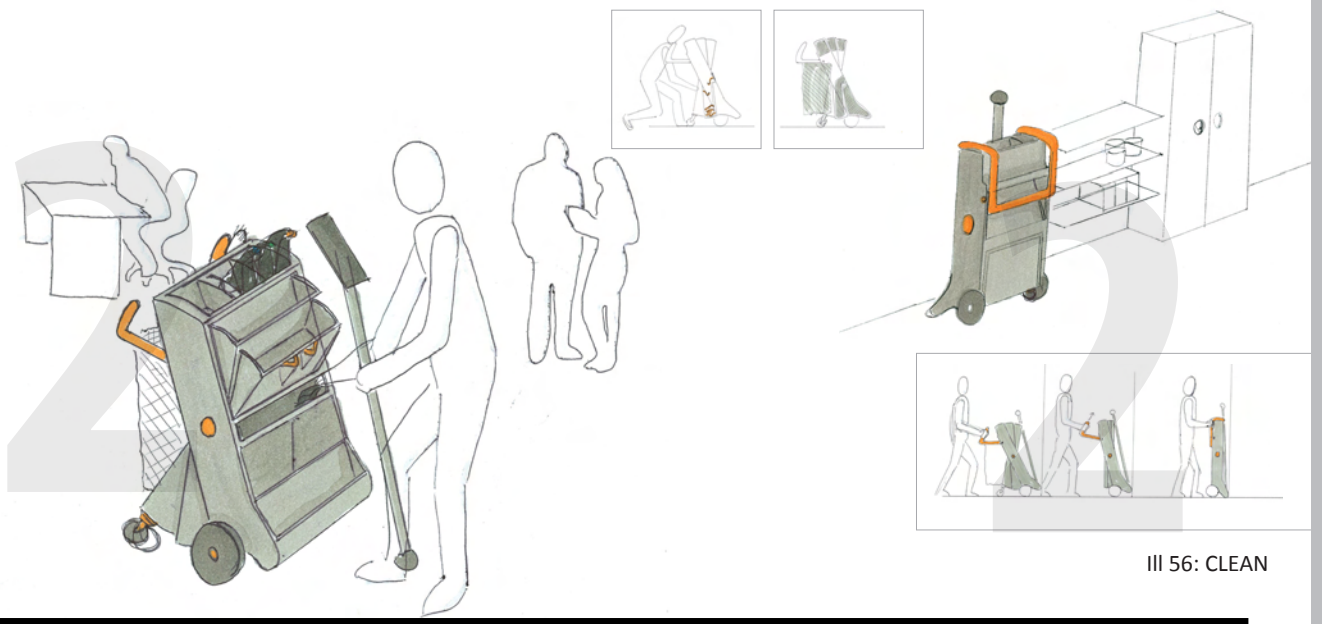


Ill 55: ERGO

## FLEX

FLEX is focused on storage. Its folding system takes inspiration in baby carriages and is quick and easy to use. It is possible both to store horizontal e.g. on a shelf or vertical e.g. in a closet. In addition, it can be transported when folded. Another criteria there is included in FLEX is that it must be easy to prepare for use and pack up for storage. Here there is worked with a washing bag, which quickly can be removed and thrown in the washing machine or handed in to the washing service. Also the buckets are easy to detach for washing. FLEX also relates to the criteria about that the cart must be logical organized as buckets in the bottom are for the floor and the mops can be reached with the mop handle, and the buckets in top are for equipment taken by hand. Due to the focus on storage and preparation, there are also highly relevant aspects that have not been treated in the FLEX concept. Among them there are lack of height adjustment and questions about stability of the cart.

FLEX is made upon the ELITO-strings: B, L, M, R, V. See app. 16.



Ill 56: CLEAN

## ERGO

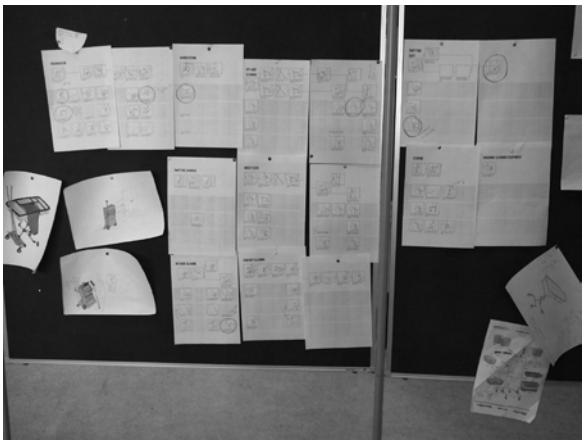
The goal with ERGO was to make an ergonomic concept. It fulfills many of the guidelines set up in “clean lines” e.g. the height is adjustability. Everything is placed in the same height which is ergonomically correct in regard to reaching it by hand. The structure also makes it very accessible as the cleaning personnel can access it from all sides. Another criteria it comply with is that it is easy to move as it has handles all the way around. The downside is cleanly the folding principle. First of all it has a large area even when it is folded and secondly the work procedures around folding it up and down are not very ergonomic. A small battery driven motor was discussed to be a possibility, but was it is deselected because of its need for recharging.

ERGO is made upon the ELITO-strings: A, E, F, U, X, Y. See app. 16.

# Step 4: Defining 1 concept

***Evaluation of the three concepts***

To have a basis for comparing the three concepts and define what the positive and negative aspects of each were, two methods were used. The concepts were arranged in a workflow where it was easy to compare them to each other in different situations, see app. 14. Rings were drawn around situations where there were elements which should be a part of the final concept, see ill 57. Also each concept was evaluated up against all the criteria, see scheme in app 15. On basis of this it was clear that the basic structure of FLEX should be used and to this some of the principles from the other concepts should be integrated. The structure of FLEX was chosen as it is a combination of workflow and storage principle, where ERGO is mostly focused on workflow and CLEAN on storage. However, there were some questions about the stability of Flex and whether the overall measures where too long in comparison to the width. Therefore a 1:1 model were built in wood and the buckets from a cleaning cart provided by DIT International was attached, see ill 58.



Ill 57: A picture of the board with the workflow on

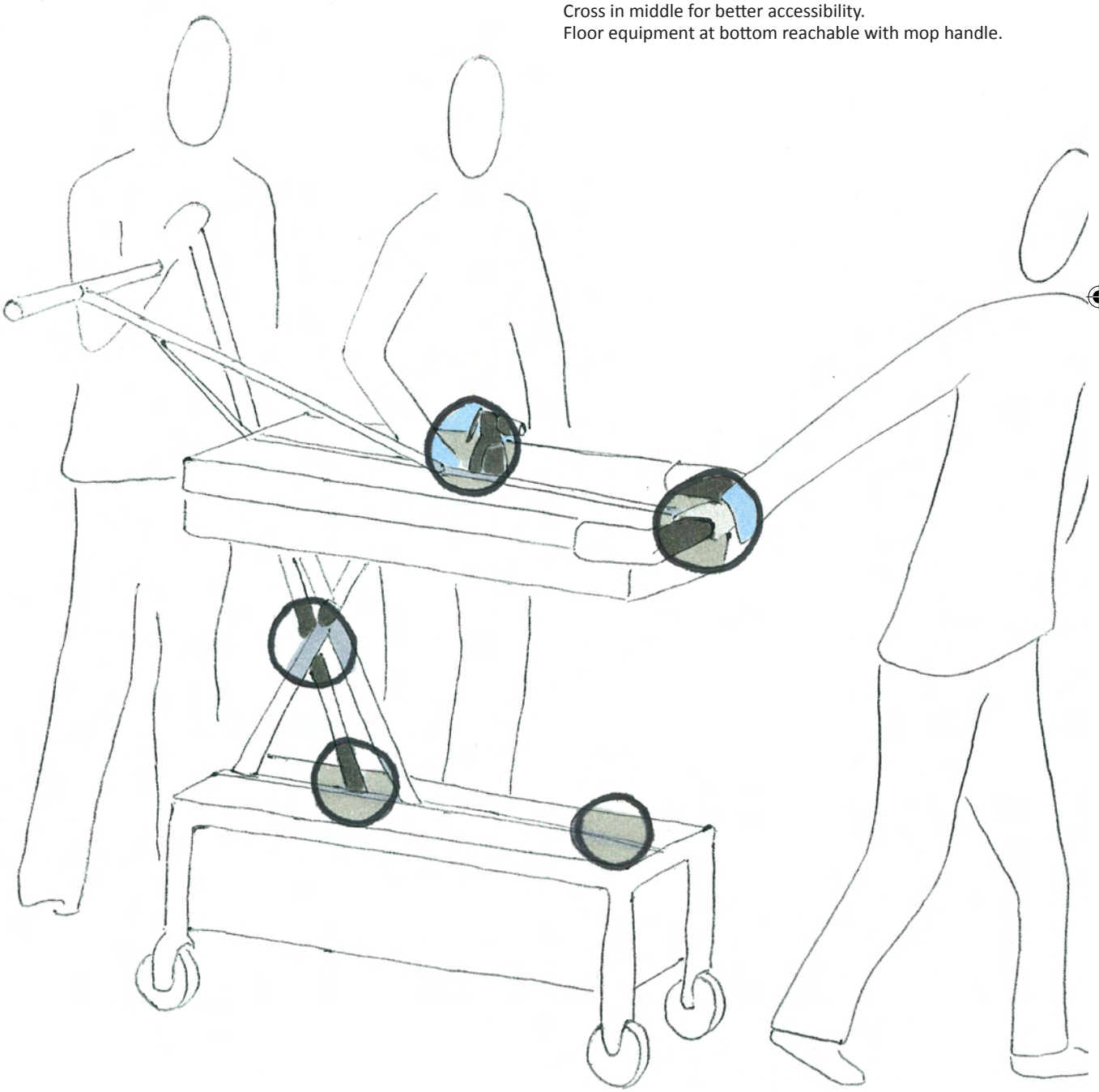
Ill 58: A 1:1 model of the structure of FLEX

The structure appeared a bit thin and the space did not seem used to the fullest as the bucket in the bottom was too wide in comparison to what was needed, but the width of the cart was not large enough for two buckets side by side. Also the crosses in the sides were blocking the access to the buckets. Therefore a new model was built where the cross was placed in the middle and where there were room for two buckets side by side, see ill 59. This model proved to be more stable than first expected. With the model it was possible to test different use situations and become more aware of how the cart should act in the different situation to fulfill the criteria. The next page presents the final concept for the Compact Cleaning Cart.

Ill 59: Model with the cross in one cross in the middle

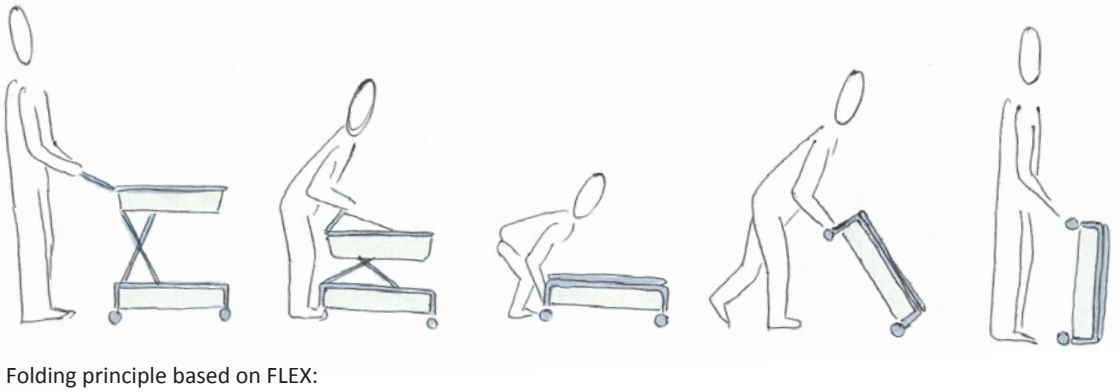
# FINAL CONC

Workflow based on FLEX and ERGO
Handle in both ends for better manoeuvrability.
Buckets placed side by side.
Cross in middle for better accessibility.
Floor equipment at bottom reachable with mop handle.



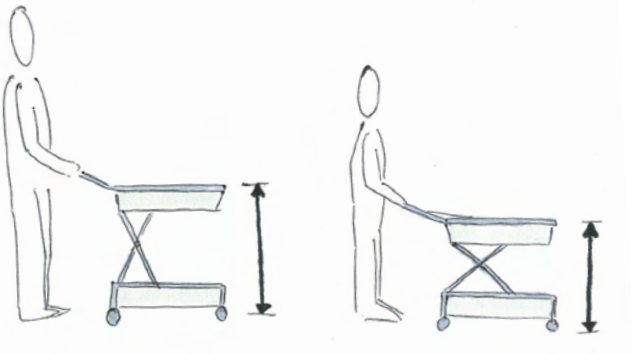
CEPT

Storage based on CLEAN:
Appear closed when stored.



Folding principle based on FLEX:
One smooth movement when folded up and down.


Helping mechanism:
Cart helps the user folding it up.



Height adjustability based on ERGO:
Adjustable to users' heights.

## Concept phase reflection

Starting the sketching without any limitations resulted in many useful principles that function as a sort catalogue where the group could pick out different principles and match them together with others to form a concept. Putting more principles together and drawing them in different use situations made it easier to see the possibilities and disadvantages of the different principles and their mix. This also resulted in a better understanding of the complexity dealt with and the many interrelations between different workflows and actors. Therefore the structure of creating three concepts each focusing on one main area were useful as it gave the possibility to get deeper into this area without being limited by too many criteria. The active use of prototyping proved really useful both internal in the group, but also when getting feedback on the workshop. It was much easier to take a stand on the different model than the drawings even though many of the models were simple cardboard models.

# PHASE4: PRODUCT DETAILING

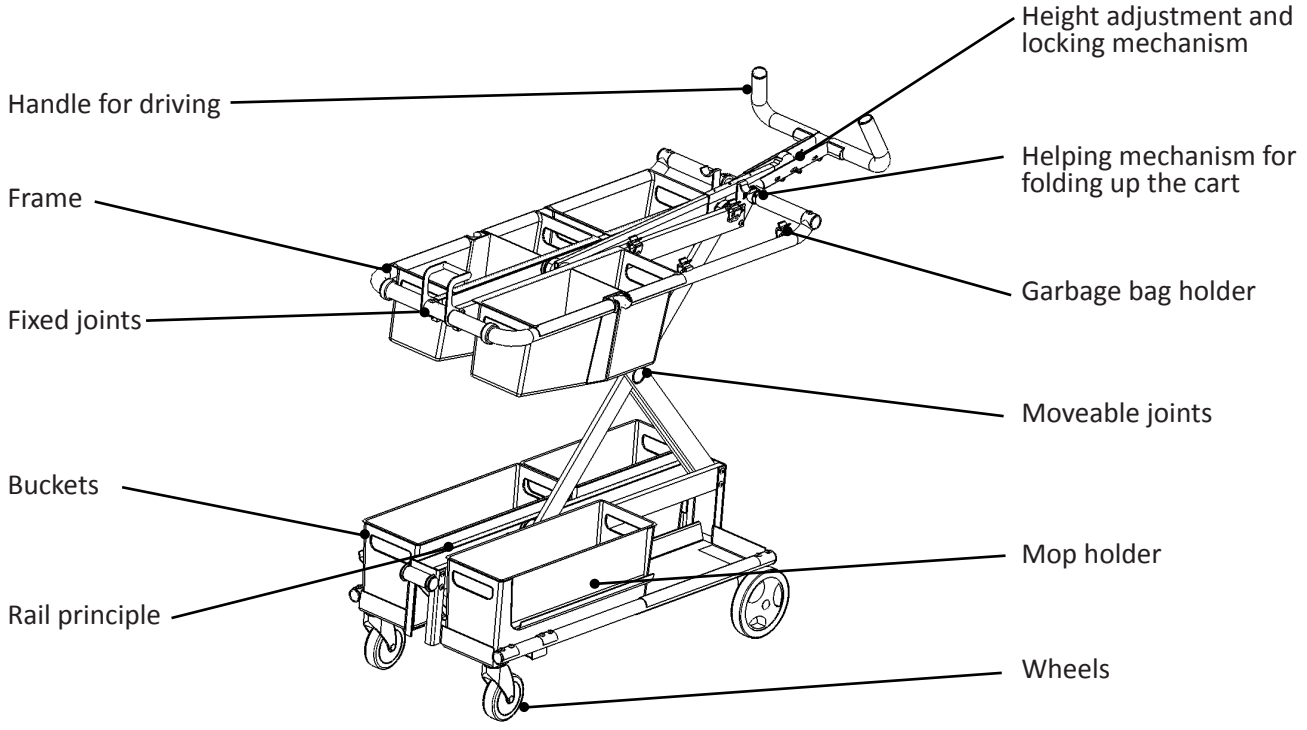
## PURPOSE

In this phase the concept will be detailed to make the solution more concrete and easier to evaluate. Because of the complex use situations, the solutions in the details are important for the overall use of the product.

## APPROACH

The software, SolidWorks, has been used in the detailing phase to relate the components to each other with their correct dimension. Many of the details have demanded physical mock-ups to be build to grasp the feeling of how the product is to interact with or how it functions. Critical elements in the structure have been investigated further in this phase by making strength and deflection calculations.

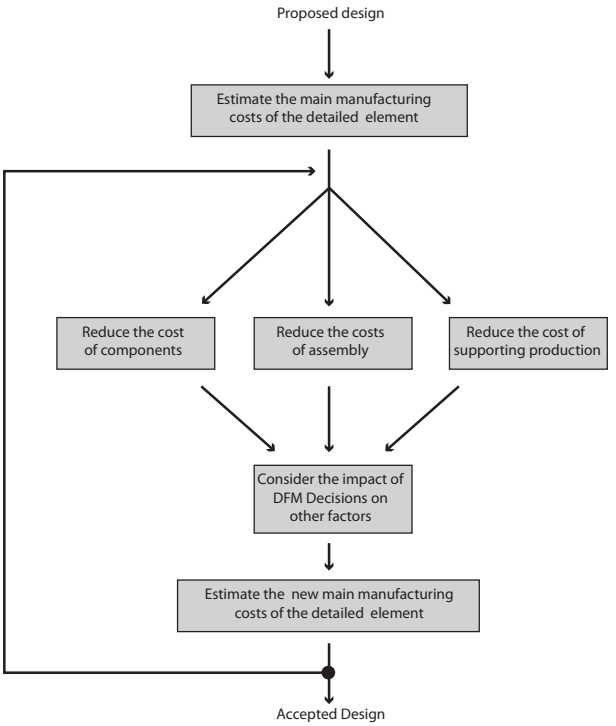
This phase is structured after the different elements of the Compact Cleaning Cart, see ill 60. Each element will be presented with a couple of the suggested solutions and an argumentation for the final solution was chosen.




Ill 60: The different elements that is detailed

## DFM method

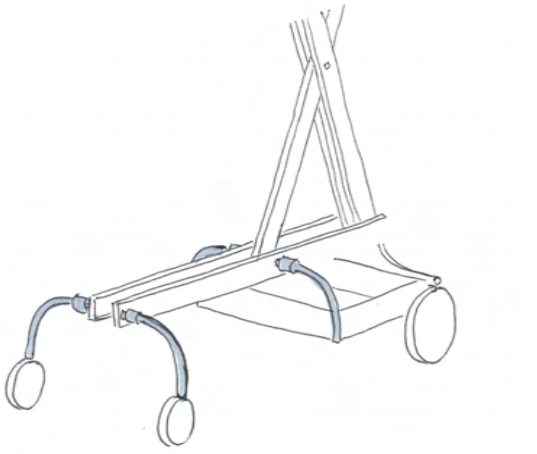
The method Design for Manufacturing (see appendix 11) has been used as an overall structure when detailing the different elements, see ill 61. Evaluations on costs of production and assembly methods have been made from the group's knowledge and the technical consultant's input. Considerations on inference with other objects have been important as well. The method has been used iterative for the each component, but the steps have not carried out as detailed as they are described in the appendix 11. Not carrying out the steps as detailed meant that the group could use the method more times instead.

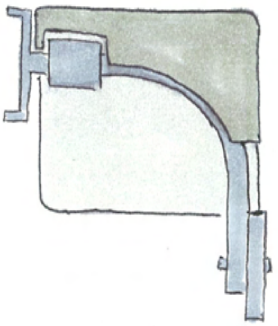



Ill. 61 The Design for Manufacturing method

# Frame

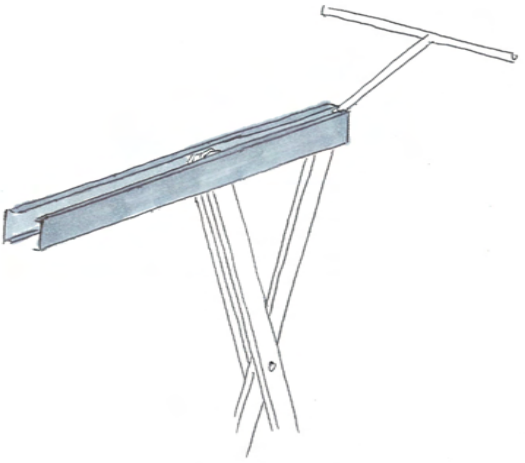
The frame sets the overall structure of the cart. Even though the structure with the cross was taken as point of departure there were several different ways of designing the frame. The frame has many assignments which all should be fulfilled and still achieve a simple structure easy to assemble and with a low cost price. First of all should it be solid with low clearance and durable materials. Second it functions as holder for the buckets, mops and the wheels.

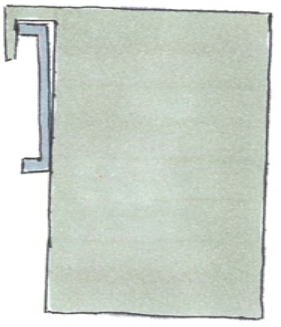




Ill 62: Round profiles attached on the rail, that carries the buckets

The wheels are connected to the rail through a bended tube. This tube is made a bit thinner closest to the rail creating a slot for the buckets to lock onto. This structure gave a negatively semiotic reference to animals with six legs, pointing out of a slim body.





Ill 63: Rail and bucket, where the bucket is attached to the rail.

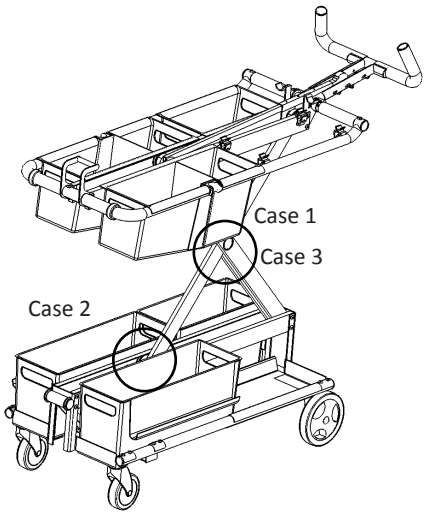
The simplest frame would be having just the rails with no outer frame. The buckets should then be attached on the rail, but without getting in the way of the folding mechanism. This however meant that all the weight of the buckets should be absorbed in one small plastic tap. Inspiration was found in the way shelves and boxes often are hanged in a refrigerator. Making the tap thicker would increase the width of the cart, which were not desirable as it easily should fit into a closet. After all, it was also necessary with some elements to fasten the wheels on and these elements were obvious to use for attaching the buckets as well.

Ill 64: final solution

The frame has two different functions to attach the buckets. In top frame the buckets are hanging down from the frame and in the bottom they are standing on the frame. This is done to have an outer frame that is connected to the handle and a bottom part that is connected to the wheels. The frame is used as the part that will be hit if the cleaning assistant is driving into unexpected objects.

## Investigation of critical elements in the frame

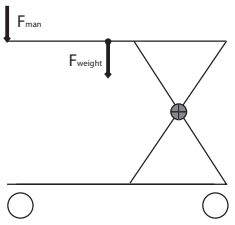
The most critical element in the frame has been investigated to find if it is strong enough to restrain the forces that it may be exposed to. It is estimated that the most critical element is the connection between the button frame and the rail as the cleaning personnel may roll the cart into a wall or another obstacle, see ill 65. Calculations in appendix xx show that the maximum tension the steel can resist is much higher than what is needed, see case 4 in appendix 17.



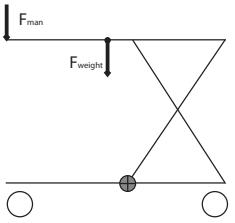

Ill. 65 Placement of critical element and forces

'Also the deflection in the frame has been investigated to find out if the deflection in the structure will be too much, so that the cleaning assistant will experience the cart as unstable. The deflection has been calculated in three different places, see ill 66.

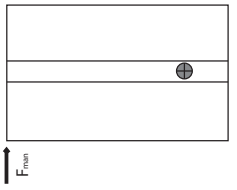
Case 1




Case 2




Case 3




Ill 66 critical places and the forces they are exposed to

The deflection that is calculated in the 3 places is:
Case 1 = 0,46mm
Case 2 = 0,26mm
Case 3 = 0,57mm

For further information on the calculations, see appendix 17.

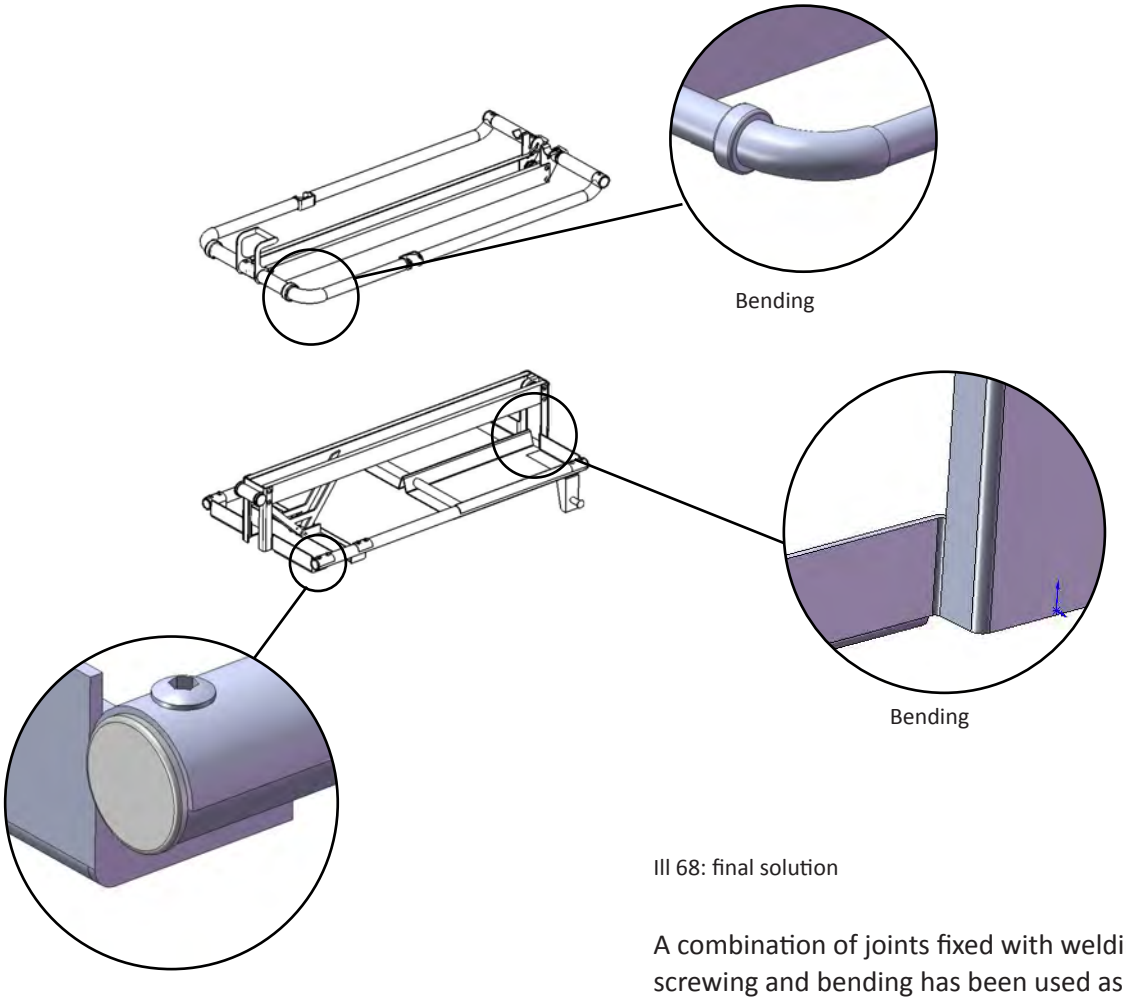
This is an acceptable deflection, but unfortunately the deflection found by the calculation is not the whole truth about how much movement the cleaning assistant will experience when using the cart. The calculations are made on a structure with fixed joints. How the moveable joints are made has a big influence on the movement in reality.

# Fixed joints

How the joints are put together has a big influence on the cart's cost price and it is therefore important the joints are made in the most appropriate way in regard to the expected sales number of 34000 carts. Different joint were considered during the development of the cart, see ill 67.

| | Ill x Welding | Ill x screwing | Ill x plastic corners | Ill x bending |
|---|---|---|---|---|
| | *Welding* | *screwing* | *plastic corners* | *Bending* |
| + | Closed connection | Can be disassembled | Good in mass production<br>Easy assembly | Quick procedure |
| - | Long production time | Needs holes and structure that makes it possible | Large start costs | Creates a radius |

Ill 67: Scheme to compare the different ways to make joints.

