

ID 4256

# PROJECT USABILITY AND USER EXPERIENCE ASSESSMENT IN DESIGN



## FINAL REPORT

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# EXECUTIVE SUMMARY

During the past few months a lot of effort has been put into successfully redesigning the Océ PlotWave 300. The Océ PlotWave 300 is a black and white (B&W) plotter that enables users to print, copy and scan large format documents. In the first phase, described in the progress report, the usability and user experience of the Océ PlotWave 300 were explored. It was found that the usability of the interface of the original PlotWave 300 inhibited some of the first time users from achieving their goals.

In this report the emphasis is mainly on the process of redesigning. Taking into account the knowledge gained from study 1 and the usability test of the original PlotWave 300, the following guidelines for the redesign were specified:

- Making the user panel more intuitive and consistent.
- Providing better guidance and feedback throughout the interaction with the PlotWave 300.
- Improving the user experience.



Figure 1: The redesigned housing of the PlotWave 300

To improve the original PlotWave 300 and create a pleasant user experience, the metaphor of the ideal co-worker was introduced. This metaphor formed the basis for the decisions made concerning the redesign. The plotter should have strong communication skills, provide a good first impression and create a deep relationship with its users. Combining the insights gathered in phase 1 the following design goal was formulated: "The redesign aims to provide a pleasant and intuitive user experience for both experienced and inexperienced users. The plotter should be straightforward and adaptive to its users and also offer continuous feedback and guidance." This resulted in an initial concept, of which the main aspects are the interactive preview window in the screen interface and the clear and direct guidance it gives in the form of text and lights in the housing.

In order to assess the quality of the redesign (in terms of usability and user experience) a second user study was performed. A prototype of the housing and the screen interface was created to approximate the concept as close as possible. Five participants (with diverse backgrounds) were observed and interviewed during and after interacting with the prototype. After analyzing the results from study 2 the following conclusions about the redesigned PlotWave 300 were drawn:

- The usability of the redesign is significantly improved since the redesigned system can be operated with fewer button presses, shorter task completion times and less frustrations expressed.
- The amount of positive comments in regards to the interaction with the redesigned machine in combination with the high scores for the systems pragmatic qualities (AttrakDiff) indicates a system with a sufficiently high usability, although there is still room for improvement.
- The redesign generally provides clear guidance through the incorporation of light indications and clear messages on the user panel leading to a straightforward and intuitive user experience.
- The redesign is generally perceived as having characteristics in line with the identified user experience metaphor: The redesign is essentially communicative, professional and pleasant to use.
- Improvements can be made to the redesign to better guide the user through the interaction of printing,

scanning and copying. The user should be provided with useful guidance regardless of the order in which he interacts with the machine. The user panel should provide a clear grouping of features as well as a consistent design.

Some adaptations to the concept were made on the basis of the results from study 2. An overview of the most important features of the final concept is presented in the enumeration below (also see figure 1 and figure 2).

- To increase the “what you see is what you get” factor, a preview window is part of the interface (figure 2). This preview window allows the user to directly manipulate the document settings which provides clear feedback on actions taken, hereby increasing the participants’ confidence while making changes.
- The user is offered more guidance, both in the form of text on the screen and through the lighting strips located at the paper input slot, the paper output slot, the top delivery tray and the USB-slot. Whenever the user needs to perform an action incorporating one of these slots they light up. The paper input slot and the USB-slot, can be used immediately when

approaching the plotter, they therefore light up when the PlotWave senses a person entering the room.

- The workflow is improved so that it responds directly to the actions the user performs. The machine predicts and emphasizes what the user is most likely to do next. An example of this is when the user inserts a USB stick: It’s most likely that the user wants to scan to or print from USB, so only those options are initially presented.
- By changing the position of the screen from the side to the center and integrating it in the housing the focus of the user can be on the plotter as a whole.

Based on the results of study 2 it can be concluded that the final redesign of the PlotWave 300 shares a lot of commonalities with the ideal co-worker metaphor as it is perceived as practical, clearly structured, professional and inviting. Another conclusion that follows from the results is that users receive more feedback and guidance. All in all the redesign provides a pleasant and intuitive user experience, is straightforward and adaptive and offers continuous feedback and guidance: therefore the design goal has been reached.

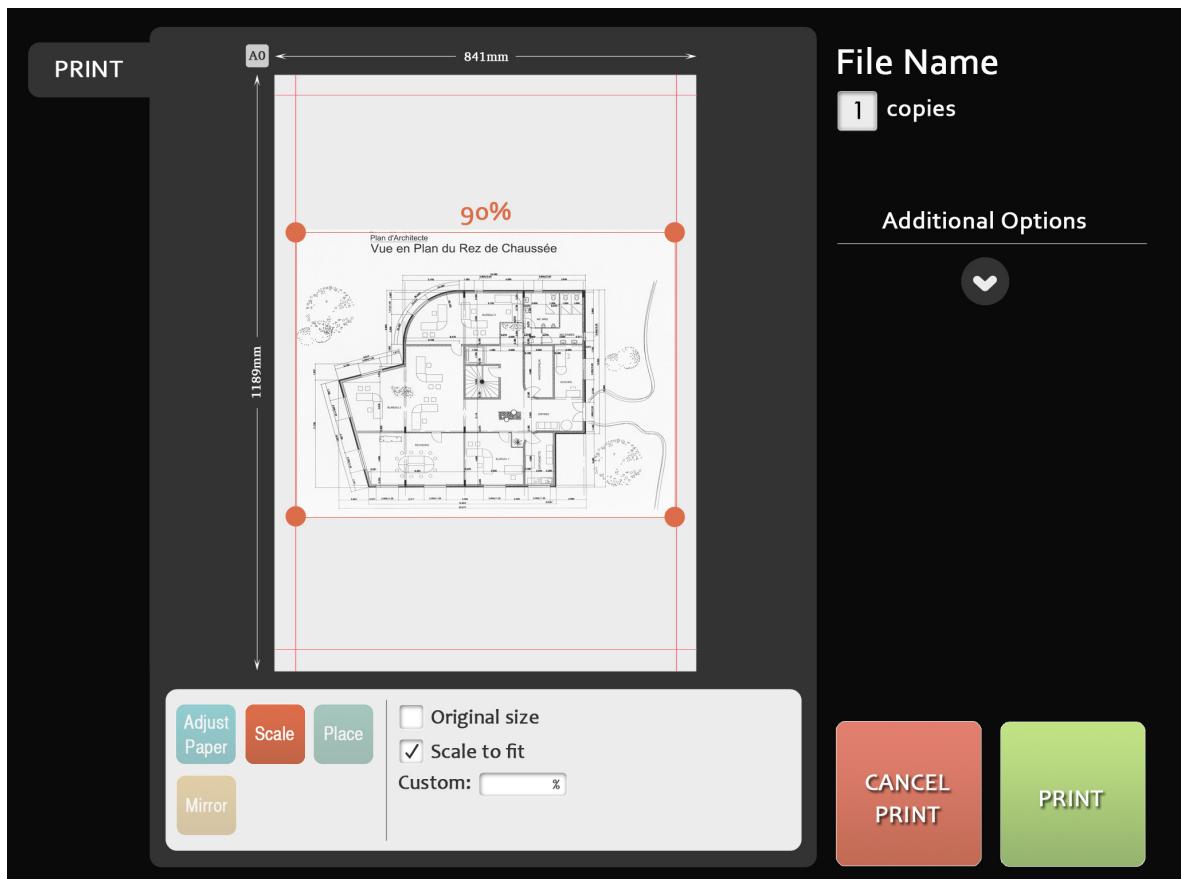


Figure 2: The redesigned interface of the Océ PlotWave 300



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# INTRODUCTION

During the past few months a lot of effort has been put into successfully redesigning the Océ PlotWave 300 (figure 3). The Océ PlotWave 300 is a black and white (B&W) plotter that enables users to print, copy and scan large format documents. The first design phase, described in the progress report, was mainly about exploring the usability and user experience of the original PlotWave 300. During this period a lot of data was gathered and thoroughly analysed to gain rich insights on how to redesign the plotter. In this report the emphasis is mainly on the process of redesigning.

Chapter 1, Previous works, provides a brief outline of the insights gained in the analysis of the original PlotWave 300 in terms of usability and user experience. These insights form the basis of our redesign and are referred to throughout the report. In order to gain inspiration for our redesign a metaphor was created. This metaphor was used to define the user experience the team aimed for in the redesign. A description of it can be found in chapter 2, UX targets.

The design goal is described in chapter 3. In this chapter the problem definition and design requirements are presented, providing a base for the development of the initial redesign. Readers interested in the initial redesign are encouraged to look into chapter 4, the design proposal.

In order to assess the quality of this redesign (in terms of usability and user experience) a second user study was performed. The methods and results of this user study are described as well as discussed in chapter 5, Study 2. The evaluation of the design proposal in relation to the results from study 2 can be found in chapter 6, The evaluation of the design proposal. In chapter 7, The final redesign, all the insights presented in the previous chapters come together to form the final redesign. The project is concluded with a reflection on the design process.



Figure 3: The Océ PlotWave 300

# 01 THE PREVIOUS WORKS

This chapter briefly describes the functionality of the Océ PlotWave 300. It also provides a summary of the team's first impressions of the plotter together with the main conclusions from Study 1, where the usability of the PlotWave 300 was investigated. A more elaborate disquisition can be found in the progress report.

## 1.1 DESCRIPTION OF THE PRODUCT

The Océ PlotWave 300 is a black and white (B&W) plotter for the professional market that enables users to print, copy and scan large format technical documents. Users can interact with the plotter through the drivers, the user panel (Figure 4), the housing of the plotter and the Express WebTools.

## 1.2 TEAM'S IMPRESSIONS OF THE PRODUCT'S USABILITY

In order to get a first impression of the PlotWave 300 the team visited Mr. van Buren, an Océ user, at Machinefabriek Kreber BV. The products functionality and usability was briefly discussed with Mr. van Buren and the team got a chance to explore the product. The main conclusions from this first encounter are presented below:

- The team was surprised by the user panel not being a touch screen. Furthermore the four soft keys, as can be seen in Figure 4 (the red arrows), were sometimes noted as unresponsive and hard to interact with. The numeric pad in the user panel seemed redundant to the team, since the user would easily be able to control the input of numbers with the scroll wheel.
- The team concluded that the design of the housing suits a professional office environment. The release button for releasing a scanned/copied document was somewhat problematic to interact with when also holding a document, and the team was confused about where to insert a document due to the insufficient use cues. Appropriate feedback on process and waiting times was lacking.
- The Express WebTools were understood by the group as an alternative way of printing, replacing the

need for drivers. Since getting to know a new system always requires time and effort the team questioned the necessity of offering the user these tools.

## 1.3 CONCLUSIONS FROM STUDY 1

To investigate the usability of the Océ PlotWave 300 a user test was performed at the headquarters of Océ in Venlo. In this test, five participants tried to complete a set of tasks concerning printing, scanning and copying. This test, study 1, showed that the Océ PlotWave 300 has strong and weak points. These are illustrated in figure 5.



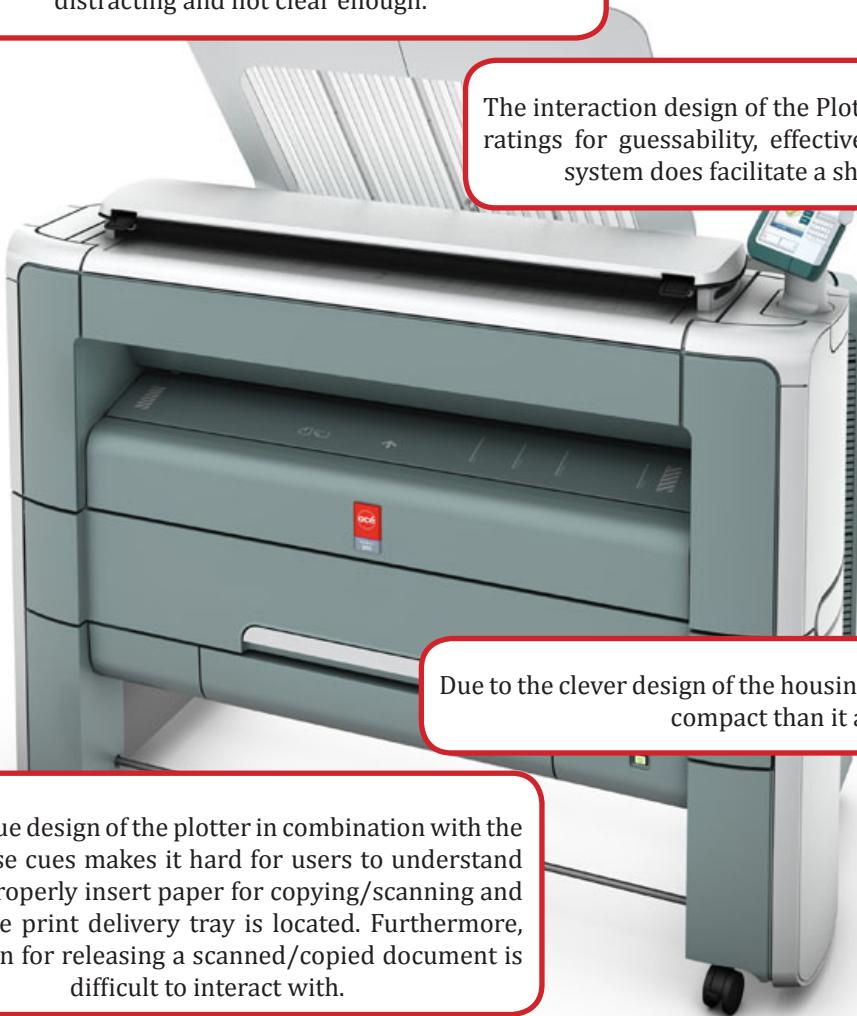
Figure 4: Detailed picture presenting the user panel part of the Océ PlotWave 300. The red arrows show the four soft keys.

The user panel gives the impression of featuring a touch screen. This results in users having difficulties in understanding how to interact with the screen and buttons.

Most of the participants are already familiar with using similar drivers to print, so most users would not benefit from the Express WebTools. In addition, participants found that the jargon and layout used in the Express WebTools are distracting and not clear enough.

The use of several buttons sharing the same function adds to the confusion and makes it hard for users to find the right buttons to press.

The interaction design of the PlotWave 300 has lead to low ratings for guessability, effectiveness and efficiency. The system does facilitate a short learning curve.



The unique design of the plotter in combination with the lack of use cues makes it hard for users to understand how to properly insert paper for copying/scanning and where the print delivery tray is located. Furthermore, the button for releasing a scanned/copied document is difficult to interact with.

Most of the redesign opportunities lie within the domain of the user panel and the housing. The subsequent redesign phase will therefore be focused on these two elements.

Many frustrations in usage originate from lack of guidance in how to proceed after an action is taken, often leaving the user in a state of confusion.

Figure 5: the main points found in the Océ PlotWave 300

# 02 UX TARGETS

The goal of this chapter is to briefly describe the UX targets used for the redesign of the PlotWave 300. A discussion about the user experience of the Plotwave 300 and any other plotter or printer for that matter almost immediately results in a discussion about the implementation of technology. In our opinion a strong technological focus in the beginning of the design process inhibits creativity. To counter the aforementioned problem, it has been decided to use the metaphor of an “ideal co-worker” to provide the level of abstraction that leads to innovative ideas on the one hand and the simplicity to facilitate a rich discussion that can be understood throughout a multidisciplinary design team on the other hand.