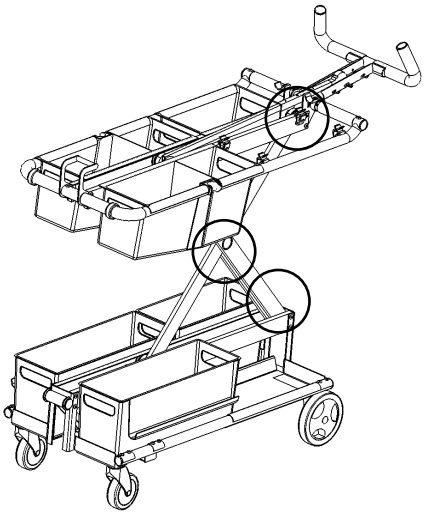



Ill 68: final solution

A combination of joints fixed with welding, screwing and bending has been used as these fits the number of produced cleaning carts. The selection between the different methods has been selected from functionality and production criteria. See illustration 68 for a further description of the different methods used.

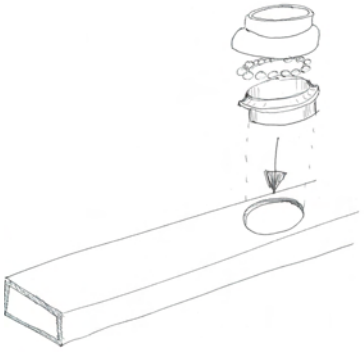
# MOVEABLE JOINTS

The moveable joints have a risk of creating instability in the structure. Small gaps or loose joints could give play in the structure. Inspiration for the joints was found in the way the headset connects the handlebars to the frame on a bicycle. An overall principle was created from this, which could be integrated in all the moveable joints on the cart with smaller adjustments. Illustration 69 shows the joints where this principle is needed and illustration 70 shows the actual principle.

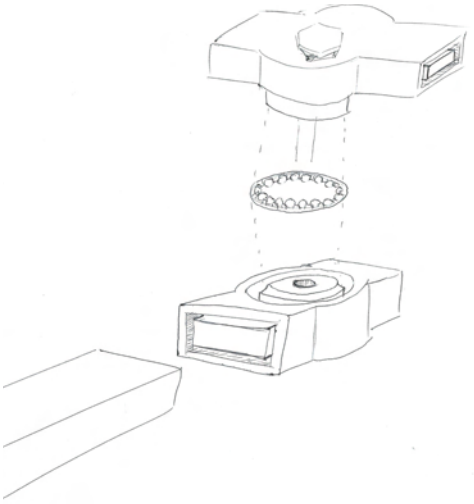


Ill. 69: Illustration of the cart with rings around the joints where the bearings is placed.

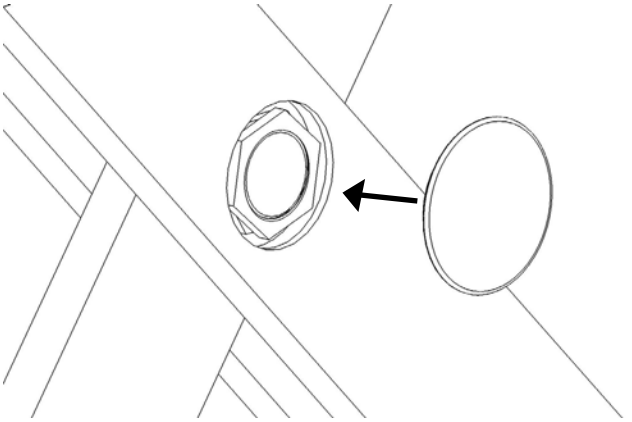
Two ways to do the attachment of the bearings has been sketched. Illustration 70 presents one options and ill 72 shows the selected solution.



Ill. 70: An exploded view of the principle used in the moveable joints. The bearings are angular thrust ball bearings which when tightened gives a high stability in the joints.



Ill 71: Joints made in plastic. The plastic joints support the expression of that the cart can be folded, because the joint become visual.

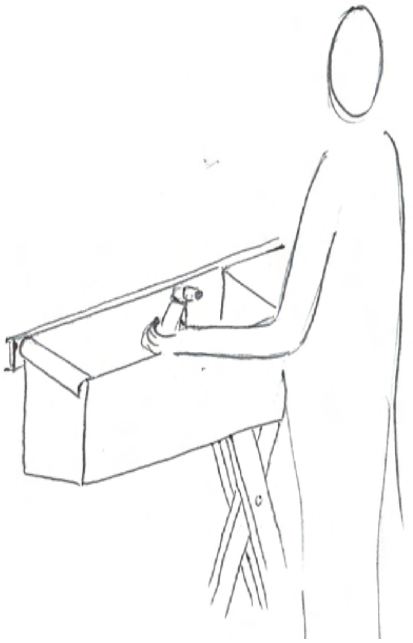


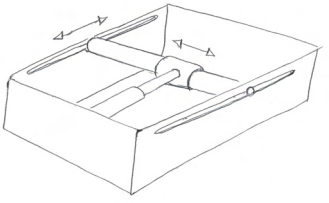
Ill 72: Final solutions, to fit the bearings in the metal profiles there are drilled holes. This solution has been selected because is its best suited for the number of elements produced, and the metal structure has the most strength. A round plastic plug is put in the drilled holes to visually support that the joints can rotate and at the same time it covers the bolt.

Having the joints with the pressed bearings gives a minimum play. Together with the total deflection in the structure found to be maximum 1mm, see appendix 17, the structure can be evaluated to be stable during use.

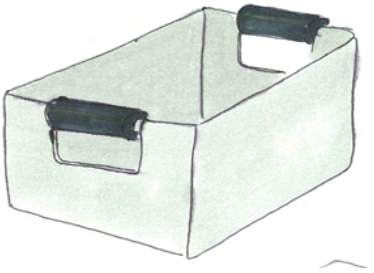
# BUCKETS

The buckets need to live up to many aspects. The overall criterion is that they can fit into each other when collapsed. The illustrations below present different solutions on accessibility for the user, how to take the buckets of for washing, how to hold their content when raised to vertical position and how to fit into each other when collapsed. At the same time the buckets are large and thereby a dominating element on the cart, meaning that they have huge influence on the overall expression. The bucket shall be possible to mould with a slip angle on 2%.

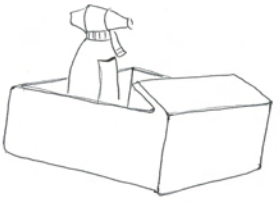




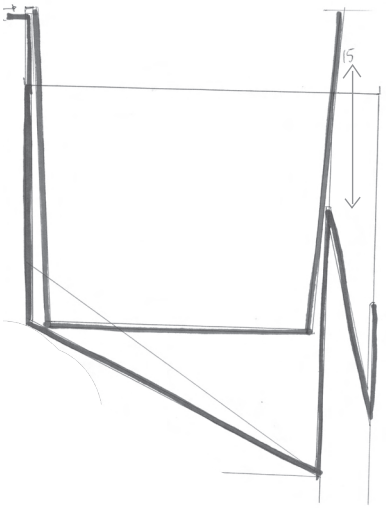
Ill 73: Different sketches have been made on how to make the buckets accessible for the cleaning personnel. The first sketch shows how the bucket could be angled towards the cleaning personnel. The second shows considerations about placement of the buckets and their size.



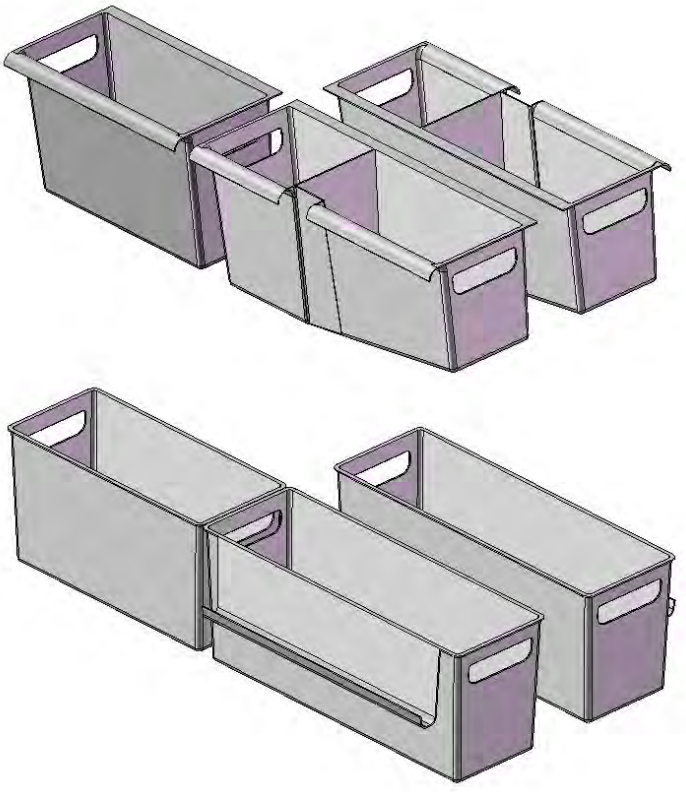
Ill 74: When the buckets are used they get dirty and it is necessary to be able to take them of for washing. The sketch holds a solid handle the user can grab when taking off the bucket. However, having a handle like this would complicate the mould for creating the bucket, making it expensive.



Ill 75: The bucket should hold its content when raised to vertical position. This could be done with adjustable bars as shown on the first sketch. This would probably quick become annoying for the user. Another suggestion was having edges on the buckets. The photo shows experiments with having the sides tilting which proved to work.




Ill 76: To make sure that the bucket could fit into each other and find the right shape, drawings were made from the side in scale 1:1.



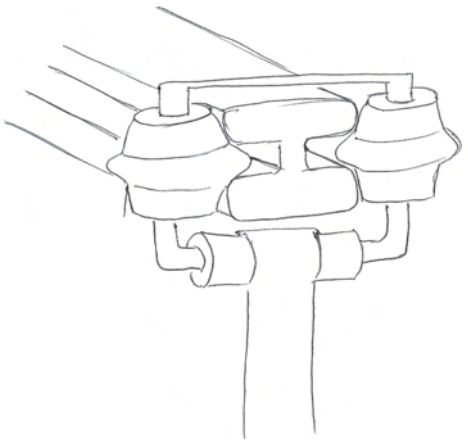
Ill 77: final solution

The top bucket is tilted 8 degrees to support that the content will not fall out when the cart is tilted. This depends on how the content is placed in the buckets. The contents can be placed in a way so it will fall out, but the test have shown the bucket needs to be much filled before this will be a problem. The angle of the bucket makes it easier for the user to get the detergent in the bucket closets to the handle. Holes for handles have been made in the bucket, to make it possible for the cleaning assistant to take the buckets of the cart to clean it.

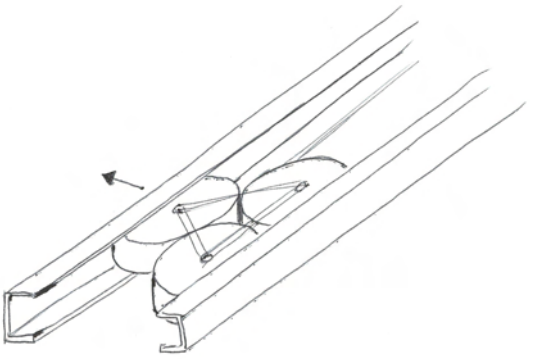
# RAIL PRINCIPLE

The rails are an important part of the structure and how they are formed has big influence on the play in the cart. To avoid twists in the construction, two rails are placed parallel in both top and bottom.

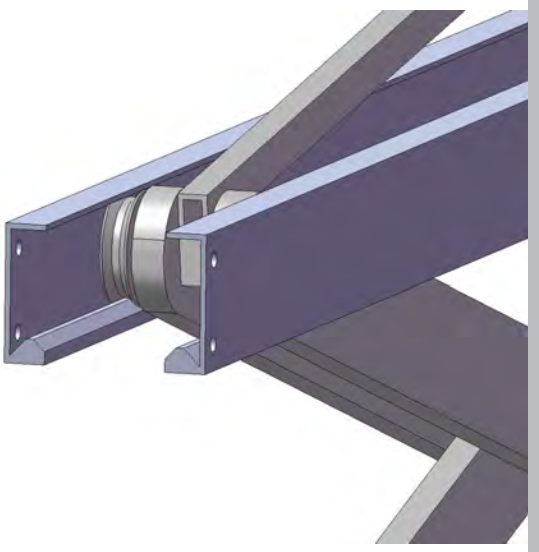
Ill 78: Some tables can be pulled in two parts, making it possible to put in an extra top leaf. This is done by adding rail with bearing on a string. This principle could be used on the Compact Cleaning Cart, but it would demand that the joint connected to the rail was possible to turn. Needing this joint to turn a wheel is an obvious solution, which makes the string bearing not useful.



Ill 79: By tightening two wheels together on each side of a rail, a construction is made which can obtain forces in one direction without play occurs. However, this construction would be about 7 cm wide and as two of them would be necessary to avoid twisting; this solution is too wide for the Compact Cleaning Cart.



Ill 80: By having three wheels placed in a rail like illustrated it is possible to adjust one of the wheels to have just the right pressure in the rail in order to easily roll without any play. This solution is based on a simple principle and yet it still becomes complicated as there are many parts. The solution therefore seems too complicated in regard to the task it has to solve on the cart. It is not necessary that there is absolutely no play in the rail.

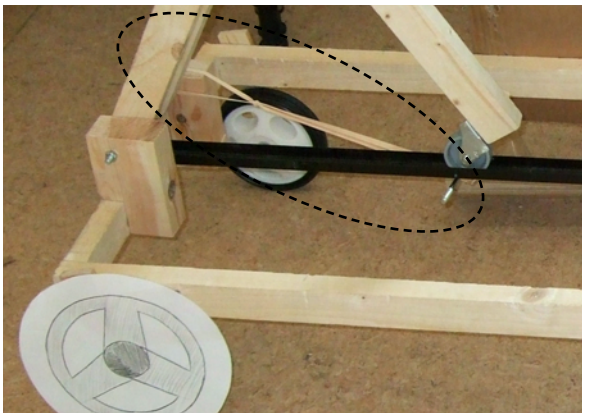


Ill 81: final solution. We accept some play as the joints have none in order to make a simple construction which does not take up much space. The rails are made of extrude aluminium, because the precision of the rails are important because the wheels could get stuck if the profiles where made of bended steel.
The wheels are v-shaped for less play (see sketch). This also have influence on the rails that have a similar shape to fit the wheels. The rails are closed in the top to secure that the wheels not will get out of the frame when the cart is tipped.

# HELPING MECHANISM FOR FOLDING UP THE CART

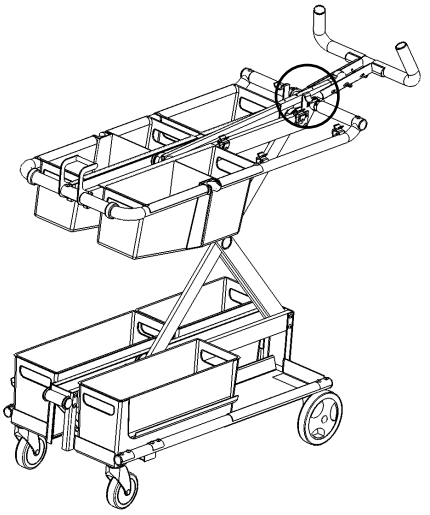
In order to make it easy and ergonomic for the cleaning personnel to fold in and out the cart a helping mechanism has been developed.

The spring principle has been chosen because of its simplicity, and low weight. Tests have been made with a rubber band, see ill. 82. The test showed that the placement of the spring and how strong it is has a big influence on the function of the spring.



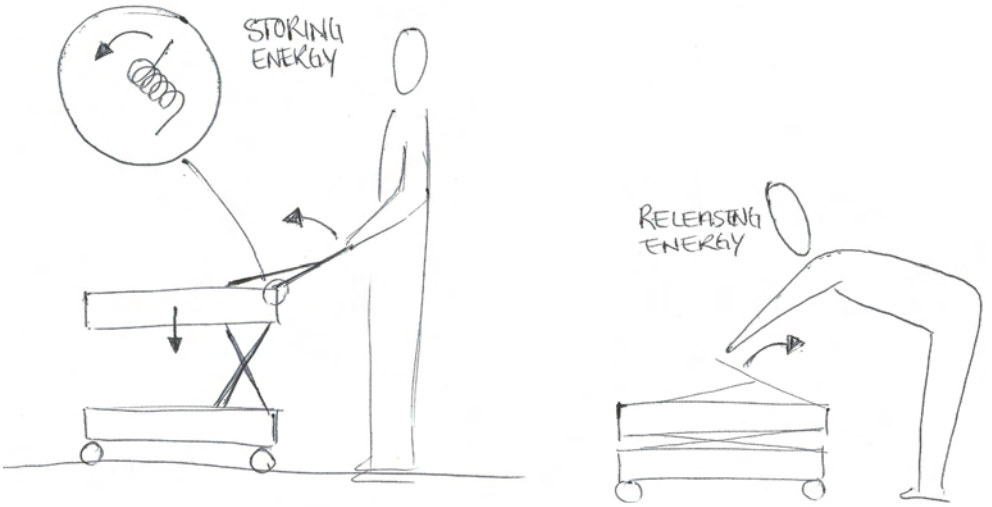
Ill 82: Spring test with rubber bands. When folding the cart the rubber band/spring is pressed, so that it will help lifting during unfolding of the cart. Having the spring placed as shown on the photo means that it should be very long and also have so large a diameter that it cannot fit into the rail (source: Karin Glargaard, Sodemann Industrifjedre, 2008)

The solution is a torsion spring placed in the joint between the handle and the frame, see ill 83. This is the best place to fit a spring, because the momentum in this joint is almost linear. This makes it suitable for using a spring as the spring force also is linear.

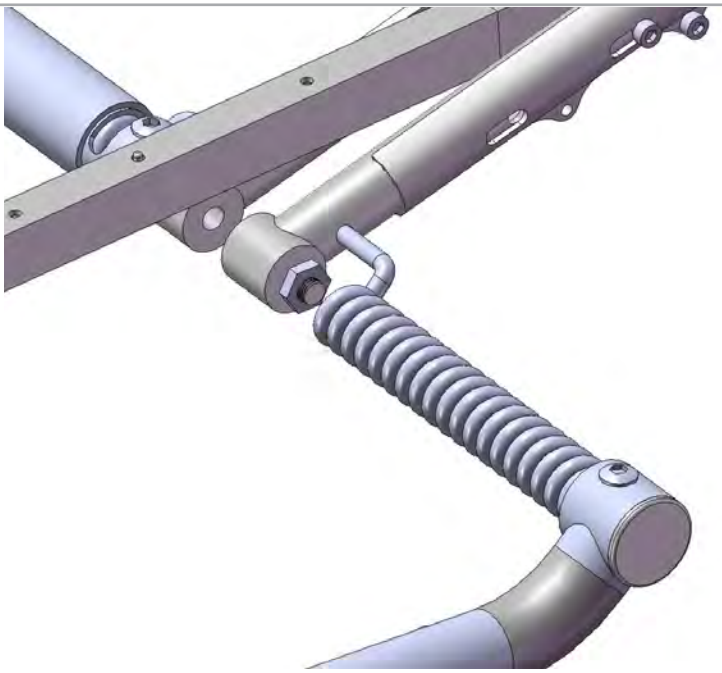


Ill 83. Placement of spring.

A torsion spring works by twisting the spring, so the force is obtained in the spring. When pressing the handle down the spring will obtain the weight of the cart, and when it later will be unfolded, it will use this force to lift the cart, see ill 84.



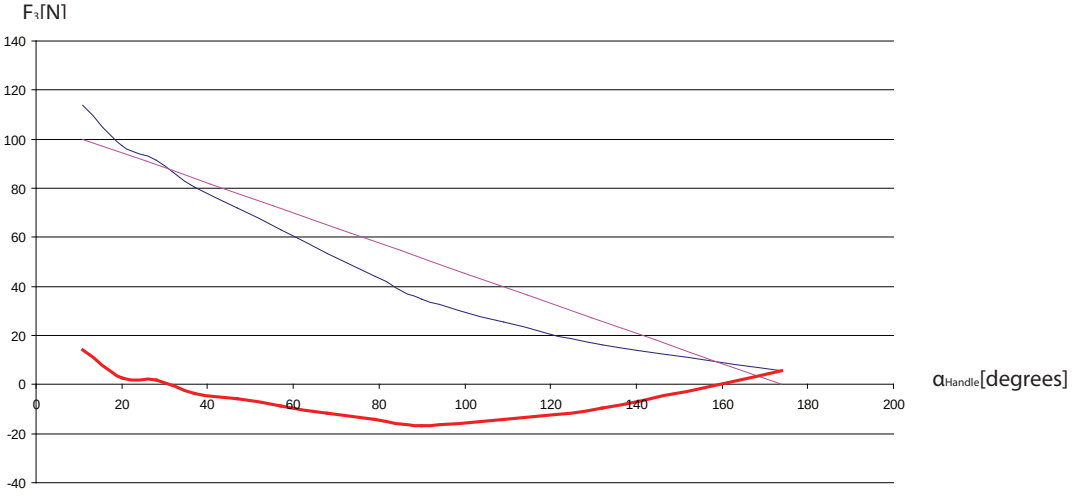

Ill 84: Principle of torsion spring



Ill 85: Final

Illustration 86 holds a diagram showing the force that the user needs to pull, when lifting the cart with a spring and without. The spring is placed inside the frame, so that it is not visible, dust collecting or interfering with the handle.

From calculations it is found that a spring that produces 1,5Nm is needed in each side, see appendix 18 for further information about spring calculation, and the forces that the user pushes to unfold the cart.

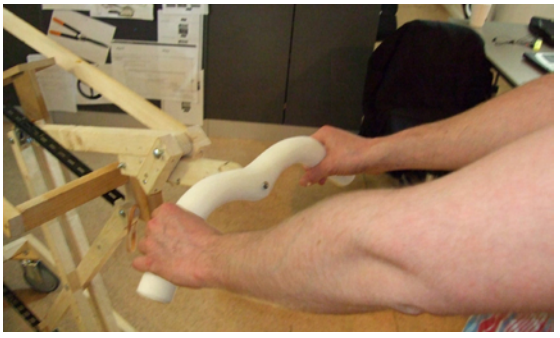



Ill. 86. The graph shows the force the user needs to pull.
- The blue curve shows the force that is needed to pull the handle without the spring
- The purple curve shows the force the spring is providing
- The reed curve shows the force the cleaning assistant shall pull and push the handle

## Handle for driving

When pushing a cart around all day it is important that the handle is formed appropriate. Some sketches where made but it quickly became clear that it was necessary to mock up some of the suggestions to try out how it was natural to hold on to them and how they functioned when collapsing the cart. Suggestions are shown in ill 87-89 and the final solution is presented in ill 90. The handle shall be used to both unfold the cart, and to drive the cart.

Ill 89: Model 3 is similar to model 2, but it is shaped so that the handle can be folded down in the buckets, when the cart is folded. The handle is big and has as model 2 many areas that can not be used.



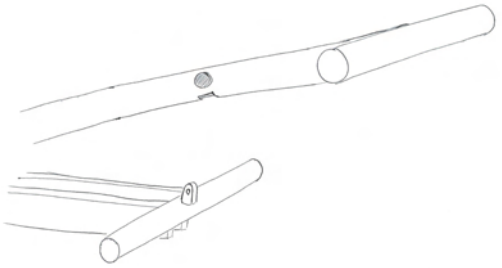
Ill 87: The model is shaped so it is very natural to hold for the wrist when pushing the cart forward. However, it does not give the user possibility to change grip. When the cart is folded down it is not obvious how to take a grip on the handle to fold it up.

Ill 90: The final solution is a combination of model 1's simplicity and model 3's functionality. The handle can work both when collapsed and when unfolded. When driving over steps, it is possible to press the handle down and lift the front wheels. The handle is shaped so it can be folded down into the buckets.

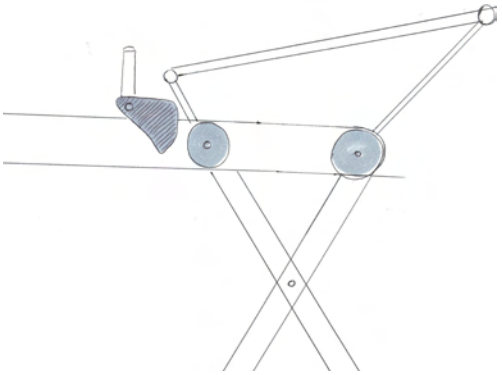
Ill 88: Model 2 is shaped so the places where user holds when lifting the cart are not the same as where is hold when pushing the cart. This gives each area on the handle a function. The handle fills a lot and have many unusable placed.

# HEIGHT ADJUSTMENT AND LOCKING MECHANISM

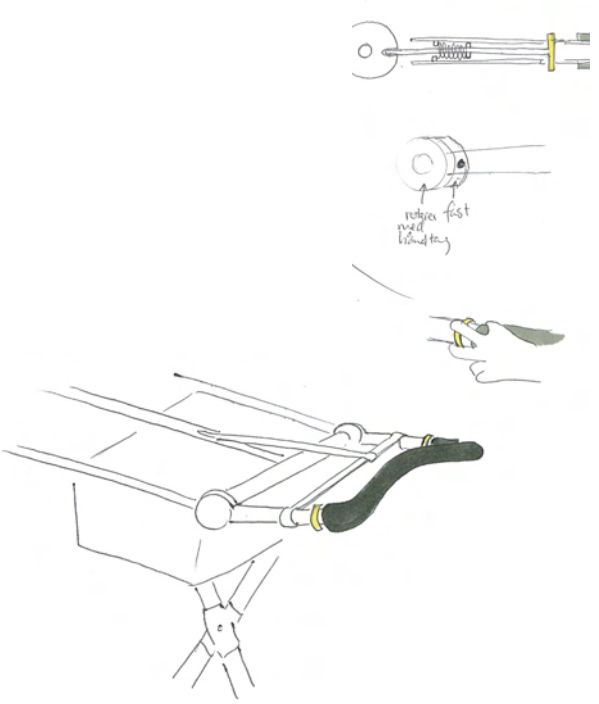
When folding up the Compact Cleaning Cart a mechanism must make sure that it can be adjusted in the right height and also that it does not collapse unexpected. When collapsed a mechanism must hold the cart together so the user can handle the cart without it folds open. The way the cart is being unfolded has to be easy for user to understand and follow a logical workflow. The locking mechanism has to consist of two motions for safety reasons, so that the cart only will fold when the user intents it to. The cart shall be able to adjust to the heights 90, 100, 110, measured up to the handle.



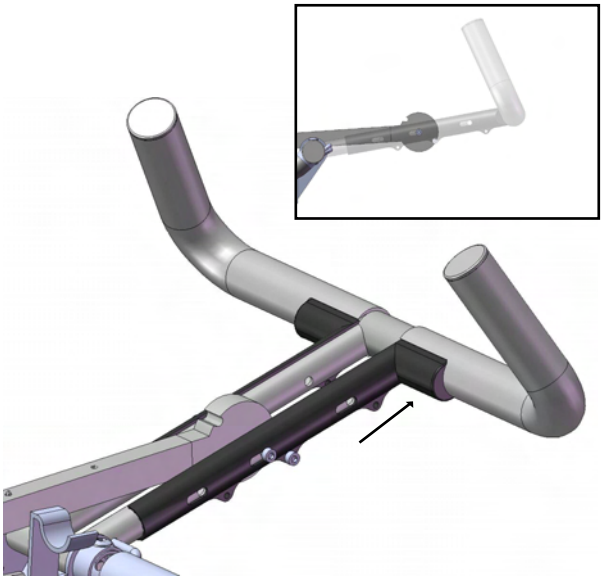
Ill 91: Locking mechanism 1
The locking mechanism is placed on the profile that is connected to the handle. The mechanism works by pushing a button. The button is placed a different place than the handle, making it difficult to both press the button and move the handle for folding the cart.



Ill 92: Locking mechanism 2
This locking mechanism is placed in the rails to hide it away. This principle does that the button sits faraway from the handle, and it will thereby not be obvious how to unlock the mechanism.

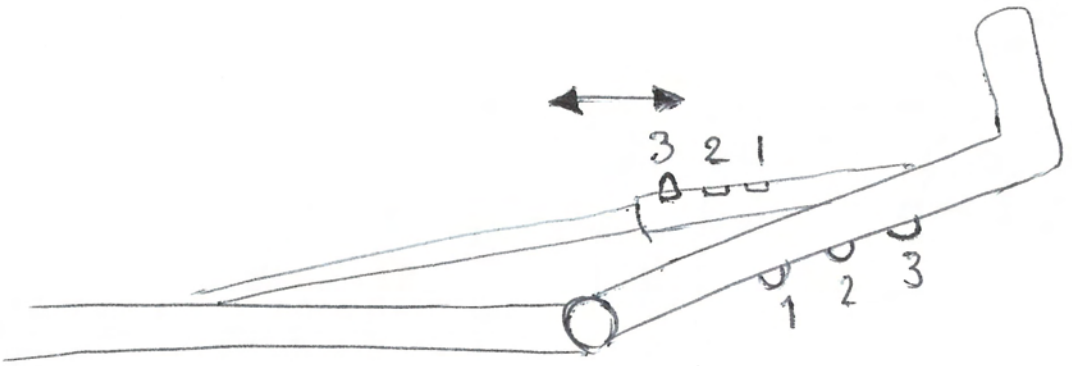


Ill 93: Locking mechanism 3
Principle 3 is a locking mechanism that is placed in that handle. This makes the flow easy for the user to unfold the cart in one motion.



Ill 94: final solution
The final solution works by two buttons in the handle that can be pressed down to unlock the mechanism. After this the handle should be moved in a circular movement to fold the cart. This movement is not logical when the intention it to push the cart, which prevents the cart for folding unexpected. The buttons are placed in the center so it does not interfere when using the handle for other purposes like maneuvering and passing steps. The buttons are placed strategically right both when they needs to be unlocked before folding and unfolding the cart, see ill 95.

Ill 95: Two photos of the model. The photos show that when folding the cart up the buttons are pressed with the thumb and then folding the cart down the index finger is used.




Ill 96: Principle of high adjustment

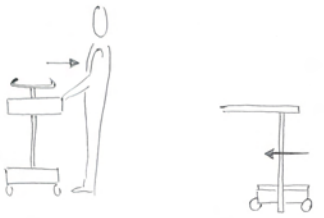
The cart can be adjusted in height to fit the different physical sized user group. The cart can be adjusted to 3 heights. To adjust the heights there is two places on the cart that shall be adjusted, see Ill. The adjustment of heights needs tools, and is therefore not an easy manoeuvre to do. However, it has been discovered during in observations that the users of the carts are very often the same so an adjustment of the cart every time is thereby not needed. The mechanism looks technical to symbolise that it is not an adjustment that shall be done every time the cart is used.

# WHEELS

The cart has to be durable in many different situations. In some of these it is an advantage to have wheels fixed in one direction and in others it is more useful to have free wheels. Ill 97 shows the advantages of the different configurations of wheels. It shall be possible for the cleaning assistant to drag the cart when cleaning and to pass steps.

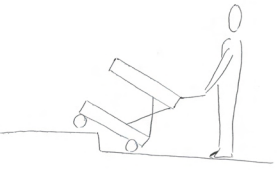
The most important situations are the actual use situation as this make up the largest time. During tests it became clear that it was possible to drag the cart towards you in most situations even though the back wheels were fixed. Also pushing the cart under the table was possible with two fixed back wheels. A solution was discussed where the back wheels could be fixed manually or automatically when needed, but these solutions seemed to complicate the product more than necessary. When collapsing the cart, the person would be standing behind the back of the cart. Fixed front wheels would therefore be preferable to tilt the cart to vertical position. Tilting the cart on the free wheels makes the cart act uncontrollable. Ill 97 presents different suggestions on how to solve this.

A

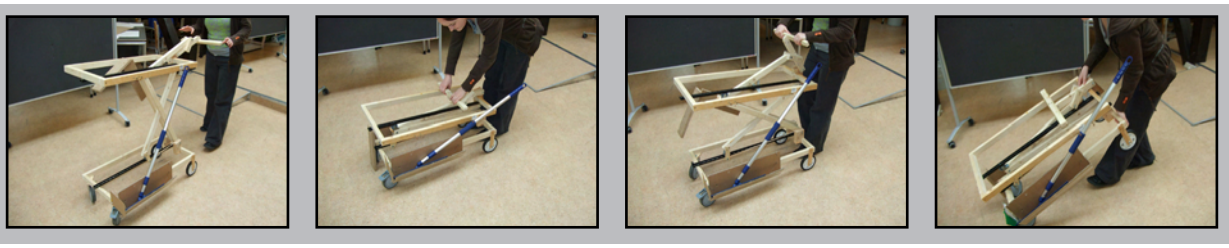


B

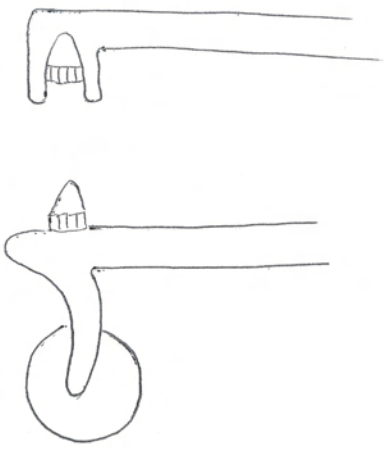
C



Ill 97:
A: Having four free wheels means it is easy to pull the cart in any direction. Also it is easy to push it underneath a table.
B: Fixed front wheels and free back wheels means it is easier to flip to the vertical position for storage.
C: Fixed back wheels and free front wheels make it easier to drive over steps.

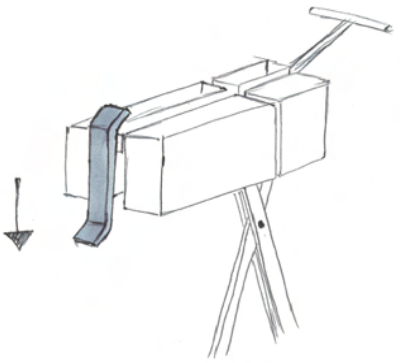


Ill 98: One way of doing it is having a foot coming down which will support the cart when it is tilted. This functions well, but is visual a very dominating object and the movement of it when folded down gives negative associations to a guillotine.



Ill 99: Fixes the wheels when collapsed

A way to lift the cart to vertical could be to fix the front wheels when the cart is collapsed. This could be done in one motion, so that the wheels get fixed in one motion. The problem with this solution is that all wheels are fixed and it is therefore not possible to move that cart around when collapsed. The cart will thereby not be able to push under a table.

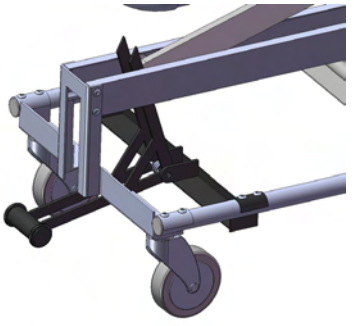


Ill 100: The foot on the top part of the cart

A simple solution could be to put a foot on the top frame of the cart and when the cart is collapsing the foot will function as a tipping foot, so that the front wheels do not touch the ground when tipping the cart. When the cart is unfolded the foot will be visible and without a function it will thereby just be in the way.

1

2



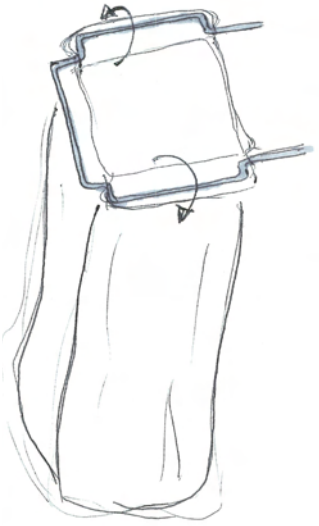
3

Ill 101: final solution

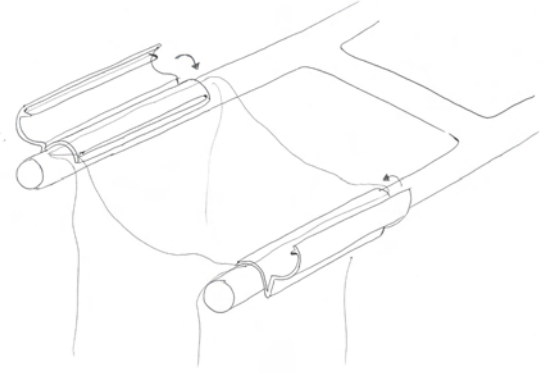
The final solution is an integrated foot that will work as tipping foot when the cart is folded. The foot is only shown when the cart is folded. The front wheels can still turn and it is thereby possible for it to be pushed around when folded.

# GARBAGE BAG HOLDER

Garbage bags are collected by hand and put into a larger garbage bag. A plate underneath the garbage bag is needed in order to support it. The garbage bag needs to be quick to attach and detach on the cart, and be strong enough to hold the content. Illustrations 102-103 presents some of the suggestions and illustration 105 holds the final solution.

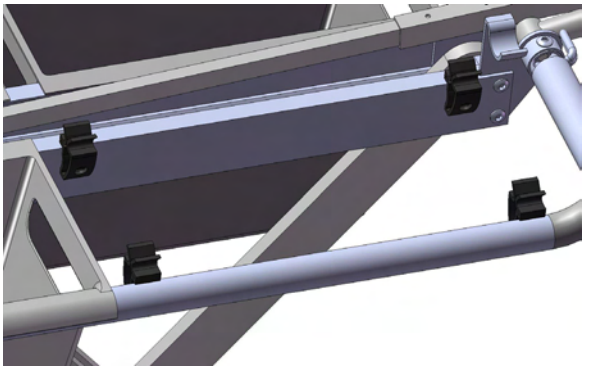


Ill 102: standard holder. It is quick and easy to attach the bag but nothing is holding it and therefore the bag easily slips of when full.



Ill 103: Plastic bag clips (noget der klipses ned over, smalt eller langt). This solution is inspired by the clips used for closing a plastic bag. It would hold the bag in place, but it takes two actions to both attach and detach the bag as the user first should put the bag on and then close the clips.

Ill 104: Model
To test the principle models has been made. The model shown on the picture is the selected solution.



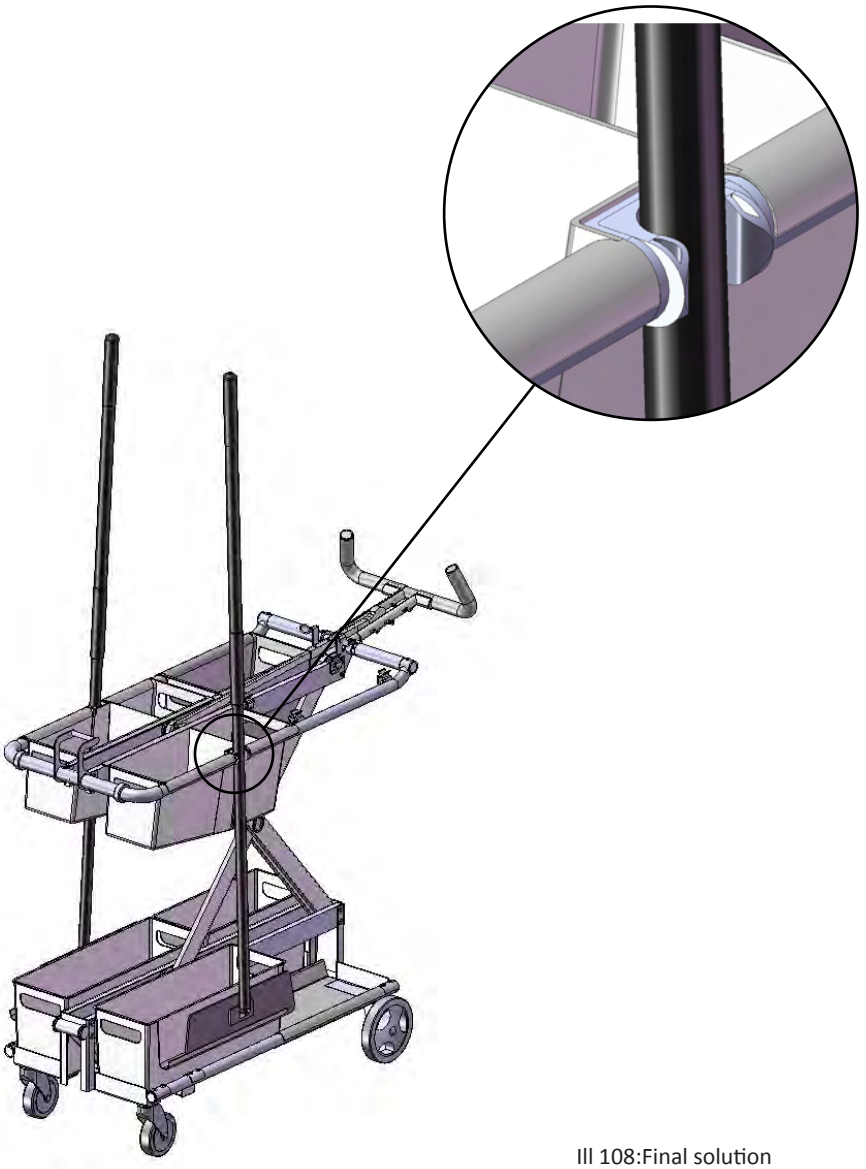
Ill 105: final solution. The bag is quick and easy to slip into the holder and due to the holder's angle; the bag will not be pulled out of it. However, when detaching the bag it is easy to get it off by pulling it straight upwards. One of the holders has an extra function as holder for the mob when collapsed.

# MOP HOLDER

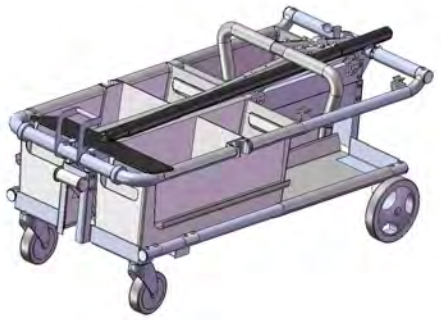
The mop handle shall be possible to place on cart both when stored and during use. The cleaning assistant shifts between mopping the floor and other work, and quick placement on the cart is therefore necessary. The mop handle shall together with the rest of the cart be presented organized to give clients the feeling of that the cleaning assistant is doing her best.


Ill 106: combined holder during storing and use
Illustration shows a holder of the mop handle that is the same both during cleaning and storing, so that the mop handle does not need to be move when cart is being folded. This principle does that the cart will become wider because the mops handles is placed on the side of the cart. The two mop handles when stored will make it difficult to unfold the cart.

Ill 107: ways to control mops under use
A solution where the mop handle is placed different when stored and during use will give a more organized expression when the cart is stored and makes it easier to unfold the cart. It has therefore been looked at how a mechanism for placing the mop handle on the cart could look.



Ill 108:Final solution



Conclusion on mop holder
A mop holder that uses the bucket to hold the mop in the button frame and a holder in the top frame has been selected. The holder in the top has a slip solution that makes it easy to attach the mop and take it again.
The holder for mop handle during storing is a solution where the mop handle is pressed down in a holder and another holder secures that mop handle do not fall out.

# EXPRESSION

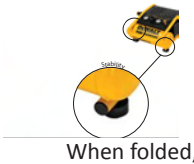
The overall expression of the cleaning cart takes point of departure in the moodboard developed in the analysis and it is both when the cart is folded and when it is unfolded (ready for use) that the elements from the moodboard is to be incorporated. The expression has gradually been developed in the entire concept and detailing phase and by all time, it has been the intention not to make the expression limit the functionality of the cart. Rather, functionality and expression should be coherent. A few of the sketches can be seen on ill. 109. The following describes the final expression and examples on how it relates to the moodboard.

Overall expression

When the cleaning cart is folded, it looks closed and organized and signals that it has finished it's job. When open, it shows its function of transport and storage, while being accessible. Having the crossed beams in the middle gives an open, accessible structure. The cross also reveals that the cart can be collapsed. The accessibility is in two levels, one for reaching with hands and one placed lower, which can be reached with the mop handle. The frame all-round the buckets in top and bottom gives a robust and protected look.

Ill. 109: Two sketches where there have been worked with the expression of the cart.

Ill. 110: Choice of colour
Different colour combinations have been tested out. The selected solution uses colours to expresses where the user shall be in contact with the cart, like the handles.



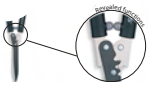
When folded, the cart can stand on a foot and two points on the frame. These are made robust and stand out from the cart and signals that the cart can stand on them safe.

When folded together, the buckets fold into each other. This signals a closed structure.

All buckets are placed behind the metal frames and thereby signal protection.

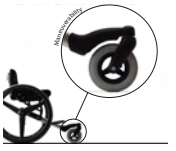
The mop handle can be placed in a holder that is integrated in the frame. The holder both signals and gives accessibility to the user.

The soft rubber covering on the frames signals that these can be used as handles.

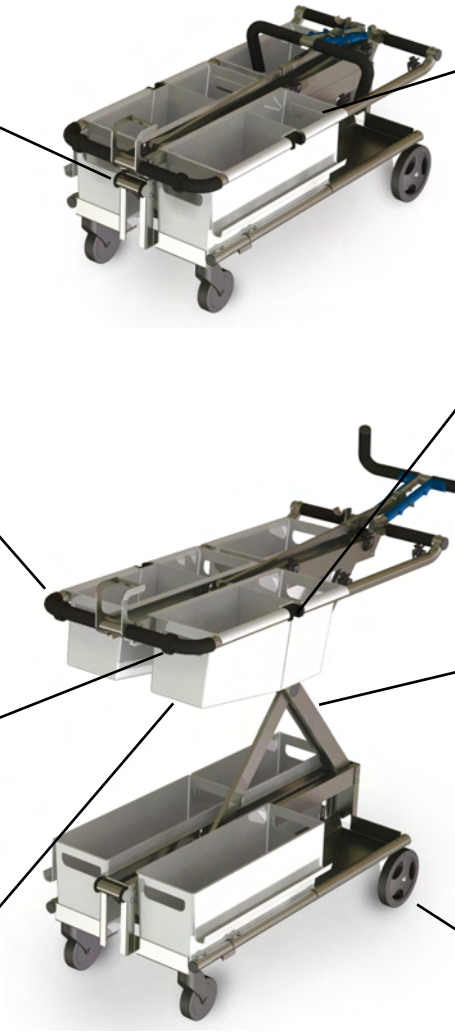


When folded out, the crossed beams in the middle signals that the cart be folded down.

The buckets on the cart are not all vertical or horizontal. Instead, the angled lines are used to create a more dynamical look.



A large wheel in the back and rotateable wheels in the front signals a high manoeuvrability.



Ill. 111: final product

## Conclusion on expression

Different elements from the moodboard have been incorporated in the solution, to create a serious, quick and comprehensibility expression. The main expression of the cart is very much influenced of the use principles, these have therefore been supported with shape and colour principles, to secure the right use and understanding of the product.

# REFLECTION ON DETAILING PHASE

A cleaning cart has many functions and consists of many small solutions which need to be tied together and that have been the biggest challenge of this phase. Changing one element has an influence on the rest of the cart and in the workflow. Therefore many redesigns have been made. When making decisions that have influence on many aspects, the criteria have functioned as a very important element to make sure that the right decisions where chosen.
It is important to be aware of what is most important for the Compact Cleaning Cart to be a success.
The Design for Manufacturing method could have been used on a more detailed level, but functioned well as it involved thoughts on production in the development process. It could be useful to use the method more thoroughly to make the compact cleaning cart even more production ready than it is at the current state.

# PROCESS REFLECTION

The project has been planned to be carried out with focus on three areas: user centred design, active prototyping and market research. The following text is a reflection upon whether these focus areas has been sufficiently covered in the project and what changes in the process could have been made to make it even better.

## USER CENTRED DESIGN:

"Understanding work procedures of a complex use situation through observations, interviews and analysis of collected data."

### Arranging appointments

Not only are the observations rather time consuming, but so is the time used to set the appointment up. The person in charge is always busy, but nobody else can set up the meeting. In addition, when starting up the project, the group knew little about both the project and the cleaning procedures and therefore it was difficult to decide how to use the different contacts. It was quickly learned that the only way forward is to "jump in to it", start somewhere and then work from there. You do not get anything if you do not ask. A big barrier in creating appointments for observations quickly were the many different persons which had to agree to participate in this. Going through a service provider, meant the he would have to get approval both from the cleaning personnel and the client. This could take several days and end out in a negative response. Therefore a more direct approach was taken by walking around from door to door and asking if it was possible do an observation of the cleaning at that company.

### Using personas

It was important for the group that the observations covered many different user types and environments to get a wide range of information, also including conflicting information. A big difference was especially seen in how the professional cleaning assistants and the non-professional cleaning personnel work. Both types of users have been important as the cleaning cart is targeted both. To comprehend the data, three personas were made, each covering different types of user. This was a really good way to limit the data into concrete persons which were much easier to relate to than them all at once. However, some of the observations made seemed to have printed themselves better into the minds of the group members than the three personas, resulting in that the group during the development process often referred to specific persons observed in stead of the personas. In this way some of the observations were prioritized higher than others and information for other observations could be lost in this process. This taught the group that much more work must be put in personalizing the different personas in order to make them stand out as actual characters, which creates images in the mind that can compete with the actual persons met.

### Observation method

Overall the structure of "context-of-use co-research methodology" was used, but as the group became more and more experienced in the observations, the method was used more freely. By doing several observations with the same subject, one can have a tendency to look focused for certain actions observed earlier.. Therefore the group at each observation tried to come with an open mind, not having any prejudices of how the cleaning assistant might act. From earlier experiences with observations it was learned that three persons is too many to observe one person as this makes too much interference. Instead, observations were always made by two group members.

### AEIOU and ELITO

Having gathered all the observation data on

photos, videos and notes it was necessary to process it. Two methods were applied, which were not used by the group before. This was the AEIOU and the ELITO framework. Just the fact the method forces the group to print the data and hang it on a board was found helpful. First of all, all group members were introduced to all observation data during this, and second the AEIOU framework made the group reflect on what kind of observations were made in order to be able to add it to the right category. Having the observations structured, the ELITO framework was good at getting the data transformed into more tangible values and phrases. Both methods took some time to adjust to, but will surely be less time consuming the next time. The process was divided into several small steps which next time can be handled at once as the group now has more of an overview of the two methods. The actual practical method of using small paper notes put on the board with pins did not turn out very well. It was too time consuming to move the notes around. Next time a more flexible system must be set up on a surface where the post-it notes easily can stick.

### Workshop

There are different levels of involving the actors around the product on. In this project it was chosen to use them in observations and in a workshop. The goal of the workshop was not to involve the users in the actual development phase, but to get comments and learn more about how they would interact with the product suggestions, as these people are experienced and know all the large and little problems. In that way it was more a test of the products than an actual workshop. The more concrete the material for the tests is, the better the users can relate to it. Still there is a balance in quickly creating the material, get comments and move on, in stead of using a lot of time on creating material which could have been understood easier in another way. It was a positive experience, seeing how well the cardboard models and sketches were understood by the users.

### Conclusion on the use of user centred design

There are more ways of doing user centred design, but the focus in this project has been observations and processing of these. The user observations have been a very integrated and important part of the project. New methods have been learned and used with success - by that the group's competences within the area has been improved.

## ACTIVE PROTOTYPING:

"Use prototypes as an active part in the development process to explore and communicate solutions"

### Barriers

There are different media to express ideas and solutions. Some of them come easier e.g. sketching in hand or on computer. Doing actual prototypes demands a bit more work and materials than many other methods. This is often a barrier to get stated on the prototyping as a part of the development and to overcome this barrier active prototyping has been set as a focus area of this project.

### Level of detailing

Active prototyping has been discovered to be a great tool in some situations and not useful in others. As it is very time demanding it is important to be aware of when to use it and on what level to use it, meaning it is essential to know what the goal of the prototype is before making them. In that way it is possible to hit the right level of detailing of the prototype.

### When to use prototypes

The awareness level of using prototypes has been very high in the group and many discussions on when to built a prototype, what type and how has been carried out. In this project the prototypes had been very useful when grasping a special size of e.g. buckets or shape e.g. of the handle. In many cases the prototypes have helped making a decision which could not have been made on basic of e.g. a drawing. It is often easier to relate to a physical model than it is to relate to a flat drawing. Also

further development of ideas has in some cases been easier by using prototypes.

### Conclusion on the use of active prototyping

Many prototypes have been created in this project and many of them in very short time, just being a few cardboard boxes put together. The group have experienced that it does not have to be very time consuming to build a prototype and to get a concerned case decided through it. It is about knowing what the goal of the prototype is and then quickly put something together of the present materials.

## MARKET RESEARCH:

"Systematically gathering, recording and analyzing data and information about customers, competitors and the market so the product developed relates to its context."

### Network of actors

There are other actors in contact with the product than the end user. Even though much focus in this project has been on user centred design in regard to the end users, it has also been important to see the product from other viewpoints. Therefore a network of actors have been mapped and investigated. Here many conflicting interests have been found and it has been a challenge to structure these interests, to create a united set of useful criteria.

### Getting information about actors

The group has tried to get as much information as possible though direct contact to the actors. The Internet can provide basic information but many of the keys to transform the information into useful knowledge are gained through conversations with the actors. They have the experience and explanations which cannot be found elsewhere. But at the same time it is important to be critical towards the knowledge gained this way, as the different actors mainly sees the situations from their point of view.

### The market

One of the more difficult actors to investigate has been the competitors. DIT International has been visited and this gave a relatively big understanding for their company, their values and their products. However, the other representatives of the competitors have not been visited and the information on the Internet did not give the same understanding for them as where gained for DIT. By taking inspiration in the Vita Riis analysis, the group set up a set of design parameters and place the competitors and the Compact Cleaning Cart in relation to this in a strategy canvas. Even though the foundation on which this strategy canvas was mainly made from the group's own perception, it still functioned as a useable tool for the group keep focus on what is important. If the strategy canvas should have been constructed on a better foundation, it should have been based on the different actors' opinion and not the group's. A more methodical approach to this issue would have been preferred.

### Conclusion on the use of market research

A context has been developed for the Compact Cleaning Cart. Not all the viewpoints, creating the context for the Compact Cleaning Cart, has been investigated on the same level, but an understanding for all of them has been gained.

## CONCLUSION ON THE FULFILMENT OF PROCESS GOALS

The group has focussed their process to revolve around the three process goals and thereby worked within all the areas and developed their skills. It has been natural to integrate these areas in the development process and therefore some good area to have skills within when in the future working with product development.

# PRODUCT REFLECTION

The following is a reflection upon whether the Compact Cleaning Cart fulfills the criteria.

## ERGONOMICS

Ergonomics is an important part of the Compact Cleaning Cart as it is a part of improving the cleaning personnel's work procedures which is stated in the problem formulation for the project.

### Height adjustable

It fulfils the guidelines set up by "clean lines" except from the large height adjustment of the handles from 85-130. During the development process, it has beem evaluated that this large range is not necessary, based on tests on small and tall persons. The heoght adjustment has been limited to 90cm-110cm, meaning that the cart fits users in the height of 150cm-195cm.

### Work flow

The structure of the cart is designed so it takes into consideration that the user should not bend or twist. This is made by having the equipment used by hand on the top, in a height adjusted to the user. The equipment which should be used on the floor can be reached with the mop handle in the bottom of the cart. Also the cleaning method chosen, the moisturising method, is ergonomic correct as the user only handles the needed amount of water. On the downside it uses a lot of mops, which the cleaning personnel have to put into the washing machine.

### Folding mechanism

In the folding mechanism a spring is added to help the user fold and unfold the cart in order to avoid heavy lifts. There are also taken a lot of precautions in the folding mechanism in regard to safety such as the two position locking mechanism and mop holders with makes sure that the mop handle can be placed securely. Still there is a safety risk connected to folding the cart as it is possible to get a finger stuck. However, when standing behind the cart to unfold/fold it, the person is not in contact with critical places where fingers could get stuck.

## WORK SPEED

The work speed is connected to efficiency which have been an important aspect for the Compact Cleaning Cart.

### Logical use and order

The cart should be logical how to use and this is done e.g. done by the logical structure described in the part about "ergonomics" above. Also the materials are used to make it logical where to hold. Shaping of e.g. the handles of the buckets makes it evident how to lift the buckets of the frame. Also the colours are used to express how the product should be used. The blue adjustment mechanism signalize where the user should grab to unfold and fold the cart. A logical structure of the cart helps the cleaning personnel maintain order. However, it has been observed that many cleaning personnel somehow has added items to their cart, giving the cart an unorganized expression, see ill x. It is not possible to predict whether the cleaning personnel also will add items to the Compact Cleaning Cart, but it seems more unnatural as the structure dictates that all equipment should be kept in buckets. On the carts observed, the structure already invited to add items as the original structure has hooks to hang items on.

### Manoeuvrability

There are handles in both ends on the cart to make it easy to move and turn the cart. The handle in front does that the cleaning assistant is not forced to go back to the same handle every time the cart needs to be moved.

Assembly, preparation and storage
Due to the storage principle the cart can be transported totally assembled, which means

that the buyer or cleaning personnel do not have to waist time assembling the cart. When it arrives it is ready for use. The folding up and down is created in one smooth movement and the spring helps. After use, it can be stored with items in the top buckets and when the dirty mops are thrown in the washing machine the bottom part is empty and the cart is ready to fold.

# PRICE

The price of the Compact Cleaning Cart is dependable of the number of carts produced. The different productions method has among other been chosen in regard to this.

## Plastic buckets

The plastic buckets and their mould are a large part of the expenses for the Compact Cleaning Cart. If the buckets were kept even simpler, standard buckets might have been possible to use. However, the buckets are a big part of the cart and it is important that they functions in regard to all the criteria set to them. Therefore it was chosen create special buckets that were relatively simple to mould. The two large bottom buckets are alike and the same mould can be used.

## Lifetime

The cart is made in very durable materials such as metal and plastic. The main issue will not be if the material can last 10 years but if the folding mechanism will continue to work. Dust can enter the rails and stop the mechanism, but this can be repaired. The joints' principle is taken from other products, which have a very long lifetime as well, and needs to resist even tougher environment. Therefore the cart must be expected to last 10 years.

## Cost

The limit for the cost price was 1470 Dkr, but it was estimated that the cost price would be 1740 Dkr., see appendix 19 for further details. Therefore the criterion for the cost price is not fulfilled. The main reason for this is that the processing of many of the parts, e.g. the end parts for the rails, becomes relatively expensive as they have to be both waterjet cut, bended and welded. Having used the method Design For Manufacturing, the group has been aware that this would be expensive parts, but the development of these have been downgraded in order to get the Compact Cleaning Cart to function as intended. This means that the cost price probably could be lowered if some of the parts would be redesigned in regard to fit better into production, though another turn of Design For Manufacturing.

# STORAGE SIZE

The storage is the basis of the project and it has therefore been highly prioritized.

## Storage

The cart has a size of 45cm x 95cm x 43cm when folded and is therefore not smaller than the limitations set at 50cm x100cm x 40cm. Even though it exceeds the limited measures a bit, it does not have much influence on the storage places where it is imagined to be stored in and there is therefore the same range of storage options. The fact that it can be stored both horizontal and vertical gives many storage possibilities

# CONFIGURATION

Many of the existing carts on the market can be configured. The Compact Cleaning Cart is only made in one edition.

## Only one edition

Having only one edition fitting both one type of floor wash and two types of floor wash could possibly result in either having too much space or having too little. There will be places where the cleaning cart does not have enough space on it e.g. if a place have a need for separating the garbage or need to bring exceptional many refill items. However, it has been observed that the needs are not that different from place to place and therefore the Compact Cleaning Cart is sufficient in most situations. This assumption is supported by statements from retailers and service providers saying that the focus often is on one model even though there are more

configurations of it. Thereby they say that the configuration possibilities in most cases are superfluous.

# EMOTIONAL SELLING POINTS

The emotional selling points are evaluated up against the shape board.