## 2.1 METAPHOR

People generally have strong emotions towards the machines that fail them. This can even go as far as people displaying physical violence towards machines. A survey performed by the University of Maryland into computer rage found that there were people that went as far as shooting their computers (Computer Rage: Reported Acts of Rage Against Computers, 2005 [Online]). An

explanation for this might be given by Fogg (2002), who found that people display a wide array of social responses towards machines and draws the conclusion that people see machines (e.g. computers, printers etc.) as social actors. Taking this knowledge into account creates an interesting opportunity to define the UX targets in accordance to the metaphor described in figure 7. A more elaborate description of these UX targets can be found in appendix 1: UX targets metaphor.

## 2.2 CHARACTER

In order to take the metaphor a step further the ideal co worker needs character. What will people think while walking away from the redesigned Plotwave 300? Was it friendly, professional or was it grumpy? Adding character influences the user experience in a major way.

In order to come up with the ideal character, the team decided upon a list of words describing the intended character of the redesign. In order to gain more structure these words were clustered, the results of which can be found in figure 6.

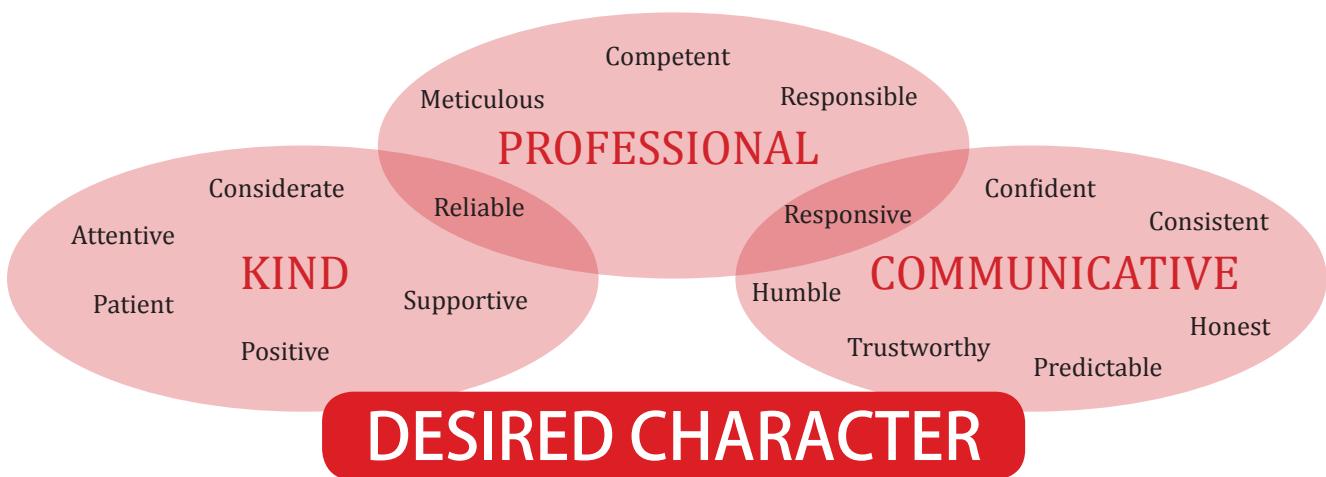


Figure 6: The characteristics of an ideal co worker

# PLOTWAVE 300: THE IDEAL CO WORKER



## DEALS WITH MISTAKES

A good coworker knows how to deal with your mistakes as well as his own. If an error occurs, the PlotWave 300 should offer an explanation of what went wrong and how to solve this.

## COMMUNICATIVE

An ideal co worker speaks your language and keeps you informed on a regular basis. The PlotWave 300 should provide the user with fast and clear feedback on what is happening, using clear jargon and icons.

## DEPENDABILITY

Good co workers are reliable, they keep their promises and respect agreements. The plotter should be responsive and transparent, as transparency creates trust: what you see is what you get.

## GOOD FIRST IMPRESSION

People decide in a few seconds if they like you, so good co workers have a strong first impression. This is also the case with plotters: users make some assumptions based on what they already know and combine this with the visual cues the machine provides.

## DEEP RELATIONSHIP

A great coworker knows you and you know him. You don't have to spell everything out but can suffice with shortcuts which he then understands, which deepens your relationship. This is why the PlotWave 300 should interpret the actions of the user and anticipate to this: the user should have the feeling that the plotter understands him.

## USES DOWNTIME PRODUCTIVELY

When a good coworker is not busy with tasks because he finished them, he uses the free time in a useful way. For the plotter it would be ideal if it could use the downtime (nights, weekends) to do maintenance jobs like cleaning, which can be done without human intervention.

Figure 7: The UX targets

## 2.3 CONCLUSION

In this chapter the user experience targets were explored by using the metaphor of “The ideal co-worker” (see also figures 6 and 7). In table 1 the characteristics of the metaphor are translated into specific focus points for the PlotWave interaction.

Focus point	Description
Providing status updates	Providing good status updates makes the user aware of what the plotter is doing.
Providing feedback	Constantly providing feedback shows the user that the plotter knows what the user is trying to do.
Using comprehensible language	Speaking to the user in a way he understands, while avoiding incomprehensible jargon.
Clear visual language	Using icons and figures that have meaning to the user.
Avoid ambiguity	Avoid having multiple buttons performing the same function, since doing so might create confusion for occasional users.
Responsive buttons	Improve trust in the plotter by having responsive buttons that perform the function they were intended to perform.
What you see is what you get	Presenting the machine in a way that communicates its functions to avoid disappointment.
Beautiful design	Wow-ing potential customers by having an attractive visual design for the interface and housing.
Uses downtime productively	By also performing tasks when not working on user assigned job efficiency could be increased.
Dealing with errors	When an error does occur, user perception should be shifted by creating messages the user understands and feels okay about.

Table 1: Summary of UX targets

# 03 DESIGN GOAL

The findings presented in this chapter are based on the research done in the earlier stages of the project. The problem definition described in paragraph 3.1, forms the foundation for the design goal found in paragraph 3.2. The design specification can be found in appendix 2: Design Specification.

## 3.1 PROBLEM DEFINITION

The problem can best be described by drawing attention to the discrepancy between what Océ has set out to achieve with the PlotWave 300 and how users experienced the product during the usability study. Users should be able to walk up to the PlotWave 300 and operate it even if they had no prior experience with it. However, during the usability study it became clear that for some of the participants this was not the case as they were unable to perform certain tasks. Although “walk up and use” is an interesting starting point for a redesign, it is just as important to take into account the users that use the PlotWave 300 on a daily basis.

**“How can one redesign the PlotWave 300 in a way that makes it intuitive to use and understand for first time users as well as frequent users?”**

Solving this problem presents a great opportunity for Océ to increase market share since users don't see printing/plotting as their main job but as a tool to achieve their goal. There is usually a lot on their minds that has very little to do with printing but more with their day to day business, which is why they want to step up to the machine and get results easily and quickly.

At the moment it is not a simple task for first time users to operate the PlotWave 300. Frequent users have learned to use the machine, but even they come across features that are lacking in terms of usability. First time users will also meet problems using the plotter. This makes it more difficult for them to use this tool and may eventually make them dislike using the PlotWave 300 again. As a result, people might not be willing to purchase a new Océ plotter when needed.

## 3.2 DESIGN GOAL

By combining the results from Usability study 1 with the main conclusions from the User experience targets, the design goal was formulated as follows to guide the team in the coming design phase:

**The redesign aims to provide a pleasant and intuitive user experience for both experienced and inexperienced users. The plotter should be straightforward and adaptive to its users and also offer continuous feedback and guidance.**

# 04 DESIGN PROPOSAL

This chapter briefly describes the design concept as presented during the usability and UX study 2 (See Chapter 5: Study 2). The concept is the result of an iterative design process based on the results from study 1. The concept is threefold: the interface, the housing and the workflow. For a more detailed description of the final concept (including the incorporated improvements after study 2), see Chapter 7: Final Redesign.

## 4.1 INTERFACE

The screen is a touch screen which is in line with common practise for devices today. This facilitates a clean design

and enhances the feeling of control.

The interface is based on a non-layered design philosophy meaning that all settings can be adjusted in the same screen (see figure 8). By avoiding deep menu structures the team aims to communicate transparency, simplicity and control to the users of the redesigned PlotWave. The interface is designed in a way that directs the user's attention to the main interface element: the print/scan/copy preview image. This feature gives a clear overview which enhances the user confidence through communicating: what you see is what you get, there won't be any unpleasant surprises.

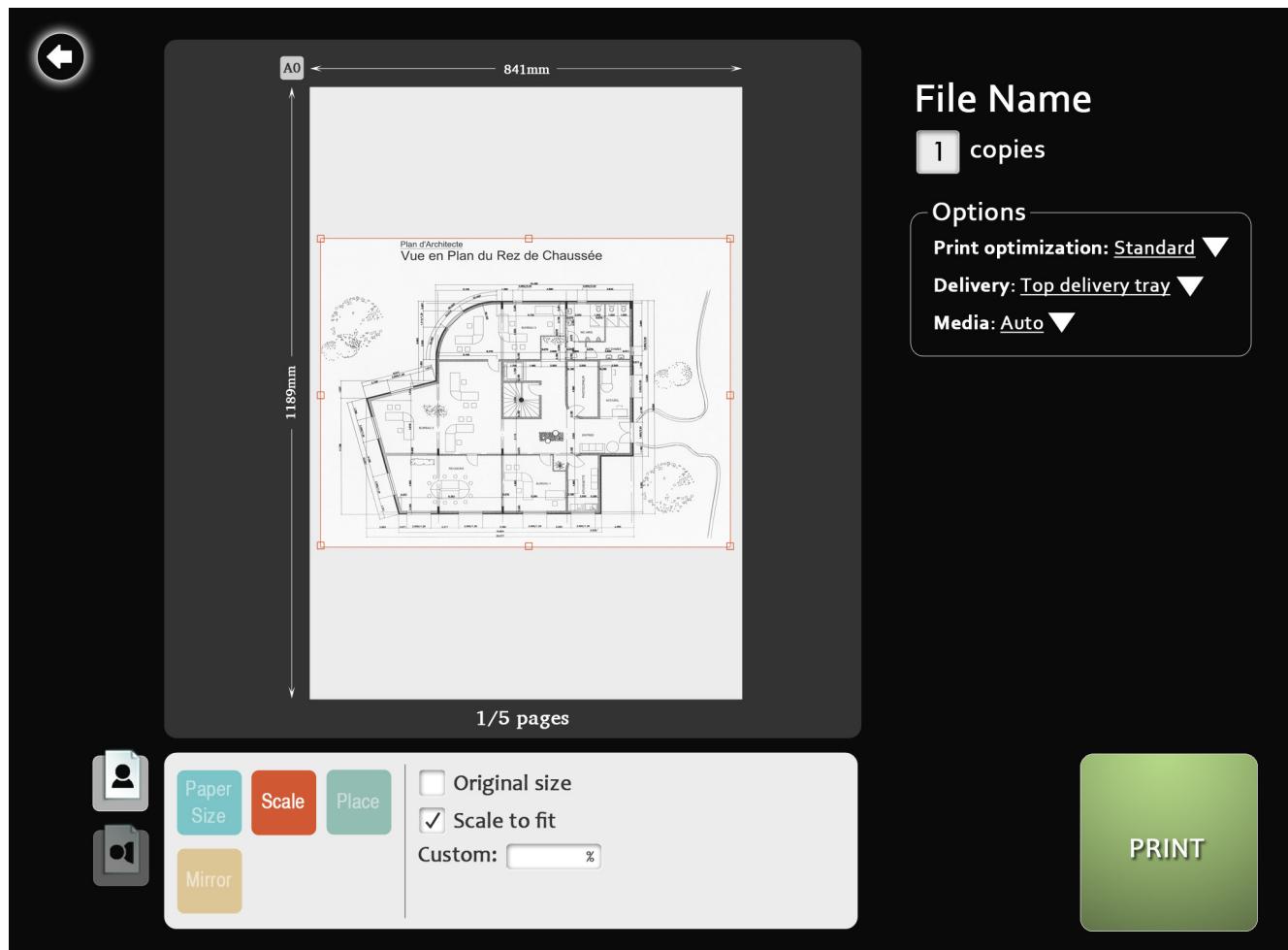


Figure 8: The main interface for printing

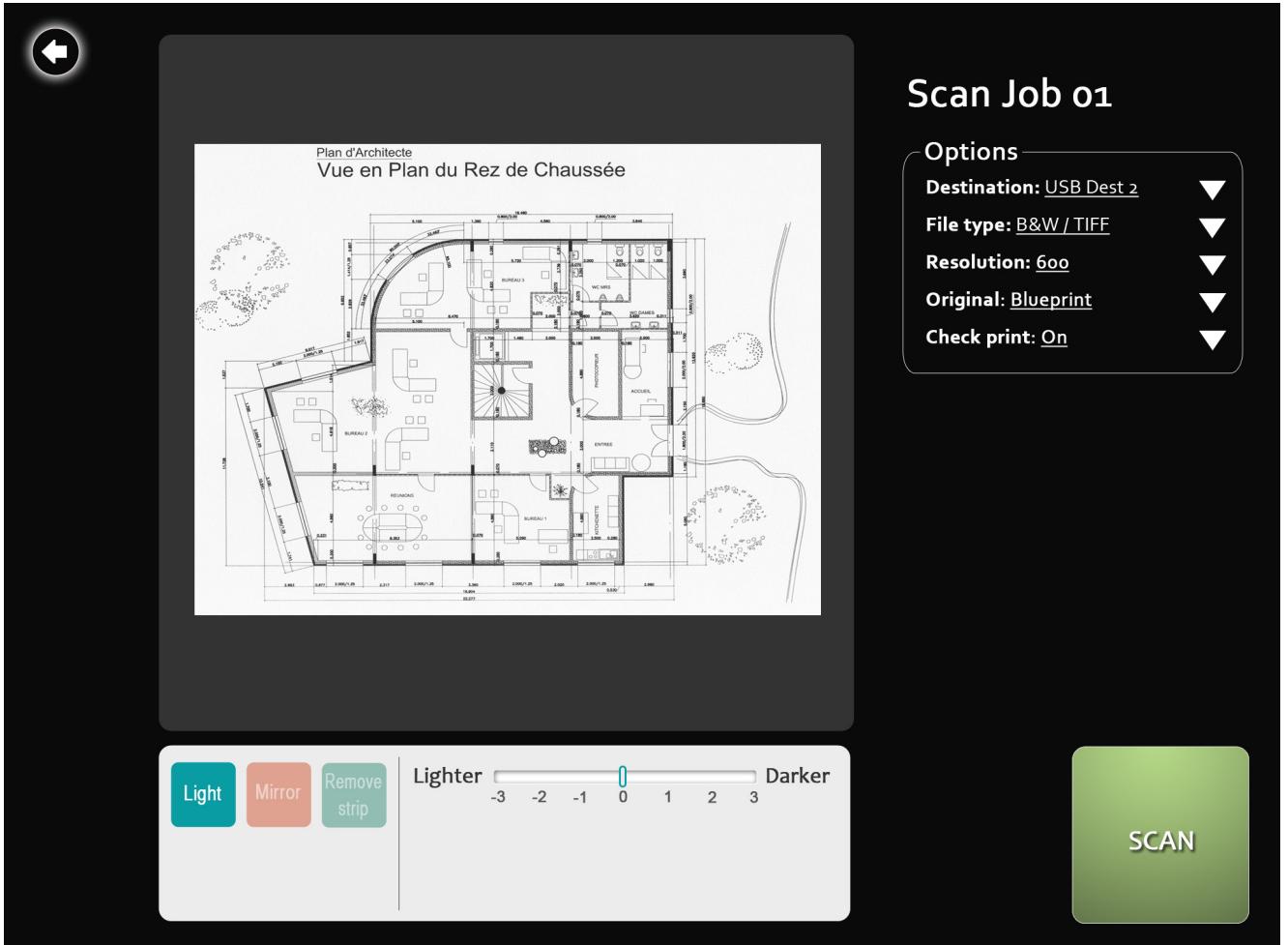


Figure 9: The main interface for scanning

The settings are divided into two categories. One category, located below the preview window, contains all options for editing the preview. Selecting one of these options allows for direct manipulation of the final result. The other category, located to the right of the preview window features the additional options. Colour coding of the buttons aims to provide additional guidance. A clearly noticeable confirm button is positioned in the bottom-right corner providing a clear call to action.