### Shape board

More of the elements on the shapeboard are used in the cart. The saddle bags of the motorcycle is used in the shaping of the buckets to create dynamic expression. The large white surfaces of the buckets helps create a serious expression and the same does the frame around the buckets by visualizing that the cart is protected and thereby important. The cross in the center creates very open structure with easy accessible buckets. There are not added unnecessary items to the cart to keep it simple and understandable. Doing this the, important elements cart be highlighted e.g. like the locking mechanism.

# CONCLUSION

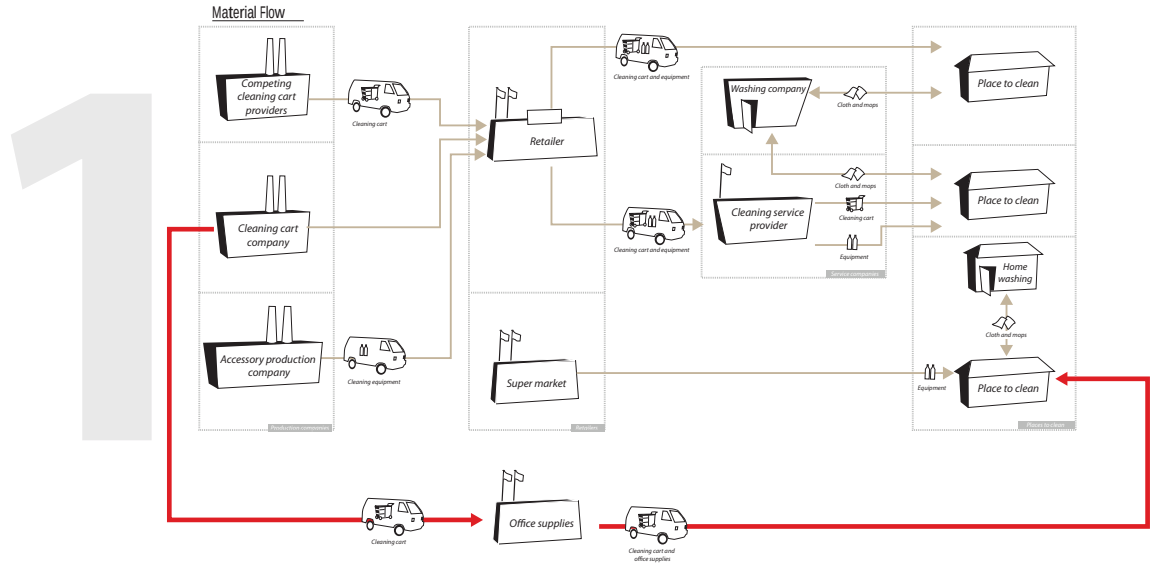
It has been possible to a large extend to fulfill most of criteria. What was downgraded was the production, but this was still thought into the product in some of the solutions created. The project has been a functional case for fulfilling the process goals and the product has been taken to a state where drawings for production and assembly has been made. By that, the goal of the project has been fulfilled and have gained the group greater competences as designers.

# THE COMPACT CLEANING CART IN PERSPECTIVE

The Compact Cleaning Cart in perspective
Following is opportunities for the Compact Cleaning Cart discussed.

## Sales approach

The Compact Cleaning cart has potential to be sold to a market segment which the retailers of cleaning cart currently are not in contact with. There are different possibilities for this. On illustration 112-114 are some possibilities shown and by each is a list with pros and cons.

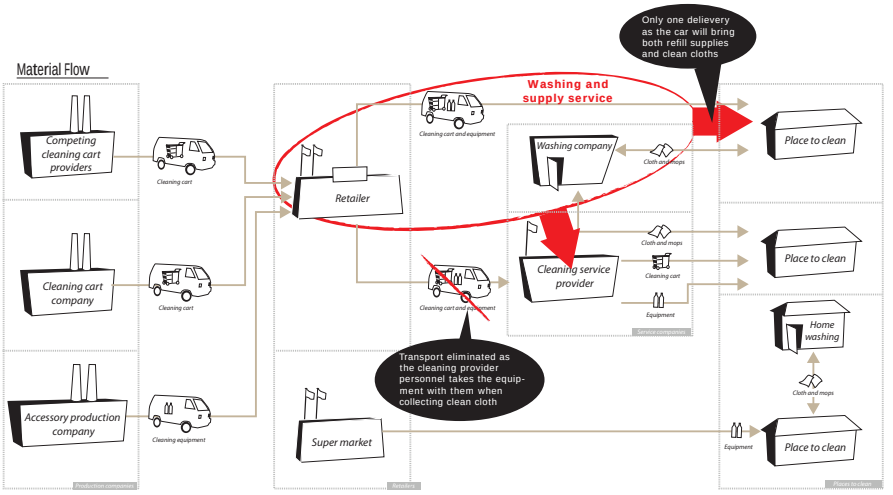



Ill 113:IDEA: Combining retailer and washing company in one service.

\+
- Have already established contacts to buyers
- The office suppliers reach new costumer
- Fits to Compact Clean Cart concepts

\–
- Suppliers of office supplies may not be interested in selling cleaning carts, because it is a different product group
- It is a onetime deal
- Conflict between the two retailers

2

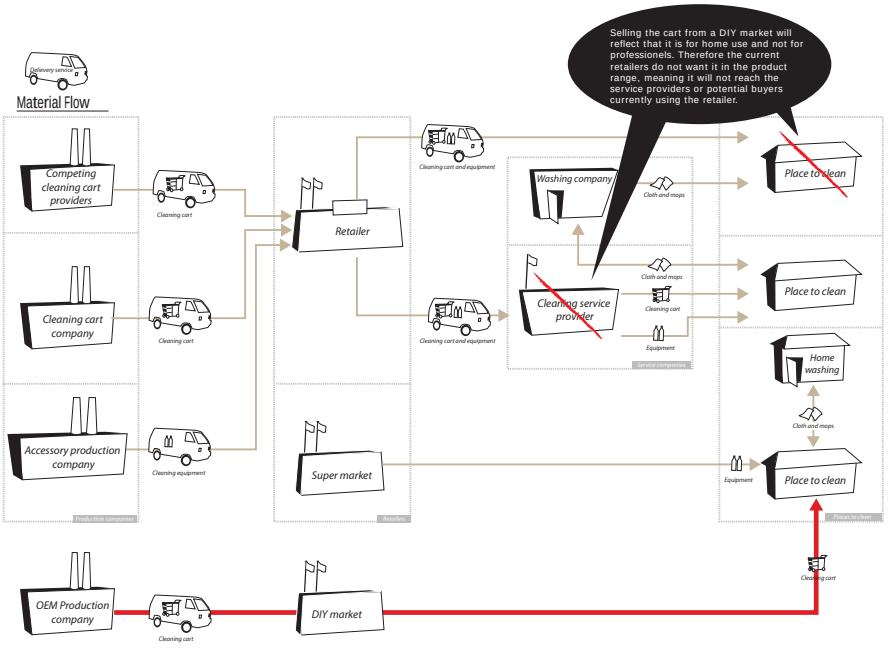



\+
- God service for clients not using service providers
- Money made on refill items instead of sell of carts. Continues money earning

\–
- Competes against existing retailer
- Hard get clients to change retailer
- The buyers can easiest be reached through their current provider of suppliers
- The potential sales figures is low

Ill 112: IDEA: Selling the compact cleaning cart through an already established contact e.g. office supplies.

3




\+
- Focused on smaller firms
- New product range
- More exposed then existing retailers
- Fits to Compact Clean Cart concepts

\–
- No service providers will buy it in a DIY retailer, a big part of the target group do thereby not buy the compact clean cart
- Conflict between being a professional product and being sold at a nonprofessional store

Ill 114: IDEA: Selling the cart through DIY markets where the clients come

## International market

The compact cleaning cart is developed with point of departure in the Scandinavian market and its attitude towards the importance of ergonomics. Even though this is valued very high in the Scandinavian market, the international market does not share the same attitude. This became clear at the meeting with DIT International who sells their cart mainly on ergonomic sales points. If the Compact Cleaning Cart should be sold on the international market, the main selling points will change to have more focus on the improvement of the cleaning personnel's efficiency. On the international market the Compact Cleaning Cart will set it self apart with the feature of being storable in limited space.

## The next step

When the cart has been developed to a certain state it is time for it to be put into production. There are different ways of address this. One could be to contact a production company and present the Compact Cleaning Cart for them. It would be important to be ready to adjust the Compact Cleaning Cart to their production system. Another possibility could be to contact a big retailer or maybe one of the actors who in this project has been conceived as competitors, which could be interested in having the Compact Cleaning Cart as product in their port folio.

# ILLUSTRATIONS

Own illustrations and photos are not stated

Ill 9: http80.197.243.bmp
Ill 10: www.rezahygiene.bmp
Ill 23: gettyimages.com
Ill 24: gettyimages.com
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Title: Design gennem 200 år
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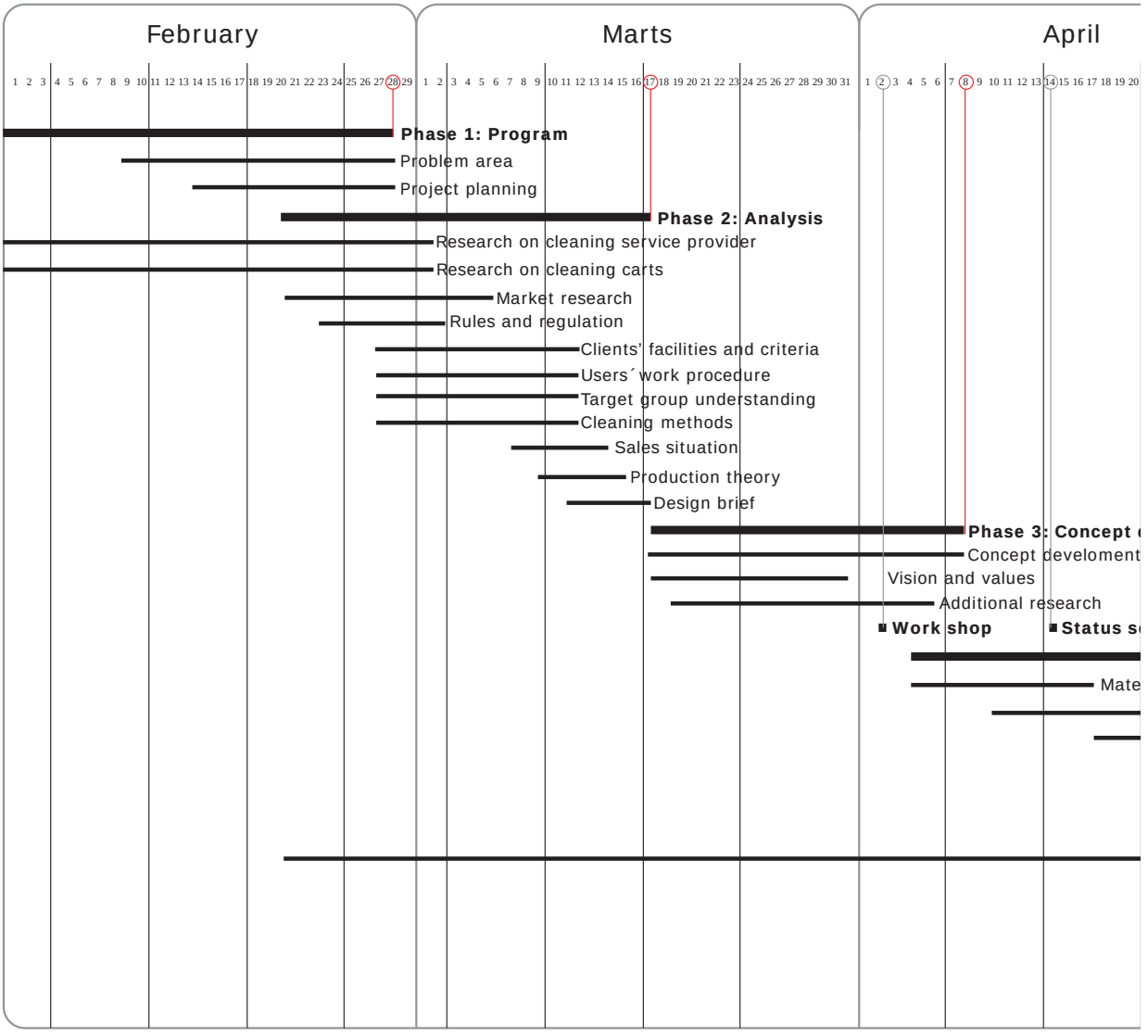
Aurtho: Arbejdstilsynet
http://www.at.dk/sw4753.aspVisited
30.01.2008 10:00

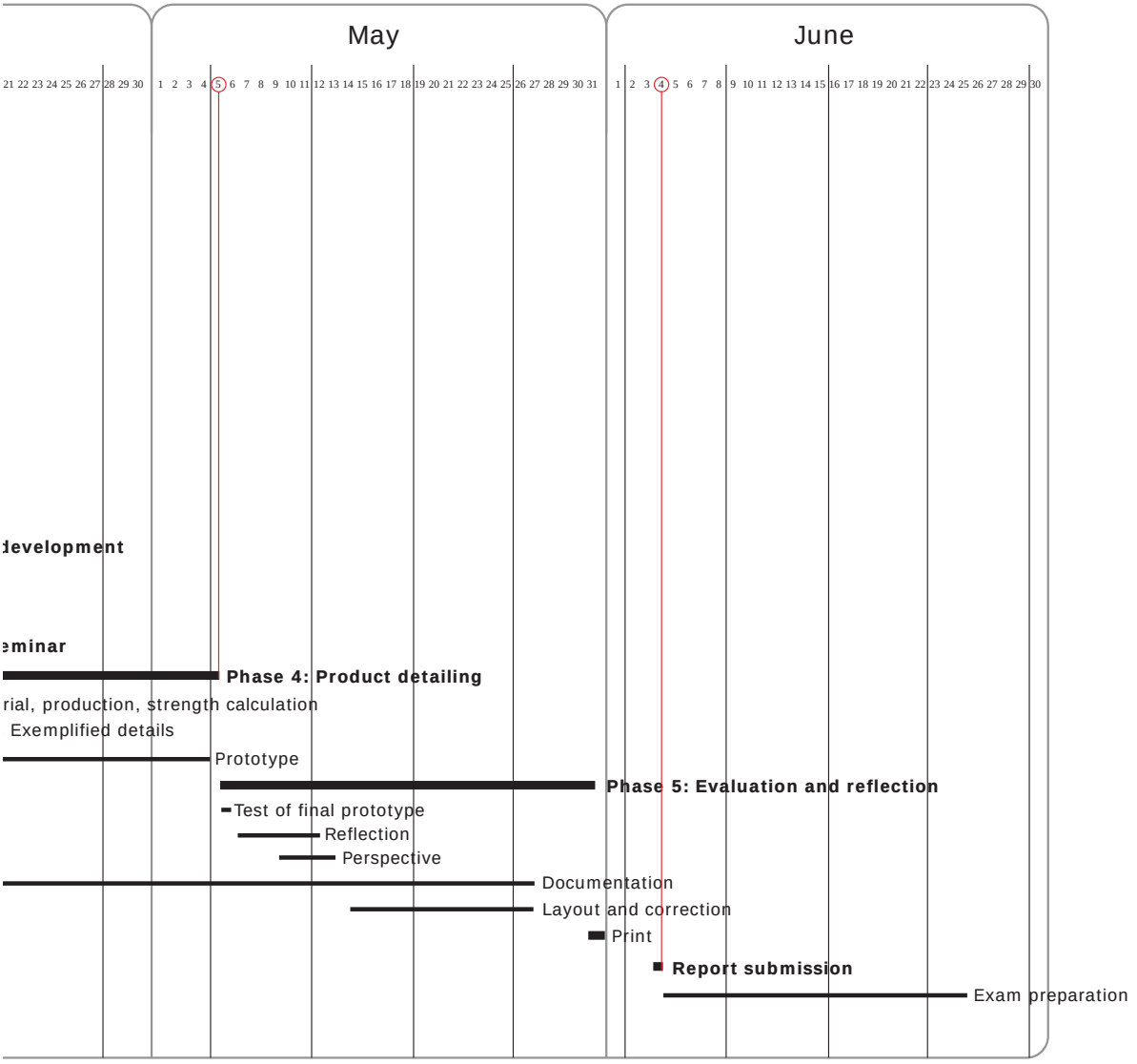
# APPEN

# ÍNDICES

# APPENDIX 1: TIME SCHEDULE

This appendix illustrates how the time of the project period was administrated. The schedule has been updated parallel to the project, so the group always had an overview of the time.





# APPENDIX 2: THE ADVANTAGES OF USING A CLEANING CART

## Purpose

There are both advantages and disadvantages in using a cart when cleaning. To make sure that it overall is an advantage to use a cleaning cart and to be aware of the disadvantages, a fictive environment has been set up where the cleaning procedures with and without cart is illustrated, see ill 2.1. It is based on observations made of different cleaning personnel at different clients, see appendix 7.

## Cleaning procedure with a cleaning cart

The grey line illustrates the route of the cart. At every grey dot the cart is left and the cleaning assistant enter the room nearest to it or the area around it. Here first the garbage is collected and thrown in the bag on the cart. Then surfaces are wiped off and at last the floor is cleaned and sometimes washed. A more detailed description of the cleaning procedure is described in the following.

### Arrival and preparation

Typically the cleaning assistant starts the day early in the morning about 4. They do not bring any supplies themselves. Clothes and personal belongings are left in the cleaning room. A typical cleaning room is about 2m x 2,5m and here the cleaning cart and some of the required equipment are stored. The room is sometimes shared with other storing functions leaving few shelves for cleaning equipment. In bigger companies there are typically a larger room shared by all the cleaning assistants where a bigger stock of equipment is kept. Here is often also a washing machine.
Depending on the cleaning personnel the cart is either prepared in the end of the assignment or in the morning. The cart is packed with the appropriate number of cloth and mops, toilet paper and tissue. Buckets are filled with water and soap, typically a big bucket for floors, one for toilets and one for tables. The large bucket is often either filled by pouring water several times from a smaller bucket or by using a hose mounted on the tap to avoid heavy lifts.

### Work flow

The cleaning personnel have a special route they follow every time. It can vary due to other activities taken place in the cleaning areas such as meeting. A program often dictates what should be cleaned and often all rooms must be cleaned everyday, but only a certain part must be cleaned thoroughly. This programs are not always followed but instead the cleaning assistant has created own routines and priorities the time they have to carry out the assignments they find most important to keep the area clean. The cleaning can be divided into 4 routines that are repeated at every visit at the client: rooms, kitchen, toilets and thorough cleaning.

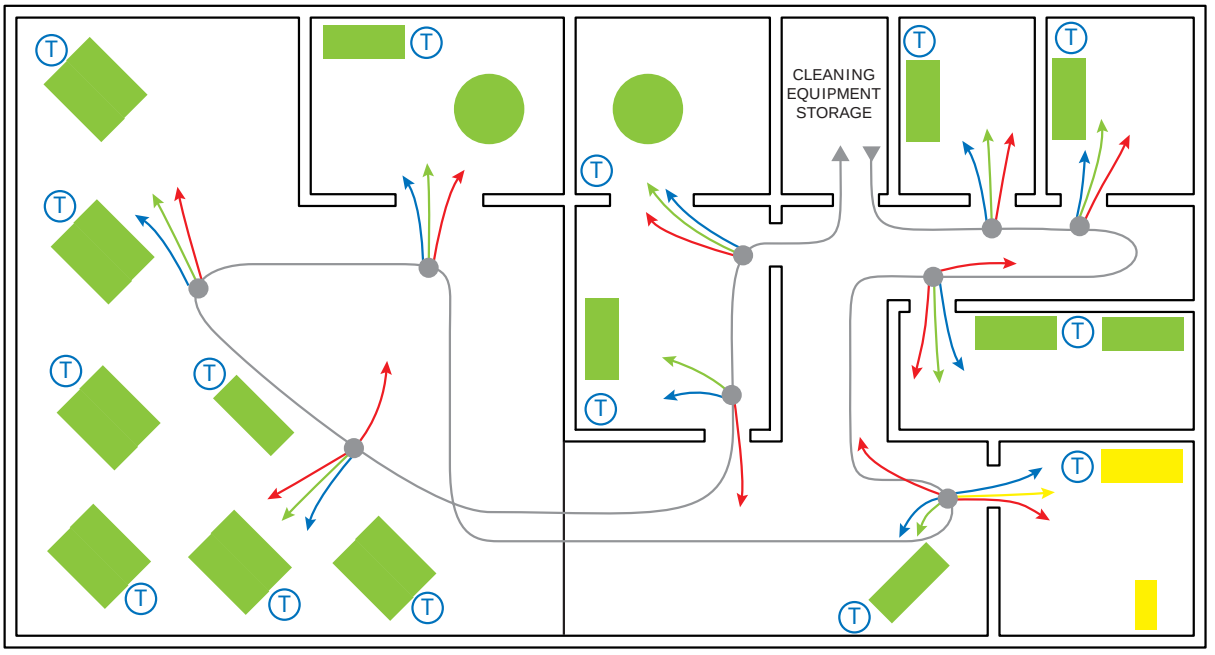
### Rooms

This routine is used for group rooms, office rooms, gangways and likely. The routine is repeated for approximately 40-60 m2 at the time:
1. Collecting waste
Waste on floor and tables is removed and put into waste bags. Often waste are just picked up from the bins without changing the bags and carried to the cart. New bags are put in the emptied bins.
2. Cleaning tables
A cloth from the bucket with soap water for tables is wringed out. All tables are cleaned with the cloth, on clear surfaces. Papers on the tables are mostly not moved. The top of PC screens and desktops are also cleaned. When finished, the cloth is put back into the bucket for table water.
3. Sweeping floors
A dry microfiber mop is taken from the cart and used for sweeping the floors. This collects dirt on the floor which is taken up with a small broom and dustpan and then put into the waste bag.

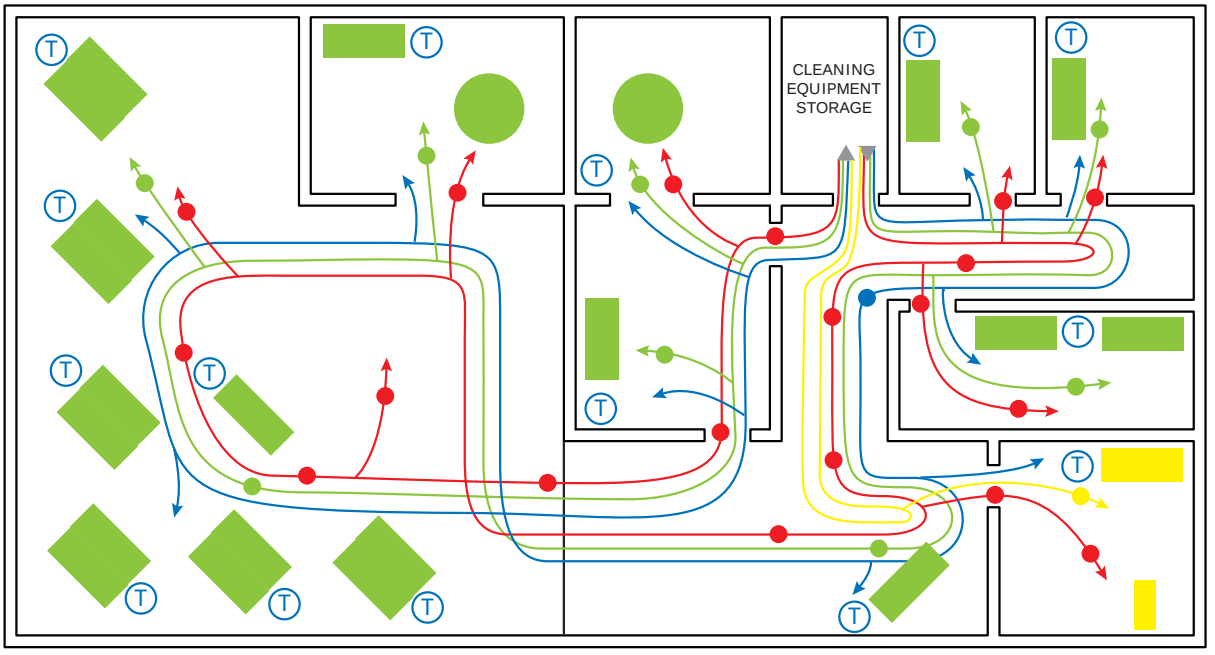
### Toilets

This routine is used for one toilet area at the time. The cart is placed outside the toilet area and the cleaning personnel must therefore

CLEANING PROCEDURE WITH CART




CLEANING PROCEDURE WITHOUT CART




Work procedure for collecting trash
Work procedure for wiping off surfaces
Work procedure for cleaning floors
Work procedure for cleaning toilets
Route walked when collecting trash
Route walked when wiping off surfaces
Route walked when cleaning floors
Route walked when cleaning toilets
Route the cart drives

Trash bin
Tables
Toilet interior
Trash is dropped here and picked up later
Bucket for surfaces are set down here
Bucket for floors are set down here
Bucket for toilets are set down here
Places where the cart is placed

Ill. 2.1: Cleaning procedures compared for when cleaning by using carts or buckets.

return to this between some of the actions:
1. If a mop that needs to drip off is used, it is dipped into the floor bucket and put on a drip tray to drip off.
2. A bottle of sanitary detergent is sprayed into the toilets. Sometimes it is kept by the toilets and sometimes on the cart.
3. A scrubbing sponge and a cloth from the toilet bucket is wringed out and brought in to clean the bathroom sinks and the toilets on the outside.
4. The toilet brush behind the toilet is used to clean the inside of the toilet and it is checked whether the toilet paper needs to be changed.
5. The cloth and sponge a brought back to the toilet bucket.
6. Toilet paper is changed if this is necessary.
7. The floor is cleaned with the wet mop.

**Kitchen**
Cleaning the kitchen basically consist on the same procedure as for rooms. Universal detergent is sprayed into the sink and the table cloth is used to clean it.
1. The kitchen table is cleaned with the table cloth.
2. The floor is sweeped with the dry microfiber mop

**Thorough cleaning**
Every day a certain area is cleaned thoroughly. This typically involves washing floors and dusting of shelves and other surfaces that are not cleaned every day.
1. The bottom window frames are cleaned with the table cloth.
2. The radiators are cleaned with a dust brush.
3. The chairs are put on top of the table.
4. The floor is cleaned with the wet mop. Some cleaning assistants sweep it with a dry mop afterwards, but others skip this to save time. Depending on the cleaning mehod the mop is either changed or rinse through for about every 5m2.

**Finalizing**
When finished, the cart is rolled back to the cleaning room. If the cloth from the dry microfiber mop is reusable it is put out to wash otherwise it is thrown away and a clean cloth is put on. The cloth for the wet mop is also put out to wash and a clean is put on. Depending on the facilities at the client the cleaning assistant either washed the cloths and mops at the client or put them into a box, that will be picked up once a week to be washed. Buckets are emptied for water and rinsed. The sink in the room is cleaned quickly and all waste bags are collected and brought to a container.

Cleaning procedure without a cleaning cart
When cleaning without a cart one task is finished at the time in stead of finishing one area at the time. First the garbage is collected illustrated by the blue line. A large bag is carried around collecting all the small bags. To avoid carrying too much bases are often made on strategic well placed spots, where some of the bags are left, see the blue dot. Then all surfaces are wiped off. For this, a bucket with water is carried around to each room. At last the floors are cleaned. First the route is walked with a broom and a dust pan and afterwards it is walked with a bucket with water for washing the floors. A more detailed description of the cleaning procedure is described in the following.

The cleaning is not structured in regard to the rooms as it is when using a cart but in stead it is structured in regard to the single assignment. Therefore preparation and finalizing are done for every assignments carried out. Depending on the cleaning personnel the assignments can be carried out in different orders. The cleaning are in the following divided into 4 areas.

**Wiping off surfaces**
Detergent is put in a bucket. Together with cloth, it is brought from the storage closet to a tap and filled with water. It is carried to the first room where the bucket is placed on the floor or a chair and the cloth is wringed out. The surfaces are wiped off and the bucket is moved to the next area where the procedure is repeated. When all surfaces are cleaned the water is poured out. The bucket is placed in the closet and the cloth are either placed in the closet or put out for wash.

**Collecting waste**
The waste is collected from all the areas. Either new bags are stored in the bin or new ones are brought from the closet. The waste is carried to a container.

Sweeping floors
Some has a regular broom and others have a mop. The broom/mop and dust pan are collected. The floor is wiped. Movable furniture are moved around or put on other furniture to clear the floor. The dust is swept with the cleaning assistant from room to room until a doorstep occurs. Here the dust is swept on the dust pan and thrown away. When all areas are swept the broom/mop and dust pan is put back in the closet.

Washing floors
Detergent is put in a floor bucket by the closet. The bucket is brought to a sink and filled with water. It is carried to the first cleaning area. The mop is made ready to clean the floors in respect to the used cleaning method. An area on about 5 m2 is cleaned, before the mop again is cleansed in the floor bucket. For about every 20 m2 the bucket are moved by hand.

## Conclusion
Regarding work procedures a cart is absolutely preferable, see scheme on ill. 2.2. It reduces the work load for the personnel and provides more variation in the assignments. At the same time the cleaning has a better possibility to be fitted into the program of the employees at the place cleaned as one area is finished at the time. The disadvantages are all practical aspects and by creating a cart which is possible to store in a limited space and can overcome 3cm steps these disadvantages becomes very small compared to the advantages.

### Why use a cart in stead of buckets

Advantages
- Finishes one area at the time and do not disturb the workers more than once.
- Vary in the work assignments minimising repetitive work.
- Cart can carry more equipment securing that the right equipment is present for the task making it done better and faster.
- Avoiding heavy lifting of buckets (red dot is 10 kg and green dot is 5 kg).
- Avoiding lifting of all bags around the environment (each T represents about 0,5 kg).
- Saves time as the cleaning assistant does not have to walk the route more than once.

Disadvantages
- A standard cart takes up more storing place than buckets.
- More expensive to invest in
- Not as flexible regarding steps and narrow places as buckets.

Ill 2.2: Advantages and disadvantages of using a cleaning cart

# APPENDIX 3: SALES VOLUME

Estimations has been made on how many Compact Cleaning Carts can be sold.

| Danish Market | | | |
|---|---|---|---|
| | Service providers | Companies hiring own cleaning personnel | Total |
| Number of places cleaned | 46000* | 16100* | |
| % places having the need for a Compact Cleaning Cart | 20** | 60 | |
| Potential sale | 9200 | 9660 | |
| Potential buyers in the next 10 years | 40 | 40 | |
| Estimated sale over 10 years | 3680 | 3864 | **7544** |

| Scandinavian market | | |
|---|---|---|
| People in Scandinavia [mio] | | 24,7 |
| People in Denmark[mio] | | 6 |
| Ratio | | 4,49 |
| Potential sale in DK | | 7544 |
| Estimated sale in Scandinavia | | **33879** |

Ill 3.1: Estimated sales volume

* Arbejdsmiljø og helbred hos rengøringsassistenter i Århus amt
and http://www.bygherreforeningen.dk
** Estimation based on interview with service supervisor Laila Holst from ISS,
and service supervisor Thomas Saaby from IDA Service

# APPENDIX 4: COMPETING CLEANING CARTS

## Purpose

There are already many cleaning carts on the market. Some of the main players are DIT International A/S, Johnson Diversey, Rubbermaid and Numatic. These are chosen as representatives for the market and will be used in the following. The purpose of this appendix is to account for that the market the Compact Cleaning Cart intents to occupy is not already overloaded. In addition it holds an analysis accounting for the standard of the cleaning carts that the Compact Cleaning Cart indirectly competes against. This analysis will also provide inspiration on how the structure of cleaning carts can be made.

## Existing cleaning carts

To get an idea of how the existing cleaning carts are constructed and what they possess, four carts are selected and analyzed with inspiration in Vita Riis' model (Engholm 2001). The pictures used in the analysis represent one of the possible configurations of the carts.

The equipment the four carts carry is overall the same, but they are structured in different ways, see ill 4.1-4.4 on next page. An overall rule is buckets for floor water is placed near the ground and the detergents, cloths and such is placed on top for easy access. In addition all of them have room for a garbage bag and except Numatic also storage space for toilet paper and other consumer goods. The carts on the pictures are not all set up to use the same cleaning method for the floors but more of them can be configured to fit the cleaning method preferred by the person using the cart. All of the carts are on wheels so they can be pushed around.

Overall all of the carts have good aspects which are worth considering when developing a new cleaning cart. The cart from DIT International A/S has multiple configuration possibilities meaning that it can be adjusted to the individual using the cleaning cart and to the specific cleaning assignment. The Johnson Diversey Boxcart cart uses colors as a codex for the different uses of the buckets and this is done in a discrete way so it does not take control of the overall expression of the cart. Looking at the Numatic cart the concept of the structure can be drawn forward as an example of a clear structure that expresses simplicity and a feeling of order. The Rubbermaid cart gives the expression of durability due to its color references like hummer H2 and the Dewalt radio; this is an important aspect when creating a work aid that will be used every day. Overall the maneuverability and the way the cleaning personnel can interact with the cart are important and this should be considered when developing a new cart.

## Interest in regard to competing cleaning carts

- The cart should express a clear structure, simplicity and order.
- Multiple configuration possibilities in comparison to the different needs.
- Make signatures that show the different use of cleaning equipment, ex. colored buckets for different contents.
- Limit the use of different colors, to secure that the colors not take control over the overall expression of the cart.
- Use colors on the Compact Cleaning cart that is coherent with the service providers and cleaning personnel's needs for the cart.
- The cart shall differentiate from current cleaning cart by competing on other values

# DIT INTERNATIONAL A/S 6000 D.KR

**Production/Materials**
Bended steel tubes coated with Rilsan to seal the surface. Plastic elements are added to the steel structure.

**Joints**
Plastic connections visualizes the large possibilities for configurations.

**Handles**
A vertical handle all the way across the cart gives possibility to hold in different positions. The handle is adjustable in height.

**Construction**
A system based on a bottom frame and some vertical frames. These can be put together in varies ways and combined with a range of buckets and baskets. Many configuration possibilities.

**Wheels**
Four wheels free to turn in all directions gives good maneuverability.

**Structure/Shape**
The pipe structure gives the cart an industrial look. It is very open, revealing all the cart's content which is an advantage for the personnel, but also easily makes the cart appear messy.

**Colors**
Colors are used as codes for the functions of the buckets. Otherwise blue is the main color.

Ill 4.1 DIT

# RUBBERMAID 2000 D.KR.

**Production/materials**
Mainly plastic elements.

**Joints**
Made in plastic but seems solid.

**Handles**
No possibilities to adjust handles in height.

**Construction**
A platform like a bookcase with wheels gives possibility to vary the buckets on the shelves. Different covers can be added to the sides of the cart. The structure leaves few possibilities for configuration.

**Wheels**
As the middle wheel is fixed in one direction it can make maneuvering difficult.

**Structure/Shape**
The boxes make the cart seem closed and orderly, but also makes it harder for the personnel to get to the content of it.

**Color**
Mainly use of black and yellow gives the cart a coherent expression. Adding a blue plastic bag would interfere with this look. Yellow and black are typically used on tools and the cart could therefore be associated with durability.

Ill 4.2 RUBBERMAID

Ill 4.3 Johnson

# JOHNSON 6300 D.KR

**Production/material**
Steel frame with plastic elements added.

**Joints**
Welded joints. Many joints hidden behind the covers.

**Handles**
Handles gives possibility to hold according to the height of the user. Can be pushed with both hands.

**Construction**
A fixed base consisting of a bottom frame and vertical frames. Within this different buckets can be added.

**Wheels**
Four wheels free to man oeuvre in all directions. Brake on two of the wheels.

**Structure/Shape**
The frame is wrapped in plastic covers which from the sides hides the content of the cart. This also means that the cart only can be accessed from the ends.

**Color**
The colors of the cart are black and grey, making it more neutral than a colorful cart. Handles on the buckets are colored to indicate the different uses.

# NUMATIC 1300 D.KR

**Production/Materials**
The elements are mainly plastic.

**Joints**
Plastic parts are screwed on the axle. It seems weak and random.

**Handles**
Only one handle can course unhealthy twists in the personnel's back when rolling the cart. Apparently there is no height adjustment.

**Construction**
The cart is based on one axle. This means that it is not very stable when rolling it and that it has to handle a high force in the joint where the axle it fixed to the bottom of the cart. Very little possibilities for configuration.


Ill 4.4 Numatic

**Wheels**
The cart has four wheels free to turn in all directions, but the handle still makes it harder to man oeuvre than if it was equipped with handles for both hands.

**Structure/Shape**
Built around an axle and this round shape are followed all the way through the cart giving it a clear expression of where it starts and where it ends.

**Colors**
Bright colors brakes the cart up in different areas but are not used to signalize the use. Seems random chosen and do not give the cart a coherent expression.

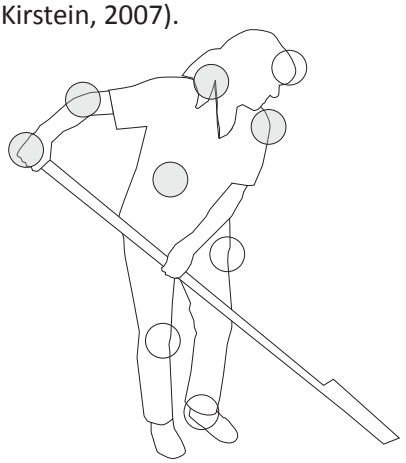
# APPENDIX 5: DANISH WORKING ENVIRONMENT AUTHORITY

## Purpose

Ergonomics is a widely used term that describes relations between objects, systems or environments and the human using it. Although it also can be used on studying cognitive and organizational aspects, this project will deal with physical ergonomics, which is about physical and physiological responses of the human body. In relation to cleaning carts, it is about studying how the body reacts when using and working with the cart. The purpose of examining this is to find critical routines where fatigue and discomfort can be reduced though design of a new cleaning cart. In this way, a healthier and more effective working environment can be established.

## Injuries and causes

According to occupational therapist at ISS Facility Service, Niels Kirstein, reported injuries can roughly be divided in to two groups. One group is injuries caused by sudden accidents such as falling over a step or cutting oneself on a sharp edge. Any circumstances that can lead to such injuries should be avoided in the design of a cleaning cart as expressed in the rules from the Working Environment Authority concerning design of technical equipment, presented later in this appendix. Another group of injuries are caught as result of longer periods of wear down, such as ergonomically incorrect work. For cleaning assistants, this type of injuries is typically expressed by pain in the neck, back, shoulder, elbow and wrist, see ill. 5.1 (interview with Kirstein, 2007).



Ill. 5.1 | Typical injuries expressed by pain in the neck, back, shoulder, elbow and wrist illustrated with grey circles.

In the following, concrete causes that produce injuries are listed. They are listed prioritized, with the most influential first, on the background of a meeting with the safety council at ISS. The different causes are highly interrelated which means that often it is a combination of causes that leads to an injury.

"Cheating"

An obvious cause for injuries is incorrect or unintended methods for cleaning. Cheating in procedures might be able to save the assistant time or maybe the correct method is considered difficult. An example that has been observed is that some does not use gloves and therefore get problems with cracked hands. Most wear-down injuries could be avoided if the assistants used the intended methods and routines.

Ignorance

As for cleaning assistants cheating, an amount of assistants are performing unintended routines due to ignorance. Routines are self-taught and the intended procedure is simply not part of their awareness. As a part of this cause, it is a problem that many cleaning assistants have no or little education and training within the area (KAD, 2004).

Repetitive work

Work done for repetitively or for long durations can lead to injuries, even for small loads or strains. This is because oxygen is hindered to be absorbed in muscles and sinews, when they are in use for long periods of time. Therefore, to consider the working environment, the whole organization of procedures for a day, month or even years must be considered instead of only the single procedure. Mopping, whether it is dry or wet, is a very repetitive activity where you strain your arms for long periods of time, every day. As wet mops typically are heavier, these produce the most strain. An examination on the area shows that the amount of issues in the right shoulder and elbow increases proportional to hours of daily mopping (KAD, 2004).
Variation between work procedures is the best organization of the cleaning work as this will strain different muscles.

High tempo
Increased focus on efficiency within the cleaning business creates a higher pressure on the cleaning assistants. Procedures are speeded up and could possibly lead to unintended work positions or accidents.

Heavy lifts
Lifting heavy buckets can develop back issues. This can also be considered as cheating, as this is against the recommendations from the Danish Working Environment Authority.

Outer positions
Stretching and bending your body for longer periods of time or repetitively can be unhealthy. An example related to cleaning is stretching your body and arms in order reach the end of table when cleaning it. Also, twisting your body while pulling or pushing the cart can be unhealthy. To avoid the twists, feet and nose should point in the same direction.

Arrangement of location
The arrangement and furnishing of the location has a large influence of the cleaning procedures. Arrangement of tables and types doorframes, steps and stairs can make cleaning with a cart difficult or impossible. In office environments, a large amount of garbage bags are often present. This makes a lot of bends and lifting and creates a large burden for cleaning assistants (Interview with Niels Kirstein, 14 marts 2008, safety council at ISS).

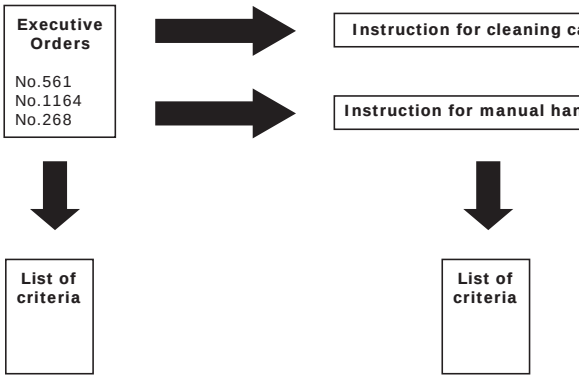
Wrong equipment
In the recent years there has been a large focus on choice and configuration of equipment in the cleaning industry. On this reason, much cleaning equipment has been replaced in favour of more healthy equipment. On the other hand, replacing equipment completely is long process and therefore equipment of all kinds can be found in the industry. The group has observed by themselves that some employees at large cleaning service providers are equipped with un-adjustable cleaning carts, not fitting the height of the employee.

## Interests in regard to ergonomics

-Making it less possible for the cleaning assistants not to cheat when using the cleaning cart, and thereby follow the right routines that secures that they do not get injuries.
-The cleaning cart should support that cleaning procedures has been speeded up, in a way that still gives the cleaning assistants healthy working positions and flow.
-Avoid heavy lifts
-Avoid repetitive work procedures
-Low weight
-Handles are shaped so they are naturally to hold
-Allowing variation in the work procedures

# RULES AND REGULATION

The actors involved with the Compact Cleaning Cart shall are subject to the following executive orders: Design of technical equipment, Manual handling at work and Working environment act. Again relevant criteria are drawn forward.
The Working Environment Authority has created a folder and a set of guidelines on basis of the executive orders and also from these some criteria has been drawn forward as relevant to this project. The connection between the different sources used in this chapter is shown in ill 5.2.




Ill 5.2. The connection between the executive orders and guidelines.

## Executive orders

The Danish Working Environment Authority has set up several rules to ensure safe and healthy working environments (www.at.dk, 2008). The rules are often very general, as they must relate to most types of branches. The most relevant are shown here:

**Design of technical equipment**
Executive order nr. 561
A cleaning cart is defined as being technical equipment and must therefore meet the regulations put up by the Danish Working Environment Authority in executive order no. 561 about design of technical equipment. This Executive Order concerns regulations on the design, marking, instructions for use, examination and marketing of all types of technical equipment. The areas of relevance to this project are listed as criteria below.

**Interests in regard to design of technical equipment:**
- The cart should be designed so it does not involve safety or health risks when installed.
- The cart should be constructed in materials that can handle the use situation and in a way that can handle the use situation both regarding strength and durability.
- The cart should be constructed so the use of it does not expose the user or others to danger.
- Use of colours or symbols for marking must be clear and durable
- Accessible parts of the cleaning cart must be designed to avoid sharp corners, edges, rough surfaces, etc., that could cause injury.
- The shaping shall ensure as far as possible that the cart is easy to clean and that cleaning of and near it can take place without risk to health or safety.
- The cart will be moved and must be designed with this in view.
- The cart must be accompanied by the necessary instructions for use to allow it to be used, transported, set up and maintained. The instructions should contain requisite information, plans, diagrams, etc., describing the equipment and its operation. It must contain information about any special safety precautions that are necessary. The instructions for use must be adequate, and easily understood by the anticipated users.

**Manual handling at work**
Executive order nr. 1164
Companies handling technical equipment must meet the regulations put up in executive order no. 1164 to ensure that the manual handling of technical equipment is safe and healthy. Manual handling is defined as lifting, carrying, dragging etc by one or more employees. This also means that producers of technical equipment must have these rules in mind when developing products. The order states that manual handling should be arranged to avoid risk for safety and health and that this arrangement includes use of technical aids. This means, that this order actually states that a cleaning cart should be used when cleaning. The areas of relevance to this project are listed as criteria on next page.

**Interests in regard to manual handling at work:**
- Work with manual handling must be planned and carried out in a way so it is secure. The cart must support this.
- Loads that need to be handled should be designed so its' weight, shape, balance, surface and placement do not lead to unsafely or unhealthy conditions.
- Handling of loads should not involve an unhealthy work position, meaning that large physical effort, body twists, unstable work positions, repeating loads for especially the back. The cart should support a healthy work conditions.

## Working environment act

Executive order nr. 268
All companies must apply to certain rules set by the government to ensure healthy and safe working environments. Work carried out by employer's family is not involved by this order. This executive order is describing how the organizational part should handle the working environment such as laws on creating health and safety groups within the company to ensure a great cooperation and communication within the area. The areas of relevance to this project are listed as criteria below:

**Interests in regard to working environment act:**
- The cart should have the needed safety protection equipment
- Can be used as intended without risks for safety or health
- With the cart should follow necessary instructions about use, maintenance, transport and preparation.

## Instructions

**Instruction for cleaning carts**
An incorrect configured cleaning cart could very easily lead to injuries. This is a focal point in Denmark. The Danish Working Environment Authority has created a folder containing information and advice on how cleaning carts should be configured. This is done to achieve healthy work procedures, which are consistent with existing rules on manual handling. As the folder is based on the executive orders above some of the criteria that could be drawn from the folder are already stated above. Additional criteria are stated below.

**Interests in regard to instructions for cleaning carts:**
- The cart should be configured to suit the cleaning tasks and the person using it
- Emptying waste bins on the cart must be done below elbow height.
- Equipment should be fixed to the cart and not be able to fall off
- The most frequently used items should be easiest to access and be placed within 30 cm from the underarm. Light items, used rarely should be placed within 50 cm
- Buckets should be placed securely and in a height that suit the person using it.
- Buckets with water must easily be placed and removed from the cart. Buckets with more than 7 litres must be placed in a way that allows filling and emptying them without removing them from the cart, in order to avoid heavy lifts.
- The cart should be easy to clean and store.
- Handles should have a diameter of 3-4 cm, be adjustable in a height between 85-130 cm and placed with room for the hands and so the user does not run his legs into it during use.
- Handles for one hand should be at least 15cm wide and placed with an appropriate distance from each other. Handle for two hands should be at least 45cm wide.
- Handles should be stable. They should give a steady grip and must not be slippery or cold.
- Wheels should run smooth, have a diameter of min. 10 cm and be selected due to the surface the cart should run on.
- At least one of the wheels should have a foot break
- Press for mops must not worsen the stability of the cart and must take ergonomic concerns (uddrag fra Arbejdstilsynet, 1998: Check på rengøringsvogne og –maskiner)

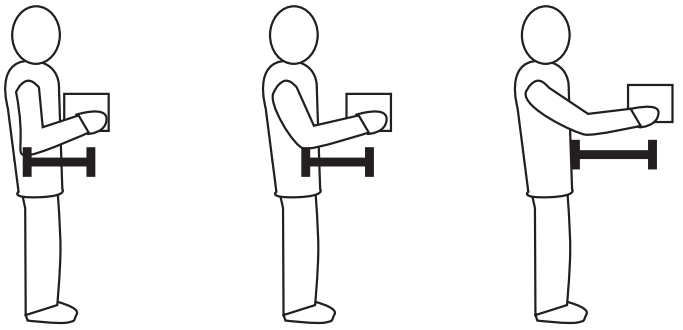
## Instruction for manual handling: Lifting, pulling, pushing

**AT-Instruction D.3.1**

This instruction is made to state the rules for manual handling and how to evaluate and avoid risks. It states that risk of injuries are connected to the amount of weight to be moved, the force needed to move it, the method used and the duration or frequency of work. Lifting and carrying is evaluated as shown on ill. 5.3 and this will be these guidelines will be followed when developing the Compact Cleaning Cart. The most important information from the instruction has been extracted and is in the following stated as criteria.

**Interests in regard to instruction for manual handling: Lifting, pulling, pushing:**

- The equipment must fit the loads it is supposed to transport and suit for the location it is supposed to used on
- Wheels must be chosen according to the ground/floor surface
- Handles should be adjustable in height and placed in a height of around 70% of the users shoulder height or 100cm +/- 10 cm. The grip should be 45 cm wide and 3-4 cm thick.
- The fully loaded technical equipment must not limit the view for the user.
- The cart should be ready for unpredictable occurrences that possibly could create sudden needs for stopping or changing direction.
- The cart should support the cleaning methods that create as little loads as possible for the user.
- The cart should be designed to limit extreme body positions (see ill 5.3 )



| | Close to the body | Underarm distance about 30 cm | Underarm distance about 45 cm |
|---|---|---|---|
| Unhealthy lifting | > 50 kg | > 30 kg | > 15 kg |
| Healthy lifting, under optimum conditions | 11-50 kg | 7-30 kg | 3-15 kg |
| Healthy lifting | < 11 kg | < 7 kg | < 3 kg |
| Total lifting per day | > 10 ton | > 6 ton | > 3 ton |
| Unhealthy carrying | > 20 kg | > 12kg | > 6 kg |

Ill. 5.3: Lifting and carrying.
*Optimum conditions: The lift is done in front of the body, between middle-thigh and elbow height for an object intended for lifting

# APPENDIX 6: CLEANING SERVICE PROVIDER

## Intro

The future buyers of a compact cleaning cart will be the cleaning service providers and smaller companies with needs for a compact cleaning cart. These buyers are investigated to find their needs and to find out how the current system around cleaning is working. The research includes marketing possibilities, cleaning providers' image and their work environment demands.

## Approach

ISS and IDA Service have been chosen to investigate and focus on as they are some of the biggest providers of cleaning service in Denmark, and thereby represent a big part of the cleaning market. The Internet will be used to get knowledge about the different cleaning service providers and to inspire for questions for the interview. The service provider will be contacted and a meeting will be set up. The basic questions for the interview are listed below. In addition, the interviewed are asked to fill out a scheme dealing with the importance of different parameters when choosing a cleaning cart. In the end of the meeting the group requests an arrangement for observing cleaning personnel. The results of the interviews and internet search are presented in this appendix.

## Interview questions

The following shows the questions that have been the point departure for the interviews with cleaning service providers.

**Interview with service providers:**
How are appointments with clients arranged?

How is the work flow for the cleaning personnel planned?

Who orders cleaning carts?
- What are the demands to the cleaning carts?
- Are all carts the same or are they adjusted to the assignments/personnel
- What brand are chosen and why?

In what way are the cleaning carried out in smaller companies where there is no room for a cleaning cart?
- What it stored at the place and what is brought?
- How do the mops get cleaned?
- What types of companies is it?
- How many?

What determines when to use a cart?
- m2, type of floor, toilets, levels

Is the problem with lack of space for storing a cleaning cart known?
- Is there interest for a cleaning cart the demands less space for storage?
- What would be a reasonable price to pay for a compact cleaning cart?
- How many carts of this type would your service use?

What separates you from other service providers?

## IDA Service

Based on interview with head of department, Thomas Saaby

### About IDA Service

IDA is the 4th biggest cleaning provider in Denmark and have 1150 employees. Their head office is placed in Aalborg. IDA service provides cleaning in both the private and the public sector. IDA Service strives to make the best service at a fair price. Through training and further education of the cleaning personnel, IDA Service tries to be prepared for future demands, especially within environmental issues (ida-service.dk, 2008).

### The system

When IDA Service comes into contact with a client, they visit them to determine how often and how thorough the cleaning should be. On basis of the area and the use of it, a price is calculated. A paper on how the cleaning should be done is made and put on the cleaning cart. After this the service manager has responsibility for the contact between the client and the cleaning personnel. The service manager shows a new assistant the cleaning assignments and takes care of finding and instructing substitutes. If detergents or other equipment is missing or broken, the cleaning personnel report this to the service manager. The used mops are collected by another employee who washes them at the headquarter and brings clean mops back. He also brings the detergents and such, when the service manager has ordered it.

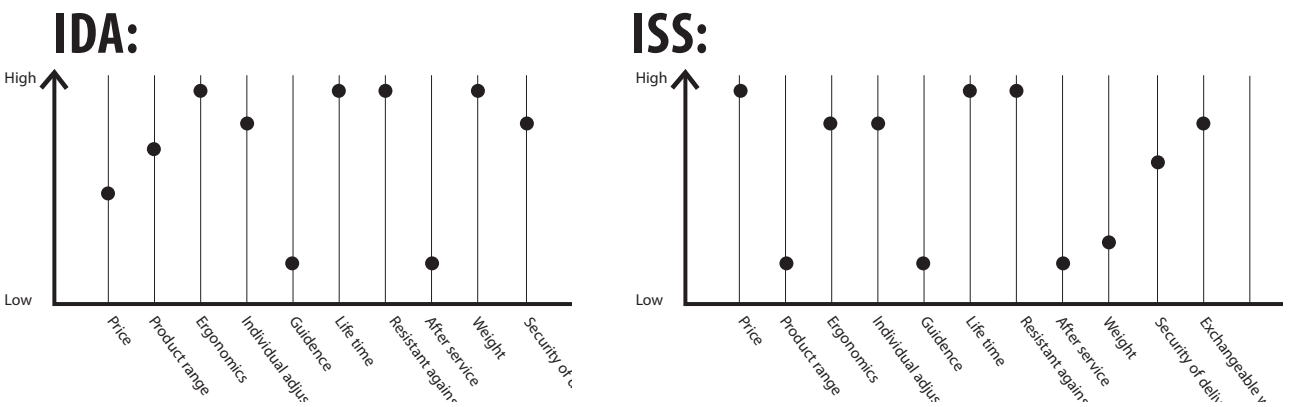
### Choice of cleaning cart

The service manager is responsible for ordering cleaning carts. IDA Service uses the supplier Clean Care for about 90% of their supplies including their cleaning cart. For some products, IDA has chosen to produce their own products when they feel the existing products does not live up to their standards. As they use Clean Care, IDA Service uses Tina's Trolleys. IDA Service chose the ERGO-system of Tina's Trolleys as these can be adjusted in height to fit the cleaning personnel. When they choose which type of cleaning cart it should be, it is important that the size fits the task. Thomas Saaby compares the cart to a lady's handbag: "If it is big, she will just fill it up with all sorts of unnecessary equipment". Thus the cart becomes heavy and harder to push around. About 80% of the carts are the one illustrated on ill 6.1. Illustration shows the parameters important to IDA Service when choosing a cleaning cart.

### The need for a Compact Cleaning Cart

IDA Service does have clients who do not have room for a cleaning cart. Often the clients are not interested in storing a cart because it takes up space and is not an object they can have standing about in a company. However, IDA Service does in most cases succeed in convincing them that there is a need for one. Sometimes they find compromises like storing it in a corner, covering it with a sheet. Therefore only 2-3% of the permanent jobs are carried out without the use of carts, but it is estimated that in 20% of the jobs, there would be interest in replacing their existing carts with a Compact Cleaning Cart. This is about 600 of IDA's places.

Ill. 6.1: Tina's Trolley Ergo




Ill.6.2: Importance of different parameters for the service providers when choosing a cleaning cart

## ISS Facility Service A/S

Based on interview with customer relation manager, Laila Holst

**About ISS**

ISS is an international company with base in Denmark. They employ 435.000 people worldwide and are Denmark's largest provider of facility services for companies i.e. services within cleaning, catering, office support and property management (issworld.com, 2008). This makes them able to both provide single service solutions as well as complete solutions within facility services.

At customer contactthe physical circumstances at the client is discussed along with the service ISS provides. This is circumstances like working hours of employees, size and organization of rooms, type of surfaces. Cleaning assistants are involved in this process to make sure the correct solution is found before signing the contract.

At ISS' different headquarters around the country, the cleaning personnel can pick up fresh cleaning equipment. A group of cleaning assistants cleans in smaller companies and drives in car from place to place. At the bigger places cleaned by ISS, employees are employed on a regular basis. Here a cleaning room is set up with a small stock of equipment and a washing machine to clean mops. Then the service manager is driving around to fill up when new cleaning equipment when needed.

**Choice of cleaning cart**

ISS buy their carts through their cleaning supplier, Johnson Diversey, who sell almost all types of cleaning equipment. Johnson Diversey has 3 types of brands within cleaning carts that ISS choose from. ISS select which one is needed out from the needs a costumer has. Illustration 6.2 shows the parameters important to ISS when choosing a cleaning cart.

As ISS has a large amount of companies located in smaller premises, ISS often experience that the space for storing cleaning equipment is very limited. Therefore, a compact cleaning cart could be of great interest for ISS. In around 40 % of their customers, this is present according to Laila Holst, resulting in a possible maximum of 2000 carts within ISS Denmark. Regarding the price, they are willing to pay the same as the existing carts they are buying (Source: Laila Holst)

## Interests in regard to service providers

- Sold at a full-range suppliers of cleaning equipment
- Fulfills ISO 14001 and 18001
- Can be organized to fit the given task
- Easy to maintain order
- Exchangeable parts
- Easy to handle/turn
- Adjustable height of handle

# APPENDIX 7: SERVICE PROVIDER'S CLIENTS

## Intro

The clients are the ones hosting the areas where the service provider cleans. Their criteria in regard to cleaning are therefore also important. These have been covered in this chapter, together with information on the different types of environments at companies.

## Approach

The clients have been visited as part of observing the cleaning personnel. Hereby, information on the environments is gained. The cleaning personnel and the service provider has also been interviewed in order obtain further information on the clients.

## Result

The environments that the compact cleaning cart has to function in are many and very different; some have steps or even stairs. Often places with limited space for storage also are limited in space in other areas, which influences the cleaning situation, such as narrow passages between tables. Appendix 12 holds a description of each of the observations made, where more information about the environments can be found.

The clients want as much of the cleaning done before their own working hours. Although cleaning assistants are starting early at the day, there will be some cleaning in the clients working hours. This means that the cart is visible to the client.

## Interest in regard to clients:

- The cleaning cart should be able to pass steps on 10 cm
- The cleaning cart should be presentable to others
- It should be easy to maintain order so that the cart is always presentable

# APPENDIX 8:
# SMALLER COMPANIES HIRING OWN CLEANING PERSONNEL

## Purpose
Other than cleaning service providers, companies that employ their own cleaning personnel are customers of cleaning carts as well. These represent a little over a third of the market, and are therefore a big group to potentially buy the Compact Cleaning Cart. These companies are investigated to define their interests.

## Approach
A group of the cleaning personnel that the group has observed are employed by this type of companies. Through observing the cleaning personnel, information on their employers has been gained regarding instructions, demands and their relations. In two of the places, by a dentist and a wellness center, the manager in charge of the cleaning employee has been interviewed in order to gather further information. The questions asked have taken point of departure in the list of questions below. The questions are targeted for companies without a cleaning cart, but they have also been used for those with cart.