The concept provides clear indications of process status, for example through screen animations for estimated waiting times.

## 4.2 HOUSING

A main feature of the redesigned housing (see figures 10 and 11) is that the screen is now incorporated in the housing and located in the centre to guide and focus the user's attention to the housing and screen as a whole.

This also provides a sturdy and compact solution, adding to a design expression in line with the teams UX targets and design goal.

The main shape of the plotter is more rounded than the original PlotWave 300. This is meant for creating a friendlier and more welcoming appearance.

Light strips are incorporated to guide the user's attention to certain areas which require it. They are located at the print top-tray, the scanner input (see figure 11), the scanner output, the release-paper button and the USB-input.

## 4.3 WORKFLOW

The concept aims to be intuitive and is designed in accordance to how users are most likely to interact with the PlotWave. The redesign allows for multiple ways of starting a usage scenario (first inserting USB

drive or document or first selecting an option from the menu). No matter how the user starts the interaction the information on the screen will adapt. The user should not have to “tell” the plotter something more than once. E.g. after inserting a document only the most probable options will be available (scanning or copying). Since the option of printing is very unlikely, it will in those cases be left out from the start screen presented in Figure 12. A strong connection is formed between physical user actions (i.e. inserting paper) and screen animations. This in order to create a strong feeling that the PlotWave truly understands the user. E.g. When a document is inserted a preview image will, for example slide into the screen interface from the same direction. For a flowchart describing this interaction, see figure 36.



Figure 10: The concept for the housing



Figure 12: The start screen



Figure 11: The concept with activated light strip for scanner input area

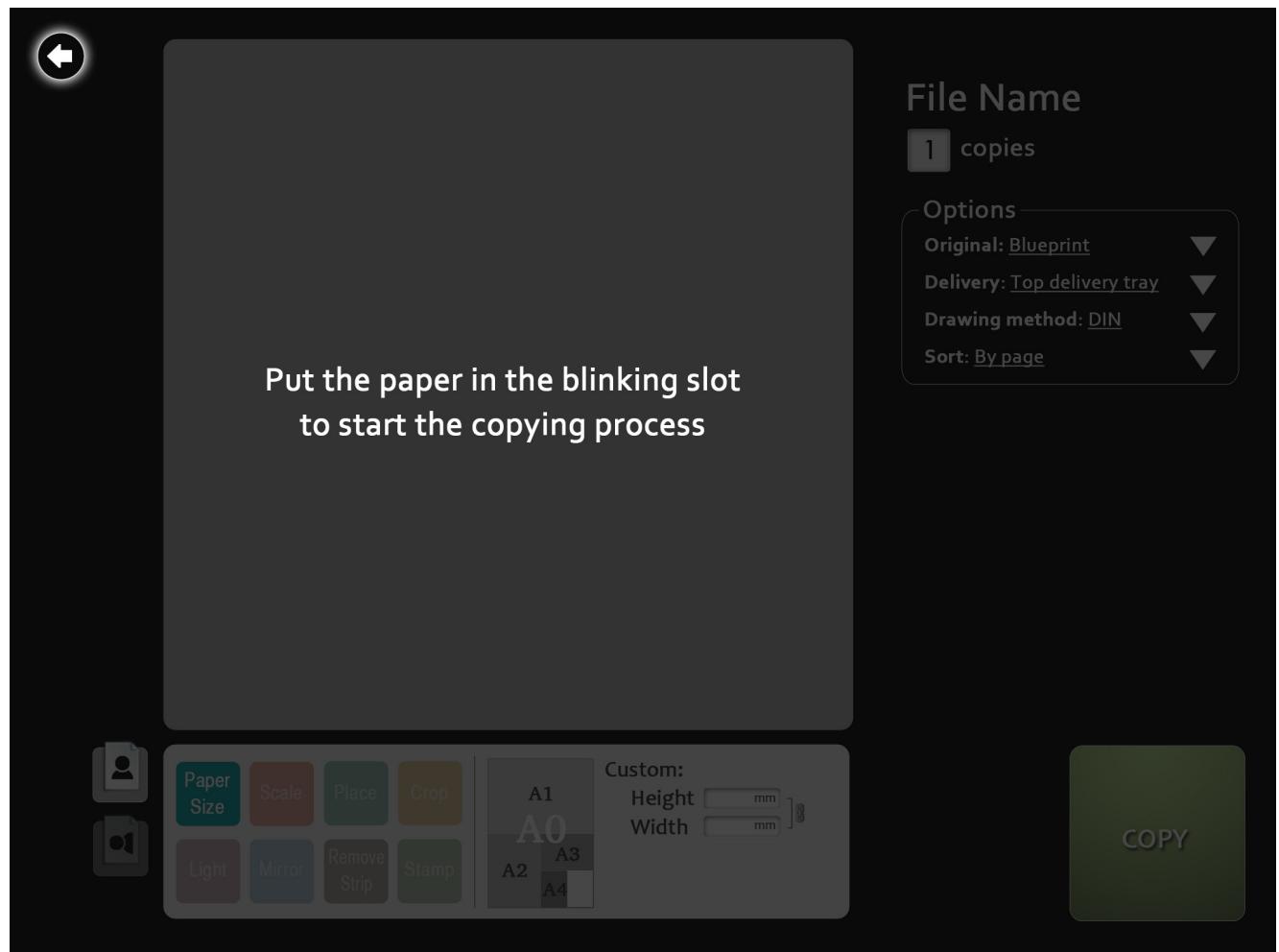


Figure 13: The information supports the user actions

# 05 STUDY 2

In order to assess the quality of the redesign in terms of usability and user experience, a second user study has been performed. In this chapter a thorough account of the study has been provided. The first paragraphs are focused on providing the reader with a detailed description on what the study will be about.

## 5.1 AIM OF THE STUDY

In order to truly benefit from user study 2 it is important that the aims for the research are clearly specified from the start. The aims mentioned below form the backbone for the user study.

The aims are to verify that:

- The usability of the redesigned plotter has been improved compared to the original design.
- The usability of the redesigned plotter is sufficiently high.
- The majority of the users will have a pleasant and intuitive user experience while interacting with the redesigned plotter.
- The redesigned plotter expresses the values and the characteristics of an ideal co-worker and therefore perceived as trustworthy, kind, professional and communicative.

## 5.2 RESEARCH QUESTIONS

Following the guidelines provided by the research aims (see also 5.1) a number of questions have been formulated to further define the structure of study 2:

- Is the usability of the redesign in terms of effectiveness, efficiency and guessability improved in comparison to the original design?
- Is the learnability of the redesigned system as good as in the original design?
- How do the users experience the interaction with the redesign in terms of pleasantness and intuitiveness?
- Is the interaction with the plotter similar to a possible interaction with an ideal co-worker?
- To what degree does the redesign fulfill the aspects of the team's design goal?
- How do the users experience the appearance of the redesign as well as the positioning of the screen?

## 5.3 RESEARCH METHODS

In an effort to answer the research questions (5.2) and satisfy the aims of the study (5.1) it was imperative to design the research in a fitting way. In this paragraph the incorporated methods and techniques will be presented, for a more detailed overview see Appendices 2-5.

### 5.3.1 PARTICIPANTS

Study 2 was performed with the help of 5 participants. Interesting to note is that one of the participants of study 2 had also collaborated in study 1. Therefore, this participant is of extra interest in the evaluation of how the redesigned PlotWave compares to the original. All collaborating participants can be considered highly educated. Participants were specifically selected on their specialised knowledge to provide richer insights than regular participants would. For an overview of the professional/educational backgrounds see figure 14. As in study 1, there was a nice variance in the ages of the participants ranging from 22-42. On the contrary to study 1 where there were no female participants, 2 out of the 5 participants for study 2 were female.

### 5.3.2 TEST SET-UP

When the participant entered the room he/she received a short introduction in which he/she was carefully explained how the research was to be performed and what could be expected. Perhaps the most important part of this introduction was the encouragement to think out-loud during the tasks. After this the participant was asked to fill out an initial questionnaire (see Appendix 5). Having filled out the questionnaire the participant had to perform three carefully selected tasks related to the domains of printing, copying and scanning (see Figure 15). Each task was followed by a question form in which the participant was asked to note down the effort the task required (see Appendix 5). After all the tasks had been performed an in-depth interview (see Appendix 4) was held in which the user had the opportunity to share his insights on the usability and user experience of the plotter. To conclude the study participants were asked to fill out an AttrakDiff (see 5.3.5) online evaluation form (see Appendix 6).

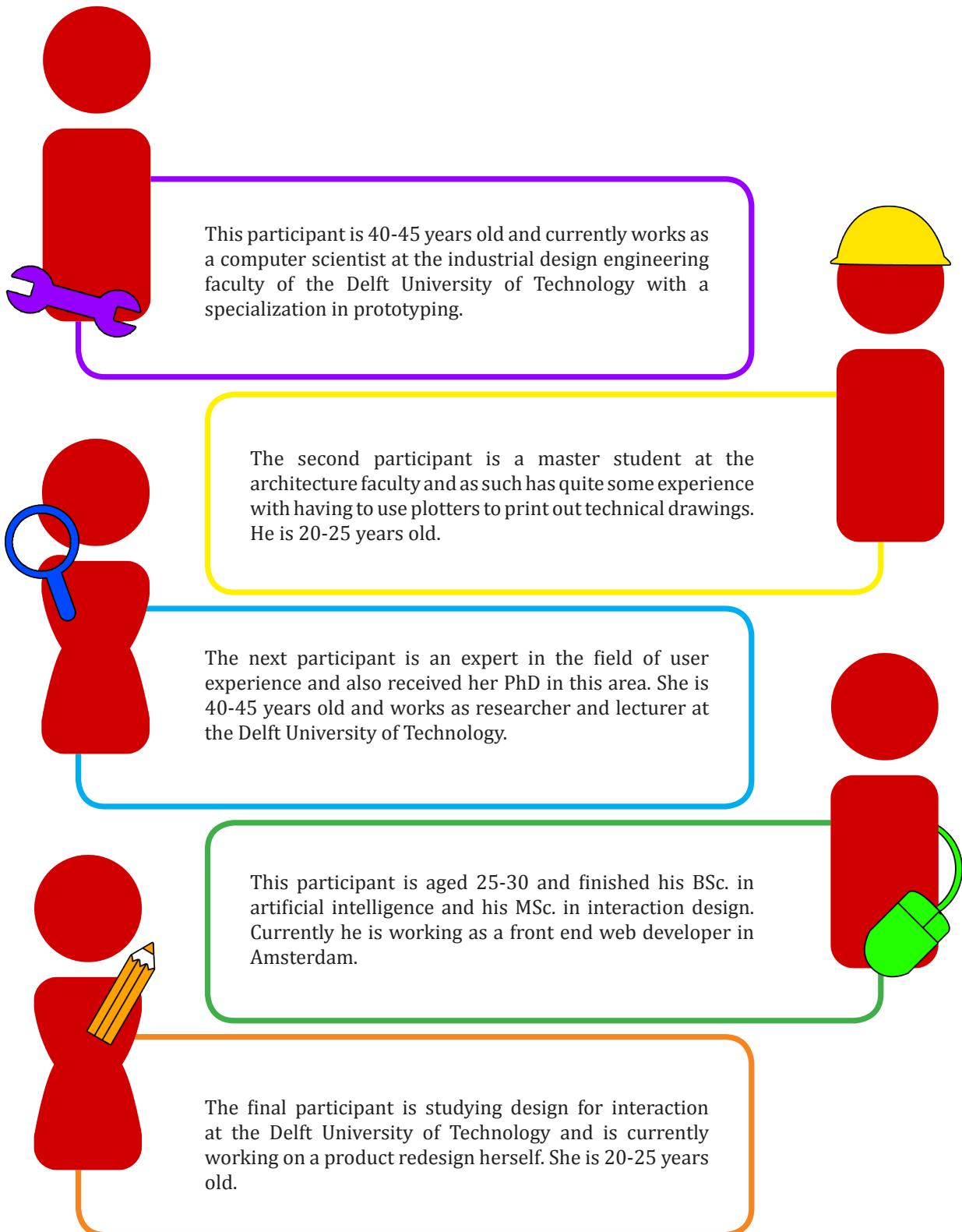


Figure 14: descriptions of the participants



Figure 15: The user test set up

### 5.3.3 PROTOTYPING

To increase the quality of the data gained from the user test, a lot of effort was put in the prototyping of the concept. The reasoning behind this was that a prototype that participants can interact with in a realistic way provides much richer insights in a user test as it gives users the chance to truly experience the concept as it was envisioned. It should be noted however that even though the prototype was to a high degree representative for the concept, some aspects were missing due to limitations in time and materials. Sometimes the aspects mentioned during the user test were in the actual concept however they had not made it to the prototype. It is therefore not unthinkable that the state of the prototype might have influenced the user experience results to some degree. The prototyping effort was split up in two parts; the building of the housing and the programming of the interface. The housing was built from cardboard, wood and Christmas lights (see figure 16). In the housing there was a recess in which an iPad could be placed. The iPad ran the interface prototype which was built using HTML5, CSS and Javascript (see figure 17).

### 5.3.4 DATA COLLECTION

To properly document study 2 notes were taken during the entire process. In addition to the written notes each participant was also filmed during the tasks as well as during the final interview. Table 3 provides an overview of the data that was collected and the methodologies/techniques that were incorporated.



Figure 16: The housing prototype

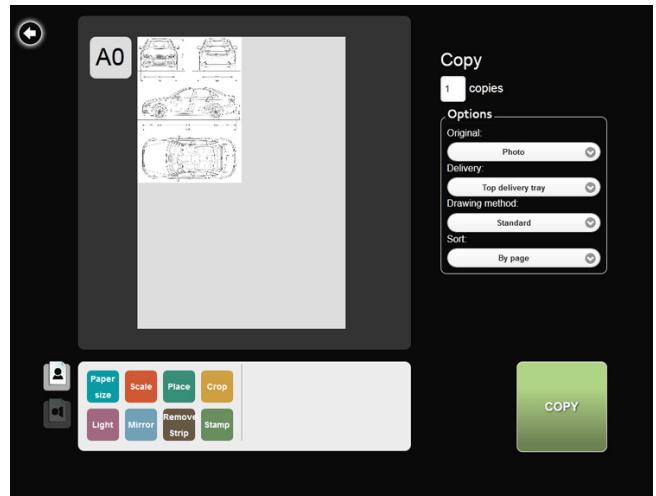


Figure 17: The interface prototype

METHOD	DATA
Questionnaire	The initial questionnaire looked into previous experiences with plotters and the aesthetic qualities of the redesign.
Number of frustrations	Exclamations and non-verbal indications of frustrations were counted for each task.
Number of button presses	For each task the number of buttons the user pressed in order to finish the task was counted
Time to finish a task	For each task the time it took the user to finish was noted down.
Effort rating	After having finished a task participants were asked to rate the task on the basis of the effort it took them.
Thinking out loud	Throughout the performance of the tasks participants were stimulated to share their feelings and ideas concerning the user experience and usability.
Final interview	To evaluate how the user experienced the redesign a final interview was held in which there was room to elaborate on matters that had come up during the tasks and share insights not mentioned earlier.
AttrakDiff	An online evaluation form in which four different dimensions are tested namely Pragmatic Quality, Hedonic quality – Stimulation, Hedonic quality – Identity and Attractiveness. Each dimension is evaluated by the use of word pairs.