## Interview questions
Do you have any special demands for the cleaning?

Who is responsible for ordering the equipment?

Have you considered buying a cleaning cart?
- Why/why not?
- What would you pay for cleaning cart?
- What demands do you have to a cleaning cart?

Why is a cleaning service provider not chosen?

## Result
The choice of employing their own cleaning personnel is preferred in order to have a direct and personal contact the cleaning assistant. This makes the employer more influential on the cleaning and gives more flexibility in rushed periods or likely.

The cleaning personnel typically give orders to their employer when new equipment is needed. Then the employer orders new equipment from a retailer. The employer has little awareness on cleaning products and on what is most ergonomically, although he/she wants the best for the cleaning assistant. The group has experienced that some companies has not been thinking of that a cleaning cart could make the cleaning at their company healthier. Appendix xx holds a description of each of the observations made, where more information can be found.

## Interest in regard to companies who hires own cleaning personnel
- The cart should be storable in small spaces.
- The cart has to clearly express the extra values and advantages that it gives the client, personnel and cleaning assistants.

# APPENDIX 9: RETAILERS

## Intro

The retailer is the contact between the buyers of cleaning equipment and the producers. There are two main types of retailers. One is mainly for smaller companies and private people, selling the cleaning carts from shops. These will be represented by Støvsugerhuset, Rationel and K.O. Bayer's, all located in Aalborg. The other is mainly serving bigger companies and cleaning service providers like IDA Service, who has a bigger consumption of cleaning equipment. These are represented by Stadsing, Clean Care and Johnson Diversey.

## Approach

To get a basic knowledge about the different cleaning service providers the Internet was used. From this the retailers was chosen and a set of questions was worked out. The three shops in Aalborg were visited by the group members and an interview was performed in the shops. Pictures were taken of the cleaning carts' placement in the shop. The other three retailers were contacted through phone and thereafter the questions were emailed to them. Unfortunately only Stadsing had the time to answer the questions. The experience from the different shops and the questions asked is presented in this appendix.

## Interview questions

The following shows the questions and answers from the e-mail interview with Stadsing, translated to English. The same questions have been the point departure for the visits in the cleaning equipment shops.

*- How many cleaning carts do you sell per year?*
Approx. 500

*- What type of cleaning cart is preferred by your costumer?*
Drip system carts without press

*- Who buys the most cleaning carts from your firm (institutions, smaller companies…)?*
Institutions

*- Does the cleaning cart get customized when bought at your company?*
No, we have 7-8 different models

*- How do you find out what kind of cleaning cart/configuration the costumer needs?*
In cooperation with our customers

*- Does the costumer know what kind of cleaning cart they need?*
In 9 out of 10 cases has the customer decided the cleaning method they will use, from this is the choices limited to 2-3 models.

*- How do you sell cleaning carts? From a shop or is a salesmen driving around to the costumer?*
The sale goes throw our own salesmen.

*- Does the costumer have demands to the size of the cleaning cart in regard to storage?*
Yes, and in regard to the furnishing in rooms that needs to be cleaned

*- What parameters have influence on the choice of brand sold in the company?*
All our cleaning carts are made from own drawings and we have exclusive right on the carts. The producers is chosen out from price and quality

*- Do you have the cleaning carts in stock or are they ordered each time you get an order?*
We have all carts in stock

*- Can cleaning carts be delivered directly to the costumer from the producers?*
No

*- Who assemble the cleaning cart?*
The producers

*In our project we focus on places with no place to store a cleaning cart, and the cleaning assistants therefore perform the cleaning with use of buckets. We want to develop a cleaning cart, which can be used these places and give the cleaning assistants a more safe and healthy work procedure.*

*- Are you familiar with this problem?*
yes

*- Will a cleaning cart that fulfills these needs be possible to sell in your shop?*
yes

## Johnson Diversey

Johnson Diversey is one of the largest cleaning equipment providers in the world. Their headquarter is located in USA and they have a departments all over the world, including one in Denmark, which again is one of the largest in Denmark. By that they operate in a large network with a great amount of knowledge and expertise, used to give the customers the best possible advices. Along, they are always in progress of developing new products and solutions for cleaning, which now has resulted in a huge product program. They have their own cleaning cart, BOXvogn, but also sells other brands of carts, e.g. DIT. Their customers are large service providers and large companies.

## Rationel

Rationel is a little shop located in Aalborg, with the main business of being a window polishing firm. They mainly sell consumer goods such as cloth and other cleaning equipment that often needs to be renewed. They also sell cleaning buckets and cleaning carts, and have a cart placed in their window showroom. Cleaning carts are mainly sold to smaller companies like dentists, and often only one cleaning cart is sold at the time. Rationel only sells cleaning carts from Tina's Trolleys, and this brand is chosen due to the service they provide. Tina's Trolleys can have a cleaning cart ready for Rationel to pick it up the day after Rationel places the order. This day to day service is possible, because Tina's Trolleys is placed close to Aalborg. Because of this service, Rationel do not have to have cleaning carts placed in the shop, instead they mainly sell them through pictures in brochures. In smaller companies it is often the cleaning assistants who come and buy the cart. The costumer, most commonly a cleaning assistant, therefore has a great deal of knowledge about what their needs are, but not necessary what kind of product and configuration they need to fulfill them. Here the sales personnel can help them find the right cart. The interviewed sales person in Rationel has earlier worked as cleaning assistant with 17 years experience and finds this experience useful when selecting carts.

Ill. 9.1: Picture taking inside Rationel

## Støvsugerhuset

As the other retailers visited in Aalborg, Støvsugerhuset has also chosen to sell Tina's Trolleys. This is due to the price and the location of the company just outside Aalborg. Tina's Trolleys delivers to Støvsugerhuset or directly to the customer. Støvsugerhuset sell about 50 carts a year and mainly carts with drip systems for the floors. Their costumers are mainly smaller companies like auto mechanics, bars, shops or offices and this type customer is often most interested universal carts. Universal carts have

limited possibilities for being configured, but in return they are about 800 D.kr cheaper. Typically it is the cleaning assistant (sometimes assisted by a manager) that comes to purchase the cleaning equipment. Støvsugerhuset helps them choosing and configuring the cleaning cart, consumer goods, vacuum cleaner and other equipment, so they have the everything they need to clean. The customers at Støvsugerhuset often has a demand for the size of the cleaning cart and sometimes prefer a cart only for the floor and then additional buckets for water and equipment for other assignments.

The most sold cart at Støvsugerhuset is the one on ill 9.2. This covers the basic needs: garbage bag, 2-3 universal buckets, a couple of baskets for equipment and consumer goods and a system for washing the floors.

## Interest in regard to retailers:

- There is a need for quick delivery, meaning that the cleaning cart has to be quick to assemble
- Sales material that makes it easy to sell the cart without having it physically
- Compact Cleaning Carts in two versions both as a configurable cart and a cheaper universal cart.
- The features that the compact cleaning cart has in comparison to others have to be visible for the costumer

Ill. 9.2: Most sold cart at Støvsugerhuset

# APPENDIX 10: CLEANING PERSONNEL

## Intro

This appendix holds a description of the methods used for observation, how the observations where chosen, a description of the methods used for processing the observations and a presentation of the results.

## Approach

The observations followed the context-of-use co-research method, see ill 10.1, starting out with a short introduction and afterwards the observation is carried out. The cleaning procedure was documented with camera, both pictures and movie sequences. The observations have been arranged so only two of the group members attended each observation. This was done in order to have as little influence on the cleaning personnel as possible.

***1. Contacting people:***
Arranging meetings by telephone with users of cleaning carts. They will be briefed shortly about the purpose and process and told not to prepare anything.
***2. Initial contact:***
Meeting at their work location. Presentation of the schedule for the day.
***3. Doing an activity:***
The user prepares his cleaning cart for use and uses it as he normally does. The group is observing, using photo and video camera.
***4. Interview and assignment:***
The user is interviewed through pre-made questions. A picture association assignment is given to the user to express his view on a perfect cleaning cart. Words must support/ explain the interpretation of the pictures.
***5. Analysis of information:***
All information is gathered from all meetings. The use situations, problems, special behaviors etc. are analyzed.
***(6. Follow up with users)***
If needed, users are contacted again to clarify questions or problems.
(Lindsay, 2004).

Ill 10.1: The method used for observations.

In the end of the observation an interview is carried out. The notepaper with the subjects the group especially kept an eye on and the interview questions are shown below.

## Procedure for observation/interview of cleaning personnel

**Introduction:**
Presentation of the group and our project
Plan for the day

**Observation of cleaning sequence:**
- as much as possible are filmed and photographed
Arrival
How is the arrival?
What do the cleaning personnel bring?
Check time.

Storage and preparation
Where is the cleaning equipment stored (Cabine/room/..., size)
What is stored?
How are the work procedure prepared (preparation of carts/buckets)

Physical conditions
What type of business is the client?
How many rooms
How is the interior? (many furniture, surfaces, narrow passages...)

Cleaning procedure
In what order is cleaned?
Which methods are used?
What equipment is used?
What work positions seems especially straining?
Are there repetitions? Which?

Remember: Check time, how much time is used on the different assignments?

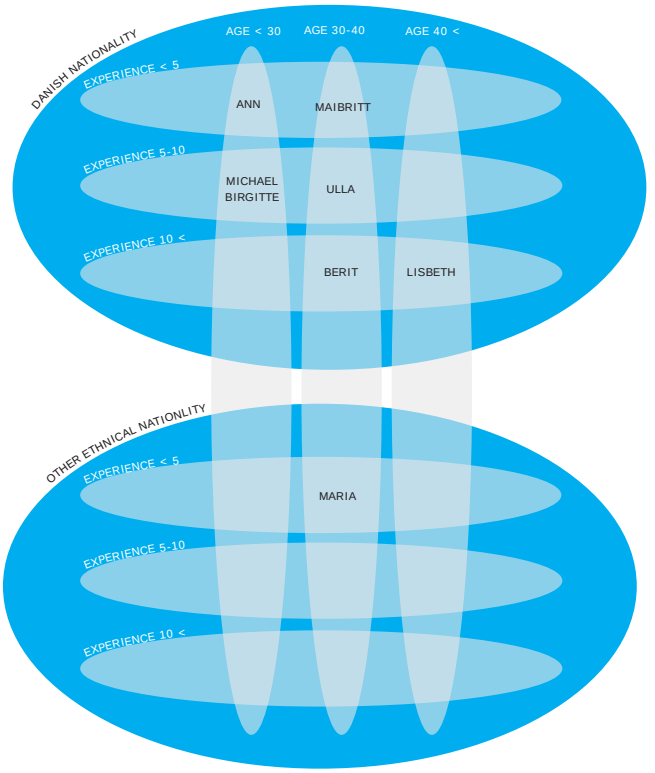
**Interview**
Name:
Age:
Observed at:
Employed at:
Work hours:
Years of experience:

Does the observed cleaning represent a typical day?
Do you always follow this structure of work?
Did you plan the structure of the cleaning your self?
How and how often do you have contact with your superiors? (Checkups, instruction…)
Which problems do you experience in the work with cleaning?
Do you lack any types of equipment or likely?
Did you experience any problems with the cart?
Did you experience any types of injuries in relation to the cleaning?
Do you have any education or courses within the area of cleaning?

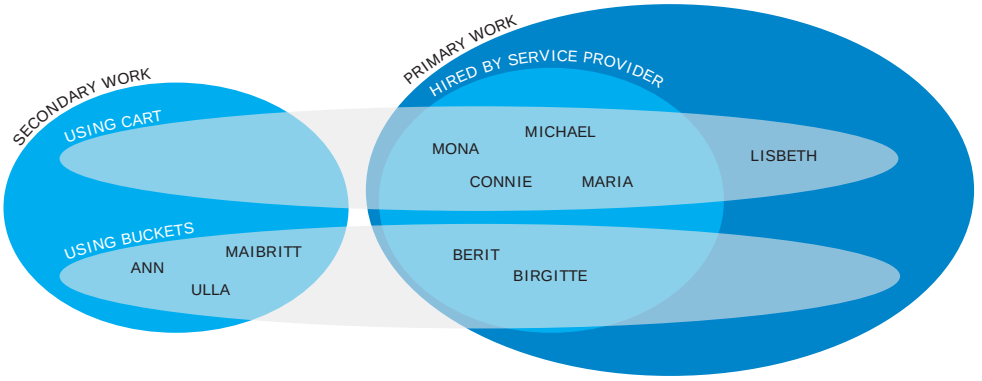
## Choice of observations

The observations and interviews of the cleaning personnel have been made so it cover a wide area of users both concerning work related aspects, see ill 10.2, and personal data, see ill 10.3. The work related aspects are divided into whether it is the user's secondary job or primary job. Secondary jobs are when cleaning is done as a part of another job such as a caretaker cleaning the institution where she works or if the cleaning is a spare time job during an education. Primary jobs are when cleaning is a full time job. Some of these are hired by a service provider and others are hired directly by the client where they clean. Both users who use a cart and users cleaning by using buckets have been observed.

Also in regard to personal data the user observations has been covering a wide area, both regarding age and experience. 10.3 part of the cleaning personnel hired by service providers are of other ethnical nationality (arbejdsmiljø og helbred hos rengøringsassistenter i Aarhus amt, 2004). These have not been as willing to be observed and therefore many of the observations have been made when an observations of a colleague was made.




Ill 10.2: User observations illustrated in regard to personal data.




Ill 10.3: User observations illustrated in regard to work related aspects.

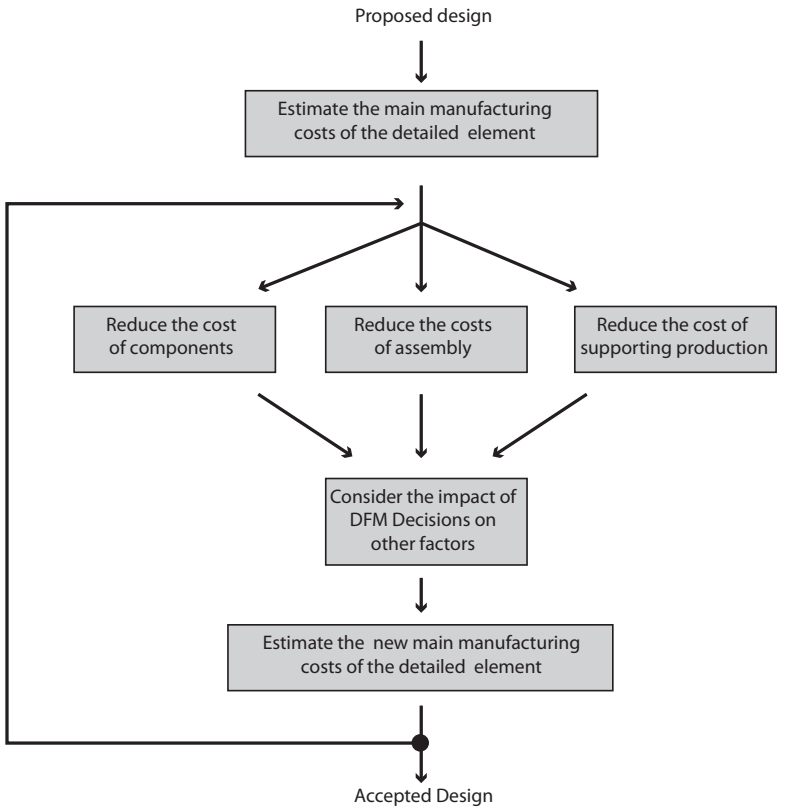
# APPENDIX 11: PRODUCTION COMPANY

It is in the interests for the production company to have a good balance between what the carts cost to produce and what they can be sold for. Therefore they want to put as much value into the product as possible for as little money as possible. This balance must be thought into the product and a method for doing this is the Design for Manufacturing method, see ill: 11.1.

In a traditional product development process, many of the decisions made in the concept phase determine a big part of the product's final cost price. However, there is not always focus on actual impact these decisions has on the final product in regard to cost price. In the concept phase the overall product architecture is determined and thereby crucial strategic decisions about the product's technology, part combinations and custom parts. Awareness of these decisions' impact is important when making a product with profit potential.

Typically many of the cost reducing decisions are made in the detailing process, through materials, production methods and assembly. By integrating thoughts about the manufacturing earlier in the process, they can become a part of a coherent concept unlike if the manufacturing concerns only where taken into consideration later where they would a price reduction on a concept.

In this project the manufacturing of the cleaning cart will be considered both during the concept development phase and the detailing phase. In the concept development phase a point of departure in regard to manufacturing will be taken in the criteria listed in the end of this chapter. These criteria will force the concept development to involve thoughts about manufacturing. In the detailing phase a method for Design for Manufacturing is used to secure that the product will be developed with thoughts of manufacturing in mind. The method forces the group to look for possibilities to reduce costs on components and assembly as well as costs surrounding the production. The method will be used several times (iterative) until an acceptable cost price is reached. The method are described on next page.




Ill 11.1.: The design for manufacturing method (Ulrich and Eppinger)

## The method is based on 5 steps (text after Ulrich and Eppinger):

*Step 1 Estimate the manufacturing cost*
Make an estimation of the manufacturing cost of current concept. The manufacturing cost can be divided up in 3 parts:
- Component cost: The cost of the standard parts purchased from suppliers and custom part with new production systems e.g. new moulds.
- Assembly cost: The process of assembling incurs labor cost and cost for equipment and tooling.
- Overhead cost: Overhead cost is the category used to encompass all the other cost, like shipping cost and maintenance.

*Step 2 Reduce the cost of components*
- Understand the process constraints and cost drivers: Find parts that are costly in production, and elements that could be changed due to high production price, ex. small corner radius that could be increased.
- Redesign components to eliminate processing steps: Simplify the components and eliminate irrelevant processes that are not necessary for the final result.
- Chose the appropriate economic scale for the part process: From the numbers of expected products to be produced, relevant production methods are found to the lowest cost price.
- Use of standardized components and processes: Locate non standardized component and processes, which can be exchange with standardized components and processes.

*Step 3 Reduce the cost of assembly*
- Keeping score: Estimate the time it takes to assembly the product and find the numbers of elements that need to be assembled. Locate element that is time consuming when being assembled.
- Integrate parts: Integrated several of function in fewer components, to reduce time of assembly.
- Maximize ease of assembly: Design each part to be symmetrical from, so that the part does not have to be oriented for assembly. In automatic assembly, symmetrical parts do not require special sensors or mechanisms to orient them correctly. The worst part is one that is slightly asymmetrical which may be installed wrong because the worker or robot could not notice the asymmetry. Or worse, the part may be forced in the wrong orientation by a worker (that thinks the tolerance is wrong) or by a robot. So, if symmetry can not be achieved, make the parts very asymmetrical. Then workers will less likely install the part backward because it will not fit backward.
- Consider customer assembly: Consider parts that can be assembled by costumers, and thereby safe cost price.

*Step 4 Reduce cost of supporting production*
- Minimize the systemic complexity: Minimize the element and system that supports the product like retailers, types of production methods, parts, people…
- Error proofing: Anticipate the possible failure modes of the production system and to take appropriate corrective actions early in the development process.

*Step 5 Consider the impact of DFM on other factors*
- The impact of DFM on product quality: The reduction in price that cause by DFM can result in a deficient quality, this has to be evaluated to secure that the product have the expected quality from the users point of view.
- The impact of DFM on external factors: A component with low cost can be expensive in other areas like reuse and lifecycle costs.

## Interests in regard to design for manufacturing

- Maximize ease of assembly ex. Design each part to be symmetrical from, so that the part does not have to be oriented for assembly.
- Integrated several of function in fewer components, to reduce time of assembly.
- Consider parts that can be assembled by costumers, and thereby safe cost price.
- Simplify the components and eliminate irrelevant processes that are not necessary for the final result.
- Use standardized components and processes
- Parts that are costly in production, and elements that could be changed due to high production price, ex. small corner radius that could be increased
- From the numbers of expected products to be produced, relevant production methods are found to the lowest cost price.

# APPENDIX 12: OBSERVATIONS

## Jyske Bank

Cleaning assistant
Lisbeth, ~56 years, full-time employee at Jyske Bank

Environment
The cleaning at Jyske Bank is happening at 3 different floors, by the same person. A cleaning cart is placed on two of the floors, each in a cleaning room. On the last one, there is many steps and that makes it hard to come around with a traditional cleaning cart. At this floor, buckets are used for cleaning, which are placed in a closet in one of the toilets.

Work description
The worker that is hired at Jyske Bank has earlier been at a professional cleaning service provider company, and has therefore a great deal of knowledge about how to clean. The cleaning assistant is responsible to order all the cleaning equipment, and has decided what kind of cleaning cart that she wanted. If inventory is not placed properly for her when cleaning, she has often asked for getting it moved. An example for this is that she got the stove moved so that she easier could clean under it every day.

Need for a Compact Cleaning Cart
Since it is only one of the floors that do not have a cleaning cart and a cleaning room, this is the only place that a compact cleaning cart could be placed. At that floor, there is limited space for storing, but also a lot of steps. If a compact cleaning cart should be bought it would be necessary that it could pass these steps in a correct ergonomic work procedure.

Ill 12.1: Picture from Jyske Bank

## Tandlægerne Nørregade

Cleaning assistant
Ann, 24 years, studying at the university, employed 2 hours three times a week

Environment
The dentists in Nørregade are located on the second floor. They have four clinic rooms, a kitchen, a toilet, a bathroom and 4 other rooms. Their cleaning equipment is stored in a normal closet, ~60x60x200cm.

Work description
Due to the line of business the dentist have certain demands to cleaning. The dental equipment is cleaned by the clinic assistants. The cleaning assistant is hired to go out with garbage and clean floors, tables and toilets 3 times a week. This is done not only to have a clean environment, but also to send a clear signal to the customers, that this place is clean. One of the dentists has made a manual for the cleaning procedure. This is made on background of experience. The personnel on the clinic are responsible for buying cleaning supplies. They do this through some of there permanent suppliers of other equipment for the clinic.

It has been chosen to employ an assistant directly as the clinic priorities the personal contact. If there are problems or a change in the cleaning routines, it is easier to get this communicated to an assistant employed directly, than an assistant employed through a cleaning provider.

Need for a Compact Cleaning Cart
The dentists in Nørregade have considered a cleaning cart but could not find any that fulfilled their needs. This mainly concerns the size of the existing carts as there are no room for such at the clinic. In addition the cleaning assistant is also responsible for washing the stairs and a cart useful for this would be preferable. It would be unreasonable to pay about 4000 D.Kr for a cart like this. (Source: Inger Maltbæk, Dentist)


Ill 12.2: Picture from Harmonie


Ill 12.3: Picture from municipal institution

## Harmonie

Cleaning assistant
Maibritt, ~32 years, full-time employed as a wellness and massage therapist

Environment
The wellness clinic is located on second floor. They have 3 spa rooms, 2 large rooms plus a kitchen that has to be cleaned every day. All floor surfaces are either made of wood or linoleum. Since the clinic is in an old building there are some steps on approximately 5 cm inside the clinic. Cleaning equipment is kept with their products in stock behind a curtain in a corner of their main room.

Work description
Harmonie is a massage and spa clinic and wants to have a high quality image. Therefore the treatment rooms are cleaned thoroughly after each use, which is several times a day. Buckets with soap-water are used with cloths and mops for cleaning. There are no cleaning personnel hired at Harmonie, instead it is the masseuses that clean the rooms. They are being instructed in how clean by the other masseuses.

Need for a Compact Cleaning Cart
The owner and responsible for the buying the cleaning equipment at Harmonie have not considered to buy a cleaning cart, before being contacted by the group. But see it as a positive thing that a cart would make their work more ergonomic, but the problem with all the steps that the cart have to drive over, will still be to big a problem for them to consider buying one. Also, as the spa rooms are cleaned after each treatment, a compact cleaning cart will have to be put up very often.

## Municipal institution

Cleaning assistant
Ulla, ~32 years, full-time employed as pedagogue in the institution

Environment
The institution is placed in an old house with lot of small rooms. The structure of the house is mainly based on small long corridors with lots of small rooms on each side. Other than that there are two toilets, a bath and a kitchen.
The cleaning equipment is placed different places in the house. The soap and other cleaning equipment are placed in a laundry room. Buckets on wheels are placed in a shower, in one of the toilets where it has to be lifted out from.

Work description
The house is being cleaned by a social worker at night that has the cleaning as a secondary job. The cleaning is therefore not put in system and is individual from worker to worker. The social worker is not given any instructions in how to clean, only very basic information provided by other social workers at the institution. A bucket on wheels is brought around and used with cloths and mops.

Need for a Compact Cleaning Cart
The environment that is cleaned at the municipality institution has a limited space for cleaning cart. A compact cleaning cart that can be stored in for example a closet could fit into this environment and fulfill the existing needs for cleaning. If the cleaning cart will improve the working conditions, both regarding efficiency and ergonomics, it will be in interest for the institution to by one. But they will only play a minimum meaning that the price not may be higher then conventional cleaning carts.


Ill 12.4: Picture from Nordjyske Stiftstidende


Ill 12.5: Picture from Aalborg University

## Nordjyske Stifstidende

Cleaning assistant:
Connie, ~50 years, full-time employee at IDA

Environment
Large buildings with both carpet and plain floors. The rooms Mona cleans are spread in the building. A common cleaning room in the basement with washing machine, stickers on the doors shows with day there a thorough cleaning. Everybody employed at Nordjyske is nice to Mona and respects the cleaning. At the area, Nordjyske and IDA shares some of the floor cleaning machines (IDA put a new battery in their machine)

Work description
Six cleaning assistants are employed; each has a cleaning cart which is kept in cleaning rooms several places. The cleaning is arranged by managers at IDA service and the cleaning assistants are supposed to follow a certain procedure. This is written in an instruction that each cart is equipped with. It describes how the daily cleaning should be done, including floor wash, sweeping tables, emptying bins etc. In addition, the instruction instructs in what area the thorough cleaning is supposed to be done each day.

Need for a Compact Cleaning Cart
Already using cleaning carts.

## Aalborg University, Toldboden 1st floor

Cleaning assistant
Mona, ~46 years, full-time employee at IDA

Environment
Both large and small office/group rooms, all with wooden floor. The cart is stored in a room that normally is used by the janitor. Here is also room for some extra cleaning equipment.

Work description
As for all IDA employees she supposed to follow an instruction. But Mona has her own routine. For about every 50 m2, she has routine of first emptying garbage bins, then washing tables and finally sweeping the floor. This is repeated for the next approx. 50 m2. A certain area is cleaned thorough each day where panels, shelves and floors are washed.

Need for a Compact Cleaning Cart
Cleaning carts are already used, but as the storage room is intended for the janitor, he would probably prefer a smaller one.

## Aalborg University, Toldboden 2nd floor

Cleaning assistant:
Maria, ~35 years, immigrate, full-time employee at IDA

Environment
Open group rooms in a large room. A cleaning room on approx. 3x3 m is set aside to store the cart and other equipment.

Work description
Maria always gets help of her husband which makes the cleaning faster. Bins are emptyied and the floor is sweeped very fast. Tables are not washed. In a certain area the floor is washed.

Need for a Compact Cleaning Cart
Already using cleaning carts.

SID Job
Cleaning assistants
Kirsten, ~47 years, full-time employee at Blæksprutten
Trine, ~34 years, full-time employee at Blæksprutten

Environment
An office on the 2nd floor with no room for storing cleaning equipment. Under a shelve, in the corner of a room there is room for some cleaning articles, approx. 50x50x50.

Work description
Vacuum cleaner, mops, mop cloths and and table cloths are brought up from the car. The carpets are vacuumed and floors in kitchen and toilets are washed with mops. The mops are used without buckets. Instead the mop cloths are prepared in the kitchen sink.

Need for a Compact Cleaning Cart
There is no room for a normal cleaning cart, but a compact cart could possibly be placed in this place. This would reduce the amount of things the assistants should carry up each time and make the work more efficient.

## Wheelchair repair

Cleaning assistants
Kirsten, ~47 years, full-time employee at Blæksprutten
Trine, ~34 years, full-time employee at Blæksprutten

Environment
A wheel chair repair shop where a kitchen, a office and some toilets are cleaned.

Work description
Vacuum cleaner, mops, mop cloths and and table cloths are brought up from the car. All floors are first vacuumed and then washed with mops. The mops are used without buckets. Instead the mop cloths are prepared in the kitchen sink. Lots of chalk removal is used in the toilets.

Need for a Compact Cleaning Cart
There is no room for a normal cleaning cart, but a compact cart could possibly be placed in this place. This would reduce the amount of things the assistants should carry up each time and make the work more efficient.

Ill 12.6: Picture from wheel chair repair

# APPENDIX 13: PERSONAS

Three personas were made for use in the development of the Compact Cleaning Cart. In the report the personas' product benefit specifications are presented and these are made on basis of the descriptions below. The descriptions give a more coherent understanding of the three personas.

## Maria

Based on
Primary observation: Toldboden1
Secondary observations: Nordjyske1, Nordjyske2, Nordjyske3, Airport1

Maria is from Vietnam and came to Denmark with her husband six years ago. She has no education but worked for a day care for two years before she was hired at ISS to clean Aalborg Airport. She is very happy for her job as she knows the routines and knows what needs to be done each day. She enjoys the contact with her colleagues, but prefers walking in her own area, where she can relax and do not have to make conversation. She does take Danish lessons but is embarrassed by her own pronunciation and therefore always answers shortly. She had a bit difficulty when starting as she did not know the routines and the instructions she was given was very short. Therefore she did not go places she was not sure that she was allowed to go or clean things she was not strictly told to as she was afraid of doing something she were not allowed to. She has a program for the cleaning attached to the cart but she has never read what is on it as the instruction did not take point of departure in it. And now she knows her routines it is not necessary. Maria is only 155cm tall and this makes some of the cleaning assignments difficult. It is hard for her to reach and therefore strains her body in outer positions. The cart she used, she has inherited from the later cleaning assistant and it cannot be adjusted to fit her size. However, Maria does not see this as a problem. She is happy for the cart even though it is not optimal and do not want to cause trouble by asking for a new one. She does a great effort to keep the cart in order as she believes it tells a lot about how she is and how she does her job.
Maria has no intention of ever returning to Vietnam. She has two children just started kindergarten and their homeland is Denmark. She takes great pried in being able to both have a job and raising the children. She feels that the job as a cleaning assistant is very suited for her as it fits into her lifestyle and everyday routines.