Table 3: Data collection and employed methods

### 5.3.5 DATA ANALYSIS

Triangulation formed the basis in the design of the research to ensure the reliability of the insights gained from the user study. Triangulation is the idea that when an insight stems from two or more independent measurement processes the reliability of the insight is greatly improved (Webb et al. (1966)). The combination of the tasks, interviews, questionnaires and measurements provides a framework in which related insights will arise on multiple levels. Also between participants similarities in insights are likely to arise. To support triangulation and maintain an overview of the data, clustering was used to group related insights together.

participants had previously worked with a large format plotter although none of them had worked with them on a daily or even weekly basis. As mentioned in paragraph 5.3.1, one participant had worked with the original Océ PlotWave 300 during study 1.

Part 2 of questionnaire 1 evaluated some basic aesthetic qualities of the redesign. In figure 18 the results are compared to the results from study 1 (except for the question on size for which no comparable data existed

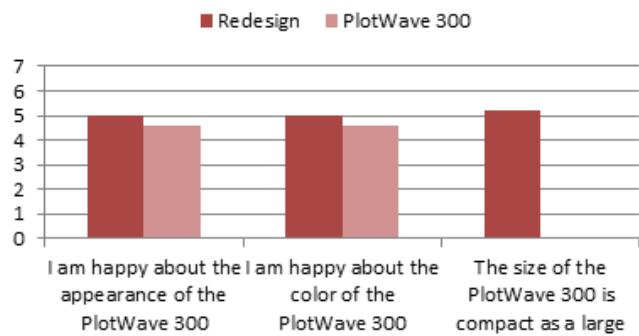


Figure 18: Average results from study 2 in comparison to results from study 1

## 5.4 RESULTS & DISCUSSION

This paragraph presents the results from study 2. The study did not only provide rich insights on what aspects of the redesign could be improved, it also resulted in a better understanding of the qualities of the concept through the eyes of the participants.

### 5.4.1 QUESTIONNAIRE 1

The initial questionnaire provided knowledge into the participants' experience with plotters: 4 out of 5

within study 1). From the graph it can be seen that the appearance of the redesign is more than satisfactory to the participants. These results are also supported by high values for attractiveness (ATT) expressed by the participants in the AttrakDiff questionnaire (see section 5.4.7). Due to the relatively small number of participants and small variance in results the data unfortunately does not allow for any meaningful conclusions on whether the PlotWave 300 is actually improved.

#### 5.4.2 INTERFACE DESIGN AND NUMBER OF BUTTON PRESSES

During study 1 as well as study 2 the number of button presses for finishing a given task was counted. For comparison it should be taken into account that the redesign features a touch screen and the original did not. Due to this, navigation in the original would lead to more button presses. Nevertheless, a significant decrease in button presses can be seen in figure 19.

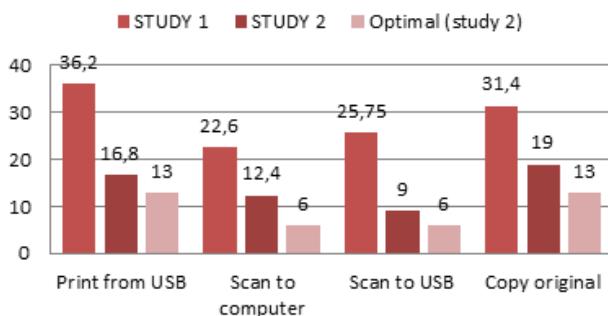


Figure 19: The average number of button presses per task

The number of button presses is a good measure for how well thought out and simple the interface is. A user that gets lost in a menu structure has to press more buttons to find his way out. A straightforward interface minimizes the amount of button presses needed for the goal to be reached in this case printing/copying/scanning. The optimal number of button presses for a given task can also be seen in figure 19.

Based on the interviews with the participants, the interface was perceived as nicely designed.



"I would say the interface has a very nice interface".

One of the participants noted the importance of an interface which is easy to use.



"... I reckon an easy interface in this situation can be quite handy because... ehh, usually you have a final presentation and you probably haven't slept the past few days. Then it's really nice to have something simple as well as not have to figure out, kind of, how to get your files..."

Most participants had positive comments about the transparent menu structure where all settings could be adjusted in the same window.



"I like the fact that the menu isn't very deep, options are generally very limited"



"...there's only three buttons on the first page. Once you go further, you get to more setting details. It's simple"



"That's my big issue, it's like about half of the things, maybe a third of the things I don't have an idea what the implications are, but just trying it out is too expensive (in terms of paper and toner costs)".



"In the interface the word blueprint is sort of confusing, since originally blueprint meant a white on blue drawing but nowadays a blueprint can be any technical drawing".

Unlike the right menu, the menu at the bottom was understood very easily by everyone. Only the button for paper orientation was unclear to some participants. Regarding the right menu one of the older participant was not able to read the text very well due to the size of the lettering. The other participants made no mention of this. Participant 1 did note that the buttons could be a bit bigger. However during the tasks none of the participants miss clicked the buttons.



"Options, it's kind of small for me this thing. Print size is already too small for me... this is jumping around bit for me to be honest".



"The preview screen is a very powerful feature", "Preview is genuine a very important function for sure"



"Oh! That's pretty cool actually, that I can do it".

Four out of five participants expressed that they did not understand the separation between the two menus. Only participant 5 understood that the bottom menu contain the options to edit the preview and the right menu contain the additional settings. For the other four participants, this meant unnecessary confusion leading them to look for settings in two different areas.



"There must be an organizing principle but I cannot guess it. So when I want to do something I have to look in two places. Is it here or is it there?".

Considering the guidance provided by the interface, one participant stated how it would be useful to clearly state in the top of the screen in what menu (copying, scanning or printing) the user is operating. Furthermore several participants noticed how improvements could be made to better direct their attention and guide them through the sequence and order of adjusting the print, copy and scan settings. In relation to this also positioning and size of the preview window was discussed. All participants were very positive about the preview window.



"I don't think the interface is too full, I just don't know what to focus on first"

Four out of five participants thought it was possible to adjust the settings in the preview area all at once. In the redesign the user instead has to start by clicking the button corresponding to the operation and then make the adjustments in the preview area. On the one hand it inhibits users to make unwanted changes on the other hand it limits some of the freedom in manipulating the preview. Furthermore some participants noticed how the quality setting is not visualized in the preview window. The preview does not provide the user with information on possible bleed meaning the data that falls outside the printable area (borders).

#### 5.4.3 LEARNABILITY

Since the tasks "Scan to Computer" and "Scan to USB" are almost identical they provide good insight on the learnability of the system. The learnability can be seen in figure 20 in which the two tasks are compared on the basis of number of button presses and time taken for

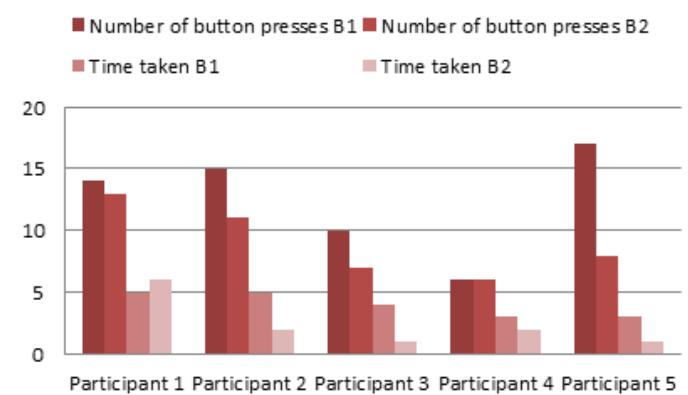


Figure 20; Comparing nearly identical task B1 (Scan to computer) and B2 (Scan to USB)

each participant. All participants manage to decrease the number of button presses (most of them significantly) on the second task giving reason for the conclusion that the learnability of the device is at least sufficient.

The rated effort per task also clearly indicates the systems learnability. As can be seen in Figure 20, task B2 "Scan to USB" has a lower effort rating than "Scan to computer" which is rated highest.

Figure 20 also indicates how the redesigned plotter provides a quite effortless interaction. Only "Scan to computer" was rated as 3 on a scale from 0 to 7, and all other tasks lower than that. The median and average are also very close which indicates a focused result. It should be noted that the order of the tasks was different for each participant.

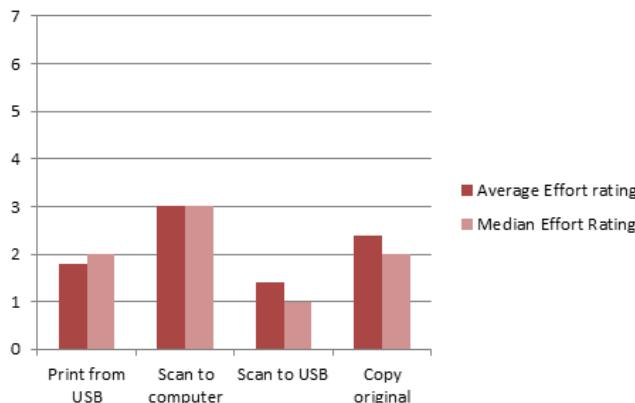


Figure 20: Average ratings of perceived effort per task

#### 5.4.4 TIME TO COMPLETE TASK

An important factor in the usability of a device is the time it takes you to reach the desired state. In figure 21 the times it took users to finish a given task can be seen. It is important to note that the user was asked to think out loud during the tasks which sometimes lead to a conversation between the researcher and the participant. Although this process is very functional for gathering interesting qualitative data it takes away from measuring the fastest time in which the user could finish the task. This is also the reason why the measured times are quite far away from the optimal time in which an experienced user can finish the tasks. The times from study 2 are not fully comparable to the times measured in study 1 because paper in- and output for the redesign was simulated in a faster way to save time.

#### 5.4.5 NUMBER OF FRUSTRATIONS

Just like in study 1 the number of frustrations that participants demonstrated during a given task was counted. It is important to note that the tasks chosen for study 2 are very comparable to the tasks in study 1. In figure 22 the counted number of frustrations can be seen next to the frustration results of study 1. In figure 22 the decrease of frustrations (in percent) is presented.

Looking at figure 23 it can easily be seen that with the redesign of the PlotWave 300 a more than significant decrease of frustrations has been facilitated. Most tasks featured around six times less expressions of frustration, only the copying task fell short of this number and offered only two times less expressions of frustration. Participant

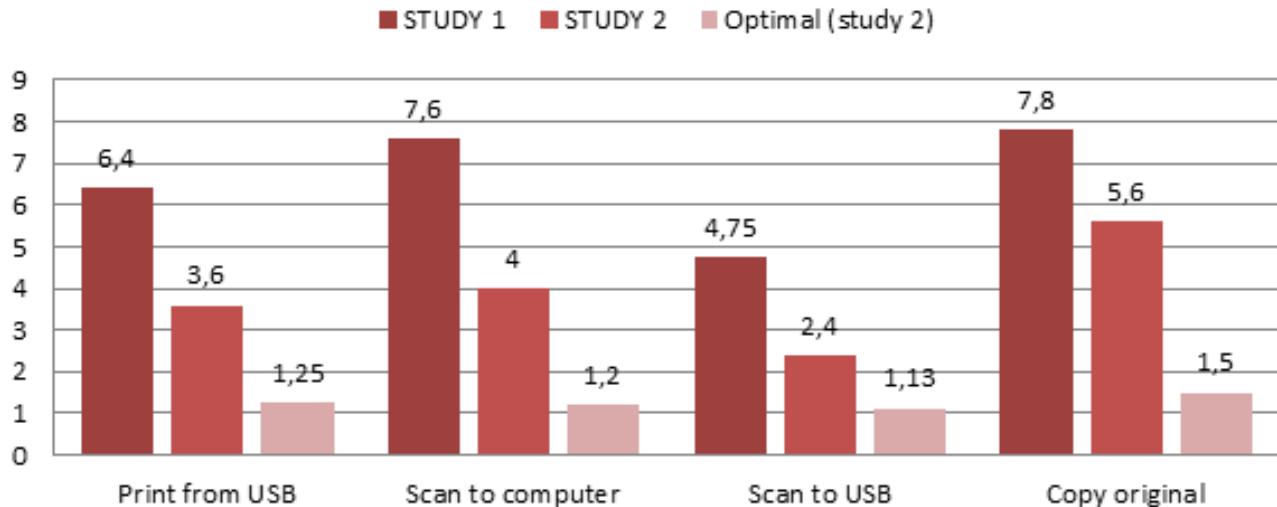
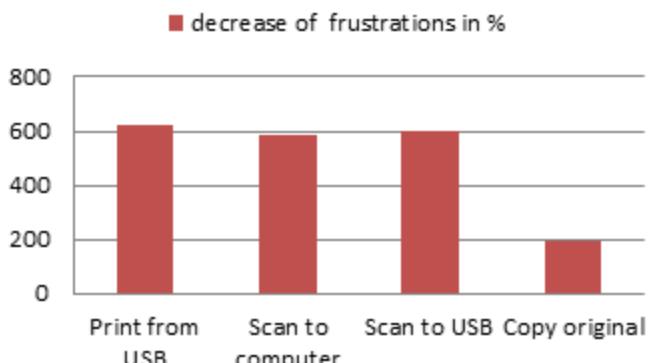
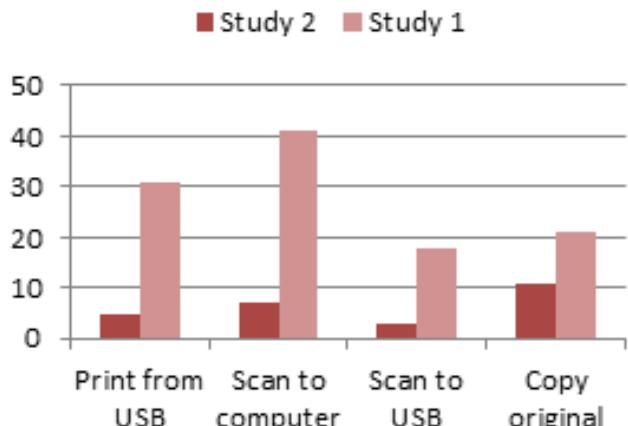


Figure 21: Average time taken for finishing a task



1 (who was involved in both studies) provides further proof that the amount of experienced frustrations has actually decreased with the redesign. Frustrations are a good measure for the user experience. The relationship between frustrations and user experience is inverse, meaning that the more experienced frustrations the less positive the user experience. From this it can be concluded that the user experience has become more positive for the redesigned PlotWave 300. During the tests all participants expressed comments in line with a positive user experience.



"If I compare it (the plotter) to previous plotter experiences that I have had - that's just a nightmare... but this, this is just easy!"



"Very straightforward. Very clean. Logical options. Logical ordering Simple design. I like it"

In line with the positive user experience, four out of five participants also clearly stated during the tests that they would recommend the redesigned plotter to other people as well as be confident in performing the tasks again. The fifth participant would recommend it and be confident a second time, if the hierarchy and grouping of elements for the menu interface would be improved.

#### 5.4.6 THE HOUSING

The analysis of test recordings confirmed many previously presented insights but it also led to a better understanding of the usability and UX specifically concerning the housing of the redesigned plotter.

##### 5.4.6.1 GUIDANCE

An interesting observation made was that 4 out of 5 participants started the copy, scan or print process by inserting the original document or USB respectively rather than first pressing the corresponding button. The redesign features light guidance when a setting is chosen from the interface. However when interfacing directly with the housing the user got confused by the fact that no indication was given for where to insert the original document.



"I think it should also say whenever any part is ready to do something, like I could put the paper in in the beginning, this should also always that I can start doing that".

After finishing a task all participants forgot to take out the USB, which could lead to user annoyance. The USB slot was clearly noticeable for all participants). Participant 1 stated that the location of the USB-slot might increase the risk of bumping into the USB drive and hereby breaking it.



"It would be really cool if it tells me in the screen your USB is still in..."

A reoccurring problem the participants dealt with was the uncertainty in whether the original document had to be placed face-up or face-down when inserting it for copying or scanning. This caused two participants to not finish their tasks correctly the first time of trying.



"Right now I am not sure about, ehmm, if I should put it face-up or face-down... so I just assume I am supposed to put it face-down"



"I really liked the position of the screen because of the height and the angle. It's easy to use while standing up which is what I expect to be doing"

In general participants felt there was enough guidance, specifically the light indications for the paper in- and output, the USB slot and the release button were appreciated by the participants. These features steered the interaction into the right direction in an intuitive and helpful manner.



"In general I felt there was enough guidance"



"...but I really do like the visual feedback on the plotter, I think it is pretty awesome!"



"It's a little bit weird that release button is on top of the paper output. Because this is a very long document, then I will be around here, and then I have to press here".

#### 5.4.6.2 SCREEN/USER PANEL POSITION

Since changing the position and the orientation of the screen was one of the bigger changes in comparison to the original PlotWave 300 the study also investigated on whether this change was a welcome addition. As it turned out, four of five participants were happy about the position of the screen. Only participant 4 would have liked to see the screen located a bit more to the right. The way the screen is now integrated into the machine was received positively. The participants also appreciated the new touch screen display.



"The position of the screen is perfectly logical".

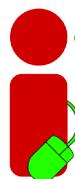
#### 5.4.6.3 RELEASE BUTTON

Even though the purpose of the release button (holding on to the paper) was understood by all of the participants, they were not convinced about the solution that this button provided. A lot of frustrations were noticed when participants could not take out the paper immediately. The interaction with the release button can be quite awkward mainly due to the fact that the user might need to hold the document with two hands leaving no hand to push the release button.

#### 5.4.6.4 LACKING FUNCTIONALITIES

Most of the insights from the study concern aspects of the redesign that need changing in order to improve the system, however also a few new ideas arose which had not (yet) been implemented. The most important feature that was identified as missing was a cancel button. Two participants noted that they would be unable to get their original document back after inserting it without going through the total sequence of copying/scanning.

When adjusting the paper size, all five participants tried to click the button-like text stating the paper size in the upper left corner. However this was not a button in the redesigned interface.



"I would have expected that when I clicked there something would have happened"

#### 5.4.7 ANALYSIS OF ATTRAKDIFF

The results from the AttrakDiff questionnaire further confirm the rather positive user experience and the high usability of the redesigned system. Four different dimensions are tested in an AttrakDiff questionnaire (See Appendix 5).

In Figure 24 the mean values of 28 word-pairs are presented. The four dimensions are represented on the vertical axis and each dimension consists of seven word-pairs. The horizontal axis shows a scale from -3 to 3. Values close to -3 indicates an average perception of the redesign close to the first word in a word-pair and vice versa. Positively rated word-pairs indicate a positively perceived user experience, where the value 3 is optimal.

As can be seen from the diagram, the majority of the mean values of the word-pairs are located in the above 0 or even above the value 2 region which indicates that the redesign is generally fine, though there is some room for improvement. Only three word-pairs fall into the value below the 0 region, this within the HQ-S and PQ dimensions. People perceive this plotter to be more technical than human, more cautious than bold and more undemanding than challenging.

The pragmatic quality dimension (PQ) of an AttrakDiff questionnaire supports the evaluation of the systems usability. The results within this dimension are mostly high with values above 0 or even close to the value 2 region. Measurements from the user tests are in line with the values of PQ, indicating a system with an overall good usability and furthermore showing a clear improvement in usability in comparison to study 1.

The redesigned plotter is very close to the ideal co-

worker metaphor which was used to describe the intended user experience targets. The redesigned system is perceived by the participants as straightforward and practical, clearly structured, presentable and inviting. In general the results indicate that the redesigned plotter successfully assists its users and enables them to achieve their goals. The participants are stimulated by the product, and they can generally identify themselves with it. They find the plotter essentially professional and pleasant to use. Furthermore the high value of ATT shows that the overall product is perceived as very attractive.

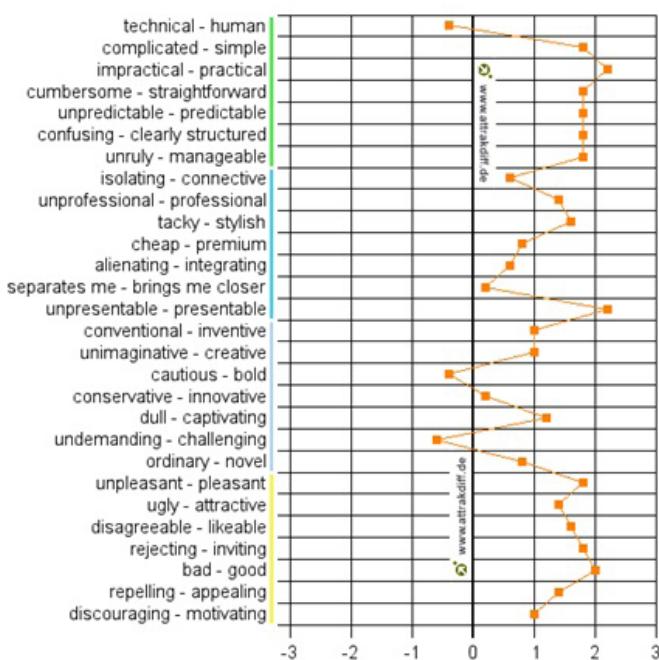


Figure 24: Diagram of results from AttrakDiff, word pairs

Dimension	Definition
Pragmatic Quality (PQ):	Describes the usability of a product and indicates how successfully users are in achieving their goals using the product.
Hedonic quality – Stimulation (HQ-S):	Mankind has an inherent need to develop and move forward. This dimension indicates to what extent the product can support those needs in terms of novel, interesting, and stimulating functions, contents, and interaction- and presentation-styles.
Hedonic quality – Identity (HQ-I):	Indicates to what extent the product allows the user to identify with it.
Attractiveness (ATT):	Describes a global value of the product based on the quality perception.

Table 4: Attrakdiff dimension definitions (AttrakDiff: A service provided by user interface design GMBH, 2011 [Online])

## 5.5 CONCLUSION

After having evaluated the usability and user experience of the redesigned Plotwave 300, the following conclusions can be drawn in relation to the aims of the study and the main research questions:

- The usability of the redesign is significantly improved over the original plotter since the redesigned system could be operated with fewer button presses, shorter task completion times and less frustrations expressed.
- The amount of positive comments in regards to the interaction with the redesigned machine in combination with the high scores for the systems pragmatic qualities (AttrakDiff) indicates a system with a sufficiently high usability, however there is still room for improvement.
- The redesign provides clear guidance (in most cases) through the incorporation of light indications and clear messages on the user panel leading to a straightforward and intuitive user experience.
- The redesign is generally perceived as having

characteristics in line with the identified UX targets: The redesign is essentially communicative, professional and pleasant to use.

- Improvements can be made to better guide the user through the interaction of printing, scanning and copying. The user should be provided with useful guidance regardless of the order in which he interacts with the machine. The user panel should provide a clear grouping of features as well as a consistent design. The option to cancel an action should always be available.

## 5.6 ADAPTATIONS TO CONCEPT

A number of adaptations was needed to improve the concept according to the results from study 2. A list (see table 5) was created in order to facilitate the development of a final, improved concept. The final concept is described in chapter 8: the final redesign.

Domain	What to change
The interface layout	The distinction between the bottom menu (adjusting the preview) and the right menu (additional options) should be more clear for the user.
	The size of the buttons should be increased.
	The font size within the additional options menu (to the right of the preview window) should be increased to improve readability.
	The size of the preview image should also be increased.
	The used space within the interface should be minimized.
	There should be more consistency in the design of buttons (i.e. the shadows and gradients).
	It should be specified at the top of the screen what you are doing at that moment, printing, copying or scanning.
Release button	The release button should be replaced by a mechanical mechanism that releases your paper when you pull it.

<b>Jargon</b>	The jargon used within the interface should be adjusted to the knowledge of the target group.
	<i>Space</i> should be called <i>position</i> in the screen interface.
	Settings for quality (i.e. dpi) should be understandable for inexperienced users, so it should say if a specific dpi quality is regarded as high or low.
<b>Paper input</b>	There should be an icon indicating which side of the original document should be up when inserting it for scanning/copying.
	The lights indicating the location of the paper input slot should be activated when the user approaches the plotter.
	It should not matter where in the scanning slot the user inserts the document (i.e. to the side or more to the center).
	There should be a way of getting your original document back without having to finish the copying or scanning process.
<b>Preview window</b>	The user should be able to manipulate both scale and position in the preview window simultaneously.
	The preview image should include the bleed meaning the data that falls outside the printable area (borders).
<b>Guidance</b>	The slots the user can interact with from the start (the USB slot and the paper input slot) should light up when he approaches the plotter.
	The user should be alerted when he forgets his USB-stick in the plotter.
<b>Other</b>	The USB slot should be relocated to a position which minimizes the chance that a user would bump into the USB drive, hereby damaging it.

Table 5: Adaptations to the final concept concluded from study 2

# 06 EVALUATION OF THE DESIGN PROPOSAL

In this chapter the design proposal will be evaluated by comparing it to the design goal and the design specification. The design proposal does not incorporate the changes mentioned in paragraph 5.6, Adaptations to concept. However the results from study 2 will be taken into consideration.

## 6.1 EVALUATION OF THE DESIGN GOAL

The design goal states that: "The redesign aims to provide a pleasant and intuitive user experience for both experienced and inexperienced users. The plotter should be straightforward and adaptive to its users and also offer continuous feedback and guidance."

Several features, like the light strips and the preview window, are incorporated in the redesign to give the user clearer feedback and guidance. Both experienced and inexperienced participants took part in Study 2. During the interviews, four out of five participants mentioned that they found the interaction with the redesigned PlotWave 300 to be pleasant. However four participants commented on the somewhat unclear separation of the two menus in the screen interface. It is therefore concluded that the design goal has been reached to a high degree. Improvements can still be made in order to fully satisfy the design goal (see paragraph 5.6).

## 6.2 EVALUATION OF THE UX TARGETS

The main aim of the UX targets was to create a plotter that works with you (not for you) as an ideal co-worker would. The characteristics of an ideal co-worker are listed in figure 25.

When looking at the results from the AttrakDiff questionnaire it can be concluded that the redesign is very close to the ideal co-worker metaphor: it is perceived as straightforward, practical, clearly structured, presentable and inviting. Most importantly the redesign helps the user reach his goals, just as an ideal co-worker would. The participants felt stimulated by the plotter and they could identify themselves with it. However it's interesting to note that the plotter was perceived as being more technical than human. Not surprisingly since the product is indeed very technical, big and grey. However, in general it can be stated that the UX targets have been reached.

## 6.3 DESIGN SPECIFICATION

In order to evaluate to what degree the design proposal fulfills the design specification, the redesign has been compared to the requirements earlier stated (see chapter 4.3). Table 6 presents a selection of the main requirements that were evaluated and in what way these criteria have/have not been incorporated in the redesign.

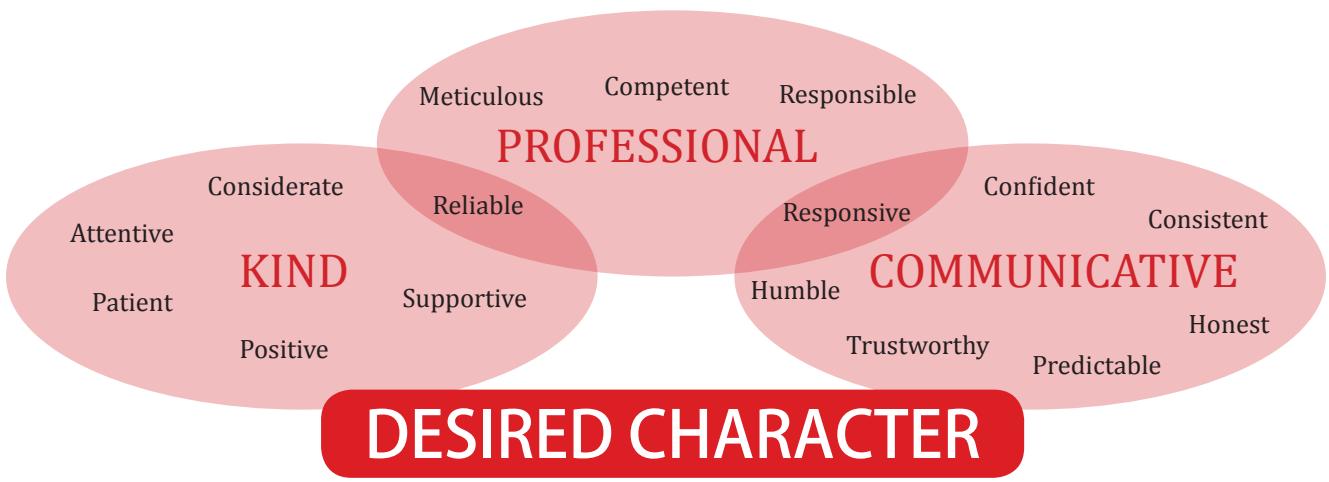


Figure 25: The characteristics of an ideal co-worker.

All in all, the evaluation of the design proposal as compared to the design specification strengthens the conclusions drawn from study 2. All of the requirements that are not

yet fully met in the redesign as described in the design proposal, have been improved or where possible fulfilled, in the final concept described in chapter 7: Final concept.