## Pernille

Based on
Primary observation: Ulla, Ann, Maibritt
Secondary observations: Nordjyske5

Pernille is educated care taker and loves her job as helping others gives her a feeling of being appreciated. A part of her job is cleaning the kitchen, toilet and gangway areas when she is on the night shift. The work at night do that she is alone in most of the time during work. This is absolutely not her favorite part of the job, but she understands that this is necessary to make things work at the institution. She has no education in cleaning and no guidance in regard to what should be done and how, the only instruction she got is from her colleagues that is doing the same job. Her experience basis is the cleaning at her own apartment and therefore she basically carries it out as she would have done at home. She has no physical inconvenience with the job and takes no ergonomically concerns in regard to the way she lifts or wrings a cloth. The equipment she has available is not the newest and often many assignments takes longer because she does not have the right equipment or because the organization of the work is not optimal planned. She does not feel a time pressure, but takes her time. If there are assignments more interesting to do she often cut corners and is not as thorough as she maybe should be with the cleaning.

## Mona

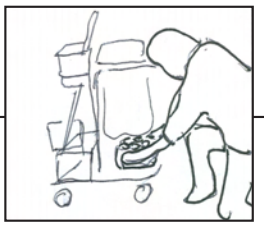
Based on
Primary observation: Connie, Lisbeth, Toldboden2
Secondary observations: Nordjyske4

Mona has been in the cleaning branch for several years. Originally she served her apprenticeship in the local grocery shop, but as this closed down, she started taking in small cleaning jobs. Over time she has been employed by different cleaning service providers, but has been with IDA Service for 18 years now. Many things have changed over the years and Mona is not happy with the development. Formerly she used to have colleagues, but now she almost always walks around alone. Also the rules have become stricter. There are so many things she cannot do the way she used to because the authorities believe it is healthier to do it another way. However, as she walks around alone she does it the way she finds most suited and what is possible with the tools she is provided with. The inspection she has very little respect for as she does not believe the few inspections gives a reel picture of how the cleaning is done. The inspectors are always very busy because so many administrative assignments are put on there shoulders. Even though things are not as they use to be, Mona still does not consider changing job. This is what she does and this is what she believes she is good at. And she does enjoy the job as it gives her great flexibility. If she wants to meet an hour later she can do that, or if she needs to answer the phone she can always do that. The job also allows gives her much time for daydreaming and planning what she wants to spend her time on when she gets home. Some of the places she cleans the time is tighter than others, but as long as she does not go around watching the clock all the time she avoids stress and manages to get the job done anyway. Mona always packs her cart in the end of the cleaning so it is ready for next time. She knows exactly where she has her things and can see if somebody has been messing with her cart. She is not satisfied with the conditions provided to her at the places she cleans and she believes the companies should prioritize the cleaning higher both in the every day but also when they do the interior. Mona has some problems with her right shoulder, but she considers this as a natural consequence of being in this branch so long. Even though the job is a physically challenging she weighs a bit more than she should according to the doctors. For Mona this is not seen as a problem. She is happy with the way she is and has come to terms with the extra pounds.

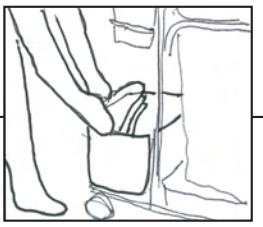
# APPENDIX 14: WORKFLOW

## PREPARATION

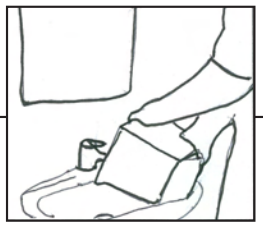
*Taking cleaning cart out from storing place*



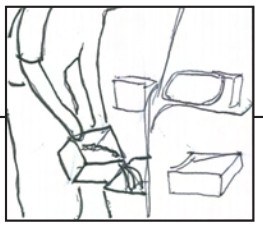
*Fill cleaning cart with equipment*



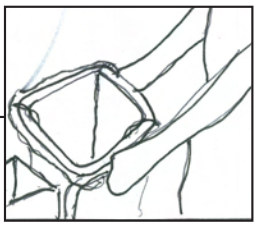
*Fill clean mops in buckets*



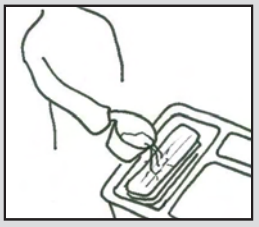
*Get water from tap and put soap in water*



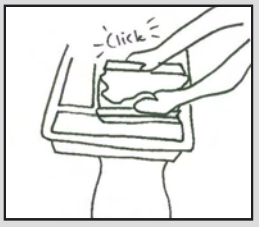
*Put water with soap over mops and cloth for moisturizing*



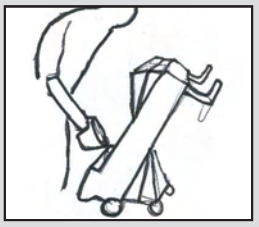
*Put new garbage bag on garbage bag holder*



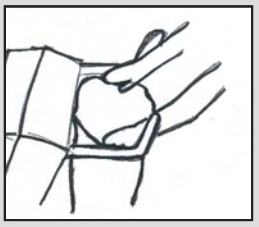
*Put water with soap over mops and cloth for moisturizing*



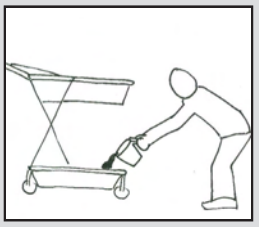

*Pu new garbage bag on garbage bag holder*



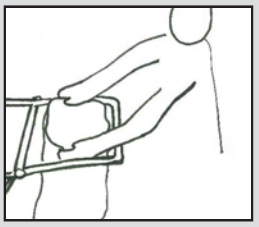
*Put water with soap over mops and cloth for moisturizing*



*Pu new garbage bag on garbage bag holder*

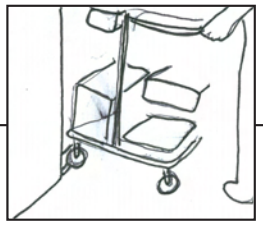


*Put water with soap over mops and cloth for moisturizing*

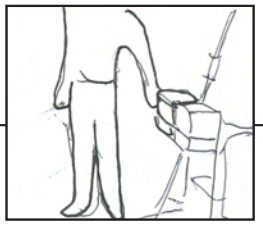


*Pu new garbage bag on garbage bag holder*

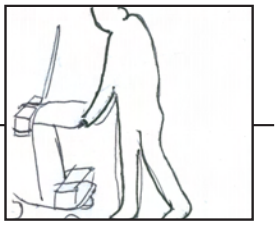
# MANOEVERING



*Driving cart over steps*



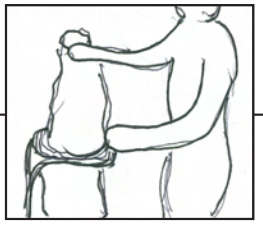
*Driving over small distances draw in cart*



*Driving over big distances use handles*

# EMPTYING GARBAGE

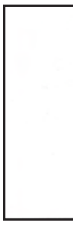
*Empty garbage bag, if filled*



*Put filled garbage bag in bigger garbage bag on cart*

*Put new bags in*

# INTEF

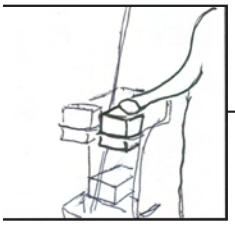


*Take clo*

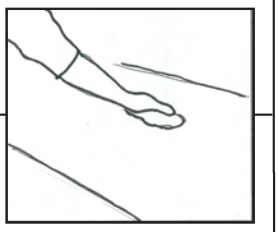
*Take clo*

*Take clo*

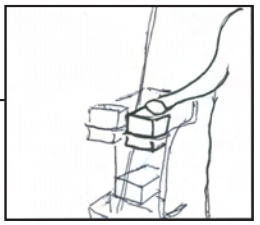
# 'ERIOR CLEANING



ke cloth

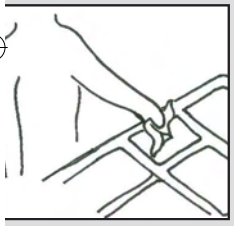


clean surfaces

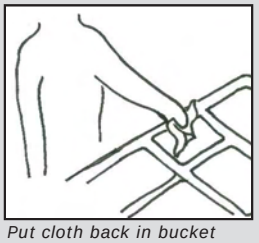


Put cloth back in bucket

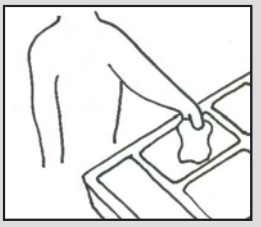
put dirty cloth in bucket for equipment to be washed



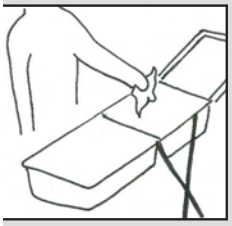
ke cloth



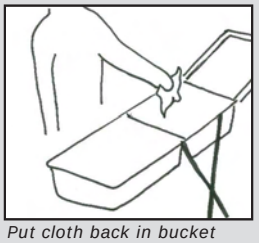
Put cloth back in bucket



put dirty cloth in bucket for equipment to be washed

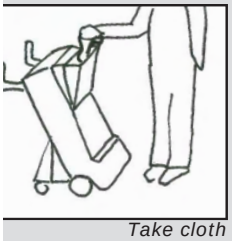


ke cloth



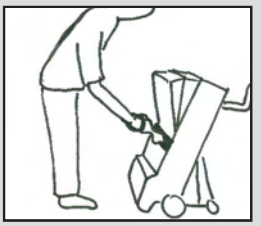
Put cloth back in bucket

put dirty cloth in bucket for equipment to be washed



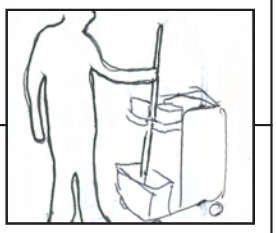
Take cloth

Put cloth back in bucket

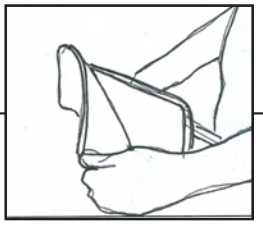


put dirty cloth in bucket for equipment to be washed

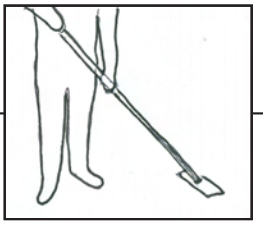
# DRY MOP CLEANING



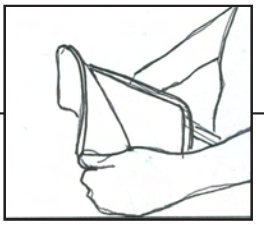
*Take mop from holder on cart*



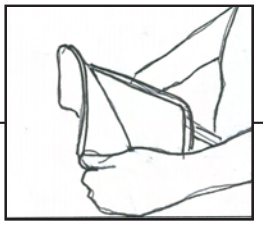
*Put disposal microfiber mop on head of mop*



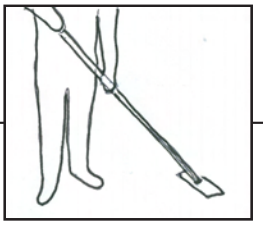
*Clean floor with mop*



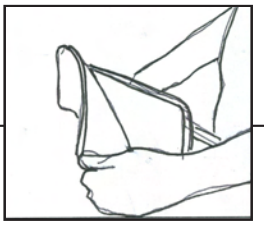
*Take dirty microfiber of by using hands*



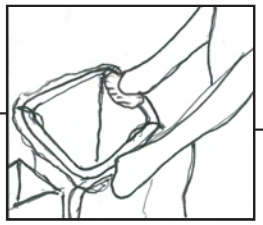
*Put microfiber mop on head of mop*



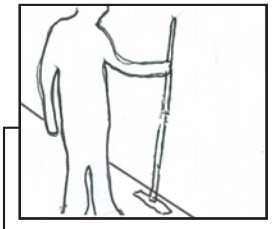
*Clean floor with mop*



*Take dirty microfiber of by using hands*

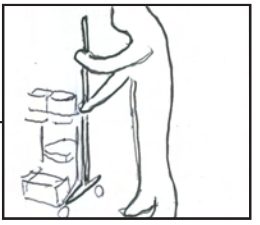


*put dirty mop in garbage bag on cart*

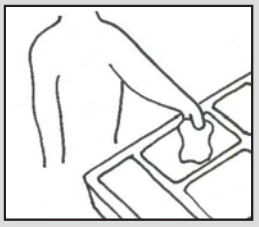


*Place mop at wall*

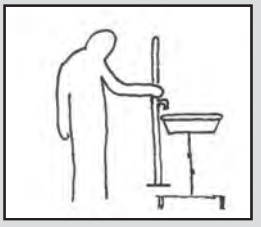
*put dirty mop in bucket for equipment to be washed*



*Place mop in holder for transport to next area to be cleaned*



*put dirty mop in bucket for equipment to be washed*

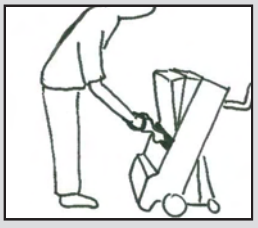


*Take mop from holder on cart*

*Place mop in holder for transport to next area to be cleaned*

*put dirty mop in bucket for equipment to be washed*

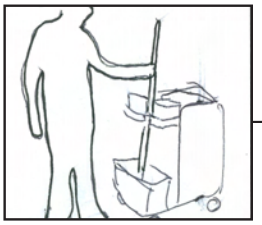
*Place mop in holder for transport to next area to be cleaned*



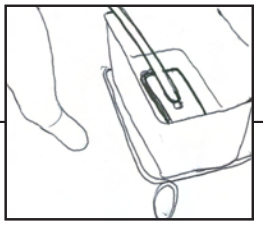
*put dirty mop in bucket for equipment to be washed*

*Place mop in holder for transport to next area to be cleaned*

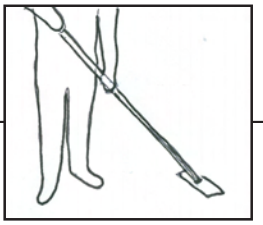
# WASH FLOOR



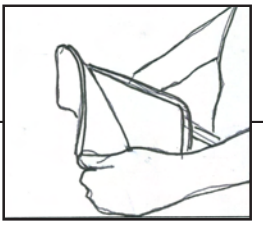
*Take mop from holder on cart*



*Take clean mops by putting mop head with velcro in bucket*

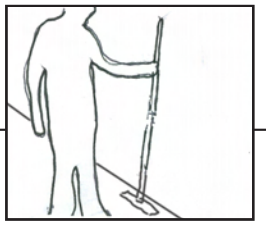


*Wash floor*

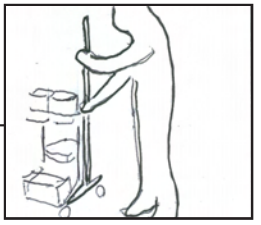


*Take dirty mops of by using hands*

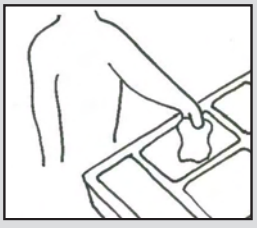
*put dirty mop in bucket for equipment to be washed*



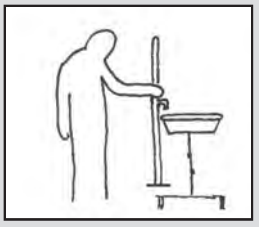
*Place mop at wall*



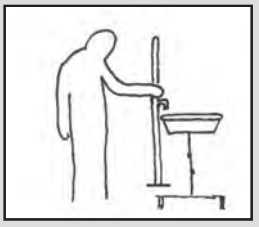
*Place mop in holder for transport to next area to be cleaned*



*put dirty mop in bucket for equipment to be washed*

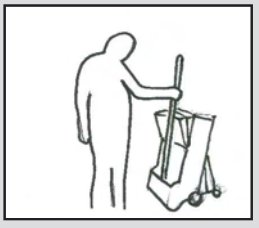


*Take mop from holder on cart*

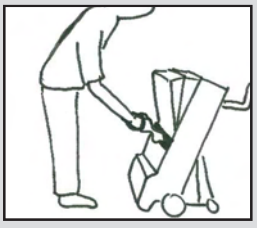


*Place mop in holder for transport to next area to be cleaned*

*put dirty mop in bucket for equipment to be washed*



*Place mop in holder for transport to next area to be cleaned*

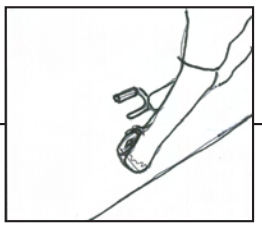


*put dirty mop in bucket for equipment to be washed*

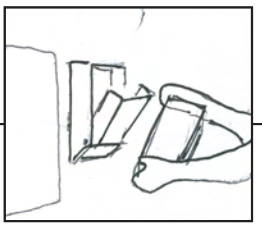
*Place mop in holder for transport to next area to be cleaned*

# SANITARY CLEANING

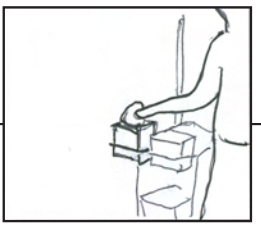
*Pick up toilet paper and hand paper*



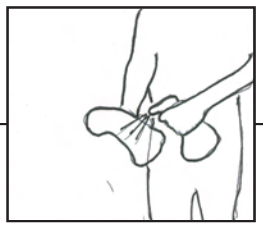
*fill toilet paper in holder*



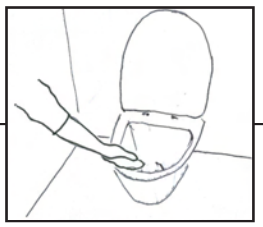
*Fill paper in holder for hand paper*



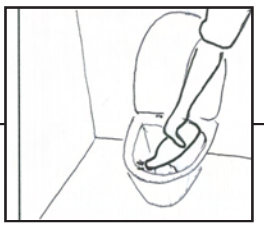
*Take cloth for sanitary cleaning*



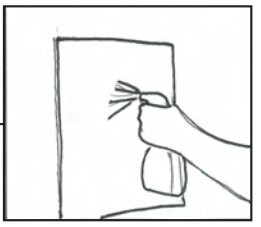
*Spray cloth with detergent*



*clean surfaces*



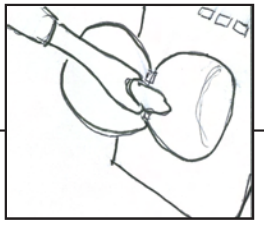
*spray toilet with detergent*



*Spray mirros with detergent*

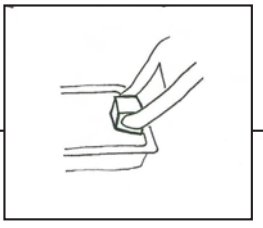
# EMPTYING CART

*Take dirty cloth*

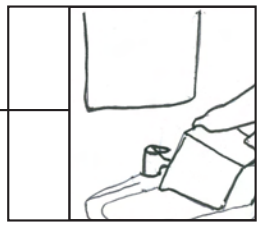


*put dirty cloth in washing machine*

*Collect dirty mops in bag for washing company*

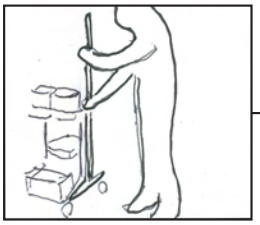


*Washing company picking dirty mops up*

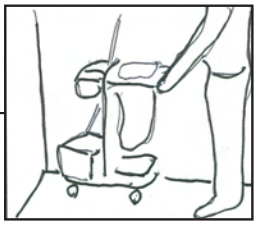


*wash bucket under tap*

# STORING

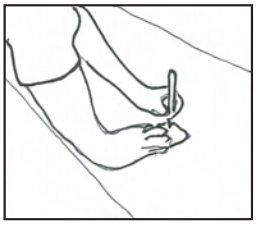


*Place equipment in order*



*Place cleaning cart for storage*

# ORDERING CLEANING EQUIPMENT



*Order the cleaning equipment that is needed*

# APPENDIX 15: SCHEME WITH CRITERIA

| | ERGO<br>+ | - | CLEAN<br>+ |
|---|---|---|---|
| Use | Handle all round cart makes it easy to always push or pull the cart<br><br>The cart is accessible from more sides.<br><br>Can contain storage items when stored<br><br>The mop handle can be placed all round cart, allowing easy change between work procedures. | | The cart is quick to put away for storage |
| Work loads | All buckets are placed high. This avoids bending down to reach equipment<br><br>Height adjustable | When folding the cart, the weight of the cart is lifted. This is unhealthy.<br><br>Horizontal handles gives an unnatural position of hands. | A large wheel in the back helps passing steps and runs smoother on e.g. carpet surfaces |
| Environment | | Wide structure<br><br>If stored vertically, the equipment must be removed<br><br>Not easy to pass steps | The cart can pass over steps |
| Safety | | Mop handles hangs dangling when stored temporary on the side | |
| Production | Many steel tubes have the same length and thereby reduces the amount of components | | Plastic parts are cheap to mass produce. |
| Marketing | | The bottom seems unused and like waste of space. | When folded out, the folding principle is obvious |
| Content on cart | | | |
| Expression | Adjustability: flexible joints<br>High manoeuvrability:<br>free wheels and handle all round<br>Accessibility:<br>open structure | No direction | Structure: special fitted equipment<br>Robust:<br>closed structure<br>Hygiene:<br>large clean surfaces<br>Revealed functions:<br>The folding principle is obvious when folded out |

| - | FLEX<br>+ | - |
|---|---|---|
| Can not contain storage items when stored<br><br>Logical where to place equipment due to their special fit | Can contain storage items when stored<br><br>The cart is small enough to be sent assembled which prevents assembly by customer or retailer | Sliding parts could collect dirt/dust |
| No height adjustment of handle or buckets<br><br>Bending down when filling/emptying the cart | No bending down during cleaning | No height adjustment of handle or buckets<br><br>Bending down when filling the cart<br><br>Could be unstable during driving due to the narrow structure |
| | The cart can pass over steps<br><br>Narrow structure is easy to come around with<br><br>Can be stored in many positions and places | |
| | | |
| The plastic parts are complex and could have a high initiation price | Simple attachment of buckets | Sliding parts could be expensive |
| Looks very different than existing carts | Looks like a cleaning cart | |
| Only one mop handle | | |
| Looks heavy and clumpsy rather than quick | Adjustability:<br>flexible joints<br>Forward pointing:<br>look of frame | Not as structured as the other concepts |

# APPENDIX 16: AEIUO AND ELITO


A1


A2


B1


B2


B3


C1


C2


D1

| AEIOU | Key metaphor | Observation |
|---|---|---|
| Activities | | |
| A | Why go to the water when the water can come to you | She sits down to wring the cloth (A1) |
| | | The bucket is put on a chair (A2) |
| B | You have made your bed | The bucket is put in the sink and filled (B1) |
| | | Soap is pumped into the floor bucket without lifting it. (B2) |
| | | Buckets are rinsed with water after use (B3) |
| | | |
| C | The line of least resistance) | Use cart to transport several garbage bags(C1) |
| | | |
| | | |
| | | The wooden floor is cleaned with the same water as vinyl floor (C2) |
| | | |
| D | Home sweet home | Waste bag carried by hand until bigger bag is emptied. This is put on cart. (D1) |
| | | |
| | | |
| E | Conquer all obstacles | The cart is pulled in the bucket while getting through a door (E1) |
| | | |
| | | |
| F | We only have to hands | It is difficult to find a place to put the mop (F1) |

| Judgement | Value | Interest |
|---|---|---|
| | | |
| Bending down often is not healthy | Healthy work position | Buckets should be placed in the right ergonomic height |
| It is easier to reach the bucket in this height | Convenience | The cart should focus on providing a healthy high of buckets |
| It is hard work to lift water or detergent | Health | Heavy buckets can be filled and emptied without lifting them |
| Takes time to prepare the cart | Efficiency | Cart should be easy and quick to prepare |
| The equipment is easier to use next time | Hygiene | Cart should be easy to clean |
| A lot of time and effort is used | | The cart should be quick to pack up for storage |
| Easier than walking twice | Efficiency | The cart is a working tool and must have a strong construction. |
| Heavy to lift bags, but the many bags also makes the cart heavier | Health | |
| The cleaning personnel will use the cart in the way they find most efficient even though it is not constructed for it. | | |
| Done to save time and effort | Efficiency | The cart must make sure that it is possible to bring the needed supplies |
| Damages the floors | | |
| Own routines are made. | Efficiency | The cart should be designed to fit the work procedures of the cleaning personnel |
| | Adjustability | The user should be able to personalise the cart |
| | Personalisation | |
| Actions are done in the easiest way and not the most ergonomic | High manoeuvrability | The cart should be easy to manoeuvre |
| | Convenience | Handles all the way around |
| | Flexibility | |
| The mop is unstable when resting on the wall | Flexibility | The mop should be able to be attached to the cart from different sides |


E1


F1







| Environment | | |
|---|---|---|
| G | It is a bumpy road | The cart is taken outside to the container (G1) |
| | | Drives on different surfaces (G2) |
| H | No dripping | Water is spilled when going over bumps (H1) |
| | | |
| I | The step climber | A step makes it necessary to drive another way (I1) |
| | | |
| J | The chameleon | Buckets can be filled on the cart due to a hose on the tap (J1) |
| | | The kitchen sink is used to get water (J2) |
| K | Make me proud | Storage room shared with other functions used all day (K1) |
| | | |
| | | |
| | | |
| L | Peekaboo! | Storage of cleaning equipment on the floor in a hall way under a table (L1) |
| | | Storage of cleaning equipment behind curtain in a bathroom (L2) |
| M | A black hole | Cleaning equipment placed in closet (M1) |
| | | The closet for storing equipment has a high edge (M2) |
| N | The wide ocean | Large floor areas have to be cleaned (N1) |
| | | |



| | | |
|---|---|---|
| The environments are not designed for the cart and has different surfaces | Manoeuvrability | The cart must be able to drive on different surfaces |
| | Freedom | |
| The can get slippery and may even get damaged | Clean | The cart must have buckets preventing the water from spilling. |
| Can leave spots | Functionality | The cart must support a cleaning method with limited use of water. |
| Takes time go around | Manoeuvrability | The cart should be able to pass steps |
| There are often steps because the building is old | | |
| Not all places have tubes on the tap | Efficiency | The cart must be easy to install |
| Not all places have a sink dedicated to cleaning | Adjustability | The cart must be adjusted to the environment it is put in |
| Cleaning is not prioritised and can make the cleaning personnel feel un appreciated. | Proud | The cart must change the thought that cleaning is a secondary job. |
| | Awareness | |
| | Integration | |
| | Appreciation | |
| Unorganised storage but always visible, can make the cleaning personnel feel that they are messy | Order | The cart must have a clear organisation |
| | Presentable | |
| The storage of cleaning equipment are often limited to a closet | Space | The cart must be able to fill very little to give the personnel the feeling of having enough storage space |
| The cleaning equipment needs to be lifted over the edge | Flexibility | The cart must be easy to lift and have low weight |
| Cleaning large floor areas involve repetitive work and this is unhealthy | Health | The cart should give the cleaning personnel opportunity to easy shift between different tasks |
| | Variation | |


m1


M2


N1


R1


S1


T1


T2


U1


V1

| AEIOU | Key metaphor | Observation |
|---|---|---|
| **Objects** | | |
| R | The job is to remove dirt but there is nowhere to put it | A bag for dirty mops was attached to the cart (R1) |
| S | I don't bother to be healthy | Ergonomic handle are too heavy so the cleaning personnel deselect it (S1) |
| T | I'm taking care of the world | Extra waste bag were attached with clips as the waste was sorted to spare the environment (T1)<br>A garbage bag is tied to the frame of the cart (T2) |
| U | A spanner in the work procedure | There are unused items on the cart (U1) |
| V | Store my stuff | Tools and some detergents are left on the cart when it is stored (V1) |

| Judgement | Value | Interest |
|---|---|---|
| | | |
| One many carts there are no separate place for dirty mops and cloth. Therefore the cleaning personnel needs to add a plastic bag them self, making the cart seem unorganised and not used the way it is supposed to. | Organisation | The cart must be designed for the all the steps in the cleaning procedure e.g. include room for dirty mops |
| | Functionality | |
| | Comprehensibility | |
| There are many tool which are sold on being ergonomic, but they are not used as they either are not fully ergonomic (e.g. too heavy) or because they are too time consuming. | Ergonomics | The cart must be designed for tools that are quick to adjust to the user |
| | Efficiency | The cart must compromise ergonomics with time and convenience |
| | Convenience | |
| The cart is lacking space for garbage | Environmental | The cart must have a flexible garbage bag holder that can be configured to hold one or more bags |
| | Functionality | |
| Unnecessary weight is moved around | Efficiency | The cart must be designed to store the equipment needed and not invite the cleaning personnel to bring unused items |
| | Health | |
| These objects are always brought on the cart and therefore it is just extra work to put them on a shelf and back again the next morning. | Efficiency | The cart should be able to be stored with the detergents |


O1


P1


Q1


X1


Y1


Y2

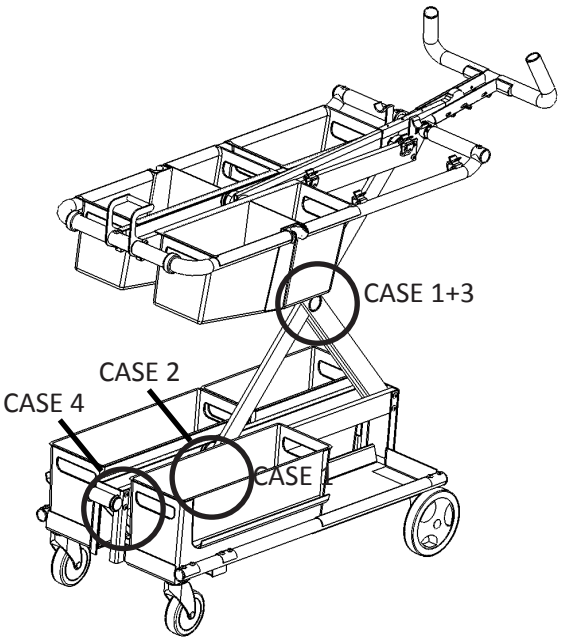

Z1

| AEIOU | Key metaphor | Observation |
|---|---|---|
| **Interactions** | | |
| O | Chitchat | Meeting others during cleaning and talking with them (O1) |
| P | Its for your own sake | Instruction on how to perform lifts so it does not harm the body (P1) |
| Q | I know – do you know? | Communication with employer is done by writing notes. (Q1) |
| **Users** | | |
| X | What? | The cleaning personnel had not education (X1) |
| Y | Extra nice fit | The assistant has difficulty collecting the dirt off the floor (Y1) |
| | | The cart is too tall for the cleaning personnel (Y2) |
| | | |
| | | |
| Z | You can make me fit | Makes own modifications on cart. A garbage bag holder welded on (Z1) |
| | | |

| Judgement | Value | Interest |
|---|---|---|
| | | |
| Cleaning is often a lonely job and the contact with the employees at the workplace is important for the cleaning personnel | Fellowship | The cart must not be an barrier for conversation with others |
| The personnel do not follow the instructions, but create their own routines. | Health | The cart must contribute to healthy work procedures and not support the cleaning personnel in choosing unhealthy procedures |
| The cleaning personnel are the best at knowing what supplies are needed | Communication | The cart must be a part of a system that improves the flow of information around the cart. |
| | | |
| The personnel do not know how the work are carried out in the most healthy way | Enlightenment | The cart must help the user to clean in the most healthy way |
| Not all cleaning personnel has a good physical condition | Individualism | The cart must be designed to fit a range of cleaning personnel |
| Cleaning personnel comes in all sizes | Adjustability | |
| When a new cleaning assistant is hired she inherit the cart of the cleaning assistant before her | Health | The cart must clearly express the value given to the user and the client |
| | | The cart must be easy to install at new places |
| The cleaning personnel consider the cart as their personal belonging | Personalised | The cart should support the user in the felling that it is theirs. |
| The cart is not sufficient for the assignments/tools | Flexibility | The cart must be able to be configured to a given task. |

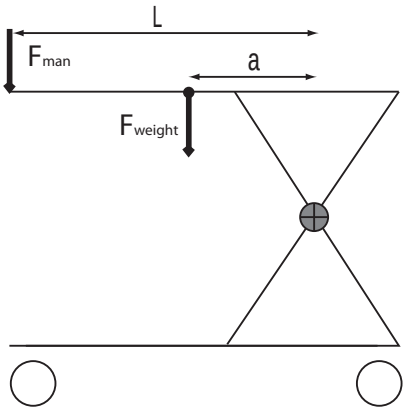
# APPENDIX 17: CALCULATIONS

The structure with one cross in the middle of the cleaning cart makes it necessary to calculate if the deflection of the cross exceeds an accepted value. When the cleaning assistant uses the cart it is important that she feels comfortable using it. This means the cart should have a limited play when it is pushed around. Three areas with influence on the play have been investigated to see if they exceed an acceptable level on 2 mm, see ill 16.1. Also a calculation of whether the frames most critical element can stand the pressure it could be exposed to, is included in this appendix. Throughout the calculations the joints have been calculated as fixed joint.