Requirement	Is this requirement met in the Design Proposal?
It should be clear where and how the paper is inserted as well as retrieved including clear indications of paper orientation (which side should be facing up).	Partly – there are lights indicating where the paper will come out and where you have to insert the original document, but there is no clear indication of the paper orientation.
The interface should either incorporate physical buttons or a touch screen.	Yes – there is a touch screen and there are no physical buttons.
There should be a consistent use of symbols, buttons and actions to perform during use.	Partly – they are consistent in their functions, but they are not consistent in their design (shadows, gradient).
An option for going back, regret or stop a process should always be available.	Partly – the user can go back to the initial screen however there is no easy way to get back a document from the scan slot.
Overlapping functionality in menu options should be avoided.	Yes – the menu is more consistent and does not include redundant buttons or features.
Less is more; the number of button presses should be minimized to maximise usability.	Yes – all original settings are located in one screen and can be accessed easily using a minimum amount of button presses.
The aesthetics of the interface fit the professional segment.	Yes – the use of colors suits a normal office environment (looking at comparable products).
There are use cues to help the user understand the behaviour of the plotter.	Yes – there are lights indicating where the focus should be and animations to indicate the progress.
There is proper feedback and step-by-step guidance, enabling the user to interact with the plotter in an intuitive way.	Yes – the use of lights ensures this and the way the plotter responds to the users actions (based on the workflow flowchart) facilitates step-by-step guidance.
The plotter uses laymans terms – logical use of words, symbols and descriptions for actions.	No – participants from study 2 mentioned they did not understand some of the functions in the interface.

Table 6: Evaluation of the design criteria

# 07 THE FINAL REDESIGN

In this chapter the final redesign of the PlotWave 300 is presented. Adjustments have been made to the original design proposal (see Chapter 4) based on the results of Study 2. These adjustments are described here together with a more detailed description of the final concept. Additional images presenting the concept can be found in Appendix 7.

## 7.1 THE REDESIGN

The concept is explained in threefold: the interface, the housing and the workflow. Together these parts make up the final redesign.

### 7.1.1 THE INTERFACE

The redesign features a touch screen, hereby keeping the design as clean and simple as possible. The single screen design incorporates a preview window as a main feature, providing a clear overview of the expected print/scan/copy outcome (see figures 26 and 27). The preview can be directly manipulated by adjusting the scale, position, rotation and mirroring of the image. Standard settings (E.g. centering an image) can also be directly selected from the menu below the preview image. Handles are presented in the preview functioning as use cues for the selected function. The handles feature snapping functionality to aid the user in reaching his goals (e.g.

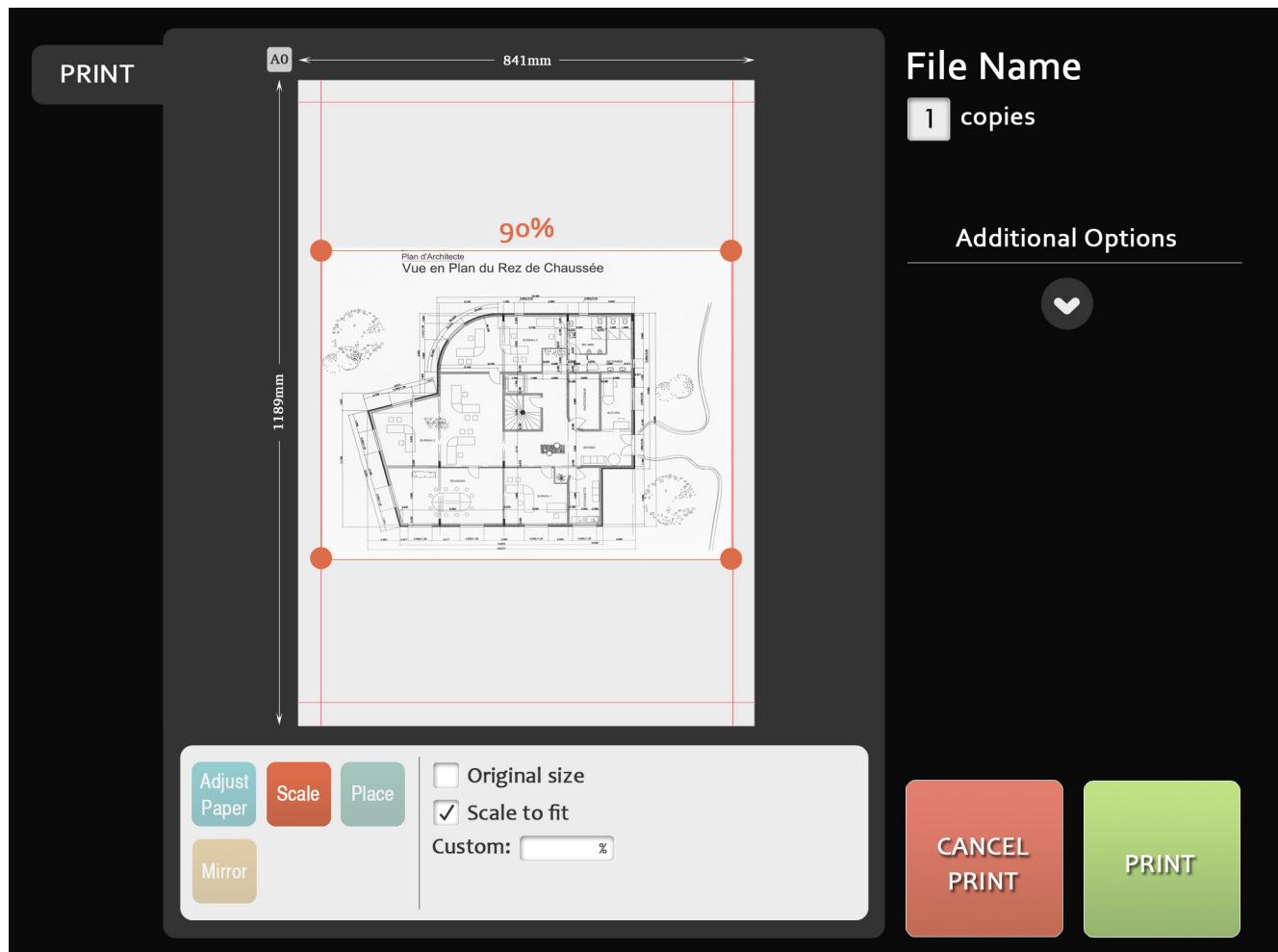


Figure 26: Main screen interface for printing with scale setting activated. Note the scale handles in the preview image

when the user positions the preview close enough to the center it will move to the exact centre of the paper).

The two methods for adjusting the preview are closely connected. As soon as the user changes a menu option, the accompanying handles appears in the preview window and the preview reacts to the changes made. Similarly once a user starts interacting with the preview window the accompanying menu option is activated and the settings are updated accordingly.

The menu for additional settings regarding the print/scan/copy-quality can be found to the right of the interface. In case of specific requirements this menu provides the possibility for optimization. The options are initially hidden to create a cleaner and (for first-time users) less distracting design but can easily be activated by pressing a dropdown menu.

After the user has inserted the document to start of the copy/scan process it is quickly scanned to generate a preview. However, the user should be able to cancel the job and get the paper out again at any given time. The start screen therefore includes a button to eject the document and a cancel button in the main screens for copy/scan/print enables the user to go back to the start screen (figure 28).

The interface is designed for optimal feedback and guidance providing the user with animations indicating progress. This helps the user understand what is happening and why during the interaction with the plotter. Figure 29 shows an example of this for when a document is being printed. The screen describes where the print will appear by displaying an image of the plotter with a lit paper output slot. Furthermore the screen indicates an estimate of the remaining time.

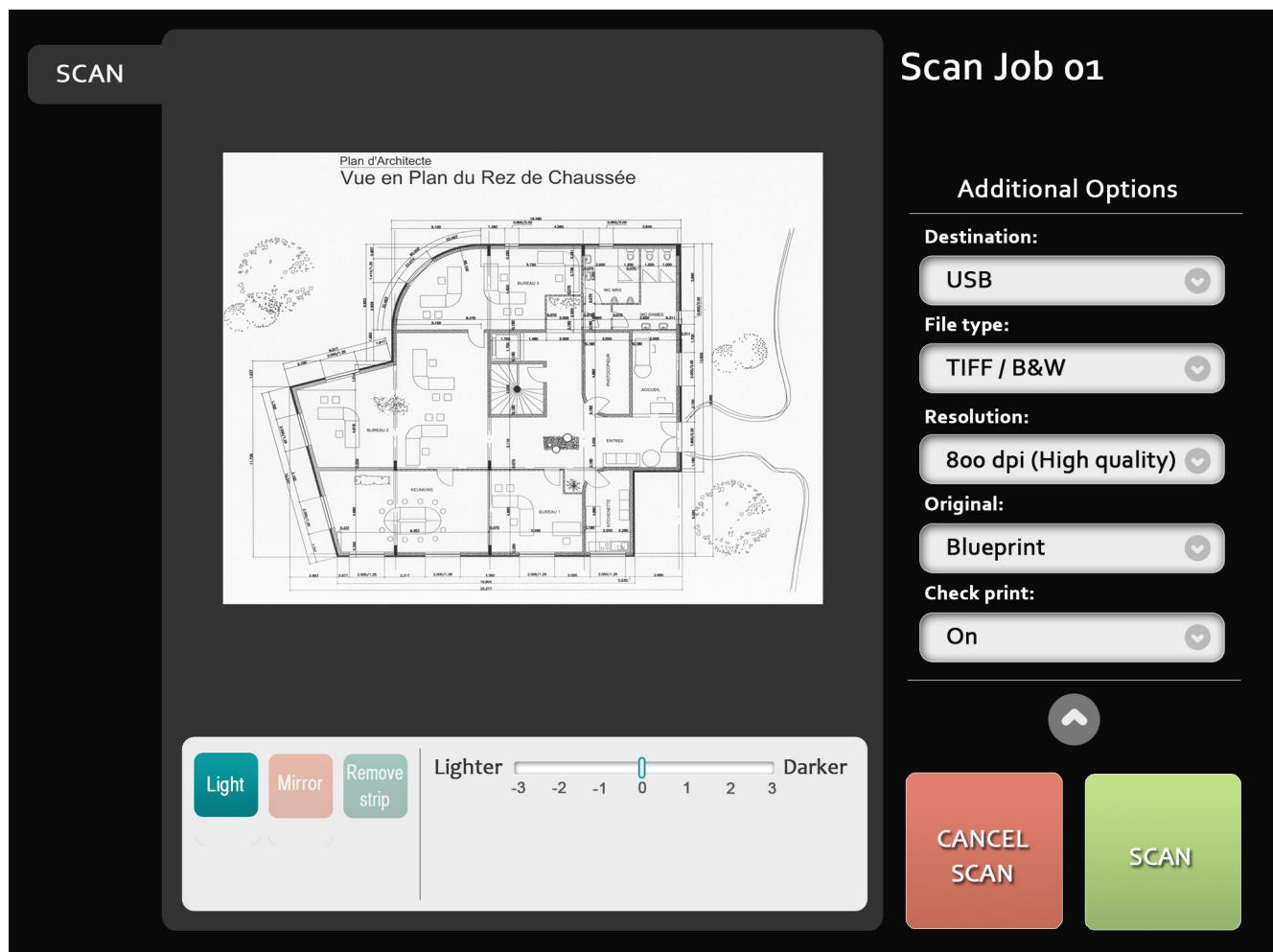


Figure 27: Main screen interface for scanning with drop-down menu activated



Figure 28: Start screen with eject paper button

### 7.1.2 THE HOUSING

The screen is incorporated in the housing and located in the centre of the redesign in order to guide and focus the user's attention to the housing and the screen as a whole (figure 30). This makes it easier for the user to interact with and acknowledge feedback from the system. The integration of the screen makes for a sturdier solution than the original user panel on top of the PlotWave. Due to the angle and height of the screen, even wheelchair users are able to interact with it. The height, width and depth are the same as the original plotwave, the size of the screen is the same size as the screen found on an iPad (figures 30 and 31).

When large format documents are printed there is a risk of them covering the screen, hindering the user from achieving proper visual feedback. The redesign therefore has an adjustable top delivery tray. According to an interview with Abbie Vanhoutte from Océ, large prints

like this are quite uncommon. But when needed, the top delivery tray normally slanting forward, can be tilted to the back guiding the print in this direction rather than to the front of the plotter.

The new screen position was leading for the development of the main housing shape. The entire top of the plotter is glossy and black. Together with the rounded sides this enhances a professional and appealing expression. When the screen is dark, it cannot be distinguished from its surrounding area. When a user approaches the screen, it lights up which adds to the plotter being perceived as kind and welcoming (figure 35). The rounded design makes the device look compact while it actually has a large extra compartment at the back hidden from the users just like the original PlotWave 300 (figure 31).

Light strips are used for further guiding the users' attention to different parts of the plotter. They are located



Figure 29: Screen interface for when a print is loaded

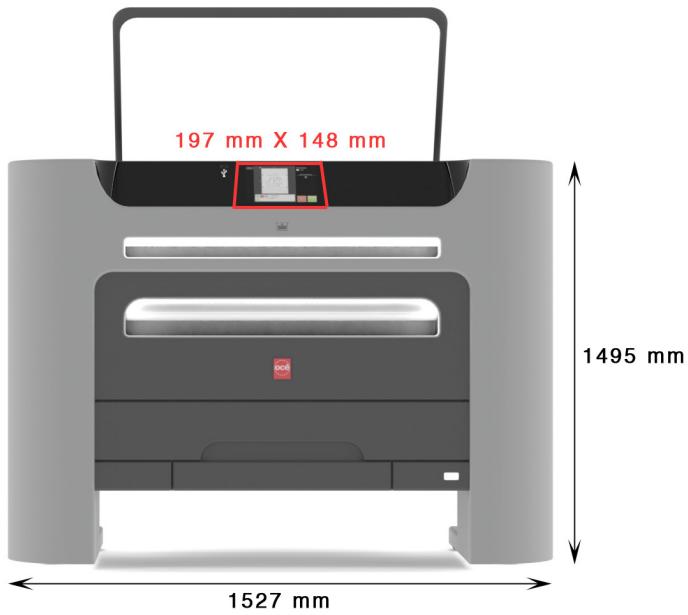


Figure 30: A front view of the final redesign

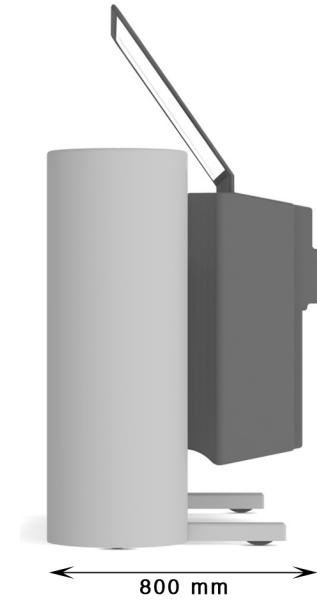


Figure 31: A side view of the final redesign.



Figure 32: Redesign with paper input light activated

at the top delivery tray, paper input slot, paper output slot and at the USB slot. The paper input lights changes colour from white to red when a paper is inserted wrongly (i.e. tilted), and turns to green when it is placed correctly (figure 32)

The release button for letting go of a scanned/copied document is difficult and non-intuitive to use as concluded from study 2. This function is in this concept replaced by a mechanical solution that senses the difference in force between a document hanging (won't be released) and a paper being slightly pulled by a user (will be released).

The USB-slot is located on the left side of the screen (figure 33). This is a noticeable and logical position close enough to the screen but with room for the user to properly interact with the interface. The USB slot position is carefully chosen to not have the USB drive stick out from the plotter and risk it being destroyed by someone walking by.



Figure 33: A close-up picture of the USB slot

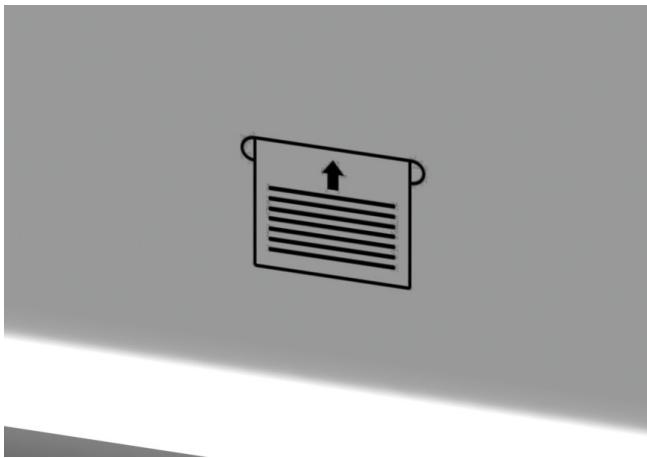


Figure 34: Icon close to the scanning slot indicating that the document should be inserted face-up

As concluded from study 2, users are very likely to forget their USB drive in the plotter. As the redesigned plotter sense when a person is approaching, it also sense when a user is leaving - and alerts the user in case the USB drive is left behind. The reminder is given through the

use of a short but penetrating sound, bringing the users' focus back to the plotter. The light near the USB-slot will be blinking, indicating to the user where he/she should direct the attention. Another use cue that has been added to the concept based on the results from study 2 is an icon on the housing displaying that the paper should be inserted face-up (figure 34).

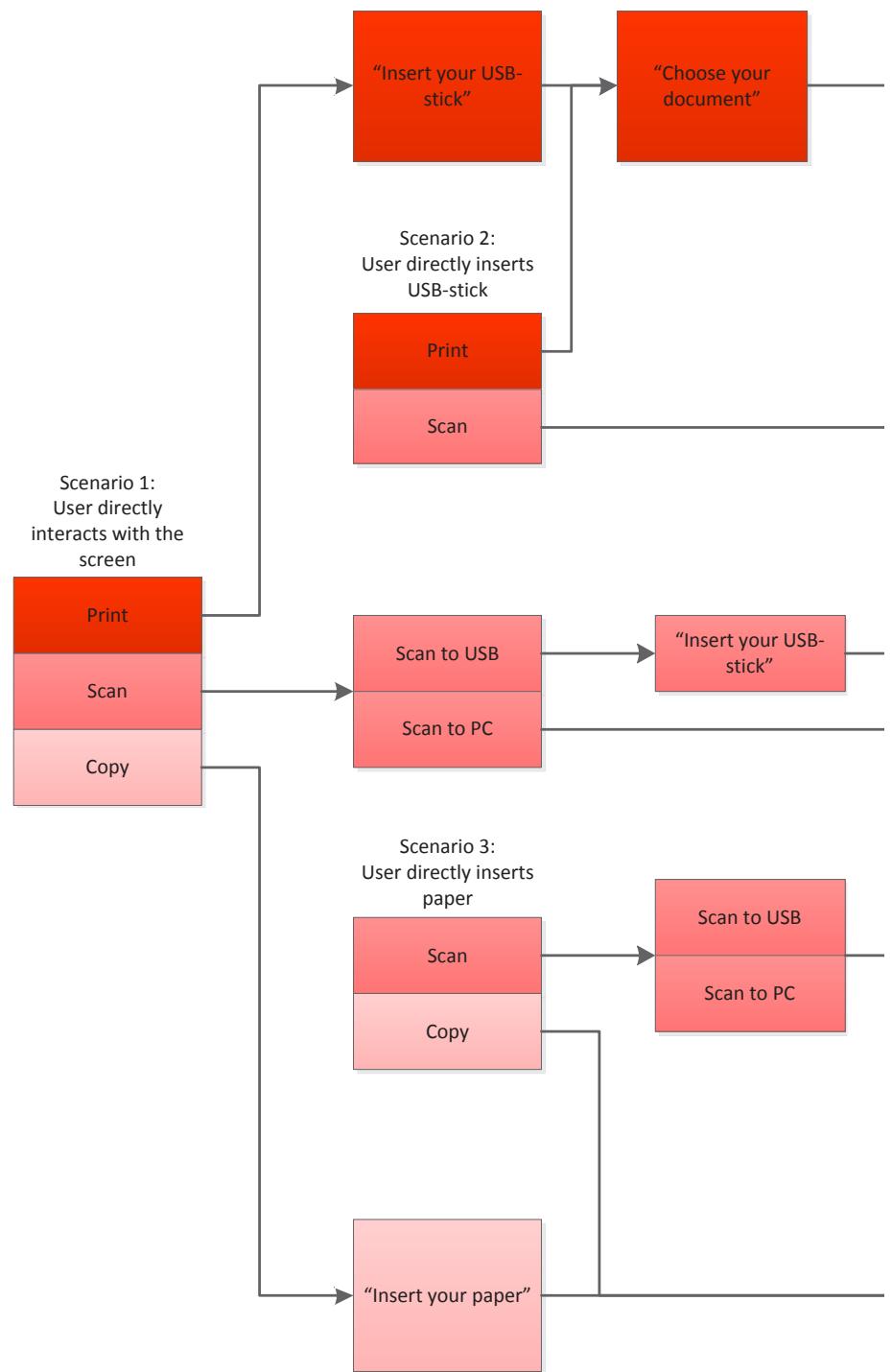
### 7.1.3 THE WORKFLOW

An important aspect to consider in a product is the way the user interacts with it. As concluded from study 1, every user is different and prefers a different working order when approaching a plotter. A strong feature in the redesign is its ability to adapt to its user. Figure 36 illustrates the three different workflows possible.

The user can choose to start by interacting with the screen, or by directly inserting a USB drive or document. When a user approaches the plotter, it will sense this and immediately light up the start screen as well as the USB-slot and the scanning slot. The indications will remain activated until the user either walks away, inserts a USB



Figure 35: Concept as seen by a user approaching it: Start screen, USB- and scanning slot activated



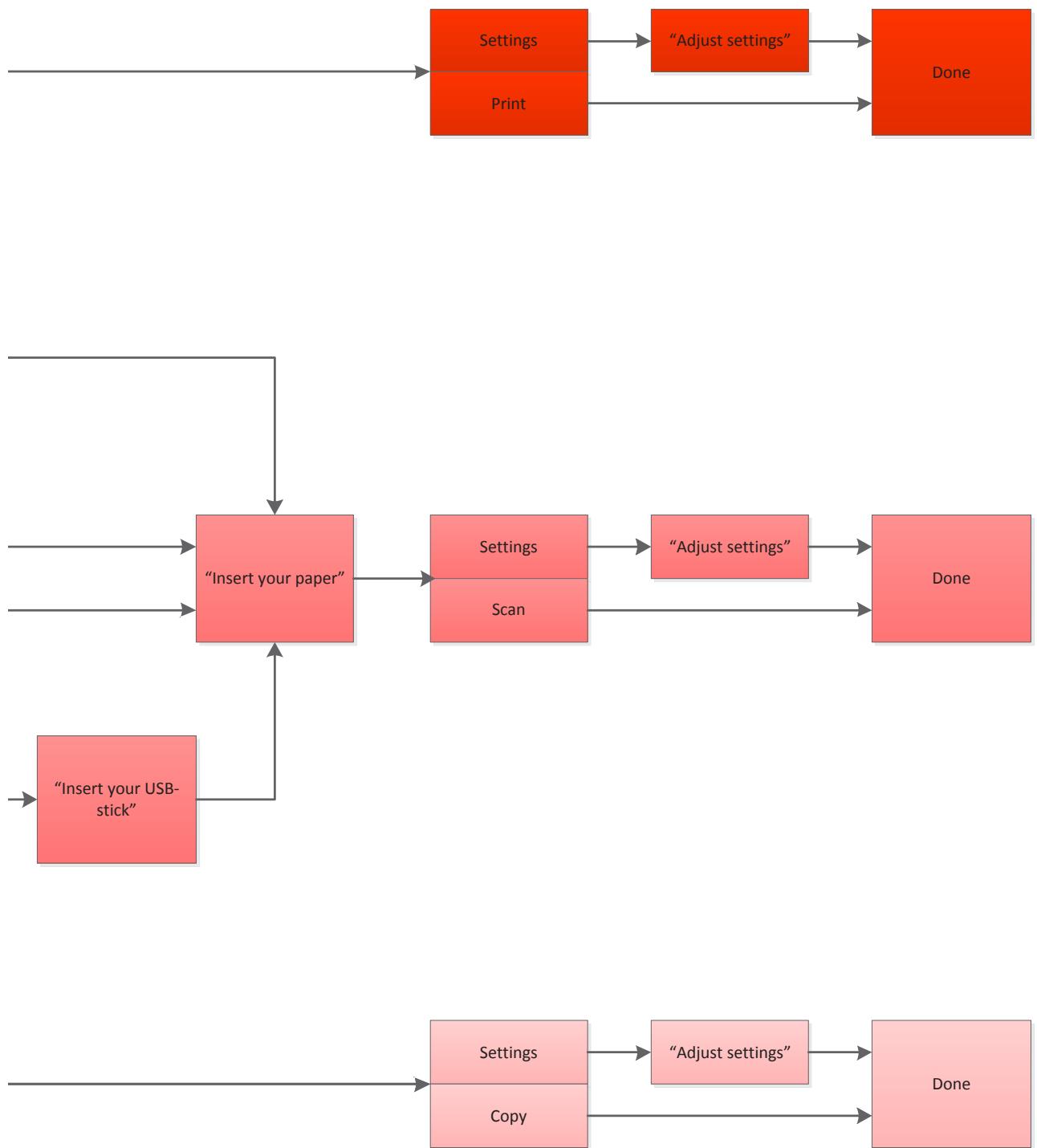


Figure 36: A flow-chart presenting the workflow

drive or document, or selects an option in which the slots cannot be used (i.e. the USB-slot light will turn off when the user presses copy).

The redesigned PlotWave responds to user actions outside the screen just as well as it responds to choices made within the screen menus. When a user inserts a USB drive he is presumably not in need of a copy - as this action does not incorporate a USB drive. The same goes for documents: when a user inserts a document it is rather clear that he either wants to copy or scan (and not print). The redesign strives to guide the user to the most logical interactions while omitting the options the user won't need. The user should feel that the redesigned PlotWave is cooperative and supportive, just like an ideal co-worker. Obviously, the user can always go back when he needs to and select any option (copy, scale or print) from the start screen.

User actions outside the screen are in the concept closely related to the information presented on the screen. When a document is inserted in the scanner slot - positioned directly underneath the screen – a preview image will slide into the screen in the same manner as the document slides into the machine. A similar interaction is designed for when a USB drive is inserted. These animations give direct feedback on user actions and increase intuitiveness. Furthermore it closely connects the screen to the different parts of the housing.

The storyboard in figure 37 describes a user scenario in which the user is copying a file.

## 7.2 FUTURE IMPROVEMENTS

Due to time constraints some of the outcomes from study 2 have not inspired changes to the final concept. They are instead briefly described in this chapter.

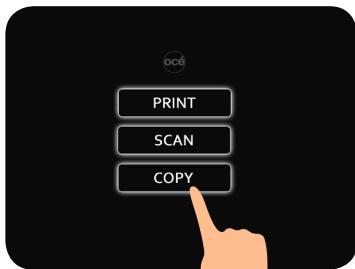
- The meaning of different paper sizes could be indicated on the housing, as users are not always aware of what a certain size actually is. Screen information cannot provide the users with this awareness.
- Handling large documents sometimes leads to an awkward interaction with the redesigned PlotWave. On the original PlotWave 300 this was partly solved by the option of adding a catching bag underneath the scanning paper output; this accessory could also be added to the redesign. Océ could also consider finding a solution for the somewhat awkward paper interaction.
- The redesigned screen can be accessed by wheelchairs users, but the top delivery tray is as in the original plotter positioned fairly high and to the back, sometimes making it hard to reach for this target group. A better solution requires further research into alternative positions for providing the users with a more ergonomic interaction.
- Since some menu options are initially hidden, it could be useful to provide a short options summary close to (or on) the confirm (copy/print/scan) button in the main screen.
- It should be possible to change the language settings in the Plotwave since Océ is an international company.
- There is still a lot of jargon used in the screen interface. Words like drawing method and blueprint might lead to confusion/insecurity for the user. The team mainly used the same options and wording as in the original PlotWave 300. In order to change the number of available options and the jargon used, more research needs to be done into the target group – their behaviours, wishes and understandings. Some settings might be taken out and others added. In upcoming PlotWave versions a help function could be implemented to facilitate users in understanding the workings of the plotter.



1. User approaches the plotter



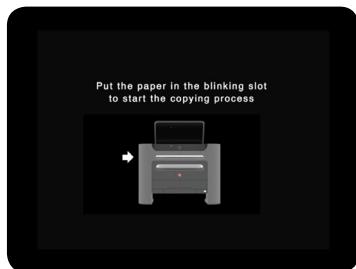
3b. Blinking lights indicate the position of the scanning slot



2. User selects the copy option from the main menu



4. User has inserted the document and the preview is generated



3a. Interface urges the user to insert the original document



5. The preview appears on the screen



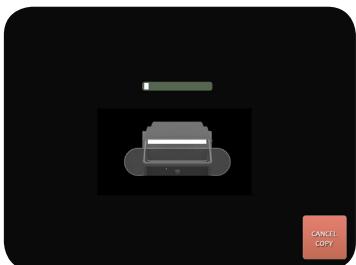
6. User adjusts the scale of the document



7. User adjusts the position of the document on the paper



8. User adjusts the additional options to optimize the finishing



9a. User has pressed the copy button and the status window has appeared



9b. The light near the paper output lights up



10. The original document comes out and the lights start blinking



11a. The copy comes out of the top delivery tray



11b. The progress can be seen from the status window



12. The copy is ready to be collected

Figure 37: Story board about the use of the Plotter



# CONCLUSION

Having gone through the process of redesigning the PlotWave 300 it was found that it is a complex task to successfully redesign a product that offers such a wide functionality range (copying, printing and scanning). After spending a considerable amount of time on analyzing the data gathered from the first usability study and exploring possible design directions, the concept started to take form. This resulted in an initial concept in which communication and guidance were accentuated.

User study 2 was a great opportunity to test whether the right design direction had been chosen. To truly benefit from study 2 it was necessary to enter an intensive prototyping phase in order to make the concept experiential. This turned out to be crucial to the success of the study since users could interact with the prototype as they would with any other plotter (up to a certain degree).

From study 2 many insights were gained on the flaws and merits of the redesign. Analysis of the results led to the conclusion that although the concept can still be slightly adjusted, it was an improvement over the original PlotWave 300 in terms of user experience as well as

usability. Knowing that the main design goals had been satisfied it was time to redesign the redesign to further improve on it. Because of the strong foundation the concept provided and the rich data collected in study 2 most problems were quite trivial in solving. However the issues concerning the structuring and layout of the menu elements took quite some effort to redefine.

Many strong features are incorporated in the final redesign. It is designed to integrate clear feedback while constantly adapting to its users. Light strips are implemented for guiding the user's attention. The user panel is integrated in the housing and provides a non-layered interface centered around a preview window – which can be directly manipulated by the user.

The final redesign is representative of the characteristics drawn from the metaphor of the ideal co-worker. All in all it can be stated that the redesign provides a pleasant and intuitive user experience, is straightforward and adaptive to its users and also offers continuous feedback and guidance. In other words the design goal has been reached.



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# APPENDIX 1

## UX TARGETS METAPHOR

This appendix further elaborates on the user experience targets metaphor described in chapter 3: "PlotWave 300, the ideal co-worker." The characteristics of this ideal co-worker and how this relates to a plotter design are discussed below.