Ill. 16.1| 3d drawing of cart that shows critical elements.

**Case 1.**
The point of first case is to find the deflection of the cart if a person presses down on the cart, see ill 16.2.



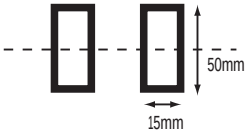

Ill. 16.2|Exemplified part

$$F_{weight} = 10kg \cdot 9{,}82m/s^2 = 98{,}2N$$

$$F_{man} = 200N$$

$$L = 650mm$$

$$a = 200mm$$

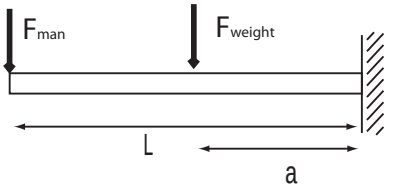



Ill. 16.3| Sectional view of profile

Inertia momentum, I, is found by using Solidworks and E is the module of elasticity for steel.

$$I = 2{,}0 \cdot 10^5 mm^4$$

$$E = 2{,}1 \cdot 10^5 N/mm^2$$




Ill. 16.4| Forces and dimension on cart

Formula for calculating the deflection added by F-man:

$$\delta_1 = \frac{F_{man} L^3}{3EI}$$

Formula for calculating the deflection added by F-weight:

$$\delta_2 = \frac{F_{weight} a^2}{6EI}(3L - a)$$

The two formulas put together to get the total deflection of the frame:

$$\delta_{total} = \frac{F_{man} L^3}{3EI} + \frac{F_{weight} a^2}{6EI}(3L - a)$$

Values put in the equation:

$$\delta_{total} = \frac{200N \cdot 650mm^3}{3 \cdot 2{,}1 \cdot 10^4 N/mm^2 \cdot 2{,}0 \cdot 10^5 mm^4}$$

$$+ \frac{98{,}2N \cdot 200mm^2}{6 \cdot 2{,}1 \cdot 10^4 N/mm^2 \cdot 2{,}0 \cdot 10^5 mm^4}$$

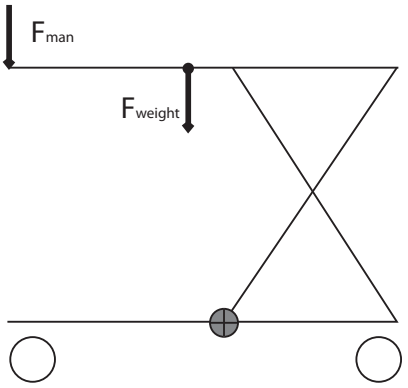
$$\cdot (3 \cdot 650mm - 200mm)$$

$$\delta_{total} = \underline{\underline{0{,}46mm}}$$

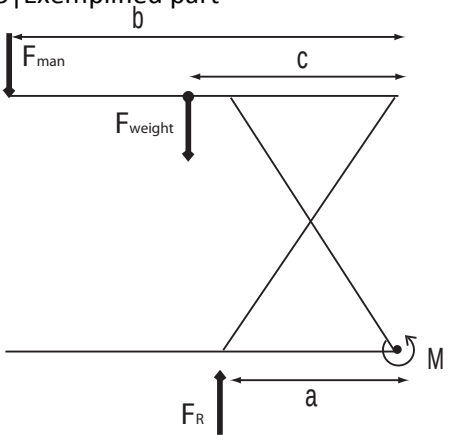
The deflection when the cart is being pressed down by a person with 200N is 0,46mm and does therefore not exceed the limit set at 2mm.

**Case 2**

The whole top structure presses down the rails. Since the rails are not supported in the middle they have been investigated to see whether the current structure is deflection too much. The deflection must maximum be 2 mm.




Ill. 16.5|Exemplified part




Ill. 16.6|Exemplified part with dimensions

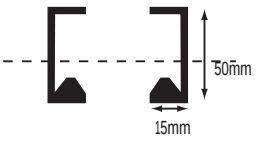
$F_{weight} = 10kg \cdot 9{,}82m/s^2 = 98{,}2N$

$F_{man} = 200N$

$a = 300mm$

$b = 800mm$

$c = 400mm$




Ill. 16.7| sectional view of profile

Inertia momentum, I, is found by using Solidworks and E is the module of elasticity for steel.

$$I = 1{,}3 \cdot 10^5 \, mm^4$$

$$E = 2{,}1 \cdot 10^5 \, N/mm^2$$

The momentum is used to find the force that pushes down on the rails:

$$M = F_R \cdot a - F_{man} \cdot b - F_{weight} \cdot c$$

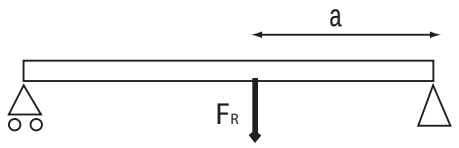
$$M = 0$$

$$F_R = \frac{F_{man} \cdot b + F_{weight} \cdot c}{a}$$

Values put in the equation

$$F_R = \frac{200N \cdot 800mm + 98{,}2N \cdot 400mm}{300mm}$$

$$F_R = 664N$$




Ill. 16.8|Forces and dimension on cart

Formula for calculating the deflection added by F-up:

$$\delta = \frac{F_{up} b \left(L^2 - b^2\right)^{3/2}}{9\sqrt{3}EI}$$

Values put in the equation:

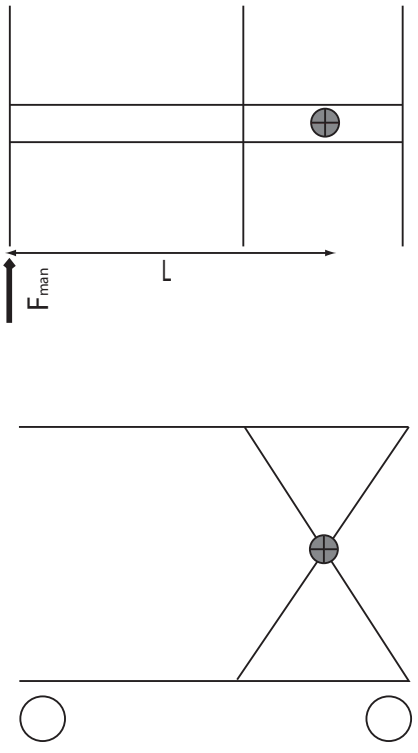
$$\delta = \frac{664 \cdot 300mm \cdot \left(800mm^2 - 300mm^2\right)^{3/2}}{9\sqrt{3} \cdot 2{,}1 \cdot 10^5 \, N/mm^2 \cdot 1{,}26 \cdot 10^5 \, mm^4}$$

$$\delta = \underline{0{,}25mm}$$

The deflection when the cart is being pressed by a person with 200 N is 0,25mm, which is lower than the maximum on 2 mm.
When adding the two calculated bends it gives a total bend on 0,72mm which is acceptable

**Case 3**

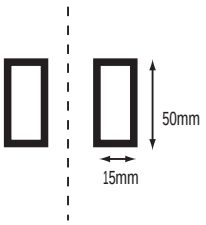
When the cart is pushed from the side some deflection can occur. This deflection has been investigated to find out if it will have influence on the use of the cart. It is estimated that a bend under 2mm will have no influence on the use. On ill 16.9 the forces and the element that is being investigated is shown.




Ill. 16.9|Exemplified part

$$F_{man} = 200N$$

$$L = 650mm$$




Ill. 16.10| Sectional view of profile

Inertia momentum, I, is found by using Solidworks and E is the module of elasticity for steel.

$$I = 1{,}52 \cdot 10^5 \, mm^4$$

$$E = 2{,}1 \cdot 10^5 \, N/mm^2$$


Ill. 16.11|Forces and dimensions on cart

Formula used to find the deflection F-man gives:

$$\delta = \frac{F_{mand} L^3}{3EI}$$

Values put in the equation

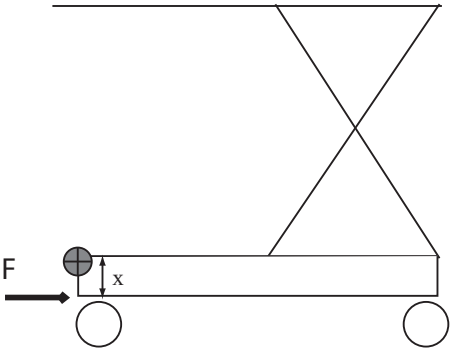
$$\delta = \frac{200N \cdot 650mm^3}{3 \cdot 2{,}1 \cdot 10^5 \, N/mm^2 \cdot 1{,}52 \cdot 10^5 \, mm^4}$$

$$\delta = \underline{0{,}57mm}$$

The deflection when the cart is being exposed to a pressure of 200 N on the side of the cart, gives a deflection of 0,57mm, which is acceptable.

**Case 4**

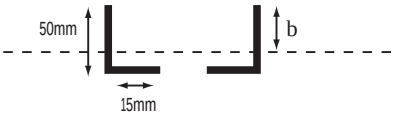
The most critical element in the frame has been investigated to find if it can resist the pressure that it is exposed to. The situation calculated is if the cleaning personnel pushed the front of the cart into an obstacle.




Ill. 16.12| Exemplified part

$$F = 1000N$$

$$x = 120mm$$

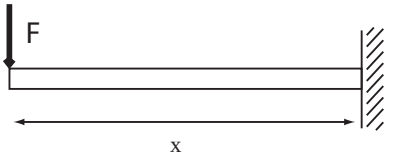



Ill. 16.13|Sectional view of profile

Inertia momentum, I, is found by using Solidworks and E is the module of elasticity for steel.

$$I = 2{,}3 \cdot 10^4 \, mm^4$$

$$E = 2{,}1 \cdot 10^5 \, N/mm^2$$




Ill. 16.14|Forces and dimensions on cart

The momentum in the investigated element is:

$$M = F \cdot x$$

$$M = 1000N \cdot 120mm$$

$$M = 1{,}2 \cdot 10^5 Nmm$$

The tension is found by using following formula:

$$\sigma = \frac{M}{I} \cdot b$$

Values put in equation to find tension

$$\sigma_{max} = \frac{1{,}2 \cdot 10^5 Nmm}{2{,}310^5 mm^4} \cdot 15{,}5mm$$

$$\sigma_{max} = 80N / mm^2$$

$$\sigma_{steel} \geq \sigma_{max}$$

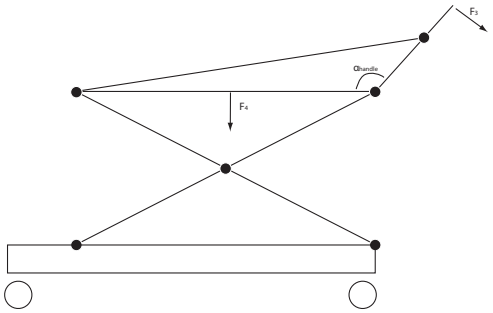
$$2{,}1 \cdot 10^5 N / mm^2 \geq 80N / mm^2$$

The tension in the element is below the maximum tension that the material can resist.

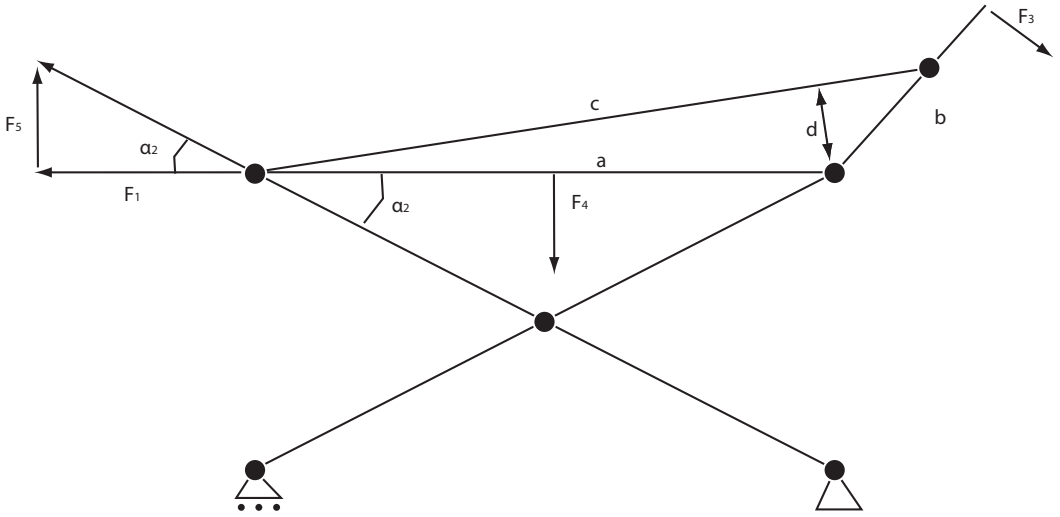
# APPENDIX 18: SPRING CALCULATIONS

To make the unfolding situation easier a spring is attached in the joints by the handle on cart. The illustration 17.2 shows the different parameters that are used to find the force the cleaning assistant needs to pull the handle with to make it unfold, F3.

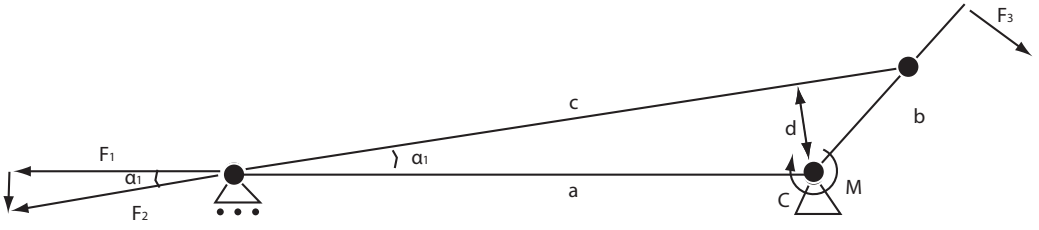
The mass of the top part of cart has been calculated to 6kg. This is calculated without equipment.



Ill. 17.1|Exemplified part




Ill. 17.2|Forces and dimensions on cart




Ill. 17.3|Forces and dimensions on the top of cart

The momentum around point C is described by:

$$M = F_3 \cdot b - F_2 \cdot d$$

To find F3 it is isolated

$$M = 0$$

$$0 = F_3 \cdot b - F_2 \cdot d$$

$$F_3 = \frac{F_2 \cdot d}{b}$$

F2 can be described through F1, because F5 = F4

$$F_1 = \frac{m \cdot g}{Tan\alpha_2}$$

$$F_2 = \cos\alpha_1 \cdot F_1$$

The description of F1 is substituted into the description of F2:

$$F_2 = \frac{\cos\alpha_1 \cdot m \cdot g}{Tan\alpha_2}$$

The description of F2 is substituted into the description of F3:

$$F_3 = \frac{\cos\alpha_1 \cdot m \cdot g}{Tan\alpha_2} \cdot \frac{d}{b}$$

d can be described by a

$$\sin\alpha_1 = \frac{d}{a}$$

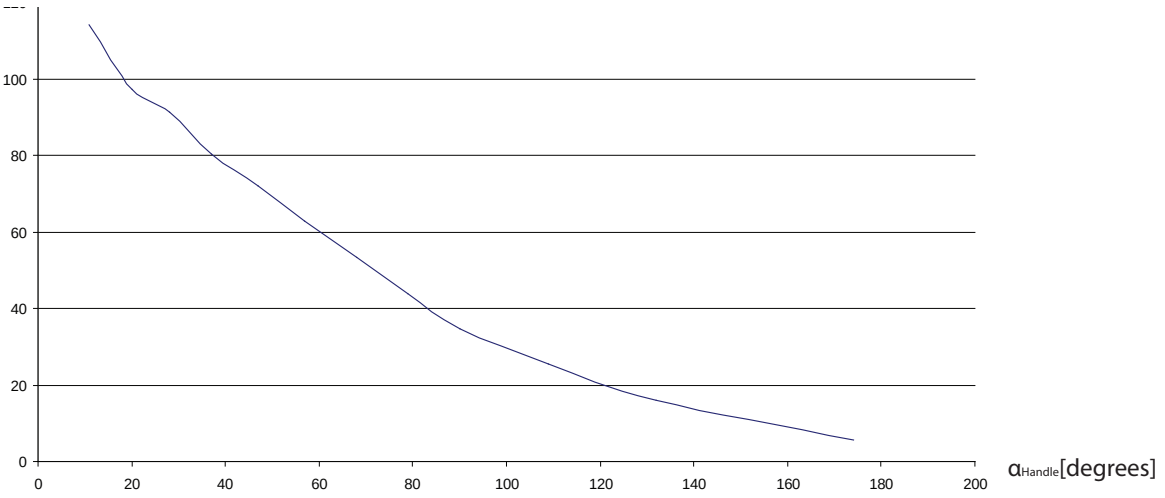
$$d = \sin\alpha_1 \cdot a$$

This gives the function for F3:

$$F_3 = \frac{\cos\alpha_1 \cdot m \cdot g}{Tan\alpha_2} \cdot \frac{a \cdot \cos\alpha}{b}$$

Where the angles α1, α2 and length a is variable parameters

This put in a diagram show that the function of F3 is almost linear, see ill 17.4. Because of this a spring is ideal to use to give the structure stability.




Ill 17.4 | The blue curve shows the force that is needed to pull the handle without the spring

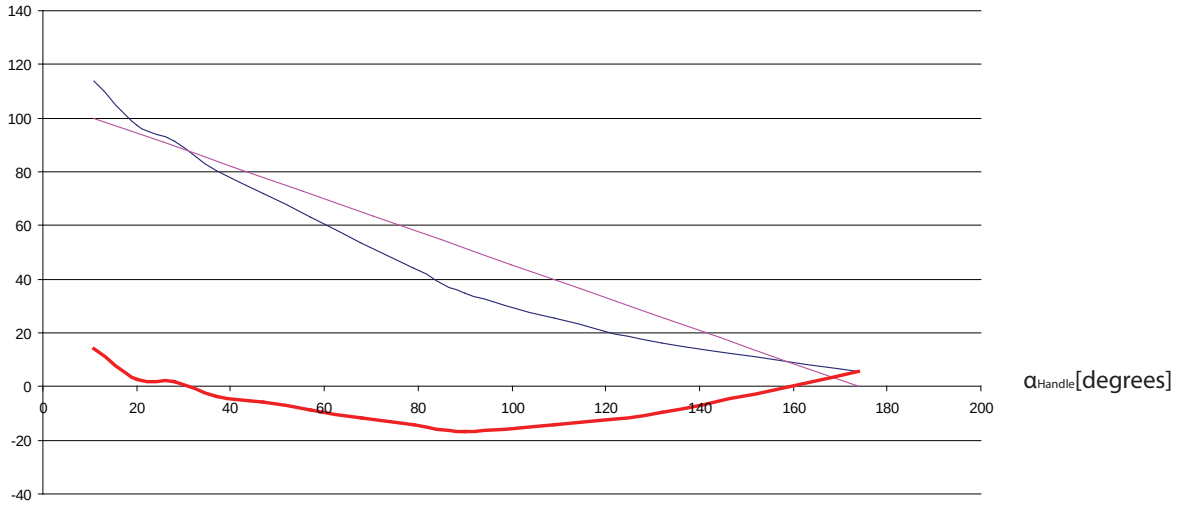
From this function a linear curve that describes the function best has been made, see ill 2. Out from this the maximum momentum has been found:

$$M_{spring} = F_{3\max} \cdot b$$

$$M_{spring} = 113N \cdot 300mm$$

$$M_{spring} = 33900Nmm$$

From this curve it has been found that the springs need to have a maximum of 30000Nmm. This will help the cleaning assistant unfold the cart. The red line in the diagram shows the forces that she needs to pull in the handle with. In most of the time the forces are negative meaning that the cart can lift it self.




Ill. 17.5| The graph shows the force the user needs to pull.
- The blue curve shows the force that is needed to pull the handle without the spring
- The purple curve shows the force the spring is providing
- The reed curve shows the force the cleaning assistant shall pull and push the handle

# APPENDIX 19: COST PRICE

| Component | Material | Processing | Dimension | Unit price | Units | Price |
|---|---|---|---|---|---|---|
| | | | mm | kr | | kr |
| **Bottom frame** | | | | | | |
| Rail | Aluminium | Extrusion*, Drilling + thread | 880 | 45 | 2 | 90 |
| Rail front endpart | Stainless steel | Waterjet cutting, Bending | - | 45 | 1 | 45 |
| Rail back endpart | Stainless steel | Waterjet cutting, Bending, Welding | - | 50 | 1 | 50 |
| Side tube | Stainless steel | Drilling + thread | Ø26, 840 | 40 | 2 | 80 |
| Back tray | Stainless steel | Water jet cutting, Bending | - | 35 | 1 | 35 |
| Back tray tube | Stainless steel | Welding | Ø20, 380 | 15 | 1 | 15 |
| L-foot mount | Stainless steel | Waterjet cutting, Bending, Welding | - | 25 | 1 | 25 |
| L-foot | Stainless steel | Waterjet cutting, Welding | - | 23 | 1 | 23 |
| L foot rubber ring | Rubber | - | Ø28 | 2 | 2 | 4 |
| L-foot bolt | Stainless steel | - | M8, 50 | 2 | 1 | 2 |
| L-foot nut | Stainless steel | - | M8 | 0,5 | 1 | 0,5 |
| Spring | Stainless steel | - | - | 6 | 1 | 6 |
| Front wheel | Plastic, Stainless steel | - | Ø100 | 25 | 2 | 50 |
| Back wheel | Plastic ø15 | - | Ø150 | 15 | 2 | 30 |
| Back wheel mount | Stainless steel | Waterjet cutting, Bending | - | 12 | 2 | 24 |
| Bearing unit | Stainless steel | - | Ø20 | 25 | 1 | 25 |
| End plug | Plastic | - | Ø23 | 1 | 2 | 2 |
| Flat head screw | Stainless steel | - | Ø3, 3 | 0,5 | 24 | 12 |
| Assembly | - | - | - | 150 | 1 | 150 |
| **Total** | | | | | | **668,5** |
| | | | | | | |
| **Top frame** | | | | | | |
| Rail | Aluminium | Extrusion, Drilling + thread | 880 | 45 | 2 | 90 |
| Rail front endpart | Stainless steel | Waterjet cutting, Bending, Welding | - | 35 | 1 | 35 |
| Rail back endpart | Stainless steel | Waterjet cutting, Bending, Welding, Thread | - | 50 | 1 | 50 |
| Side tubes | Stainless steel | Bending, Drilling, Welding | Ø26, 840 | 60 | 2 | 120 |
| Side tube rubber cover | Rubber | - | Ø26 | 8 | 2 | 16 |
| Side tube rubber ring | Rubber | - | Ø26 | 4 | 2 | 8 |
| Side tube mop holder | Silicone rubber | Injection moulding* | - | 4 | 2 | 8 |
| Back tube | Stainless steel | - | Ø26 | 9 | 2 | 18 |
| Back tube rubber cover | Rubber | - | Ø26 | 7 | 2 | 14 |
| Garbage holder | Silicone rubber | Extrusion* | - | 7 | 4 | 28 |
| Spring | Stainless steel | - | - | 15 | 2 | 30 |
| Bearing unit | Stainless steel | - | Ø20 | 25 | 1 | 25 |
| Flat head screw | Stainless steel | - | Ø3, 3 | 0,5 | 24 | 12 |
| End plug | Plastic | - | Ø22 | 1 | 2 | 2 |
| Assembly | - | - | - | 125 | 1 | 125 |
| **Total** | | | | | | **491** |
| | | | | | | |
| **Cross + Handle** | | | | | | |
| Cross bar | Stainless steel | Waterjet cutting, Welding | 823 | 45 | 3 | 135 |
| Bearing unit | Stainless steel | - | Ø20 | 25 | 1 | 25 |
| Rail wheel | Nylon | - | - | 6 | 2 | 12 |
| Rail wheel bolt | Stainless steel | - | M8, 65 | 2 | 2 | 4 |
| Rail wheel nut | Stainless steel | - | M8 | 0,5 | 2 | 1 |
| Handle | Stainless steel | Waterjet cutting, Bending | Ø26 | 40 | 1 | 40 |
| Handle rubber cover | Rubber | - | - | 10 | 2 | 20 |
| Handle connector | Stainless steel | Welding | - | 25 | 2 | 50 |
| Handle connector bolt1 | Stainless steel | - | M4, 68 | 1,75 | 1 | 1,75 |
| Handle connector bolt2 | Stainless steel | - | M4, 58 | 1,75 | 1 | 1,75 |
| Handle connector nut | Stainless steel | - | M4 | 0,35 | 2 | 0,7 |
| Handle end plug | Plastic | - | Ø22 | 1 | 2 | 2 |
| Cross connector, part1 | Stainless steel | Welding, Drilling | - | 15 | 1 | 15 |
| Cross connector, part2 | Stainless steel | Drilling | - | 10 | 1 | 10 |
| Cross connector endpart | Aluminium | Waterjet cutting | - | 15 | 1 | 15 |
| Cross connector spring | Stainless steel | - | - | 2 | 1 | 2 |
| Final assembly | - | - | - | 120 | 1 | 120 |
| **Total** | | | | | | **455,2** |
| | | | | | | |
| **Buckets** | | | | | | |
| Top bucket right front | PP Plastic | Injection moulding* | - | 25 | 1 | 25 |
| Top bucket left front | PP Plastic | Injection moulding* | - | 25 | 1 | 25 |
| Top bucket right back | PP Plastic | Injection moulding* | - | 15 | 1 | 15 |
| Bottom bucket front | PP Plastic | Injection moulding* | - | 20 | 2 | 40 |
| Bottom bucket back | PP Plastic | Injection moulding* | - | 20 | 1 | 20 |
| **Total** | | | | | | **125** |
| | | | | | | |
| **TOTAL PRODUCTION PRICE** | | | | | 131 | **1739,7** |

* The processing of this part will include a initial cost for tooling prices which is not included here