### STRONG COMMUNICATION SKILLS

To have a good working relationship communication is imperative. A good co-worker therefore keeps you informed on a regular basis and the communication should seem to be effortless. During the usability study it was found that people often didn't know what the PlotWave 300 was doing at some point in time.

Then there's the matter of feedback. It is up to the interface of the plotter to guide the user in achieving his goals. The user should not be left guessing on whether his action will lead to the desired result. This implies that feedback needs to be fast and direct. In our user test people often had to wait for the printed document to evaluate whether the job had been correctly performed.

A majority of users seem to be unaware of the jargon the PlotWave 300 uses for certain settings. This can lead to some confusion. When the design team asked participants to resize a copy of a given document people saw a setting named "paper size" on the user panel yet changing this setting did not lead to the desired result.

The icons used in the interface of the user panel lack a clear meaning to its users. There is a saying in Human Computer Interaction "A picture is worth a thousand words, but only if you explain it in 1500 first" and this is most definitely true for the PlotWave 300 interface.

### DEPENDABILITY

Without trust you have nothing. In the workplace you need people you can depend upon. Reliability and integrity are key ingredients for inspiring trust in others. Good co-workers know this and keep to their promises and respect agreements. They are in a way very predictable, what you see is what you get.

The PlotWave 300 has several functions that can be confirmed in multiple ways, which can be experienced

as confusing. Ambiguity leads to uncertainty and uncertainty leads to distrust.

The four soft keys have no feedback in the form of making noise or moving, in itself this might not be a deal breaker however when the same buttons are quite unresponsive (i.e. sometimes they work and sometimes they don't) it becomes real frustrating for the user. Buttons like this make the user start doubting whether he pressed the correct button and if so the user starts mistrusting the interface since it failed to receive his input.

### GOOD FIRST IMPRESSION

Sometimes you have to introduce a co-worker to clients or friends and you want this process to go smoothly. There is only one chance to make a first impression and it should always be good, people decide in a few seconds whether they like you or they don't.

Upon first encountering a machine like the PlotWave users make some assumptions based on what they already know about devices like the PlotWave and combine this with the visual cues the machine provides. As concluded from our usability study, users generally expect the PlotWave 300 to feature a touch screen. When they realize that the machine does not feature a touch interface they already have a few awkward screen presses behind them. This is related to having a design communicate the features.

In order to convince clients to buy your product you need to impress them in a short period of time, for which you usually only get one chance. In our opinion, the color theme and overall look used in the interface can be called neutral at best and one of the participants in the usability study even drew the comparison between the visual interface and Windows 3.1 (in the sense of being old fashioned) on the basis of looks. This does not make a good first impression.

### DEEP RELATIONSHIP

A great co-worker knows you and you know him. You don't have to spell everything out but can suffice with shortcuts which he then understands. You don't only know each other's strengths but also each other's weaknesses.

This saves a lot of time for both parties. A relationship like this doesn't just happen it requires effort from both sides but the rewards are more than worth it. A deep relationship as described leads to increased productivity and friendship in the workplace.

Currently users get to know the PlotWave 300 but the favor is not returned by the machine. It's like having to introduce yourself over and over again. The PlotWave 300 does not adapt to its users and it does not remember how you used the device before. It provides you with the same menu structure every time you walk up to the machine. There is a huge opportunity for improving upon this interaction. In an ideal world the plotter would know what you want through an extensive knowledge of your previous encounters. For the user it would feel like the machine understands him.

## USES DOWNTIME PRODUCTIVELY

When a good co-worker is done with his tasks, he uses his free time in a useful way. An example would be preparing for a new task or to clean up the work area. In other words, when a good co-worker isn't given any tasks he is proactive in staying useful for the company.

Printers generally need maintenance to stay functioning in the way that is expected. Most of these maintenance jobs like cleaning might be performed without any human intervention. Though other tasks like replacing a toner cartridge requires someone to manually take out the cartridge and put in a new one. These tasks require downtime and this downtime can be devastating during a period of peak usage.

## DEALING WITH MISTAKES

Whenever you are dealing with people, mistakes will be made. A good co-worker knows how to deal with your mistakes as well as his own. The latter is perhaps the hardest but a good co-worker provides some sort of explanation and a well meant apology making it easier to forgive him. Ideally the explanation gives you the idea that a mistake like this isn't likely to occur again.

As far as we can tell Océ products seem reliable as printing equipment comes. However when something

does go wrong it is important that the user receives an explanation about what it was that went wrong in layman's terms. This is important to decrease loss of trust in the system, if the user loses his understanding of what is happening within the system he loses faith and the plotter becomes a magical device that seems beyond his understanding.

# APPENDIX 2

## DESIGN SPECIFICATION

The design requirements listed in this appendix (see table 7) are based on research and usability tests performed by the team. The requirements are divided into primary (absolutely necessary) and secondary (desirable) criteria, and are formulated as measurable as possible.

Category	Questions to spark ideas	Primary criteria	Secondary criteria
Customer	For whom is the product intended?	Professional architects and engineers.  First-time as well as experienced users.	Anyone.
Aesthetics	What appealing features would the product have?	The product should incorporate at least one new feature that is not yet (by the team) found in any other plotter.	At least 90% of the users should be able to notice a design where care is taken to details.
Function	What are the functions and features of the product?  How often will the product be used?	The product should at least fulfill the functions of the original PlotWave 300 as an all-in-one, black-and-white machine which is able to print, scan and copy large format documents.  The product gives direct (maximum of two clicks only) access to the basic settings for copy, scan and print.  The interface should either incorporate physical buttons or a touch screen.  The product should be designed for occasional as well as frequent use.	Detailed settings should be separated from basic functions and positioned in a deeper layer of the interface structure.  The user should be able to reach and change any setting in the menu in less than 10 clicks.  It should be possible for any targeted first-time user to replace cartridges and paper rolls without use of an instruction.
Ergonomics	What are the anatomical requirements/limits considering body postures of users?  What are the physical requirements/limits?	The interaction with the product should not for any user imply physical strain or discomfort.  The product should be easy to assemble and disassemble to fit through an office door (height: 2015 mm, width: 830 mm, as found on <a href="http://www.karwei.nl">www.karwei.nl</a> ), as this is where the product is normally located.	A possible user panel positioning should be appropriate also for wheel chaired users.
Quality	During what work-load must the product assure quality in function?	The product should be able to assure a high quality plotter result during an unceasingly day-to-day demand.	The aesthetics of the interface fit the professional segment.

Usability	<p>How easy is the product to use?</p> <p>Will a user guide be needed?</p> <p>How will the user be guided to the right actions?</p>	<p>A (first-time) user should be able to walk up to the product and directly understand how to achieve a desired task or how to figure it out.</p> <p>The product should provide proper feedback and step-by-step guidance, enabling the user to interact with the plotter in an intuitive way.</p> <p>The product should be designed with help of use cues guiding the user to the right actions.</p> <p>It should be clear where and how the paper is inserted as well as retrieved including clear indications of paper orientation (which side should be facing up).</p> <p>The product should always during user interaction display processing status and give active machine response to user actions.</p> <p>There should be a consistent use of symbols, buttons and actions to perform during use.</p> <p>An option for going back, regret or stop a process should always be available.</p>	<p>In the design, form should be used for indicating function and intended use, creating a “transparent” system.</p> <p>The interface should be so intuitive that the users are guided to take the shortest route to every menu they want to change.</p> <p>Overlapping functionality in menu options should be avoided.</p> <p>In case of buttons these should be associative with the looks and use of similar buttons in other applications.</p> <p>Less is more; the number of button presses should be minimized to maximize usability.</p> <p>The plotter uses laymans terms – logical use of words, symbols and descriptions for actions.</p>
Environment	<p>How will the product relate to the environment?</p> <p>Where is the product to be used?</p>	<p>The product should be possible to transport in parts.</p> <p>The product should be at least as eco-friendly as the original Océ PlotWave 300 cutting the energy usage in half compared to market standards.</p> <p>The product should be possible to place as part of an open-office structure or in a separate room close to the users.</p>	<p>The product should have a form/color expression in line with an environmental focus.</p>
Safety	<p>How will you ensure that the product is safe?</p>	<p>The system should provide the user with guidelines for necessary actions to be taken when a problem occurs.</p> <p>There should be no risk of getting hands/ties or other protruding parts stuck in the plotter.</p>	<p>In case of a panel interface design, a sturdy technique for attaching it to the body of the machine should be used.</p>

Table 7: The Design specification

# APPENDIX 3

## STUDY 2 - SCENARIOS

This appendix further describes the scenarios used during study 2 to help the participants simulate a real life situation. The study was made up of three main tasks; printing, scanning and copying and aimed to cover the system domains chosen for the test; the housing of the plotter as well as the user interface.

In order to prevent and neutralize carry-over (resulting in that the result of one task is (partly) influenced by the task before) the order of the tasks was randomized.

### SCENARIO FOR TASK (A): PRINTING

"Imagine it is Monday morning and you are sitting in your office a bit tired from the weekend. Your boss walks by, she gave you this memory stick with a technical drawing on it that needs to be printed (the instructor give the participant a memory stick with the file to be printed). She asks you to make the printout according to the following settings:"

- Number of prints: 2.
- Paper orientation: landscape.
- Size of document: A2.
- Rescale image to size: A3.
- Position of image on paper: Top left corner.

"Your boss specifically stated she wants the print out as soon as possible".

### SCENARIO FOR TASK (B): SCANNING

i) "Imagine that you got this technical drawing – a very important document from your colleagues. Because of the value of the document you would like to save it digitally on your desktop as a back-up. You want to scan the document with the following settings:"

- Number of scans: 1.
- Paper orientation: Portrait.
- Size of document: A0.
- Save on: Desktop (without checking the results - no computer needed)

ii) "When finished scanning, you realize that you also need the document saved on your USB. To save some time, not having to start up your computer again you decide to scan the document again but now save the scan on your USB memory stick. The settings are:"

- Number of scans: 1.
- Paper orientation: Portrait.
- Size of document: A0.
- Save on: USB.

### SCENARIO FOR TASK C: COPYING

"Imagine that you have to present your last project results in an important meeting later today. You have prepared the PPT presentation and are ready to go when you realize that you also need to show the hard copy of your plan to the board during the presentation (the instructor give the participant a hard copy of the plan, size A1). You already have one print-out of the plan (A1), so you decide to make your copies with the following settings:"

- Number of copies: 2.
- Size of document: A1.
- Rescale image to size: A2.
- Position of image on paper: Centered.

# APPENDIX 4

## STUDY 2 - INTERVIEW

### INTERIM INTERVIEW

After each of the three tasks presented during the tests in study 2, a short retrospective, semi-structured interview was performed, giving the opportunity for the participant to immediately express their feelings and opinions about the interaction. This also gave the instructor the chance to directly ask questions that arose from observing the participant.

The interview had a few structured questions as can be seen below, and was for the rest depending on what the participant expressed during the test and his/her interaction as observed by the instructor.

Q1: Was it easy for you to print/scan/copy with the redesigned Océ PlotWave 300 and why/why not? Were there any difficult parts for you?

Q2: What did you like or dislike the most during printing/scanning/copying with the redesigned Océ PlotWave 300?

Q3: Was there any confusion during printing/scanning/copying?

### FINAL INTERVIEW

A more detailed and extensive interview was conducted as a final part of the test (study 2). This experience interview covered the overall interaction and user experience after trying out the main features of the plotter.

Q1: In general, do you think is it straightforward for you to perform all these three tasks?

Q2: Was it a pleasant experience for you to perform these tasks? (refer to the metaphor ideal co-worker: trustworthy, kind, professional and communicative)

Q3: What do you like and dislike the most about the screen interface?

Q4: Do you think the plotter provided sufficient feedback and guidance?

Q5: Do you feel comfortable with the positioning of the screen?

Q6: Do you think you can easily perform these tasks next time without any hassles?

Q7: When looking at your effort ratings, could you describe an everyday product that demands a similar level of effort when being operated?

Q8: Will you recommend this plotter to other people? Why/why not?

Q9: Is there anything else you would like to add?

# APPENDIX 5

## **STUDY 2 - QUESTIONNAIRE AND EFFORT RATINGS**

## INITIAL QUESTIONNAIRE

In the beginning of the test the appearance of the redesigned plotter was evaluated by the help of a short questionnaire and pictures of the CAD-model.

## PART 1

Q1: Have you ever used any large format plotters? If the answer is no, please go to Part 2.

- YES NO

Q2: How often do you use it?

- On a daily basis    On a weekly basis    On a monthly basis

Q3: Where did you use this plotter?

- At school At work At home Other

Q4: What was the brand of the large format plotter you used?

## PART 2

Please rate the following question from a scale of 1-7, 1. Disagree Strongly 2. Disagree 3. Disagree Somewhat 4. No Opinion 5. Agree Somewhat 6. Agree 7. Agree Strongly

Q1: I am happy about the appearance of Oc  PlotWave 300. Please rate from a scale of 1-7

Q2: I am happy about the color of Océ PlotWave 300.  
Please rate from a scale of 1-7

Q3: The size of Oc  PlotWave 300 is compact as a large format plotter. Please rate from a scale of 1-7.



## EFFORT RATINGS

After each task the participant rated the test on a mental efforts scale (from no effort to extreme effort):

After finishing the task:

Please indicate, by marking the horizontal axis below, how much effort it took you to complete the task you have just finished.

A horizontal scale with seven numerical tick marks labeled 1, 2, 3, 4, 5, 6, and 7. Below the scale, the words "No effort" are positioned under the first tick mark, and "Extreme effort" is positioned under the last tick mark.

# APPENDIX 6

## QUESTIONNAIRE OF ATTRAKDIFF

Technical	---0---0---0---0---0---0---	Human
Complicated	---0---0---0---0---0---0---	Simple
Impractical	---0---0---0---0---0---0---	Practical
Cumbersome	---0---0---0---0---0---0---	Straightforward
Unpredictable	---0---0---0---0---0---0---	Predictable
Confusing	---0---0---0---0---0---0---	Clearly structured
Unruly	---0---0---0---0---0---0---	Manageable
Isolating	---0---0---0---0---0---0---	Connective
Unprofessional	---0---0---0---0---0---0---	Professional
Tacky	---0---0---0---0---0---0---	Stylish
Cheap	---0---0---0---0---0---0---	Premium
Alienating	---0---0---0---0---0---0---	Integrating
Separates me	---0---0---0---0---0---0---	Brings me closer to people
Unpresentable	---0---0---0---0---0---0---	Presentable
Conventional	---0---0---0---0---0---0---	Inventive
Unimaginative	---0---0---0---0---0---0---	Creative
Cautious	---0---0---0---0---0---0---	Bold
Conservative	---0---0---0---0---0---0---	Innovative
Dull	---0---0---0---0---0---0---	Captivating
Undemanding	---0---0---0---0---0---0---	Challenging
Ordinary	---0---0---0---0---0---0---	Novel
Unpleasant	---0---0---0---0---0---0---	Pleasant
Ugly	---0---0---0---0---0---0---	Attractive
Disagreeable	---0---0---0---0---0---0---	Likeable
Rejecting	---0---0---0---0---0---0---	Inviting
Bad	---0---0---0---0---0---0---	Good
Repelling	---0---0---0---0---0---0---	Appealing
Discouraging	---0---0---0---0---0---0---	Motivating

# APPENDIX 7

## MORE IMAGES OF THE INTERFACE

This appendix presents more images of the final interface design.

